SANITATION AND WATER QUALITY FACTORS ASSOCIATED WITH DIARRHEA OCCURRENCE IN HOMABAY AND KISUMU COUNTY BEACHES, KENYA

BY

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DECLARATION

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This thesis is my original work and it has not been presented for any degree in Maseno University or any other University.

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DEDICATION

To my family, the Shisanya's for standing with me throughout the time period of my studies. To my little baby Precious, mummy loves you.

ABSTRACT

In Kenya, surface water bodies are the final destination for most pollutants. Western and Nyanza Regions in close proximity to Lake Victoria are characterized by inadequate sanitation services, chronic water shortages and poor water quality where only 8% have access to safe water. Unsanitary conditions are associated with scarcity of clean and potable water consequently leading to diarrheal diseases that plague residents. The microbiological quality of drinking water and risk factors associated with diarrheal cases in households living along Lake Victoria basin is uncertain. The broad objective of this study was to assess sanitation and water quality factors associated with diarrhea occurrence Homabay and Kisumu County beaches, Kenya. Specifically, the study established sanitation practices by households living along Lake Victoria; determined microbiological quality of drinking water consumed by households; identified household water treatment methods and established the risk factors associated with occurrence of diarrhea in these households. A descriptive cross sectional study design was adopted. Microbiological water quality was determined using standard microbiological water quality assessment methods whereas data on sanitation practices and household water treatment methods were collected using semi-structured questionnaire developed from WHO/UNICEF household water quality survey guidelines. The target population was 1600 households where 422 households were randomly sampled guided by proportionate sample size dependent on the household population of the beaches along Lake Victoria. Proportions of diarrheal cases were determined by use of Chi-square test and multivariate logistic regression was used to determine the risk factors associated with microbiological quality of water and the occurrence of diarrhea. A majority, 327 (77.49%) were female, 152 (36.02%) were aged between 25-34 years, 382 (90.52%) were married, 292 (69.19%) had primary education level and 120 (28.5%) were traders. Sanitation practices in relation to occurrence of diarrhea were significant with covering of drinking water containers and access to safe drinking water indicating highest significance at 63.64% (OR=3.04, 95% CI [1.45-6.37], p=0.0025) and 46.92% (OR=1.65, 95% CI [1.08-2.51], p=0.0202) respectively. Households with latrines, dish racks, and hand washing equipment reported diarrhea incidences at 45.34%, 42.97% and 42.69% respectively. Water treatment was significant in explaining occurrence of diarrhea, (OR=0.47, 95% CI [0.30-0.73], p<0.0001). A significant higher percentage of diarrhea incidences reported among children <5 years at 36%. Higher levels of education and professionals reported significantly lower incidences of diarrhea at (OR=0.18, 95% CI [0.02-1.47], p<0.0001). The study identified safe disposal of human excreta, hand washing and treatment of drinking water as key sanitary practices and recommends they be embraced in order to reduce the occurrence of diarrhea. Quality of water improved at the household level subject to treatment. The study has added knowledge to be used by stakeholders in interventional measures to improve Water, Sanitation and Hygiene in beach communities and positively contribute to achieving Sustainable Development Goal number 6.

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ABBREVIATIONS AND ACRONYMS

AIDS	-	Acquired Immune Deficiency Syndrome
APHA	-	American Public Health Association ARGOSS
CFU	-	Colony Forming Units
CHV	-	Community Health Volunteer
CI	-	Confidence Interval
DNA	-	Deoxyrebonucleic Acid
EC	-	Escherichia colae
FC	-	Fecal Coliforms
FS	-	Fecal Streptococci
GOK	-	Government of Kenya
HIV	-	Human Immune Deficiency Virus
LBDA	-	Lake Basin Development Authority
MCI	-	Millennium City Initiatives
MDG	-	Millennium Development Goals
MOH	-	Ministry of Health
MPN	-	Most Probable Number
OAEL	-	Observed Adverse Effect Level
OD	-	Open Defecation
ODF	-	Open Defecation Free
OR	-	Odds Ratio
SDG	-	Sustainable Development Goals
TC	-	Total Coliforms

UNEP	-	United Environmental Program
UNICEF	-	Unite for Children
VIP	-	Ventilated Improved Pit Latrine
WASH	-	Water, Sanitation and Hygiene
WHO	-	World Health Organization

OPERATIONAL DEFINITION OF TERMS

Beach communities: Households living along the shores of Lake Victoria, obtaining their socio economic livelihoods from around these beaches.

Colony Forming Unit: A mass of individual cells of same organism growing together reported as per unit volume

Community Health Volunteer: Selected community members who work in health related issues linking community members to health facilities and are supervised by a community health extension worker

Diarrhea: Passage of loose or watery stool three or more times in a day due to ingestion of water or food contaminated by feaces.

Household: a dwelling unit where occupants share cooking arrangement.

Risk factors: Any attribute, characteristic or exposure of an individual that increases the likelihood of developing a disease, in this case, unsafe water, poor sanitation and hygiene practices are risk factors towards diarrhea occurrences among the study participants.

Poor Sanitation and Hygiene: lack of improved water handling practices and unavailability of human waste disposal facilities leading to open defecation and failure to observe hygiene practices such as hand washing and safe storage of drinking water in the household.

Sanitation and Hygiene Practices: Includes improved water handling and practices such as availability of human waste disposal and hand washing, availability of dish rack and covering of water containers at the household level.

Unimproved water sources: Surface or underground drinking water in the study areas; mainly from rivers, lake and shallow wells.

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CHAPTER ONE

INTRODUCTION

1.1 Background Information

Globally, 159 million people still collect drinking water directly from surface water sources, 58% live in sub Saharan Africa, 892 million worldwide still practice open defecation with only 15% in having hand washing facilities Sub Saharan Africa (WHO, 2017). Poor water quality, poor sanitation and hygiene are attributed to 88% of cases of diarrhea (WHO and UNICEF, 2013), indicating the importance of promoting and practicing good sanitation and hygiene practices. Diarrhea is the leading cause of mortality among all ages 1.31 million deaths in 2015 as well as leading cause of DALYs because of its disproportionate impact on young children 71.59 million DALYs, diarrheal deaths reduced by estimated 20.8% from 2005 to 2015 while improved safe water and sanitation decreased diarrheal DALYs by13.4% (Troeger et al., 2017).

Safe drinking water, sanitation and hygiene are protective against diarrheal disease, a leading cause of child mortality. Water, sanitation and hygiene interventions were associated with lower risk of diarrhea morbidity in which point of use filter intervention with safe storage reduced diarrhea by 61%, improved water quality reduced diarrhea by 76% and promoting hand washing with soap reduced risk of diarrhea by 30% (Wolf et al., 2018). Estimates indicate that only 20% of Kenyan rural population access safe water of which only 8% is for both Nyanza and Western Region (LBDA, 2004). Diarrhea in Kenya accounts for 25% of all children illnesses accounting for 30% bed occupancy in the pediatric wards and is the 2nd cause of mortality among children (MOH, 2004). The government therefore targets to reduce diarrhea, pneumonia, malaria and malnutrition morbidity from 70-40%, (NHSSP, 2010).

In the Lake Victoria region, poor waste disposal mechanisms and inadequate toilet facilities have been reported along the lake shores (ARGOSS, 2001). Consumption of fecally contaminated water is the main route of transmission of enteric pathogens in many regions of the world lacking proper sanitation practices and improved water quality. The association between sanitation practices and diarrhea cases among households along Lake Victoria shores is not known. Indicator organisms are used as signals of fecal pollution in the assessment of drinking water quality (Noble *et al.*, 2005).The microbiological quality of household drinking water along Lake Victoria region is uncertain. The relationship between water contamination at the source and at the household level is also not clear among the beach communities of Lake Victoria, Kenya. This study will therefore seek to determine the microbiological quality of drinking water both at the source and at the household level and determine its association with diarrheal cases in households living along Lake Victoria region of Kenya.

Household based water treatment has been shown to be one of the most effective and cost effective means of preventing waterborne diseases in development and emergency settings and in areas where water sources are unimproved, (IFGA, 2006-2010). Improvement of household water quality can have a big health impact and can reach a large population over a short period of time, (UNICEF, 2008). Household water treatment prevents recontamination in homes, and ensures microbiological quality of drinking water at point of consumption. According to (Sobsey, 2002), this translates to improved health. The association of household based water treatment practices and the occurrence of diarrhea is not known within the Lake Victoria region. Many household based water treatment methods have been adopted but it is not clear how a given method affects water quality in relation to the occurrence of diarrheal diseases.

According to a study by (Pruss-Ustun *et al.*, 2007), it is estimated that about 94% of diarrheal diseases are caused by modifiable environment which means that improving the environment through increased access to clean water and sanitation could decrease occurrence of diarrheal diseases. The indicators associated with the occurrence of diarrhea infection vary from socio economic, behavioral, environmental and biological factors. In a study to assess diarrhea morbidity and associated factors, latrine presence, water shortage and solid waste disposal were associated risf factors to diarrhea occurrence with prevalence of diarrhea in Open Defecation Free village recorded at 9.9% while in Open Defecation villages was 36.1% showing open defecation as a risk factor to diarrhea (Ayalew, Mekonnen, Abaya, & Mekonnen, 2018). The risk factors associated with the occurrence of diarrhea within Lake Victoria region have not been adequately described. This study aims to explore self-reported diarrhea and associated risk factors among households along Lake Victoria, Kenya.

1.2 Problem Statement

Pollution of lake water, due to many activities such as lack of safe management and disposal of human wastes along the shores of Lake Victoria resulting in direct fecal contamination of surface and groundwater supplies compromising the microbiological quality of household drinking water. . Raw sewage from the neighboring cities is discharged into Lake Victoria. Predominant health issues in the lake basin are linked to unsafe water contaminated by microbial, chemical and poor disposal of human excreta and surface runoffs.

Along the lake shores, beach communities are using microbiologically contaminated water ideally not fit for human consumption according to World Health Organization safe drinking water standards that stipulates 80 CFU/100ml drinking water. This therefore called for urgent need to assess the quality of water used in terms of microbial contamination, treatment and household sanitation practices. This was assessed by the current study.

1.3 Significance of the Study

Sustainable Development Goal number 6 advocates for clean water and sanitation. Having missed the targets of Millennium Development Goals 2015, the SDGs delineates that by 2030, achieve equitable access to safe and affordable drinking water, adequate and equitable sanitation and hygiene for all and improving water quality (WHO, 2017). Improved sanitation practices among beach communities would reduce diarrheal incidences among beach communities in the Lake Victoria region, Kenya and positively contribute to achieving SDG 6.

Pollution of lake water sources implied occurrence of diarrhea among the beach communities.

Community Led Total Sanitation intervention has been put in place by the Ministry of Health with indicators such as use of sanitary facilities, hand washing to reduce on occurrence of diarrhea.

Detection of fecal coliforms, E-coli in drinking water both at the source and at the household level brought out the relationship between water contamination at the source and in homes. This informed the MOH and beach communities around Lake Victoria Kenya on best water handling practices and improved sanitation practices for improved health. Treatment of water in the household was significant in reducing occurrence of diarrhea. Despite water treatment at household level, there was evidence of recontamination where coliform count exceeded acceptable limit of 80 CFUs/100ml of water.

The study informed public health specialists on the microbiological quality of household drinking water and its association with diarrhea incidences among Lake Victoria beach communities. This information assisted the County Government, Ministry of Health and other health providers understand household practices around water and sanitation, discover challenges in implementing recommended practices and identify possibilities for future interventions with interventions reducing prevalence of infant mortality rate among beach communities.

Beach communities are among the most vulnerable groups where accessibility to potable drinking water is key. Subsequent recontamination during transport and storage of water is common especially for people utilizing common drinking water sources. Understanding the knowledge gaps on diarrhea and the contributing risk factors specifically for the Lake Victoria beach communities in Kenya would assist public health specialists and community health workers with provision of quality education on diarrheal diseases. The study identified suitable water treatment methods and highlighted gaps in diarrhea prevention mechanisms that would contribute to improved health for beach communities.

1.4 General Objective

The broad objective of this study was to assess sanitation and water quality factors associated with diarrhea occurrence in Homabay and Kisumu County beaches, Kenya.

1.4.1 Specific Objectives

1. To establish sanitation practice (s) by households living along Lake Victoria, Kenya.
2. To determine the microbiological quality of drinking water from unimproved sources consumed by households living along Lake Victoria, Kenya.
3. To identify household water treatment methods for drinking water from unimproved water sources used by households living along Lake Victoria, Kenya.

