2019-03

Influence of water, sanitation and hygiene interventionson common infections and nutritional status amongunder-five children in semi-pastoral communities, Arusha

Mshida, Hoyce Amini

NM-AIST

https://doi.org/10.58694/20.500.12479/296

INFLUENCE OF WATER, SANITATION AND HYGIENE INTERVENTIONS ON COMMON INFECTIONS AND NUTRITIONAL STATUS AMONG UNDER-FIVE CHILDREN IN SEMI-PASTORAL COMMUNITIES, ARUSHA

Hoyce Amini Mshida

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Life Sciences and Engineering of the Nelson Mandela African Institution of Science and Technology

Arusha, Tanzania

March, 2019

ABSTRACT

Under-nutrition and common infections among children aged below five years in semi-pastoral communities of northern Tanzania could be contributed by poor water, sanitation and hygiene (WASH) practices. The burden of these practices to the health of children under-five years seem to be given less consideration and much focus is on curative measures, vaccination and food supplementation. WASH interventions have been reported elsewhere to reduce the problems of under-nutrition and common infections among this age group. However, no any WASH intervention done in semi-pastoral communities to reduce the problems of under-nutrition and common infections among children under-five years. This study assessed the influence of WASH interventions on common infections and nutritional status among children under-five years in semi-pastoral communities of Arusha, Tanzania.

The study reviewed hospital attendance registers from Monduli and Longido District hospitals for year 2013 to 2015 to identify the existing trends of common infections among under-five children, followed by a household survey where a total of 310 mother-child pairs were randomly selected and data on child morbidity, WASH practices, cultural and socio-demographic characteristics was collected through facilitated interviews. Anthropometric measurements and hemoglobin levels of under-five children were taken. Thereafter, participants from Longido District were divided into intervention and control groups. The intervention group was provided with WASH package consisting of health education and nano-filters for filtering drinking water. The control group continued with their normal WASH practices. After six months follow up, assessment to determine the effectiveness of the interventions on diarrhea prevalence and nutritional status among under-five children was done. Samples of fresh milk ready to feed children and drinking water from storage containers were also tested to see status of *E. coli* in samples from the two groups.

About two third of under-five patients attended the hospitals were suffering from infectious diseases. Household survey revealed that 87% of respondents did not have toilets and 96% of those with no toilets were practicing open defecation. About 12% of respondents reported washing hands with soap during critical moments while 46% of respondents reported using unsafe surface water for domestic purposes. Again, 31.6% of under-five children were stunted, 61.2% were anemic while 15.5% had suffered from diarrhea two weeks preceding survey. Children fed on complementary foods kept in calabash/*kibuyu* ($p < 0.001$) had increased risk of suffering from diarrhea. Use of surface water for domestic purposes was

strongly associated with diarrhea, stunting and/or under-weight ($p < 0.001$). After intervention, incidences of diarrhea ($p = 0.03$) and rate of underweight ($p = 0.02$) were significantly reduced among under-five children when compared to those from the control group.

Conclusion: Use of surface water for domestic purposes, storage of complementary foods in calabash/*kibuyu,* and lack of formal education among mothers of under-five children were found to contribute significantly to diarrhea and under-nutrition among this participant population. This study highlights the need for health education promotion and treatment of drinking water at the point of use to address the problems of under-nutrition and common infections among children under-five years in semi pastoral communities and similar settings.

Key words: WASH, under-nutrition, under-five children, infectious diseases, semi-pastoral communities.

DECLARATION

I, **Hoyce Amini Mshida** do hereby declare to the Senate of Nelson Mandela African Institution of Science and Technology that this dissertation is my own original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

_____ _____

Name and signature of candidate **Date**

The above declaration is confirmed

_____ _____

Name and signature of main supervisor **Date**

COPYRIGHT

CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance of a dissertation entitled; **Influence of water, sanitation and hygiene interventions on common infections and nutritional status among under-five children in semi-pastoral communities of Arusha, Tanzania** in fulfillment of the requirements for the Degree of Doctor of Philosophy in Life Sciences and Engineering at Nelson Mandela African Institution of Science and Technology (NM-AIST).

Name and signature of supervisor 1	**Date**
Name and signature of supervisor 2	**Date**
Name and signature of supervisor 3	**Date**

ACKNOWLEDGEMENTS

I would like to thank the almighty God for granting me good health and ability to accomplish my PhD studies. I am also greatly thankful to everybody who in one way or another assisted on finalizing my long way academic journey.

I would like to also, acknowledge the support from the Government of Tanzania for funding my studies. Furthermore, I recognize the support from School of Life Sciences and Bio-Engineering at the Nelson Mandela African Institution of Science and Technology.

Special appreciations and thanks should go to my supervisors, Prof. Martin Kimanya, Dr. Neema Kassim and Dr. Emmanuel Mpolya, for their tireless guidance and mentorship during my study period.

While in the field, everything could be impossible without the assistance and support from Village Executive Officers and Ward Executive Officers particularly Mr. Yohanna Loito, Sima Molel and Magreth Malisa who accompanied me to Maasai bomas to make sure questionnaire exercise, anthropometric measurements, testing of hemoglobin levels of under-five children, collection of water and fresh milk samples and interventions were smoothly conducted. Special thanks should also go to Arusha Regional medical officer and District medical officers for Monduli and Longido District hospitals who granted me permission to conduct a research in the mentioned Districts. I will also never forget the support I got from NM-AIST laboratory technicians, Dr. Beatus Lyimo, Lydia Munuo and John Mshanga, during laboratory analysis of microbial contamination in water and complementary foods samples.

My special thanks and appreciation goes to my spouse Mr. Didas, my son Davis and my daughter Alice for their love, patience and support during my studies. I also, thank Innocent (adopted son) for his courage and company during my entire period of study. I am also grateful to my colleagues and classmates for their support of all kind. Again, I appreciate the encouragement I got from my brothers Wilson, Hackman and Denis as well as my sisters Caroline, Flora and Haika without forgetting my parents Mr. and Mrs. Aminiel Mshida.

DEDICATION

This work is dedicated to my lovely family. I thank God so much for giving me Didas, Davis and Alice in my life. Without them my academic journey could be difficult. I once again thank them all for their prayers, company and good wishes that gave me strength and hope always.

Special appreciations go to my parents and relatives who tirelessly encouraged me with healthful words and a push for tenacity which always ring in my ears.

…Success does not depend entirely on individual's efforts….

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

CDC	Centre for Disease Control
CF	Complementary foods
ENA for SMART	Emergence Nutritional Assessment software for SMART
FFQ	Food Frequency Questionnaire
FFT	Food Frequency Table
HAZ	Height for Age z-score (Stunting)
HHs	Households
HWZ	Height for Weight z-score (Wasting)
MDGs	Millennium Development Goals
MKUKUTA/NSGRP	Mkakati wa kukuza uchumi na kupunguza umaskini Tanzania/National Strategy for Growth and Poverty Reduction
MoHSW	Ministry of Health and Social Welfare
NDHS	National Demographic and Health Survey
NIMR	National Institute of Medical Research
NM-AIST	Nelson Mandela African Institution of Science and Technology
RCH	Reproductive and Child Health
SDGs	Sustainable Development Goals
SPSS	Statistical Package for Social Sciences
SSA	Sub Saharan Africa
TDHS	Tanzania Demographic and Health Survey
TFNC	Tanzania Food and Nutrition Center
TNNS	Tanzania National Nutrition Survey

UNICEF	United Nation Children's Funds
USAID	United States Agency for International Development
WASH	Water, Sanitation and Hygiene
WAZ	Weight for Age z-score (underweight)
WHO	World Health Organization

CHAPTER ONE

1.1 Introduction

This research examined the influence of water, sanitation and hygiene (WASH) practices on common infections and under-nutrition among under-five children in semi-pastoral communities of Longido and Monduli Districts. Common infections in this population referred to infectious diseases such as diarrhea-associated infections, worms-caused infections, eye/ear infection, skin infections, amoebiosis, typhoid fever and upper respiratory infections (ARI). The study explored further the role played by selected WASH interventions in reduction of common infections particularly diarrhea and under-nutrition among under-five children in Longido District. The study argues that prevalence of common infections and under-nutrition among under-five children in semi-pastoral communities may be impacted by poor WASH practices. The study hypothesized further that integration of WASH interventions at the community level could contribute in improving the nutritional status and reduce prevalence of common infections among under-five children. The communities under study may be unaware on the extent to which poor WASH practices affect their health and that of under-five children. This study is important among semi-pastoral communities in northern Tanzania as it is the first known study to document the role played by WASH interventions in relation to improvement of drinking water quality using nano-filtration and health education in reducing common infections and improving nutritional status of under-five children in that particular context.

The study started by reviewing patients' attendance registers from the two District hospitals of Longido and Monduli to affirm the trend of common infections among under-five children attending these facilities for years 2013, 2014 and 2015. Then, a baseline household survey was conducted in four villages, two from Monduli (Meserani and Makuyuni) and two from Longido (Kimokouwa and Orbomba). In total 310 mother-child pairs randomly sampled from the identified villages were involved in this survey. Therefore, 160 participants were randomly sampled from Monduli while 150 participants from Longido District. A facilitated questionnaire was used to gather information from mothers of under-five children where information on socio-demographic, economic and cultural characteristics, WASH practices, child morbidity, and child feeding practices was collected. Information regarding child mortality due to infectious diseases was not gathered in this study. Anthropometric measurements and hemoglobin levels of under-five participating children were documented.

The baseline data paved the way for an intervention study where participants from Longido District were involved in a planned intervention. The District was intervened after showing high prevalence of common infections and under-nutrition among under-five children when compared to that of Monduli District.

The two villages, Orbomba and Kimokouwa from Longido which were previously involved in baseline survey were randomly assigned to intervention and control groups. The intervention group was provided with Nano-filters® for improving drinking water quality and health education was given to mothers/caregivers for improving their WASH practices particularly hygiene behavior. Also, all under-five children from both groups were dewormed to control confounders in this study. The control group proceeded with their normal WASH practices. A follow up visit was done bimonthly for six months followed by post assessment to identify any improvements on nutritional status and reduction on common infections prevalence particularly diarrhea among under-five children.

This dissertation is paper based with three original papers and one review paper of which one paper was published to the *Journal of Environmental and Public Health,* the second paper was published to the *American Journal of Tropical Medicine and Hygiene,* the third paper was published to the *Journal of Biodiversity and Environmental Sciences* and the forth paper was resubmitted to *PLoS One*. Figure 1 below describes the outline of the dissertation.

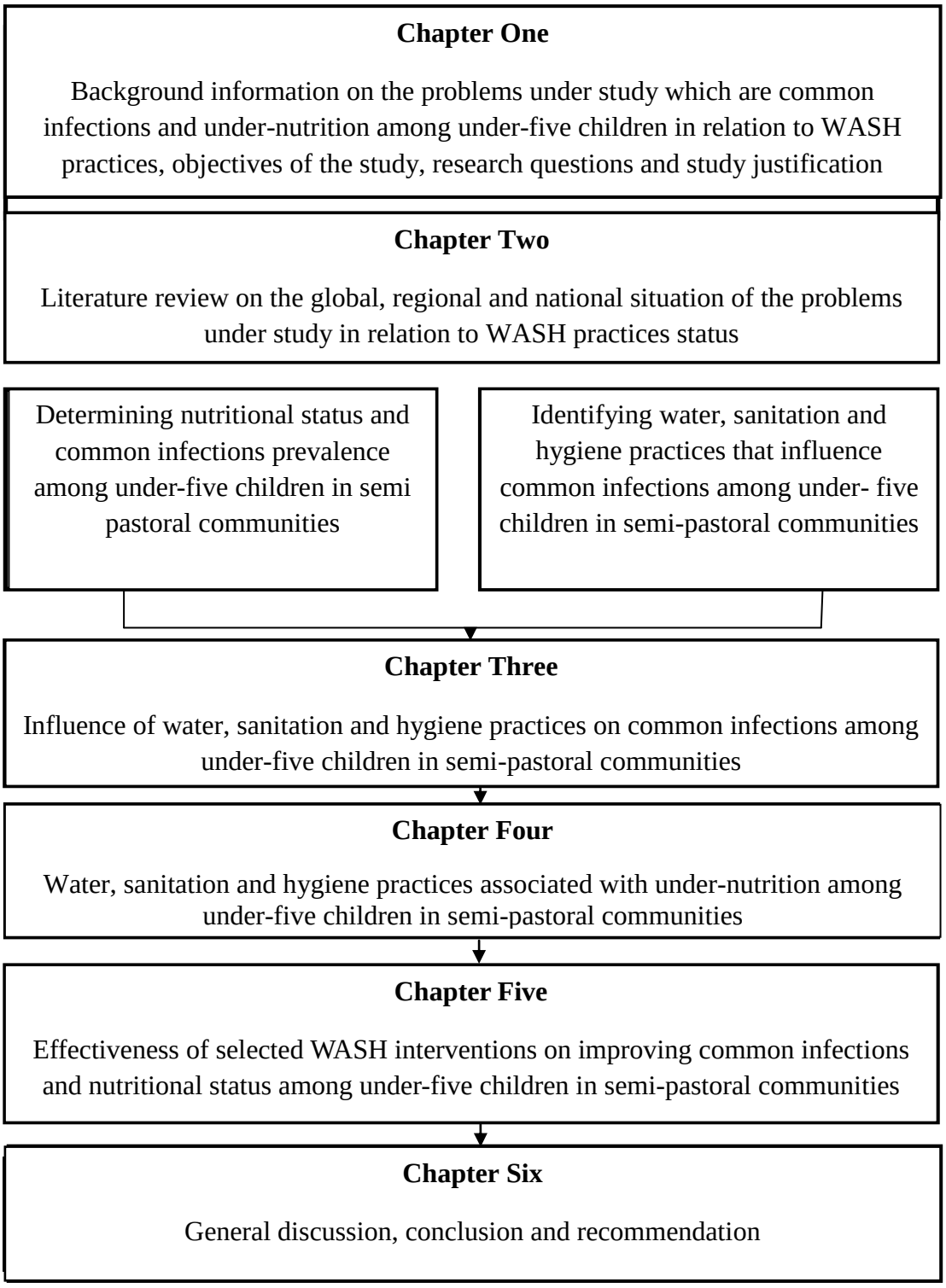


Figure 1: Outline of the study.

1.2 Background Information

Water, sanitation and hygiene practices (WASH) are among fundamental basic human rights although they have received little attention in developing countries (Arnold *et al.,* 2013; United States Agency for International Development [USAID], 2015). Studies show that, poor WASH practices contribute significantly to the problem of under-nutrition and infectious diseases among under-five children in developing countries particularly Sub Saharan Africa (SSA) (Arnold *et al.,* 2013; Lim *et al.,* 2013; Walker *et al.,* 2007). The majority of children in these countries are living in poor environmental conditions which impacts negatively to their health status (Waddington *et al.,* 2009a; World Health Organization [(WHO)]/United Nations Children's Fund [UNICEF], 2015). Regardless of the known facts on the importance of the first 1000 days of life and its potential in child growth performance and development, little have been done in developing countries to ensure that children in this age group are free the potential risk factors for mortality and morbidity such as under-nutrition and infectious diseases (Cairncross, 2010).

1.2.1 Under-nutrition problem among children aged below five years

Literatures show that, 45% of all deaths and 11% of global disease burden in under-five children is due to under-nutrition (Too-Kong, 2014; UNICEF, 2015; USAID, 2015). Infectious diseases are known to be the immediate cause of under-nutrition and the two problems forms a vicious cycle. Another immediate cause of under-nutrition among under-five children is inadequate dietary intake. Improper child care, lack of health care services, poor environmental conditions such as poor WASH and food insecurity contribute indirectly to the problem of under-nutrition among this age group (Shetty, 2000). The aforementioned factors embed political, economic, social and cultural aspects. Under-nutrition among under-five children is categorized into three different forms which are stunting/chronic malnutrition (height for age z-score [HAZ]), under-weight/acute malnutrition [WAZ], and wasting (weight for age z-score [WAZ] (UNICEF/WHO, 2014). According to UNICEF report of 2015, 20% of under-five children globally were stunted, 14% and 8% were under-weight and wasted respectively (UNICEF, 2015). The problem of under-nutrition among under-five children has been reported to be critical in SSA and Southern Asia (Lomazzi *et al.,* 2014). In Tanzania, the National Demographic and Health Survey of 2015 reported a prevalence of 34.7% stunting, 13.7% under-weight and 4.4% wasting among under-five children. In addition, prevalence of stunting, under-weight and wasting for Arusha Region where this study was conducted was

36%, 20.1% and 6.5% respectively (NBS and MACRO, 2015). Regardless of nutrition interventions taking place globally and Tanzania in particular, the aforementioned prevalence of under-nutrition among under-five children in Tanzania and Arusha Region in particular are high according to WHO standards (WHO, 2010) therefore need immediate attention.

1.2.2 Infectious diseases situation in under-five children

Infectious diseases particularly acute respiratory infections and diarrhea have been reported as major public health threats to childhood survival in developing countries (Zeleke and Zewdie, 2014; UNICEF, 2015). Diarrhea which is mainly caused by *Escherichia coli (E. coli)* and *Rotavirus* among other pathogens has been reported as the second leading cause of under-five child mortality globally and the first in SSA despite the fact that it can be cured and prevented (Walker *et al.,* 2013). It kills about 1.26 million young children annually worldwide which exceed the mortality due to malaria, tuberculosis and HIV/AIDs combined (Cairncross *et al.,* 2010). The NBS and MACRO (2016) reported that, 9% of all deaths among under-five children are due to diarrhea while 12% of the said aged group suffers from diarrhea annually. Acute respiratory infections (ARI) remain the leading cause of mortality among under-five children globally and two third of such infections are caused by bacteria specifically, the *pneumococcus* and *Haemophilus influenza*, (Ramani *et al.,* 2016; UNICEF, 2009a; 2009b). Globally, about 6.6 million under-five children die every year; 95% of these cases occur in low-income countries and one third of the total deaths are due to ARI (Tazinya *et al.,* 2018). Similarly, environmental enteropathy, which results from regular ingestion of fecal bacteria, has been reported in under-five children (Humphrey, 2009). Soil-transmitted infections, such as Ascariasis, whipworms and hookworms affect about 1.2 billion, 800 million and 750 million people worldwide, respectively, with the majority being under-five children (Ziegelbauer *et al.,* 2012). Other infectious diseases which are common among under-five children include ear/eye infections and skin infections. The above mentioned infections are believed to emanate from poor environmental conditions such as poor WASH practices and they contribute significantly to the problem of under-nutrition among under-five children. The Sustainable Development Goals (SDGs) number three of achieving good health and wellbeing to all by 2030 will continue be a night mare in developing countries unless strategies for eradicating risk factors for child mortality and morbidity consider integrating and mainstreaming WASH interventions into nutrition and disease prevention measures.

1.2.2 WASH situation

Despite various efforts taken by many entities including Joint Monitoring Program (JMP), UNICEF, and WHO to ensure improved WASH for all by 2030 892 million people globally still practice open defecation, 423 million depend on unimproved water sources, and 159 million use surface water for domestic purposes. Again, the number of people with basic sanitation services globally, was 5 billion whereas 2.3 billion were still using unimproved sanitation services (WHO/UNICEF/JMP, 2017). The MDGs report of 2015 declared that, majority of SSA including Tanzania and Southern Asia countries could not meet the target of halving the number of people without improved sanitation, adequate water supply and child mortality. Thomas *et al.* (2014) reported that 12% of Tanzanians were practicing open defecation, 76% owned unimproved sanitation facilities while 43% relied on unsafe water sources for domestic purposes. However, before implementation of MDGs the NBS and MACRO of 1999 reported that 14% of Tanzanians were practicing open defecation, 86% owned unimproved sanitation facilities and 48% were using unsafe water sources for domestic purposes. Study done in Babati District in Manyara Region showed that about 51% of the households owned unimproved sanitation facilities, 14% were sharing sanitation facilities while 5% of the households were practicing open defecation. Again 13% of households had handwashing facilities, 52% relied on shallow wells, 29% on surface water and 19% on boreholes/deep wells as their main source of domestic water (WaterAid report, 2019). The health consequences of poor WASH practices to individuals and the nation at large may be obvious. Just like other developing countries, Tanzania has not prioritized WASH policies, and this is likely to be one of the major obstacles for improving WASH practices. Thus, a thorough understanding of the current situation of WASH situation in Tanzania especially in marginalized communities and its implication to people's health as well as the disease burden due to poor WASH is needed. Understanding the current situation of WASH is important as it can help practitioners design effective strategies for reinforcing and improving existing WASH laws to reduce risk for child mortality and morbidity including under-nutrition and infectious diseases.

1.2.3 WASH interventions for improving health status of under-five children

WASH interventions have been reported to improve the nutritional status and reduce infectious diseases among under-five children (Dangour *et al.*, 2013; Fewtrell *et al.*, 2005). Improvement of water quantity and quality was reported to improve child growth and

development by a longitudinal study done by Martorell (2010). Diarrhea associated diseases which are among the major threat to under-five children survival could be reduced by 41% by ensuring adequate and safe domestic water supply and promotion of hand washing practice (Pickering and Davis, 2012; Freeman *et al.,* 2014). Enteric infections including worms among under-five children were reduced significantly by improving sanitation conditions in the households (Strunz *et al.,* 2014; Cairncross *et al.,* 2010). A study done in Nepal also reported improved hygiene behavior among mothers following health education provision (Gautam *et al.,* 2017). However, the sustainability and adherence of these interventions continues to be a major challenge when addressing the problem of WASH in developing countries due to economic and social- cultural aspects.

1.3 Problem Statement and Study Justification

Despite the reported potential contribution of WASH practices in improving nutritional status and health of individuals (Chase and Ngure, 2016; USAID, 2015), these practices has received little attention in semi-pastoral communities. Furthermore, there is limited documentation on the extent of how poor WASH practices may affect nutritional status and contribute to common infections among under-five children in those communities. Initiatives for addressing the problems of infectious diseases and under-nutrition among under-five children in those communities and nationwide have focused mainly on curative measures, vaccinations against rotavirus, polio, measles, and food supplementation including vitamin A, iron and iodine supplementation and fortification of oil and flour (Chase and Ngure, 2016). However, only 20% of under-nutrition (stunting) among under-five children could be addressed with nutrition interventions with 90% coverage (USAID, 2015), indicating that the remaining 80% could be attained by interventions other than nutrition. Therefore this study assessed the influence of WASH practices on common infections and nutritional status among children below five years of age in semi-pastoral communities of Longido and Monduli Districts of Arusha Region and evaluated the effectiveness of selected WASH interventions in improving such health challenges.

1.4 Research Objectives

1.4.1 General objective

The main objective of the study was to assess the influence of water, sanitation and hygiene interventions on common infections and nutritional status among under-five children in semi-pastoral communities in Arusha Region, Tanzania.

1.4.2 Specific objectives

i) To determine the nutritional status and prevalence of common infections among under-five children in semi pastoral communities.

ii) To identify water, sanitation and hygiene practices that influence common infections among under-five children in semi-pastoral communities.

iii) To assess water, sanitation and hygiene practices associated with nutritional status among under-five children in semi-pastoral communities.

iv) To evaluate the effectiveness of selected WASH interventions on improvement of common infections and nutritional status among under-five children in semi-pastoral communities.

1.5 Research Questions

i) What is the prevalence of common infections and nutritional status among under-five children in semi-pastoral communities?

ii) What are the current WASH practices that influence common infections among under- five children in semi-pastoral communities?

iii) What are WASH practices associated with nutritional status of under-five children in semi-pastoral communities?

iv) How effective is the selected WASH interventions on improvement of common infections and nutritional status among under-five children in semi-pastoral communities?

1.6 Ethical Clearance

Ethical clearance (Appendix V) was obtained from the National Institute for Medical Research of Tanzania. Informed written consent was sought from mothers/caregivers of the children under study prior to administration of the questionnaire and before taking anthropometric measurements and hemoglobin levels testing on under-five children participants. For the case of mothers who were not able to communicate in Swahili language, the document was prepared in Swahili language and translated by a sub-village executive officer who was a native Maasai speaker before signing. For those who could not write, a finger print signature was used. Confidentiality regarding the information collected from the survey was ensured, by giving the participants identity numbers and instead of using their names. Participants were further informed that the information collected would be used for research purposes and would not be shared by a third person.

1.7 Significance of the Study

Studies regarding the influence of WASH interventions on common infections and nutritional status among under-five children in semi-pastoral communities are limited. This study, therefore, intended to reveal WASH associated factors that contribute to common infections and nutritional status among under-five children in semi-pastoral communities and to evaluate the effectiveness of selected WASH interventions on reduction of the problems under study. Of immediate significance was documentation of the current status of WASH practices, common infections, and under-nutrition among under-five children in the population under study. The study further aimed at identifying the potential WASH factors that contribute significantly to the problem of under-nutrition and common infections among the targeted age group. Awareness of these potential WASH factors could inform specific WASH interventions that could address the problems of under-nutrition and common infections among under-five children in the population under study on top of the prevailing interventions. Findings from this study could also add scientific knowledge while informing stakeholders and policy makers of the need to incorporate and mainstream WASH along with nutrition interventions to address the problems of common infections and under-nutrition among under-five children and allocate limited resources adequately.

1.8 Conceptual framework of the study

The study hypothesized that, improvement of WASH practices among semi-pastoral communities would reduce the prevalence of diarrhea associated diseases and ultimately improve the nutritional status among children under-five years. Such practices include improvement of drinking water quality at the point of use through provision of nano filters to the households and improvement of sanitation and hygiene practices through health education promotion. Figure 2 below shows a conceptual framework of the study.

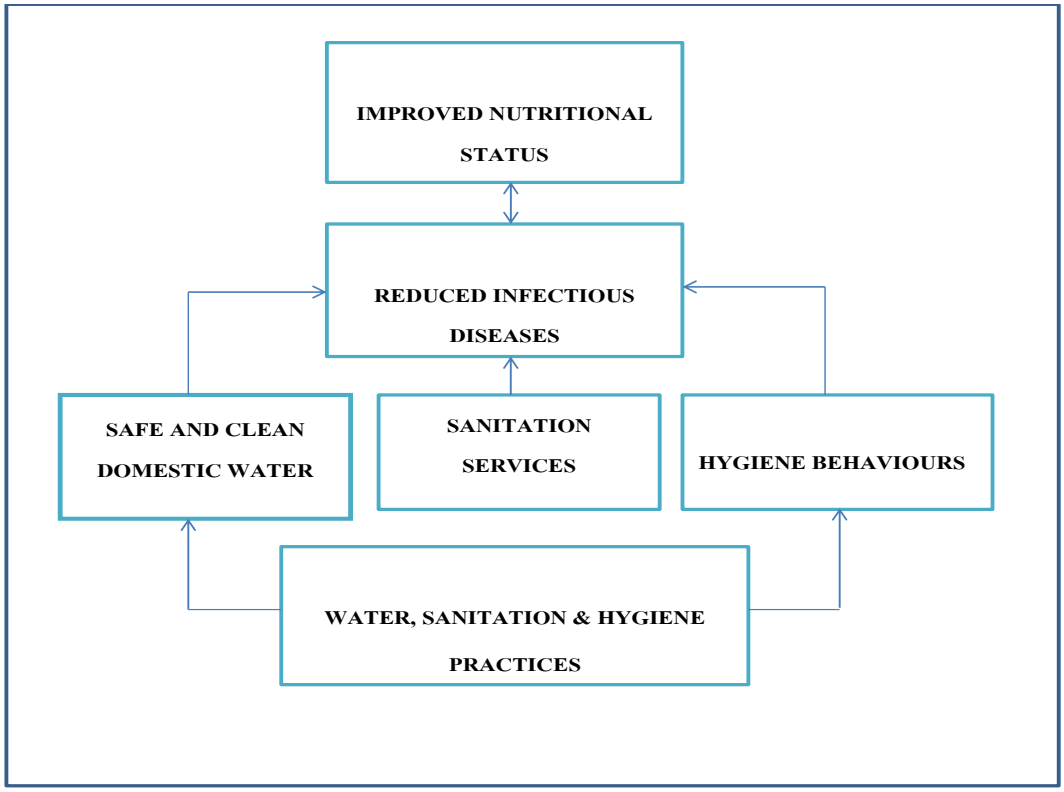


Figure 2: Conceptual framework of the study

1.9 Limitation of the Study

Despite the reported strengths, this study necessarily has some limitations. Some of the information from this study relate to questionnaire reliance on mothers' self-reporting, which might have been subjected to recall bias. The interventions covered a very small sample size, therefore the conclusion about the impact of WASH practices on common infections and nutritional status among under-five children may not be adequately substantiated. The cost of doing the intervention limited the ability to replicate or for intervalled interventions (i.e. control, filter only, health education only, filter and health education). Again, the information

regarding prevalence of diarrhea was gathered in a given short period of time, therefore may not be generalizable as diarrhea prevalence may change with seasons.

CHAPTER TWO

Literature review

Water, sanitation and hygiene practices and its impact on infectious diseases and under-nutrition among children below five years of age in low income countries[1]

Abstract

Under-nutrition among children aged below five years continuous to be a major public health threat despite numerous nutrition interventions taking place in low income countries. In 2016, about 23% of under-five children were stunted worldwide. Essentially, nutrition interventions have gained much attention globally, although it can address only 20% of stunting in this age group. The awareness that the problem cannot solely be eliminated through optimization of diets has led to the theory that diseases have potential impact to the problem and need attention as well. Majority of these diseases are believed to emanate from poor water, sanitation and hygiene practices (WASH) and may affect the nutritional status of under-five children; may lead to malabsorption, poor villi function, leaking of mucosa, inflammation of the gut and even compromised immune systems. Worms for example, tend to compete for nutrients with the child. Furthermore, costs incurred for treating infections could affect the food budget of the family. Also, when a child falls sick, whatever little food is taken is used for body recovery rather than growth. It is therefore, important to critically conceptualize the relationship between these risk factors for child mortality and morbidity and propose solutions through which such problems could be eliminated. This review paper therefore, suggests incorporating WASH interventions to nutrition and disease prevention interventions to address the problem of under-nutrition and infectious diseases among children below five years of age in developing countries and potentially reduce child mortality.

Keywords: WASH, infectious diseases, under-nutrition, under-five children, low income countries.

[1] Journal of Biodiversity and Environmental Sciences: **12**(3), 378-390, March 2018.

