DIARRHOEA AMONG UNDERFIVE CHILDREN AND HOUSEHOLD WATER TREATMENT AND SAFE STORAGE FACTORS IN MKURANGA DISTRICT, TANZANIA

Remidius Kamuhabwa Kakulu

MSc (Applied Epidemiology) Dissertation

Muhimbili University of Health and Allied Sciences

November, 2012

Diarrhoea among under five Children and Household Water Treatment and Safe Storage Factors in Mkuranga District, Tanzania

.

By

Remidius Kamuhabwa Kakulu

A dissertation submitted in partial fulfilment of the requirement for the degree of Master of Science (Applied Epidemiology) of Muhimbili University of Health and Allied Sciences

Muhimbili University of Health and Allied Sciences, School of Public Health and Social Sciences

November, 2012

Certification

The undersigned certify that they have read and hereby recommends for acceptance a dissertation entitled **Factors associated with diarrhoea among children under the age of five years in relation to household water treatment and safe storage in Mkuranga Semi-Urban areas in Mkuranga District, Coastal region, Tanzania** submitted in Partial fulfilment of requirement for the degree of Master of Science in Applied Epidemiology of the Muhimbili University of Health and Allied Sciences.

_____ _

Gideon Kwesigabo (MD, MSc, MEd, PhD)

(MUHAS SUPERVISOR)

Date_____

_____

Senga Sembuche (Bsc, Msc)
(FELTP SUPERVISOR)

Date: _____

Declaration and Copyright

I, **Remidius Kamuhabwa Kakulu**, declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other University for a similar or any degree award.

Signature _____ Date_____

This dissertation is a copyright material protected under the Berne Convention, the Copyright act of 1999 and other International and national enactments, in that behalf, on intellectual property. It may not be reproduced by any means, in full or in part, except for short extract in fair dealings, for research or private study, critical scholarly review or discourse with an acknowledgement, without the written permission of the Director of Postgraduate studies, on behalf of both the author and the Muhimbili University of Health and Allied Sciences.

Acknowledgement

I would like to express my sincere gratitude to my supervisors Dr. Gideon Kwesigabo Dean School of Public Health and Social Sciences, Ms. Senga Sembuche who have provided guidance, directions and support in the development of this dissertation. Your kind and tireless guidance is remarkable and may I acknowledge that I have learnt a lot from you and thank you very much.

Secondly thanks should go to the Field epidemiology and laboratory training program and the African Field Epidemiology Network for sponsoring my studies.

My employer Ministry of Health and Social Welfare for your permission for studying this course, it is my hope that the knowledge obtained will be useful in improving my performance at work.

Lastly but not least I would like to thank my colleagues for their comfort and company, indeed I have enjoyed studying with you.

Dedication

This work is dedicated to my dearest wife **Ms. Eveline Remidius** and my son Baraka whom provided care and comfortable environment for preparation of this work your contribution to my career is remarkable and appreciatable. May God bless my family and my footstep while climbing academic ladder.

I wish you all the best and happy life and congratulation for your patience during my absence in data collection and field investigations.

Moreover special thanks should go to my beloved father Elisa Kakulu and my late mother Esteria Kakulu for laying a good foundation of education to me. Without you I could not have grown to a person I am today in the community of elites. I will always follow your advice and directions

Thank you once again,

Remidius

Abstract

Introduction: In Mkuranga district diarrhoea was among the top ten causes of morbidity and mortality among children under the age of five. Household water treatment and safe storage also known as point of use water treatment (POU) has been shown to be an effective means of reducing diarrhoea and other diseases associated with unsafe drinking water.

The purpose of this study was to determine factors associated with diarrhoea with focus on Household water treatment and safe storage and microbial contamination of drinking water.

Methods: A Cross sectional analytical study was conducted in Mkuranga semi-urban area in Mkuranga district Coast region of Tanzania whereby a probability sample of 400 households was obtained using a multistage sampling technique. Semi-structured questionnaires were used to collect information. Moreover drinking water samples were collected from each household for micro-bacterial analysis mainly E.Coli and Total coli forms. WHO drinking water standards were used to categorize drinking water as acceptable or not. The data were entered; cleaned and analysed using Epi Info version 3.6.11 bivariate analysis was done to determine association between variables, while logistic regression was conducted to control for confounding effects, p values are reported at 95% level. The study was approved by Muhimbili University of Health and Allied Sciences Research and Publications Committee.

Results: A total of 301 children between the age of 6 months to 59 months were studied with the response rate of 95%. The mean age of study population was 2years±1.3 Standard deviation with a male to female ratio of 0.9:1. The prevalence of under five diarrhoea was 32.7%, the proportion of households that reported treating water with any method was 49.5%. Out of 301 drinking water samples tested about 37.2% were fecally contaminated with the mean E.Coli count of 2.6cfu/100ml of water (SD=±4.8cfu). Also 78% of all drinking water samples tested had total coli forms with the mean total coli form count of 69.9cfu/100ml (SD=±43.2cfu). Drinking water within unacceptable standards (Adjusted OR=20.64, 95%CI 5.84-128, p=0.00), Storing water in container without lid (Adjusted

OR=5.4 95%CI 2.6-11.3) and lack of formal education to guardians/parents (Adjusted OR=1.9, 95%CI 1.08-3.50) increased the risk of diarrhoea. Also treating water with any method (AOR=0.49, 95% CI 0.28-0.84), treating water by boiling (Adjusted OR=0.39, 95% CI 0.2-0.7), Store water in container with lid (Adjusted OR=0.31, 95%CI 0.17-0.53) and parents washing hands with soap following house activities (AOR=0.41, 95% CI 0.24-0.84) were associated with reduced risk of diarrhoea.

Conclusion: Households should be sensitized to treat their drinking water, wash hands with soap, store drinking water in containers with cover in addition adult formal education should be provided in order to reduce the under five diarrhoea in Mkuranga semi urban area.

Key words: Under five diarrhoea and HWTS in Mkuranga

Table of Contents

Certification ii

Declaration and Copyright iii

Acknowledgement iv

Dedication v

Abstract vi

Chapter 1 1

Introduction 1

1.1.1 Household Point of use water treatment technologies 3

1.2 Statement of the problem 5

1.3 Rationale of the study 7

1.4 Research questions 8

1.5 Objectives of the Study 8

1.5.1 Broad Objectives 8

1.5.2 Specific objectives 8

1.6 Literature review 9

Chapter 2 14

Methodology 14

2.1 Study design 14

2.2 Study Area 14

2.4 Sample Size 17

2.5 Sampling techniques 18

2.6 Survey Instruments 18

2.6.3. Water sampling 19

2.9 Data Management 20

2.10 Data analysis 20
Chapter 3 23
Results 23
3.1 Social-demographic characteristics of the study population 23
3.2 Social demographic characteristic of respondents 24
3.4 Reported prevalence of under five diarrhoea 27
3.5 Household water sources and water treatment practices 27
3.6 Water treatment and storage options 28
3.10 Reasons for use of different water treatment options at household level 34
3.11 Bacterial contamination of various water treatment and storage options 34
Chapter 4 38
4.1 Prevalence of Diarrhoea 38
4.2 Household water treatment and storage options 38
4.3 Reasons for use of different water treatment methods 39
4.4 Relationship between water treatment and Storage options and reported diarrhoea 40
4.5 Bacterial contamination of various water treatment and storage methods 41
4.6 Limitations of the study 42
Chapter 5 43
5.1 Conclusion 43
5.2 Recommendations 43
References 44
Appendices 52
Appendix 1: Informed consent form – English version 52
Appendix 2 - Fomu ya ridhaa 55
Appendix 3 (Questionnaire) 58

Abbreviations and Definition of Terms

Abbreviation / Term	Long form/ Definition
HWTS	Household water treatment and Safe Storage
HWT	Household water treatment
NIMR	National Institute of Medical Research
CDC	US-Centre for disease Control and Prevention
MoHSW	Ministry of Health and Social Welfare.
DHS	Demographic Health Surveys
FBO	Faith Based Organization
CBO	Community Based Organization
IDSR	Integrated Disease Surveillance and Response
FS	Faecal streptococcus
FIB	Faecal Indicator Bacteria
POU	Point of use water treatment.
Household	People who live together and share the same pot
Diarrhoea	Loose watery stool at least three times a day
E. coli	Escherichia coli
S.D	Standard deviation
AOR	Adjusted Odds Ratio
DALYS	Disability Adjusted Life Years
S.E	Standard error
95% CI	95% Confidence Interval
Acceptable level of E. coli and Total coli form in drinking water	According to WHO standard on drinking water it is when there is no any E.coli or total coli form found in 100mL of water tested.
Unacceptable level of bacterial contamination in drinking water	Means any coli form or E.coli found in 100ml of water tested.

Chapter 1

Introduction

1.1 Background

Diarrhoea disease accounted for 4.6 Billion cases and 2.16 Million deaths worldwide in the year 2004 of which more than 50% were from low income countries and most of the cases were children under five years. In the year 2004, one of the two leading cause of burden of disease was diarrhoea, also diarrhoea accounted for 32,203,037 DALYS in Africa and the majority of which are children under the age of Five years[61].Also in meta analysis of 60 studies of diarrhoea morbidity and mortality in between1990 to 2000 diarrhoea accounted for 21% of all deaths of children under five years annually and mostly from developing countries [65]

Africa and South East Asia countries accounted for 75% of all deaths; Tanzania according to Boschi-Pinto [4] was among the 15 countries that accounted for 75% of all deaths.

World health organization estimates that 88% of all diarrhoea diseases are due to unsafe water supply, inadequate sanitation and poor hygiene practices. For the year 2002 alone an estimated 1.1billion people lacked access to improved water sources [59, 8]

It was found that infectious agents associated with diarrhoea are transmitted mainly through faecal oral routes, which are bacteria, viruses and protozoa excreted in the human faeces causes' diarrhoea [5]. Also most of the pathogens that cause diarrhoea are transmitted through ingestion of contaminated water[38]. Experts in water quality and safety have developed many interventions for water treatment, these include Physical removal of pathogens (Filtration, adsorption and Let it stand and settle),Chemical treatment (assisted Let it stand and settle, chemical disinfection and ion exchange), heat and ultra violet UV radiation [63].These efforts of improving the quality of water also included steps of maintaining residual disinfection and improved storage thus the United Nations Mission of reducing to half of the 1.5billion people without access to safe water [58]

Meta analysis of 67 studies found that improved water quality may results into median reduction of 16% of diarrhoea morbidity [32]

Another finding indicated that even the safe water can become contaminated during collection, transport and drawing in the home [17].The low cost intervention of improving and preserving household water quality should be adopted [64]

WHO has formulated and sponsoring an international Network for the promotion of safe household water treatment and safe storage.

A brief analysis of 21 controlled field trials over the last 20 years dealing specifically with interventions designed to enhance microbiological quality of drinking water at household level showed a median reduction in endemic diarrhoea diseases by 42% compared with the control group [63]

Normally Children with poor nutritional status and overall health, as well as those exposed to poor environmental conditions including unsafe drinking water, are more susceptible to severe diarrhoea and dehydration than healthy children. Children are also at greater risk than adults of life-threatening dehydration since water constitutes a greater proportion of children's bodyweight. Young children use more water over the course of a day given their higher metabolic rates, and their kidneys are less able to conserve water as adults **[65]**

Interventions to improve water quality at the source, along with treatment of household water and safe storage systems, have been shown to reduce diarrhoea incidence by as much as 47 per cent [61]

Millennium development Goals 7, Target 10, calls for reducing by half the proportion of people without sustainable access to safe drinking water by 2015. Reaching this target implies that we need to tackle both the quantity (access) and quality (safety) dimensions to drinking water provision.

1.1.1 Household Point of use water treatment technologies

According to WHO there are about 37 different technologies for use at household level for treatment of drinking water in the home [14] Few have been assessed for microbial and health impact performance. In Tanzania the following are common in different places of Country.