4. To establish the risk factors associated with diarrheal cases in households living along Lake Victoria, Kenya.

1.5 Research Questions

1. What are the sanitation practices by households living along Lake Victoria, Kenya?
2. What is the microbiological quality of drinking water from unimproved water sources consumed by households living along Lake Victoria, Kenya?
3. What are the household water treatment methods for drinking water from unimproved water sources used by households living along Lake Victoria, Kenya?
4. What are the risk factors associated with diarrheal cases in households living along Lake Victoria, Kenya.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses sanitation practices by households living along Lake Victoria Kenya, microbiological quality of drinking water, water treatment methods and the risk factors associated with diarrheal cases among households living along Lake Victoria, Kenya. The chapter also gave the operational framework and a summary of the concepts to be studied. It also discussed and revealed emerging gaps in the literature and gave a summary of the emerging knowledge gaps.

2.2 Sanitation Practices

Sanitation is the hygienic means of preventing human contact from hazards of wastes to promote health. Feces, solid wastes, domestic waste water among many more hazardous substances cause health problems. This can be prevented by using septic tank sewage system or simple personal hygiene and improved sanitation. The Photo voice interviews identified a number of behavioral practices that may perpetuate the transmission of pathogens through fecal contamination of hands and drinking water, including the lack of adequate toileting facilities (especially for children); inadequate hand washing method; drinking water recontamination through contact with hands; uncovered storage containers; inconsistent chemical and/or filtration treatment of drinking water; grey water disposal into close proximity to homes; hand and dish contact with ground likely to contain traces (Badowski *et al.,* 2011). Improved management of water, sanitation and hygiene, is a critical component of the seven-point strategy agreed by WHO and UNICEF for comprehensive diarrhea control, which includes promotion of hand washing with soap, household water treatment and safe storage and promotion of community sanitation (WHO/UNICEF, 2012).

The forms of sanitation range from conventional and modified sewage to water borne onsite systems such as septic tanks, pour flush latrines to dry system some of which may include urine separation. Sanitation systems are categorized into offsite methods where fecal and household wastes are carried away to a treatment plant and onsite methods that include all forms of pit latrines. Storage and decomposition of wastes takes place at the point of disposal. The wastes may require periodic emptying and sometimes construction of new sanitation facilities (WHO/UNICEF, 2012).

According to Joint Monitoring Program Report by WHO and UNICEF focusing on SDGs by countries, worldwide, 159 million people still collect drinking water directly from surface water sources, 58% live in sub Saharan Africa, 892 million worldwide still practice open defecation with only 15% in having hand washing facilities Sub Saharan Africa (WHO, 2017). MDG targets were missed by many countries now focus is on achieving SDGs by 2030. According JMP 2014 estimates, Kenya's rural sanitation coverage by 2012 is rated at 31% improved sanitation, 48% shared, 18% other unimproved and 3% open defecation. Total sanitation coverage is estimated at 30% improved, 26% shared, 31% other improved and 13% open defecation (WHO/UNICEF, 2014). Short water supply and poor sanitation framework have overburdened major urban centers within Lake Victoria basin which faces challenges of sewage and storm water pollution. Semi treated or untreated sewage is discharged directly into water courses especially areas surrounding informal settlements.

Kisumu, a city with great influence on Lake Victoria water quality, only 24% of residents have access to private flush toilets, 37% access private pit latrines, 34% access shared toilets while 5%

still practice open defecation (GOK/World Bank, 2007). Wells are poorly constructed and protected susceptible to contamination by fecal matter and storm water. This study however did not narrow down to household sanitation coverage in the county as far as toilet availability is concerned and the communities that largely contribute to poor sanitation. This study sought to critically look into the aspects of sanitation at the household level among beach communities and identify how they could be linked to poor water quality and diarrhea occurrence in the region. Pressure on land especially in urban cities is increasing due to increasing population. Sanitation and drainage facilities pose a risk to ground water. It was therefore important to monitor the public health risk posed by contamination of ground water supplies from onsite sanitation in reduction of diarrheal diseases.

2.3 Microbiological Quality of Drinking Water

Water quality whether used for drinking, domestic purposes, food production or recreational purposes has an important impact on health. According to WHO policy framework, issues of water quality and health and the need to galvanize efforts to strengthen water supply and sanitation services are reaffirmed. The WHO Assembly Resolution WHA 64.24 calls on WHO member states to improve water quality management through support of capacity building and implementation. Resolution 64.15 on cholera highlighted the role of water, sanitation and hygiene in cholera prevention and control. WHA 45.31 on environmental health recognized that access to good quality water and sanitation is essential to primary health and fundamental to prevention of waterborne diseases (WHO Strategy 2013-2020).

Studies suggest locality specific interventions by timing and interaction between different factors. Combined interventions for improved water quality and availability have proven to lead to significant reduction in incidences of diarrheal diseases. According JMP 2014 estimates, Kenya's rural water coverage by 2012 was rated at 55% total improved, 13% piped into premises, 42% other improved, 16% other unimproved and 29% surface water. Total water coverage was estimated at 60% total improved, 20% piped into premises, 40% other improved, 16 other unimproved and 24% surface water (WHO/UNICEF, 2014).

Observed Adverse Effect Level, (OAEL) approach is integrated in routine water quality monitoring programs because complete epidemiological investigation is expensive and time consuming. OAEL requires water testing for presence of preferential fecal indicator bacteria at the point of exposure usually water source or recreational site. A sanitary survey is executed to identify fecal sources when indicator bacterium is present in excess of referential water quality guidelines and the tolerable risk threshold is breached Indicator organisms are used as signals of fecal pollution in the assessment of drinking water quality (Noble *et al.*, 2005).

Inadequate management of urban industrial waste water has led to the existence of both biological and chemical contaminants in drinking water. Consumption of contaminated water represents the greatest risk though other routes of transmission also lead to diseases and contribute to the disease burden. According to WHO estimates, 200million people are affected by schistosomiasis and around 800 million more risk infection.

Bacteria such as excreta related pathogens bacteria Escherichia coli, vibrio cholerae, salmonella specie, shigella specie are available in waste water. Total coliforms (TC), fecal coliforms (FC), fecal streptococci (FS), *Escherichia coli* (EC) and intestinal enterococci (IE) are the most common bacteria indicators used in water quality monitoring. *E-coli* and intestinal enterococci correlate well with the rate of gastrointestinal illnesses in recreational and fresh water. This correlation is useful for the development of microbial water quality guidelines. The occurrence of specific pathogens varies further according to their seasonal occurrence (Vikaskumar *et al.,* 2007). Current approaches to water quality control are based on absence of bacteria, *E- coli* or thermo-tolerant coliforms that indicate presence of fecal contamination within water samples. Absence of such bacteria often defines water as ‘safe’.

Despite its proximity to the second largest freshwater lake, Lake Victoria basin residents are characterized with chronic water shortages, poor water quality and inadequate sanitation services (MCI, 2009). Only 13% of Kisumu residents have access to piped water, 63% water kiosks and public taps while 24% obtain their water from other sources such as vendors, open wells, streams and ponds (GOK & World Bank, 2007). It’s evident that the quality of water is low while the cost of vendor provided water is unreasonable. The threat of microbial pollution-related illnesses is in most cases water borne diseases is predictable with microbial risk assessment (MRA). MRA functions as a valuable tool for risk identification and management in situations where epidemiological investigations are lacking (Gibson *et al.,* 2002).The level of fecal contamination is indicated by the presence of an indicator organism using the Observed Adverse Effect Level approach (OAEL) where a negative health effect can be expected if the indicator is present and the level of risk increases with increase in the indicator density (Al-Wasify *et al.,*2011).

Drinking water tainted by urine and feces of infected individuals is the common source of infection. Ingestion is the common entry of bacterial species into the human body (Al-Wasify *et al.,*2011). Multiplication of these organisms in the small intestine over a period of 1-3 weeks, breeches the intestinal wall, and spread to other organ systems and tissues. Water for direct consumption and ingestion via food should be of quality that does not represent a significant human health risk. Tolerable risks need to be defined as zero risk scenarios is not achievable.

2.3.1 Water Quality Analysis

The essence of water quality monitoring is to assess the concentration of fecal coliforms which exceed the levels recommended by the World Health Organization guidelines for drinking water quality. The concentration of fecal coliforms in fresh water bodies is an indirect indicator of contamination with human and animal excreta. Water contaminated with human and animal excreta pose a serious health risk and is therefore unsuitable for potable supply unless suitably treated. Fecal indicator bacteria remain the preferred way of assessing the hygienic quality of water.

Escherichia coli, thermo-tolerant and other coliform bacteria, the fecal streptococci and spores of sulphite reducing clostridia are common indicators used in water quality monitoring. This measure indicates situations where treatment is required or water quality has to be improved for safety of supply. Diarrheal diseases are largely the consequence of fecal contamination of drinking water, responsible for 80% of morbidity and mortality in developing countries (WHO, 2002). Ideal fecal indicator characteristics are difficult to find in any one organism. Many useful characteristics are however found in *E. coli* and to lesser extent in thermo-tolerant coliform bacteria.

Fecal contamination of water is routinely checked by microbial analysis where wastes from sewers is of particular significance to sources of drinking water and one of the most important water quality issues worldwide. Water contaminated by human feces contains pathogenic organisms consequently hazardous to human health. The pathogens are present in relatively small numbers and each require unique microbiological isolation technique. Indicator organisms that inhabit the gut are excreted in human feces and the presence of it in water is evidence of fecal contamination thus risk that pathogens are present. Contamination is considered severe if indicator organisms are present in large numbers. Bacteria in water present as clumps and each clump may have many bacteria associated with it.

Commonly used methods for bacteriological water testing include Membrane filtration technique and Most Probable Number (MPN). Others include the use of fluorogenic and chromogenic substrates to cultivation media (agar and liquid) to detect enzymatic activities of TC and *E. coli* (APHA, 2005). In the Most Probable Number (MPN) technique, measured portions or specified quantities of a water sample are placed in test tubes containing a culture medium. The tubes are then incubated for a standard time at a standard temperature. The presence or absence of gas in each tube is used to calculate MPN index. The results of multiple fermentation tube test for coliforms are given as MPN index.

In the membrane filter technique, the sample is filtered through a polycarbonate membrane filter which traps bacteria. The filter is placed on an agar medium or on a pad soaked with liquid media. It's incubated for 24-48 hours until colonies form. The results/counts are expressed in terms of colony forming units (CFU) rather than the number of microorganisms. Direct count can also be used after microbial cells or bacteria has been trapped. The bacteria is stained with fluorescent dye, aeridyne orange or DNA stain DAP and observed microscopically (APHA, 2005). In the plating method, the spread plate and pour plate are the commonly used techniques. A diluted sample of bacteria suspension is dispersed over a solid agar surface where each bacteria cell develops into a distinct colony. Dilutions of 1:10, 1:100, 1:1000, and 1:10000 are used.

2.4 Household Water Treatment

Water can be contaminated at the source, in the home or during the journey in between. Unprotected water sources, dirty containers and hands easily contaminate water causing illnesses. According to the International Federation's Global Agenda 2006-2010 manual, water at the source is the first stage of water contamination. This means even clean water collected from the source can be contaminated prior to use due to unsafe hygiene practices such as transport from the source using dirty containers or handling with dirty hands and utensils where every step presents an opportunity for water to be contaminated.

Household water treatment is an activity undertaken at the household level to improve drinking water quality. It has been shown to be one of the most effective and cost effective means of preventing waterborne diseases in development and emergency settings. This water treatment is a temporal measure where water sources are unimproved, (IFGA, 2006-2010). Improvement of household water quality can have a big health impact and can reach a large population over a short period of time(UNICEF, 2008). Household water treatment methods include; Disinfection, sedimentation and filtration. Disinfection ensures that water is free from disease causing germs. This may be done by chemicals, heat, or even sunlight. Sedimentation allows dirt to fall to the bottom of a water container over a given time. Filtration on the other hand ensures physical removal of dirt by passing the water through a material such as ceramic or sand (UNICEF, 2008).

Household water treatment prevents recontamination in homes, and ensures microbiological quality of drinking water at point of consumption. (Fewtrell *et al.,* 2005) in a systematic review of 15 interventions noted that household water treatment and storage is associated with a 35% reduction in diarrheal diseases compared to an insignificant 11% water source based treatment.

