USING ICT FOR DIARRHOEA INTERVENTION IN RESOURCE CONSTRAINED ENVIRONMENTS: A CASE STUDY OF NAROK COUNTY IN KENYA

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DECLARATION

I hereby declare that this thesis is my own work and has, to the best of my knowledge, not been submitted to any other institution of higher learning.

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DEDICATION

I dedicate this work to my family.

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I give all the glory to the almighty God for giving me the strength, good health and resources to undertake the research.

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ABSTRACT

Diseases are the major causes of mortality worldwide with developing countries having the highest disease prevalence. Diarrhoea is one of the major diseases worldwide and especially in poor countries with its victims being mostly children below the age of five years. Diarrhoea is most prevalent in rural areas of poor countries which is due to poor awareness about the disease. Effective use of ICTs can greatly enhance health information dessimination and consequently improve disease awareness. The aim of this study was to reduce diarrhoea prevalence by raising awareness using suitable technologies in the context environment. The study was based in Narok County, one of the counties in Kenya with most of the people living in the rural areas. The county has high diarrhoea prevalence due to low levels of awareness which is attributed to use of ineffective strategies and technologies in dissemination of health information.

A control and an experimental group from two similar sub-locations were identified for the study. Purpose sampling technique was used in data collection. The study was quantitative conducted in three parts concurrently. Part one was a retrospective chart review of dispensary records of children under the age of five years who suffered from diarrhoea. Part two consisted of a pre-test post-test experimental study of 175 mothers with children below the age of five years from each group.The experimental study was a diarrhoea intervention through awareness on children below the age of five years through their mothers who are the caregivers. A structured questionnaire was used to collect data during this phase. Part three conducted concurrently with parts one and two was a cross sectional survey on community health volunteers.

The study established that the previously used strategies and technologies had failed because they were not suitable for the area. Mobile phones were identified

as the most pervasive and preferred technology in the area for diarrhoea information dissemination.

A mobile phone-based system was developed and used in diarrhoea intervention through awareness. Diarrhoea education voice messages were sent through the system to the mothers in the experimental group for three months but not to the control group. The system was unique in that it used mobile phones, which is the most pervasive technology in the area, the messages were in voice and in the Maasai language which is the local language. This allowed the illiterate to benefit from the intervention. The system allowed interaction between the participants and the system and the system allowed participants in emergency situations to contact a health worker.

The intervention caused an improvement in diarrhoea awareness in the experimental group from 42.69% to 87.10% which was significant (effect size= 0.81) but there was no significant change in the control group ($p>0.999$). On diarrhoea prevention practices, there was a significant improvement from 36.9% to 73.0% in the experimental group (effect size=0.643) however there was no significant change in the control group ($p=0.526$). Diarrhoea prevalence significantly reduced from 28% to 19.6% in the experimental group ($p=0.002$) but there was no significant change in the control group ($p=0.557$). Using the data collected during the study, a diarrhoea intervention framework for resource constrained environments that integrates use of suitable technology in the context environment in diarrhoea intervention was developed. The framework addresses diarrhoea intervention from the awareness point of view because high diarrhoea prevalence is associated to low diarrhoea awareness. The framework can also be adopted in interventions of other diseases that can be prevented by creating awareness. The study concluded that when the right technology for the context environment is used to raise diarrhoea awareness, the awareness increases which

leads to improved diarrhoea prevention practices and consequently to reduced diarrhoea prevalence.

Keywords: Information Communication Technology, diarrhoea intervention, resource constrained environments, information dissemination, mobile phone-based system and diarrhoea intervention framework.

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DEFINITION OF TERMS

AjaxControlKit –It is a web development library which is open source.

Application Programming Interface (**API**)-It is an intermediary software that allows two applications to interact with each other.

Artefact – Concrete software development by-product

ASP. NET- It means Active Server Pages dot net. It is a server-side open source Microsoft web application framework used by web developers to build dynamic websites, services and applications.

C# - It is a combined C++ and visual basic programming language by Microsoft that is objected oriented with Java features intended to work with Microsoft's .Net platform

Cardiology- It is a branch of medicine that deals with heart diseases.

Chi-square test- A test which checks whether two variables in a population are related.

County- The chief unit of local administration which forms a territorial division in a Country.

Cronbach's alpha index –It is a measure that shows how closely related a set of items are in a group.

Dermatology-It is a branch of medicine that deals with skin diseases.

Epidemiology-It is the study of patterns, determinants and distribution of diseases in a given population.

Gateway- It is a server that routes information to a third-party application from a mobile phone.

Healthcare- It is a set of services given for the treatment of the sick.