2.1 Introduction

Under-nutrition and infectious diseases are fundamental risk factors for morbidity and mortality among children aged below five years in developing countries and have been linked with poor water, sanitation and hygiene practices (Arnold *et al.,* 2013; Lim *et al.,* 2013; Walker *et al.,* 2007). Regardless of global efforts to reduce such poverty related risks, still majority of children are born in poor environmental conditions that affect their health status (Waddington *et al.,* 2009a; WHO/UNICEF, 2015). Again, repeated exposure to infectious diseases and under-nutrition in the first 1000 days of life continue to impact negatively to the growth performance and potential development of children (Cairncross, 2010). Under-nutrition among under-five children alone contributes to 11% of the global disease burden and 45% of all deaths among this age group (Too-Kong, 2014) while infectious diseases such as diarrhea associated infections continuous to be the second leading cause of child mortality globally and the first in SSA (UNICEF, 2009a; Bado, 2016). Nevertheless, improved WASH conditions may help improve the nutritional status and reduce infectious diseases among this age group.

WASH is an acronym for water, sanitation and hygiene. The term is used in public health campaigns to address issues regarding access to adequate, safe and clean water for drinking/domestic purposes, sanitation and hygiene behaviors. The WHO and UNICEF reports state that access to drinking water means that, the water source is less than a kilometer away from its place of use and it is possible to obtain at least 20 liters per household member per day for general use purposes (WHO, 2004a; WHO/UNICEF, 2015). Safe and clean drinking water refers to water with microbial, chemical and physical characteristics that meets guidelines or international standards respecting drinking water quality (WHO, 2004a). Access to safe water means the proportion of people using improved drinking water sources such as household connections, public standpipes, protected boreholes, protected wells or springs and rainwater (WHO, 2004a; WHO/UNICEF, 2015). Sanitation means measures necessary for improving and protecting the health and wellbeing of the people through proper disposal of human and animal waste, proper use of toilets, and avoiding open defecation (Cairncross, 2010). The World Health Organization (2004a) describes sanitation as provision of facilities and services for the safe disposal of human urine and fecal excreta. Basic sanitation means the lowest cost technology for ensuring hygienic excreta and sludge disposal and clean and healthful living environments both at home and within the neighborhood (Chambers and Von Medeazza, 2013). It also includes safety and privacy in the use of such

services (MDGs Report, 2010). Hygiene refers to a set of practices performed for the preservation of people's health (Freeman *et al.*, 2014). It is the practice of keeping oneself and his/her surroundings clean including food handling to avoid illnesses or spread of preventable diseases. It also includes all circumstances and practices, lifestyle issues, premises and commodities that engender safe and healthy environments. Hygiene practices include personal hygiene, food hygiene, proper waste disposal and environmental cleanliness (Fewtrell *et al.,* 2007; Chege *et al.,* 2015). However, there is lack of demarcation between the definition of the terms sanitation and hygiene especially when it comes to the issue of environmental cleanliness and waste disposal. Nevertheless, the WHO definition for sanitation is more specific and independent from that of hygiene. It is therefore, recommended that stakeholders dealing with WASH should come up with a clear definition for the two terms to avoid misconceptions of such terms.

2.2 The link between infectious diseases and under-nutrition

Under-nutrition among children below five years of age is directly contributed by infectious diseases and the two health conditions forms a synergetic relationship (Bloss, 2004; Brown, 2013; Dewey, 2011). While studies shows the potential of dietary intake in causing under-nutrition, it has also been revealed that nutrition interventions, such as promotion of breastfeeding, improving complementary feeding practices and food supplementation, with 90% coverage may reduce the problem of under-nutrition only by 20% (Dangour *et al.,* 2013; Ngure *et al.,* 2014; USAID, 2015). This evidence shows that infectious diseases may make a significant contribution to under-nutrition among under-five children and the problem need to be addressed along with nutrition interventions for improved child health. Such infections include diarrhea, upper respiratory infections, environmental enteropathy (EE), and helminths, which are all common conditions to under-five children (Humphrey, 2009). Diarrhea associated infections emanating from poor WASH tends to inhibits absorption of nutrients by the body resulting in low nutrient status followed by compromised immunity (Cairncross, 2010b). Likewise, the undernourished child becomes vulnerable to infections due to a deteriorated immune system (Chase and Ngure, 2016). Some studies also show a strong link between under-nutrition and poor WASH (Bartram and Cairncross, 2010; Bloss *et al.,* 2004; Chambers and Von Medeazza, 2013; Checkley *et al.,* 2004; Humphrey, 2009; UNICEF, 2013) through a condition known as EE. This condition interferes absorption of food by the body and lead into malabsorption and other gastrointestinal complications including poor villi functioning and leaking of mucosa followed by poor nutritional status

and compromised immunity (Lunn *et al.*, 1991; Ngure *et al.*, 2014). Furthermore, worms immediately after invading the gastrointestinal system of an individual, tends to compete for nutrients with the host. The parasites (worm) take whatever little nutrients are consumed by a child (Morris *et al.*, 1994). Other diseases, such as respiratory infections, may lower child's appetite and compromise the immune system therefore; whatever little food is taken by the child is directed into body recovery from illness rather than growth. Skin and eye infections may also affect households` food budgets through treatment costs incurred when children fall sick (Burton *et al.*, 2015; UNICEF, 2013). Figure 3 below shows the direct and indirect causes of under-nutrition.

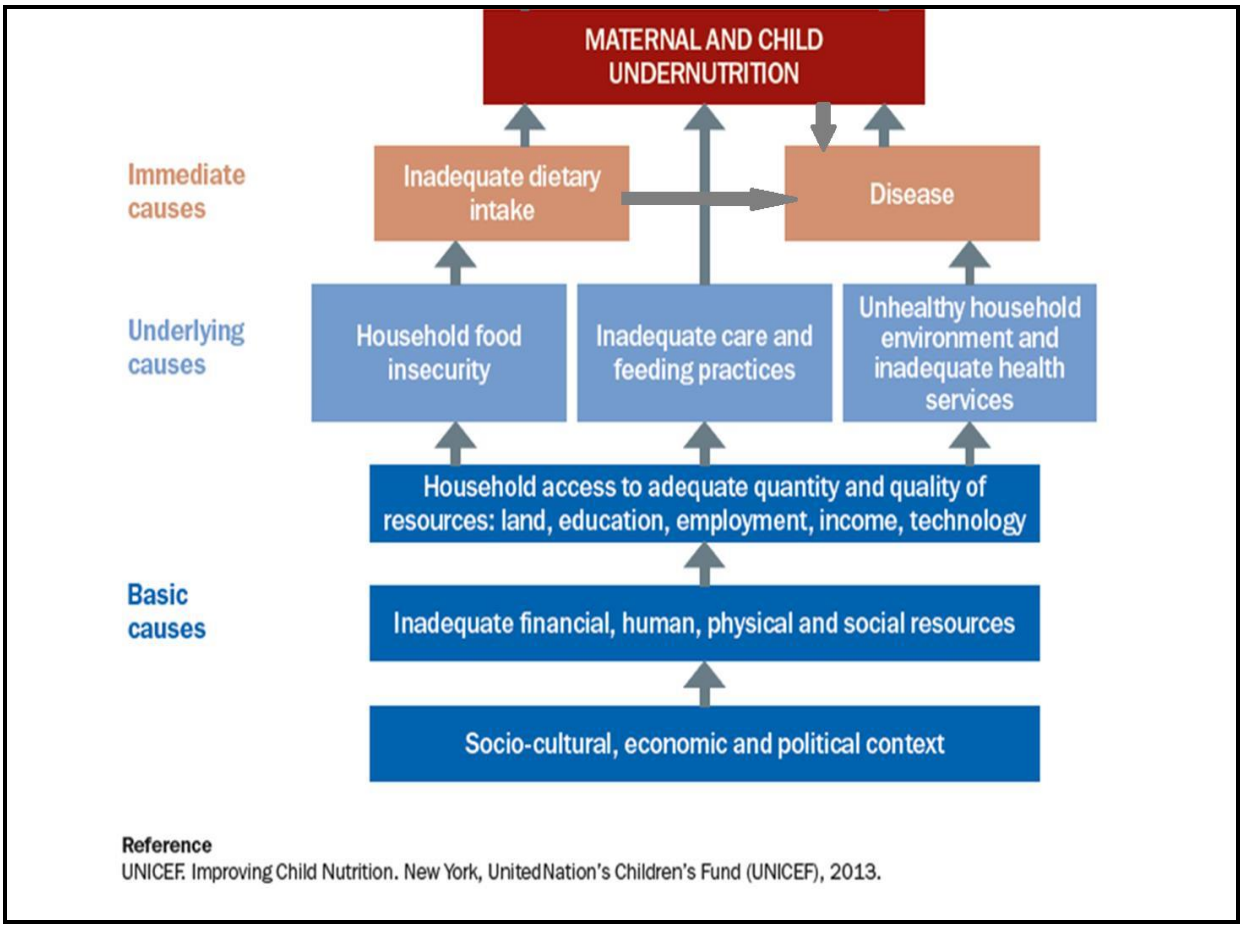


Figure 3: Underlying causes of under-nutrition as adapted from UNICEF (2013) and modified

2.3 How WASH practices impact on child health

2.3.1 Access to safe and clean drinking water

Globally, it is estimated that 780 million people depend on unimproved water sources for domestic purposes and 1.8 billion (28%) people use unsafe water (UNICEF/WHO, 2015). The use of unsafe water for domestic purposes may increase exposure to water-borne diseases (Devoto *et al.,* 2012; Chirande *et al.*, 2015). To reduce the burden of water-borne diseases among individuals, it is therefore important to treat water at the point of use to improve the microbial quality of household drinking water and reduce diarrhea associated diseases (Arnold *et al.,* 2007; Clasen *et al.*, 2007; Fewtrell *et al.*, 2005). A study done in Burundi revealed that water treatment at the point of use particularly through boiling, may reduce diarrhea prevalence by 61% (Diouf *et al.*, 2014) while treatment of water at the source did not reveal any impact on reduction of diarrhea. The findings could reflect that after treating water at the source it could be contaminated along the value chain or water may be contaminated by handlers or storage containers during collection and make it unsafe for domestic purposes. Therefore, treating water at the point of use could be more valuable and safer than treating water at the source. Nevertheless, both water quality and quantity are crucial for reduction of water-borne diseases (UNSAID, 2015). Improving water quality alone may not solve the problem of water-borne diseases due to the fact that when there is no adequate water for domestic purposes it could be a nightmare for people to practice good hygiene including hand washing and this may increase the chances of contracting water and food-borne associated diseases. Therefore, interventions aiming at improving water quality and quantity should be promoted at the household and community levels to reduce these diseases. Likewise, distance from the water source to the household may have an impact on both water-borne diseases and worm infestation. According to Diouf *et al.* (2014) and Gascon *et al.* (2000), increasing distance from the water source may reduce risk of diarrhea by reducing risk of water contamination at the source. However, the World Health Organization report of 2015 stated that increasing distance from water source to the household may increase prevalence of diarrhea as it may affect water quantity and water consumption habits in the household and hygiene practices as well. These inconsistent findings might reflect that when the water source is too close to the households, there could be an interaction between the water and sanitation facilities especially when the source is surface water or underground water which could lead to water contamination. When the water source is too far it may affect the hygiene behavior of individuals due to lack of enough water to practice hygiene. The

World Health Organization report of 2010 recommends that distance to/from water source to the point of use should not exceed a kilometer or thirty minutes walking distance. However, recommendation on the distance of a water source from the household should take into account other issues like type of water source and sanitation facilities commonly used in that specific locality to avoid water contamination along the value chain.

2.3.2 Sanitation practices

Sanitation plays a significant role in disease causation and transmission; however, improved sanitation practices have been a major challenge in developing countries due to limited resources for constructing sanitation facilities and similar effective interventions. As a result, people dispose human excreta in different ways depending on the availability and affordability of sanitation facilities. WHO, UNICEF, and JMP (2014) as well as other WASH stakeholders have been emphasizing the importance of universal good sanitation practices.

Lack of awareness on the importance of improved sanitation appears to a major problem among individuals as opposed to limited resources and could be a major contributing factor for the problem of diarrhea. A study done in Ifakara, Tanzania reported low prevalence of diarrhea in the households having latrines compared to those households without latrines (Gascon *et al.,* 2000). A systematic review done on the impact of improved sanitation on people's health reported a reduction of diarrhea prevalence by 32 - 36% (Brown *et al.*, 2013). A comparison study from Brazil revealed that communities having improved sanitary facilities enjoyed a decline in prevalence of ascariasis of up to 40% compared to the communities lacking improved sanitation facilities. Studies done in India and Ethiopia reported reduction on stunting among under-five children coming from families with sanitation facilities when compared with those without such facilities (Chambers and Von Medeazza, 2013; Fikadu, 2014). Poor sanitation practices in any community could lead to oral-fecal bacteria infections particularly *Escherichia coli (E. coli*) infections and finally poor nutritional status among individuals. Again communities practicing poor sanitation are likely to be practicing open defecation and other unsanitary behaviors which could lead to contamination of soil and water especially during rainy seasons which could later infect individuals especially children in the community. Knowing the burden of poor sanitation in causing diseases and co-morbidities (such as stunting) solidifies the importance of promoting improved sanitation among individuals and communities (Cumming, 2016).

2.3.3 Hygiene practices

Hygiene practices including food hygiene, personal hygiene, child feces disposal, and hand washing with soap during critical moments plays a fundamental role in addressing disease prevention measures. Child feces disposal, in particular contributes significantly to fecal-oral disease causation and transmission. Marginalized communities, particularly pastoralists, believe that child feces are not harmful compared to those of adults due to the reason that their feces are small compared to that of adults, smells less, do not contain many food residuals, and does not stain the child clothes (Mshida *et al.,* 2017). Also in many families, latrines are not designed to accommodate children, some smell bad, some are in dark spaces and heavens for animals (such as snakes) and pose a potential to fall in. As a result, people use alternative means including children`s potties, open defecation normally on the floor, or even in the nappies; therefore, latrines are rarely used by children and chances of contamination from child feces are high. A study done in semi-pastoral communities in northern Tanzania reported that about 20% of under-five children were using latrine to defecate whereas more than 50% were practicing open defecation and feces were left on the ground (Mshida *et al.,* 2017). A study done in Peru revealed that less than 25% of under-fives used toilets (Checkley *et al.,* 2004). A Bukinafaso study found that more than 60% of children below five years of age were practicing open defecation without removal resulting in some cases dogs were seen eating the feces (Huttly *et al.,* 1990). The reported percentages of children using toilets and those practicing open defecation in the previous mentioned studies shows that there could be some similarities in child feces disposal behavior in most developing countries. Again, poor disposal of child feces and lack of awareness on the harmfulness of the feces may pose a high risk of fecal contamination of hands, food, soil or water which may increase risks of developing fecal-oral infections. Hence, hygiene behavior change interventions to raise awareness of the harmfulness of child feces and the danger of open defecation are recommended to reduce fecal-oral infections among under-five children.

Hands are a good vehicle for disease transmission when they are not washed thoroughly with soap after coming into contact with dirt (Curtis and Cairncross, 2003). Study by Curtis and Cairncross (2003) recommends hand washing with soap during four critical moments which are: before eating or feeding a child, after coming from the toilet, before preparing food, and after attending a child having have a bowel movement. However, studies show that hand washing with soap could be a big problem than people knows and it might be under estimated (Curtis and Cairncross, 2003; Mattioli *et al.,* 2015; WHO/UNICEF/JMP, 2017). People report

that they do wash their hands with soap, however, the truth is the majority do not practice proper hand washing (Cutis, 2003). Hands are good vehicles for transmitting diarrhea causing pathogens particularly *E. coli* when contaminated. Furthermore, interventions on hand washing with soap may significantly reduce the prevalence of diarrhea more than improved sanitation (Asudi, 2016). This study showed that hands may be a potential transmission route for pathogenic bacteria from our environments to the mouth and interventions on hand washing with soap during critical moments could break the fecal-oral routes infections more than improved sanitation (Cutis *et al.,* 2009). However, integration of more than one WASH intervention could reduce prevalence of diarrhea more effectively than single intervention. Study done in Tanzania, where hand washing and sanitation promotion campaigns were done in rural wards revealed a reduction in infectious diseases and improvement in under-nutrition among under-five children when compared to children from a control group (Briceño *et al.,* 2015). Another study done in Tanzania looked at the association between the contamination on people's hands and stored drinking water revealing strong association between the two parameters and validating the importance of handwashing to individuals on disease prevention measures (Briceño *et al.,* 2012). Epidemiological evidence shows that handwashing with soap may reduce infectious diseases, specifically childhood diarrhea by 30 to 47% (Curtis, 2003). However, a review study done in 11 developing countries showed that only 17% of people wash their hands with soap after using the toilets and fear of disease did not have any influence on handwashing behavior (Curtis, 2003; 2009). The findings highlight the importance of promoting handwashing practices with soap during critical moments through behavior change campaigns as well as construction of hand washing facilities at household level and community at large. However, the campaigns should go hand in hand with health education to create awareness on the relationship between infectious diseases and WASH practices to the communities. Again studies to determine the actual number of people practicing handwashing with soap during critical moments should focus much on observation rather than interviews to determine the actual practice. Unhygienic behavior among individuals remains as a potential source of water/food-borne diseases; therefore, promoting hygiene behavior change may be effective means of reducing these diseases in developing countries.

2.4 Factors contributing to poor WASH

Although WASH practices assist in meeting basic human needs of access to quality and safe water, sanitation and hygiene, less priority is given to such practices by the majority in developing countries. Poor WASH practices among individuals and communities could be due to various factors including socio-economic, cultural, demographic, behavioral, and geographical factors as well as poverty. Study done in Nigeria revealed that low priority on funding WASH programs by the government, lack of a well-defined institutional framework for WASH, unfavorable policy environments, weak and poorly enforced public health laws, poorly motivated sector professionals were among the factors which contributed to poor WASH practices (Fewtrell *et al.,* 2007). A Cambodia study revealed that socio-economic, cultural, and demographic factors were among the factors contributing to poor WASH practices (Fewtrell *et al.,* 2007). For the case of Tanzania, lack of clear policies and regulations with respect to sanitation and hygiene together with limited resources are among the contributing factors to poor WASH practices (Thomas *et al.,* 2013). The problem of poor WASH practices in developing countries is critical and has been contributing significantly to child mortality and morbidity. To solve the problem, multi-displinary approach kind of strategies which involve different sectors within the government are crucial. Given the burden of poor WASH practices on disease causation, it is therefore important for the developing countries to priotize WASH aspects so as to reduce disease burden due to poor WASH practices.

2.5 Initiatives to combat poor WASH

The SDGs targets zero population without WASH facilities by 2030. However, for this target to be achieved, it is crucial for stakeholders responsible for WASH to commit themselves by priotizing the issue to develop compelling solutions for improving health and quality of life through implementation of appropriate programmes. The MDGs projected a 50% reduction by 2015, in people without sustainable access to improved drinking water and basic sanitation had (Waage *et al.,* 2010). Therefore, an estimate of 784 million people had to gain access to an improved water source while an estimated 173 million people on average per year had to begin using improved sanitation facilities. It was further expected that about 790 million people which is 11% of the world population would remain without access to an improved water supply and 1.8 billion people which is 25% of the world`s population would remain without access to adequate sanitation (Too-Kong, 2014). Tanzania is among the list of East

and Southern African countries that did not meet MDG number 3 and number 7 targets (7c) to halve child mortality and the proportion of people without sustainable access to water supply and basic sanitation (WHO, 2015). This failure could be due to population growth characterized by rapid urbanization, which the government could not service due to limited capacities and resources (Thomas *et al.,* 2013). Even though Tanzania has implemented a number of national sanitation and hygiene campaigns since its independence as a way of reducing WASH-associated infections, the majority of its people do not practice good WASH (Malebo and Tenu, 2012). It is therefore, argued that to achieve the global goals of combating infectious diseases and reducing child mortality, initiatives should start at the individual level and then progress to the community level as some WASH practices are habitual in nature. However, the national sanitation and hygiene campaigns should be evaluated and reviewed regularly to make it more valuable and productive.

2.6 Impact of WASH on common infections

Lack of adequate and safe water, sanitation services, coupled with poor hygiene practices, causes deaths and illnesses to thousands of children every day (Bosch *et al.,* 2002). It also contributes to almost 30% of the total burden of disease in developing countries and 75% of all life years lost (Aziz *et al.,* 1990). It is further estimated that in developing countries each year, about 801 000 children under-five years die from infectious diseases, particularly diarrhea and most of these infections are due to poor WASH practices. This reality contributes to 11% of the 7.6 million deaths of children under the age of five years which is equivalent to about 2 200 deaths per day (UNICEF, 2009). Also, poor WASH practices contribute to about 88% of deaths from diarrheal diseases globally (Garus Pakowska, 2013). It is therefore, crucial to address WASH concerns and ensure strategies for improving such practices are in place to reduce global burden of infectious diseases. A number of studies have associated the high prevalence of infectious diseases particularly diarrhea with poor WASH practices (Bado *et al.,* 2016; Cairncross *et al.,* 2010; Nuhu and Mwapambije, 2016). Soil-transmitted infections such as Ascariasis, whipworms, and hookworms affect about 1.2 billion, 800 million, and 750 million people worldwide, respectively, have also been associated with poor WASH practices (Mascarini-Serra, 2011). Similarly, environmental enteropathy which is mainly a result of regular ingestion of fecal bacteria due to poor sanitation and hygiene conditions has been reported in under-five children (Humphrey, 2009; Ngure *et al.,* 2014). Factors, such as unhygienic handling and storage of complementary foods (CF), poor handwashing practices, and disposal of child feces, open defecation, lack of

safe water sources for domestic use by the majority as well as poor solid and liquid waste disposal continue to be major health threats among under-five children (Cairncross, 2010; Gautam, 2015, 2017). However, improved WASH practices could be a solution to minimize the incidences of WASH associated infections among under-five children (Fewtrell *et al.,* 2005; Waddington *et al.,* 2009a). Again integrating more than one WASH intervention could result in significant reduction of infectious diseases among under-five children and reduced mortality.

2.7 Impact of WASH on child nutritional status

The nutritional status of children under-five years of age depend on improved WASH practices such as hygiene conditions of the household members and their surroundings, proper disposal of waste as well as availability of adequate and safe water in the household. Poor WASH practices may affect the health status of children and may also affect their growth performance. A report from UNICEF (2013) stated that poor WASH accounts as much as 50% of maternal and childhood underweight taking into account the relationship between diarrhea diseases and under-nutrition. WASH interventions implemented with 99% coverage may reduce stunting prevalence by 2.4% at 36 months of age (Bhutta *et al.,* 2008) and 860 000 child deaths due to under-nutrition (Prüss-Üstün *et al.,* 2008). Study done in Ethiopia also revealed a reduced prevalence of stunting by 12% as a result of WASH interventions (Fenn *et al.,* 2012). It was also reported that children living in environments with improved sanitation and hygiene conditions were taller for their age and less stunted than those living in unsanitary and unhygienic conditions (Lin *et al.,* 2013). Also handwashing with soap and 15 minutes reduction in water collection time were linked to improve child nutritional status (Curtis and Cairncross, 2003; Pickering *et al.,* 2015). Currently there is insufficient research done on the impact of WASH on the nutritional status of under-five children although numerous studies are available on the contribution of WASH and infectious diseases. Few researchers have reported the link between poor WASH practices and under-nutrition although the relative contributions of poor WASH to under nutrition remains controversial. Improved child health and good growth performance may not depend solely on improved WASH practices but also on improved maternal care, good child feeding practices including exclusive breastfeeding as well as health education interventions with emphasis on individual hygiene behavior change, change in belief and norms that may have negative impact on child health as well as change in health care seeking behaviors.

2.8 Conclusion and recommendation

Developing countries particularly SSA countries are facing the problem of under-nutrition which contribute significantly to morbidity and mortality of children aged below five years. The immediate causes of under-nutrition include inadequate dietary intake and diseases. Other factors are underlying causes which include food insecurity, poor child feeding practices, lack of health care services and poor WASH conditions embedded with political, social, cultural and economic factors. Having known the nature of the problem of under-nutrition and its contributing factors, it is therefore recommended that multi displinary strategies targeting on improved WASH and disease prevention interventions be incorporated into nutrition interventions to solve the problems of child mortality and morbidity in developing countries.

CHAPTER THREE

Influence of water, sanitation and hygiene practices on common infections among under-five children in Longido and Monduli Districts of Arusha-Tanzania2

Abstract

The study aimed at assessing water, sanitation and hygiene practices, and their influence on infectious diseases among under-five children in semi-pastoral communities of Arusha Region, Tanzania. The study was cross sectional in design. Prevalence of infectious diseases among under-five children was derived from patients` attendance registers. Mothers randomly sampled from households were interviewed using facilitated questionnaire. Information regarding child morbidity, socio-demographic, and WASH practices was gathered. Hospital data revealed that two thirds of under-five patients visiting the hospitals annually were suffering from infectious diseases. Mean percentage of diarrhea prevalence between years 2013 - 2015 in Longido was higher than the mean percentage of the respective years prevalence in Monduli ($p = 0.02$). Household surveys showed that 15.5% of under-five children suffered from diarrhea. Children who consumed foods kept in calabash/*kibuyu* ($p < 0.001$) or used un-boiled cows` milk ($p = 0.01$) or were drinking surface water ($p = 0.04$) or born to uneducated mothers ($p = 0.01$) had increased risk of developing diarrhea compared to their counterparts. Storing complementary foods in calabash/*kibuyu* was strongly associated with diarrhea among under-five children. To address the problem, communities under study need to be motivated through health education on food hygiene, proper handling of food storage containers, and domestic water treatment at the household level.

Key Words: Water, sanitation, hygiene, diarrhea associated infections, under-five children, Arusha Region.

[2] Journal of Environmental and Public Health, **2017** (9235168): 8 pp. September, 2017

3.1 Introduction

Diarrhea remains the second leading cause of mortality and morbidity among under-five children worldwide and the first in Sub-Saharan Africa (SSA) (Walker *et al.,* 2013; Zeleke and Zewdie, 2014). Despite the fact that diarrhea can be cured and prevented, it is the cause of death in about 1.26 million young children annually worldwide which exceeds the mortality due to malaria, tuberculosis and HIV/AIDs combined (Cairncross *et al.,* 2010). Furthermore, the lives of about 800 under-five children are lost daily due to diarrhea worldwide (United Nation Children Fund [UNICEF], 2009a) and the highest rates of child mortality are in SSA and Asia (UNICEF, 2009b; Walker *et al.,* 2013; Sustainable Development Goals [SDGs], 2015). A number of studies (Bartram and Cairncross, 2010; Brown *et al.,* 2013; Chambers and Von Medeazza, 2013; Diouf *et al.,* 2014; Strunz *et al.,* 2014) have associated high prevalence of diarrhea in developing countries with poor WASH practices. Soil-transmitted infections, such as Ascariasis, whipworms and hookworms, that affect about 1.2 billion, 800 million and 750 million people worldwide, respectively, have also been associated with poor WASH practices (Ziegelbauer *et al.,* 2012). Similarly, environmental enteropathy, which is mainly a result of regular ingestion of fecal bacteria due to poor sanitation and hygiene conditions, has been reported in under-five children (Humphrey, 2009; Lunn *et al.,* 1991). Factors, such as unhygienic handling and storage of foods, poor handwashing practices, poor disposal of child feces, open defecation, lack of safe water sources for domestic purposes by the majority, and poor solid and liquid waste disposal continue to be major health threats among under-five children. Other factors include socio-economic conditions of the households, such as literacy, level of income of the family members and early introduction of CF to children, which may increase chances of water/food-borne diseases (Kumi-Kyereme and Amo-Adjei, 2015; Muhimbula and Issa-Zacharia, 2010; Strunz *et al.,* 2014; Zeleke and Zewdie, 2014). However, improved WASH practices may significantly minimize the incidences of WASH associated infections among under-five children (UNICEF, 2009a; WHO, 2015; Woldt *et al.,* 2015).

Tanzania is among the East and Southern African countries that did not meet the Millennium development goals 3 and 7 targets (7c) to halve by 2015 child mortality and proportion of people without sustainable access to water supply and basic sanitation (Malebo and Tenu, 2012; WHO/UNICEF, 2015). This failure could be due to population growth caused by rapid urbanization, which the government is unable to service due to limited capacities and resources. Even though Tanzania has implemented a number of national campaigns including

Mtu ni Afya (Humanity is Health), *Maji ni Uhai* (Water is life) and the ongoing national sanitation and hygiene campaigns as a way of improving WASH practices and reducing WASH-associated infections (Leach and Kilama, 2009; Lemons, 2009; Thomas *et al.*, 2013), 14% of its households still practice open defecation, 76.4% use unimproved pit latrines, and 42.7% use unsafe drinking water sources from rivers and ponds (Malebo and Tenu, 2012; Thomas *et al.*, 2013). Furthermore, about 9% of all deaths annually among under-five children are due to diarrhea (Muhimbula and Issa-Zacharia, 2010) and about 12% of the same age group suffer from diarrhea associated infections, annually (NBS and MACRO, 2015).

WASH associated infections among under-five children are endemic in semi-pastoral communities as per reviewed hospital records of 2013 to 2015. Also, several studies have reported a strong correlation between WASH practices and infectious diseases among under-five children. WASH practices among semi-pastoral communities are poor but the extent such practices influence infectious diseases has not been documented. This study assessed the influence of WASH practices on common infections particularly diarrhea associated infections among under-five children in semi-pastoral communities of Longido and Monduli Districts of Arusha Region. It is expected that findings from this study will inform policy makers and other stakeholders about programmatic interventions that have the potential to stem the problem under study as well as add scientific knowledge.

3.2 Materials and Methods

3.2.1 Study area

The study was conducted in the semi-pastoral communities of Longido and Monduli Districts of Arusha Region, in the north eastern corner of Tanzania. The Districts are bordered with Kenya to the North, Kilimanjaro Region to the East, Manyara Region to the South, Simiyu and Mara Regions to the West. Monduli District covers 6 992.67 km^2 and has a population of 158 929 people and is divided into twenty wards. Longido District covers 7 885.01 km^2 and has a population of 123 153 people and is divided into eighteen wards (National Bureau of Statistics [NBS], 2012). The Maasai tribe is the dominant ethnic group in both districts and the major are semi-nomadic. Other tribes include Mang`ati and Waarusha.

3.2.2 Study design and tools

The research employed a cross-sectional study design in which a standardized questionnaire adopted from the UNICEF survey on monitoring WASH practices at household level in Gaza

in 2009 was modified to fit the semi-pastoral communities and administered to mothers/caregivers (UNICEF, 2009). Information on WASH, socio-demography, morbidity, and child feeding practices was gathered. Hospital records from the respective district hospitals were reviewed and trends of common infections among under-five children who attended the District hospitals for three consecutive years (2013 to 2015) were derived.