In a study describing factors determining childhood diarrhea in Nyanza western Kenya, those who had access to improved drinking water source were 45.7% with 54.3% reporting to treat drinking water in the household. (Kawakatsu, Tanaka, Ogawa, Ogendo, & Honda, 2017). Another study by (Misati, 2016) investigated household safe water management in Kisii County Kenya where 106 samples were collected from wells, springs, and rain water tanks with all 34 water samples from wells testing positive for fecal coliforms with highest median of 2.4CFU/100ml. 58% of the sampled households did not treat water with majority, 95% covering their drinking water containers. In a study to investigate knowledge and practice on drinking water and sanitation in household survey in India, 15.3% of the households did not treat drinking water, 32.3% practiced OD while 66% practiced hand washing (Pachori, 2016). The purpose of this study is to understand household water treatment methods among beach communities and link this with the occurrence of diarrheal in the particular households.

2.5 Risk Factors Associated with Occurrence of Diarrhea

The health impact of populations in relation to diarrhea are estimated from three major risk factors; unsafe water, sanitation and hygiene, solid fuel use and indoor-outdoor pollution (Prüss-Ustün *et al.,* 2008). The study investigated risk factors to occurrence of diarrhea considering consumption of unsafe water, poor sanitation in terms of lack of latrines resulting to open defaction and household hygiene practices specifically hand washing after toilet use. Diarrhea, according to the World Health Organization is the passage of three or more loose or liquid stools per day. It is a symptom of infection in the intestinal tract that can be caused by bacterial, viral and parasitic organisms. In most occasions, contaminated water, food or poor hygiene are the mechanisms through which diarrheal diseases such as typhoid, cholera, dysentery and guinea worm infection are transmitted. It is estimated by World Health Organization that in 2008, diarrheal diseases claimed lives of 2.5 million people. The burden is greater for children under five years than the combined HIV and AIDS and malaria burden.

2.5.1 Poor Sanitation

Sanitation according to the SDG standards is ensuring access to adequate and equitable sanitation facilities where there is safe disposal and management of human waste aiming to protect human health and to stop transmission of diseases especially through fecal- oral route (WHO, 2017). Sanitation and hygiene interventions are estimated to generate 36% and 48% reduction in diarrhea respectively among children below 5 years. In the study investigating sanitation and hygiene specific risk factors to diarrhea among selected countries, Kenya reported high proportion of households without access to latrines 30%, hand washing demonstrated protective effect against diarrhea in children below 5 years of age in Mozambique in India. OD was significant risk factor to diarrhea in Kenya, Mali, Mozambique and Pakistan with wealth index significantly associated with occurrence of diarrhea (Baker et al., 2016).

In a study to evaluate diarrhea morbidity and associated factors in Dangla district, North West of Ethiopia, the prevalence of diarrhea in Open Defecation Free (ODF) villages was 9.9% and 36.1% in Open Defecation (OD) villages. The presence of a latrine, water shortage and solid waste disposal had statistical significance to diarrhea occurrence and the study concluded that prevalence of diarrhea in under 5 year old children was low in ODF villages (Ayalew et al., 2018). In Kenya, a similar study was conducted to assess the effect of eliminating OD to reduce diarrheal morbidity, in 4 sub counties of Busia and Kisumu counties. Namabale and Bunyala recorded a decline in prevalence of diarrhea cases from 9.8 to 5.7% and 38.6 to 31.6% for Nambale and Bunyala respectively. In Kisumu County, prevalence of diarrhea in Nyando declined from 19.1 to 15.2% showing significant difference in diarrhea prevalence in OD verses

ODF villages. This showed that ensuring safe disposal of human waste coupled with practice of hygiene such as hand washing reduced diarrhea in children (Njuguna, 2016). Many studies have suggested locality specific interventions by timing and interaction between different factors in an effort to address public health issues. For example, specific sanitation and human excreta disposal interventions are necessary for localities such as beaches and recreational environments. There is need to define tolerable risks in water quality monitoring as zero risk scenarios is not achievable.

2.5.2 Household Hygiene

Hand washing at critical times is a key component to ensuring that SDG 6 targets are met. According to a study by (Badowski *et al.,* 2011), Understanding Household Behavioral Risk Factors for Diarrheal Disease in Dar es Salaam, information about challenges to preventing spread of fecal pathogens within the household and potential routes of contamination such as fecally contaminated hands were discussed . The study however did not clearly link these sanitation practices to the occurrence of diarrhea in households. This study therefore aimed at identifying household hand washing practices and their relationship to diarrhea occurrence. In a study to assess prevalence and determinants of diarrhea among children under 5 years in Ethiopia, 21.5% of children reported diarrhea in 2 weeks and the main factors affecting occurrence were the residence, sex of child, methods of complementary feeding, types of water storage and hand washing practices where more than 30% of latrines did not have hand washing facilities (Ante, 2017).

Innovative approaches for conventional hand washing with soap ensuring hand washing was convenient and economical with end user input using dual tippy taps in Kisumu Kenya showed that prevalence of hand washing with soap and water after contact with feaces was estimated to be 15% (Whinnery et al., 2016). Further studies indicated that types of drinking water sources, households whose water sources are shared with livestock, volume of daily water collected, availability of latrine, presence of faeces in the compound, hand washing after visiting the toilet and number of rooms were the sanitation predictors associated with childhood diarrhea (Bitew, Woldu, & Gizaw, 2017).

2.5.3 Unsafe drinking water

Pathogenic microorganisms are transmitted to humans through ingestion of contaminated water either directly or via food or poor hygiene. To minimize the public impact and the transmission of these pathogenic microorganisms, it's essential to protect water sources by preventing contamination, protecting populations from ingestion of contaminated water through treatment (Ministry of Health New Zealand, 2007). Poor quality water can cause disease outbreaks and can contribute to background rates of diseases manifesting themselves on different time scales. (WHO Strategy 2013-2020) Initiatives to manage the safety of water support both public health and socio economic development. In Africa, an intervention was implemented in Zambia to determine water handling practices, prevalent beliefs about causes, treatment and prevention of diarrhea. Households using this intervention had improved water quality and fewer episodes of diarrhea (Quick *et al.,* 2002).

In a Global Burden of Disease Study 1990- 2016 to investigate morbidity and mortality due to *shingella and Escherichia-coli* diarrhea, *E-coli* was the 8th leading cause of diarrhea mortality in 2016 among all age groups accounting for 51186 deaths and about 3.2% of diarrheal deaths, also responsible for 4.2% diarrhea deaths in children below 5 years of age (Khalil et al., 2018). In Trans Nzoia County Kenya, Prevalence of Escherichia coli was 90.2% and age of patients affected explained 53% of variation in prevalence in a study for Epidemiology of Antimicrobial

Resistance among *E-coli* strains (Ang 'ienda et al., 2016). This is a revelation that microbiologically contaminated water mainly with E-coli is a risk factor to occurrence of diarrhea, a factor which this study seeks to investigate among beach communities.

According to a comprehensive Cochrane review in 38 randomized controlled trials and 53000 people in 19 countries, it was found that household based interventions were more effective in preventing diarrheal diseases at 47% than improved wells, boreholes and standpipes at 27% (Clasen *et al.,* 2006a). In a study conducted in Dominican Republic, the turbidity levels of drinking water are potentially a significant factor in occurrence of diarrheal disease. It is also possible that the difference between types of treatment used for different sources may impact on the indicator levels (Kraft *et al.,* 2010). According to a study conducted in Zambia, peri-urban areas of Lusaka, 6500 bio sand water filters were installed in 10 communities to support household water treatment and storage practices, water quality results from filtered water indicated on average 94% removal of *E-coli* but contamination in storage containers (WHO/UNICEF, 2012).

In an intervention to improve water quality and hygiene in developing countries by CDC and Pan American Health Organization, a point of use water disinfection using sodium hypochlorite, a 20 litre durable plastic storage vessels with lid, community education about causes and prevention of diarrhea and proper use of the intervention was used. In trials carried out in the peri-urban and rural population of Latin America using this safe water system, water quality improved while diarrheal disease incidences reduced by 40% *(*Quick *et al.,* 2002*)*. Different factors such as methods of waste disposal, water sources and treatment methods are key in acceptable water quality and reduced water borne diseases. Combined interventions for improved water quality and availability have proven to lead to significant reduction in incidences of diarrheal diseases.

2.6. Operational Framework

The Operational Framework describes the independent and dependent variables that the study focused on to achieve the objective.

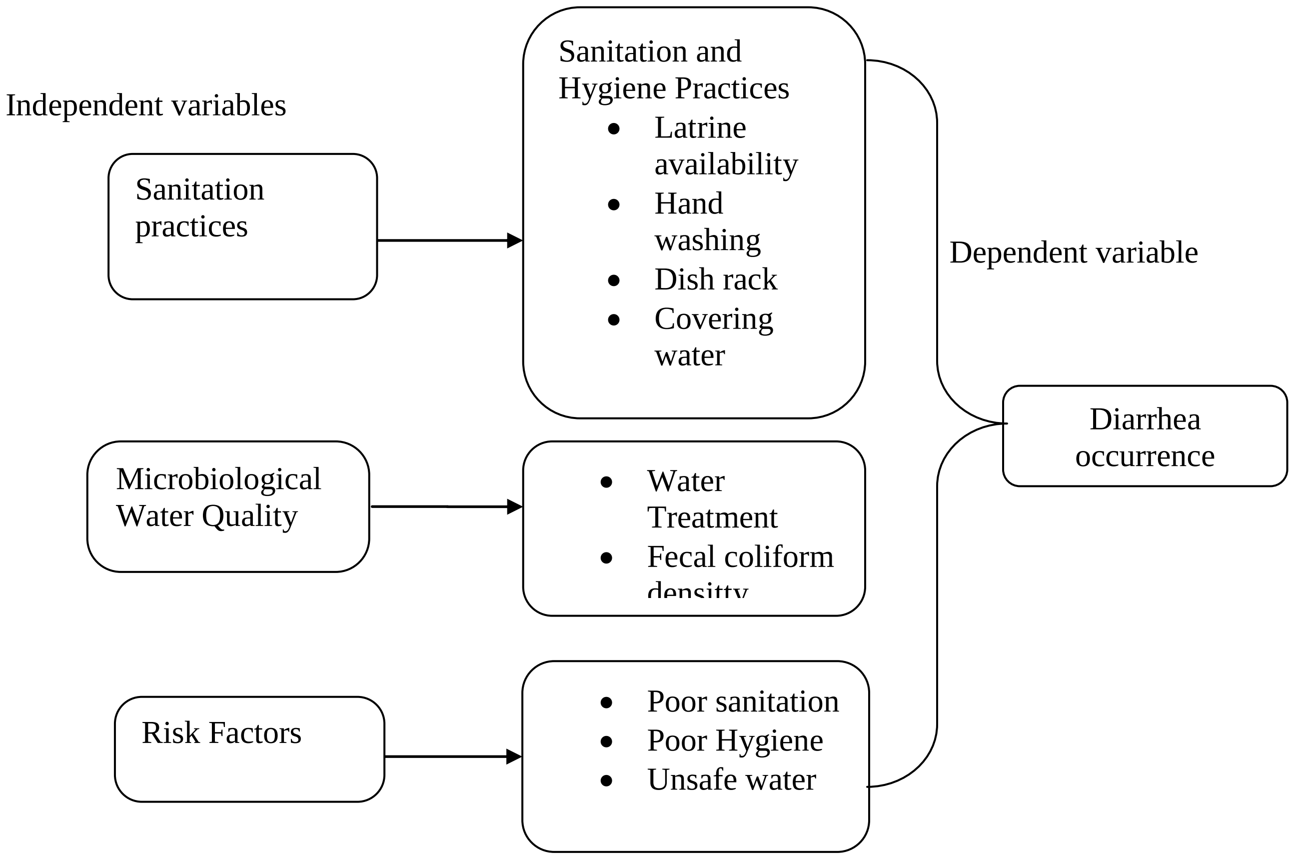


Figure 2.1: Operational Framework

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter discusses the methods used in carrying out the study. The chapter was organized into the following sub-headings; research design, area of study, target population, sample size and sampling procedure, research instruments, reliability and validity of the instruments, data collection procedures , data analysis techniques and ethical considerations.