1.1.2 Chlorination

This is the most widely-practised means of treating water at the community level; apart from boiling, it is also the method used most broadly in the home. The source of chlorine can be sodium hypochlorite, chlorinated lime, or high test hypochlorites (chlorine tablets) which are usually available and affordable. The sodium hypochlorite solution is packaged in a bottle with directions for users to add one full bottle cap of the solution to clear water (or two caps to turbid water) in a standard-sized storage container; agitate; and wait for 30 minutes before drinking. Chlorine must be added in sufficient quantities to destroy all pathogens but not so high that taste is adversely affected. At doses of a few mg/l and contact time of about 30minutes, free chlorine inactivates more than 99.99% of enteric pathogens, the notable exceptions being Cryptosporidium and Mycobacterium species. Its impact in reducing diarrhoeal diseases has been documented [1]

1.1.3 Filtration

Household filters potentially present certain advantages over other technologies. They operate under a variety of conditions (temperature, pH, turbidity), introduce no chemicals into the water that may affect use due to objections about taste and odour, are easy to use, and improve the water aesthetically, thus potentially encouraging routine use without extensive intervention to promote behaviour change. Higher quality ceramic filters treated with bacteriostatic silver have been shown effective in the lab at reducing waterborne protozoa by more than 99.9% and bacteria by more than 99.9%, and their potential usefulness as a public health intervention has been shown in development and emergency settings [22,23]

The improving quality of locally-fabricated silver coated ceramics is particularly promising as a sustainable and low-cost alternative [3]Slow-sand filters remove suspended solids and

microbes by means of a slime layer (schmutzdecke) that develops within the top few centimetres of sand are capable of removing 99% of enteric pathogens if properly constructed, operated and maintained. **Bio-sand filter** is a simpler but more advanced version designed specifically for intermittent use and is more suitable for household applications. It has been tested both in the laboratory and the field [13, 16]

1.1.4 Combination Flocculation and Disinfection (Aqua tabs)

The most challenge for household-based treatment is how to treat high turbid water, solids normally use up free chlorine and other chemical disinfectants. Turbidity can be managed by simple Let it stand and settle and pre-treatment. The use of alum can be effective and low-cost option for assisted Let it stand and settle but again disinfection is required such forms of assisted Let it stand and settle have been shown to reduce the levels of certain microbial pathogens, especially protozoa which may otherwise present a challenge to chemical disinfectants. Certain manufacturers have combined flocculation and time-released disinfection in a single product that is sold in sachets for household use. One such product has been shown to reduce waterborne cysts by more than 99.9%, viruses by more than 99.9% and bacteria by more than 99.99% [15]

1.1.5 Boiling

Boiling or heat treatment of water with fuel is effective against the full range of microbial pathogens and can be employed regardless of the turbidity or dissolved constituents of water. WHO recommend bringing water to a rolling boil for 1minute; this is mainly intended as a visual indication that a high temperature has been achieved; even heating to pasteurization temperatures (60^{o} C) for a few minutes will kill or deactivate most pathogens. However, the cost and time used in procuring fuel, the potential aggravation of indoor air quality and associated respiratory infections pose a threat to public health.

1.1.6 Straining in cloth

Pouring turbid (cloudy) water through a piece of fine, clean cotton cloth will often remove a certain amount of the Suspended solids contained in the water. If the cloth is dirty, additional pollutants may be introduced! Purpose-made monofilament filter cloths can be used in areas where guinea worm disease (dracunculiasis) is endemic. Such cloths are

effective in straining out the copepods in the water. These tiny water creatures act as intermediate hosts for the larvae which transmit the disease. Some guinea-worm eradication projects supply a large-diameter drinking straw with a filter mesh on one end so that copepods are strained out when water is sucked up the straw.

1.1.7 Storage and settlement

Storing water for just one day can result in the die-off of more than 50per cent of most Bacteria; conditions in storage vessels are usually not conducive to their survival! Longer periods of storage will lead to further reduction.

The *cercariae*, which are an intermediate host in the life cycle of schistosomiasis, can only live for 48 hours after leaving a snail if they do not reach a human or animal host. So storing water for more than two days effectively prevents the transmission of this disease

1.2 Statement of the problem

Diarrhoea was defined as having loose or watery stools at least three times per day, or more frequently than normal for an individual. Though most episodes of childhood diarrhoea are mild, acute cases can lead to significant fluid loss and dehydration, which may result in death or other severe consequences if fluids are not replaced at the first sign of diarrhoea.

Between 2004 and 2009 the diarrhoeal disease in Tanzania affected about 2.5Million children under five years and caused 3191 deaths with Case Fatality Rate (CFR=0.12%), which is an average of 430,314 cases and 532 deaths per year and the period prevalence of 588/10,000 population of under five years. In Tanzania, a child gets about 5 episodes of diarrhoea per year and the most frequently affected regions in the country are Shinyanga, Mara, Rukwa, Dodoma, Mbeya, Pwani and Kigoma [66]

Diarrhoea was the fourth contributor of Outpatient visit and the fifth cause of Mortality among children under the age of five years in the year 2009 in Tanzania. [67] Mkuranga was among the top ten districts in Tanzania leading for diarrhoea among under five children despite improvement in water, hygiene and sanitation by AMREF since 2001

In Mkuranga diarrhoea among children under the age of five years was among the top ten causes of outpatient and inpatient attendance with the Outpatient prevalence of 12% [68]

Children with poor nutritional status and overall health, as well as those exposed to unsafe drinking water are more susceptible to severe diarrhoea and dehydration than healthy children. Children are at greater risk than adults of life-threatening dehydration since water constitutes a greater proportion of children's bodyweight

Young children use more water over the course of a day given their higher metabolic rates, and their kidneys are less able to conserve water as adults [65]

Most pathogens that cause diarrhoea have similar mode of transmission – from the stool of one person to the mouth of another. This is known as faecal-oral transmission.

Interventions to improve water quality at the source, treatment of household water and safe storage systems, have been shown to reduce diarrhoea incidence by as much as 47 per cent.

Out of Tanzanian total population of 34.5 million people, access to safe drinking water among rural and urban populations are 42% and 73% respectively this is in accordance to Population and Housing Census of 2002. In that case a large population relies on water from ponds, rivers and other unsafe sources of which there rarely treated or disinfected.

Poor health associated with consumption of untreated drinking water at household level is one of the most significant concerns in Tanzania and other developing countries. Water, sanitation and hygiene related diseases claim many of the childhood illness in Tanzania.

The Tanzania National strategy for growth and reduction of poverty has indicated that the proportion of Urban and rural household using water from unprotected sources are 53% and 47% respectively and that water is rarely treated or disinfected.

In Mkuranga district more than 68% of the households depend on water from shallow wells which are not treated regularly by authorities due to constrain of budget [68]

Millennium Development Goals (MDG) target 7 call for reduction by half the proportional of people without sustainable access to safe drinking water by 2015.Reaching this target

imply tackling both quantity(access) and quality (safety) dimensions. Household interventions especially household water treatment and safe storage can make immediate contribution to the safety component of this target and would significantly contribute to MDG.

Household water treatment also known as point of use water treatment (POU) has been shown to be an effective means of reducing diarrhoea and other diseases associated with unsafe drinking water [14]

In 2005 systematic review, researchers concluded that diarrhoea can be reduced by 39% through household water treatment and safe storage (HWTS) [11]

Despite the gain in health due to household water treatment indicated in various research works still there is low coverage of household water treatment in Tanzania ranging from 30% in rural areas to 52, 5% in urban areas [69]

Numerous studies on drinking water treatment and diarrhoea have been undertaken outside Tanzania have shown relationship between general diarrhoea and household water treatment. Data are scarce on factors associated with diarrhoea among Children under the age of five years in relation to household water treatment and Safe storage. It is therefore necessary to consider the role of household water treatment and safe storage on diarrhoea among children under the age of five years. This study attempted to fill the gaps created by earlier studies in view of providing a more appropriate framework on the relationship between household water treatment and safe storage and diarrhoea among children under the age of five. These data generated by this study will help to design important intervention on diarrhoea in the community by promoting the use of existing technologies to treat drinking water the study have also documented the microbial contamination of drinking water.

1.3 Rationale of the study

The significance of this study was to understand the relationship between under five diarrhoea and Household water treatment and safe storage. Also to generate information of

what people do to make their drinking water safe by understanding different local water treatment options and to what extent they reduce the bacterial load in drinking water. Therefore with this information the government and communities can build upon popular and effective water treatment technologies and storage options which are effective and acceptable.

1.4 Research questions

1. Why people do not treat their drinking water as the measure of reducing diarrhoea in the community.

2. What is the association between reported diarrhoea and bacterial contamination of drinking water?

3. What is the relationship between reported diarrhoea and reported water treatment?

4. What are other risk factors which are associated with microbial contamination of drinking water?

1.5 Objectives of the Study

1.5.1 Broad Objectives

Factors associated with diarrhoea among children under five in relation to Household water treatment and safe storage in Mkuranga District Coast Region.

1.5.2 Specific objectives

1. To determine the prevalence of reported diarrhoea among under five children in Mkuranga.
2. **T**o determine the proportion of households that uses any HWTS options.
3. To determine the relationship between various HWTS options and reported diarrhoea
4. To determine the reasons for use of different water treatment options at household level
5. To document the level of bacterial contamination of various water treatment and storage options.

1.6 Literature review

The World Health Organization estimated that about 1.1billion people lack access to improved drinking water and many more drink water that is grossly contaminated [60].Also 1.8Million people die every year from diarrhoea disease the vast majority children under five.

Studies examining water contamination show that safe storage can be an effective barrier toward prevention of diarrhoea diseases. [52], however another study[70] found that it was not enough to prevent occasional extreme contamination of drinking water.

With regards to Point of Use (POU) water quality evaluation, four studies of flocculant-disinfectant measured compliance through product consumption [20] reported the biggest impact on diarrhoea.

Studies on POU flocculants-disinfectant on reduction of diarrhoea through a case control study. They found a big impact on diarrhoea approximately 70% reductions as compared to controls. This reduction was attributed by high compliance rate of refugees which was around 85%. [9]

Examination of bias in POU water treatment trials, finding zero impact across five placebo controlled trials, three of which were conducted in developing countries they concluded that there is no enough evidence for widespread promotion of household water treatment [53]

Some evidence linking the length of trials to reduced effectiveness of water chlorination intervention. In this report the issue of sustainability of the technologies should be considered when evaluating their effectiveness. There is therefore a considerable controversy as to the scalability of the water quality interventions as well as the need for better understanding of what determine use and performance in the long term [1.14]

In Rwanda it was found that low contamination in water measured at source but significantly higher contamination levels at Point of use, also another study found a substantial contamination in household water compared to source water arguing that the

recontamination is due to both household collection of water from multiple water sources and partial recontamination of water in transport and storage [71, 72]

A meta analysis of 32 studies supports the findings that water treatment at the point of use (POU) particularly flocculation or disinfection is more effective in reducing risk to diarrhoea disease than water source improvements [8]

Three meta analysis examine the impact of hand washing on diarrhoea risk analysed 17 studies and found that hand washing hygiene reduces the risk of diarrhoea by 50% [19]

The World bank independent evaluation Group (IEG 2008:17) concluded that though there is evidence on improvement of health outcome due to hand washing, sanitation and point of use water treatment there is no health gain for water treatment at the source.

Interventions to improve water quality particularly when deployed at the household level are effective means of preventing endemic diarrhoea diseases, a leading cause of mortality and morbidity in developing countries. The laboratory assessment of gravity fed ultra - filtration water treatment device at moderate turbidity of (15NTU) the device achieved log10 reduction values of 6.9 for *Escherichia coli* 4.7 for *MS2 Coliphage* and 3.6 *Cryptosporidium oocyst* thus exceeding levels established for microbiological purifiers [30]

The biosand filters (BSF) is a promising household water treatment technology used by more than 500,000 globally. Randomised study in 2009 to measure the effectiveness of biosand filters in reduction of diarrhoea during 6 month period in which 75 BSF households had significantly improved drinking water quality on average as compared with 79 control households ($p<0.001$), BSF households had 0.53 times the odds of diarrhoeal disease as control household indicating a protective effect against water borne diarrhoea disease[73]

Point of use water treatment (HWTS) has been advocated as means to substantially decrease the global burden of diarrhoea and to contribute to the Millennium development goals, however there is no enough evidence on the acceptability and non-health benefits of the methods [53]

The argument that the promotion of household water treatment (HWT) among poor population by Schmidt WP et al is premature that there is no enough evidence for scale up. This argument is puzzling because more than 850 million people in 58 low and middle income countries already report treating water at home before drinking and this reduces morbidity and mortality due to diarrhoea [30]