3.2.3 Sampling and sample size

A multistage sampling technique was employed whereby Longido and Monduli Districts were purposively selected for this study. A simple random sampling technique was employed to obtain four wards, two from each district. One village from each ward was randomly selected whereby Orbomba and Kimokouwa villages from Longido and Meserani and Makuyuni villages from Monduli were sampled. From each village, households with under-five children were purposively selected for the study. For households with more than one under-five children, only one child was randomly selected for the study. Sample size was calculated based on the cross sectional study sample size calculation formula as follows; $n = z^2P(100-P)/\varepsilon^2$, Where: n is minimum sample size, z is a value corresponding to the confidence level = 1.96, P is anticipated prevalence of 25% of WASH practices among semi-pastoral communities, and ε is a margin of error which is 5% with confidence interval of 95%. A total of 310 mother-child pairs, 150 from Longido and 160 from Monduli were sampled. The sample size took into consideration 7.2% attrition rate.

3.2.4 Inclusion and exclusion criteria

Children aged 6 – 59 months were involved in this study. Children who their parents were not willing to participate or seriously ill or under medical care during survey date were excluded from the study.

3.2.5 Definition of terms

Diarrhea in this study was regarded as a common symptom of gastrointestinal infections caused by pathogens such as bacteria, viruses, or protozoa and characterized by child having loose or watery stools at least three times per day or more (Morris *et al.,* 1994). WASH associated infections referred to water/food-borne infections which are normally transmitted through fecal-oral routes such as diarrhea diseases and helminths (Strunz *et al.,* 2014). Semi-pastoral communities in this study were referred as communities engaged more on raising livestock and partly cultivating food crops in small scale and has a tendency of moving from

one place to another to search fresh pastures and water for their herds especially during dry season (Bowen, 2010a, b).

3.3 Ethical Clearance

Ethical clearance was obtained from National Institute for Medical Research of Tanzania. Informed written consent was sought from mothers and caregivers of the children under study prior to administration of the questionnaire. Confidentiality regarding the information collected from the survey was ensured by identifying participants using IDs rather than using their names.

3.3 Data management and analysis

Data collection tools were pre-tested in semi-pastoralists community of Arusha Region and validated accordingly. The household survey was conducted by well trained and qualified enumerators. Data cleaning was done every evening after the surveys were conducted then double entered into Epi-data™ version 3.3.1 by two qualified personnel before transferred into SPSS™ Version 20 for statistical analysis. Descriptive analysis was done to obtain frequencies and percentages of WASH variables, child feeding practices, child morbidity information, and socio-demographic characteristics of the study subjects. Logistic regression analysis was conducted to reveal variables associated with diarrhea. Variables with *p*-values less than 0.05 were then run as a multivariable model using backward stepwise selection (known as the Wald method) and confounders, such as vaccination against rotavirus, were controlled. Variables with *p*-values less than 0.05 were considered as independent predictors for diarrhea associated infections among under-five children. An independent sample t-test was done on hospital data and mean percentages of WASH associated infections for both Monduli and Longido District hospitals were compared.

3.4 Results

3.4.1 Common infections among under-five children

Data reviewed from Longido and Monduli District hospitals revealed that about two-thirds of the under-five patients who visited the district hospitals seeking medical care were suffering from infectious diseases. According to the hospital records, the most common infections among children under-five years of age were respiratory infections, diarrhea associated infections, skin infections, eye and ear infections, and intestinal worms. Independent t-test analysis did not show any significant difference between the mean percentages of overall

infectious diseases in the two districts (p = 0.6). According to household questionnaires, common infections which were reported were respiratory infections (34.5%), skin infections (15.3%), diarrhea associated infections (10.8%), cold/flue (10.8%), malaria (5%), multiple infections (19%), and eye/ear infections (6%).

WASH associated infections among children under-five years of age, as obtained from the Longido hospital attendance register for year 2013 - 2015, were diarrhea associated infections (13.4%) and intestinal worm infections (3%). For Monduli District hospital were diarrhea associated infections (10%) and intestinal worm infections (3%). Prevalence of diarrhea associated infections among under-five children residing in Longido was significantly higher compared to that of children residing in Monduli (p = 0.02); this pattern was not mirrored in the case of worm infestation (p = 0.4). Table 1 shows mean percentages of WASH associated infections among under-five children that attended Longido and Monduli District hospitals for three consecutive years.

Table 1: Mean percentages of infectious diseases among under-five children as per hospital records for year 2013 to 2015

Type of disease	**Mean (±SD)**		**p-value**
	Longido	**Monduli**	
Infectious diseases	70.9 ± 5.3	72.8 ± 1.7	0.6
WASH associated infections			
Diarrhea associated infections	13.4 ± 1.3	9.8 ± 1.1	**0.02***
Worm infestation	2.9 ± 0.6	3.3 ± 0.3	0.4

3.4.2 Socio-demographic characteristics of the study participants and variation of diarrhea prevalence

The study accessed 310 pairs of mothers/caregivers and children aged 6 - 59 months. The mean (SD) age of the children was 29.8 ± 17.1 months. Mothers aged 20 - 29 years constituted the largest group sampled (55.8%). About half of the mothers did not have any formal education, whereas the rest attained primary education (45%), secondary education (5%) and college/university levels of education (1%). Most of the mothers (96.1%) were married and more than half had more than one under-five year old children. The number of under-five children per mother ranged from one to four. Data from questionnaire also revealed that under-five children in Longido were suffering from WASH associated infections such as diarrhea associated infections (16.9%). In Monduli, the prevalence of WASH-associated diseases such as diarrhea diseases was 13.3%. Table 2 shows the distribution of prevalence of diarrhea two weeks prior survey date in relation to socio-demographic characteristics of the study subjects.

Table 2: Diarrhea prevalence among under-five children in relation to socio-demographic characteristics

Variable	n	Diarrhea (%)	p-value
Sex of the child			
Male	155	27.1	
Female	155	29.7	0.6
Age of the child			
6 months-11 months	58	29.3	
12 months-23 months	64	31.2	0.8
24 months-59 months	188	27.1	0.7
Time the CF was introduced to the child			
Before 6 months	278	27.7	0.4
6 months and above	32	34.4	
Breast feeding status			
Yes	119	24.1	
No	191	35.3	0.03
Education status of the mother			
No education	145	31.7	0.2
With education	165	25.5	
Age of the mother			
20-29 years	173	32.4	0.6
30-39 years	98	25.5	0.9
40 years and above	30	13.3	
Village			
Makuyuni	81	12.3	
Meserani	79	12.7	0.7
Kimokouwa	64	43.1	0.001
Orbomba	86	43.7	0.001

CF: complementary foods

3.4.3 WASH practices

Respondents from both districts reported obtaining water from different sources on a seasonal basis. About 85% of respondents from Longido and 100% from Monduli reported to access less than 20 litres of water per person per day for general uses. About 35% of respondents from Longido were dependent mainly on surface water for domestic purposes compared to 11.5% of respondents from Monduli. Figure 4 below shows the surface water pond traditionally known as *silange* which is mainly used as domestic water source by people from Orbomba village.

Results showed that about 21% and 6.3% of households from Longido and Monduli, respectively had latrines of which two third were traditional pit latrines (Fig. 5). Open defecation was practiced by 44% and 55.6% households from Longido and Monduli with no latrines, respectively, and the rest were practicing other defecation methods including cut style defecation method (digging a small hole using a hoe, defecate inn and bury). Disposal of child feces to the toilets was practiced by 20% of participants from Longido and 5.6% from Monduli. More than half of the respondents from both Longido and Monduli reported to use children feces in feeding their dogs with a belief that, children feces are harmless and useful to dogs.

Hand washing with soap during critical moments was practiced by 9.3% of respondents from Longido and 2% from Monduli. Complementary foods were kept either in a Thermos™/vacuum container, hotpot or calabash/*kibuyu* after preparation (Fig. 6). The latter case was being used by about 20% and 11.3% of participants from Longido and Monduli, respectively. About 78.4% of the respondents reported boiling cow's milk prior feeding children. When they were asked to explain how boiling of cows` milk was done, it was noted that about half of them were just warming the milk and not boiling. Ten percent and 2% of participants from Longido and Monduli, respectively, reported boiling water for drinking purposes.

Figure 4: Surface water from pond/*silange* a main source of domestic water for people from Orbomba village.

Figure 5: Traditional pit latrine from Kimokouwa village.

3.4.4 Predictors of diarrhea

Diarrhea prevalence among under-five children in the population under study was predicted by environmental, behavioral and socio-demographic factors. Children fed on complementary foods (CF) kept in *kibuyu* (Fig. 6) were 4 times more likely to suffer from diarrhea compared to those fed on CF kept in Thermos™/vacuum containers or hotpots (AOR = 4.1; 95% CI = 4.3-19). Children fed on cow's milk, which was not boiled, were about 3 times more likely to develop diarrhea compared to those fed on boiled cow's milk (AOR = 2.9; 95% CI = 1.3-6.3). Mothers who reported using tap water for domestic purposes were more than one times less likely to have children suffering from diarrhea compared to those who reported using surface water such as ponds/*silange* (AOR = 1.2; 95% CI = 1.02-4.1). Children born to mothers with no formal education were 1.3 times more likely to develop diarrhea compared

to children born to mothers with formal education (AOR = 1.3; 95% CI = 1.1-5.6). Children residing in Kimokouwa and Orbomba villages of Longido were 3 times more likely to develop diarrhea compared to children residing in Makuyuni villages of Monduli (AOR = 3.2; 95% CI = 3.3-10.2). There was no any association between the practice of giving children`s feces to dogs and diarrhea among under-five children. Table 3 illustrates independent predictors of diarrhea among children under-five years of age in select semi-pastoral communities of Longido and Monduli Districts.

Figure 6: A Maasai woman pouring milk from *kibuyu* ready to feed her child.

Table 3: Predictors of diarrhea among children under-five years of age

Variable	n	Diarrhea %	COR (95% CI)	p-value	AOR (95% CI)	p-value
Education status of the mother						
No education	145	31.7	1.4 (0.9-2.2)	0.2	1.3(1.1-5.6)	**0.01***
With education	165	25.5	1		1	
Age of the mother						
20-29 years	173	32.4	1.4 (0.3-6.2)	0.6	0.2(0.1-0.8)	**0.02***
30-39 years	98	25.5	1.1 (0.3-4.3)	0.9	0.3(0.1-1.4)	0.1
≥40 years	30	13.3	1		1	
Preparation of cow's milk prior to feeding the child						
Boiled	243	19.3	1		1	
Not boiled	67	61.2	6.6(3.7-11.8)	0.001	2.9(1.3-6.3)	**0.01***
Storage of prepared complementary food						
Thermos™/hotpot	213	13.1	1		1	
Calabash/*kibuyu*	97	62	4.7(6.1-18.9)	0.001	4.1(4.3-19)	**0.001***
Source of drinking water						
Tap water	166	17	1		1	
Surface water	144	41.7	3.5(2.1-5.9)	0.001	1.2(1.02-4.1)	**0.04***
Name of the village						
Makuyuni	81	12.3	1		1	
Meserani	79	12.7	1.1(0.6-2.1)	0.4	1.5(0.7-3.2)	0.3
Kimokouwa	64	43.1	3(2.7-16.2)	0.001	3.1(2.2-14.4)	**0.001***
Orbomba	86	43.7	3.2(2.8-13.5)	0.001	3.4(2.5-16.4)	**0.001***

* *= p<0.05, excluded value: Age of the mother from 16-19 years (n=9), COR; crude odds ratio, AOR; adjusted odds ratio, CI: confidence intervals.*

3.5 Discussion

This study documents WASH practices in semi-pastoral communities and their influence on WASH associated infections particularly diarrhea. Storage of already prepared CF such as milk and porridge in *kibuyu* for later use is a common practice among semi-pastoral communities and revealed an association with diarrhea among under-five children. Food stored in *kibuyu* may be rendered unsafe to children as the *kibuyu* is rarely washed and rinsed with herbal extract which is traditionally believed to preserve foods. The usefulness of the herbal extract is not proven and its safety is not determined. In addition, the child sometimes

sips food from the *kibuyu* directly which may introduce pathogens to the food. The findings from the present study are in line with other studies which reported that poor handling and storage of CF may contribute to diarrhea among children (Aheto *et al.,* 2015; Fawzy *et al.,* 2011; Muhimbula and Issa-Zacharia, 2010; Oluwafemi and Ibeh, 2011). Proper storage of already prepared CF, thorough washing of food storage containers and safe, clean drinking water may reduce risks of diarrhea among under-five children in the population under study.

Cow`s milk is commonly used in African societies as CF for children as the majority cannot afford baby formulas. Findings from this study showed that children fed on cow`s milk, which is not boiled, were at higher risk of developing diarrhea compared to those fed on boiled cows` milk. This could be due to the reason that cows` milk may be a vehicle for transmission of pathogens from the host animal or the milk might have been cross contaminated during milking. The findings from the present study are similar to findings from other studies (Århem, 1989; Chege *et al.,* 2015; Fawzy *et al.,* 2011; Nestel and Geissler, 1986; Oluwafemi and Ibeh, 2011) which reported an association between diarrhea and feeding children unboiled cow's milk. In addition, other studies reported 15% to 70% of diarrhea among children under-five years of age worldwide could be reduced by ensuring hygienic handling, storage and thorough cooking of CF (Curtis *et al.,* 2009; Freeman *et al.,* 2014; Gautam *et al.*, 2017).

Surface water is unsafe for domestic purposes and may lead to water borne diseases It was noted that surface water is the main source of domestic water for the majority of the population under study. Findings from this study confirmed that, children from households with access to tap water had less odds of developing diarrhea compared to children from households using surface water for domestic purposes. The most common possible sources of surfaces water contamination in these communities could be open defecation, offering children`s feces to dogs, and sharing water sources with livestock. Such unsanitary practices may increase chances of surface water contamination especially during rainy season. The findings are in line with other studies (Diouf *et al.*, 2014; Gascon *et al.*, 2000; Karambu *et al.*, 2013; Zeleke and Alemu, 2014) which reported high prevalence of diarrhea among children residing in households relying on surface water for domestic purposes. Ensuring safe water for domestic purposes, through water treatment at the point of use including use of water filters, may reduce incidences of diarrhea among under-five year old children in these communities. Boiling of water for drinking purposes could also minimize the problem of

diarrhea although water may be re-contaminated during cooling and also the practice may be economically and environmentally unsustainable to the communities under study.

Children born to mothers with no education were at higher risk of developing diarrhea compared to children belonging to educated mothers. Educated mothers may be more exposed to child care consideration including safe preparation, handling and storage of food, proper disposal of child feces and proper feeding practices. The findings from this study align with other studies (Gascon *et al.,* 2000; Joshi *et al.,* 2011; Kumi-Kyereme and Amo-Adjei, 2015) which reported high prevalence of diarrhea among children born to mothers with no education.

Place of residence has also been identified as one of the factors contributing to incidences of diarrhea (Diouf *et al.,* 2014; Joshi *et al.,* 2011). Children from Longido were at higher risk of developing diarrhea than children from Monduli which was attributed to the majority of respondents from Longido reporting use of surface water from ponds (*silange*) which may be unsafe compared to respondents from Monduli District who had access to tap water emanating from military piped water source. Another reason could be storage of CF in *kibuyu* was practiced more by those in Longido than in Monduli. Findings from other studies (Gascon *et al.,* 2000; Diouf *et al.,* 2014; NBS and MACRO, 2015) concurred with this finding.

3.6 Conclusion

Prevalence of WASH associated infections particularly diarrhea associated infections among semi-pastoral communities of Arusha Region was higher compared to that of the Tanzanian National Demographic and Health Survey of 2015 and could be contributed by poor WASH practices. Children fed on CF kept in *kibuyu* or cow's milk which was not boiled or using surface water or belong to uneducated mothers or residing in Longido had higher risk of developing diarrhea compared to their counterparts. To address the problem under study multi-displinary strategies targeting on health education including food hygiene and safety and treatment of drinking water along the value chain may reduce the prevalence of diarrhea associated infections among under-five children in the study population. Also, studies to examine the magnitude of CF contamination particularly food kept in *kibuyu* as well as impact of diarrhea associated infections on nutritional status of under-five children are recommended to further address the problem of child morbidity in the population under study.

3.7 Study limitations

The cross-sectional design of the study could not allow determination of a cause-effect relationship between diarrheal associated infections and WASH. Also some of the information obtained through questionnaire relied on mothers` self-reporting which might have involved recall bias. The findings cannot be generalized to all pastoral communities because it was conducted in semi-pastoral communities setting and with a limited sample size.

CHAPTER FOUR

Water, sanitation and hygiene practices associated with nutritional status of under-five children in selected semi-pastoral communities Tanzania[3]

Abstract

Under-nutrition among under-five children is a public health concern in developing countries and has been linked to poor water, sanitation and hygiene (WASH) practices. This study aimed at assessing WASH practices and their association with nutritional status of under-five children in selected semi-pastoral communities of Arusha. The study was cross sectional in design. Mother-under-five child pairs from 310 households in four villages of Monduli and Longido Districts were involved and anthropometric measurements such as weight and height of children were measured using weighing scale and length/height board, respectively. Children`s age were recorded from clinic cards. Hemoglobin (Hb) level of each child was measured using Hemo Cue® Hb 201+ photometer machine. Structured questionnaires were used to gather information on water, sanitation, and hygiene practices, child morbidity, demographic and socio-cultural characteristics. Prevalence of childhood stunting, under-weight, wasting and anemia were 31.6%, 15.5%, 4.5% and 61.2%, respectively. Diarrhea prevalence, as per the household survey, was 15.5%. Children having diarrhea two weeks preceding the survey ($p = 0.004$), children using surface water for domestic purposes ($p < 0.001$), and those from uneducated mothers ($p = 0.001$) had increased risk of being stunted and under-weight. Children introduced to complementary foods before six months of age ($p = 0.02$) or belonging to polygamous families ($p = 0.03$) had increased risk of being stunted. Consumption of unboiled cow`s milk ($p = 0.05$) or being a boy ($p = 0.03$) was associated with underweight among under-five children. Prevalence of under-nutrition among under-five children in the population under study was alarming and it could be contributed to by poor water, sanitation, hygiene, and socio-cultural factors. This study underlines the importance of incorporating WASH including hygiene behavior change strategies in formulation of interventions that promote nutrition and diseases prevention in pastoral communities.

Key Words: WASH practices, under-nutrition, under-five, Arusha

[3] American Journal of Tropical Medicine and Hygiene: **98**(5), pp. 1242-1249

4.1 Introduction

Poor nutritional status among under-five children is a public health concern in developing regions and is responsible for more than one third of under-five children deaths globally (UNICEF, 2013). The problem may impact negatively on a child's physical and mental growth, increase diseases vulnerability and severity, and delay recovery from illnesses (UNICEF, 2013). It may also lead to chronic child morbidities and disabilities, including impaired mental development (Black *et al.,* 2010). Poor nutrition during early stages of child`s life may also lead to stunting, which is an irreversible condition and mostly associated with a number of complications including poor school performance (Sharifzadeh *et al.,* 2010). In some severe cases, poor nutrition may lead to clinical conditions, such as kwashiorkor, marasmus, and even death (UNICEF, 2013).

Globally, one in every five under-five children was stunted (Waage *et al.,* 2010a). Despite the fact that the rate of stunting had declined in some regions including Asia by one third between 1990 to 2015 the same trend has not been evidence in Sub Sahara Africa (SSA). Also, one of 13 under-five children were wasted (Adelo and Temesgen, 2015) whereas one in every seven under-five children remained underweight which SSA and southern Asia accounted for nearly 90% of all cases. The current Tanzania Demographic and Health Survey (TDSH) reported that 34.7% of under-five children were stunted, 13.7% underweight and 4.4 % were wasted (NBS and MACRO, 2015/16).

A number of environmental, social, demographic, cultural, and economic factors contribute to poor nutritional status among children younger than 5 years of age (Chase and Ngure, 2016). The indirect causes of under-nutrition include food insecurity, improper child care practices, lack of health care services, and environmental conditions such as poor WASH (UNICEF, 2013). Likewise, under-nutrition is associated with inadequate dietary intake and diseases such as cholera and intestinal worms; the conditions which are believed to be associated with poor WASH practices. Diarrhea associated infections, for example, tends to inhibit absorption of nutrition by the body and may lead to compromised immunity. Also undernourished children become vulnerable to infections due to deteriorated immune system (Chase and Ngure, 2016; Humphrey, 2009) leading to vicious cycle of infections and under nutrition (USAID, 2015). Other infections, including intestinal worms, may interfere with the digestion process by competing with the host for nutrients (Morris *et al.,* 1994; Ngure *et al.,* 2014). The overall disease burden and treatment costs of diarrhea-associated infections and

its consequences may affect the households food budget, which may limit the amount of food available, resulting in risk of insufficient nutrient intake and under-nutrition among vulnerable groups, particularly under-five children (Burton *et al.,* 2015; Prüss-Üstün *et al.,* 2014; UNICEF, 2014).

On the other hand, studies have reported that children living in unsanitary and unhygienic environments may become under-nourished even in absence of diarrhea or intestinal worms (Humphrey, 2009). A child may develop a condition known as environmental enteropathy as a result of repeated ingestion of fecal bacteria which in turn may overload to the gut and cause malabsorption, leaking mucosa, poor villi functioning and inflammation of gut cells, the conditions which may lead into body faltering (Burton *et al.,* 2015; Lunn *et al.,* 1991; Ngure *et al.,* 2014). A study carried out in India documented that even children coming from wealth families where balanced meals are available were often stunted (Schmidt, 2014). It has also been estimated that improved WASH practices may rescue up to 45% of child deaths a year globally that are due to under- nutrition (Curtis and Cairncross, 2003; Black *et al.,* 2013). Furthermore the global efforts to combat child malnutrition are presently focusing on multidisciplinary interventions as nutritional interventions with coverage of 90% only achieve 20% improvement in growth faltering (Chase and Ngure, 2016). However, most of the people in developing countries still practice poor WASH (Lomazzi *et al.,* 2014; WHO/UNICEF, 2015). For the case of Tanzania, 42.7% of its people rely on unsafe water sources for their domestic uses, only 36.8% have access to piped/tap water, 14% still practice open defecation, and 76.4% use traditional pit latrines (Benova *et al.,* 2014; WHO, 2004). Likewise, some people walk long distances to fetch water that may limit amount of water available in the household for practicing good hygiene. The task of fetching water is a responsibility of women and children and may also affect time for mothers to feed and take care of the youngest children (Pickering and Davis, 2012).

Water sanitation and hygiene practices are fundamental human rights and contribute significantly to the nutritional status of under-five children. However, these practices are hampered by poor infrastructure and low socioeconomic status of many households in low-income countries. Water for domestic purposes is scarcely among pastoral communities and majority relies on surface water which is unsafe for human consumption (Lyimo *et al.,* 2016). In addition this water source is shared between human and both wild and domestic animals (Lemons, 2009). Water treatment measures such as boiling are yet to be implemented because of financial and cultural barriers (Gilman and Skillicorn, 1985). Furthermore, open

defecation is still practiced in most communities and the few with sanitation facilities own traditional pit latrines, which poses a risk of fecal contamination (Thomas *et al.,* 2013). At the same time, foods are unhygienically prepared, stored, and consumed in open environments that can be contaminated by flies. Kitchen wares and clothes are unhygienically handled, and handwashing is rarely practiced (Gautam *et al.,* 2017). Cold chain, including refrigeration, is not feasible because of limited infrastructure and unaffordability (Gautam, 2015). In addition to using unsafe water, latrines surfaces are not easily and frequently washed, increasing susceptibility to harbor pathogens.

The World Health Organization (WHO) recommends exclusive breastfeeding for children for six months (UNICEF, 2013); however, most children in developing countries are introduced to complementary foods before the recommended age (Sheth and Dwivedi, 2006). Such practice has been reported as one of the major contributing factors to diarrhea-associated diseases and under-nutrition among under-five children (Fawzy *et al.,* 2011). In addition, most of complementary foods are unhygienically prepared and stored and may pose a risk of food borne diseases to children (Aheto *et al.,* 2015).

Several studies have reported a strong correlation between WASH practices and under-nutrition among under-five children. Likewise, WASH practices in semi-pastoral communities, may be poor but the extent such practices influence nutritional status of under-five children has not been investigated. As a result, efforts to combat under-nutrition among under-five children in semi-pastoral and pastoral communities do not incorporate WASH interventions and the main focus has been primarily on nutrition interventions. This study assessed the influence of WASH practices on nutritional status among children younger than five years of age in semi-pastoral communities of Longido and Monduli Districts of Arusha Region. Findings from this study are crucial in supporting WASH interventions including hygiene behavioral change initiatives, in addition to vaccination, supplementation, and fortification interventions that have received much attention in developing countries, particularly Tanzania.

4.2 Materials and Methods

4.2.1 Study area

The study involved semi-pastoral communities of Longido and Monduli districts of Arusha region, in the north eastern corner of Tanzania. To the North the Districts are boarded by

Kenya, to the east, Kilimanjaro Region, to the south Manyara Region, and to the west Simiyu and Mara Regions. The two Districts were selected based on the recommendation made by a previous survey that recommended an evaluation of a correlation between nutrition and environmental conditions. (Bowen *et al.*, 2010a, b). Longido District has 7 885.01 km squire & a population of 123 153 and is divided into eighteen wards. Monduli district has 6 992.67 km square and a population of 158 929 people and it is divided into twenty wards (NBS and MACRO, 2010). Maasai tribe is the dominant ethnic group in both Districts and majority are semi-pastoralist in nature.

4.2.2 Study design, sample size and sampling protocol

The study was cross-sectional in design. Sample size was calculated based on the cross sectional study sample size calculation formula of n = z2P (100-P)/ε2 Where n is a minimum sample size, z is a value corresponding to the confidence level = 1.96, P is prevalence of stunting in Arusha Region which is 36% (NBS and MACRO, 2010) and ε is a margin of error which is 5% with a confidence interval of 95%. Using this formula, a total of 354 children aged between 6 – 59 months inclusive, was determined as an adequate sample size. However, the number was increased to 373 to carter for 5% attrition rate (or a response rate of 95%). During data management and cleaning, a total of 310 observations were determined eligible for further analysis. This resulting sample size (i.e., reduced from 373 to 310) yielded an increase of margin of error by 10% (from 5% to 5.48%), which is considered safe for our study purposes.

The sampling frame for this study was under-five children aged between 6 – 59 months, inclusive. A simple random sampling technique was used to obtain four wards, two from each District. Four villages, one from each ward, were randomly selected whereby Orbomba and Kimokouwa villages from Longido District and Meserani and Makuyuni villages from Monduli District were selected to participate in the study. From each village, households with under-five children were sampled purposively. For households with more than one under-five children, only one child per household was randomly selected for the study.

4.2.3 Assessment of child's nutritional status and hemoglobin levels

Anthropometric measurements of height and weight were taken from each index child by qualified nutritionists from Monduli and Longido District hospitals and the principal investigator. The length of each child aged 6 - 23 months was measured using a UNICEF

length board and weight was measured using a hanging weight scale (Seca™ Model 881). For children aged from 24 to 59 months, a UNICEF height board and a stand-weighing scale were used to measure height and weight, respectively. Age was recorded from the child clinic card. WHO Z-score indices were used as reference where Z-score of < -3, between < -2 to ≥ - 3 were regarded as severe and moderate under-nutrition, respectively and ≥ -2 was regarded as normal (De Benoist *et. al.*, 2012). Hemoglobin levels of the index children were measured by laboratory technician from the said District hospitals using Hemo Cue® Hb 201+ photometer (AB, Sweden) machine, and recorded in g/dl. Categorization of Hb levels was done based on WHO standards, where Hb level > 11 was regarded as normal while < 7, 10-10.9 and 7 - 9.9 were regarded as severe, mild and moderate anemia, respectively (De Benoist *et al.,* 2008). Both anthropometric measurement scales and Hemo Cue® machine were calibrated using machines available at Monduli and Longido District hospitals every morning before going to the filed.

4.2.4 Survey of WASH practices

A standardized questionnaire adopted from a 2009 UNICEF survey on monitoring WASH practices in household level in Gaza (UNICEF, 2009) was customized to fit the semi-pastoral communities and administered to mothers/caregivers of the index children as described in (Mshida *et al.,* 2017) article. The questionnaire was used to collect data on WASH, socio-demographic characteristics, morbidity and child feeding practices. Diarrhea was regarded as proxy for common infections as described in (Mshida *et al.,* 2017) article. The questionnaire was pre-tested as previously described on section 3.3 of Chapter Three.

4.2.5 Ethical Clearance and Informed consent

Ethical clearance was obtained from National Institute for Medical Research of Tanzania. Informed written consent was sought from mothers or caregivers of children under study, prior administration of the questionnaire, taking anthropometric measurements and testing for child Hemoglobin levels. Confidentiality regarding the information collected from the survey was ensured.

4.3 Data Analysis

Data cleaning was performed daily during the survey by exchanging questionnaires among enumerators to see if there was any missing data and in case of missing data, the respective household was consulted. Information about WASH, socio-demographic, morbidity and child

feeding data were then double entered into Epi-data Version 3.3.1. by two different qualified personnel then transferred into Statistical Package for Social Sciences (SPSS) Version 20 (IBM, Armonk NY) for analysis. For anthropometric data, ENA for SMART software was used to calculate Z-scores including weight for height, weight for age and height for age Z-scores. After calculating Z-scores, data were transferred into SPSS for further analysis. Descriptive statistical analysis such as mean, range, standard deviations, frequencies and percentages was done to determine the socio-demographic characteristics of the population. Logistics regression analysis was done to find out the relationship between nutritional status of under-five children (dependent variables) and WASH practices and child morbidity (independent variables). Multivariable analysis specifically a backward stepwise (Wald method) for control of confounders, was used to look for factors associated with under-nutrition among children younger than five years of age. Confounders including child deworming, vaccination against rotavirus, hand washing with soap, water treatment, child birth weight, child feeding frequency and breastfeeding status were controlled through multivariate analysis. Any variable with p-value less than 0.05 were regarded as a predictor for under-nutrition.

4.4 Results

4.4.1 Socio-demographic characteristics of study participants

The study engaged 310 mother/caregiver-child pairs. Forty-eight percent of participating households were from Longido and the rest from Monduli. Mothers aged 16 - 19 years constituted the smallest group (3%) while those aged 20 - 29 years constituted the largest group (56%). About half (51%) of the mothers had formal education. Also, 95.6% of the households were father headed and more than half (52%) of the households had more than one child below five years of age. Nineteen percent of the index children were aged 6 - 11 months, 20.6% aged 12 - 23 months, 20% aged 24 - 35, 19% aged 36 - 47 months, and 21.6% aged 48 - 59 months. The maximum number of under-five children in the households visited was four and the minimum was one (Supplemental Table 11).