Healthcare system-It is an organization of institutions,resources and people that deliver health care services to a population.

Hoteling's T-test- It is a multivariate analysis test which is used in structural equations models to test for the significance of parameters and loadings/indicators.

Hypertext Preprocessor (PHP)-It is a programming language used to write dynamically generated pages and create database-driven web sites.

JQuery- It is a library for JavaScript that can be used to add extra functionalities to a website by web developers.

Latent variables- These are variables that are not observed directly but are inferred from other directly observable variables.

Morbidity- The condition of absence of good health.

Mortality-The state of being susceptible to death.

Narok-It is a County south west of Kenya. The word Narok is Maasai name derived from the word "Enkare Narok" which means black waters, named after the river that passes through the County.

Nurse-A licensed healthcare worker whose job is to take care of the ill mostly under the supervision of a dentist, physician or sometimes can work independently in health promotion and maintenance.

Partial least squares (PLS) structural equation modeling-This is a method where parameters of a set of equations in a structural equation model are

estimated by combining principal components with regression-based path analysis.

Prototype-It is an original working model through which other new versions of the same can be derived.

Radiology-It is a branch of medicine that uses radiation in disease diagnosis and treatment.

Resource contrained environments – Areas characterised by inadequate hospitals, schools, poor infrastructure, low levels of literacy and generally high morbidity and mortality.

System administrator –It is an individual who manages, configures and ensures smooth running of computer systems mostly networked computers.

Telemedicine-This is the delivery of healthcare services remotely through telecommunications set-up.

Teleophthalmology –This is a field in medicine which deals with provision of eye care through telecommunications technology using digital medical equipment.

Twitter Bootstrap – It is an open-source JavaScript, HTML and CSS framework used in front-end web development.

ACROYNMS

ACRONYM	FULL WORD
AIDS	Acquired Immune Deficiency Syndrome
AMREF	African Medical and Research Foundation
API	Application Programming Interface
CDC	Centre for Disease Control and Prevention
CHV	Community Health Volunteer
GP	General Practitioner
GPP	Generation Partnership Project
ICT	Information Communication Technology
IDE	Integrated Development Environment
ITU	International Telecommunication Union
NACOSTI	National Commission of Science, Technology and Innovation
SDGs	Sustainable Development Goals
SMS	Short Message Service
SQL	Structured Query Language

TB	Tuberculosis
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
mPEP	Mobile Post Exposure Prophylaxis
VCT	Voluntary Counselling and Testing
WHO	World Health Organization

CHAPTER 1: INTRODUCTION

This chapter presents the context of the study, the research problem, the aim and objectives of the study, the significant contribution of the study and the structure of the thesis.

1.1 CONTEXT OF THE STUDY

Diarrhoea is defined as the passage of three or more loose or liquid stools per day (WHO, 2017). Globally it is the ninth deadliest disease causing about 1.4 million deaths annually (UNICEF, 2017). Diarrhoea is the second highest deadliest disease for children below the age of five years accounting for about nine percent of the deaths globally (WHO, 2018). In Africa diarrhoea kills 2.2 million people every year making it the fourth top deadliest disease, it accounts for 46% of deaths of children below the age of five years making it one of the major causes of mortality for children in that age bracket (Dioso and Elmi, 2017). Diarrhoea is the fourth cause of morbidity in Kenya accounting for seven percent of sickness and twelve percent of all deaths, it is the second deadliest disease for children below the age of five years accounting for over 20% of the deaths in that age bracket (Darvesh et al., 2017; Institute of Economic Affairs Kenya, 2018). Morbidity due to diarrhoea is further concentrated in marginalized communities within resource limited countries (Mokomane et al., 2018; Macharia et al., 2019).

In Narok County in Kenya, diarrhoea contributes to more than 40% of the mortality in children below five years of age which is highly attributed to poor hygiene in the area (AMREF, 2015; Kenya Ministry of Health, 2015). Diarrhoea can easily be prevented by adoption of good hygienic practices but in rural Narok, people lack that knowledge (Narok County Government, 2018). This ignorance is attributed to the ineffective ways used to disseminate diarrhoea prevention information (Tankoi, Asito and Adoka, 2016). Consequently the focus of this study is on feasible methods of diarrhoea intervention through information dissemination in rural Narok

County.The study focus is on children below the age of five years because they are the most affected by diarrhoea.

Narok County is resource constrained and has more than 90 per cent of the population living in rural areas practising pastoralism (Tankoi, Asito and Adoka, 2016). In rural Narok, health facilities and health workers are scarce, schools are few and the road infrastructure is poor. Therefore, a new approach to disease intervention which bypasses the physical constraints, namely Information communication technology (ICT) is required (Narok County Government, 2018).