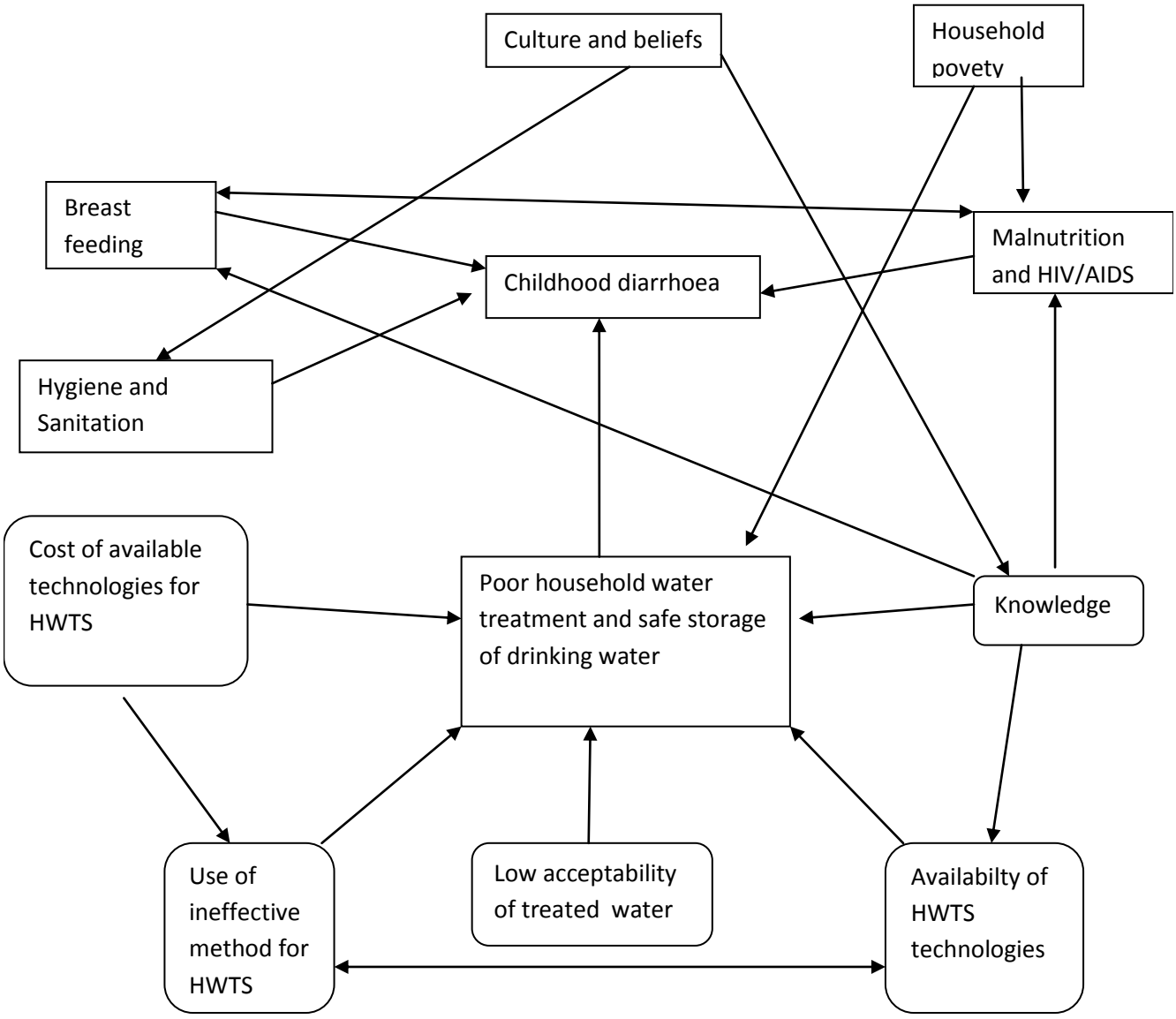
The reduction of indicator organisms were observed to be slightly higher in households that used chlorination no significant differences were seen between households with no chlorine (1.5log10 median reduction for chlorinated households and 0.31-0.55log10 for non-chlorinated households thus demonstrating less effectiveness of chlorine under field condition as compared to laboratory condition. This is because of human factors such as improper storage and chlorine dosing [74]

The study done in 2009 concluded that further research is need on home water treatment technologies used at local level and their effectiveness on water borne diseases [17]

Diarrheal-related diseases rank high among the top ten diseases and about 54% of diseases diagnosed and treated in health facilities are water, sanitation and hygiene related .According to Tanzania Ministry of Health and social Welfare report diarrhoea was the fourth contributor of Outpatient visit and the fifth cause of Mortality among children under the age of five years in the year 2009 [67]

Data is scarce on factors associated with diarrhoea in relation to household water treatment methods employed at local level and their relationship with bacterial quality of water.

CONCEPTUAL FRAME WORK: CHILDHOOD DIARRHOEA



This conceptual framework is my own design model which has drawn experiences from known determinants and contributing factors for under five diarrhoea. This model has identified four potential determinants for under five diarrhoea. These include Poor household water treatment and safe storage, Poor breast feeding practices, Malnutrition and poor hygiene and sanitation. Further analysis of the factors that directly or indirectly influence the level of determinants that is contributing factors includes:

Poor household water treatment and safe storage is influenced by availability of HWTS options, costs of the treatment methods, low acceptability of treated water, and use of ineffective water treatment methods and knowledge of existing water treatment technologies.

Poor breast feeding is influenced by knowledge on the importance of breastfeeding, HIV/AIDS and culture. In case of poor hygiene and sanitation is due to poverty and behaviour. Lastly malnutrition is influenced by household poverty, HIV/AIDS and knowledge on proper feeding practices.

Chapter 2

Methodology

2.1 Study design

Cross sectional analytical study

2.2 Study Area

The study was conducted in Mkuranga District in Pwani Region in the period between August to November 2011. Mkuranga District is the sixth district of the Coast Region which was inaugurated on 1st July, 1995, when the former Kisarawe District was divided into two districts, namely Kisarawe and the new Mkuranga District. The District has a total of 2432 sq. kms. Whereas 447 sq. kms. are covered by water (Indian Ocean), 52 sq. kms. are forest reserve area and 1034 sq kms of land suitable for cultivation.

The District lies between latitude 6^0 35 and 7^0 30 south of the equator and between longitudes 380 45 and 39^0 30 to the east. It is boarders with the Dar es Salaam Region to the north, Indian Ocean to the East, Rufiji District to the south and Kisarawe District to the West. From the climatically point of view the District experiences dual rainfall. The shorter rains (Vuli) which start in October to December, and long rains (Masika) covering the month of March to June. The average rain fall is about 800 – 1000 millimetres per annum. The rainfall distribution however is not very reliable within the seasons.

Administratively the district is divided into 4 Divisions, 18 Wards, 109 Registered Villages and 436 hamlets. The distribution of Wards Villages and hamlets (Vitongoji) per Divisions is as shown in table 1.

Table 1: Distribution of Wards, Villages and Hamlets per Division

S/N	Division	Area Sq Km	Percent to District Area	Number of Wards	Number of Villages	Enumeration area
1.	Mkuranga	823	33.8	5	29	143
2.	Kisiju	425	17.5	5	29	110
3.	Mkamba	1024	42.1	6	33	133
4.	Shungubweni	160	6.6	2	10	40
	Total	**2432**	**100**	**18**	**109**	**426**

The headquarter of the district is situated at the fast urbanizing town of Mkuranga about 50 kilometres from Dar es Salaam along Kibiti – Lindi highway.

Table 2: Access to Water Sources (Shallow well)

Distance	Number of Households	Population	%
< 400 m	13607	68,033	32
≤ 400 – 100 m	32810	119,049	55
> 1 Km	5540	27,697	13
TOTAL	**51,957**	**214,779**	**100**

The above table2 show 68% of the populations does not have easier access to water supply. (Mkuranga district profile report 2010)

Table 3: Important population groups in Mkuranga District, 2010

Population group	%	Total
Children under 1 Year	3.1	7,937
Children under 5 Year	15.2	38,026
Women of child bearing age 15 – 49 Years	22.5	50,770
Fertility (expected pregnancy per Year)	3.1	7,937
Number of Orphans/Vulnerable children	5.5	8,653

Table 4: Main OPD diagnosis 2010

S/N	Diagnosis	Total number of cases
1.	Malaria	50121
2.	Pneumonia	24095
3.	ARI	18467
4.	UTI	18180
5.	PEM severe	12301
6.	Diarrhoea	4570
7.	Eye	4213
8.	Anaemia	4082
9.	Intestinal worms	3991

2.3 Study population

The study population was children under the age of five years whereby their caretakers were interviewed about diarrhoea. The caretakers in this case included child's father, mother or any relative with sufficient information on the child and household characteristics.

2.4 Sample Size

The sample size was calculated using cluster sampling technique in order to account heterogeneous characteristics of children under the age of five. The following formula below for cluster sampling was used to quantify the minimum sample size when the parameter intended to be measured is the proportion.

$$N = g \times \frac{Z^2 P(100-P)}{\varepsilon^2}$$

Where:

N= Sample size

g=Design effect

P= Prevalence of under five diarrhoea. The prevalence of under five diarrhoea in Tanzania is 15% , proportional of household who treat water in urban area is 52.9% and 30% in rural area in Tanzania[75] .Also the proportional of household who treat water in Arusha urban is 36% [75] Since the study was carried out in Mkuranga semi- urban area thus the minimum community prevalence of 15% was used.

ε= Margin of error (ε= 5%)

Z= Standard Normal deviate (1.96)

$N = 1.5 \times 1.96^2 * 2(100-12)/5^2 = 294$

N= 294 children under five.

If we assume a non response rate of 10% then the required households will be N/Response rate= 294/0.90 = 326 children. Sample size for this study was 327 children.

2.5 Sampling techniques

The sampling technique was probability sampling with multistage sampling techniques. Four wards were identified by district Executive Director to constitute Mkuranga semi urban area that is having both rural and urban characteristics. These were Mkuranga, Mwalusembe, Vikindu and Kimanzichana. Using simple random sampling 2 villages were selected from each ward giving a total of 8 villages. The up to date number of households in each village were obtained from the village Executive Officers, then using PPS the exact number of households to be taken in each village were calculated. For the first household we identified the geographical center of the village with the assistance of village chairman and counted all households from the center to the edge of a village and select one household from one to total counted and that was the first household to visit. This method was done for all eight villages in order to exhaust the sample size of 400 households.

2.6 Survey Instruments

The following data collection methods were used to obtain the information

2.6.1. Semi – structured questionnaire: Was used to collect the demographic and descriptive data. The questionnaire was divided into four main sections. The first section assessed the demographic characteristics of respondents that are age, sex, marital status, level of education and social economic status. The second section assessed the household characteristics that are size of household, prevalence of diarrhoea general health of the household members, water sources and treatment practices and storage of household drinking water. The third section assessed the issues related to hygiene and sanitation like hand hygiene, toilet use and type. The last part documented the water testing results.

2.6.2 Nutritional status of children

The Maternal and Child Health cards (MCH) were used to assess the nutritional status of Children. The MCH card is divided into three zones identified by colours that are green, gray and red. If a child is shaded on green that means his/her nutrition status is good and the average score is in between 80-100%.Similarly the score in between 60-79% means malnourished and below 60% is severe malnourished. In this study we combined both

malnourished and severe malnourished to malnourished. Also we had an inclusion criteria whereby only mothers/caretakers whom child had MCH cards were enrolled for the study.

2.6.3. Water sampling

Water sampling was done by technicians from Temeke Water quality laboratory whereby 500mL of drinking water was sampled from each household with a study population.The caretaker was asked to use the same container they normally use to collect water for drinking and pour them into Sterile Winchester bottles containing chlorine deactivating agent. The bottles stoppers were shielded by Aluminium foil in order to avoid hand contamination and adhere to aseptic techniques. We assigned identification number to each household and recorded time of sampling, source of water sampled, type of storage container used and water treatment status. All samples were stored in a small cooler with ice packs immediately after collection and were tested within 6 hours of collection. Membrane filtration was done to test water samples collected from each household for microbiological indicators mainly E.Coli and total coli forms whereby 100mL of each household sampled water was passed through a 0.45 micron filter on a metal apparatus any particles were removed and left on filters placed on Petri dish coated with mColiBlue 24 media. There was a positive and a negative control consisting of contaminated water and purified water before each set of sample to ensure equipments and filtration process were working well. Then Petri dishes were incubated over 24-48 hours depending on availability of electricity. The presence of blue colonies represented E.coli and red colonies indicated total coli forms. WHO guideline on drinking water quality of 2004 was used to classify water as acceptable or not. Water with no detectable level of E,coli or Total coli form in 100mL of water tested were regarded as acceptable otherwise it was termed as unacceptable.

2.7 Training of field staffs

The study involved research assistants who prior to the study were recruited and properly trained for proper data collection.

2.8 Pre-testing of the research instruments

The instruments of this study were pre-tested at Mbagara ward in Dar es Salaam, the area with the characteristics more similar to those of Mkuranga. The research assistants used this opportunity to get used to the questionnaire and gain more interview skills. Moreover instruments were tested to check whether they generate the intended data. Errors noted in the pre-test exercise including the interview protocol were corrected before actual data collection in Mkuranga.

2.9 Data Management

Filled questionnaires were checked for completeness at the end of each data collection day within the field so that to identify any missing data before leaving the field. At the end of each data collection day all field questionaries were handled to the principal supervisor for safe storage.

2.10 Data analysis

The data capture screen was prepared based on the dependent and independent variables of the study. The data field incorporated the check codes in order to ensure quality data entry.

The data was entered; cleaned and analysed using Epi Info version 3.6.1 and graphics by excel software. The following are dependent and independent variables that were analysed.

Dependent variable (Predicted variable)	**Independent variable (Predictor variable)**
Prevalence of reported diarrhoea <5 years. Proportional of household using HWTS	1.Demographic characteristics • Age • Sex • Occupation • Marital status • Level of education
Prevalence of reported diarrhoea <5 years. Proportional of household using HWTS	2.Water sources • Deep well • Shallow well • Rain water • Rivers/Lakes
Water test results	3.Proportional • Acceptable level. • Above permissible level.
Prevalence of reported diarrhoea <5 years. Proportional of household using HWTS	4.Storage facilities • Presence/absence of storage facility • Type of storage facility
Utilization of HWT	5.Know/do not know existing HWTS
Utilization of HWT	• Cost • Availability • Knowledge about diarrhoea.