3.2 Study Area

The study was carried out at Rang'ombe, Alum, Kolunga, Olambwe, Ogal and Mawembe beaches and their water collection points along the shoreline of Lake Victoria within Homabay and Kisumu counties. Lake Victoria is the largest fresh water lake in Africa and second largest in the world with an area of 68,800km^2 spanning 400 km North to South and 240 km East to West. It has a long shoreline of 3500km with a catchment area of 42460km^2 in the Kenyan side. The lake has approximately 278 beaches and islands spread in 5 counties of Homabay, Migori, Kisumu, Siaya and Busia. Its coastline ranges from papyrus swamps to rocky and sandy beaches for tourism and fisheries.

The lake's basin is estimated to accommodate over 40 million people with many economic activities including fishing, tourism, water, energy, agriculture, trade and industry, (UNEP, 2006). A majority of the people living in the lake basin, approximately 80% engage in small scale agriculture, fishing and animal husbandry (Makalle *et al.*, 2008).

3.3 Study Design

A descriptive cross sectional study design using both laboratory experiments and quantitative approaches. Microbiological water quality was determined using standard microbiological water quality assessment methods whereas data on sanitation practices, household water treatment methods and diarrhea cases was collected using semi-structured questionnaire developed from WHO/UNICEF household water quality survey guidelines.(to be moved to the right section).

3.4 Study Population

The study targeted residents of households within Ogal and Mawembe beaches in Kisumu County, Kolunga and Olambwe beaches in Mbita and finally Rang'ombe and Alum beaches in Homabay County along Lake Victoria, Kenya. Household heads were the study respondents. In case of absence of head of house, the eldest occupant of the house or care giver falling within the defined age bracket responded to the study questionnaire. The target population comprised of 1600 households which were distributed among the 6 selected beaches along Lake Victoria Kenya. This was informed by the number of households in every beach which varied from beach to beach.

3.4 .1 Inclusion criteria

Only households that drew surface or underground drinking water were included in the study.

3.4.2 Exclusion criteria

Consenting households that met the inclusion criteria but mixed their water from improved and unimproved sources were not included in the study. Improved sauces included those households that used piped tap water or roof catchment drinking water. These sauces were considered improved.

3.5 Sample Size Determination and Sampling Techniques

The sample size was determined using the formula by Fisher's *et al.*, (1998): $N = \frac{Z^2 (p)(q)}{d^2}$

Where; n = the desired sample size (if the target population is greater than 10,000)

Z = the standard normal deviate 1.96 at 95% confidence interval, p = 0.5, q = 1 – p = 0.5, d = level of statistical significance set at 0.05.

Therefore, $n = [1.96^2(0.5) \times (0.5)] \div 0.05^2 = 384$

422 households was the sample size for the study. This came about after an addition of 10% to buffer sampling error or nonresponse rate (Mugenda & Mugenda, 2003). Microbiological quality was tested in water samples obtained from 128, (30% of 422) households. An equivalent number of 128 water samples also collected from drinking water sources at the beaches. 30% of sample size was used as it is representative enough for a descriptive study.

3.6. Sampling Techniques

The study used Stratified random sampling technique. The 6 selected beaches formed a strata in which each beach was a stratum of all beaches selected. This study was drawn from a larger study around Lake Victoria by Lake Victoria Comprehensive Research for Development (LAVICORD) which informed selection of 6 beaches for Public Health research interventions. This was based on diarrhea cases reported in health facilities serving these beaches. Among the sub counties bordering the lake, Mbita, Karachuonyo and Kisumu west reported the highest number of diarrhea cases in which the beaches selected are located in Kasgunga, Kanyaluo and North West Kisumu wards that had highest number of diarrhea occurrence (Appendix III). Estimated number of households for the 6 beaches was obtained from local administration totaling to 1600 households. To obtain the sample size per beach, the sample household was divided proportionately based on the total number of households per particular beach. For Alum beach which had 400 households for example, sample households was obtained as; (400/1600 x 422=105). To obtain sampling interval, the household population was divided by the sample size; N/n (1600/422=4). Once the sample households in every beach were known, a systematic random sampling technique was used where every 4th household starting from the first household from the lake shoreline was sampled in all directions proportionately from the selected beaches (stratum). After identification of households to be sampled, 30% of these was obtained for water sampling and an equivalent from drinking water sources. A table of proportionality was then developed to represent the target beach number of households, sample households per beach and water sampling. This is illustrated in Table 3.1.

Table 3. 1: Sample Proportions to Population Size

Name of Beach	**Total households per beach**	**Sample size**	**Number of water samples (30% of sample size)**
1. Kolunga	300	79	24
2. Olambwe	300	79	24
3. Ogal	200	53	16
4. Mawembe	200	53	16
5. Rang'ombe	200	53	16
6. Alum	400	105	32
Total	**1600**	**422**	**128**

3.7 Data Collection Tools

A semi structured questionnaire (Appendix VII) was used to obtain socio demographic information of the respondents, their sanitation practices including availability of a toilet or pit latrine, handwashing facilities, and dish rack, and water treatment methods before consumption. Data on the occurrence of diarrhea among households within the last 2 weeks was also collected using a semi structured questionnaire. This information was supplemented by laboratory experiment data generated through testing for microbiological quality of drinking water obtained from unimproved water sources and households. Microbiological contamination of water was recorded in terms of Colony Forming Unit, CFU/100ml of water. Variables to be measured were sanitation practices, coliform density in drinking water and risk factors to occurrence of diarrhea. Sanitation practices were measured against basic requirements of sanitation and hygiene including availability of human waste disposal facilities, availability of hand washing facilities, use of dish racks and safe water storage and handling practices such as covering of drinking water containers. Microbiological contamination of drinking water was assessed based on the number of fecal coliforms in drinking water from the sources and at the household. The standard number of coliforms acceptable per 100 ml water was 80 CFUs/100ml drinking water. Water treatment was assessed upon whether it was practiced or not and the method of treatment used. Risk factors to occurrence of diarrhea were derived using inferential statistics.

3.8 Data Collection Procedures

The completed questionnaires were collected daily by the lead researcher from the research assistants and checked for completeness and consistency. Study codes were used on the questionnaires to avoid unique identification of the respondents. Access to recoded data was restricted to primary researchers only and security codes assigned to computerized data records.

Community Health Volunteers (CHVs) were used to identify households that sourced their drinking water from unimproved sources. The research assistant made introductions on the purpose of visit in the household and identified head of the house. The Research Assistant also obtained informed consent to carry out the study and obtained information as per the questionnaire.

A total of 128 water samples were collected from the households and an equivalent amount from drinking water sources along the shoreline of the 6 beaches. 300 milliliter plastic bottles sterilized with ethanol were placed in an ice cooler box and ferried to the sampling households and water sources. Corresponding numbering was done for the sample from the households similarly with samples from the sources. The samples were collected in the early morning hours before sunrise and placed immediately into the cooler box to maintain cool temperatures. Transportation to the laboratory was done within 3 hours after sampling and stored in the refrigerator. At the laboratory, microbiological contamination of the water samples from the beaches and at the household level were analyzed using membrane filtration method **(**Appendix IV**)**. The number of water samples positive for total and fecal coliforms were recorded and results expressed as percentage of total water samples analyzed.

3.9 Pre-testing Study Instrument

The study questionnaire was pretested at Dunga beach Kisumu County because of its similarity in characteristics as the selected study beaches. A sample size of 42 households were selected for pretesting. The information gathered was cross checked with other secondary data to ensure effectiveness and accuracy of the tool. Based on the performance of the study tool, necessary adjustments were made to improve the suitability of the questionnaire. Pretesting was done to ensure reliability and validity of the study instruments and also gave an estimated time that would be taken to collect data.

3.9.1 Reliability

Reliability was achieved using internal consistency (Cronbach's alpha) technique. This requires a single administration of test to estimate internal consistency and computed as follows:

Alpha = Nr/ (1-r (N-1)

Where: r= Mean inter-item correlation

N= Number of items in scale.

SPSS v18 was used to generate inter-item correlation matrix first, then summed up and estimated the average. Coefficient of 0.78 implied that there was a high degree of reliability.

3.9.2 Validity

content validity technique was used to address the match between test questions and the content the study subject area were intended to assess the extent to which a test or the questions on a test appear to measure a particular construct as viewed by lay persons, targeted clients, those being examined and the test user. Public Health specialists were used to measure the content validity where 15 panelists were used.

Using Lawshe's formula termed the Content Validity Ratio (CVR):

CVR = $(ne – N/2)/N/2$

Where: CVR = Content Validity Ratio

ne = number of panelists indicating "essential"

N = total number of SME panelists

Substituted as follows; CVR = $(14 – 15/2)/15/2$ = 0.8666.

Thus the questionnaire past the overall test of validity.

3.10 Data Analysis

SPSS was used to enter data from the questionnaires and that obtained from microbiological contamination of water samples in the laboratory. Descriptive analysis was done on population demographic profile and multivariate logistic regression analysis done to determine the relationship between sanitation practice (s) and occurrence of diarrhea. A chi-square test was done on microbiological water quality in relation to household diarrheal occurrences. Proportions of diarrheal incidence were calculated in relation to various water treatment methods then a bivariate analysis using Odds Ratio of developing diarrhea following each method of treatment determined. In the results, comparisons were made between quality of drinking water at the source and at the household in terms of *Escherichia colae* count, which were also linked to the incidences of diarrhea in the household. Water quality at different beaches were also compared. The results were presented using tables and histogram.

3.11 Ethical Considerations

The proposal was initially cleared by the School of Graduate Studies, Maseno University. Ethical clearance was obtained from Maseno University Ethical Research Committee (MUERC), (Appendix IX). Further approval was sought from the Beach Management Units and the relevant administration officers from the study location. The benefit of this study was explained to the study participants and other concerned parties.

Participation in the study was voluntary and data obtained from the study was treated with confidentiality. The research assistant first introduced oneself in every household that suited the inclusion criteria and stated the intention of the visit where the respondent agreed to listen. The research assistant thereafter described the research in detail including the study objectives, rights of participation, hazards or dangers if any to the prospective participant in a language best understood. The research assistant then verified if the prospective participant had understood the details of the research by re-narrating or paraphrasing the discussion. Arising concerns were clarified to ensure clear understanding. Participants in agreement with the clarifications consented through signing of the consent form provided for each household visited.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter described the participants' characteristics, established household sanitation practices, presents the microbiological quality of drinking water from unimproved water sources, identified household water treatment methods and established the risk factors associated with diarrheal occurrence in households along Lake Victoria, Kenya.

4.2 Participant's Characteristics

The study had 422 participants with females constituting 327 (77.49%) and males 95 (22.51%). The study participants were segregated in age groups of 10 years class with 15-24 years and 45 plus years as the lowest and highest respectively. Slightly above a third of the respondents belonged to 25-34 years age group at 152 (36.02%), and 45 plus years at 106 (25.1%). Most of the participants were married 382 (90.52%), with 15 (3.55%) of them being single. Those who fell in any other category not represented above constituted 25 (5.92%). Majority of the participants interviewed had attained primary education at 292 (69.19%), 92 (21.8%) had secondary level education with only 9 (2.13%) having attained tertiary level of education. Out of the study participants interviewed 114 (27.08%) were small scale farmers, 120 (28.5%) traders, 18 (4.28%) professionals, 53 (12.59%) casual laborers, 66 (15.68%) fish mongers and 50 (11.88%) were unemployed. Almost all of the study participants comprised of the Christian community, at 421 (99.76%) as shown in Table 4.2.

Table 4.2. Participants Social Demographics

(n=422)

4.3

Socio Demographic	**Characteristics**	**Number**	**Percentage (%)**
Gender	Male	95	22.5
	Female	327	77.5
Age Bracket	15-24	62	14.69
	25-34	152	36.02
	35-44	102	24.17
	>45	106	25.12
Marital Status	Single	15	3.56
	Married	382	90.52
	Other	25	5.92
Education Level	Primary	292	69.19
	Secondary	92	21.8
	Tertiary	9	2.13
	Other	29	6.87
Occupation	Farmer	114	27.08
	Trader	120	28.5
	Professional	18	4.28
	Casual	53	12.59
	Fisherman	66	15.68
	Other	50	11.88

Sanitation Practices

The study also assessed sanitation practices of the individuals categorized by beach. Most of the interviewed participants from Alum, Ogal and Olambwe reported slightly over 50% access to safe drinking water except Mawembe and Rang'ombe which had 25 (47.17%) and 23 (43.4%) respectively. Notably, higher percentages of access to safe drinking water were reported nearly at every household of Kolunga and Ogal beaches at 77 (97.47%) and 51 (96.3%) respectively. The number of residents accessing safe drinking water was significantly different across the beaches, $p<0.001$.