Information communication technology can be defined as tools, services and applications that facilitate processing, transmission and communication of information by electronic means (Sanchez et al., 2019). Harishanand et al. (2017) points out that effective use of ICTs can greatly enhance information transmission and knowledge which can consequently empower citizens in managing their health.

Over the last few decades the world has witnessed an exponential growth in information and communication technologies (ICTs) with the number, quality and reach of ICTs increasing. The penetration has increased, infrastructure improved, literacy increased and the number of new ICTs in the market grown (Gray et al., 2018; Jorgenson and Vu, 2016). The increase in number, improved infrastructure and the high penetration of ICTs has resulted to their wide adoption in different fields including the health sector (Adekunle, 2016). A study on the role of ICTs in the health sector of developing countries concluded that in order for the technology to be effective it should be relevant, local and simple (Bloom et al., 2017).

A report by the Kenya Healthcare Federation (2018) on the role of information communication technology in achieving universal healthcare in Kenya shows that ICT is useful in improving access to health information in rural Kenya. The report points out challenges in the use of most ICTs as poor infrastructure, lack of access,

low ICT literacy, expensive and high maintenance cost. The authors of the report observe that the key to successful use of ICTs in enhancing access to health information is that the ICTs must be suitable to the environment of implementation (Kenya Healthcare Federation, 2018).

A report by the Kenya Ministry of Health (2016) titled “Kenya National e-health Policy 2016-2030; Towards attainment of the highest standard of health through adoption and use of information communication technology” points out the challenges of implementation of e-health in rural areas of Kenya as high cost of e-health systems, low ICT literacy, unavailability of the ICTs, intermittent power failures and lack of ICT infrastructure. The report points out that for effective utilization of ICTs, they must be selected to fit the context of their application. This is because the ICTs used in the cities, which are better resourced and have higher levels of literacy may not be effective in rural areas which are poorly resourced and have low literacy levels (Kenya Ministry of Health, 2016). The report by the Kenya Ministry of Health is echoed by the Narok County ICT roadmap 2015-2020 (Narok County Government, 2015).

Kenya National Government, Narok County Government and non- governmental organizations have engaged in spirited campaigns through radios, televisions, seminars, posters and public meetings to disseminate diarrhoea information in the rural areas of Narok. These approaches have not been successful due to low levels of literacy among the people, their lifestyle and the challenges identified by the Kenya Ministry of Health (AMREF, 2015; Kenya Ministry of Health, 2016; UNESCO, 2018).

Due to the failures of the previously used approaches in dissemination of diarrhoea information in rural areas, it is necessary to use an approach that uses familiar technology and available infrastructure (Njoroge et al., 2017; Communication Commission of Kenya, 2015) . Studies conducted in rural areas in developing countries, have indicated that mobile phones enhance health information-delivery,

communication and information retrieval over long distances between patients and healthcare service providers (Njoroge et al., 2017). Mobile phones enable consultation between patients and health workers in remote places and facilitate consultations among health workers themselves (Bardosh et al., 2017).

Currently the Ministry of Health has created an enabling environment to encourage innovations in mobile technology that are focused in health improvement. It has identified mhealth as a major pillar of e-health in Kenya where 68% of the existing e-health applications are based on mobile phones (Kenya Ministry of Health, 2016).

According to the Communications Authority of Kenya report of July to September 2018 the mobile phone subscription in Kenya was at 46.6 million, which was 100.1% penetration, in rural areas the penetration was at 60.5% (Communications Authority of Kenya, 2018). This high penetration especially in rural areas and government support presents an enabling environment for development of mhealth interventions for rural areas including diarrhoea intervention in rural areas of Narok.

1.2 RESEARCH PROBLEM

Studies have shown that diarrhoea is a major problem especially for the children below the age of five years globally, in Kenya and in Narok County (AMREF, 2015; Darvesh et al., 2017; Institute of Economic Affairs Kenya, 2018; WHO, 2018). Diarrhoea prevalence among children below five years of age in Narok County is about 20%, it is a major cause of morbidity and mortality for that age group (AMREF, 2015). Studies have shown that diarrhoea can easily be prevented and controlled if people have the necessary knowledge needed to exercise preventive measures and recognize symptoms of the disease (Narok County Government, 2018; WHO, 2017). Consequently the Government of Kenya and the county government of Narok have made efforts to reduce the prevalence of diarrhoea in the rural areas of the county through educational programs on televisions, public