The chi-square test was used to test for significance of results and the significance level were set at $p<0.05$ and 95% Confidence limits. The univariate, bivariate and multivariate analysis were performed to assess the risk factors.

2.11 Ethical consideration

Prior to the commencement of the study ethical clearance was obtained from Muhimbili university of Allied Health Sciences (MUHAS) research and publications committee. In addition to that permission from local Government Authorities was obtained. Informed consent was sought from each individual participant (parents, guardians) before commencement of an interview. Also participants were free to answer some of the questions or end interview at any time when they feel to do so. Moreover all information gathered was handled confidentially.

Chapter 3

Results

3.1 Social-demographic characteristics of the study population

A total of 301 children between the age of 6 months to 59 months were studied with the response rate of 95%, table 5 below shows the distribution of study population by village.

Table 5: Distribution of study population by village in Mkuranga Semi-urban areas, Mkuranga district, 2011

Village	Frequency	Percent(%)	95% CI
Kimanzichana Kusini	62	20.6	16.3-25.7
Kipara	42	14.0	10.3-18.5
Bigwa	41	13.6	10.1-18.1
Kimanzichana Kaskazini	41	13.6	10.1-18.1
Mwandege	37	12.3	8.5-16.7
Tengelea	29	9.6	6.7-13.7
Sunguvuni	28	9.3	6.4-13.3
Kitonga	21	7.0	4.5-10.6
Total	301	100.	

Table 6 shows the distribution of study population by their demographic characteristics. The results showed that about 158(52.5%) of the study population were male and the rest 143(47.5%) were females. The mean age of study population were 2years (standard deviation of 1.3 years).Also about 216 (71.7%) and 279 (92%) were well nourished and ever/currently on breastfeeding respectively.

Table 6: Distribution of study population by their demographic characteristics in Mkuranga Semi-urban areas, Mkuranga district, 2011

Characteristics	Frequency	Percent(%)	95% CI
Sex			
Male	143	47.5	46.7-58.3
Female	158	52.5	41.7 53.3
Age distribution			
6months to 1 year	97	32.2	27.0 -37.9
1 - 3 years	198	65.8	60.1 -71.1
Above three and less 5 years	6	2.0	0.8-4.5
Nutrition status			
Malnourished	85	28.3	23.3 -33.8
Well nourished	216	71.7	66.2 -76.7
Breast feeding (Ever/Currently)			
Yes	279	92.7	89.0-95.3
No	22	7.30	4.7-11.0

3.2 Social demographic characteristic of respondents

Table 7 shows Caretaker's characteristics whereby three quarters (74%) were mothers, with the mean age of 33years (SD of 14 years), 232(77.3) married and about 86(28.6%) had no formal education.

Table7: Distribution of respondents by their demographic characteristics in Mkuranga Semi-urban areas, Mkuranga district, 2011

Characteristics	Frequency	Percentage	95% CI
Relationship of respondent to a child (N=301)			
Aunt	10	3.30	1.7 -6.2
Brother	2	0.70	0.1 -2.6
Father	39	12.60	9.2 -17.0
Grandmother	20	6.60	0.3 -3.1
Grand father	3	1.00	4.2 -10.2
Mother	224	74.10	68.7 -78.9
Others	5	1.70	0.6 -4.1
Age group (N=301)			
<=18	19	6.10	3.6 -9.4
>18 – 38	206	69.00	63.4 -74.2
>38 – 58	52	17.20	13.1 -22.0
>58 – 60	5	1.70	0.5 -3.9
>60	19	6.10	3.6 -9.4
Marital status (N=301)			
Married	232	77.30	72.2 -81.9
Single	46	15.0%	11.2 -19.6
Divorced	2	0.30	0.1 - 2.4
Widowed	16	5.30	3.1 - 8.5
Cohabiting	5	1.70	0.5 - 3.8
Level of education (N=301)			
None	86	28.60	23.6-34.1
Primary	188	62.50	56.7-67.9
Secondary	26	8.60	5.8-12.5
College+	1	0.30%	0.0-2.1

3.3 Social economic characteristics of households

Table8 shows the social economic characteristics, it was found that about 152(52.7%) of household use pit latrine with slab, 246(81.7%) have no electricity connection, 222(73.8%) have radio, 269(89.4%) have no refrigerator, 187(62.1%) their houses are built with temporally building materials and 179(59.7%) wash hands with soap

Table 8: Social Economic Characteristics of caregivers in Mkuranga Semi-urban areas, Mkuranga district, 2011

Characteristics	Frequency	Percentage	95%CI
What type of toilet do household members normally use?(N=301)			
Flush/Pour flush to septic tank	11	3.40	1.6 -6.1
Flush/Pour flush to pit latrine	16	5.40	3.1 -8.6
Flush/pour flush to else where	13	4.40	2.3 -7.3
Ventilated improved pit latrine	6	1.70	0.5 -3.9
Pit latrine with slab	157	52.70	46.8 -58.5
Pit latrine without slab/open pit	93	31.20	26.0 -36.8
No facility/bush	5	1.30	0.4 -3.4
Radio?(N=301)			
Yes	222	73.80	68.4-78.60
No	79	26.20	21.4-31.70
Refrigerator?(N=301)			
Yes	32	10.60	7.5-14.80
No	269	89.40	85.3%-92.60%
House unit building material (N=301)			
Temporary	187	62.10	56.4-67.60
Permanent	114	37.80%	32.1-43.30
Do you use soap for hand washing following house activities(N=301)			
Yes	179	59.70	53.9 -65.3
No	122	40.30	34.7-46.1

3.4 Reported prevalence of under five diarrhoea

Table 9 shows the prevalence of diarrhoea in the community. The results showed that about 98(32.7%) reported diarrhoea among their children in two week period prior to data collection.

Table 9: Prevalence of reported under five diarrhoea Mkuranga Semi-Urban areas, Mkuranga district, 2011

Characteristics	Frequency	Percentage	95% CI
Did the child experience Diarrhoea in the past 2 weeks?(N=301)			
Yes	98	32.70	27.4 -38.3
No	203	67.30	61.7 -72.6

3.5 Household water sources and water treatment practices

Table 10 shows distribution of household and sources of drinking water .The results show that about 160(53.6%) of the household depend on water from shallow wells and 141(46.8%) from deep well.

Table10: Frequency distribution of household sources of drinking water Mkuranga Semi-Urban areas, Mkuranga district, 2011

Water source	Frequency	Percentage
Deep well	141	46.8
Shallow well	160	53.2
Total	**301**	**100**

Table 11 shows household water treatment practices, it was found that about 149(49.5%) of households reported treating water with any method (boiling, strain on cloth, use of chlorine and Let it stand and settle), one hundred fifty two households do not treat (50.5%) their drinking water and the common reasons given for not treating were belief that the water is safe from the source 44(29.8%), knowledge of existing methods of water treatment 40(27.8%) and costs 37(26.3%)

Table 11: Household Water treatment practices Mkuranga Semi-Urban areas, Mkuranga district, 2011

	Frequency	Percentage	95% CI
Do you do anything to make water safer to drink?(N=301)			
Yes	149	49.5	38.3 -59.2
No	152	50.5	48.2 -61.8
Why don't you treat your drinking water?(N=152)			
I do not know any method of treatment	40	27.8	21.7-34.6
Costs	37	26.3	20.3-33.0
Bad taste and smell of treated water	2	1.0	0.1-3.6
Belief that water is safe from the source	44	29.8	23.5-36.7
Used to drink untreated, nothing happen to us	12	7.6	4.3-12.2
I don't know	10	5.1	2.4-9.1
Others	7	2.5	0.8-5.8

3.6 Water treatment and storage options

Table12 shows water treatment and storage options whereby boiling and Let it stand and settle methods were frequently practiced as methods for water treatment, 65(43.6%) and 60(40.3%) respectively. About five respondents (3.4%) reported using chlorine (water guard). Also 228(76%) reported to store their drinking water in bucket with lid, 37(12.3%) in bucket without lid the minority of respondents reported using small pans, soil pot and jerry cans as drinking water storage containers.

Table 12: Household water treatment and safe storage Options (HWTS) Mkuranga Semi-Urban areas, Mkuranga district, 2011

	Frequency	Percentage	95% CI
What do you normally do to make water safe to drink (N=149)			
Boiling	65	43.6	35.5 - 52.0
Use of chlorine	5	3.4	1.1 - 7.7
Let it stand and settle	60	40.3	32.3 - 48.6
Strain with cloth	19	12.8	7.9 - 19.2
Which container do you normally store water for drinking (N=301)			
Bucket with a lid	228	76.0	70.8 - 80.7
Bucket without a lid	37	12.3	8.8 - 16.6
Small pans without lid	1	0.3	0.0 - 1.8
Jerry cans without lid	7	2.3	0.9 - 4.7
Soil pot without lid	27	9.0	6.0 - 12.8
How do you draw water for drinking from containers (N=301)			
Use small pan	17	5.7	3.3 -8.9
Use a cup	278	93.0	89.5-95.6
Others(jug etc)	6	1.3	0.1-2.4

3.7 Relationship between reported under five diarrhoea and demographic and economic characteristics

Table 13 shows relationship between diarrhoea and demographic and economic characteristics. Diarrhoea was significantly associated with education of caretakers, breast feeding and caretakers washing their hands with soap after household activities .Other factors showed no significant relationship

Table13: Relationship between diarrhoea and demographic and economic factors, Mkuranga Semi-urban area 2012

Characteristics		N	OR	95% CI	P value
Demographic characteristic of study population					
Sex	Male	142	1.01	0.62-1.65	0.945
	Female	157	1		
Age	Up to 1year	97	1.05	0.62-1.75	0.97
	Above 1 and less than 5years	204	1		
Nutrition status	Malnourished	85	1.5	0.90-2.50	0.07
	Well nourished	216	1		
Breast feeding	Ever /.current breast feeding	279	0.22	0.08-0.55	0.001*
	Never	22	1		
Demographic characteristics of respondents					
Age	Less than 20years	53	1.01	0.52-1.95	0.89
	More than 20	248	1		
Respondent relationship	Mother	224	1.57	0.88-2.80	0.16
	Other	77			
Marital status	Married	236	1.59	0.85-2.98	0.185
	Single	65			
Education	No formal	86	2.03	1.2-3.4	0.005*
	Formal	215	1		
Economic characteristics					
Presence of hygiene toilet	Yes	205	1.19	0.71-2.0	0.57
	No	96	1		
Electricity?	Yes	55	0.58	0.29-1.14	0.155
	No	246	1		
Own a Radio	Yes	221	0.91	0.52-1.57	0.846
	No	80	1		
Own refrigerator?	Yes	32	0.93	0.42-2.05	0.985

	No	269	1		
House unit building materials	Temporally	187	1.58	0.95-2.64	0.103
	Permanent	114	1		
Hand washing with soap following house activities	Yes	180	0.38	0.23-0.63	0.0001*
	No	121	1		

***Factor statistically significant at p<0.05**

3.8 Bivariate analysis on relationship between HWTS and reported diarrhoea

Table 14 shows the bivariate analysis on the relationship between diarrhoea and water treatment and safe storage options. It was found that water treatment with any method was significantly protective by 51% against diarrhoea among under five children. Treatment by boiling had a protective factor of 61% to diarrhoea. Other methods did not show any significant association toward diarrhoea diseases to children under five years. Also storing water in a bucket with lid was significantly protective with the protective factor of 69% and storing water in bucket without lid significantly increased the risk to diarrhoea. Moreover diarrhoea related with the mechanism of drawing water for drinking in which using a cup had a protective effect of 66% while using small pan increased the risk to diarrhoea by four folds refer table 14 below.

Table 14: Relationship between reported under five diarrhoea and water treatment and storage practices Mkuranga semi-urban areas Mkuranga district, 2011.

				Under five diarrhoea status	
Characteristics		**N**	**OR**	**95% CI**	**P-v alue**
Treatment with any method	Yes	149	0.49	0.28-0.84	0.00*
	No	152	1		
Treatment by boiling	Yes	65	0.39	0.20-0.77	0.00*
	No	236	1		
Treatment by Chlorine	Yes	5	0.51	0.05-4.67	0.47
	No	296	1		
Treatment by Strain on Cloth	Yes	19	0.37	0.10-1.3	0.11
	No	282	1		
Treatment by local Let it stand and settle	Yes	60	1.14	0.63-2.07	0.33
	No	241	1		
Water storage methods					
Bucket with lid	Yes	228	0.31	0.17-0.53	0.00*
	No	73	1		
Jerry cans without lid	Yes	7	0.33	0.04-2.84	0.273
	No	294	1		
Soil pot without lid	Yes	27	2.05	0.93-4.56	0.04
	No	274	1		
Use a cup to draw water	Yes	278	0.34	0.14-0.8	0.02*
	No	23			
Source of drinking water	Deep well	141	0.57	0.34-0.95	0.03*
	Shallow well	160	1		

3.9 Multivariate analysis

Table15 shows predictor model for under five diarrhoea by including all factors that had a $p<0.05$ in bivariate analysis in order to establish the final model and adjust for confounding variables. Treating water by boiling, storing water in covered containers (bucket with lid) and guardians/parents washing hands with soap following household activities and whether a child ever breast fed or currently on breast feeding were found significantly associated with under five diarrhoea.