4.4.2 Child feeding practices

A total of 79% mothers reported breastfeeding *ad-libitum*. About 82% of the children received complementary foods (CF) before six months of age. More than half of the children (56%) were fed up to three times per day whereby 52% consumed cereal based foods prepared as porridge and 49% consumed fat and fat products twice per day. Sugar/sugar products and milk/milk products were consumed once per day by 90% and 60% of the children, respectively. Beans and nuts were also consumed once per day by 36% of the under-five children. The majority of the children did not consume eggs (52%), juice and fruits (98%), vegetables (61 %), potatoes (63%) and tubers (52%).

4.4.3 Water safety and accessibility, sanitation and hygiene practices

Forty-six percent of respondents reported depending mainly on surface water for domestic purposes; 50% had access to tap water while the rest were using other sources including shallow wells. The majority (72%) of the respondents were not sure of the safety of their water source; while 90% of them reported not treating water at the point of use and 4% reported treating water by boiling prior drinking although no observation was carried out on how drinking water was boiled and stored. The condition of drinking water containers was observed been poor in 65% and 57% of the households in Longido and Monduli districts respectively. Figure 7 shows the condition of drinking water containers in one of household Meserani village, Monduli. However, 86% of respondents, who reported using surface water, indicated sharing the water sources with animals. Respondent reported access to either surface water or tape water with 16% of them accessing the recommended amount of water per person per day of 20 litres (UNICEF, 2015) for general use purposes. In addition, water sources were visited and observation on hygiene condition of these sources was noted. Figure 8 shows one of the unprotected boreholes in Orbomba village in Longido District.

Figure 7: Households` cooking water storage containers in one of the surveyed households.

Regarding sanitation, 87% of the households did not have toilets. The majority (52%) of these households did not want to build toilets because their culture restricts Maasai men from being seen to have visited toilets. Ninety six percent of those who did not have toilets practiced open defecation and the rest used other means including defecating in the cattle`s traditional *boma*. Eighty eight percent of those reported to have toilets were using traditional pit latrines and 70% of the toilets were shared by more than one family. Sixty five percent of respondents reported giving children feces to dogs as food. About 8% of respondents used cow dung as charcoal in cooking, while 5.5% used it as manure for their farms. Five percent of respondents reported using garbage to feed animals while 4% reported disposing to the garbage pits.

Figure 8: Unprotected borehole in Orbomba village at Longido District.

The majority (97%) of the participants reported washing hands at different moments although only 11% reported using soap. Twelve percent of respondents reported washing hands with soap during the four critical moments, which are before eating/feeding the child, after visiting toilets, after touching dirty things and before preparing food. Eighty six percent of the respondents reported washing hands only before/after meals. All respondents reported feeding their under-five children with cows` milk, while 22% of them were using unboiled cow`s milk. Sixty nine percent of the respondents were using Thermos™/vacuum containers/hotpots and 31% calabash (traditionally known as *kibuyu)* to store already prepared CF. A significant number of respondents (94%) were feeding their children using hands, cups and spoons interchangeably on a convenience basis related to the form of food, while very few 4% reported to save food to children while it is hot. Three percent of respondents reported washing children's` utensils with hot water and soap, drying and cover them neatly. The majority of children (89%) wore dirty clothes, 81.3% had long dirty nails and 40% were bare foot.

4.4.4 Nutritional status and haemoglobin levels among under-five children

Table 4 shows the percentage distribution of under-nutrition and diarrhea associated problems in the population under study.

Table 4: Current status of under-nutrition and diarrhea problems among under-five children

Variable	n	Percentages
Stunting	98	31.6
Under-weight	48	15.5
Wasting	14	4.5
Low Haemoglobin level/Anemia	190	61.2
Diarrhea	48	15.5

Figure 9 below describe the prevalence of stunting (31.6%) among children under-five years in a study population in comparison to that of WHO standard population. The normal distribution curve for the study population was flatter, skewed to the left and deviated from the mean when compared to that of reference population of WHO. This indicates high prevalence of stunting among children under-five years' therefore needing public health attention.

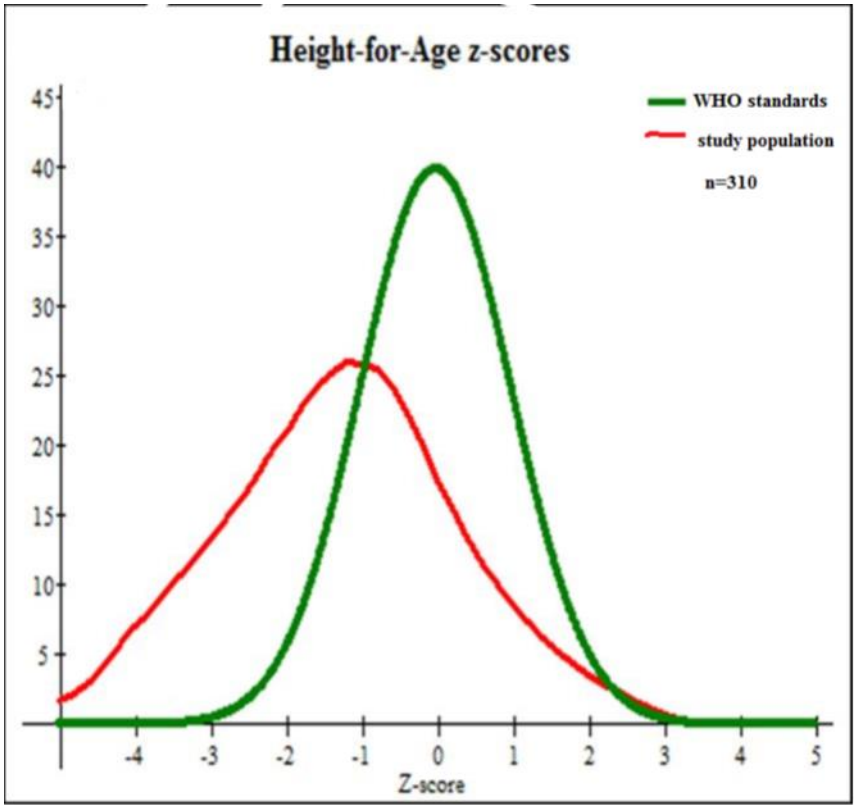


Figure 9: Prevalence of stunting among children under-five years

Figure 10 below describe the prevalence of under-weight (15.5%) among children under-five years in a study population in comparison to that of WHO standard population. The normal distribution curve of the study population was slightly flatter, skewed to the left and deviated from the mean when compared to that of WHO reference population indicating moderate under-weight.

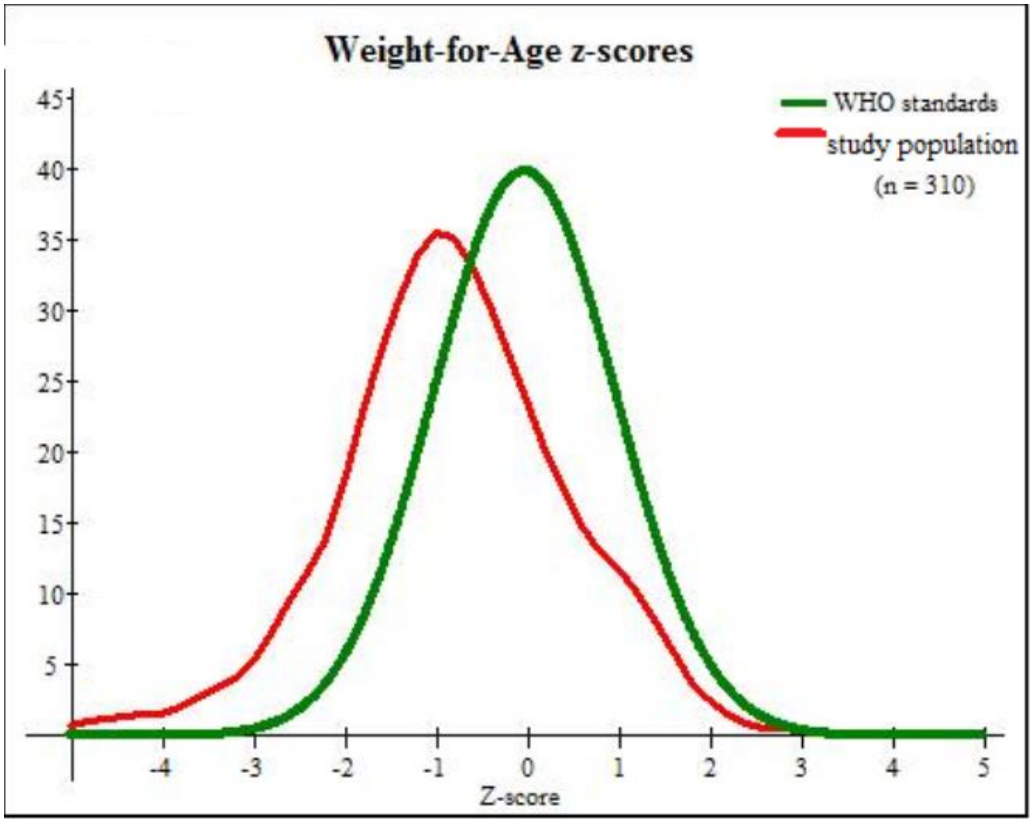


Figure 10: Prevalence of under-weight among children under-five years

Figure 11 below describe the prevalence of wasting (4.5%) among children under-five years in a study population in comparison to that of WHO standard population. The normal distribution curve of study population was closely inline with that of WHO reference population indicating an acceptable prevalence.

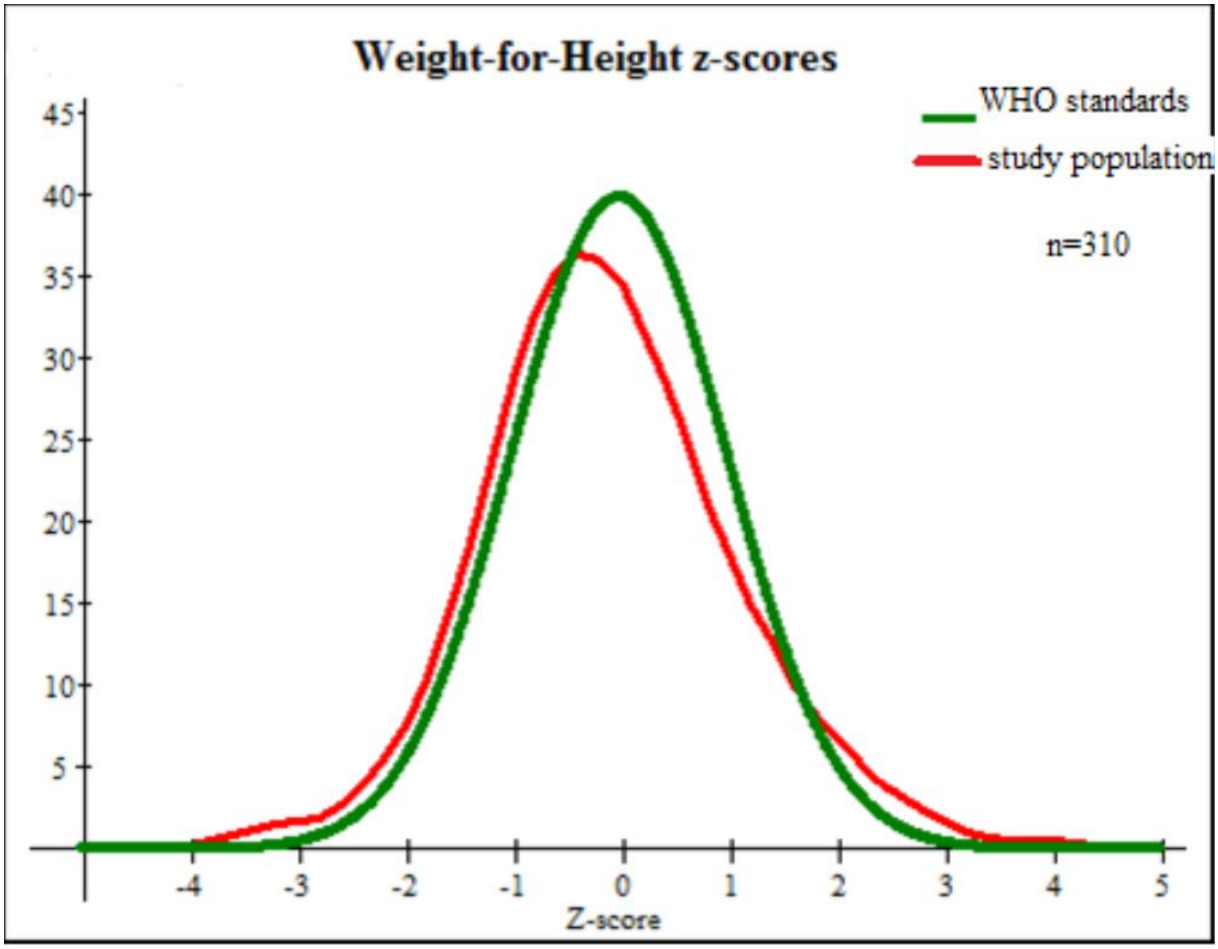


Figure 11: Prevalence of wasting among children under-five years

Figure 12 below describes the prevalence of severe, moderate and mild anemia among children under-five years in a study population. The overall prevalence of anemia among children under-five years was high (61%) as per WHO cut-off point which states that prevalence of anemia >40% is high and therefore need immediate attention.

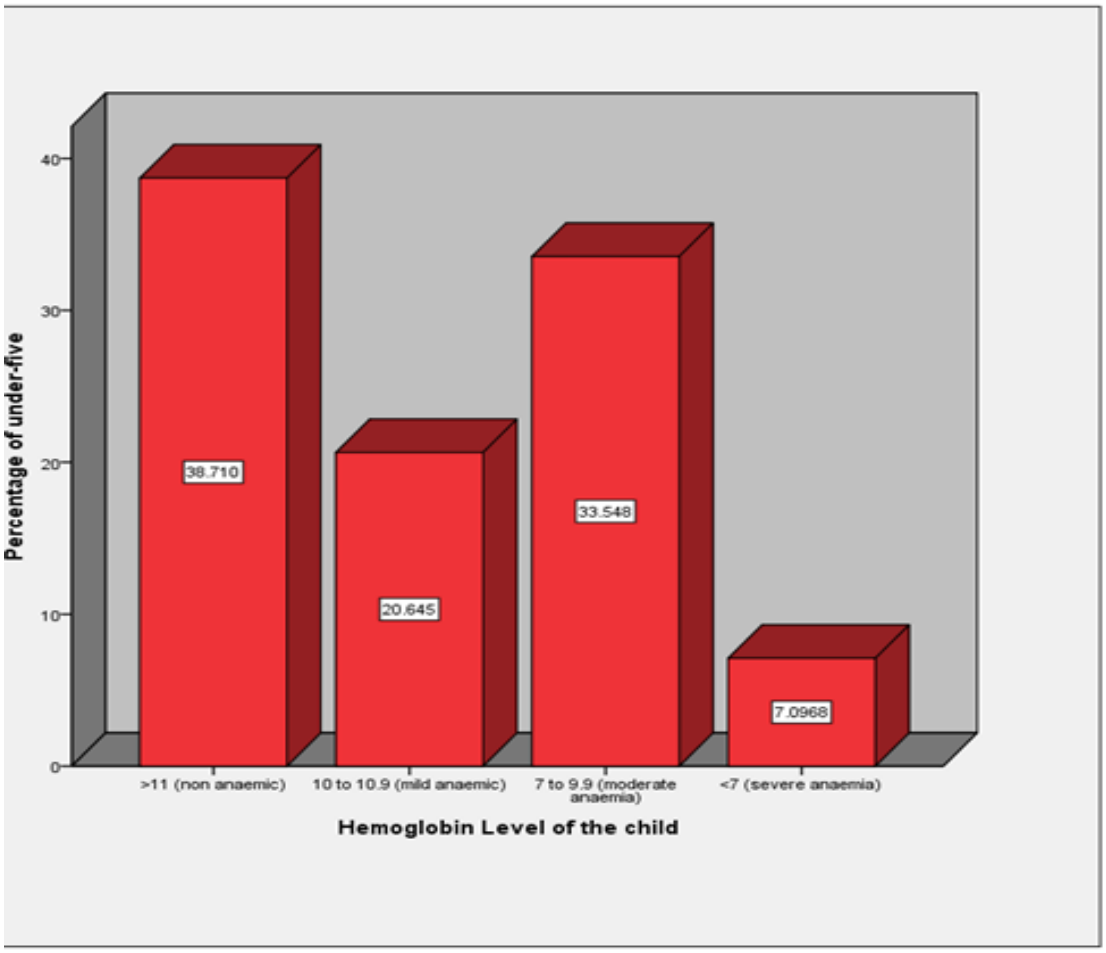


Figure 12: Prevalence of anemia among children under-five years

4.4.5 Factors associated with under-weight among under-five children

Children in households relying on surface water for domestic purposes were 9 times more likely to be under-weight compared to those in households with access to tap (AOR: 9.2; 95% CI: 9.1-60.5). Children having diarrhea for the two weeks prior to the survey were 2.5 times more likely to be under-weight compared to those who did not have diarrhea (AOR: 2.5; 95% CI:1.1-6). Children fed on unboiled cow's milk were 2.5 times more likely to become under-weight compared to those fed on boiled cow`s milk (AOR: 2.5; 95% CI: 1-6.7). Children who belonged to mothers with no education were 3 times more likely to be underweight (AOR: 2.9; 95% CI: 1.5-5.4) compared to children who belonged to mothers with education. Boys were 2 times more likely to be underweight compared to girls (AOR: 2.1; 95%, CI: 1.1-3.9). Table 5 shows the independent predictors for under-weight among under-five children.

Table 5: Under-weight among children aged below five years and its associated factors

Variable	n	Underweight %	COR (95% CI)	p-value	AOR (95% CI)	p-value
Use of surface water	144	32.2	7(3.5-14.1)	0.000	9.2(9.1-60.5)	**0.000***
Introduction of CF before 6 months	278	18.8	0.8(0.3-2.2)	0.7	1.9(0.7-5.9)	0.3
Having diarrhea two weeks before survey	88	19.3	1.3(0.7-2.5)	0.4	2.5(1.1-6)	**0.004***
Consuming cow's milk not boiled	67	17.7	1.6 (0.7-3.6)	0.3	2.5(1-6.7)	**0.05**
Keeping CF in kibuyu	97	17.4	1.3 (0.6-2.4)	0.5	1.5(0.7-3.8)	0.4
Mothers with no education	145	23.4	2.6(1.3-5.1)	0.002	2.9(1.5-5.4)	**0.001***
Being a boy	155	18.2	2.1(1.1-4.2)	0.04	2.1(1.1-3.9)	**0.03***

* *p value ≤ 0.05, CF: Complementary Food; This is a summary table for supplemental table three*

4.4.6 Factors associated with stunting among under-five children

Children from households using surface water for domestic purposes were 13 times more likely to be stunted compared to those in households using tap water for domestic purposes (AOR: 13; 95% CI: 5.8-30). Children introduced to complementary foods before the age of six months were about 3 times more likely to be stunted compared to those introduced to complementary foods at the age of six months and above (AOR: 2.8; 95% CI: 1.2-6.5). Children reported having diarrhea for the past two weeks were about 3 times more likely to become stunted compared to those reported not having diarrhea (AOR: 2.6; 95% CI: 1.4-5). Children who belong to polygamy families were almost 3 times more likely to be stunted compare to those belonging to single wife families (AOR: 2.5; 95% CI: 1.4-4.4). Table 6 shows factors associated with stunting among under-five children.

Table 6: Factors associated with stunting among under-five children

Variable	n	Stunting %	COR (95% CI)	p-value	AOR (95% CI)	p-value
Use of Surface water	144	48.8	3.5(2.2-5.8)	0.000	13(5.8-30)	0.000*
Introduction of CF before 6 months	278	50	2.3(1.1-4.9)	0.02	2.8(1.2-6.5)	0.02*
Having diarrhea two weeks before survey	88	41	1.8(1.1-2.9)	0.03	2.6(1.4-5)	0.004*
Consuming un-boiled cow`s milk	67	32.8	1.1(0.6-1.9)	0.9	1.8(1-3.8)	0.1
Keeping CF in kibuyu	97	36.1	1.3(0.8-2.2)	0.3	1.2(0.6-2.4)	0.7
Mother having more than two under-five children	41	45	2(1.1-3.5)	0.03	1.5(0.9-2.1)	0.4
Polygamous marriage	278	50	2.3(1.1-4.9)	0.02	2.5(1.4-4.4)	0.003*
A child having an age of two years and below	132	56.5	3.4(1.3-8.6)	0.01	1.7(1-2.6)	0.2
Mother being below thirty years old	68	37.2	1.1(0.6-1.9)	0.2	1.2(0.7-2.3)	0.1
Mothers with no education	145	43.4	3.4(1.6-5.9)	0.000	2.8(1.4-4.8)	0.001*

*CF; complementary foods, *P value ≤ 0.05; This is a summary table for supplemental table 2*

4.5 Discussion

This study shows that in the semi pastoral communities of Longido and Monduli, the use of surface water for domestic purposes was associated with stunting and under-weight, among under-five children. This could be due to high contamination of surface water resulting from unsanitary practices, such as open defecation or pollution by animals drinking from or defecating inside the water sources (Lyimo *et al.,* 2006, 2017) which was also reported by most of respondents. Furthermore, during the rainy season, water runoffs from surroundings may carry garbage and fecal matter and find its way through streams to the ponds and contaminate surface water. People using surface water for domestic purposes may be infected with waterborne diseases if measures to treat such water prior to consumption are not taken. On the other hand, piped water sources, such as tap water, may be comparatively less contaminated therefore reducing risks of waterborne diseases (Devoto *et al.,* 2012). The finding mirrors a prior study done in Tanzania (Chirande *et al.,* 2015) which reported that children using unsafe drinking water had increased risk of being stunted compared to those who had access to tap water. Another study done in Bangladesh reported that children belonging to wealthy families where clean and safe water is reliable were less under-nourished compared to those belonging to lower wealth quintile who do not have access to safe water (Hong *et al.,* 2006). Dangour *et al.* (2013) also reported that interventions to improve water quality at the point of use and supply could significantly improve nutritional status among children under-five years of age.

Poor WASH practices have been reported to contribute to 50% of under-nutrition among under-five children globally (USAID, 2015). Findings from this study showed that children who had diarrhea during the two weeks prior to the survey date had an increased risk of being stunted and underweight compared to those who had not. This finding could relate to the fact that diarrhea tends to affect absorption of nutrients by the body due to limited time the food spends in the stomach, lowers appetite, and the uptake of the nutrients for recovery from the infection rather than growth (Fawzy *et al.,* 2011; UNICEF, 2009a). Likewise, under-nutrition may prolong the duration and frequency of diarrhea and worsen health condition of the child due to a weakened immune system (Ngure *et al.,* 2014). Diarrhea may also have an indirect contribution to under-nutrition through the costs for medication that households spend in treatment which may affect their food budget (Chase and Ngure, 2016). The findings from this study are similar to those from a study done in Tabora which reported an association

between diarrhea and under-nutrition (Safari *et al.,* 2015). A study done in Ethiopia also confirmed that 12% of stunting among under-five children could be eliminated by preventing diarrhea through WASH interventions (Fenn *et al.,* 2012). Black *et al.* (2003) also reported that up to 25% of stunting among under-fives may be contributed by diarrhea episodes. Furthermore, Checkley *et al.* (2008) reported an association between childhood diarrhea and stunting. Therefore, improved WASH practices serve as a means of improving child nutritional status through reduction in diarrhea-associated infections and other WASH-related infections.

The study further confirmed that introduction of complementary food to children before six months of age may contribute to the risk of stunting. Normally, the gut and immune system of the child is not yet well established to digest semi solid foods. Therefore, a child may be vulnerable to autoimmune infections due to increased gut permeability (Halken and Host, 1996). Early introduction of complementary foods to children may also cause food-borne infections, environmental enteropathy and parasitic infections as a result of unhygienic handling of such foods, including storage in ambient temperatures, use of unsafe water to wash storage containers, use of unhygienic kitchen clothes to dry child utensils or not washing hands with soap when preparing such foods (Gautam *et al.,* 2017). Study from Kenya reported an association between stunting and early introduction of complementary foods to children younger than six months of age (Bloss *et al.,* 2004). A study done in Mali also revealed that about 55% of CF samples had fecal coliform bacteria and could be the main contributing factor for poor nutritional status and infections among under-five children (Touré *et al.,* 2013). It is important to promote food hygiene practices and exclusive breastfeeding for six months as per WHO recommendation as means of reducing infections and improving nutritional status among under-five children (Black *et al.,* 2003; Koyanagi *et al.,* 2009; UNICEF, 2009a).

Furthermore, the findings revealed that children from mothers with no formal education had increased risk of been stunted and under-weight compared to children from mothers with formal education. This could be due to educated mothers often having better understanding of food, nutrition, and hygiene aspects which enhance appropriate child feeding and care than their counterpart (Checkley *et al.,* 2008; Wenlock, 1980). In addition, educated mothers contribute directly and indirectly to the socio-economic condition of their households (Mosha and Philemon, 2010; Nyaruhucha *et al.,* 2006), a situation that may contribute to the increase of food choices and diversity, accessibility, and affordability within the households. It has

also been reported that every additional year of maternal education yields a reduction in child mortality by 5 - 10%; hence, education is the best investment for reducing poverty, improving health, and social wellbeing of the household and the entire community (UNICEF, 2013).

Polygamous marriage is a common practice among pastoral and semi-pastoral communities of Arusha. Findings from this study revealed that children who belong to polygamous families had an increased risk of being stunted compared to children who belong to monogamous families. The reason could be that polygamous families are normally large: therefore; whatever resources that are available in the family have to be divided among the large number of family members, and this may have impact on the nutritional status of children. The findings are in line with studies done in Zambia and Ethiopia which affirmed an association between stunting and polygamous/large family size (Fawzy *et al.,* 2011; Fenn *et al.,* 2012).

Findings from this study also revealed that being a boy increased the risk of being underweight than being a girl. The findings are in line with findings from a comparison study done in six Sub Saharan African countries which reported higher prevalence of under nutrition in boys than girls, the reason being that boys are more vulnerable to health inequalities than their female counterparts (Wamani *et al.,* 2007). Likewise, for the case of semi-pastoral communities, young girls may always be closer to their mothers therefore may be fed more frequently compared to boys.

Underweight among under-five children was also associated with feeding children on cow`s milk which was not boiled. It is likely that during milking, the milk could be contaminated by the host or by the handler and increase risk of food-borne diseases such as salmonellosis to the users especially when consumed un-boiled. The findings are mirrored in studies carried out in Kenya which revealed high prevalence of infections among under-five children consuming unboiled cow`s milk (Arhemk, 1989; Nestel and Geissler, 1986).

4.6 Conclusion

Prevalence of under-weight and stunting among under-five children in the select semi pastoral communities under study was alarming and could be due to poor WASH practices. As previously reported in other studies diarrhea-associated infections are mainly contributed to by poor WASH practices and could contribute to stunting and under-weight. The poor WASH practices in these communities were the use of surface water for domestic purposes,

feeding children on untreated cow's milk, and storing complementary in *kibuyu*. The study also identified socio-cultural practices associated with stunting or underweight. These are polygamy, lack of any formal education, and introduction of complementary foods before six months of age. This study, therefore, underlines the importance of incorporating WASH strategies including hygiene behavior changing strategies in formulation of interventions that target promotion of nutrition and diseases prevention in pastoralists` communities and similar settings. It also recommends further research to determine and quantify the role of WASH interventions in improving nutritional status among under-five children in pastoral communities.

4.7 Study limitations

This study was a cross-sectional design therefore the cause-effect relationship between under-nutrition and inadequate WASH practices or other studied factors could not be established. Some of the information was obtained through questionnaire which relied on mothers` self-report. This implies that mother's views may be subjected to recall bias. The findings from this study cannot be generalized for all pastoralists' communities as it is based on small sample size from one region. Furthermore, this study neither directly observed any behaviors nor quantifies the microbiological contamination in water, milk or food to conclude its association with under-nutrition. Also, diarrhea prevalence was measured once and it may have seasonal effect and reporting-bias**.**

CHAPTER FIVE

Effect of water, sanitation and hygiene interventions on common infections and nutritional status among children under-five years in selected semi-pastoral community of Longido District in Tanzania[4]

Abstract

Under-nutrition among children aged below five years is a public health concern in developing countries and it contributes significantly to morbidity and mortality of this age group. The problem is contributed to by multiple factors including infections emanating mostly from poor water, sanitation, and hygiene practices (WASH). The aim of this study was to evaluate the short term effect of selected WASH interventions on common infections and nutritional status among children under-five years in semi-pastoral community of Longido District. A longitudinal case-control study design was employed with two homogeneous groups of mother-child pairs as control and intervention groups. Mothers from the intervention group were provided with water-filters to improve quality of drinking water at the household level and health education. The control group did not receive any intervention, hence continued with habitual WASH practices. Bimonthly reinforcement follow-ups were done on intervention group for duration of six months while normal follow-up visits were done to control group. Thereafter, a post assessment was done using a questionnaire to capture information on diarrheal incidences among participating under-five children and compliance with filtered drinking water for the case of intervention group. Anthropometric measurements and hemoglobin levels were taken from index children in both control and intervention groups. *Escherichia coli (E. coli)* counts were also tested in ready to feed fresh milk and drinking water for children in both groups.

Post assessment results showed that about 97% of intervention households were drinking water from the installed water filters. Anthropometric measurements showed significant weight gain among children from intervention group when compared to children from the control group ($p = 0.02$). The number of children reported as having diarrhea two weeks before the post assessment date decreased significantly in the intervention group when compared to that of control group ($p = 0.03$). The mean hemoglobin levels of children from intervention group were higher compared to those of children from control group ($p < 0.001$).

[4] PLoS ONE (re-submitted)

Mean *E. coli* counts from drinking water and ready to drink fresh milk for children was minimal in the intervention group compared to that of control group ($p < 0.001$). As a result, WASH interventions reduced diarrhea prevalence and improved both nutritional status and hemoglobin levels of under-five children significantly. Therefore, the study recommends interventions such as promotion of health education and treatment of water at the point of use for addressing the problem of infectious diseases and under-five nutritional status in the study population and similar settings. Integration of WASH measures to nutrition interventions for addressing the problem of under-nutrition among children below five years is also recommended.