More than two-thirds of the participants interviewed from all the beaches, 70%, reported that they were covering their drinking water containers. Strikingly, all the participants at Mawembe beach reported that they cover their drinking water. The variation across the beaches was statistically significant ($p<0.001$)**.**

Installation and availability of hand washing equipment amongst households of all the beach communities was very minimal. Ogal and Rang'mbe beaches reported 20 (37.74%) and 17 (32.08%) respectively with Olambwe beach reporting as low as 5 (6.33%). The variation in the installation and availability of hand washing equipment across the beaches was statistically significant, $p<0.001$.

Availability of a dish rack as a sanitation practice was averagely embraced among beach community households at 40 (50.63%), 32 (60.38%) and 39 73.58%) for Kolunga, Ogal, and Rang'ombe respectively. However, Olambwe beach reported significantly low coverage in the number of dish racks available at 7 (8.86%). Factors such as household income, space availability and knowledge on the importance of use of dish racks in the beaches influenced their availability, $p<0.001$

All the participants interviewed from all the beaches, Alum, Mawembe, Ogal, and Olambwe had below 50% latrine coverage with Kolunga and Rang'ombe reporting slightly above 50%, 44 (55.7%) and 29 (54.72%) respectively. The variation in latrine coverage from one beach to the next was statistically significant, p=0.004. Additionally, the study found out that, of those who had toilets from all the beaches, only 7 (4%) had an improved pit latrine while the rest had regular pit latrines. Those without a human waste disposal facility reported defecation in the bushes and burying at 182 (77%) and 55 (23%) respectively. This was reported alongside many reasons for not having a toilet such as increased cost of construction, cultural practices among others.

Table 4. 3. Sanitation Practices

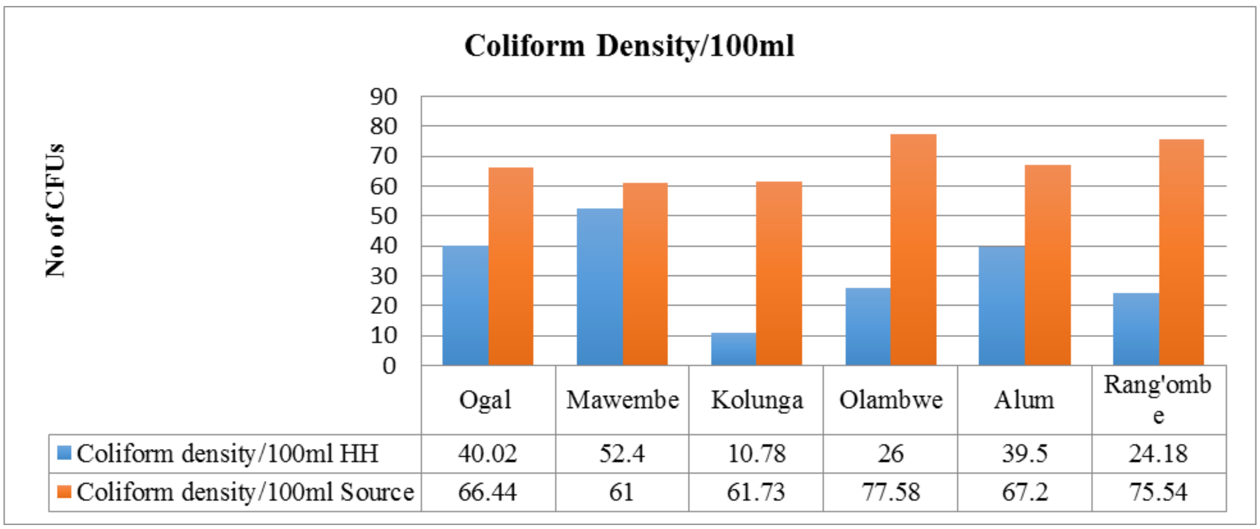
	Name of Beach						
Variable	**Alum**	**Kolunga**	**Mawembe**	**Ogal**	**Olambwe**	**Rangombe**	***p* value**
Safe drinking water	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**<0.001**
Yes	58 (55.24)	77(97.47)	25 (47.17)	51 (96.23)	58 (73.42)	23 (43.4)	
No	47 (44.76)	2 (2.53)	28 (52.83)	2 (3.77)	21 (26.58)	30 (56.6)	
Cover water							**<0.001**
Yes	102(97.14)	7 (98.73)	53 (100)	43 (81.13)	76 (96.2)	37 (69.81)	
No	3 (2.86)	1 (1.27)	0 (0)	10 (18.87)	3 (3.8)	16 (30.19)	
Latrine							**0.004**
Yes	46 (43.81)	44 (55.7)	17 (32.08)	26(49.06)	23 (29.49)	29 (54.72)	
No	59 (56.19)	35 (44.3)	36 (67.92)	27(50.94)	55 (70.51)	24 (45.28)	
Handwashing							**<0.001**
Yes	12 (11.43)	20(25.32)	6 (11.32)	20(37.74)	5 (6.33)	17 (32.08)	
No	93(88.57)	59(74.68)	47 (88.68)	33(62.26)	74 (93.67)	36 (67.92)	
Dish rack							**<0.001**
Yes	34 (32.38)	40(50.63)	21 (39.62)	32 (60.38)	7 (8.86)	39 (73.58)	
No	71 (67.62)	39(49.37)	32 (60.38)	21(39.62)	72 (91.14)	14 (26.42)	

4.4 Microbiological Quality of Drinking Water

The average number of CFUs at the source was 68.25 CFU/100ml while that at the household was 32.15CFU/100ml, this meant that the majority of the households subjected water to treatment before use, hence reduced amount of fecal coliforms. Most, 56 (43.91%), of the household water tested had between 0-19 CFUs, 50 (39.24%) of them had between 20-80 CFUs with the least household at 22 (16.84%) testing between 181 and 135 CFUs.

It was evident that water treatment was most effective at Olambwe beach where the average coliform density from source to household reduced by 51.36 CFUs. Water treatment was least effective at Mawembe beach with coliform density reducing by only 8.6 CFUs as shown in Figure 4.1 and 4.2 below.

Microbiological quality of drinking water from unimproved sources consumed by households living along Lake Victoria, Kenya



	Ogal	Mawembe	Kolunga	Olambwe	Alum	Rang'ombe
Coliform density/100ml HH	40.02	52.4	10.78	26	39.5	24.18
Coliform density/100ml Source	66.44	61	61.73	77.58	67.2	75.54

Figure 4. 1. Coliform Density/100ml water at Source and Household

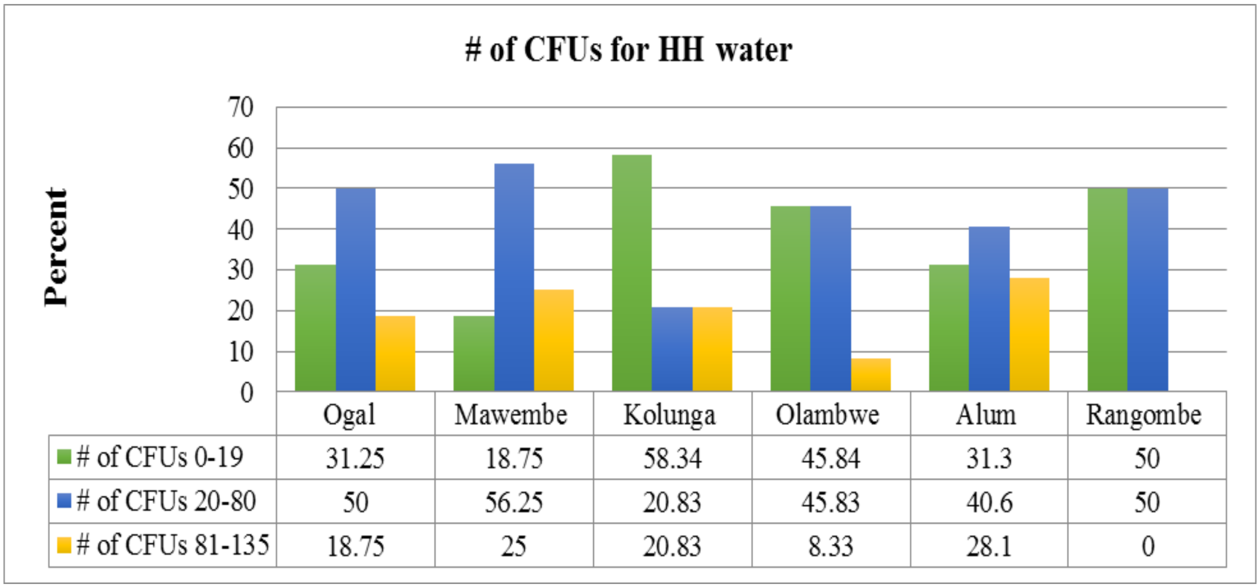


Figure 4. 2. Number of CFUs for Household Water

The relationship between the fecal coliform density at household and the diarrhea occurrence

It was established that there was a significant relationship between fecal coliform density at household and the diarrhea incidence, p=0.041 C.L=95%.

Households in Mawembe beach were more at risk of developing diarrhea compared to residents at Kolunga beach. Rang'ombe beach residents were more at risk of developing diarrhea compared to residents at Kolunga beach.

Table 4. 1. Mean CFUs by Beach and Diarrhea Occurrence

		Unadjusted	
Beach	**Mean CFUs**	**uOR(95%CI)**	***p* value**
			0.041
Kolunga	10.7	ref	
Olambwe	26	3.92 (0.21-4.13)	0.021
Alum	39.5	4.1 (0.43-5.98)	0.371
Mawembe	52.4	4.98 (1.31-6.87)	0.001
Ogal	40	3.1 (0.41-7.12)	0.032
Rangombe	24.18	1.9 (0.67-2.48)	0.864

4.5: Household Water Treatment

Using bivariate analysis to determine water treatment correlates, the study established that residents of Kolunga and Ogal beaches had 7.49 and 2.65 times more likely to treating their drinking water respectively before consumption (OR=7.49 [2.98-18.8], $p<0.0001$; OR=2.65, [1.2-5.85], $p<0.016$) as compared to inhabitants of Alum beach. Notably, however, participants from Rang'ombe beach reported a 0.8 chance of household water treatment with reference to those from Alum beach (OR=0.8 [0.41-1.57], $p<0.521$).

Table 4. 5. Correlates of Water Treatment by Beach

	Treat water n (%)		
Beach	**Yes**	**OR (95%CI)**	***p* value**
			<0.0001
Alum	65 (61.90)	ref.	
Kolunga	73 (92.41)	7.49 (2.98-18.8)	**<0.0001**
Mawembe	40 (75.47)	1.89 (0.9-3.97)	0.091
Ogal	43 (81.13)	2.65 (1.2-5.85)	0.016
Olambwe	62 (78.48)	2.24 (1.15-4.37)	0.017
Rangombe	30 (56.60)	0.8 (0.41-1.57)	0.521

4.5.1: Demographic correlates of water treatment

According to this study, those married had a 3.93 possibility of treating water with reference to being single (OR=3.93 [1.39-11.16], p<0.01). Further, participants with secondary as the highest level of education attained are more likely to treat water compared to those with primary level of education (OR=3.66 [1.76-7.63], p<0.0001). Professionals have a higher likelihood of treating water compared to farmers (OR=5.22[1.14-23.79], p<0.033). These are well illustrated in Table 4.6.

Table 4. 2. Demographic correlates of water treatment

	Treat water n (%)		
	Yes	**OR (CI 95%)**	**P value**
Gender			0.6806
Male	72 (75.79)	ref.	
Female	241 (73.70)	0.90 (0.53-1.52)	
Marital Status			**<0.001**
Single	7 (46.67)	ref.	
Married	296 (77.49)	3.93 (1.39-11.16)	0.01
Other	10 (40.00)	0.76 (0.21-2.77)	0.68
Age (years)			**0.062**
15 -24	49 (79.03)	ref.	
25 - 34	122 (80.26)	1.08 (0.52-2.24)	0.838
35 - 44	77 (75.49)	0.82 (0.38-1.75)	0.602
> 45	65 (61.32)	0.42 (0.20-0.87)	0.019
Education			**<0.001**
Primary	209 (71.58)	ref.	
Secondary	83 (90.22)	3.66 (1.76-7.63)	0.001
Tertiary	9 (100.00)	-	
Other	12 (41.38)	0.28 (0.13-0.61)	0.001

The occupation (p=0.0018**)** and religion (p=0.021) of the respondents was important in explaining water treatment practices at the household. Water source was not important in whether a household would treat water or not (p=0.7552). Additionally, the study found that 313

(74%) of the participants from all the beaches treat their water. Of those who treat water, a majority, 119 (70.26%) use chlorination as a method of treatment, 50 (16.03%) use filtration while 40 (13.12%) boil their water as shown in figure 4.3.