Table 15: Model of under five diarrhoea logistic model Mkuranga semi-urban areas Mkuranga district, 2011.

Predictor variables		**N**	**AOR**	**95%CI**	**p value**
Treat water by boiling	Yes	65	0.53	0.24-0.89	0.04*
	No	236	1		
Store water in bucket with lid	Yes	226	0.33	0.15-0.72	0.005*
	No	40	1		
Draw water using a cup	Yes	278	0.37	0.13-1.08	0.07
	No	23	1		
Water stored in Soil pot without lid	Yes	27	0.93	0.34-2.53	0.89
	No	274	1		
Guardians/parents wash hands with soap following house activities	Yes	180	0.41	0.24-0.83	0.006*
	No	121	1		
Child ever/currently on breast feeding	Yes	279	0.24	0.09-0.65	0.00*
	No	22	1		
Education of parents/guardians	No formal	86	1.9	1.08-3.50	0.02*
	Formal	215	1		
Source of drinking water	Shallow well	160	1.14	0.61-2.11	0.67
	Deep well	141	1		

3.10 Reasons for use of different water treatment options at household level

Table 16 shows reasons pointed out for use of different water treatment options at household level whereby the common reason for boiling water 25(%) was not aware of another treatment option. Four out of five households who reported chlorinating their drinking water believed this option to be effective while six out of 19 (33.3%) households that strain water with a cloth reported that this method was preferred by family members

Table 16: Reasons for use of different water treatment options Mkuranga Semi-Urban areas, Mkuranga district, 2011

Treatment option	Don't know other option (%)	Cheap (%)	Method is effective (%)	Others (%)	Total
Boiling	25(37.9%)	20(31.0%)	12(19.0%)	8(12.1%)	65
Chlorine	0(0.0%)	1(20.0%)	4(80.0%)	0(0.0%)	5
Let it stand and settle	19(33.3%)	14(24.1%)	17(25.9%)	10(16.7%)	60
Strain in cloth	5(27.8%)	5(27.8%)	2(11.1%)	7(33.3%)	19

3.11 Bacterial contamination of various water treatment and storage options

Table 17 shows status of bacterial contamination of drinking water by looking at two parameters that is E. coli and total coli forms. Out of 301 water samples tested 112 (37.2%) were feacally contaminated with E. coli count from one colony forming unit (cfu) and above per 100ml of water. Similarly about 78% of samples had total coli form and about 68% samples tested total coli form count exceeded 50cfu per 100ml of water tested. Based on these results only 20.9% samples were within the acceptable drinking water standards

Table17: Status of bacterial contamination of drinking water in Mkuranga Semi-Urban areas, Mkuranga district, 2011

Lab. Parameter	Number of samples	Percentage	95% CI
E.COLI(cfu)			
0	189	62.8	57.1 -68.3
1+	112	37.2	30.6-45.4
TOTAL COLI (cfu) (N=301)			
0	65	21.6	17.2 -26.8
1-50	30	10.0	6.9 -14.1
50+	206	68.4	62.9-73.7
Water safety remarks (N=301)			
Acceptable	63	20.9	16.6-26.1
Not acceptable	238	79.1	74.0 -83.5

Table 18 compares the number of samples which had no detectable E.coli / total coli forms (acceptable) as per water treatment method used. The proportional of samples with water within unacceptable level of bacterial contamination varied by treatment method highest being strain in cloth 17/19 (89.5%) followed by use of chlorine four out of five samples tested (80%), Let it stand and settle 43/60 (71.7%) and the least was boiling 43/65 (66.2%)

Table18: Level of bacterial contamination of various water treatment methods Mkuranga semi-urban, Mkuranga district 2011

Water treatment methods	**Level of bacterial contamination**		
	Acceptable level (%)	**Not acceptable (%)**	**Total**
Boiling	22(33.8%)	43(66.2%)	65
Use of chlorine	1(20.0%)	4(80.0%)	5
Let it stand and settle	17(28.3%)	43(71	60
Strain with cloth	2(10.5%)	17(89.5%)	19
TOTAL	**42**	**107**	**149**

Table 19 compares the number of water samples without detectable level of E.coli/Total coli forms (acceptable) as per storage containers used. It was found that storing water in bucket without lid had many sample within unacceptable bacterial level of 89.2%, followed by Soil pot (88.9%), Jerry cans 85.7% and the least was bucket with lid (75.9%) .

Table 19: Level of bacterial contamination of various drinking water storage containers mkuranga semi-urban, Mkuranga district 2011

Drinking water storage containers	**Level of microbial contamination**		
	Acceptable level (%)	**Not acceptable (%)**	**Total**
Bucket with a lid	55(24.1%)	173(75.9%)	228
Bucket without a lid	4(10.8%)	33(89.2%)	37
Small pans	0(0.0%)	1(100%)	1
Jerry cans	1(14.3%)	7(85.7%)	8
Soil pot	3(11.1%)	24(88.9%)	27
TOTAL	**63**	**238**	**301**

Table 20 shows the relationship between bacterial contamination and under five diarrhoea. It was found that household which used drinking water with detectable E.coli and Total coli forms their children were 21 times likely to significantly develop diarrhoea as compared to that drinking water without microbial contamination.

Table 20: Relationship between bacterial contamination and under five diarrhoea Mkuranga semi-urban area, Mkuranga district 2011

Lab. results	Diarrhoea		OR (95%CI)	p value
	Yes	No		
Not acceptable	40.4%	59.6%	20.64(5.82-128.3)	p<0.001
Acceptable	3.2%	96.8%		

Chapter 4
Discussion

4.1 Prevalence of Diarrhoea

The prevalence of reported under five diarrhoea was found to be 32.7% higher than what was reported by Mkuranga District Health Profile of 12% in the year 2010.The difference in prevalence is due to the fact that the district include only diarrhoea reported at health facility. The fact that it is not common for all diarrhoea cases to be captured at health facilities, it will depend on community health care seeking behaviour. Other diarrhoea cases are managed at home or at traditional health attendant the data which will miss in the health records thus underestimating the magnitude of diarrhoea in the community. So the observed prevalence might be the true prevalence of diarrhoea in Mkuranga semi –urban areas. Also in Ethiopia a study for environmental determinants of diarrhoea among under five children in Nekemte town a semi-urban area found a prevalence of under five diarrhoea of about 28.9% almost similar to the present study [33], also the study by Issaka Kanton [10] in Ghana found a prevalence of under five diarrhoea to be 38%.

4.2 Household water treatment and storage options

The study also determined the proportional of respondents who treat water for drinking with any method locally available and accessible to them. It was found that about 49.5% reported treating their water with any method (boiling, strain in cloth, use of chlorine and Let it stand and settle).Water treatment by boiling and Let it stand and settle were frequently practiced by respondents as methods of water treatment, fewer reported using water guards and strain in cloth (Table 12).

The reasons pointed out for not treating drinking water with any method were belief that water is safer from the source, knowledge of existing water treatment methods and costs (Table 12).Also the majority of respondents reported using buckets, Soil pot, jerry cans and small pan for storing drinking water. The proportional of water treatment recorded by this study was higher than that was found by study done in Arusha by in 2009, but within the range indicated in the Tanzania Demographic Health Survey of 2010

In Egypt it was found that 5.9% of households treated their water with any method (95%CI 5.2-6.7%) filtration and let it stand and settle were the common methods practiced [76]. Also in study done by Ghislaine Rosa by extracting data from national surveys and reports on scope of HWT in 67 countries indicated that the proportion of water treatment by boiling in Uganda were 39.8% and Zambia (15.2%) whereby in Latin America chlorine is practiced by 17.1% of the households while Guinea Bissau (70.9%) and Mali (24.0%) strain drinking water through cloth[34]

4.3 Reasons for use of different water treatment methods

The study further identified the factors for the use of different water treatment methods. In this case it was found that the majority who boil their water do so because the method is cheap and they do not know other options, those who use chlorine believe that the method is effective, Let it stand and settle do not know other option and that the method is cheap and those straining in clothing do so because family members prefer the method (table16).The explanation for the observed findings is that in Coastal region that include Mkuranga the availability of fuel especially firewood is not a problem because of presence of bushes and tree where people can go to chop firewood free that is why boiling was found to be cheap.

The present study has noted key areas for intervention that is where the people reported that they do not know other methods of water treatment. And if some respondents prefer strain in cloth then we can promote filtration and improved Let it stand and settle using flocculants disinfectant and ceramic filters. Households that report treating their water simply by strain through a cloth or let it stand and settle methods that are unlikely to render water microbiologically safe under most circumstances. This suggests that a substantial number of households are committing time and effort to treat their water, although these methods have proved little effectiveness at improving the microbiological quality of water. Research has shown that many householders judge the quality and safety of their drinking water based on aesthetics (suspended solids, colour, odour, and taste) [35, 57]

4.4 Relationship between water treatment and Storage options and reported diarrhoea

The study moreover determined the relationship between under five diarrhoea and other independent variables. Water treatment by any method protected children against diarrhoea by 51% protective factor and water treatment by boiling protected children by 61% that is 10 fold higher than any method. Chlorination, Let it stand and settle and straining on clothing showed no significant impact on diarrhoea disease among children. Water treatment by boiling is known to be effective against a full range of microbial pathogens and that can be employed regardless of turbidity or dissolved constituents of water. The findings of this study are supported by study done for evaluating effectiveness of water treatment methods[15] Treatment by chlorination were not found to be significant in reduction of diarrhoea disease among children this might be due to human factors like proper dosing for residual chlorine. The ineffectiveness of chlorine under field conditions was also observed in a study done in 2009 [74].The alternative explanation for the present study may be due to small sample size were by only five respondents reported to use chlorine as method of water treatment.

Proper storage especially using container with a lid (bucket with lid) was also found protective against diarrhoea diseases by 69% and storing water in bucket without lid increased the risk to diarrhoea other storage containers without lid had no significant impact on diarrhoea disease among children under the age of five years. This can be explained by the fact that once the container is not covered it allows cross contamination different from the covered containers. The findings emphasize the need for storing our drinking water in covered containers. These findings are supported by study done in Malawi in which the improved bucket for storing drinking water had a reduction of diarrhoea among children under five by 31% .[52] Also the study done in Bolivia[52] on proper storage the results were similar to the present study whereby proper storage exhibited less E. Coli contamination and families in the intervention had 43% fewer diarrhoea in Intervention group than in control group.

The logistic regression shown on (table 15) suggested that point of use water treatment especially boiling had a greater association on reduction of under five diarrhoea where the

majority of care takers have formal education, store their water on covered containers, wash their hands with soap following house activities and breast feeding. Well nourished children decreases susceptibility to many childhood illness including diarrhoea. Moreover water sources were found not significant related to diarrhoea.

4.5 Bacterial contamination of various water treatment and storage methods

The study also has documented the level of bacterial contamination among different water treatment and storage options.

The study found that 37.2% of all samples tested were fecally contaminated with the mean E.Coli count of 2.6cfu/100ml of water (Standard deviation± 4.8cfu).Also about 78% of all samples tested had total coli forms with the mean total coli form count of 69.9cfu/100ml (SD=±43.2cfu).Based on the laboratory results and WHO guidelines for drinking water quality of 2004 only 20.9% were within the acceptable drinking water quality standards. It was noted that respondents who were using water within unacceptable WHO standards reported diarrhoea among their under five children 21 times as compared to those drinking water within acceptable WHO standards in terms of bacterial contamination (table 20) .Further analysis through logistic regression still showed significant association to diarrhoea disease by 20 times as compared with drinking water within acceptable standards (table21).

Treating water through straining in cloth, use of chlorine and letting it stand and settles had higher proportions of their samples within unacceptable level while boiling exhibited fewer samples in not acceptable level (table18).The presence of bacteria in treated water can be explained by the fact that some of the methods like strain in cloth, letting water stand and settle are not effective against bacteria in water. Also the ineffectiveness of chlorine was also found in 2009 study in which the author suggested that it might be due to human factors such as proper dosing[74]. In order chlorine to be effective residual chlorine of 0.2mg/L should be maintained. In case of boiling, the boiled water can be easily contaminated through mishandling especially through cross contamination using handlers unhygienic hands. A study among Tanzanian mothers the researcher found a Geometric mean increases in colony forming units per two hands ranged from 50 (cleaning dishes) to

6310 (food preparation)[2].Therefore if precautions are not taken while handling drinking water then contamination might occur.