Key words: WASH intervention, under-nutrition, under-five children, pastoral community, Tanzania

5.1 Introduction

Under-nutrition among children aged below five years is a public health concern globally and it is responsible for up to 45% of all deaths in this age group (Black *et al.,* 2013). The problem could be caused by either direct or indirect factors. The direct causes of the problem include insufficient dietary intake and diseases (Chase and Ngure, 2016). It can also be caused by indirect factors such as food insecurity, poor WASH practices, poor child care and lack of adequate health services. Both direct and indirect factors causing under-nutrition could be driven by socio-cultural and economic factors (UNICEF, 2013). Diarrhea in particular, regardless of being a leading cause of deaths among children under-five years in Sub-Saharan Africa (SSA) it also forms a synergetic relationship with under-nutrition (Bado *et al.,* 2016; Ngure *et al.,* 2014; TNNS, 2014). Both under-nutrition and diarrhea have been reported as major threats to children growth and survival (Dewey and Mayers, 2011).

Improved WASH is likely to reduce infectious diseases among under-five children by providing conducive and safe environments for growth (Cairncross *et al.,* 2010; Dangour *et al.,* 2013). Improved WASH is among the fundamental human rights and may impact negatively on childhood growth performance, yet many households in developing countries have limited access to water, sanitary environments, health facilities and education. Tanzania did not meet the Millennium Development Goal number seven of cutting by half the proportion of people without improved water and sanitation services by 2015 (WHO, 2015). Furthermore, about 1.8 billion people globally do not have access to safe drinking water, 2.4 billion people do not have access to basic sanitation services, while more than 80% of waste

water resulting from human activities is directed into water bodies causing water contamination (UNICEF/WHO, 2015). Annual death tolls due to diarrhea worldwide are 2 million of which 90% are due to poor WASH conditions (UNICEF, 2009a; UNICEF, 2014).

WASH interventions including water treatment at the point of use, hand washing with soap, health education, and provision of sanitation facilities have been reported to reduce both diarrhea and under-nutrition among under-five children. Treatment of water at the point of use alone may reduce diarrhea by 34% (Waddington *et al.,* 2009a). Hand washing with soap during the four critical moments (before eating or feeding the child, after using the toilet, after attending the child and before preparing meals) reduced diarrhea by 40% and improved child growth (Curtis and Cairncross, 2003; Freeman *et al.,* 2014). Provision of sanitation facilities, such as latrines, reduced diarrhea prevalence by 28% and improves nutritional status through elimination of fecal-oral infections such as enteric infections particularly environmental enteropathy (Humphrey, 2009; Ngure *et al.,* 2014). Studies done in Tanzania and Vietnam also showed an increase in number of households without sanitation facilities increased children faltering cases (Quattry, 2014). Again, studies done in Mali and India revealed that open defecation increased the risk of stunting (Alzúa *et al.,* 2015; Spears, 2013). Though WASH interventions have been less considered when focusing on nutrition and wellbeing of children, nutrition interventions which has being widely studied revealed that interventions with up to 90% coverage may reduce the problem of under-nutrition among under-five children by only 20% (Chambers and Von Medeazza, 2013). This contrasting evidence has set a ground for potential stakeholders to reconsider WASH interventions for nutrition and wellbeing of the rural and undeserved societies.

A baseline study reported in chapter three and four revealed high prevalence of diarrhea and under-nutrition among under-five children in semi-pastoral communities (Mshida *et al.,* 2017, 2018). Such high prevalence could be a threat to growth performance and functional development of children under-five years in a study population. The baseline study reported further that, WASH practices among these communities were poor and contributed significantly to under-nutrition and high prevalence of common infections in children below five years of age (Mshida *et al.,* 2017, 2018). However, strategies to address such problems have traditionally focused on vaccination and nutrition interventions such as food supplementation and fortification. Again, the potential role of WASH interventions particularly promortion of health education and water treatment at the household level on

improving child nutritional status and reducing common infections in semi-pastoral communities has not been documented. This study, therefore, aimed at evaluating the effectiveness of an intervention package for filtration of drinking water and delivery of health education on reduction of common infections and improvement of nutritional status of children aged below five years.

5.2 Materials and Methods

5.2.1 Study area

This study was conducted in selected households of Kimokouwa and Orbomba villages in Longido District. Longido District covers 7 885.01 km squire, it is divided into eighteen wards and has a total population of 123 153 people. The district is dominated by Maasai who are semi-pastoralists in nature. To the North the district is boarded with Kenya, to the East, Kilimanjaro region, to the South Manyara region, and to the West Simiyu and Mara regions. The District was selected based on the findings from the baseline survey which revealed high prevalence of under-nutrition and diarrhea among children residing in Longido compared to those of Monduli District (Mshida *et al.*, 2018). Table 7 below summarizes the prevalence of under-nutrition, diarrhea and hemoglobin levels among under-five children in Longido and Monduli districts as reported by Mshida *et al.* (2018).

Table 7: The status of variables of interest for Longido and Monduli pre intervention phase

Variable	Longido n (%)	Monduli n (%)	Chi-squire	P- value
Wasting/HWZ	8 (5.3)	6 (3.8)	1.4	0.5
Stunting/HAZ	93 (35.2)	57 (28)	3.9	0.1
Under-weight/WAZ	24 (16)	27 (17.5)	1.1	0.9
Hb levels	104 (69.3)	86 (53.8)	9.8	**0.02***
Diarrhea prevalence	68 (45.3)	20 (12.5)	41.1	**0.001***

5.2.2 Study design, sample size and sampling protocol

The study employed a longitudinal case-control design. Two villages named Orbomba and Kimokouwa from Longido District were assigned to intervention and control groups

respectively. Purposively, households with under-five children aged between 6 – 59 months, inclusive were selected to participate in the study. Sample size was calculated based on the cross sectional study sample size calculation formula as follows; $n = z^2P\ (100\text{-}P)/\varepsilon^2$, Where: n is minimum sample size, z is a value corresponding to the confidence level =1.96, P is anticipated prevalence of 25% of WASH practices among semi-pastoral communities, and ε is a margin of error which is 5% with confidence interval of 95%. Therefore a total of 150 mother-child pairs, were sampled out of which 70 formed the intervention group and 80 formed the control group. The sample size took into consideration 5% attrition rate. A bimonthly follow up on WASH practices, child nutritional status, and common infections was done for six months starting from November 2015 to April, 2016.

5.2.3 Household Interviews

Baseline information on WASH practices, socio-demographic characteristics, morbidity, child feeding practices and nutritional status were gathered as reported by Mshida *et al.* (2018) in chapter four. Water filters (Nano Filter®) from Gongali Model Co. Ltd, Arusha-Tanzania were collected from Gongali head office located at Nane-Nane grounds in Njiro, Arusha and a complete package installed at each household of the intervention group.

5.2.4 Interventions

(i) Assigning households to intervention and control groups

Orbomba and Kimokouwa villages were assigned to intervention and control groups. This was done by writing the name of each village in an independent piece of paper, fold it properly, and toss them up, and let them fall down. Thereafter, the first paper to be picked first was assigned to intervention group whereas the last one was assigned to control group. Therefore, the first paper to be picked was written Orbomba and the second was Kimokouwa village. Figure 9 below illustrates the procedures used to sample intervention and control groups.

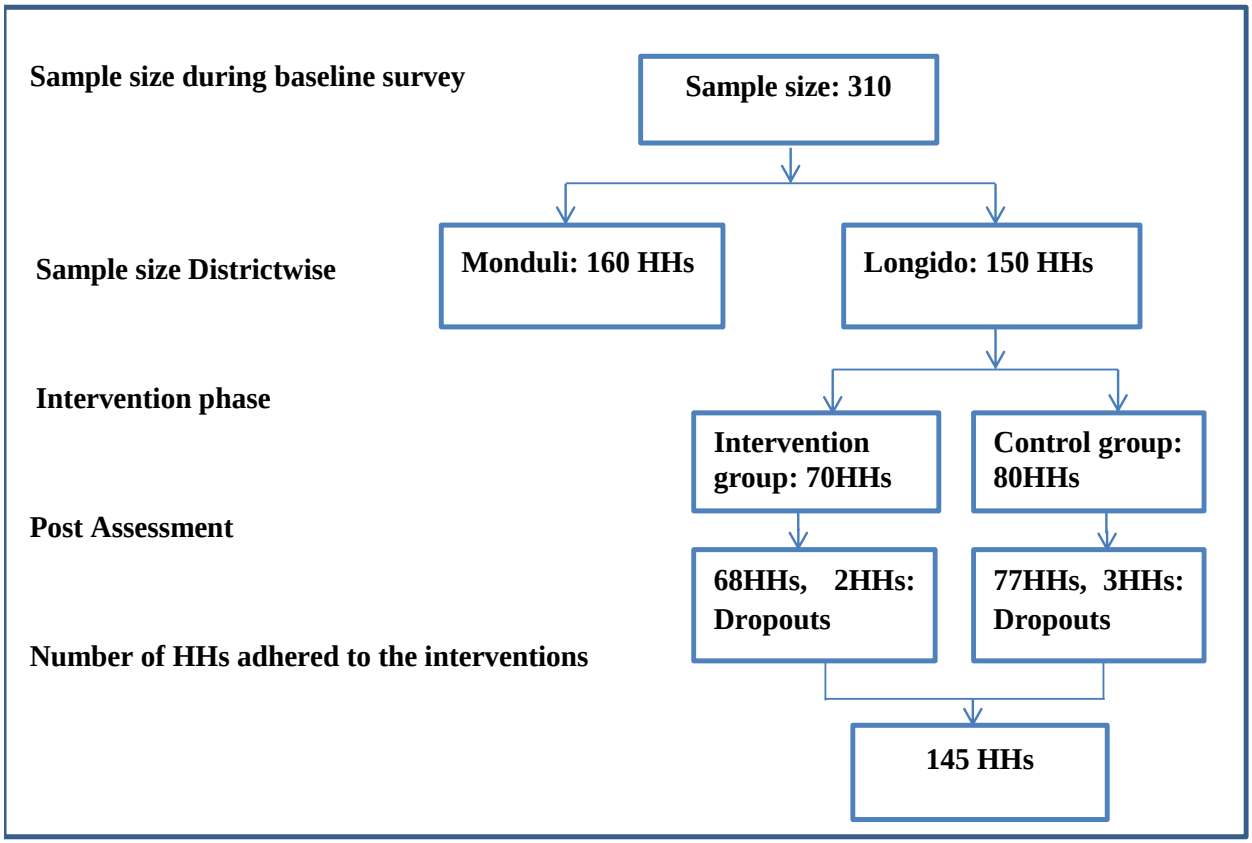


Figure 13: Sub sampling and clustering households into intervention and control group.

(ii) Assigning water filters to the intervention group

The intervention group was provided with water filters for treating drinking water at the point of use. Each filter handles up to 20 liters of water in two hours, and therefore, each filter hub served up to about twenty households. Filters were installed and assigned to four households who took the responsibilities of managing and maintaining them. Demonstration on the use and maintenance of water filters was given by the technician from the supplier, Gongali Model Nano Filter Company. Filters were serviced after every four months by the technician from the manufacturer. Figure 10 below shows Maasai woman fetching water from ready to use water filter installed in one of the household in Longido District.

(iii) Suitability of the Nano filters

Nano filter is a slow sand filter which is effective in removing bacteria and other microorganisms from water. It contains nano-materials made up of sodium silicate and silver which is capable of removing toxic heavy metals from water including copper, fluoride, and other chemical contaminants. Water passes through grinded bones, sand particles, and thereafter through the nano-materials. Filtered water is 99.9% free from biological, physical and chemical contaminants and is safe and clean for domestic purposes (Hilonga, 2015). Nano filter can also be calibrated to eliminate target contaminants of a specific geographic location. Gongali Model Company where has a nano-filter laboratory where all water tests are conducted before installation of filters is done. Therefore, based on the parameters observed from specific water samples, some components of nano-filter are included to the filters. For example, if Fluoride is found in a specific area, then a component that removes Fluoride is added to the filter. The properties of nano-materials are modified to target specific contaminants identified in each area. Note that the water contaminants vary from place to place due to natural sources for instance nature of rocks or human activities.

Nano filters were selected for this study as there is no any existing intervention for improving water quality in semi-pastoral communities using such filters. The filters are efficient in improving water quality, easy to use, affordable and appropriate to the study community in terms of durability and workability. Though the filters were obtained using research funds, sustainability of the intervention, has been vested by providing instructions on use. Again, provision of the filters was preceded with education intervention where users were trained on the cost-benefit of using clean water. Each water filter was assigned a focal person who was connected to the company`s technician for further maintenance and guidance where needed.

The company has a dedicated technician permanently located in its sub-brunch in Longido area for maintenance and guidance to customers.

(iv) Health education

Training on WASH practices was conducted for mothers using the manual attached in Appendix V. Mothers with under-five children from intervention group were trained by the principal investigator with assistance from Longido District Health officer. The intervention was participatory in nature and focused on improved WASH practices and its associated infections. Women from intervention group were divided into two main groups – each comprised of 35 participants. Flow of information from the intervention to control group was insignificant due to the fact that the selected study groups were located more than 100 km from each other. The intervention group was trained for seven days. The training was in the form of theory and practical including demonstrations. WASH practices, such as hand washing with soap during critical moments as described in Chapter Three (Mshida *et. al.*, 2017), proper handling of child feces, proper handling, cooking and storage of CF, personal hygiene, and proper disposal of household waste were discussed and demonstrated to the participants using flip charts and posters. Discussions about diseases associated with poor WASH practices particularly fecal-oral infections, their transmission routes, signs and treatments of such infections were illustrated using the teaching manual attached in Appendix V to increase the awareness of mothers on such infectious diseases. At the end of the training, mothers were provided with posters illustrating how improved WASH practices prevent fecal-oral infections. Ad hoc follow up visits were done without any appointment twice in every month for a period of six months and observation was done to see if mothers were practicing what they have learnt. Assessment was done six months after the intervention using key outcome indicators including diarrhea incidences among under-five children (as a proxy for common infections), nutritional status, and *E. coli* status of drinking water and fresh milk ready to feed. The study used *E. coli* status in ready to drink/feed fresh milk to determine the hygiene status of CF. Again, ready to drink fresh milk was selected as proxy for CF, as it is commonly used by the majority of mothers as CF than any other food and also it is easy to carryout microbiological tests in fresh milk than any other foods such as porridge or *Loshoro* which is a Maasai traditional food commonly used as CF. Knowing the status of *E. coli* in ready to drink/feed fresh milk could show whether there was improvement on hygiene behavior and adherence on the use of filtered water among participants. However, the control group received health education at the end of the intervention study. To make the

intervention sustainable, copies of training manuals were given to the District Health Officer for further training and follow ups. Although there is an ongoing national sanitation and hygiene campaigns across there country, there has not been any WASH intervention or program done in any prior study.

(v) Controlling confounders

As one of the means of controlling confounders in this study, all children from the intervention and control groups were administered with the recommended dose of albendazole tablets (Zentel, manufactured in India) 400 mg per one tablet. Deworming was repeated after 3 months. Other confounders including number of meals given to a child per day, gender of the child, birth weight, exclusive breastfeeding, and time that CF was initiated to the child were adjusted during data analysis.

Figure 14: A Maasai woman from one of the intervention household in Longido taking drinking water from ready to use nano filter

5.2.5 Collection of water and ready to drink fresh milk samples for post assessment

To assess the adherence status of the interventions, microbiological testing for *E. coli* in drinking water and ready to drink fresh milk intended for index children were performed. Water samples were taken from the water sources, drinking water storage containers, and from the water filters using sterilized disposable falcon tubes of 100 ml each. From each household, 100mls each, of water from drinking water storage container and ready to drink fresh milk were collected. A total of 145 samples in each parameter were collected beside the

5 dropout households. Samples were taken by qualified laboratory technician from the Nelson Mandela African Institution of Science and Technology. Collection of the samples with falcon tubes ensured a space of 2.5 cm as per WHO microbiological sample collection guideline, which requires air space to be left for the microorganism's survival (WHO, 1996). Samples were kept in cooler boxes with ice packs and transferred to the NM-AIST laboratory within six hours and immediately analyzed. The same procedure was followed during collection of milk samples. A total of 145 samples of drinking water and ready to drink fresh milk were analyzed.

5.2.6 Detection of *E.coli* from water samples and fresh milk

Escherichia coli (E. coli) in water samples was tested using standard method for water quality testing as described by as described herein (Calderon *et al.*, 1991). Acetate membrane filters of 47 mm nominal pore size of 0.45 µm were used. Samples taken from taps and water filters were not diluted, whereas samples from ponds/*silange* and streams were diluted with distilled water at a ratio of 1:10. Negative control in this case was 100 ml of sterilized distilled water. After diluting 10 ml of water into 90 ml of distilled water, 10 ml were taken from the diluted sample using pipette and filtered using membrane filter; thereafter the membrane filter was placed into Hicrome agar on a petri dish. In the case of fresh milk, a dilution of 1:100 was done followed by pipetting 10µm onto a petri dish containing Hicrome agar and the sample was spread evenly using sterilized beads. All samples were incubated at 44 ± 0.2˚C for about 24 hours. Negative control for the case of fresh milk was 100 ml of pasteurized fresh milk from Brookside Dairy Limited Company (Kenya), the only pasteurized fresh milk available in the market. Blue color colonies in appearance were regarded as *E. coli*. (Fig. 11).

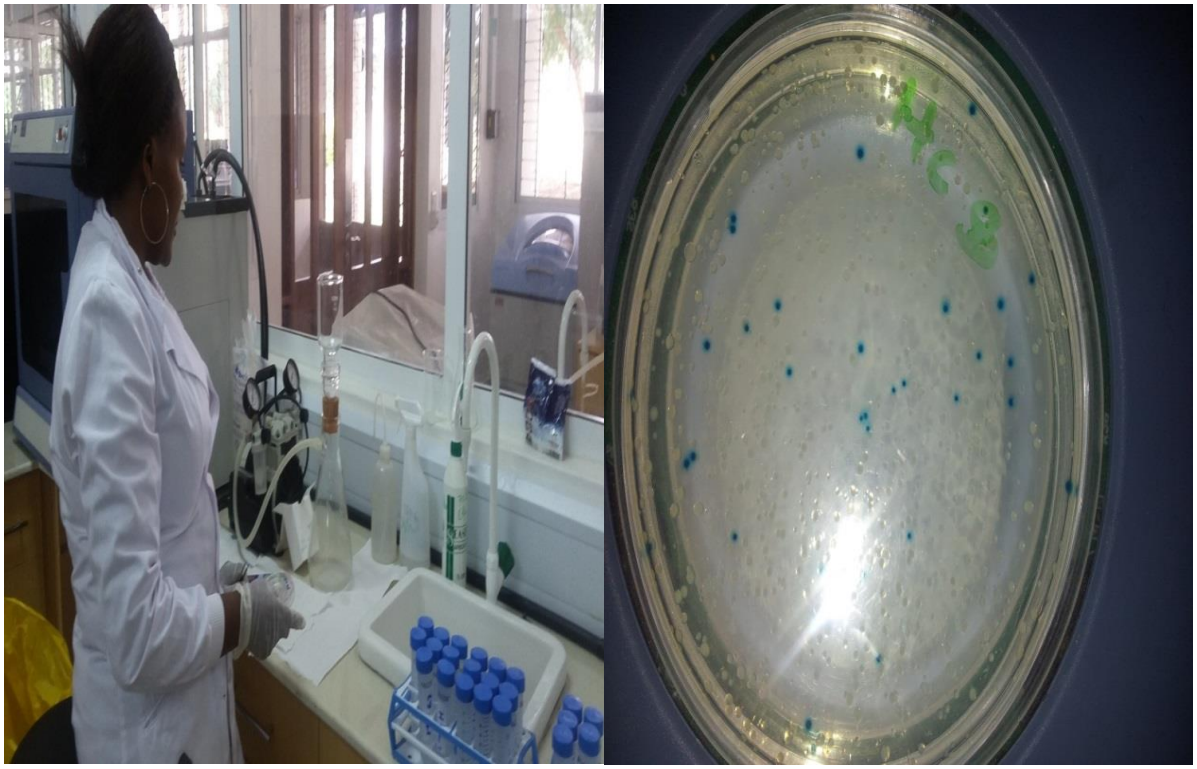


Figure 15: To the left, membrane filtration, to the right *E. coli* blue colonies from fresh milk samples

5.2.7 Assessment of child's nutritional status

Anthropometric measurements specifically height and weight were taken from the index children in both intervention and control groups. Length of children aged 6 - 24 months was measured using UNICEF length board and weight was measured using hang-up weighing scale (Seca™ Model 881) as described by Mshida *et al.,* 2017. For children aged 24 to 59 months a UNICEF stand-weighing scale and height board were used to measure their weight and height respectively. Age of the child was recorded from the reproductive and child health clinic cards. The WHO (2005) Z-score indices were used as reference where Z-score < -3 and < -2 & ≥ -3 were regarded as severe and moderate under-nutrition, respectively and > -2 was regarded as normal. Hemoglobin levels of the index children were measured using Hemo Cue® Hb 201+ photometer (AB, Sweden), and recorded in g/dl. Categorization of Hb levels was done based on WHO standards, where Hb level > 11 was regarded as normal while < 7, 10 - 10.9 and 7 - 9.9 were regarded as severe, mild and moderate anemia, respectively (De Benoist *et al.,* 2008). All measurements were taken before and after intervention. Anthropometric measurement tools and Hemo Cue machine were calibrated regularly using the similar tools available at the District hospital of the respective study area.

5.2.8 Assessment of common infections

Mothers were asked whether their children had diarrhea two weeks preceding post assessment date and information were noted down. Diarrhea was regarded as proxy for common infections; therefore other childhood common infections were not assessed during post assessment.

5.3 Ethical Clearance and Informed consent

Ethical clearance was obtained from National Institute for Medical Research of Tanzania (Appendix V). Informed written consent was sought from mothers or caregivers of children under study, prior administration of the questionnaire, during anthropometric measurements and testing for children`s hemoglobin levels. The consent for taking photos to be used in publication was separately sought from two participant mothers (Appendix VI). Confidentiality regarding the information collected from the survey was ensured.

5.4 Data Analysis

Data cleaning was done as described in section 3.3 of Chapter Three by Mshida *et al.* (2017). For anthropometric data, ENA for SMART software was used to calculate Z-scores including weight for height, weight for age and height for age z-scores (De Benoist *et al.*, 2012). A Descriptive analysis was done to determine the frequencies and percentages of socio-demographic characteristics and WASH behaviors of the intervention and control groups before and after intervention phase. Independent student t-test was employed to compare *E. coli* cfu in samples of water and ready to drink fresh milk. Likewise, independent student t-test analysis was done to calculate the mean proportions of *E. coli* from samples collected from the water sources, drinking water storage containers as well as from water filters. Cross tabulation analysis was done to compare WAZ, HAZ, WHZ and diarrhea between and within the two groups.

5.5 Results

5.5.1 Socio demographic characteristics of the participants

Out of 150 households (70 intervention and 80 control), there was only 3.3% drop out for various reasons such as vacating family bomas to an area with access to water and pasture for their livestock. There was no significant difference in socio-demographic characteristics, water sources, socio-economic status and WASH associated practices between the control

and intervention group before interventions. Likewise, child morbidity and feeding practices, diarrhea prevalence, and under nutrition did not differ significantly among the two groups before intervention phase as shown in Table 8 below.

Table 8: Socio-demographic and WASH associated factors of the two groups

Variables		n	Intervention %	Control %	p-value
Gender of the child	Male	67	42	58	
	Female	78	51	49	0.2
Child age group	6- 11 months	36	33	67	
	12-23 months	34	50	50	
	24-35 months	33	58	42	
	36-45 months	19	47	53	
	46- 59 m0nths	23	48	52	0.2
Mothers age	16-19 years	3	33	66	
	20-29 years	88	40	60	
	30-39 years	43	54	47	
	40 and above	11	46	54	0.2
Marital status	Married	138	47	53	
	Unmarried	7	49	51	0.5
Mothers level of education	No education	66	42	58	
	With education	79	50	49	0.3
Number of meals per day	Less than three	78	49	51	
	Three to five	67	44	56	0.5
Cow's milk boiled	Yes	102	42	58	
	No	43	58	42	0.1
Means of storing CF	Vacuum flask/Hotpot	81	43	57	
	Kibuyu	64	52	48	0.3
Toilet available	Yes	28	43	57	
	No	117	48	52	0.6
Handwashing with soap during CM	Yes	29	48	52	
	No	116	47	53	0.3
Source of drinking water	Safe	52	54	46	
	Unsafe	93	43	57	0.2
CF initiation	Before six months	134	47	53	
	After six months	11	49	51	0.4

CF: complementary foods, CM: critical moments

5.5.2 Baseline and post intervention nutritional status and diarrhea prevalence

Results from baseline data revealed that there were no any significant difference in the prevalence of under-weight ($p = 0.6$), stunting ($p = 0.3$), wasting ($p = 0.9$) and diarrhea ($p = 0.3$) among under-five children in the intervention and control groups. However, after intervention, data revealed significance reduction in underweight (WAZ) among under-five

children in intervention group (p = 0.02). It was further noted that the prevalence of diarrhea decreased significantly among under-five children in the intervention group when compared to children from the control group (p = 0.03) as indicated in Table 9.

Table 9: Status of common infections and nutrition before and after intervention

Variable	n	Percentages (%)		p-value
		Intervention group	Control group	
Baseline				
Underweight	23	44	56	0.6
Stunted	45	42	58	0.3
Wasted	8	50	50	0.9
Diarrhea	39	54	46	0.3
Post intervention				
Underweight	20	19	81	**0.02***
Stunted	41	43	57	0.3
Wasted	7	43	57	0.95
Diarrhea	34	31	69	**0.03***

** P-value with significant level*

5.5.3 Underweight status before and after intervention

Prevalence of underweight among children under five years improved significantly after intervention when compared to that of baseline survey. Figures 12 and 13 show the underweight normal distribution curve of study population before and after intervention in comparison with that of WHO reference population. The normal distribution curves for study population before intervention deviated from the mean, skewed to the left and became more flatter when compared to the WHO normal distribution curve of reference population of the same age group. However, after intervention, the normal distribution curve of study population showed a significant improvement on underweight when compared to that of baseline survey.

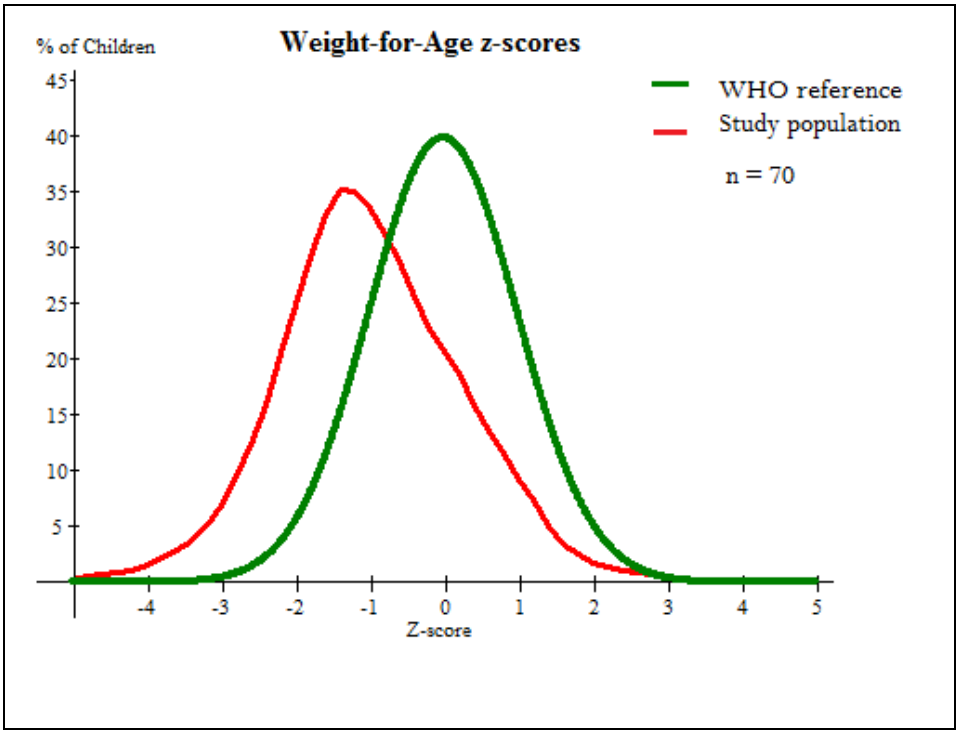


Figure 16: Normal distribution curve of under-weight prevalence before intervention

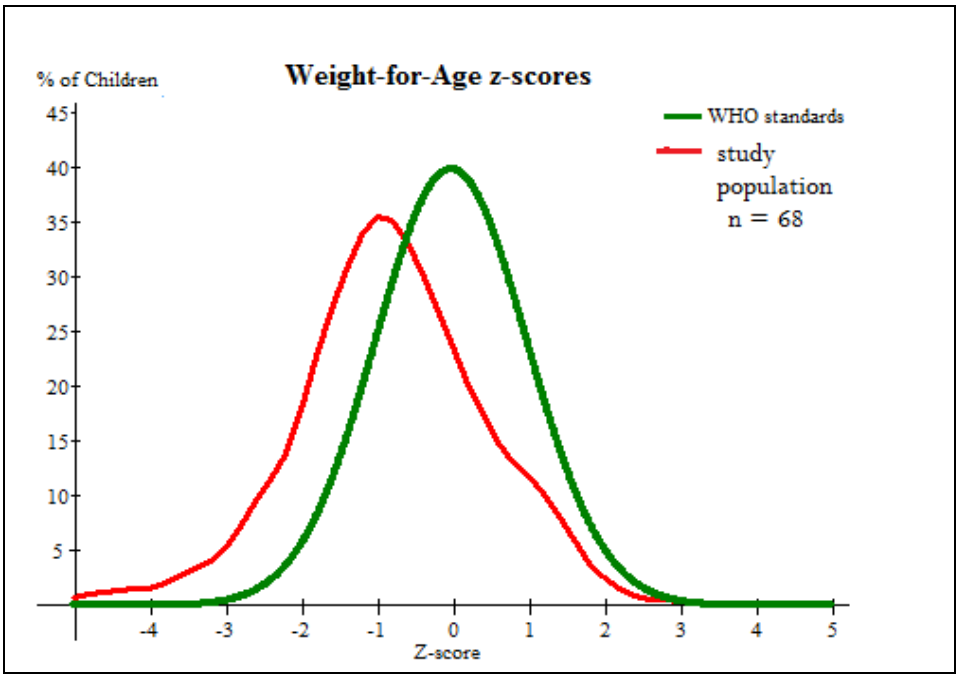
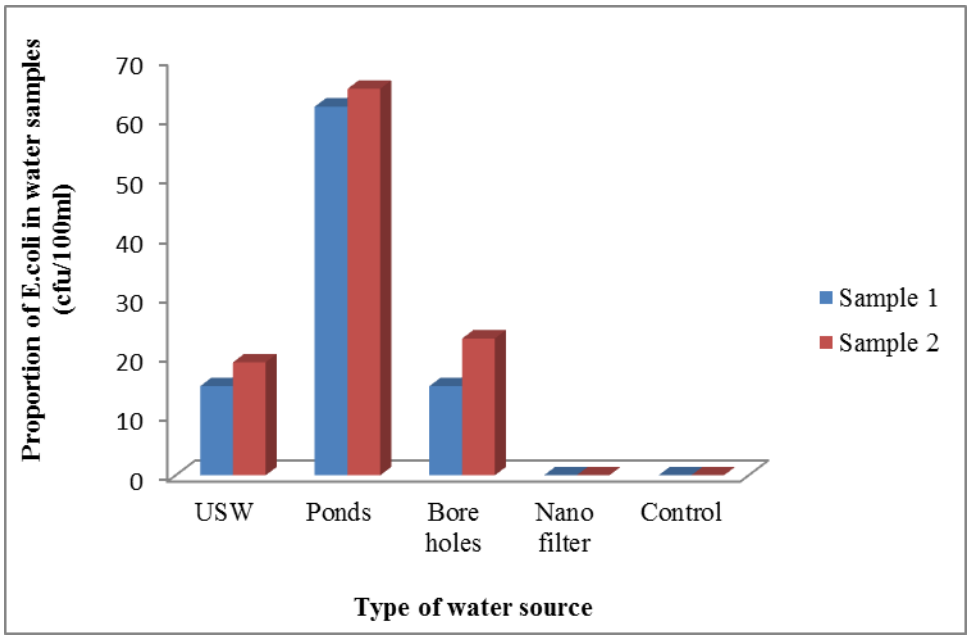


Figure 17: Normal distribution curve of under-weight prevalence after intervention

5.5.4 *Escherichia coli* status in different water sources

The results on water quality revealed that, water from ponds which was the main source of domestic water for the majority of households from both intervention and control groups were highly contaminated by *E. coli*. All water from open boreholes and unprotected shallow wells was contaminated. When filtered using nano filters, the same water samples were found to be free *E. coli* (Fig. 12).