Table 4.11. Correlates of water treatment with reference to occupation, religion and water source

	Treat Water n (%)	**-**	
	Yes	**OR (95% CI)**	**P value**
Occupation			**0.0018**
Farmer	69 (60.53)	ref.	
Trader	99 (82.50)	3.07 (1.68-5.62)	**<0.0001**
Professional	16 (88.89)	5.22 (1.14-23.79)	0.033
Casual	40 (75.47)	2.01 (0.97-4.16)	0.061
Fisherman	48 (72.73)	1.74 (0.90-3.36)	0.1
Other	41 (82.00)	2.97 (1.31-6.70)	**0.009**
Religion			0.021
Christian	312 (74.11)	ref.	*0.001*
Muslim	1 (100.00)	-	
Water Source			0.7552
Lake	311 (74.76)	ref.	
River	0 (0.00)	-	
Well/Spring	2 (66.67)	0.68 (2.37-3.70)	**<0.0001**

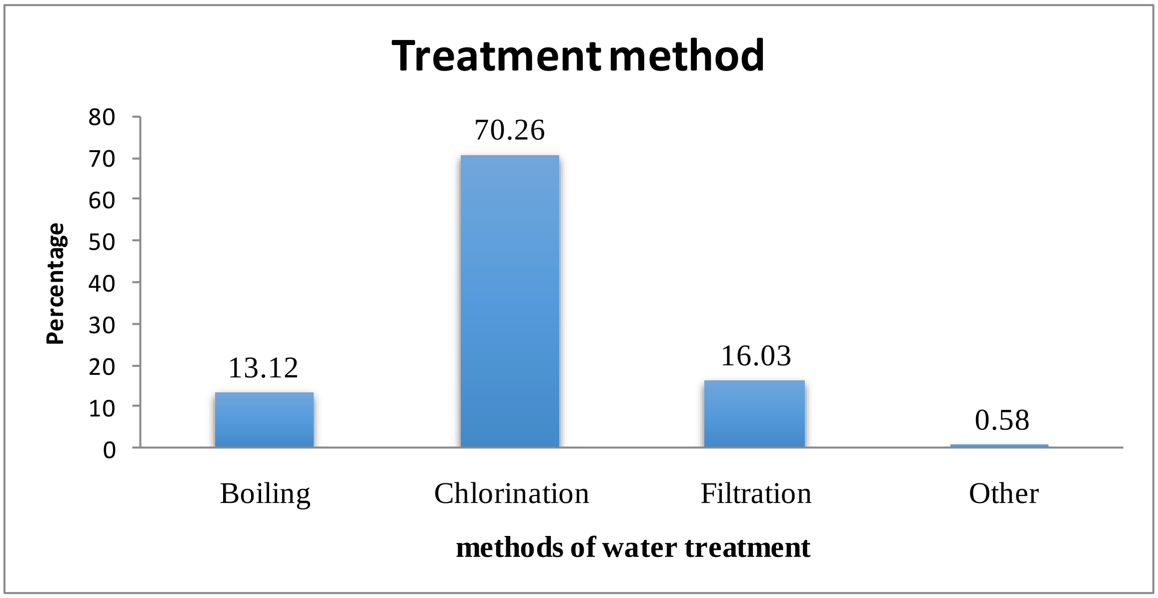


Figure 4. 3. Water Treatment Methods

The study revealed that treatment of water was important in explaining the occurrence of diarrhea at the households, p=0.001. It was evident that households that treated water were less likely to have incidences of diarrhea compared to those that did not treat water. (OR=0.47 [0.30-0.73], p<0.001).

Table 4. 3. Diarrhea occurrence in relation to water treatment

Diarrheal occurrence with treating or not treating water			
	Diarrhea	OR (CI 95%)	P value
Treat Water			**0.001**
No	57 (52.29)	ref.	0.001
Yes	106 (33.87)	0.47 (0.30-0.73)	

4.6: Risk Factors Associated with Occurrence of Diarrhea

The study revealed that gender of the respondent was not important in explaining the incidence of diarrhea at the household p=0.3049. The study also established that age of the participant was not important in explaining the variation of diarrheal incidence at the household level, p= 0.9488. The study revealed that that education (p=0.1172), occupation (p=0.3117) and water source (p=0.6056) of drinking water were not important in explaining the incidences of diarrhea among households living along Lake Victoria, Kenya as shown in Table 4.4.

Table 4. 4. Socio Demographics and diarrhea occurrence

	Diarrhea occurrence	**Unadjusted OR**	
Variable	**Yes n (%)**	**uOR (95%CI)**	***p* value**
Gender			**0.3049**
Male	41 (43.16)	ref.	
Female	122 (37.31)	0.78 (0.49-1.25)	
Age (years)			**0.9488**
15 -24	22(35.48)	ref.	
25 – 34	60 (39.47)	1.19 (0.64-2.19)	0.586
35 – 44	39 (38.24)	1.13 (0.58-2.17)	0.724
> 45	42 (39.62)	1.19 (0.62-2.28)	0.594
Education			**0.1172**
Primary	119 (40.75)	ref.	
Secondary	30 (32.61)	0.70 (0.43-1.15)	0.163
Tertiary	1 (11.11)	0.18 (0.02-1.47)	0.1
Other	13 (4.83)	1.18 (0.55-2.55)	0.671

Occupation			**0.3117**
Farmer	46 (40.35)	ref.	
Trader	42 (35.00)	0.80 (0.47-1.35)	0.399
Professional	3 (16.67)	0.30 (0.08-1.08)	0.065
Casual	22 (41.51)	1.05 (0.54-2.03)	0.887
Fisherman	29 (43.94)	1.16 (0.63-2.14)	0.638
Other	20 (40.00)	0.99 (0.50-1.94)	0.966
Water Source			**0.6056**
Lake	160 (38.46)	ref.	
River	2 (66.67)	3.20 (0.29-35.58)	0.344
Well/Spring	1 (33.33)	0.80 (0.07-8.89)	0.856

The study established that participants who reported not to have access to safe drinking water had a 1.65 chance of developing diarrhea (OR=1.65, 95% CI [1.08-2.51], p>0.0202) compared to those who do. Out of the study participants who reported not to cover their drinking water, there was a 3.04 chance of developing diarrhea compared to those who covered their drinking water (OR=3.04, 95% CI [1.45-6.37], p<0.0025).

Furthermore, those without a human waste disposal facility were 1.96 more likely to develop diarrhea compared to those who had (OR1.96, 95% CI [1.31-2.94], p<0.001).

The study also assessed availability and use of hand washing equipment for participants with human waste disposal facility. It was found that amongst households which did not have hand washing equipment installed were 2.76 more likely to develop diarrhea compared to those who had (OR=2.76,95% CI [1.55-4.92], p<0.0002). Additionally, households without a dish rack had a 1.57 chance of developing diarrhea compared to those that had (OR=1.57, 95% CI [1.05-2.36], p<0.0271).

Table 4. 5. Risk Factors of diarrhea occurrence

Variable	**Diarrhea Occurrence Yes n (%)**	**Unadjusted uOR (95%CI)**	***p* value**
Safe water			**0.0202**
Yes	102 (34.93)	ref.	
No	61 (46.92)	1.65 (1.08-2.51)	
Covering water			**0.0025**
Yes	142 (36.50)	ref.	
No	21 (63.64)	3.04 (1.45-6.37)	
Latrine			**0.001**
Yes	55 (29.73)	ref.	
No	107 (45.34)	1.96 (1.31-2.94)	
Handwashing			**0.0002**
Yes	17 (21.25)	ref.	
No	146 (42.69)	2.76 (1.55-4.92)	
Dish rack			**0.0271**
Yes	56 (32.37)	ref.	
No	107 (42.97)	1.57 (1.05-2.36)	

The study revealed that there was a significant association between the number of diarrhea episodes and the beach where a household stayed along Lake Victoria p=0.001. All the beaches reported incidences of diarrhea. Moreover, nearly all the beaches reported slightly above 70% one episode of diarrhea occurrence in households except Alum and Mawembe which reported 16 (35.56%) and 9 (56.25%) respectively.

Alum beach significantly reported a higher percentage of diarrhea incidences occurring twice at 23 (51.11%). Nearly all the beaches had very minimal or no diarrhea episodes of 4 or more times except for Mawembe which reported 2 (12.50%).

Table 4. 6: Diarrhea episodes by beach

Variable			**Name of beach**				
	Alum	**Kolunga**	**Mawembe**	**Ogal**	**Olambwe**	**Rang'ombe**	***P* value**
Diarrhea episodes							**0.001**
Once	16(35.56)	23 (79.31)	9 (56.25)	14(77.78)	20 (71.43)	18 (78.26)	
Twice	23(51.11)	4 (13.79)	2 (12.50)	4 (22.22)	7 (25.00)	5 (21.74)	
Thrice	5 (11.11)	2 (6.90)	3 (18.75)	0 (0.00)	0 (0.00)	0 (0.00)	
4 &more	1 (2.22)	0 (0.00)	2 (12.50)	0 (0.00)	1 (3.57)	0 (0.00)	

More than one third of the incidences of diarrhea were reported amongst children aged 5 years and below at 36% followed by those participants aged 21 years and above at 26.86%. Households with persons aged 16-20 years recorded the lowest percentage of diarrhea at 5.14%.

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter discusses the findings of the study as per the objectives in relation to past experiences and research work.

5.2 Sanitation Practices

It has been found out in a number of studies that sanitation and hygiene practices are important in improving public health. One such study was conducted in Ethiopia to determine prevalence and determinants of diarrhea among children below 5 years of age found out low availability of hand washing facilities and poor water storage practices in the household (Ante, 2017). Another study by (Misati, 2016) in Kisii County in Kenya investigating household safe water management found out that a majority, 95% covered their drinking water containers while water samples from unimproved saurces mainly from wells tested highest for fecal coliforms. (Whinnery et al., 2016) conducted a study in Kisumu evaluating innovative approaches for hand washing and found out low prevalence of hand washing after contact with feaces. Another study conducted in Northern Ethiopia to assess childhood diarrheal morbidity and sanitation predictors in nomadic communities, hand washing, availability of latrine and types of drinking water sources were sanitation predictors to diarrhea occurrence (Bitew et al., 2017). The current study presented similar findings with low availability of latrines and hand washing facilities . The low availability of these basic sanitation parameters at the household could be attributable to lack of knowledge and awareness on sanitation issues by beach communities and their remote areas of residence.

5.3 Microbiological Water Quality

Fecal coliforms, *E. coli* counts exceeded acceptable limits of 20-80 CFU/filter/100ml as stipulated by (WHO 2011), guidelines for drinking water quality for potable water. The results from the current study indicated that water samples from all the beaches were contaminated beyond acceptable limits. This contamination could be linked with many factors including the population density, type of settlement, sanitation arrangement and behavior, an indicator of pollution from temporary latrine structures, underground seepage from sanitation facilities and open defecation from beach communities along Lake Victoria. This gross pollution is exposure to health risks for the local communities. These findings were similar to a study by (Misati, 2016) which investigated houshold safe water management and found out that water samples from unimproved saurces mainly from wells tested highest for fecal coliforms.

Similarly with another study to assess human fecal contamination in Southern California Coastal Drainages, fecal contamination was detected in all but two sites indicating the additional value of the human-associated marker as a routine monitoring tool (Cao et al., 2017). Contamination may also be due to a myriad of activities in and along the lake including bathing, direct drinking by animals, human defecation in the lake, swimming, and surface runoffs. This escalates the probability of ingestion of fecal coliforms both at the source and in homes when not treated.

Another study to evaluate microbial quality of drinking water distributed in Khartoum state using MPN and chromogenic media based techniques revealed that 47.5- 90% showed positive isolation of bacteria, 73.3% showed negative bacteria growth during winter. Fecal pollution indicator bacteria was isolated at 11.2% at winter and 2.6% at summer. Failure to treat river water before use was a significant predictor of diarrhea.