Water stored in bucket without lid recorded high proportional of water samples within unacceptable standards followed by soil pot, jerry cans and the least was bucket with lid. These findings suggest that bacterial contamination vary by how water is stored, that is respondents storing their drinking water in containers with lid (bucket with a lid) had a difference of 10% less than those who store water in open containers. These findings highlight the importance of covering our drinking water to avoid cross contamination. These findings are not similar to study done in Malawi were all drinking water samples collected in two villages (100%) tested coli form positive and 90% tested E. coli positive[12]

4.6 Limitations of the study

Being cross sectional it is reliable to biases when determining the associations of independent variable to dependent a more analytical study is needed to compliment this study.

Chapter 5

Conclusion and Recommendations

5.1 Conclusion

There is a significant association between under five diarrhoea and point of use water treatment and safe storage. There are also locally available treatment methods which some are effective and others not. We can use that opportunity to promote water treatment and storage practices which are effective and still benefit from the gain of preventing diarrhoea among our children under the age of five years.

5.2 Recommendations

1. Health education should be provided on the importance of treating water by boiling and storing them in covered containers.
2. Advocacy should be done on other effective methods of water treatment approved by WHO to replace less effective local methods currently practiced
3. The advocacy on hand hygiene with detergent (soap) to children care takers should be emphasized as it protects the children against diarrhoea.
4. Since the people prefer strain their water in cloth because it is not related to objectionable odour it is the high time to promote filtration by ceramic filters.

References

1. Arnold B, Colford J (2007). Treating water with chlorine at point-of-use to improve water quality and reduce child diarrhoea in developing countries: a systematic review and meta-analysis. Am J Trop Med Hyg. 76(2):354-64
2. Amy J.Pickering etal (2011).Bacterial Contamination among Tanzanian mothers varies temporally and following household activities, Journal of tropical Medicine and International Health ,Vol.16,No.2 pp233-239
3. Brown J, Sobsey M (2007). Use of Ceramic water filters in Cambodia. Field Note. Washington, DC: WSP/Unicef
4. Boschi-Pinto, C, Velebit, L. And Shibuya, K. (2008). Estimating child mortality due to diarrhoea in developing countries. Bulletin of the World Health Organization ; vol. 86, no. 9 ; p. 710-717.
5. Byers KE, Guerrant RL, Farr BM. Fecal-oral transmission. In:Thomas JC, Webber DJ editor(s). *Epidemiologic Methods for the Study of Infectious Diseases*. Oxford: Oxford University Press, 2001:228–48.
6. Clasen T, Boisson S (2006a). Household-based ceramic water filters for the treatment of drinking water in disaster response: an assessment of a pilot programme in the Dominican Republic. Water Practice & Tech. 1:2 doi:10.2166/WPT.2006031
7. Clasen T, Roberts I, Rabie T, Schmidt W, Cairncross S (2006a). Interventions to improve water quality for preventing infectious diarrhoea (a Cochrane Review). In: The Cochrane Library, Issue 3, 2006. Oxford: Update Software
8. Clasen T, Haller L, Walker D, Bartram J, Cairncross S (2007). Cost-effectiveness analysis of water quality interventions for preventing diarrhoeal disease in developing countries. J. Water & Health 5(4):599-6

9. Doocy S, Burhnam G (2006). Point-of-use water treatment and diarrhoea reduction in the emergency context: an effectiveness trial in Liberia. *Trop Med Int Health*. 11(10):1542-52

10. Issaka Kenton Osumanu (2007)Household environmental and behavioural determinants of childhood diarrhoea morbidity in the Tamale Metropolitan Area (TMA), Ghana, Danish Journal of Geography 107(1):59-68

11. Fewtrell L, Kaufmann R, Kay D, Enanoria W, Haller L , Colford J (2005). Water sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *Lancet Infect. Dis.* 5:42-52

12. George C(unpub) assessment and comparison of microbial quality of drinking water in Chikwawa, Malawi ,University of Strathclyde, Department of Civil Engineering :*E-mail*: g.c.c.jabu@strath.ac.uk

13. Hijnin WA, Schijven JF, Bonne P, Visser A, Medema GJ (2004). Elimination of viruses, bacteria and protozoan oocysts by slow sand filtration. *Water Sci Technol* 50(1):147-5

14. Sobsey MD (2002). *Managing water in the home: accelerated health gains from improved water supply*. Geneva: TheWorld Health Organization (WHO/SDE/WSH/02.07)

15. Souter PF, Cruickshank GD, Tankerville MZ, Keswick BH, Ellis BD, Langworthy DE, Metz KA, Appleby MR,Hamilton N, Jones AL, Perry JD. Evaluation of a new water treatment for point-of-use household applications to remove microorganisms and arsenic from drinking water. *J Water Health*1(2):73-84

16. Stauber CE, Elliott MA, Koksai F, Ortiz GM, DiGiano FA Sobsey MD (2006). Characterisation of the biosand filter for E. Coli reductions from household drinking water under controlled laboratory and field use conditions. *Water SciTechnol*. 54:1-7

17. Wright J, Gundry S, Conroy (2003). Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. *Trop. Med. & Int'l Health* 9(1):106-17.

18. Daniele S. Lantagne, Robert Quick, and Eric D. Mintz, Household Water Treatment and Safe Storage Options in Developing Countries: A Review of Current Implementation Practices

19. Cairncross S (2003). Water supply and sanitation: Some misconceptions. *Tropical Medicine and InternationalHealth*, 8:

20. Chiller TM et al. (2006). Reducing diarrhea in Guatemalan children: A randomized controlled trial of a flocculant-disinfectant for drinking water. *Bulletin of the World Health Organization*, 84(1):28–35.

21. Clasen T (2002). The public–private partnership for the Central American handwashing initiative: Reflections from a private sector perspective. *Tropical Medicine and International Health*, 7:197–200.

22. Clasen T (2006). *Household water treatment for preventing diarrhoeal disease* [PhD thesis]. London, London University, London School of Hygiene & Tropical Medicine.

23. Clasen T, Cairncross S (2004). Household water management: Refining the dominant paradigm. *Tropical Medicine and International Health*, 9(2):1–5.

24. Clasen T, Edmondson P (2006). Sodium dichloroisocyanurate (NaDCC) tablets as an alternative to sodium hypochlorite for the routine treatment of drinking water at the household level. *International Journal of Hygiene and Environmental Health*, 209:173–181

25. Clasen T, Menom S (2007). Microbiological performance of common water treatment devices for household use in India. *International Journal of Environmental Health Research*, 17(2):1–11

26. Clasen T et al. (2007a). Cost-effectiveness analysis of water quality interventions for preventing diarrhoeal disease in developing countries. *Journal of Water and Health*, 5(4):599–608.

27. Clasen T et al. (2007b). Household-based chlorination of drinking water using sodium dichloroisocyanurate (NaDCC) tablets: A randomized, controlled trial to

assess microbiological effectiveness in Bangladesh.*American Journal of Tropical Medicine and Hygiene*, 76(1):187–192.

28. Clasen T et al. (2008a). Microbiological effectiveness and cost of disinfecting water by boiling in semi-urban India. *American Journal of Tropical Medicine and Hygiene*, 79(3):407–413.
29. Clasen T et al. (2008b). Microbiological effectiveness and cost of boiling to disinfect water in rural Vietnam. *Environmental Science and Technology*, 42(12):4255–4260.
30. Clasen T et al. (2009). Comment on Household water treatment in poor populations: Is there enough evidence for scaling up now? *Environmental Science and Technology* (in press).
31. Crump JA et al. (2005). Household based treatment of drinking water with flocculant-disinfectant for preventing diarrhea in areas with turbid source water in rural western Kenya: Cluster randomized controlled trial.*British Medical Journal*, 331(7515):478–484.
32. Feachem RG et al. (1983). *Sanitation and disease: Health aspects of excreta and wastewater management.* London, John Wiley & Sons.
33. Girma R.etal ,2008 Environmental Determinants of diarrhoeaamong underfive children in Nekmte town,Western Ethiopia:Ethiop J.Health Sci,Vol.18,No.2
34. Ghislaine Rosa and Thomas Clasen(2010),Estimating the scope of household water treatment in low and Medium income countries AM.J.Trop.med.hyg,82(2) pp.289-300.
35. Griffith DC, Kelly-Hope LA, Miller MA. Review of reported cholera outbreaks worldwide, 1995–2005. American Journal of Tropical Medicine and Hygiene. 2006;75:973–977. [PubMed]
36. Jim Wright and Stephen Gundry (2009) Household characteristics associated with home water treatment analysis of Egyptian Demographic and Health survey,Journal of water and health Vol.7.1

37. Kols A , 2009 . *Supply and Demand for Household Water Treatment Products in Andhra*

Pradesh, Karnataka, and Maharashtra,India. PATH. A Catalyst for Global Health . Seattle, WA

38. LECLERC, H., SCHWARTZBROD, L. & DEI-CAS, E. (2002). Microbial agents associated with water borne diseases. *Crit Rev Microbiol* 28, 371-409.

39. Lijima Y et al. (2001). Prevention of bacterial diarrhea by pasteurization of drinking water in Kenya.*Microbiology and Immunology*, 45(6):413–416.

40. Luby SP et al. (1999). Limited effectiveness of home drinking water purification efforts in Karachi, Pakistan. *International Journal of Infectious Diseases*, 4:3–7.

41. Luby S et al.(2001). A low-cost intervention for cleaner drinking water in Karachi, Pakistan. *International Journal of Infectious Diseases*, 5(3):144–150.

42. Luby SP et al. (2006). Combining drinking water treatment and hand washing for diarrhoea prevention, a cluster randomised controlled trial. *Tropical Medicine and International Health*, 11(4):479–489.

43. Makutsa P et al. (2001). Challenges in implementing a point-of-use water quality intervention in rural Kenya. *American Journal of Public Health*, 91(10):1571–1573.

44. McGuigan KG et al. (2006). Batch solar disinfection (SODIS) inactivates oocysts of *Cryptosporidium parvum* and cysts of *Giardia muris* in drinking water. *Journal of Applied Microbiology*, 101(2):453–463.

45. Migele J et al. (2007). Diarrhea prevention in a Kenyan school through the use of a simple safe water and hygiene intervention. *American Journal of Tropical Medicine and Hygiene*, 76(2):351–353.

46. Mintz E, Reiff F, Tauze R (1995). Safe water treatment and storage in the home: A practical new strategy to prevent waterborne disease. *JAMA: The Journal of the American Medical Association*, 273:948–953.

47. Mintz E et al. (2001). Not just a drop in the bucket: Expanding access to point-of-use water treatment systems. *American Journal of Public Health*, 91(10):1565–1570.

48. O'Reilly CE et al. (2008). The impact of a school-based safe water and hygiene programme on knowledge and practices of student and their parents: Nyanza Province, western Kenya, 2006. *Epidemiology and Infection*, 136(1):80–91.
49. Quick RE et al. (1999). Diarrhoea prevention in Bolivia through point-of-use water treatment and safe storage: A promising new strategy. *Epidemiology and Infection*, 122(1):83–90.
50. Quick RE et al. (2002). Diarrhoea prevention through household-level water disinfection and safe storage in Zambia. *American Journal of Tropical Medicine and Hygiene*, 66(5):584–589.
51. Reller ME et al. (2003). A randomized controlled trial of household-based flocculant-disinfectant drinking water treatment for diarrhoea prevention in rural Guatemala. *American Journal of Tropical Medicine and Hygiene*, 69:411–419.
52. Roberts L et al. (2001). Keeping clean water clean in a Malawi refugee camp: A randomized intervention trial. *Bulletin of the World Health Organization*, 79:280–287.
53. Schmidt W, Cairncross S (2009). Household water treatment in poor populations: Is there enough evidence for scaling up now? *Environmental Science and Technology*, 43(4):986–992.
54. Sur D, Manna B, Deb AK, Deen JL, Danovaro-Holliday MC, et al. Factors associated with reported diarrhoea episodes and treatment-seeking in an urban slum in Kolkata, India. Journal of Health, Population and Nutrition. 2004;22:130–138.
55. Sobsey MD (2002). *Managing water in the home: Accelerated health gains from improved water supply*. Geneva, World Health Organization (WHO/SDE/WSH/02.07).
56. Souter PF et al. (2003). Evaluation of a new water treatment for point-of-use household applications to remove micro-organisms and arsenic from drinking water. *Journal of Water and Health*, 1(2):73–84.
57. USAID, 2006 . *Bringing Consumers to the Table: Perceptions and Practice of Household Water Treatment Methods in Nepal. Hygiene Improvement Project* . Washington, DC : USAID .