USW: unprotected shallow wells

Figure 18: Average proportions of *E. coli* cfu/100 ml of water collected from different sources during intervention phase.

5.5.5 *Escherichia coli* status of water and milk samples

There was a significant mean difference between *E. coli* counts in water samples taken from drinking water containers from intervention households when compared to those of the control groups ($p < 0.001$). Similarly, there was a significant mean difference between *E. coli* counts in samples of ready to drink fresh milk taken from intervention group when compared to those of control group ($p < 0.001$). There was a significant gain in hemoglobin levels in children from the intervention group when compared to children from control group. Table 10 shows the mean difference in water samples and hemoglobin levels between the two homogeneous groups.

Table 10: Average mean of *E. coli* cfu/100ml in water, fresh milk and hemoglobin levels during post intervention assessment

Variable	Mean (95% CI)		P-value
	Intervention group	Control group	
E. coli count (cfu/100 ml) in drinking water	6.71±3.43	21.57±16.13	<**0.001**
E. coli count (cfu/100 ml) in fresh milk	7.7±3.27	29.13±16.21	<**0.001**
Hemoglobin levels of children	10.8±1.89	9.05±1.87	<**0.001**

5.6 Discussion

WASH interventions, particularly treatment of water at the point of use by the use of water filters, have significantly reduced both diarrhea prevalence and under-weight in under-five children of the population under-study significantly. This study is believed to be the first study in which water filters in addition to health education were introduced to Maasai community to improve the quality of drinking water and WASH practices with ultimate aim of reducing diarrhea and under-nutrition prevalence among under-five children. A study done in Kenya where Maasai children living in households provided with solar disinfection for improving water quality revealed 9.3% decrease in diarrhea prevalence (Conroy *et al.*, 1996, 1999). Similarly, a study done in Liberia showed that improvement of water quality at the point of use reduced diarrhea prevalence by 90% and diarrhea incidence by 83% (Doocy and Burnham, 2006). The reduction in diarrhea prevalence is also in line with study done in Guatemala which showed a reduction of diarrhea prevalence by 16% after improving the quality of drinking water at the household level (Chiller *et al.,* 2006). A study by Prüss-Üstün *et al.* (2008) and Fewtrell *et al.* (2005) also revealed reduction of diarrhea by 64% after improving water quality at the point of use. A study by Luby *et al.* (2006) which evaluated the impact of water treatment at the point of use and found a reduced child diarrhea by 51%. Findings from this study proved that treatment of water at the point of use could significantly reduce risk of diarrhea in communities where resources for improving water supply system are limited.

Findings from this study also revealed that by improving water quality at the point of use could reduce underweight prevalence among under-five children. Improved water quality is free from microbial contamination and is likely to reduce water-borne diseases including diarrhea, which has negative impact on the nutritional status of under-five children. The findings from this study are consistent with a study done in Lesotho which reported that improved water quality had positive effects on WAZ especially when combined with sanitation improvement (Esrey, 1996). Another study done in rural Zimbabwe reported that the risk of a child being under-nourished was reduced where improved drinking water and sanitation facilities were available (Ngure *et al.,* 2014). Improvement of water quality at household levels may contribute into solving the problem of under-nutrition in the study population and similar settings.

However, the study showed no significant improvement on stunting among children under-five years after intervention. The reason could be due to the fact that stunting in children is irreversible and it normally develops during the early stages of child life. Any intervention targeting on improvement of child stunting may not give remarkable results especially when it is done after a child is borne. It is therefore, recommended that nutrition interventions targeting on improving the nutritional status of children under-five years particularly stunting should be done during the first 1000 days of life for significant results (UNICEF, 2015).

Low hemoglobin levels among under-five children are the most common nutritional deficiency in developing countries where poor WASH practices are prevalent. Findings from this study showed significant improvement in hemoglobin levels among under-five children in intervention group compared to control group. This could be due to the fact that, reduction of pathogens from drinking water through water filtration might have reduced risks of water-borne infections among children including worms thereby improving child health. Again hygiene education given to mothers might have reduced risks of contamination of CF and food-borne disease burden. WASH related infections including diarrhea and worms infestations are the major cause of anemia (Weiss and Goodnough, 2005). Therefore it is likely, that interventions to improve WASH practices reduced the problem of low hemoglobin levels among under-five children in the study population.

E. coli is an indicator organism for fecal contamination that causes diarrhea diseases. Presence of *E. coli* in water and milk samples indicates high risk of diarrhea diseases among under-five children in the studied population. Findings from the post assessment study

revealed that, levels of *E. coli* in water and ready to drink fresh milk samples were significantly reduced following water filtration and health education interventions; hence, children from the control group had increased risk of developing diarrhea compared to children from the intervention group. Similar to findings from previous study reported increased risk of diarrhea with increasing levels of total coliform in water (Hedge *et al.,* 2016), though contrary to studies done in Kenya and Rwanda which revealed that microbiological indicator of water quality did not have any association with neither diarrhea nor under-nutrition (Null *et al.,* 2018; Sinharoy *et al.,* 2016).

5.7 Conclusion

WASH interventions, such as improvement of drinking water quality at the point of use and promortion of health education, reduced diarrhea prevalence and improved the nutritional status of under-five children in the study population. The use of water filters reduced water borne *E. coli*, and burden of water-borne diseases. Hygiene education to mothers of under-five children might have improved food hygiene practices and thus reduced food contamination as was seen in milk samples from intervention group revealing decreased levels of *E. coli* compared to those of the control group. However, studies on long-term WASH interventions with wider coverage at affordable costs in a randomized control trial to determine the best-fit approaches are recommended.

5.8 Recommendations

Health education campaigns to emphasize the need for improved WASH practices and creating awareness to the community and potential stakeholders on the relationship between poor WASH, infectious diseases and under-nutrition among under-five children are recommended. This study recommends further, integration of WASH interventions particularly water treatment and health education promortion into nutrition interventions to improve the growth performance of under-five children and reduce child morbidity in the population under-study. Policy makers and stakeholders dealing with child health should consider strategizing for multi-sectoral and multi-disciplinary programmes to overcome the problem of under-nutrition and infections among under-five children.

CHAPTER SIX

General discussion, conclusion and recommendations

6.1 General Discussion

Under-nutrition and infectious diseases continue to be the major risk factors for child mortality and morbidity in developing countries (USAID, 2015). These risk factors have been linked with poor water, sanitation and hygiene conditions prevailing mostly in poor resource settings. The most at risk groups are children from marginalized communities living in environments with limited water, sanitation and hygiene facilities. Such situation underline the need for proposing specific WASH interventions which could be incorporated into nutrition interventions to address these risk factors for child mortality and morbidity in a sustainable manner. The goal of this study was to contribute toward solving the problem of under-nutrition and infectious diseases among children from marginalized communities. The aim of this study was to assess the effectiveness of selected water, sanitation and hygiene (WASH) interventions on reduction of common infections and improvement of nutritional status among under five-children in semi-pastoral community. The goal was approached through the following specific activities.

The first activity was to determine prevalence of common infections among under-five children. This step was achieved using patients` attendance registers of Monduli and Longido District hospitals. The most common infections among children under-five years were flue/cold 35%, skin infection 15%, diarrhea 15%, pneumonia 11%, eye infection 5%, and ear infections 0.5%. About two-third of under-five children who attended the District hospitals were suffering from one or two forms of infectious diseases. High prevalence of infectious diseases among under-five children in these areas could be contributed to by poor WASH practices among other factors. Some of the poor WASH practices which revealed association with the observed infectious diseases included the use of untreated surface water for domestic purposes, improper child feces disposal, sharing water sources with animals, children being surrounded by environments contaminated with animals waste, and unhygienic child feeding practices particularly poor storage of complementary foods. The speculations are in line with other studies which reported high prevalence of infectious diseases among under-five children in poor WASH conditions (Cairncross *et al.*, 2010; Sinharoy, 2016). These results underscore the need for measures to protect children from multiple infectious diseases that may result in under-nutrition.

Following the prevalence of common infections among under-five children, the study assessed the status of WASH practices and under-five child morbidity in a selected households using facilitated questionnaire. Identified WASH practices were further associated with reported common infections among under-five children. The results showed that the population under study was practicing poor WASH; majority were using untreated surface water for domestic purposes, latrines were owned by less than 5% of the study participants, child feces were openly disposed, water sources were shared between human, domestic and wild animals, and complementary foods were not handled in a hygienic manner. Such poor WASH practices revealed association with reported common infections particularly diarrhea. These findings are in line with those from other studies which indicated a strong link between infectious diseases among under-five children and poor WASH practices (Brown *et al.,* 2013; Checkley *et al.,* 2008; Muhimbula and Issa-Zacharia, 2010). Ensuring WASH facilities are in place and promoting good hygiene behaviors among individuals and community at large may potentially address the problem of common infections among under-five children in the population under study.

The study further explored the influence of the observed WASH practices on the nutritional status of under-five children. To achieve this objective, the nutritional status of children was assessed using anthropometric measurements, and hemoglobin levels. The findings revealed higher prevalence of under-nutrition among under-five children than previously reported prevalence within the national demographic survey for Arusha Region (NBS and MACRO, 2015/16). The prevalence of under-nutrition among children was observed to be higher in Longido than Monduli District. The analysis from this study showed that infectious diseases emanating from poor WASH practices contributed significantly to the observed poor nutritional status among children in the study population. Similar findings were reported by studies done in Tanzania and Bangladesh which reported high prevalence of stunting among under-five children in communities practicing poor WASH (Chirande *et al.,* 2015; Hong *et al.,* 2006). This means that interventions to improve WASH practices may significantly improve nutritional status of under-five children. Similar inference was reported by Dangour *et al.* (2013) that improved WASH practices can significantly improve the nutrutional status among children.

Apart from WASH, socio-demographic and cultural factors such as lack of formal education among primary caregivers (mothers) and polygamous marriage were observed to significantly contribute to the observed poor nutritional status of children in the study population.

Education is less prioritized by the majority of pastoral communities and especially to women who are not supported to attain necessary education but rather are subjected to early and, in most cases, polygamy. Other studies (Chase and Ngure, 2016; Nyaruhucha *et al.*, 2006) has reported similar findings that, mothers with no formal education were likely to have under-nourished children when compared to mothers with formal education. This conjecture is also supported by other studies which reported that polygamous marriages as well as larger family size increase the risk of under-nutrition among under-five children (Fawzy *et al.*, 2011; Fenn *et al.*, 2012). Discouraging early and polygamous marriages and promotion of education of women and girls and more importantly health education to women of child bearing including mothers of under-five children could reduce the problem of under-nutrition among children in the pastoral communities and similar settings.

After understanding the contribution of WASH practices to under-nutrition and common infections among under-five children, we evaluated the impact of selected WASH interventions on reduction of these inferences among under-five children in Longido District. The interventions included provision of health education for improving WASH practices including food hygiene behavior and water filters for improving water quality at the point of use. The duration of the interventions was six months. The findings showed significant reduction of underweight among under-five children and diarrhea prevalence in the intervention group. The reduction of underweight among children was probably due to the reduced cases of water and food-borne diseases particularly in the intervention group. Studies done in Lesotho and Sudan reported that improvement of water quality at the point of use can improve weight gain among under-five children (Esrey, 1996; Merchant, 2003). Additionally, other studies reported decreased prevalence of diarrhea among under-five children after being provided with solar disinfection facilities for improving the quality of drinking water (Burnham, 2006; Prüss-Üstün *et al.*, 2008). Generally, the findings from the present study indicate that health education and treatment of water quality at the point of use are among important WASH intervention strategies that may significantly reduce the diarrhea prevalence and improve the nutritional status among children in semi-pastoral communities.

6.2 Conclusion

Under-nutrition continue to be a major public health threat among children aged below five years in developing countries particularly Tanzania and one of the major health risk factors for child morbidity and mortality. Inadequate dietary intake and diseases have been identified

as major causes of under-nutrition in under-five children. Other factors such as poor child feeding practices, food insecurity, lack of health care services and poor environmental conditions particularly poor WASH practices embedded with political, social, cultural and economic factors contribute to the problem. Due to the nature of the problem under study and its root causes, it is therefore important to address it through multidisciplinary approaches particularly incorporating disease prevention measures such as improved WASH facilities as well as health education into nutrition interventions.

The findings from this study showed that WASH practices among participating semi-pastoral communities were poor. Prevalence of WASH related infections, particularly diarrhea diseases among children were higher than previously reported prevalence in the national demographic survey (NBS and MACRO, 2015). High prevalence of diarrhea in the study population is strongly associated with poor WASH practices. Such practices include, keeping complementary foods in unhygienically treated *kibuyu*, feeding children unboiled cow's milk, using surface water for domestic purposes, and sharing water sources with domestic and wild animals. Other factors, such as lack of formal education among primary caregivers and place of residence (between Longido and Monduli Districts where the latter case has access to tap water), also contributed significantly to observed cases of diarrhea. Promotion of health education with a focus on improved hygiene behavior among individuals as well as treatment of water along the value chain may reduce the problem of diarrhea among under-five children.

Furthermore, prevalence of under-nutrition (under-weight and stunting) among under-five children in Monduli and Longido Districts was high according to WHO standards. This prevalence could be attributed to by factors including poor WASH practices. Furthermore, socio-cultural factors such as polygamous marriages and mothers' level of education also contributed to the observed under-nutrition among under-five children.

On the other hand, combined WASH interventions, particularly treatment of drinking water at the household level and health education, showed significant reduction in diarrhea and improvement on child nutritional status and hemoglobin levels among under-five children. Additionally, the interventions reduced fecal contamination in drinking water and fresh milk for feeding children. Provision of water filters for improving water quality at the point of use reduced *E. coli* contamination and the burden of water-borne diseases significantly. The findings confirm that treatment of water at the point of use reduce diarrhea related infections

in the population under-study. The majority of people in the study area depend on surface water from ponds/*silange* for domestic purposes. The findings from this study suggests interventions particularly treatment of water at the household level, contribute to solving the problems of infectious diseases and under-nutrition among children under-five.

Based on the findings from this study, poor WASH practices contribute significantly to infectious diseases and subsequently under-nutrition both of which are major risk factors for under-five child mortality and morbidity. This finding emphasizes that, integrating WASH interventions into and other interventions particularly nutrition interventions can effectively address the problem of under-nutrition in marginalized communities.

6.3 Recommendations

(i) Based on the key findings from this study, longitudinal research on WASH intervention focusing on water treatment at the point of use and health education with a wider coverage is recommended to further uncover its role on improvement of nutritional status and reduction of common infections among under-five children in the study population. A long term study would potentially show the causal-effect relationship between the selected WASH interventions and its associated infections and under-nutrition among children under-five. Furthermore, studies to examine the magnitude of food contamination from traditional food storage containers e.g. food kept in *kibuyu* including safety of herbs used in cleaning *kibuyu*, assessment of the influence of WASH practices on under-five nutritional status using environmental enteropathy biomarkers which is a potential pathway through which WASH impact on under-nutrition among children under-five (Humphrey, 2009) are also recommended.

(ii) Treatment of drinking water using nano filters is highly recommended to reduce the problems of common infections and under-nutrition among children under-five. However, alternative cheaper and more affordable water filters could be opted by the study population for improving drinking water quality especially filters which are specifically able to eliminate microbiological contaminants from the drinking water.

(iii) The study recommends policy makers consider addressing the problem of poor WASH in marginalized communities, particularly semi-pastoralists as fundamental strategies for reducing the problem of under-nutrition and common infections among

children under-five. Such strategies may include improvement of water quantity and quality particularly provision of piped water supply and water treatment along the value chain as well as promotion of health education to the semi-pastoralist communities. Policy makers should also consider prioritizing and allocating sufficient budget to disease prevention rather than curative efforts. Developing countries including Tanzania have been struggling to meet the MDG number three of reducing child mortality by allocating limited resources available to the Ministry of health for fighting against infectious diseases particularly diarrhea related infections. By focusing on disease prevention measures, the problem of infectious diseases which is costing the Government huge money, could be reduced significantly.

(iv) Health personnel must consider incorporating health education programmes such as WASH to disease treatment and prevention measures to tackle the problems under study in a holist manner. Knowing that prevention is better than cure; disease prevention measures should be given priority by health personnel. For example, by addressing the problem of poor WASH in the communities through promotion of health education, people's awareness on infectious disease occurrence and prevention will also be increased and ultimately, the health facilities and medical care/treatments costs incurred may also be reduced. Promotion of health education may also open up people's minds in the communities and create awareness on the relationship that exist between WASH practices and people's health.

(v) The community under study should consider practicing good hygiene behavior including hand washing with soap during critical moments, personal hygiene, proper child feces disposal, and food hygiene as well as treating drinking water using low cost techniques to improve their health and that of their children. This could be possible through regular health education promortion and households' visits by health personnel. Health education promortion should focus on boiling of cow's milk prior feeding the child, hygienic handling and storage of CF (promote use of food storage containers other than *kibuyu*), good child care practices e.g. proper disposal of child feces, exclusive breast feeding, discouraging early & polygamous marriages and promote education to women and girls.

REFERENCES

Adelo, B. and Temesgen, S. (2015). Undernutritional status of children in Ethiopia: Application of partial proportional odds model. *Turkiye Klinikleri Journal of Biostatistics.* **7**. DOI 10.5336/biostatic.2015-47184.

Aheto, J. M. K., Keegan, T. J., Taylor, B. M. and Diggle, P. J. (2015). Childhood malnutrition and its determinants among under-five children in Ghana. *Paediatric and Perinatal Epidemiology.* **29:** 552-561.

Alzúa, M. L., Pickering, A. J., Djebbari, H., López, C., Cardenas, J. C., Lopera, M. A., Osbert, N. and Coulibaly, M. (2015). Impact evaluation of community-led total sanitation (CLTS) in rural Mali. *Documentos de Trabajo del CEDLAS*.

Århem, K. (1989). Maasai food symbolism: The cultural connotations of milk, meat, and blood in the pastoral Maasai diet. *Anthropos***.** 1-23. http://www.jstor.org/stable/10.2307/40461671

Arnold, B. F., Colford J. and John M. (2007). Treating water with chlorine at point-of-use to improve water quality and reduce child diarrhea in developing countries: a systematic review and meta-analysis. *The American Journal of Tropical Medicine and Hygiene.* **76** (2): 354-364. htpp://www.ncbi.nlm.nih.gov/pubmed/17297049

Arnold, B. F., Null., Clair, L., Stephen P., Unicomb., Leanne. S., …and Thomas. (2013). Cluster-randomised controlled trials of individual and combined water, sanitation, hygiene and nutritional interventions in rural Bangladesh and Kenya: the WASH benefits study design and rationale. *British Medical Journal.* **3** (8): e003476. http://dx.doi.org/10.1136/bmjopen-2013-003476.

Asudi, A. A. (2016). Effectiveness of water, sanitation and hygiene interventions in changing mothers' behaviour and improving child health: A case study of Kamukunji Sub County, Nairobi County. chss.uonbi.ac.ke/uon_student_projects/all?page=2

Aziz, K. M., Hoque, B. A., Hasan, K. Z., Patwary, M. Y., Huttly, S. R., Rahaman, M. M. and Feachem, R. G., (1990). Reduction in diarrhoeal diseases in children in rural Bangladesh by environmental and behavioural modifications. *Transactions of the Royal Society of Tropical Medicine and Hygiene.* **84** (3), 433-438. https://www.ncbi.nlm.nih.gov/pubmed/2260182

Badake, Q., Maina, I., Mboganie, M., Muchemi, G., Kihoro, E., Chelimo, E. and Mutea, K. (2014). Nutritional status of children under five years and associated factors in Mbeere South District, Kenya. *African Crop Science Journal*. **22:** 799-806. www.bioline.org.br/pdf?cs14033

Bado, A. R., Susuman, A. S. and Nebie, E. I. (2016). Trends and risk factors for childhood diarrhea in Sub-Saharan Countries (1990–2013): Assessing the neighborhood inequalities. *Global Health Action.* ***9***. doi: 10.1186/1824-7288-37-13.

Bartram, J. and Cairncross, S. (2010). Hygiene, sanitation, and water: Forgotten foundations of health. *PLoS Medicine.* **7:** e1000367.https://doi.org/10.1371/journal.pmed. 1000367

Benson, M. and O'Reilly, K. (2009). Migration and the search for a better way of life: a critical exploration of lifestyle migration. *The Sociological Review*. **57** (4): 608-625. https://doi.org/10.1111/j.1467-95X.2009.01864.x

Benova, L., Cumming, O., Gordon, B. A., Magoma, M. and Campbell, O. M. (2014). Where there is no toilet: Water and sanitation environments of domestic and facility births in Tanzania. *PloS one.* **9:** e106738. https://doi.org/10.1371/journal.pone.0106738

Bhutta, Z. A., Tahmeed, B., Robert, E. C., Simon, D., Kathryn, G., Elsa, H., … and Saul, S. S. (2008). What works? Interventions for maternal and child undernutrition and survival. *The Lancet*. **371** (9610): 417-440

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., De Onis, M., … and Martorell, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet.* **382:** 427-451. https://doi.org/10.1016/S0140-6736(07)61693-6

Black, R. E., Cousens, S., Johnson, H. L., Lawn, J. E., Rudan, I., Bassani, D. G., … and Cibulskis, R. (2010). Global, regional, and national causes of child mortality in 2008: A systematic analysis. *The Lancet.* **375:** 1969-1987. doi: 10.1016/S0140-6736(15)00120-8. Epub 2015 Sep 8

Black, R. E., Morris, S. S. and Bryce, J. (2003). Where and why are 10 million children dying every year? *The Lancet.* **361:** 2226-2234. DOI: 10.1016/S0140-6736(03)13779-8

Bloss, E., Wainaina, F. and Bailey, R. C. (2004). Prevalence and predictors of underweight, stunting, and wasting among children aged 5 and under in western Kenya. *Journal of Tropical Pediatrics.* **50:** 260-270. https://doi.org/10.1093/tropej/50.5.260

Boschi, P. C. (2009). The global burden of childhood diarrhoea. *International Maternal and Child Health*, Available at: www.who.org

Boschi, C., Hommann, K., Rubio, G. M., Sadoff, C. and Travers, L. (2002). Water, sanitation and poverty. *Macroeconomic and Sectoral Approaches, Available at:* siteresources.

worldbank.org/INTPRS1/Resources/383606.../13887_chap23.pdf

Bowen, P. A, Hillyard, J., Hartwig, K., Langford, S., Harvey, M. and James, S. (2010). The whole village project: Village reports for Elerai, Eworendeke, Kimoukuwa, Tingatinga, Kiserian, Sinya, and Kitendeni in Longido District. Available: http://wholevillage.umn.edu/documents/Longido.pdf 2011

Bowen, P. A., Landry, K., Espejo, N. and James, S. (2010). The whole village project: Village reports for Engaruka, Migombani, Naitolia, and Selela in Monduli District. Available: http://wholevillage.umn.edu/documents/Longido.pdf 2011

Briceño, B. and Yusuf, A. (2012). Scaling up handwashing and rural sanitation: Findings from a baseline survey in Tanzania. http://hdl.handle.net/10986/17379

Briceño, B., Coville, A. and Martines, Z. (2015). Promoting handwashing and sanitation: evidence from a large-scale randomized trial in rural Tanzania. Policy research working paper: no. WPS 7164: Impact Evaluation series, Washington DC: Wordl Bank Group. http://document.worldbank.org/curated/en/545961468165561161 /Promorting-handwashing-and-sanitation-evidence-from-a-large-scale-randomized-trial-in-rural-Tanzania

Brown, J., Cairncross, S. and Ensink, J. H. (2013). Water, sanitation, hygiene and enteric infections in children. *Archives of Disease in Childhood***.** 2011-301528. http://dx.doi.org/10.1136archdischild-2011-301528

Burton, M. J., Rajak, S. N., Hu, V. H., Ramadhani, A., Habtamu, E., Massae, P., … and Khaw, P. T. (2015). Pathogenesis of progressive scarring trachoma in Ethiopia and Tanzania and its implications for disease control: Two cohort studies. *PLoS Neglected Tropical Diseases.* **9:** e0003763. https://doi.org/10.1371/journal.pntd.0003763

Cairncross, S. and Boisson, S. (2010). Hygiene sanitation and water; Forgotten foundations of health. *PLoS Medicine*. **7**. https://doi.org/10.1371/journal.pmed.1000367

Cairncross, S., Hunt, C., Boisson, S., Bostoen, K., Curtis, V., Fung, I. C. and Schmidt, W.P. (2010). Water, sanitation and hygiene for the prevention of diarrhoea. *International Journal of Epidemiology.* **39:** i193-i205. doi:10.1093/ije/dyq035 i193

Calderon, R. L., Mood, E. W. and Dufour, A. P. (1991). Health effects of swimmers and nonpoint sources of contaminated water. *International Journal of Environmental Health research.* **1:** 21-31. DOI: 10.1080/09603129109356701

Chiller, T. M., Carlos, E. M., Beatriz, L., Maricruz, A., Robert, M. H., Bruce H. K. and Stephen P. L. (2003). Taking the dirt out of dirty water: Introducing a new flocculent-disinfectant for household treatment of drinking water dramatically reduces diarrhea in rural Guatemala. *American Society of Tropical Medicine and Hygiene.* Available online from http://www.pghsi.com/safewater/pur_abstracts.html

Conroy, R. M., Elmore, M., Michael, J., Tina, M., Kevin, G. and Barnes, J.F. (1996). Solar disinfection of drinking water and diarrhoea in Maasai children: A controlled field trial. *The Lancet.* **348**: 1695-1697. http://adc.bmj.com/

Conroy, R. M., Elmore M., Michael, J., Tina, M., Kevin G. and Barnes, J. F. (1999). Solar disinfection of water reduces diarrhoeal disease. *Archives of Disease in Childhood.* **81**: 337-338. http://adc.bmj.com/

Chambers, R. and Von Medeazza, G. (2013). Sanitation and stunting in India. *Economic and Political Weekly*. **48** (15). www.indiawaterportal.org/.../indiawaterportal

Chase, C. and Ngure, F. (2016). Multisectoral approaches to improving nutrition: Water, sanitation, and hygiene. Available at http://www.worldbank.org.

Checkley, W., Buckley, G., Gilman, R. H., Assis, A. M., Guerrant, R. L., Morris, S. S., … and Black, R. E. (2008). Multi-country analysis of the effects of diarrhoea on childhood stunting. *International Journal of Epidemiology.* **37:** 816-830. doi: 10.1093/ije/dyn099.

Checkley, W., Gilman, R. H., Black, R. E., Epstein, L. D., Cabrera, L., Sterling, C. R. and Moulton, L. H. (2004). Effect of water and sanitation on childhood health in a poor Peruvian peri-urban community. *The Lancet.* **363:** 112-118. http://dx.doi.org/10.1016 /S0140-6736(03)15261-0

Chege, P. M., Kimiywe, J. O. and Ndungu, Z. W. (2015). Influence of culture on dietary practices of children under five years among Maasai pastoralists in Kajiado, Kenya. *International Journal of Behavioral Nutrition and Physical Activity.* **12 (**1). https://doi.org/10.1186/s12966-015-0284-3

Chiller, M. L., Mendoza. E. C., Lopez, B. M., Alvarez, M., Hoekstra, M. R. and Luby P. B. (2006). Reducing diarrhoea in Guatemalan children: randomized controlled trial of flocculant–disinfectant for drinking-water. *Bulletin of the World Health Organization*. **84**: 28-35.

Chirande, L., Charwe, D., Mbwana, H., Victor, R., Kimboka, S., Issaka, A. I., … and Agho, K. E. (2015). Determinants of stunting and severe stunting among under-fives in Tanzania: Evidence from the 2010 cross-sectional household survey. *BMC Pediatrics.* **15 (**1). doi: 10.1186/s12887-015-0482-9.