5.4 Household Water Treatment

Water treatment in the household is an important practice to improved health. In the current study, water treatment was low. Consequently in this study, contamination of water at the household was relatively lower because of water treatment interventions and observation of water covering as a hygienic behavior. The methods that were used for treating drinking water included point of use chlorination, boiling, filtration. This puts more emphasis on household water treatment as was highlighted in the current study because water quality cannot be guaranteed at point of supply due to contamination during collection, transport and storage posing significant health risks to consumers. This was in agreement with a study by (Eric and Jamie, 2001) to expanding access to point of use water treatment systems, Global perspective in Zambia which indicated that water treatment using sodium hypochlorite can reduce diarrheal illnesses by 85%.

Presence of *E-coli* confirm inadequate treatment of water or post treatment contamination thus water is vulnerable to contamination through storage and distribution (Sanaa and Rawda, 2009), similarly, (Tubatsi *et al.,* 2015) noted that river water samples collected were fecally contaminated and unsuitable for domestic use without prior treatment. This is in agreement with the current study which established that there was high dependency on fecally contaminated lake water considered unimproved thus need for treatment to improve on quality.

5.5 Risk Factors Associated with Occurrence of Diarrhea

Diarrhea occurrence is influenced by various risk factors both environmental and behavioral among populations in developed and developing regions of the world. The current study sought to find out the risk factors associated with diarrhea occurrence which found out that unavailability of human waste disposal facilities led to open defecation and was one of the major risk factor to contracting diarrhea. This finding portrayed clear lack of understanding and knowledge on safe disposal of human waste and that the communities are unaware of the fecal oral route transmission of diarrhea causing pathogens. The fact that people have an alternative of open defecation in fields and water bodies in case of absence of a latrine is a clear indication of a greater risk to human health caused by human feaces. The study also found out that consumption of unsafe or untreated drinking water was another risk factor to occurrence of diarrhea. This showed that water treatment interventions especially at the source are not sufficient in ensuring improved drinking water quality. This is because microbiologically quality water from the source is prone to recontamination during transport and storage at the household. Additionally, the study found out that lack of hand washing facilities and actual practice of washing hands after use of latrines was a risk factor to occurrence of diarrhea. This showed that hand washing messages and the importance of hand washing at critical times have not been adequately passed to community members.

These findings are echoed in several other studies including a study by (Badowski *et al.*, 2011) to understand household risk factors for diarrheal disease in Dares salaam Tanzania which found out that fecally contaminated hands were potential routes of contamination that led to diarrhea. Another study conducted in Nyando and Nambale sub counties in Kenya comparing prevalence of diarrhea in OD verses ODF villages showed reduction in diarrhea where CLTS leading to ODF had been implemented thus availability and use of latrines reduced diarrhea (Njuguna, 2016). Similar studies by (Ayalew et al., 2018) and (Baker et al., 2016) in Dangla District of Ethiopia and Kenya found lower prevalence of diarrhea in ODF compared to OD communities thus presence of a human waste disposal facility was significant to diarrhea occurrence.

Sanitation and hygiene practices reduce the occurrence of diarrhea incidences significantly; therefore their absence becomes a risk factor for the occurrence of diarrhea. A study by (Cairncross *et al.,* 2010), recorded diarrhea risk reduction of 48%, 17% and 36% associated respectively with hand washing with soap, improved water quality and excreta disposal.

The study indicated a 14-40% reduction in diarrheal disease through hand washing, water treatment 70-96%-91.5% across settlements, boiling reduced diarrheal at 59.3-83.9%. Diarrhea occurrence in last 1 month was reported at 16.1, 37.7, 41.1, 49.2% in low income, medium density middle income, high density low income, informal settlements low income. Water quality reported at 54.8, 49.1, 46.4, 33.9% across the settlements (Kimani, 2013). This is in agreement with the findings of the current study which revealed a significant low occurrence of diarrhea cases when hygiene practices are observed. Supported by intervention studies elaborating point of use water treatment, hand washing reporting 40%, 35%, and 48% reduction of disease.

In a study to determine childhood diarhhea in Nyanza Western Kenya by (Kawakatsu et al., 2017), 45.7% accessed improved drinking water sources while 54.3% treated their drinking water in the household thus reported reduced cases of diarrhea.

This is because recontamination often occurs at the household level when appropriate hygiene measures are not put into practice. These findings are in agreement with study by (Wolf *et al.*, 2014) which found that inadequate water and sanitation are associated with considerable risks of diarrheal disease and that there are notable differences in illness reduction according to the type of improved water and sanitation implemented.

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter gives a summary of the findings, conclusion and recommendations.

6.2 Summary of Findings

Sanitation practices were found to be statistically significant in reducing occurrence of diarrhea. These practices are; availability and use of latrines for safe disposal of human wastes, availability and use of hand washing stations after visiting the toilet to prevent ingestion of feaces through hands and covering of drinking water containers to avoid recontamination. Water quality varied significantly from source to household level due to effective treatment methods employed by a majority of the households. Good quality water subjected to treatment at the household had minimal reported cases of diarrhea as compared to households who consumed raw untreated water and reported higher diarrhea cases. Methods of water treatment used were boiling, chlorination and filtration with chlorination used by majority of the households. Risk factors leading to occurrence of diarrhea in the study were lack of human waste disposal facilities leading to open defecation, consumption of unsafe/ untreated water and failure to observe basic household hygiene practices such as hand washing and covering of drinking water containers.

6.3 Conclusion

1. Adherence to good sanitation and hygiene practices such as use of latrines for safe disposal of human wastes, hand washing after visiting the toilet and covering of drinking water containers present a lesser risk to occurrence of diarrhea.
2. Microbiological contamination of water, fecal coliforms are presented in large quantities beyond acceptable limits in drinking water at the source compared to the household.
3. Water treatment especially at the household is an important protective measure against contracting diarrheal diseases among communities.
4. Lack of sanitation and hygiene facilities and consumption of unsafe water are risk factors associated with occurrence of diarrhea.

6.4 Recommendations from this Study to Beach Communities

1. The study recommends that communities need to adopt availability and usage of basic sanitation and hygiene practices such latrines and hand washing.
2. The study recommends sensitization of beach communities on water treatment in the household as opposed to treatment at the source as water treated at the source is still at risk of recontamination through transport and storage procedures.
3. There is need to put more emphasis on promotion of water treatment at the household by all to improve the quality of water and reduce occurrence of diarrhea.
4. The study recommends implementation of sanitation and hygiene practices and improvement of drinking water quality to reduce on diarrhea occurrence.
5.

6.5 Recommendation for Further Research

1. Risk factors in relation to diarrhea against different seasons of the year is important for further research.
2. Sanitation practices at the household level including handling of children faeces by care givers by beach communities should be researched.
3. Different household water treatment methods should be researched in relation to occurrence of diarrhea.
4. Sources of contamination of water and occurrence of diarrhea should be considered for further research.

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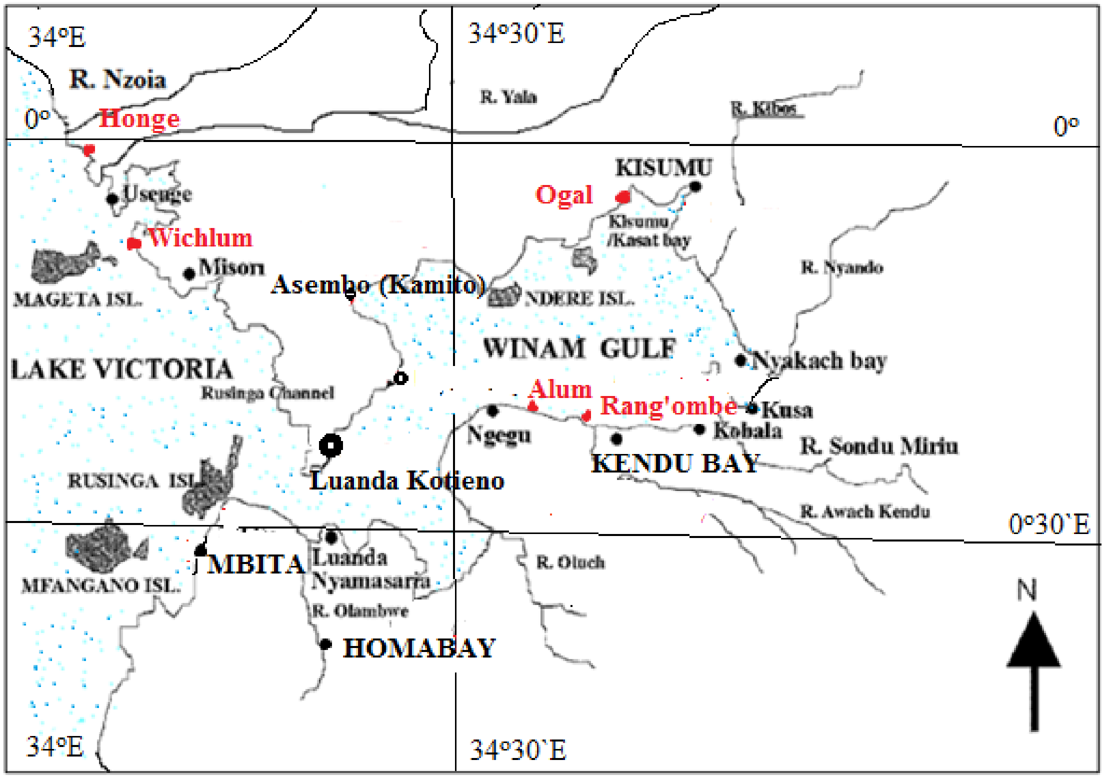
APPENDICES

Appendix I: Map of Study Area



Appendix II: Protocol on Sampling Procedures

Below is a step by step guide for the study sampling procedures

- 6 beaches are selected based on diarrhea cases reported in their respective sub counties and wards.
- Each of the 6 beaches formed a stratum for sampling.
- Stratified random sampling technique was used.
- Obtain the estimated number of households for every beach from the local administration.
- Sum up the number of households in the 6 beaches to obtain the target population in terms of households. In this case, 1600 households was obtained.
- Based on the number of households per particular beach, divide the sample households, (422) proportionately to obtain the sample size per beach.

  Example, sample size for Alum beach was calculated as follows;

  (400/1600 x 422=105).
- Divide the total number of households in the 6 beaches by the sample size to obtain sampling interval as follows;

  (1600/422=4).
- Use systematic random sampling technique to sample households once the sample households in every beach are known.
- Choose a starting point for sampling. In this study, sampling began from the first household from the beach/ lake shoreline in all directions.
- Using sampling interval of 4, every 4^{th} household is visited. In case of failure for the household to consent, the next immediate household is selected.

- To obtain the number of samples for water testing, calculate 30% of sample households per beach and an equivalent from drinking water sources. For example, 30% of 105 households for Alum beach resulted in 32 water samples.

Appendix III: Occurrence of Diarrhea in study location

Sub county	Ward (Beaches)	Diarrhea Cases
Mbita	Gembe	841
	Kasgunga	1263
	Lambwe	706
	Rusinga Island	1124
Karachuonyo	Central	530
	Kanyaluo	592
	Kendu bay town	464
	kibiri	315
	North karachuonyo	333
Kisumu west	wangchieng	807
	West karachuonyo	442
	Central Kisumu	1234
	North kisumu	221
	N.west kisumu	3578
	S west kisumu	746
	West Kisumu	402

Source: DHIS2 2014

Appendix IV: Membrane Filtration method using Hi Crome M-TEC Agar

Procedure

Step 1-Preparation of medium

- Suspend 45.6 grams of the agar in 1000 ml distilled water. (This will be dependent on the volume of medium required)

-Heat to boiling to dissolve the medium completely.

-Sterilize by autoclaving at 15 lbs pressure (121°C) for 15 minutes.

- The agar medium is cooled to 45-50°C and poured into sterile 47mm petri dishes

Step 2- Preparation of Plates

Clean up the working table and the booth using ethanol.

Spread aluminum foil at the inside of the booth, spray ethanol and wipe the surface well.

Prepare enough number of 47mm petri-dishes and pour only the agar medium on it and place them in the booth

Step 3- Filtration

Set up the filtration unit- measure water volume 100mL of each sample for filtration passing through the membrane filter for about 5min filtration time. Sample water is measured by use of 50mL pre-sterilized plastic tube

If more than one filter is used, both filters should be placed on the agar medium of the dish.