58. United Nations (2000). *United Nations Millennium Declaration*. General Assembly Resolution55/2,http://www1.umn.edu/humanrts/instree/millennium.html).
59. WHO (2004b). *Guidelines for drinking-water quality. Vol. 1. Recommendations.* Geneva, World Health Organization.
60. WHO (2007). *Combating waterborne disease at the household level.* Geneva, World Health Organization.
61. WHO (2008a). *The global burden of disease: 2004 update.* Geneva, World Health Organization
62. WHO/UNICEF (2008b). *Progress on drinking water and sanitation: Special focus on sanitation*. Geneva, World Health Organization; and New York, United Nations Children's Fund.
63. World Health Organization(199), *The Evolution of Diarrhoeal and Acute Respiratory Disease Control at WHO*, WHO, Geneva
64. World Health Organization, 'Safe Water, Better Health', WHO, Geneva, 2008, http://www.who.int/quantifying_ehimpacts/publications/saferwater/en/index.html, accessed June 2009.
65. Kosek M, Bern C, Guerrant RL. The global burden of diarrhoeal disease, as estimated from studies published between 1992 and 2000. Bull World Health Organ 2003;81: 197-204.
66. Ministry of Health and Social Welfare, Health management information System report of 2010 (Unpub)
67. Ministry of Health and Social Welfare, Health management information System report of 2009 (Unpub)
68. Mkuranga District Health Profile report of 2010 (Unpub)
69. Tanzania Demographic Health Survey report of 2010:www.Tanzania National Beural of statistics.
70. Jensen, P.K., Ensink, J.H., Jayasinghe, G., van der Hoek, W., Cairncross, S. And Dalsgaard, A., 2003. Effect of chlorination of drinking-water on water quality and childhood diarrhoea in a village in Pakistan. *Journal of health, population andnutrition*, 21 (1), 26-31.

71. Gasana, J., Morin, J., Ndikuyeze, A. and Kamoso, P., 2002. Impact of water supply and sanitation on diarrheal morbidity among young children in the socioeconomic and cultural context of Rwanda (Africa). *Environmental research*,90 (2), 76-88.
72. Kremer, M. et al., 2009, Spring Cleaning: Rural Water Impacts, Valuation, and Institutions. Available from:http://www.economics.harvard.edu/faculty/Kremer/files/SIP_2009.03.08-EMCLEAN.pdf (accessed 7 July 2009).
73. Stauber, C.E., Ortiz, G.M., Loomis, D.P. and Sobsey, M., 2009. A randomized controlled trial of the concrete biosand filter and its impact on diarrheal disease in Bonao, Dominican Republic. *American journal of tropical medicine and hygiene,* 80 (2), 286-293
74. Laura A LA McLaughlin, Karen K Levy, Nicola K NK Beck, Gwy-Am GA Shin, J Scott JS Meschke and Joseph N JN Eisenberg J Environ Health **71**(8):48-53 (2009),
75. Jim Wright & Gundry, SW. 'Household characteristics associated with home water treatment: an analysis of the Egyptian Demographic and Health Survey', *Journal of Water and Health*, **7**, (pp. 21-29), 2009. 10.2166/wh.2009.056

Appendices

Appendix 1: Informed consent form – English version

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES DIRECTORATE OF RESEARCH AND PUBLICATIONS

Title: Determination of the factors associated with under five diarrhoea in relation to Household water treatment and Safe Storage in Mkuranga District Pwani Region.

ID-NO ☐☐☐

Consent to participate in this study

Greeting! My name is …….. I am working on this research project with the objective of determining the factors associated with diarrhoea focussing on household water treatment and safe storage. We plan to talk with 400 head of household in this district. We are asking you to take part in this study because you are a patient taking ART at this clinic. You have been selected by chance.

We want you to understand the purpose of this study and your role so you may decide if you want to join. If you join, we will ask you to sign this paper (or if you cannot read/ write, make your mark in front of a witness). Please ask us to explain any words or information that you may not understand.

Information about the research

If you participate we will interview you. We will ask you about your background. We will ask about your children's health and how you prepare your drinking water. We will also ask how you feel. The interview will last about 20 min. After the interview, we will collect sample of your drinking water for quality tests.

Possible risks we will do our best to protect your privacy and study records. Our interview will be private. However, it is possible that others will learn that you joined the research. Because of this, others may treat you unfairly.

The interview questions may cause you to feel some anxiety. You may refuse to answer any question. You may end the interview at any time.

Possible benefits this study has no direct benefits but the results of this study will help to improve interventions against children's diarrhoea and water safety. We do not provide any incentive for water treatment but the interview may advice you on you how you can safely store your water from contamination.

If you decide not to be in the research

You are free to decide if you want to take part in this research or not.

Confidentiality

We will do our best to protect information about you and your part in this research. We will interview you in a private place. We will not write your name on the interview form. We will use your form number to link your interview answers to our water testing laboratory. You will not be named in any reports. Only the study staff and investigators will know your answers to the questions.

Compensation

You will not receive any money by joining this study.

Leaving the research study

You may leave the research at any time. If you leave, it will not change the health care you receive here. If you choose to take part, you can change your mind at any time and withdraw. If so, please tell the research interviewer why you wish to leave.

Your rights as a participant: This research has been reviewed and approved by the Muhimbili University of Allied Health Sciences research and publication committee.

Whom to contact

If you ever have questions about this study, you should contact the study Coordinator or the Principal Investigator Remidius Kakulu, Muhimbili University of Health and Allied Sciences (MUHAS), P.O. Box 65011, Dar es Salaam Mobile no. 0714285692 questions

about your rights as a participant, you may contact/call Dr. Gideon Kwesigabo and Ms. Senga who are supervisors of this study (Mobile:0713-457421 and respectively).

Signature:

Do you agree?

Participant Agrees ☐

Participants disagree ☐

I ---------- have read/understood the contents in this form. I agree to participate in this study.

Signature of participant ----------

Signature of witness (if participant cannot read) ----------

Signature of research assistant ----------Date of signed consent ----------

Appendix 2 - Fomu ya ridhaa

FOMU YA RIDHAA TOLEO LA KISWAHILI

CHUO KIKUU CHA AFYA NA TIBA MUHIMBILI

KURUGENZI YA UTAFITI UTAFITI KUHUSU SABABU ZA UGONJWA WA KUHARISHA KWA WATOTO CHINI YA MIAKA MITANO KWA KUANGALIA UTIBUJI NA UHIFADHI SALAMA WA MAJI YA KUNYWA KATIKA NGAZI YA KAYA WILAYA YA MKURANGA MJINI KATIKA MKOA WA PWANI.

Ridhaa ya kushiriki katika utafiti huu

Salamu! Mimi naitwa …….. .....Ninafanya utafiti kuhusu sababu za ugonjwa wa kuharisha kwa watoto wenye umri chini ya miaka mitano na utibuji na uhifadhi salama wa maji ya kunywa katika ngazi ya kaya.Tumepanga kufanya mahojiano na wakuu wa kaya wapatao 400 ambao tutawapata kwa njia isiyo ya upendeleo yaani bahati nasibu.Kwa njia hiyo ya bahati na sibu kaya yako imekuwa miongoni mwa kaya hizo hivyo tunakuomba ridhaa yako ya ushiriki katika mahojiano haya.

Tungependa uelewe malengo ya utafiti huu na umuhimu wa kushiriki utafiti huu ili uweze kuamua ama kukubali kushiriki au kukataa.Tutakuomba kutia sahihi kwenye fomu hii endapo utakubali kushiriki katika utafiti huu au kama hujui kuandika utaweka alama ya dole gumba mbele ya shahidi.

Maelezo kuhusu utafiti huu.

Endapo utakubali kushiriki tutakuuliza maswali yaliyopo katika dodoso hili.Tutakuuliza kuhusu taarifa binafsi pamoja na masuala ya kiafya ya watoto wako na familia kwa ujumla.Vilevile tutakuuliza namna unavyo andaa nakutunza maji yako ya kunywa katika kaya yako.Baada ya mahojiano tutapenda kuchukua sampli ya maji yako ya kunywa kwa ajili ya kufanya vipimo vya kimaabara juu ya usalama wake.

USIRI:

Nakuhakikishia kuwa taarifa zote tutakazo chukua hazitawekwa bayana kwa mtu yoyote isipokuwa wanofanya kwenye utafiti huu tu. Taarifa yetu itatumia majibu ya vipimo vyetu tu na sivinginevyo.

FAIDA YA UTAFITI HUU:

Hakuna faida ya moja kwa moja utakayoipata kutokana na wewe kushiriki katika utafiti huu, isipokuwa majibu yako ya vipimo vya maji utapewa ili ujue hali ya usalama wa maji yako ya kunywa. Pia vilele matokeo ya utafiti huu yataisaidia Serikali kujua uhusiano uliopo kati ya magonjwa ya kuharisha kwa watoto wadogo na usalama wa maji katika ngazi ya kaya na hivyo kuandaa mikakati ya kuhimiza juhudi za kutakatisha maji.

MADHARA:

Hakuna wasiwasi wa madhara, yoyote yatokanayo na utafiti wetu. Una uhuru pia wa kukataa baadhi ya maswali pia kukataa kushiriki katika utafiti huu wakati wowote. Ni hiari yako kushiriki katika utafiti huu. Uamuzi wako wa kutokushiriki hautakuwa na madhara yoyote kwako ya kupata huduma zako unazostahiri. Wakati wowote unaweza kujitoa katika utafiti huu, hata baada ya kutoa ridhaa yako hapo awali. Kwa kujitoa kwako hakuna adhabu yoyote wala hutanyimwa haki yoyote unayostairi kupata katika jamii.

MAWASILIANO:

Kama una swali lolote unaweza kuwasiliana na mimi Ndugu, Remidius Kakulu kwa kutumia anuani ya Chuo Kikuu Cha Afya na Tiba Muhimbili S.L.P. 65015, Dar es Salaam, Namba yangu ya simu ya kiganjani ni 0714-285692. Ukiwa na swali lolote kuhusu haki yako ya kushiriki utafiti huu unawezo kumpigia Dr. Gideon Kwesigabo kwa simu namba 0713-443212 ambaye ni msimamizi wa utafiti huu au MS.Senga Sembuche 0755-950006 wote watakupa msaada.

SAHIHI:

Je utakubali?

Mhusika amekubali ☐

Mhusika amekataa ☐

Mimi …….. nimesoma na kuelewa kilichoko katika fomu hii. Nakubali kushiriki katika utafiti huu.

Sahihi ya mhusika ……...……

Sahihi ya shahidi (endapo mhusika hajui kusoma) ……

Sahihi ya mtafiti mwandamizi ……

Tarehe ya kusainiwa ridhaa …….....……

Appendix 3 (Questionnaire)

MUHIMBILI UNIVERSITY OF ALLIED HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH AND SOCIAL SCIENCES

QUESTIONNAIRE FOR ASSESSMENT OF FACTORS ASSOCIATED WITH UNDER FIVE DIARRHOEA IN RELATION TO HOUSEHOLD WATER TREATMENT AND SAFE STORAGE MKURANGA DISTRICT IN PWANI REGION, TANZANIA.

ID NO_____DATE OF INTERVIEW_____INTERVIEWER NAME.....VILLAGE_____WARD:_____

NO.	QUESTIONS&FILTERS	CODING CATEGORIES		SKIP
PARTA:DEMOGRAPHIC CHARACTERISTICS				
1	Respondent' status (Only one respondent)	Father	1	
		Mother	2	
		Grand mother	3	
		Grand father	4	
		Other:	5	
2.	Sex (Don't ask the respondent)	Male	1	
		Female	2	
3.	Age of respondent (estimate allowed)	.....Years		
4.	Marital status	Single	1	

		Married	2
		Divorced	3
		Widowed	4
		Widower	5
		Cohabiting	6
5.	level of education (The highest level of education reached)	Primary	1
		Secondary	2
		Colleges+	3
		None	4
6	Does your household have:		yes / No
		Electricity	1 / 2
		Radio	1 / 2
		Television	1 / 2
		Mobile phone	1 / 2
		landline	1 / 2
		Refrigerator	1 / 2
7	What type of fuel does your household normally use for cooking?	Electricity	1
		Gas	2
		Paraffin	3
		Charcoal	4

		Fire wood	5		
		Animal dung	6		
		Other:	7		
8	House unit (FLOOR), record observation	Earth,sand,dung	1		
		Wood,planks,Bamboo,Palm	2		
		Parquet,or polished wood	3		
		Vinyl or Asphalt strips	4		
		Ceramic tiles,Terrazzo	5		
		Cement	6		
		Carpet	7		
		Other:	8		
9	Wall material, record observation.	Grass	1		
		Pole and Mud	2		
		Sun dried bricks	3		
		Baked bricks	4		
		Wood timber	5		
		Cement blocks	6		
		Stones	7		
		Other:	8		
10	Roofing material	Grass/Thatch/Mud	1		