Clasen, T. F. B., Joseph, C., Simon, S. and Cairncross, S. (2007). Reducing diarrhea through the use of household-based ceramic water filters: a randomized, controlled trial in rural Bolivia. *The American Journal of Tropical Medicine and Hygiene.* **70**: 651-657. https://doi.org/10.ajtmh.2004.70.651

Cravioto, J. and Delicardie, E. R. (1979). Nutrition, mental development and learning. *Human Growth.* **20**: 481-511. https://link.springer.com/chapter/10.1007/978-1-4684-0817-1

Cumming, O., Ensink J., Freeman, M. and Jenkins, M. **(**2014). Effectiveness of a rural sanitation programme on diarrhoea, soil-transmitted helminth infection and malnutrition in India. *Lancet Glob Health.* **2** (11):e645-53. doi: 10.1016/S2214-109X(14)70307-9. Epub 2014 Oct 9.

Curtis, V. and Cairncross, S. (2003). Effect of washing hands with soap on diarrhoea risk in the community: A systematic review. *The Lancet: Infectious Diseases.* **3:** 275-281. https://www.ncbi.nlm.nih.gov/pubmed/12726975

Curtis, V. A., Danquah, L. O. and Aunger, R. V. (2009). Planned, motivated and habitual hygiene behaviour: An eleven country review. *Health Education Research.* **24:** 655-673. doi: 10.1093/her/cyp002. Epub 2009 Mar 13.

Dangour, A. D., Watson, L., Cumming, O., Boisson, S., Che, Y., Velleman, Y., Cavill, S., Allen, E. and Uauy, R. (2013). Interventions to improve water quality and supply, sanitation and hygiene practices, and their effects on the nutritional status of children. *The Cochrane Library*. DOI: 10.1002/14651858.CD009382.pub2

De Benoist, B., Mclean, E., Egli, I. and Cogswell, M. (2008). WHO Global database on anaemia. Geneva: World Health Organization**.** 1993-2005.

De Onis, M., Brown, D., Blossner, M. and Borghi, E. (2012). Levels and trends in child malnutrition. UNICEF-WHO-The world bank joint child malnutrition estimates. Available at: www.unicef.org

De Onis, M., Dewey, K. G., Borghi, E., Onyango, A. W., Blössner, M., Daelmans, B., Piwoz, E. and Branca, F. (2013). The World Health Organization's global target for reducing childhood stunting by 2025: Rationale and proposed actions. *Maternal & Child Nutrition.* **9:** 6-26. doi: 10.1111/mcn.12075.

De Onis, M. (2006). WHO child growth standards based on length/height, weight and age. *Acta Paediatrica.* **95:** 76-85. https://doi.org/10.1111/j.1651-2227.2006.tb02378.x

Devoto, F., Duflo, E., Dupas, P., Parienté, W. and Pons, V. (2012). Happiness on tap: Piped water adoption in urban Morocco. *American Economic Journal: Economic Policy.* **4:** 68-99. http://dx.doi.org/10.1257/pol.4.4.68.

Dewey, K. G. and Mayers, D. R. (2011). Early child growth: How do nutrition and infection interact? *Maternal & Child Nutrition.* **7:** 129-142. DOI: 10.1111/j.1740-8709.2011.00357.x

Diouf, K., Tabatabai, P., Rudolph, J. and Marx, M. (2014). Diarrhoea prevalence in children under-five years of age in rural Burundi: An assessment of social and behavioural factors at the household level. *Global Health Action.* **7**. doi: 10.3402/gha.v7.24895

Doocy, S. and Burnham, G. (2006). Point of use water treatment and diarrhoea reduction in the emergency context: An effectiveness trial in Liberia. *Tropical Medicine and International Health.* **11:** 1542-1552. https://doi.org/10.1111/j.1365-3156.2006. 01704.x

Du Preez, M. M., Kevin G. and Conroy, R. M. (2010). Solar disinfection of drinking water in the prevention of dysentery in South African children aged under 5 years: the role of participant motivation. *Environmental Science & Technology*. **44**: 8744-8749.DOI: 10.1021/es103328j

Esrey, S. A., Habicht, J. P., Latham, M. C., Sisler, D. G. and Casella, G., (1988). Drinking water source, diarrheal morbidity, and child growth in villages with bothtraditional and improved water supplies in rural Lesotho, southern Africa. *American Journal of Public Health.* **78** (11), 1451-1455.

Esrey, S. A. (1996). Water, waste, and well-being: A multi-country study. *American Journal of Epidemiology.* **143,** 608-623.

Fawzy, A., Arpadi, S., Kankasa, C., Sinkala, M., Mwiya, M., Thea, D. M., Aldrovandi, G. M. and Kuhn, L. (2011). Early weaning increases diarrhea morbidity and mortality among uninfected children born to HIV-infected mothers in Zambia. *Journal of Infectious Diseases.* **203:** 1222-1230. doi: 10.1093/infdis/jir019.

Feachem, R. G., Mara, D. D. and Bradley, D. J. (1983). Sanitation and disease. John Wiley & Sons Washington DC, USA.

Fenn, B., Bulti, A. T., Nduna, T., Duffield, A. and Watson, F. (2012). An evaluation of an operations research project to reduce childhood stunting in a food-insecure area in Ethiopia. *Public Health Nutrition.* **15:** 1746-1754. https://doi.org/10.1017/S1368980012001115

Fewtrell, L., Kaufmann, R. B., Kay, D., Enanoria, W., Haller, L. and Colford, J. M. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: A systematic review and meta-analysis. *The Lancet Infectious Diseases.* **5:** 42-52. DOI: 10.1016/S1473-3099(04)01253-8

Fewtrell, L., Prüss-Üstün, A., Bos, R., Gore, F. and Bartram, J. (2007). Water, sanitation and hygiene: Quantifying the health impact at national and local levels in countries with incomplete water supply and sanitation coverage. *Environmental Burden of Disease*. **15**: 1728-1652.

Freeman, M. C., Stocks, M. E., Cumming, O., Jeandron, A., Higgins, J., Wolf, J., Prüss-Ustün, A., Bonjour, S., Hunter, P. R. and Fewtrell, L. (2014). Hygiene and health: Systematic review of handwashing practices worldwide and update of health effects. *Tropical Medicine and International Health.* **19:** 906-916. doi: 10.1111/tmi.12339

Fikadu, T., Assegid, S. and Dube, L. (2014). Factors associated with stunting among children of age 24 to 59 months in Meskan district, Gurage Zone, South Ethiopia: a case-control study. *BMC Public Health.* **14 (**800). https://doi.org/10.1186/1471-2458-14-800

Garus-Pakowska, A., Sobala, W. and Szatko, F. (2013). Observance of hand washing procedures performed by the medical personnel after the patient contact. Part II. *International Journal of Occupational Medicine and Environmental Health*, **26** (2), 257-264.

Gascon, J., Vargas, M., Schellenberg, D., Urassa, H., Casals, C., Kahigwa, E., Aponte, J., Mshinda, H. and Vila, J. (2000). Diarrhea in children under 5 years of age from Ifakara, Tanzania: A case-control study. *Journal of Clinical Microbiology.* **38:** 4459-4462.

Gautam, O. P. (2015). Food hygiene intervention to improve food hygiene behaviours, and reduce food contamination in Nepal. *London School of Hygiene and Tropical Medicine.* DOI: https://doi.org/10.17037/PUBS.02531624.

Gautam, O. P. S., Cairncross, S., Cavill, S. and Curtis, V. (2017). Trial of a novel intervention to improve multiple food hygiene behaviors in Nepal. *American Journal of Tropical Medicine and Hygiene.* **96**: 1415–1426. doi: 10.4269/ajtmh.16-0526.

Gil, A., Lanata, C., Kleinau, E. and Penny, M. (2004). Children's feces disposal practices in developing countries and interventions to prevent diarrheoal diseases. *Environmental Health Project USAID:* http://www.ehproject.org/PDF/Strategic_papers/SR11-Child% 20Format.pdf.2004

Gilman, R. H. and Skillicorn, P. (1985). Boiling of drinking water: Can a fuel-scarce community afford it? *Bulletin of the World Health Organization.* **63 (**157). http://www.who.int/iris/handle/10665/265068

Gorter, H. and Swinnen, J. M. (1998). Impact of economic development on commodity and public research policies in agriculture. *Journal of Theoretical Social Psychology*. **2**: 41-60. https://doi.org/10.1111/1467-9361.00027

Halken, S. and Host, A. (1996). Prevention of allergic disease. Exposure to food allergens and dietetic intervention. *Pediatric Allergy and Immunology.* **7,** 102-107. https://doi.org/.111/j.1399-3038.1996.tb00407.x

Hilonga, O. (2015). Water Nano filters from Gongali Madel. Available at https://www/ printerest.com. March, 2015.

Hodge, J., Howard, H., Boisson, S., Collin, S. M., Peletz, R. and Clasen, T. (2016). Assessing the association between thermotolerant coliforms in drinking water and diarrhea: An analysis of individual level data from multiple studies. *Environmental Health Perspectives.* **124***:*1560–1567; http://dx.doi.org/10.1289/EHP156.

Hong, R., Banta, J. E. and Betancourt, J. A. (2006). Relationship between household wealth inequality and chronic childhood under-nutrition in Bangladesh. *International Journal for Equity in Health.* **5 (**1). https://doi.org/10.1186/1475-9276-*5*-15

Humphrey, J. H. (2009). Child undernutrition, tropical enteropathy, toilets, and handwashing. *The Lancet.* **374:** 1032-1035. doi: 10.1016/S0140-6736(09)60950-8

Huttly, S. R., Blum, D., Kirkwood, B. R., Emeh, R. N., Okeke, N., Ajala, M., … and Feachem, R.G. (1990). The Imo state (Nigeria) drinking water supply and sanitation project, 2. Impact on dracunculiasis, diarrhoea and nutritional status. *Transactions of the Royal Society of Tropical Medicine and Hygiene.* **84** (2), 316-321.

Jackson, P. (2004). Local consumption cultures in a globalizing world. *Royal Geographical Society*. https://doi.org/10.1111/j.0020-2754.2004.00123.x

Joshi, P. C., Kaushal, S., Aribam, B. S., Khattri, P., D'aoust, O., Singh, M. M., … and Guha-Sapir, D. (2011). Recurrent floods and prevalence of diarrhea among under five children: Observations from Bahraich District, Uttar Pradesh, India. *Global Health Action.* **4**. doi: 10.3402/gha.v4i0.6355.

Karambu, S., Matiru, V., Kiptoo, M. and Oundo, J. (2013). Characterization and factors associated with diarrhoeal diseases caused by enteric bacterial pathogens among children aged five years and below attending Igembe District hospital, Kenya. *Pan African Medical Journal.* **16** (37): *doi:10.11604/pamj.2013.16.37.2947*

Koyanagi, A., Humphrey, J. H., Moulton, L. H., Ntozini, R., Mutasa, K., Iliff, P. and Black, R. E. (2009). Effect of early exclusive breastfeeding on morbidity among infants born to HIV-negative mothers in Zimbabwe. *The American Journal of Clinical Nutrition.* **89:** 1375-1382. DOI: 10.3945/ajcn.2008.26810.

Kulwa, K., Kinabo, J. L. and Modest, B. (2006). Constraints on good child-care practices and nutritional status in urban Dar-es-Salaam, Tanzania. *Food & Nutrition Bulletin.* **27:** 236-244. Doi: http://dx.doi.org/10.4314/thrb.v19i3.5

Kumi-Kyereme, A. and Amo-Adjei, J. (2015). Household wealth, residential status and the incidence of diarrhoea among children under-five years in Ghana. *Journal of Epidemiology and Global Health*. http://dx.doi.org/10.1016/j.jegh.2015.05.001

Leach, V. and Kilama B. (2009). Preventing malnutrition in Tanzania: A focused strategy to improve nutrition in young children. *Research on Poverty Alleviation/REPOA*, 15, November, 2009.

Lemons, A. (2009). Maji salama: Implementing ceramic water filtration technology in Arusha, Tanzania. MPH candidate thesis submitted at Emory university, America. Available at: www.who.int

Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., … and Andrews, K. G. (2013). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: A systematic analysis for the global burden of disease study 2010. *The Lancet.* **380:** 2224-2260. doi: 10.1016/S0140-6736(12)61766-8.

Lin, A., Arnold, B. F., Afreen, S., Goto, R., Huda, T. M. N., Haque, R., … and Colford, J. M. (2013). Household environmental conditions are associated with enteropathy and impaired growth in rural Bangladesh. *The American Journal of Tropical Medicine and Hygiene.* **89:** 130-137. doi: 10.4269/ajtmh.12-0629

Lomazzi, M., Borisch, B. and Laaser, U. (2014). The Millennium Development Goals: Experiences, achievements and what's next. *Global Health Action.* **7**. doi: 10.3402/gha.v7.23695

Luby, S. P., Agboatwalla, M., Painter, J., Altaf, A., Billhimer, W., Keswick, B. and Hoekstra, R. M. (2006). Combining drinking water treatment and hand washing for diarrhoea prevention, a cluster randomised controlled trial. *Tropical Medicine & International Health.* **11:** 479-489. https://doi.org/10.1111/j.1365-3156.2006.01592.x

Lunn, P., Northrop-Clewes, C. and Downes, R. (1991). Intestinal permeability, mucosal injury, and growth faltering in Gambian infants. *The Lancet.* **338:** 907-910. https://doi.org/10.1016/0140-6736(91)91772-M

Lyimo, B., Buza, J., Smith, W., Subbiah, M. and Call, D. R. (2016). Surface waters in northern Tanzania harbor fecal coliform and antibiotic resistant Salmonella spp. capable of horizontal gene transfer. *African Journal of Microbiology Research.* **10:** 348-356. DOI:10.5897/ajmr2015.7880

Lyimo, C., Shayo, R. and Lyimo, T. J. (2007). Community awareness on microbial water pollution and its effects on health development in urban Tanzania: A case study of Tabata and Kiwalani wards in Ilala District in Dar es Salaam Region. *Tanzania Journal of Development Studies.* **7:** 103-114. http://hdl.handle.net/20.500.11810/2570

Madise, N. J, Matthews, Z. and Margetts, B. **(**1999). Heterogeneity of child nutritional status between households: A comparison of six Sub-Saharan African countries. *Population studies*. **53:** 331-343.

Malebo, H., Mussa, R ., Mushi, A. K., Munga, M. A., Mrisho, M., Senkoro, K. P., Mshana, J. M., Urassa, J., Tenu, P. and Msimbe, V. (2012). Scaling up Mtumba report-Water Aid. Available at http://www.wateraid.org

Mamulwar, M. S., Rathod, H. K., Jethani, S., Dhone, A., Bakshi, T., Lanjewar, B., Jadhav, S. and Bhawalkar, J. S. (2014). Nutritional status of under-five children in urban slums of Pune. *International Journal of Medicine and Public Health.* **4:** 247. DOI: 10.4103/2230-8598.137710

Martorell, R. (2010). Physical growth and development of the malnourished child: Contributions from 50 years of research at INCAP. *Food and Nutrition Bulletin.* **31:** 68-82. doi/abs/10.1177/156482651003100108

Mascarini-Serra, L. (2011). Prevention of soil-transmitted helminth infection. *Journal of Global Infectious Diseases*. **3**: 175-182. https://doi.org/10.4103/0974-777X.81696.

Merchant, A. T., Jones, C., Kiure, A., Kupka1, R., Fitzmaurice, G., Herrera, M. G. and Fawzi1, W. W. (2003). Water and sanitation associated with improved child growth. *European Journal of Clinical Nutrition.* **57**: 1562–1568. DOI 10.1038/sj.ejcn.1601725

Mgongo, M., Mosha, M. V., Uriyo, J. G., Msuya, S. E. and Stray-Pedersen, B. (2013). Prevalence and predictors of exclusive breastfeeding among women in Kilimanjaro region, northern Tanzania: A population based cross-sectional study. *International Breastfeeding Journal.* **8 (**1). DOI: 10.1186/1746-4358-*8*-12

Michaelsen, K. F., Weaver, L., Branca, F. and Robertson, A. (2000). Feeding and nutrition of infants and young children: Guidelines for the WHO European Region, with emphasis on the former Soviet countries. *WHO Regional Publications, European Series.* No. 87.

Morris, S. S., Cousens, S. N., Lanata, C. F. and Kirkwood, B. R. (1994). Diarrhea defining the episode. *International Journal of Epidemiology.* **23:** 617-623. DOI: 10.1093/ije/23.3.617

Mosha, T. C. and Philemon, N. (2010). Factors influencing pregnancy outcomes in Morogoro Municipality, Tanzania. *Tanzania Journal of Health Research.* **12:** 243-251. http://dx.doi.org/10.4314/thrb.v12i4.51795

Moshy, V. H., Masenge, T. J. and Bryceson, I. (2013). Under-nutrition among under-five children in two fishing communities in Mafia island marine park, Tanzania. *Journal of Sustainable Development.* **6 (**1). http://dx.doi.org/10.5539/jsd.v6n6p1

Mshida, H. A., Kassim, N., Kimanya, M. E. and Mpolya, E. (2017). Influence of water, sanitation, and hygiene practices on common infections among under-five children in Longido and Monduli Districts of Arusha, Tanzania. *Journal of Environmental and Public Health.* **2017 (**8). https://doi.org/10.1155/2017/9235168

Mshida, H. A., Kassim, N., Mpolya, E. and Kimanya, M. E. (2018). Water, sanitation and hygiene practices associated with nutritional status of under-five children in semi-pastoral communities Tanzania. *American Journal of Tropical Medicine and Hygiene.* **98** (5): 1242-1249. DOI: https://doi.org/10.4269/ajtmh.17-0399

Muhimbula, H. S. and Issa-Zacharia, A. (2010). Persistent child malnutrition in Tanzania: Risks associated with traditional complementary foods (A review). *African Journal of Food Science.* **4:** 679-692.

NBS and MACRO. (2012). Tanzania population and housing census. ICF and Macro. Dodoma: Government of Tanzania.

NBS and MACRO. (2010). Tanzania Demographic and Health Survey, 2010, National Bureau of Statistics. Dar es Salaam, Tanzania, and Rockville, Maryland, USA: MoHCDGEC, MoH, NBS, OCGS, and ICF. https:// www.nbs.go.tz

NBS and MACRO. (2015). Tanzania Demographic and Health Survey and Malaria Indicator Survey (TDHS-MIS) 2015-16. Dar es Salaam, Tanzania, and Rockville, Maryland, USA: MoHCDGEC, MoH, NBS, OCGS, and ICF. http://www.measuredhs.com.

Nestel, P. and Geissler, C. (1986). Potential deficiencies of a pastoral diet: A case study of the Maasai. *Ecology of Food and Nutrition.* **19,** 1-10. https://doi.org/10.1080 /03670244.1986.9990941

Ngure, F. M., Humphrey, J. H., Mbuya, M. N., Majo, F., Mutasa, K., Govha, M., … and Curtis, V. (2013). Formative research on hygiene behaviors and geophagy among infants and young children and implications of exposure to fecal bacteria. *The American Journal of Tropical Medicine and Hygiene.* **89:** 709-716. doi: 10.4269/ajtmh.12-0568. Epub 2013 Sep 3.

Ngure, F. M., Reid, B. M., Humphrey, J. H., Mbuya, M. N., Pelto, G. and Stoltzfus, R. J. (2014). Water, sanitation, and hygiene (WASH), environmental enteropathy, nutrition, and early child development: making the links. *Annals of the New York Academy of Sciences.* **1308,** 118-128. doi: 10.1111/nyas.12330.

Njau, K. N., Muzuka, A. N. N., Machunda, R. L., Mshida, H. A., Moyo, F. and Malima, G. (In press). Achieving universal access to adequate sustainable equitable sanitation and hygiene services in the cities of tomorrow- babati sanitation reseach: A formative and baseline status research. *WaterAid.* www.wateraid.uk.org

Nuhu, S. and Mpambije, C. J. (2016). Water and sanitation services in informal urban settlements and their implications to peoples health in Tandale, Dar es Salaam, Tanzania. *International Journal of Research in Humanities and Social Studies.* **64**. Htpp://hdl.handle.net/20.500.11810/4510

Nyaruhucha, C., Mamiro, P., Kerengi, A. and Shayo, N. (2006). Nutritional status of under-five children in a pastoral community in Simanjiro District, Tanzania. *Tanzania Journal of Health Research.* **8:** 32-36.

Oluwafemi, F. and Ibeh, I. N. (2011). Microbial contamination of seven major weaning foods in Nigeria. *Journal of Health, Population and Nutrition***.** 415-419. DOI:10.3329/jhpn.v29i4.8459

Onugba, A. and Eduvie, M. O. (2005). The hydrochemistry and environmental isotopes of the aquifer systems in the Upper Benue area. *Nigeria Water Research Journal*. **16**: 80-89.

Pelletier, D. L., Frongillo, E. A., Schroeder, D. G. and Habicht, J. P. (1995). The effects of malnutrition on child mortality in developing countries. *Bulletin of the World Health Organization.* **73 (**443). PMCID:PMC2486780

Penakalapati, G., Swarthout, J., Delahoy, J. M., McAliley, L., Wodnik, B., Levy, K. and Freeman, C. M. (2017). Exposure to Animal Feces and Human Health: A Systematic Review and Proposed Research Priorities. *Journal of Environmental Science and Technology*. **51**: 11537-11552. DOI: 10.1021/acs.est.7b02811

Pickering, A. J. and Davis, J. (2012). Freshwater availability and water fetching distance affect child health in sub-Saharan Africa. *Environmental Science & Technology.* **46:** 2391-2397. ttp://dx.doi.org/10.1021/es203177v

Pickering, A. J., Djebbari, H., Lopez, C., Coulibaly, M. and Alzua, M. L. (2015). Effect of a community-led sanitation intervention on child diarrhoea and child growth in rural Mali: A cluster-randomised controlled trial. *The Lancet Global Health.* **3:** e701-e711. doi: 10.1016/S2214-109X(15)00144-8.

Prüss-Üstün, A., Bos, R., Gore, F. and Bartram, J. (2008). Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health, *World Health Organization.* **20** Avenue Appia - 1211 Geneva 27 – Switzerland. Available at https://www.who.int

Prüss-Ustün, A., Bartram, J., Clasen, T., Colford, J. M., Cumming, O., Curtis, V., … and Fewtrell, L. (2014). Burden of disease from inadequate water, sanitation and hygiene in low-and middle-income settings: A retrospective analysis of data from 145 countries. *Tropical Medicine and International Health.* **19:** 894-905. doi: 10.1111/tmi.12329. Epub 2014 Apr 30.

Rutstein, S. O. and Staveteig, S. (2014). Making the demographic and health surveys wealth index comparable. *Rockville: ICF International*. Maryland, USA

Safari, J. G., Masanyiwa, Z. S. and Lwelamira, J. E. (2015). Prevalence and factors associated with child malnutrition in Nzega District, rural Tanzania. *Current Research Journal of Social Sciences.* **7:** 94-100.

Schmidt, C. W. (2014). Beyond malnutrition: The role of sanitation in stunted growth. *Environmental Health Perspectives.* **122:** A298. DOI:10.1289/ehp.122-A298

Sustainable Development Goals. (2015). Government of Nepal National Planning Commission 2015. Government of Nepal, National Planning Commission Singha Durbar, Kathmandu, Nepal. Available at https:// www.npc.gov.np

Sharifzadeh, G., Mehrjoofard, H. and Raghebi, S. (2010). Prevalence of malnutrition in under 6-year olds in South Khorasan, Iran. *Iranian Journal of Pediatrics.* **20 (**435). Available at; PMID:23056743 PMCID:PMC3446098

Sheth, M. and Dwivedi, R. (2006). Complementary foods associated diarrhea. *The Indian Journal of Pediatrics.* **73:** 61-64. DOI https://doi.org/10.1007/BF02758262

Shetty, P. (2000). Malnutrition and obesity. *NFI Bulletin.* **21:** 6-8.

Sinharoy, S. S., Schmidt, W. P., Cox, K., Clemence, Z., Mfura, L., Wendt, R., … and Jack, W. (2016). Child diarrhoea and nutritional status in rural Rwanda: a cross-sectional study to explore contributing environmental and demographic factors. *Tropical Medicine & International Health*. **8**: 956-964. doi: 10.1111/tmi.12725. Epub 2016 Jun 16.

Spears, D. (2013). How much international variation in child height can sanitation explain? *World Bank Policy Research Working Paper*. https://elibrary.worldbank.org/doi/abs /10.1596/1813-9450-6351

Strunz, E. C., Addiss, D. G., Stocks, M. E., Ogden, S., Utzinger, J. and Freeman, M. C. (2014). Water, sanitation, hygiene, and soil-transmitted helminth infection: A systematic review and meta-analysis. *PLoS Medicine.* **11:** e1001620. https://doi.org/10.1371/journal.pmed.1001620

Tamiru, M. W., Tolessa, B. E. and Abera, S. F. (2015). Under nutrition and associated factors among under-five age children of Kunama ethnic groups in Tahtay Adiyabo Woreda, Tigray Regional State, Ethiopia. *International Journal of Nutrition and Food Sciences.* **4**: 277-288. doi: 10.11648/j.ijnfs.20150403.15

TNNS. (2014). Tanzania National Nutrition Survey. 22 Barack Obama drive, Dar es Salaam, Tanzania. *Tanzania Food and Nutrition Center.* Available at https://www.unicef.org

Thomas, J., Holbro, N. and Young, D. (2013). A review of sanitation and hygiene in Tanzania. *Department for International Development*, London. https://www.gov.uk/dfid-research.../a-review-of-sanitation-and-hygiene-in-tanzania

Too-Kong, T. (2014). The Millennium Development Goals Report 2014. New York: United Nations

Press. T. O., Coulibaly, S., Arby, A., Maiga, F. and Cairncross, S. (2013). Piloting an intervention to improve microbiological food safety in peri-urban Mali. *International Journal of Hygiene and Environmental Health.* **216:** 138-145.

Touré, O. C., Salimata, A., Maiga, A. and Cairncross, S. (2013). Piloting an intervention to improve microbiological food safety in Peri-Urban Mali. *International Journal of hygiene and environmental health.* **216**: 138-145. doi: 10.1016/j.ijheh.2012.02.003. Epub 2012 Mar 15

UNICEF. (2009a). Diarrhoea: why children are still dying and what can be done. http://www. unicef. org/media/files/Final_Diarrhoea_Report_October_2009_final. pdf.

UNICEF. (2009b). State of the world's children. Available at http://www.unicef. org/sowc09/docs/SOWC09-FullReport-EN.pdf

UNICEF, WHO. and World Bank. (2013). Joint child malnutrition estimates-Levels and trends. New York, WHO/UNICEF. http://www.who.int/entity/nutgrowthdb/jme_ unicef_who_wb.pdf

UNICEF. (2014). Statistical snapshot: Child Mortality. 20 Avenue Appia, 1211 Geneva 27, Switzerland, UNICEF. https://data.unicef.org/.../Child_Mortality_Stat_Snapshot_ web-SSA-fixed-May-12-20

UNICEF. (2015). Progress on Sanitation and Drinking Water-2015 Update and MDGs Assessment. 20 Avenue Appia, 1211 Geneva 27, Switzerland. UNICEF: 978-92-4-150329-7. Available at https://www.unicef.org/publications/index_82419.html

USAID. (2015). WASH and NUTRITION: Water and Development Strategy Implementation Brief. *USAID Report*. U.S.Agency for International Development 1300, Pennsylvania Avenue, NW Washington, DC 20523. Available at https:// www.usaid.gov

Waage, J., Banerji, R., Campbell, O., Chirwa, E., Collender, G., Dieltiens, V., … and Kingdon, G. (2010a). The Millennium Development Goals: A cross-sectoral analysis and principles for goal setting after 2015. *The Lancet.* **376:** 991-1023. DOI:10.1016/S0140-6736(10)61196-8

Waddington, H., Snilstveit, B., White, H. and Fewtrell, L. (2009a). Water, sanitation and hygiene interventions to combat childhood diarrhoea in developing countries, *Journal of Development Effectiveness.* **3**: 295–335.http://www.3ieimpact.org/en/publications /systematic-review-001.

Walker, C. L. F., Rudan, I., Liu, L., Nair, H., Theodoratou, E., Bhutta, Z. A., … and Black, R. E. (2013). Global burden of childhood pneumonia and diarrhoea. *The Lancet.* **381:** 1405-1416. doi: 10.1016/S0140-6736(13)60222-6. Epub *2013* Apr 12

Walker, S. P., Wachs, T. D., Gardner, J. M., Lozoff, B., Wasserman, G. A., Pollitt, E., … and Group, I. C. D. S. (2007). Child development: risk factors for adverse outcomes in developing countries. *The Lancet.* **369:** 145-157. DOI: 10.1016/S0140-6736(07)60076-2

Wamani, H., Åstrøm, A. N., Peterson, S., Tumwine, J. K. and Tylleskär, T. (2007). Boys are more stunted than girls in sub-Saharan Africa: A meta-analysis of 16 demographic and health surveys. *BMC Pediatrics.* **7 (**17). https://doi.org/10.1186/1471-2431-*7-17*.

Wamani, H., Åstrøm, A. N., Peterson, S., Tylleskär, T. and Tumwine, J. K. (2005). Infant and young child feeding in western Uganda: Knowledge, practices and socio-economic correlates. *Journal of Tropical Pediatrics.* **51:** 356-361. https://doi.org/10.1093/tropej/fmi048

Weiss, G. and Goodnough, L. T. (2005). Anemia of chronic disease. *New England Journal of Medicine.* **352**: 1011–23. doi: http://dx.doi.org/10.1056/NEJMra041809.

Wenlock, R. W. (1980). Nutritional risk and the family environment in Zambia. *Ecology of Food and Nutrition.* **10**: 79-86. Available at: https://doi.org/10.1080/03670244.1980.9990622

Woldt, M., Moy, G. G. and Egan, R. (2015). Improving household food hygiene in a development context. Washington, DC: FHI 360/FANTA. https://www.fantaproject.org/sites/default/.../Food_Hygiene_Technical_Brief_2015

Wollo, E. (2005). Risk factors for child under-nutrition with a human rights edge in rural villages of North Wollo, Ethiopia. *East African Medical Journal.* **82**

WHO, UNICEF. and JMP. (2014). Progress on drinking water, sanitation and hygiene: Joint monitoring programme update. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), 2014. Available at: www.wssinfo.org

WHO, UNICEF. and JMP. (2017). Progress on drinking water, sanitation and hygiene: 2017: Update and SDG Baselines. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), 2017. Licence: CC BY-NC-SA 3.0 IGO. https://creativecommons.org/licenses/by-nc-sa/3.0/igo)

WHO. (2004a). Guidelines for drinking-water quality: Third edition; recommendations: Geneva, Switzerland. Available at https://www.who.int/water_sanitation_health /dwq /GDWQ2004web.pdf

WHO. (2004b). Water, sanitation and hygiene; link to health. Geneva, Switzerland. Available at https://www.who.int/

WHO. (2005). Global database on child growth and malnutrition. Geneva: Available at https:// www.who.int/nutgrowthdb/

WHO. and UNICEF. (2010*).* Progress on Sanitation and Drinking-Water: Update. Geneva and New York: WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation.http://www.wssinfo.org/fileadmin/user_upload/resources/1278061137-JMP_report_2010_en.pdf.