Use ethanol and fire to sterilize the filter funnel when the samples are changed. Pass through 100 mL of sterilized water without filter membrane.

Step 4-Incubation

Cultural characteristics are observed after an incubation at 44.5±0.2°C for 22-24 hours

After filtration, the membrane filter containing the bacteria is placed on the 47mm petri dish containing the prepared selective and differential medium, Hi Crome M-TEC Agar.

The membrane is incubated at 35 ± 0.5°C for 2 h to resuscitate the injured or stressed bacteria.

It is then incubated at 44.5 ± 0.2°C for 22 h.

The modified method eliminates the transfer of the membrane filter to another substrate.

Step 4-Counting of CFU

The target colonies on Hi Crome M- TEC agar are purple or magenta in color after the incubation period. The colonies are counted physically or a microscope.

Appendix V: Informed Consent Form (English)

Gertrude Shisanya

C/o Maseno University,

School of Public Health and Community Development,

P. O. Box. Private Bag,

Maseno.

Phone: +254 727 710415

The Secretariat,

Maseno University Ethics Review Committee,

P.O. Box. 333,

Maseno.

RE: TO WHOM IT MAY CONCERN

I am a final year Master of Public Health student from Maseno University carrying out a research in Assessment of Risk Factors Associated with Diarrheal Cases in Households along Lake Victoria, Kenya. I will appreciate your participation in this survey as the information given will be treated confidentially and will solely be used in achieving the objectives of this research as well as inform policy formulation and implementation of interventional programs within this area.

At this point in time, you are free to ask any question for clarification purposes.

If you agree to participate in this survey, kindly verify by signing below.

Sign .... Date ……………………......

Research Assistant ………………. Date ………………………

Appendix VI: Informed Consent Form (Dholuo)

Gertrude Shisanya

C/o Maseno University,

School of Public Health and Community Development,

P. O. Box. Private Bag,

Maseno.

Cell: +254 727 710-415

The Secretariat,

Maseno University Ethics Review Committee,

P.O. Box. 333,

Maseno.

RE: NE NGA'T MA OCHUNO

An japuonjre masomo e mbalariany ma Maseno. Atimo nonro kuom gigo maricho molure gi chandruoge mag diep ne ji modak e aluora mar Nam Lolwe. Abiro duoko erokamano maduong' kuom yie mari mar timo nonroni koda nikech duoko michiwo ok bi ket ayanga nimar ibiro ti kode mana e chopo singo mar nonro kendo nyiso joma loso kendo konyo e chopo chike mar piny mangima modak e aluora ni.

Nyngi kod nambani mar mbuyi ok bi dwar kata matin.in thuolo duoko kata dagi duoko penjogi Sani in thuolo penjo penj moramora ma chandi mondo inwang' ler. Ka iyie mar bedo achiel kum joma abiro timo nonro kuomgi to tim ranyisi kokalo keto koki a nafas mowee piny ka.

Koki…………………………….. Tarik ……………………..

Janeno …………………………… Tarik ……………………

Appendix VII: Household Questionnaire

Introduction

Study inclusion or exclusion question: what is your source of drinking water?

Improved (tap water, rain water, protected springs) [ ]

Unimproved (lake, rivers, shallow wells and unprotected springs) [ ]

If tick to part i, stop and thank participant, but if tick to part ii, then move to section A

Questionnaire No…. Name of beach………………….. County……………Sub-County…………….

Section A: Background information (Tick where appropriate)

Gender i) Male [ ] ii) Female [ ]

Marital status: i) Single [ ]

ii) Married [ ]

iii) Others (specify) ______________________________

Age (years): i) < 15 [ ]

ii) 15 -24 [ ]

iii) 25 - 34 [ ]

iv) 35 – 44 [ ]

v) > 45 [ ]

Education: i) Primary [ ]

ii) Secondary [ ]

iii) Tertiary [ ]

iv). Others (specify) ____

What is your occupation?

i) Peasant farmer [ ] ii) Trader [ ] iii) Professional [ ] iv). Casual [ ] v) Fisherman [ ] v) Others (specify) ________________

Religion: i) Christian [ ] ii) Muslim [ ] iii) Others (specify)______________

Section B: Water and Sanitation Practices

What is the main source of drinking water for this household? (**Tick where appropriate**)

i) Lake [ ] ii) River [ ] iii) Wells/springs [ ] iv). Others (specify)

____

Do you have access to sufficient drinking water supply? Yes [ ] No [ ]

If No. explain i) water scarcity [ ] ii) long distance to obtain water [ ]

iii) Others (specify) ____

Do you treat the water before consumption? i) Yes [ ] ii) No [ ]

If yes, what water treatment methods do you use?

Boiling [ ]

Chlorination [ ]

Filtration [ ]

Others (specify) ____

Do you cover your drinking? (**RAs should verify this) i)** Yes [ ] ii) No [ ]

Does this household have a human waste disposal facility? (**RAs should verify this)**

Yes [ ]

No [ ]

If yes, which type?

Flush toilets [ ]

Vent-improved pit latrines [ ]

Regular pit latrines [ ]

Others (specify) ____

If no, how do you dispose off human waste?

Burying [ ]

Throwing [ ]

Bush [ ]

Others (specify) ___________________________________

If No, why don't you have a toilet of your own?

Expensive to build toilet [ ]

Cultural practice [ ]

No space for a toilet [ ]

Others reasons (explain) ________________________________

Is a hand washing facility available? (**RAs should verify this)**

i) Yes [ ]

ii) No [ ]

Do you have a dish rack in this household? (**RAs should verify this)**

i) Yes [ ] ii) No [ ]

SECTION C: Household diarrheal cases

i) In the last one (1) month, have you had any incidence of diarrhea in this household?

a) Yes [ ] ii) No [ ]

ii). If yes, which member of the family was affected?

a) $\leq$ 5years [ ]

b) 6 -10 years [ ]

c) 11-15 years [ ]

d) 16-20 years [ ]

e) $\geq$ 21 years [ ]

iii) How many episodes of diarrhea have they reported?

Once [ ]

Twice [ ]

Thrice [ ]

Four or more [ ]

iv) Did you seek medical assistance?

Yes [ ] b) No [ ]

If yes in14 (iv) above, Where did you seek medical assistance?

Nearest health facility [ ]

CHWs [ ]

Others (specify) [ ]

Thank you for your participation.

Appendix VIII: Research approval from School of Graduate Studies, Maseno University

MASENO UNIVERSITY
SCHOOL OF GRADUATE STUDIES

Office of the Dean

Our Ref: MPH/PH/00077/2013

Private Bag, MASENO, KENYA
Tel:(057)351 22/351008/351011
FAX: 254-057-351153/351221
Email: sgs@maseno.ac.ke

Date: 02nd September, 2015

TO WHOM IT MAY CONCERN

RE: PROPOSAL APPROVAL FOR GERTRUDE SHISANYA— MPH/PH/00077/2013

The above named is registered in the Master of Public Health Programme of the School of Public Health & Community Development, Maseno University. This is to confirm that her research proposal titled "Assessment of Risk Factors Associated with Diarrheal Cases in Households a long Lake Victoria, Kenya" has been approved for conduct of research subject to obtaining all other permissions/clearances that may be required beforehand.

MASENO UNIVERSITY DIRECTOR 03 SEP 2015 SCHOOL OF GRADUATE STUDIES

Prof. P.O. Owuor
DEAN, SCHOOL OF GRADUATE STUDIES

Maseno University *ISO 9001:2008 Certified*

Appendix IX: Ethical approval from Maseno University Ethics Review Committee

MASENO UNIVERSITY ETHICS REVIEW COMMITTEE

Tel: +254 057 351 622 Ext: 3050
Fax: +254 057 351 221

Private Bag – 40105, Maseno, Kenya
Email: muerc-secretariate@maseno.ac.ke

FROM: Secretary - MUERC

DATE: 18th December, 2015

TO: Gertrude Shisanya
PG/MPH/PH/00077/2013
Department of Public Health
School of Public Health and Community Development, Maseno University
P. O. Box, Private Bag, Maseno, Kenya

REF: MSU/DRPI/MUERC/00235/15

RE: Assessment of Risk Factors Associated with Diarrheal Cases in Households along Lake Victoria, Kenya. Proposal Reference Number MSU/DRPI/MUERC/00235/15

This is to inform you that the Maseno University Ethics Review Committee (MUERC) determined that the ethics issues raised at the initial review were adequately addressed in the revised proposal. Consequently, the study is granted approval for implementation effective this 18th day of December, 2015 for a period of one (1) year.

Please note that authorization to conduct this study will automatically expire on 17th December, 2016. If you plan to continue with the study beyond this date, please submit an application for continuation approval to the MUERC Secretariat by 18th November, 2016.

Approval for continuation of the study will be subject to successful submission of an annual progress report that is to reach the MUERC Secretariat by 18th November, 2016.

Please note that any unanticipated problems resulting from the conduct of this study must be reported to MUERC. You are required to submit any proposed changes to this study to MUERC for review and approval prior to initiation. Please advice MUERC when the study is completed or discontinued.

Thank you.

Yours faithfully,

Dr. Bonuke Anyona,
Secretary,
Maseno University Ethics Review Committee.

DIRECTORATE OF RESEARCH
PUBLICATION & CONSULTANCIES
18 DEC 2015
MASENO UNIVERSITY

Cc: Chairman,
Maseno University Ethics Review Committee.

Appendix X: Research approval Mbita Sub County Ministry of Health

Gertrude Shisanya,

Maseno University,

P.O Box, Private Bag,

Kisumu.

The Ministry of Health (MOH),

Mbita Sub County,

Dear sir/Madam,

REF: REQUEST FOR RESEARCH COLLABORATION

I am a student from Maseno University Kisumu City campus. I am conducting research towards my master's degree award in Public Health. The research is about Assessment of Risk Factors Associated with Diarrheal Cases in Households along Lake Victoria, Kenya. This research is meant to be carried out in your area of jurisdiction. I therefore kindly request for data from your offices to backup this research.

Any assistance accorded towards achieving this academic objective is highly appreciated.

Yours Faithfully,

Signature.........

Gertrude Shisanya.

NB:
→ Y/C FACILITY – MED 25 – OLAMBWE BEACH
→ Y/C MBITA SC HOSPITAL – KOLUNGA BEACH
→ All CHWs in research areas
The student has been given permission to seek relevant information to enable her achieve study objectives. Accord her all the necessary support/assistance at your disposal.

S.O. OYUGA – SCPHO
For: SCMOH
30/09/15

MO

Appendix XI: Research Approval from Kakdhimu West Location

Gertrude Shisanya,

Maseno University,

P.O Box, Private Bag,

Kisumu.

The Chief,

KAKDHIMU WEST Location,

Dear Sir/Madam,

REF: REQUEST FOR RESEARCH COLLABORATION

I am a student from Maseno University Kisumu City campus. I am conducting research towards my master's degree award in Public Health. The research is about Assessment of Risk Factors Associated with Diarrheal Cases in Households along Lake Victoria, Kenya. This research is meant to be carried out in your area of jurisdiction. I therefore kindly request for your permission to conduct the research

Any assistance accorded towards achieving this academic objective is highly appreciated.

Yours Faithfully,

Signature..........................

Gertrude Shisanya.

[illegible]
KAKDHIMU WEST LOCATION
ALFRED MBARA
0723 870 911
19/10/15

Appendix XII: Research Approval from Gembe West Location

Gertrude Shisanya,

Maseno University,

P.O Box, Private Bag,

Kisumu.

To see Mr. Oyuga for further assistance

30/9/15

The Chief,

Gembe west Location,

Dear Sir/Madam,

REF: REQUEST FOR RESEARCH COLLABORATION

I am a student from Maseno University Kisumu City campus. I am conducting research towards my master's degree award in Public Health. The research is about Assessment of Risk Factors Associated with Diarrheal Cases in Households along Lake Victoria, Kenya. This research is meant to be carried out in your area of jurisdiction. I therefore kindly request for your permission to conduct the research

Any assistance accorded towards achieving this academic objective is highly appreciated.

Yours Faithfully,

Signature……………

Gertrude Shisanya.

30/09/2015

Permission granted to carry the research at Olambwe Beach for one week.

E. O. ORWA

ASST. CHIEF
KASGUNGA CENT, SUB LOC
DATE 30/9/2015