		Iron sheets 2 Tiles 3 Concrete 4 Asbestos 5 Other: 6	
11.	How many people live in your household?	.....	
12.	How many people are under the age of 5?	.....	
13	Age of a child	_____	
14	Sex of the child	1.Male 2.Female	
15	Does this child on breast feeding or breastfed for 2 years before stop.	Yes 1 No 2	
16	Nutrition status (Observe MCH card)	Malnourished 1 Well nourished 2	
17	Have this child under the age of five in your household have diarrhoea in the past 2 weeks (Past 14 days)	Yes 1 No 2 →	Go 15
18	Can you tell me, the biggest problem your family faces? (Don't read to respondents, write only answers)	Poor health 1 Insufficient food 2 Lack of money to meet 3	

		basic need		
		Unemployment	4	
		Homeless	5	
		Lack of access to health services	6	
		Other:	7	
19	What is the second biggest problem your family faces (don't read to the respondent, write answers)	Poor health	1	
		Insufficient food	2	
		Lack of money to meet basic need	3	
		Unemployment	4	
		Homeless	5	
		Lack of access to health services	6	
		Other:	7	
20	What is the most frequent disease in your community (Do not read to the respondent).	Diarrhoea	1	
		HIV/AIDS	2	
		Malaria	3	
		Trauma (injuries)	4	
		Respiratory diseases	5	
		Anaemia	6	

		Skin diseases	7	
		Other:	8	
		Don’t know	9	
21	What causes diarrhoea? (Do not read to the respondent)	Drinking dirty water	1	
		Eating contaminated food	2	
		Flies/Insects	3	
		Poor hygiene	4	
		Weather	5	
		Spirits	6	
		Other:	7	
		Don’t Know	8	
22	How can you prevent diarrhoea? (Don’t read to respondent)	Wash hands more frequently	1	
		Cooking thoughly	2	
		Cover prepared food	3	
		Cleanliness (dishes, utensils)	4	
		Weather	5	
		Other	6	
		Don’t Know	7	

23.	What is the main source of drinking water for members of your household	Piped water	1		
		Water from open well	2		
		Water from borehole	3		
		Surface water	4		
		Ruin water	5		
		Water vendors	6		
24	Who is providing water at the source	Authority	1		
		CBO/NGO	2		
		Private operator	3		
		Don't Know	4		
25	Do you do anything to make water safer to drink?	Yes	1		If no. GO to 28
		No	2		
26	What do you usually do to make the water safer to drink?	Boiling	1		
		Use of chlorine (water guard)	2		
		Use water filters (ceramic filters)	3		
		Solar disinfection	4		
		Let it stand and settle	5		
		Filter with cloth	6		

		Other:	7	
27	Why do use this method for making water safer	Cost	1	
		I don't know other option	2	
		The method is effective	3	
		Cheap	4	
		I don't know	5	
		Others_____	6	
28	Why don't you treat your drinking water	Availability	1	
		Costs	2	
		Bad taste and smelly of treated water	3	
		I believe water is safe from the source	4	
		I am used to drink untreated, nothing happen to us	5	
		I don't know	6	
		Other:	7	
29	Do you store water for drinking separately from water for other domestic purposes	Always	1	
		Sometimes	2	
		Never	3	

30	Which container do you store water for drinking (observe and write answers)	Bucket with a lid	1		
		Bucket without a lid	2		
		Small pans	3		
		Jerry cans	4		
		Other:	5		
31	Do you use water for drinking for other purposes	Yes	1		
		No	2		
32	How do you draw water from your container	Use small pan	1		
		Pour directly from container	2		
		Use cup	3		
		Other:	4		
33	Do you enjoy the taste and smell of your cleaned drinking water	Yes	1		
		No	2		
		Don't Know	3		
34	Who use the water once it is treated	Mother	1		
		Father	2		
		Children	3		
		Elders	4		
		Guest	5		
		Other:	6		

Household hygiene and Sanitation					
35	When do you wash hands?	After using the toilet	1		
		Before meals	2		
		Before cooking/preparing food	3		
		Other:	4		
36	Do you use soap?	Yes	1		
		No	2		
37	Is there a place for washing hands (observe)	Yes	1		
		No	2		
38	Is there a soap in a place they wash their hands (observe)	Yes	1		
		No	2		
39.	What kind of toilet facility do members of household usually use	Flush/Pour flush to sewer	1		
		Flush/Pour flush to septic tank	2		
		Flush/Pour flush to pit latrine	3		
		Flush/pour flush to else where	4		
		Ventilated improved pit latrine	5		

		Pit latrine with slab	6
		Pit latrine without slab/open pit	7
		No facility/bush	8
		Others:	9
40	Water analysis (E.coli)	Present	1
		Absent	2
41	Water analysis (Total coli forms)	Present	1
		Absent	2
42	Lab. Remarks	Acceptable	1
		Not acceptable	2

THANK YOU FOR YOUR TIME AND COOPERATION

Appendix 4

CHUO KIKUU CHA AFYA NA TIBA MUHIMBILI

KITIVO CHA SAYANSI YA AFYA YA JAMII

DODOSO LA UTAFITI WA SABABU ZA UGONJWA WA KUHARISHA KWA WATOTO CHINI YA MIAKA MITANO KWA KUANGALIA HALI YA USALAMA WA MAJI YA KUNYWA KATIKA KAYA, WILAYA YA MKURANGA MJINI MKOA WA PWANI, OCTOBER 2011.

NAMBA_____ TAREHE YA MAHOJIANO_____

KIJIJI_____ KATA: _____

JINA LA MHOJAJI.....

NA	MASWALI	VIFUPISHO VYA MAJIBU		SKIP
SEHEMU YA 1:TAARIFA BINAFSI				
1	Mhojiwa (Chagua inayohusika)	Baba	1	
		Mama	2	
		Bibi	3	
		Babu	4	
		mwingine:	5	
2.	.Jinsi ya mhojiwa	Me	1	
		Ke	2	
3.	Umri (unaweza kukadiria)	.miaka.....		
4.	Hali ya ndoa	Hajaoa/hajaolewa	1	
		Ameoa/Ameolewa	2	

		Wameachana		3	
		Mjane		4	
		Mgane		5	
		Kimada		6	
5.	Kiwango cha Elimu	Shule ya msingi		1	
		Sekondari		2	
		Chuo+		3	
		Hakusoma		4	
6	Je kaya yenu kuna:		yes	No	
		Umeme	1	2	
		Radio	1	2	
		TV	1	2	
		Simu	1	2	
		Simu ya meza	1	2	
		Friji	1	2	
7	Huwa mnatumia nishati ya namna gani kupikia?	Umeme		1	
		Gesi		2	
		Mafuta ya taa		3	
		Mkaa		4	
		Kuni		5	

		Samadi	6
		Nyinginezo:	7
8	Hali ya nyumba (Sakafu), zungushia kinachohusika	Udongo	1
		Mbao ambazo hazina dawa.	2
		Mbao zenye dawa	3
		Vinyl au Asphalt strips	4
		Vigae	5
		Cementi	6
		Carpet	7
		Nyinginezo:	8
9	Ukuta,	Vioo	1
		Udongo	2
		Matofali mabichi	3
		Matofali yaliyochomwa	4
		Mbao	5
		Matofali ya cement	6
		Mawe	7
		Nyinginezo:	8

10	Paa	Nyasi/Makuti 1 Mabati 2 Vigae 3 Zege 4 Asbestos 5 Nyinginezo: 6	
11.	Unaishi na familia ya watu wangapi?	.....	
12.	Kuna watoto wangapi wenye umri chini ya miaka 5? (chagua mmoja bila upendeleo)	.....	
13	Umri wa mtoto uliyemchagua	_____	
14	Jinsi	Mke 1 Mme 2	
15	Je mtoto ananyonya maziwa ya mama au amenyonyeshwa kwa miaka miwili kabla ya kulikizwa?	Ndio 1 Hapana 2	
16	Hali ya lishe (angalia kadi ya kliniki)	Ana utapiamlo 1 Hana utapiamlo 2	
17	Je mtoto huyu amepata ugonjwa wa kuharisha kwa kipindi cha wiki mbili zilizopita?	Ndio 1 hapana 2	
18	Ni tatizo lipi ni la pili mnalokabiliana nalo?, zungushia	Afya mbaya 1	

	majibu usimsomee mhojiwa.	Upungufu wa chakula: 2 Ukosefu wa fedha za kujikimu kimaisha: 3 Ukosefu wa ajira: 4 Upweke: 5 Kukosa huduma za afya: 6 Nyinginezo: 7	
19	Ni ugonjwa upi unawasumbua mara kwa mara katika jamii yenu? zungushia majibu usimsomee mhojiwa.	Kuharisha: 1 HIV/AIDS: 2 Malaria: 3 Ajali: 4 Magonjwa ya mfumo wa hewa: 5 Anemia: 6 Magonjwa ya ngozi: 7 Mengineyo: 8 Sijui: 9	
20	Kuharisha kunasababishwa na nini?, Usimsomee mhojiwa zungushia anachojibu	Unywaji wa maji yasiyo salama: 1	

		Ulaji wa chakula kisicho salama	2	
		Inzi/wadudu	3	
		Uchafu	4	
		Hali ya hewa	5	
		Pepo wachafu	6	
		Nyinginezo:	7	
		Sijui	8	
21	Unawezaje kuzuia magonjwa ya kuharisha? (Usimsomee, zungushia alichojibu)	Kunawa mikono kila mara kwa sabuni	1	
		Kupika chakula mpaka kiive vizuri	2	
		Kufunika chakula	3	
		Kuzingatia hali ya usafi(vyombo n,k)	4	
		Hali ya hewa	5	
		Nyinginezo	6	
		Sijui	7	
22	Chanzo chenu kikuu cha maji ya kunywa ni:	Maji ya bomba	1	
		Visima vifupi	2	
		Visima virefu	3	
		Maji ya mito	4	

		Maji ya mvua 5 Vioski 6	
23	Maji hayo yanamilikiwa na nani?	Serikali ya mtaa 1 Asasi isiyo ya kiserikali 2 Mtu binafsi 3 Sijui 4	
24	Huwa unatakatisha maji ya kunywa?	Ndio 1 Hapana 2	Hapana nenda 27
25	Ni njia ipi unayoitumia kutakatisha maji ya kunywa?	Nachemsha 1 Waterguard 2 Chujio maalumu (ceramic filters) 3 Nguvu ya jua 4 Naacha yatulie 5 Nachuja na kitambaa 6 Nyingine: 7	
26	Kwanini unatumia njia hiyo?	Ni nafuu 1 Naiamini 2 Hamna njia nyingine 3	

		Wanafamilia wanaipendelea	4
		Sababu nyinginezo_____	5
27	Kwanini hautakatishi maji yako ya kunywa?	Hamna vitakatisho	1
		Gharama	2
		Maji yaliyotakatishwa sipendi ladha yake	3
		Naamini maji ni salama	4
		Nimekuwa nakunywa maji yasiyo tibiwa bila matatizo	5
		Sijui	6
		Nyingine:	7
28	Huwa unatunza maji yako ya kunywa tofauti na mengine	Ndio	1
		Mara chache	2
		Hapana	3
29	Nionyeshe kifaa unachotumia kuhifadhia maji (angalia na zungushia jibu)	Ndoo yenye mfuniko	1
		Ndoo isiyo na mfuniko	2

		Sufuria	3
		Madumu	4
		Nyinginezo:	5
30	Huwa unatumia maji ya kunywa kwa shughuli nyingine?	Ndio	1
		Hapana	2
31	Huwa mnachukuaje maji ya kunywa kutoka kwenye chombo yalikohifadhiwa?	Bakuli	1
		Tunamimina	2
		Tunatumia kikombe	3
		nyinginezo:	4
32	Huwa mnafurahia ladha na harufu ya maji yenu yaliyotibiwa?	Ndio	1
		Hapana	2
		Sijui	3
33	Nani huwa anakunywa maji yaliyotibiwa?	Mama	1
		Baba	2
		Watoto	3
		Watu wazima	4
		wageni	5
		Wengine:	6
HALI YA USAFI WA MAZINGIRA KATIKA KAYA			
34	Ni wakati gani mnanawa mikono?	Kutoka chooni	1

		Kabla na baada ya kula	2	
		Kabla ya kuanza kupika	3	
		Mengineyo:	4	
35	Huwa mnatumia sabuni?	Ndio	1	
		Hapana	2	
36	Mna sehemu maalumu ya kunawa mikono? (angalia)	Ndio	1	
		Hapana	2	
37	Kuna sabuni sehemu ya kunawia mikono? (angalia)	Ndio	1	
		Hapana	2	
38	Mnatumia choo cha namna gani?	Kimeunganishwa kwenye mtandao wa maji taka	1	
		Kimeunganishwa kwenye makalo ya maji taka	2	
		Ni cha shimo na wanaflush	3	
		Wanaflush kwa kutapisha	4	
		Ni cha shimo chenye bomba la hewa	5	

		Ni cha shimo chenye cement slab/magogo	6	
		Ni shimo lisilo na slab	7	
		Hamna choo/vichakani	8	
		Nyingine:	9	
39	Vipimo vya maabara (E.coli)	Present	1	Matumizi ya ofisi
		Absent	2	
40	Water analysis (Total coliforms)	present	1	Matumizi ya ofisi
		Absent	2	
41	Water remarks	Acceptable	1	Matumizi ya ofisi
		Not acceptable	1	

AHSANTE KWA MUDA WAKO NA USHIRIKIANO WAKO