WHO. and UNICEF. (2015). Progress on sanitation and drinking water–2015 update and MDG assessment. Geneva: World Health Organization. https://www.unicef.org/ Publications/index_82419.html

Zeleke, T., Zewdie, A. and Alemu, A. (2014). Determinants of under-five childhood diarrhea in Kotebe Health Center, Yeka Sub City, Addis Ababa, Ethiopia: A case control study. *Global Journal of Medical Research.* **14**.

Ziegelbauer, K., Speich, B., Mäusezahl, D., Bos, R., Keiser, J. and Utzinger, J. (2012). Effect of sanitation on soil-transmitted helminth infection: Systematic review and meta-analysis. *PLoS Medicine.* **9,** e1001162. https://doi.org/10.1371/journal.pmed.1001162

APPENDICES

Appendix 1: Supplementary Materials (Tables)

Table: **Social-demographic characteristics of the population under study**

Description	**Number/N=310**	**Percentage (%)**
Name of the district		
Longido	150	48.4
Monduli	160	51.6
Name of the village		
Orbomba	86	27.7
Kimokouwa	64	20.6
Meserani	79	25.5
Makuyuni	81	26.1
Child Age		
6 – 12 months	61	19.7
>12 – 24 months	67	21.6
>24 - 36 months	68	22
>36-48 months	57	18.4
>48-59months	57	18.4
Mother`s age		
16- 19	9	2.9
20 -29	173	55.8
30 – 39	98	31.6
40 and above	30	9.7
Mothers level of Education		
No education	144	46.5
Primary education	144	46.5
Secondary and high school	16	6.1
College and University	3	1

Type of Household		
Father headed	297	95.8
Mother headed	13	4.2
Occupation of Head of family		
Business and Livestock keeping	83	26.7
Agriculture &Livestock keeping	204	65.8
Agriculture, Livestock-keeping & Business	23	7.4
Marital status		
Single	2	0.6
Married	298	96.1
Divorced	1	0.3
Separated	1	0.3
Widower	8	2.6

Table: Independent predictors of stunting among under-five children in pastoral communities

Variable	n	Stunting %	COR(95%CI	p-value	AOR(95%CI	p-value
Main Source of domestic water						
Tap water	189	21.2	1		1	
Surface water	121	48.8	3.5(2.2-5.8)	0.000	13(5.8-30)	0.000
Time the CF was introduced to the child						
Before 6 months	278	50	2.3(1.1-4.9)	0.02	2.8(1.2-6.5)	0.02
6 months and above	32	30	1		1	
Child having diarrhea for the past two weeks						
Yes	88	41	1.8(1.1-2.9)	0.03	2.6(1.4-5)	0.004
No	222	28.4	1		1	
How cow`s milk is prepared prior feeding to the child						
Boiled	243	31.7	1		1	
Not boiled	67	32.8	1.1(0.6-1.9)	0.9	1.8(1-3.8)	0.1
Means of storing already prepared CF						
Thermos/hotpot	213	30	1		1	
Traditional Calabash	97	36.1	1.3(0.8-2.2)	0.3	1.2(0.6-2.4)	0.7
Number of wives under single husband						
Single wife/monogamy	126	22.2				
More than one wife/polygamy	184	50	2.3(1.1-4.9)	0.02	2.5(1.4-4.4)	0.003
Mothers level of education						
No formal education	145	43.4				
With formal education	165	22	3.4(1.6-5.9)	0.000	2.8(1.4-4.8)	0.001

Table: Independent predictors for underweight among under-five children in pastoral communities

Variable	n	Underwt %	COR(95%CI	p-value	AOR(95%CI	p-value
Main Source of domestic water						
Tap water	189	6.3	1		1	
Surface water	121	32.2	7(3.5-14.1)	0.000	9.2(9.1-60.5)	0.000*
Time the CF was introduced to the child						
Before 6 months	278	18.8	0.8(0.3-2.2)	0.7	1.9(0.7-5.9)	0.3
6 months and above	32	16.2	1		1	
Child having diarrhea for the past two week						
Yes	88	19.3	1.3(0.7-2.5)	0.4	2.5(1.1-6)	0.004*
No	222	11.9	1		1	
How cow`s milk is prepared prior feeding to the child						
Boiled	243	11.9	1		1	
Not boiled	67	17.7	1.6 (0.7-3.6)	0.3	2.5(1-6.7)	0.05*
Means of storing already prepared CF						
Thermos/hotpot	213	14.4	1		1	
Traditional Calabash	97	17.4	1.3 (0.6-2.4)	0.5	1.5(0.7-3.8)	0.4
Gender of the child						
Male	155	18.2	1		1	
Female	155	12.3	2(1.1-4.2)	0.04	2.1(1.1-3.9)	0.03
Mothers level of education						
No formal education	145	23.4	1		1	
With formal education	165	10.3	2.3(1.3-5.1)	0.002	2.9(1.5-5.4)	0.001

Appendix 2: Statement of Consent

Informed consent form for parents/guardian on behalf of their children (6 – 59 months) to participate in the study regarding the assessment of the influence of water, sanitation and hygiene interventions (WASH) on common infections and nutritional status among children under-five years of age in pastoral communities of Arusha

This Informed Consent Form has two parts:

- Part I: Introduction (to share information about the research with you)
- Part II: Certificate of Consent (for signatures if you agree to take part)

PART I: Introduction

I am Hoyce Amini Mshida a student from Nelson Mandela African Institution of Science and Technology. I am doing research on the topic I have mentioned and you will be given detailed information of the research and invited to be part of this research. If there are some words or anything that you do not understand, please ask me to stop and I will stop and take time to explain. If you have any question feels free to ask any time as we are going through.

1. Purpose of the research

This study aims at assessing the influence of water, sanitation and hygiene practices on common infections and nutritional status among children under-five years of age followed by health education intervention and post assessment exercise which target on improving the health of your children and their nutritional status in particular.

2. Risk and discomfort: Hardly any risk is expected and the child will feel no pain when taking hand swabs samples through hand swabbing.

3. Benefits: It is expected that there will be direct benefit to the child and the entire community including improvement of child health and nutritional status in particular.

4. Compensation: No any allowances will be given to you or to your child by participating in this study.

5. Confidentiality: Confidentiality will be maintained. However, the study results will be shared with members of research committee and will be a matter of public report.

PART II: Certificate of Consent

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this research.

Name of Participant _____

Signature of Participant _____

Date _____

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Name of Researcher _____

Signature of Researcher _____

Date _____

In case of anything contact:

1. Hoyce Amini Mshida (Principal Investigator)
   Nelson Mandela African Institute of Science and Technology
   Tel: 0756 422279
   P.O. Box 447
   Arusha, Tanzania
2. National Health Research Ethics Sub-Committee (NatHREC),
   National Institute for Medical Research (NIMR)
   Tel: +255-22-2121400
   P. O. Box 9653, Dar es Salaam, Tanzania

Appendix 3: Questionnaire

		Code
	Assessment of influence of water, sanitation and hygiene practices (WASH) on common infections and nutritional status of children under five years of age in pastoral communities, Arusha Date:……District……Ward……Village…… Household no: ……	
	A: Socio-demographic and economic information	
1.	Age of the mother……and father…… (Years) (01). 16 to 19, (02). 20 to 29, (03). 30 to 39, (04). >40	
2.	What is your Marital Status? (01). Single, (02). Married, (03). Divorced, (04). Cohabiting (05). Separated, (06). Widower	
3.	What is your Religion? (01). Christian, (02). Muslim, (03). No religion,(04).Other	
4.	Type of Household (01). Father headed …….. (02). Mother Headed……	
5.	Education level (Number of years gone to school) Father……. Mother……..	
6.	What is the occupation of the head of the house; Farther …….. Mother…….	
7.	What is the total number of children under five years of age in the household?.....	
8.	How many are you in the family including yourself?.....	
9.	How many wives are you under single husband?.....	
10.	What is the main source of staple food in the family? (01). Own farm 02). Buying from the market, 03) Relatives/friends	
11.	Does the household own any type of livestock? How many? Cattle…. Goat….., sheep, chicken others	
12.	Does any member of the household own Agriculture land? Yes/No How many acres?..... Is it being cultivated yearly (Yes/No)	
13.	How many meals per day your family usually have?.....	
14	What is the average level of income of the household per day?.....	

B: Water, Sanitation and Hygiene Practices		
	Water adequacy and safety (House, 2013)	
15.	Is Water available in your village? (01). Yes, (02). No (03). I don`t know Is it available throughout the year? 01) Yes, 02) No	
16.	What is the main source of the water? 01. Bore holes, 02. Wells, 03. Rain water, 04. Surface water, 05. Tape water, 06. Others	
17.	How far is it from home to the water source? 01. Half a kilometer, 02. One kilometer, 03. More than a kilometer	
18.	How many minutes do you take to collect water from the source? 01.15 minutes, 02. 15 to 30 minutes, 03. 30 to 1 hour, 04. More than one hour	
19.	Is the water treated? 01. Yes, 02. No, 03. I don`t know, (If the answer is yes go to question number 21)	
20.	Do you treat water at home? 01. Yes, 02. No, 03. I don`t know If the answer is no go to question no.22	
21.	What kind of treatment do you use? 01. Boiling, 02. Filtering, 03. Others (specify)	
22.	How many liters of water is available for general purpose for each one of you per day? 01. 20 litters, 02. Less than 20 liters, 03. I don`t know	
23.	Do you use the same water source to feed your animals? 01. Yes, 02. No, 03. I don`t know	
	HYGIENE PRACTICES	
24.	Do you usually wash hands? 01), Yes 02) No. When? 01. Before eating/feeding a child, 02. Before preparing food, 03. After coming from the toilet, 04. After touching dirt things, 05. After coughing or sneezing, 06. Others……	
25.	Do you wash hands using soap? 01. Yes, 02. No	
26.	If the answer is yes, in which occasion do you use soap? 01) Before eating/feeding a child, 02) Before preparing food, 03) After coming from the toilet, 04) after touching dirt things, 05)After coughing or sneezing, 06) Others……	
27.	What do you think is the reason for using soap? ……	
28.	Observation checklist	

	1. Nails cut and clean 01. Yes, 02.No 2. Hairs cut and neat 01.Yes, 02.No 3. Clothes clean 01.Yes, 02. No 4. Looking clean generally 01.Yes, 02.No 5. Wearing shoes (Yes/ No)	
	C: FOOD HYGIENE & FEEDING PRACTICES	
29.	In what condition do you save your child food? 1). Saved warm, 2). Saved cold, 03). Others (Specify)…….	
30.	Which method do you use to feed your child? 01), Hands, 02). Spoon, 03. Others (Specify)……	
31.	Who normally feed the child? 01). Myself/mother, 02), Caretaker, 03). Himself/Herself, 04). Others (Specify)……	
32.	What do you do with your child utensils to make sure are clean? ……	
33.	How do you keep your child food to make sure it is free from dirty? ……	
	D. SANITATION	
34.	Do you have toilets? (Yes/No). If "NO" Where do you defecate? …… If "NO" skip Qn 37, If "YES" skip Qn 39.	
35.	What type of toilet do you have in the household? 1. Pit latrine 2. Flashed toilet 3. Others (specify)	
36.	Where do you dispose your child feces?	
37.	If you don`t have a toilet, give a reason why? ……	
38.	How far is the defecating area from water source?	
39.	How far from the household to the toilet/defecating area?	

40.	Where do you urinate? ……	
41.	How do you dispose other household waste? ……	
42.	How many of your/households share a single toilet?	
43.	General observation on the hygiene of household surroundings/environments. 1). Proper sanitation is practiced 01) Yes, 02). No 2). Waste disposal exercise is well practiced 01). Yes, 02). No 3). Toilet available in the household 01). Yes, 02). No	
	E. Nutritional status of the child	
44.	Sex of the child……..Birth weight……	
45.	How soon did you start breastfeeding your baby after birth? 01. Immediately Less than one hour, 02.Less than twenty four hours, 03.More than twenty four hours	
46.	Are you still breastfeeding your child?	
47.	If yes, how many times do you usually breast feed your child during the day……night……	
48.	At what age (month) did you start giving your child fluids and foods other than breast milk?	
49.	What are you currently feeding your child? 01. Breast milk, 02. Breast milk, 03. Cow's milk, 04. Goat milk, 05. Juice, 06. Plain maize porridge, 07. Milky maize porridge, 08. Plain lishe porridge, 09. Milky lishe porridge, 10.Family meals, Other (specify)	
50.	If cows` milk is among complementary foods, how do you prepare the milk? ……..	
51.	Did you continue to breastfeed the child as you introduced other foods and fluids? 01. Yes, 02.No	
52.	How many times did your child eat yesterday (include breastfeeding, meals & snacks). Breastfeeding……..(times) Meals……..(times) Snacks……(times)	
53.	What do you think is the best number of times to feed young children per day apart from breastfeeding?	

54.	Are there special foods which you give to your child when he/she is sick? If yes, which food……	
55.	Are there foods you don`t give when you child is sick? Yes/No If yes, which foods……..	
56.	When your child falls sick how many times do you feed your child...during the day…….night……?	
57.	Generally, are there special foods for sick children? 1. 1. Yes 2. No If yes, what are they……..	
58.	Observation on general cleanliness of the child ….. 01. Nails cut and clean 01. Yes, 02.N 2. Hairs cut and neat 01.Yes, 02.No 3. Clothes clean 01.Yes, 02. No 4. Looking clean generally 01.Yes, 02.No 5. Wearing shoes (Yes/ No)	
	F: Morbidity information	
59.	Do you have clinic card? Yes/No	
60.	Is the child regularly taken to the RCH clinic? 01.Yes, 02.No	
61.	Is your child fully immunized according to the age? 01. Yes, 02.No. If no why…..	
62.	Has this children been ill for the past seven days? 01.Yes, 02.No	
63.	If yes what was the illness? ……	
64.	Did your child have diarrhea for the past two weeks? 01. Yes, 02. No	
65.	List down foods which were given to your child during that time……	

G: Food Frequency Questionnaire Form

Food Item	Number of Servings		Serving Size/Portion Size Normal, Oversize, Undersize
	Per Day	Per Week	
Breast milk			
Meat or Chicken			
Eggs			
Milk/Milk products			
Fruit or Juice			
Green, leafy vegetables			
Yellow or orange vegetables or fruits (sweet potatoes, mangos, pawpaw, pumpkin)			
Other vegetables			
Roots or Tubers (e.g. potatoes)			
Cereals (*ugali*, bread, rice)			
Beans or nuts			
Sugar or Honey			
Sweetened beverages			
Oils and fats			
Coffee or tea			
Loshoro			
Cooked animal blood			

Appendix 4: Training Manual Book

Health education on water, sanitation and hygiene practices

1. Sessions plan:

1.1 Session one: General Information on Health and WASH

Time frame: 1 hour

Materials:

Flip board and charts, marker pens, pens, notebooks, WASH practices pictures

Objectives:

1. To introduce to the community the general overview on WASH

2. To briefly explain the importance of WASH to individual and community health especially children.

Activities:

1. Participants brainstorming various examples of WASH issues and health conditions associated with poor WASH practices.

2. Participants have a look on pictures illustrating WASH practices and brainstorm accordingly.

Why health is important to everybody?

Health refers to the state of physical, mental and social wellbeing but not merely free from illness/sickness. Good health is crucial to children under five years of age and everybody else as it determines the growth performance of a child including cognitive, social and physical development. It is therefore important for the community to nurture the health of children.

Why it is important to practice good WASH?

Water, sanitation and hygiene practices which sometimes are termed as WASH are highly associated with peoples 'health status. Poor WASH practices may lead into poor health and vice versa. When addressing water we mean access to adequate and safe water whereby water source should not be more than one kilometer from the household and minimum average

amount of water per person per day should be not less than 20 liters. Moreover, it should not take more than half an hour from the source to the household. Also it should have recommended amount of microorganisms and minerals as per WHO standards.

Sanitation means proper disposal of both urine and human excreta. Also means avoiding open defecation.

Hygiene means keeping oneself and his/her surroundings clean. It includes personal hygiene, food hygiene and hygiene of the surroundings i.e. proper disposal of liquid and solid waste.

2.2. Session two: An Overview of Food and Personal Hygiene

Time Frame: 45 minutes to one hour

Materials:

Flip boards and charts, assorted marker pens, soaps, tape/running water, razorblades, notepads, pens and pencils.

Objectives:

1. To equip the community with knowledge regarding hygiene practices.

2. Ensure that community members understand the importance of practicing good hygiene

3. Make sure that the community is aware of various issues related to hygiene practices

Activities:

Handwashing with soap and cutting nails to be practiced by participants

Community members to brainstorm the importance of practicing good hygiene and various disease conditions associated with diarrhea.

Why personal and food hygiene are important to everybody?

It is important to keep ourselves, our food and our environment clean so as to prevent transfer of disease causing germs into water or food we eat which may finally lead us into unhealthy conditions. It also helps us to protect the health of our children. Disease causing germs are everywhere including the soil, hands, nose, mouth, skin, urine, feces, to mention but few.

Therefore, we should keep ourselves and our environment clean regularly so as to be free from water and food borne diseases such as diarrhea.

What are the issues involved?

i. Personal hygiene

Washing hand with soap during critical times including, before eating, after touching dirty things such as child bottoms, soil, animal feeds, after attending a wash room and so on.

ii. Food hygiene

Proper cooking of food, proper covering of the food, washing kitchen utensils with safe water and keep the dry, avoiding cross contamination of food, washing fruits before eating, use safe water when making juices, washing hands before food preparation and ensure the cooking place is clean and free from flies.

What will happen to us if we don`t practice good hygiene?

Spreading of water and food borne diseases especially diarrhea causing illnesses, skin diseases and eye diseases such as trachoma.

1.3 Session three: Safe Disposal of Human Excreta

Time frame: 45 minute to one hour

Materials

Materials for constructing a simple and improved toilet for demonstration purposes. Local available materials will be used.

Objectives

To ensure participants are well equipped with knowledge regarding sanitation.

To ensure that every participant understand the importance of having a latrine in his/her family.

To make sure that participants consider child excreta as any other human excreta.

To ensure that every participant is familiar with fecal oral transmitted diseases.

Activities:

Demonstration using pictures illustrating the construction of simple, improved latrine.

Brainstorming on fecal oral transmitted diseases in the study area.

Participants orient themselves with issues pertaining to proper disposal of human excreta.

Brainstorming about open defecation, the reasons for not having latrines and its impact.

What does safe disposal of human excreta mean?

Both human urine and feces should be disposed to the latrine. Excreta from children should also be treated as that of an adult. Therefore, it is important for every family to have a standard latrine which is clean, well-covered, and free from flies and odor.

Why is it important to do so?

To reduce the occurrence of diseases which are manly transmitted through fecal oral route such as cholera. Keeping our environments clean and appealing.

What will happen if we don`t do so?

Frequent occurrence of outbreaks and illnesses associated with poor sanitation including diarrhea illnesses, unpleasant environments.

What should we do to improve sanitation in our environment?

Every family should have an improved toilet, clean and free from odor. If it is a pit latrine it should have a lid and must be well covered.

What is the appropriate distance from the household to the latrine and why is it important?

The WHO recommends that a standard latrine must be 30 meters away from the household and water source to reduce chances of contamination.

1.4 Session four: Safe Disposal of Solid and Liquid Waste

Time frame: 45 minutes to one hour

Materials:

Flip board and charts, marker pens, notebooks, pens, pencils, picture showing different types of waste, Spades, hoes.

Objectives:

To equip participants with knowledge on solid and liquid waste

To ensure that participants are familiar with ways of disposing solid and liquid waste

To ensure that participants knows how to recycle various domestic waste including garbage.

To ensure that participants are aware of the importance of proper waste disposal.

Activities:

Participants to practice how to make compost manure using domestic waste.

Brainstorming different means and proper means of disposing waste.

Practicing how to separate and dispose various wastes in the public areas.

What is solid and liquid waste?

Solid waste refers to waste which are not in liquid form such as garbage, plastics, papers to mention but few, while liquid waste refers to waste which are in form of liquid such as laundry water, sewage water, kitchen waste water to mention but few.

How to dispose solid and liquid waste?

Solid and liquid waste can be separated and recycled. Garbage can be used as organic manure while plastics and papers can be recycled if properly disposed.

1.5 Session five: Safe Handling of Domestic Water

Time frame: 45 minutes to one hour

Materials

Flip charts and board, marker pens, notebooks, pens, pencils, empty water containers with lids, pictures of various water sources.

Objectives

To ensure that participants are able to distinguish safe and unsafe water.

To ensure that participants knows how to treat and keep domestic water safe.

To make sure that participants are aware of the recommendations regarding water safety, adequacy and accessibility and its importance.

To ensure that participants are able to maintain and keep water sources clean.

Activities

Participants brainstorming various issues regarding water quality.

Participants identify safe and unsafe water basing on its source.

Discussion on various means of treating water.

Water is among the basic needs for human being. Water is essential for drinking, cooking, and washing, watering and generating power. Every living organism needs water to survive. In short water is life.

What are the water sources?

Water sources include, wells, boreholes, rain, tapes and from the surface such as rivers, lakes, oceans and sea. Water from all those sources is not safe and may sometimes be contaminated and finally lead into water borne diseases such as typhoid fever, or amoebic dysentery.

What is safe water?

Safe water is water which meet the recommended WHO standards i.e. contains recommended amount of microbial, chemical and physical conditions that comply with the WHO guidelines or national standards. Water safety can be ensured by boiling, filtering or by treating using chlorine or other appropriate chemicals. Cleaning of water sources and water containers may also improve water safety. Domestic water should also be covered to prevent contamination from various sources including dusty, insects to mention but few.

1.6 Session six: Child Health and Nutritional Status in Relation to WASH

Time frame: 45 minutes to one hour

Materials

Flip charts and board, marker pens, notebooks, pens, leaflets/fliers, pictures.

Objectives

To impart knowledge to participants on the impact of poor WASH to individuals 'health particularly children.

To ensure that participants are able to identify hygiene practices which may improve or protect children from getting diarrhea related diseases.

Participants' awareness on safe ways of keeping and cooking complementary foods.

Activities

Demonstrations regarding a link between WASH and disease transmission

Participants brainstorm on the hygiene practices which may reduce water and food borne diseases in the community.

Participants' incooperate the WASH knowledge in their day to day activities.

What is the relationship between WASH and child health?

Children are the most fragile and delicate creatures therefore, very vulnerable to diseases particularly water/food borne diseases. However, families spend a lot of money for attending sick children and waste a lot of time. Health facilities get overwhelmed by people suffering from diarrhea related diseases. Moreover, diarrhea related illnesses are among the leading cause of deaths and illnesses to children less than five years of age. Children are also vulnerable to skin diseases (scabies) and eye infections such as trachoma if not kept in hygiene condition. Frequent illness to children may impair their mental and physical growth. Therefore, improved WASH practices in any community may reduce mortality and morbidity among under-five children as well as reducing growth impairments.

How to protect children from diarrhea related diseases?

Children should be kept clean all the time. How? By ensuring their personal hygiene and the hygiene of their mothers or caregiver, keeping their foods free from contamination, washing hands of both mother and child prior to feed him/her, keep the surroundings clean and make

sure the child does not play with dirty things, making sure all complementary foods are properly cooked kept safe. We should also make sure that foods are well covered and are fresh when given to kids. A minimum of two baths per day should be ensured to children. Food containers should be kept clean as much as possible. Where possible children's` feeding utensils should be sterilized prior to use.

The figure bellow indicate germs transmission route from feces via food to the host.

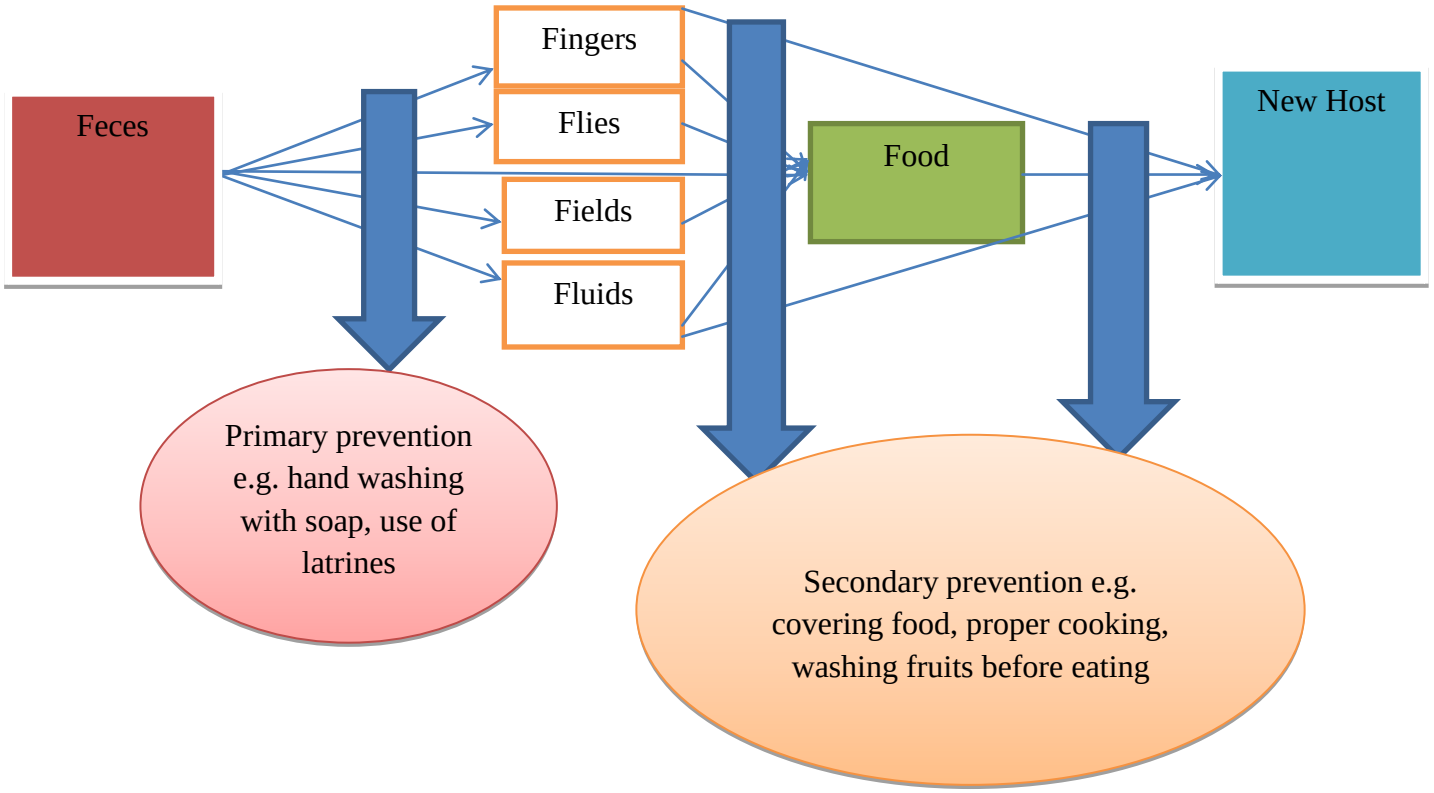


Figure 19: How germs are transmitted from environment into a new host (Adopted from, Penakalapati (2017)

Summary

- General information on health and WASH
- Personal and food hygiene
- Safe disposal of human excreta/sanitation
- Safe disposal of liquid and solid waste
- Safe handling of domestic water
- Child health in relation to WASH practices

Appendix 5: Ethical Clearance Certificate

THE UNITED REPUBLIC OF TANZANIA

National Institute for Medical Research
3 Barack Obama Drive
P.O. Box 9653
11101 Dar es Salaam
Tel: 255 22 2121400
Fax: 255 22 2121360
E-mail: headquarters@nimr.or.tz
NIMR/HQ/R.8a/Vol. IX/1972

Ministry of Health and Social Welfare
6 Samora Machel Avenue
P.O. Box 9083
11478 Dar es Salaam
Tel: 255 22 2120262-7
Fax: 255 22 2110986

11th June 2015

Hoyce Amini Mshida
The Nelson Mandela
African Institution of Science and Technology
Tengeru, P O Box 447, ARUSHA

CLEARANCE CERTIFICATE FOR CONDUCTING MEDICAL RESEARCH IN TANZANIA

This is to certify that the research entitled: Assessment of the impact of water, sanitation and hygiene practices on *Salmonella* and *E coli* infections and nutritional status of children under five years in pastoral communities, (Mshida H A *et al*), has been granted ethical clearance to be conducted in Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health & Social Welfare and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine. NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Sites: Ngorongoro, Longido and Monduli Districts.

Approval is for one year: 11th June 2015 to 10th June 2016.

Name: Dr Julius J Massaga

Signature
Ag CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Dr Margaret E Mhando

Signature
Ag CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, SOCIAL WELFARE

CC: **RMO**
DED
DMO

Appendix 6: Participants Consent for taking photos

CONSENT FORM

I the undersigned do hereby agree to the following. I am allowing Hoyce Amini Mshida, a student from Nelson Mandela African Institution of Science and Technology who is doing a research on influence of water, sanitation and hygiene interventions on common infections and nutritional status among children under-five years in Longido District to take my photo/my child`s photo and use it for educational purposes.

Participants` Name: Ngatea Olaitu

Signature: ..... Date: 07/2016

Principal Investigators`/students` Name: HOYCE A. MSHIDA

Signature..... Date: 07/2016

CONSENT FORM

I the undersigned do hereby agree to the following. I am allowing Hoyce Amini Mshida, a student from Nelson Mandela African Institution of Science and Technology who is doing a research on influence of water, sanitation and hygiene interventions on common infections and nutritional status among children under-five years in Longido District to take my photo/my child`s photo and use it for educational purposes.

Participants` Name: Namnyaki Mollel

Signature: N. Mollel Date: JULY | 2016

Principal Investigators`/students` Name: HOYCE AMINI MSHIDA

Signature: HMshida Date: 07| 2016