gatherings, radios, seminars and have also availed information in the health facilities using posters (Narok County Government , 2018). Research at grassroots level shows that these efforts have not borne much fruit as evidenced by the prevailing high prevalence of diarrhoea especially among children below the age of five years (AMREF, 2015). The reasons for the failures of the approaches according to Okeyo et al. (2019) is that most people in the rural areas of Narok County, cannot afford the devices used to disseminate health information and majority of the population are illiterate among other reasons. For diarrhoea intervention campaigns to be effective, information needs to be disseminated in a feasible manner based on the context environment (Beaulac et al., 2019). Bosomprah et al. (2016) observe that there lacks suitable mechanisms that can be used to disseminate diarrhoea information feasibly in resource constrained areas, such as Narok County. The goal of this study was to find out whether there is a feasible and suitable ICT technology that can be used for dissemination of diarrhoea information in rural Narok and if there is, implement it to reduce diarrhoea rates among children below the age of five years because they are the most affected.

1.3 AIM OF THE STUDY

The aim of the study was to develop an ICT diarrhoea intervention framework to enhance health promotion using mobile phone technology in rural communities.

1.4 OBJECTIVES

The objectives of the study were:

1. To determine the current rates of diarrhoea among the populace in resource constrained environments specifically Narok County in Kenya.
2. To determine the level of diarrhoea awareness in the community before and after the intervention.

3. To determine the current strategies including ICT technologies being used for diarrhoea intervention through information dissemination in resource constrained environments specifically Narok County in Kenya.
4. To identify the weaknesses of the current strategies including ICTs being used for diarrhoea intervention through information dissemination in Narok County.
5. To identify most feasible strategies, including ICTs, for dissemination of diarrhoea information within Narok County.
6. To develop and implement an ICT prototype that overcomes the weakness of the strategies/technologies that are currently being used in diarrhoea intervention through information dissemination in the study area.
7. To evaluate the effectiveness of the ICT prototype developed in diarrhoea intervention through information dissemination.
8. To develop a framework for diarrhoea intervention in resource constrained environments based on the outcome of the study.

1.5 JUSTIFICATION OF THE STUDY

Diarrhoea is one of the major causes of morbidity and mortality in resource constrained areas (WHO, 2017). Kenya is one of the resource constrained countries with rural areas being most affected (Ministry of Devolution and Planning, 2017). Most of her rural areas are characteristed by inadequate health facilities and workers, low levels of literacy, poor infrastructure and high levels of disease prevalence (Ilana, 2017). Narok is one of the counties in Kenya which is majorly rural (Njoroge et al., 2017). Most diseases prevalence including diarrhoea can be reduced through awareness if suitable health information dissemination technologies are employed (WHO, 2018). The high diarrhoea prevalence in Narok County is a result of poor hygiene (AMREF, 2015). The poor hygiene is due to

lack of health information which is caused by the use of ineffective technologies in health information dissemination (Okeyo et al., 2019). In Kenya Mobile phones subscription is about 100% with 60.5% penetration in the rural areas (Communications Authority of Kenya, 2018). This high penetration of mobile phones in rural areas presents a platform that can be employed for diarrhoea information dissemination in Narok County. This study develops a mhealth solution to reduce diarrhoea prevalence in Narok County.

1.6 SIGNIFICANT CONTRIBUTION OF THE STUDY

The study contributed to the local community, the healthcare givers, Kenya National government and county governments, non-governmental organisations, health informatics, and ICT.

1.6.1 Contribution of the study to the local community

The local community benefited from the study by being able to access diarrhoea information through their mobile phones. This was important because majority of the people have mobile phones unlike other technologies previously used in diarrhoea information communication such as radios and televisions (Ilana, 2017). The diarrhoea information was in the local language which everyone in the community understands. This was important because most of the previous diarrhoea information dissemination interventions used English and Kiswahili languages which are not understood by the majority of the people in the community (Kenya Ministry of Health, 2016).The information was sent in form of voice messages so that the illiterate people could understand. This was important because the majority of the people in the area are illiterate and therefore they were not able to benefit from interventions that used written information such as posters (Rosenberry and Vicker, 2017). Although the information was sent as mass messages, the system allowed the participants who missed the messages to access the information later at a convenient time. This was important because in

the previously used technologies and strategies such as seminars, radios and televisions, it was not possible to access the information later after missing out on the scheduled times (Ilana, 2017). Although the messages were sent as mass messages, they were customized to the users according to the comments they made and questions they asked. This enabled the participants to benefit more from the intervention unlike previously used technologies and strategies that gave general information to all the listeners. The system was interactive in that it allowed the participants to ask questions and make comments. This was important because individual needs of the participants were addressed unlike previously used technologies such as radios and televisions which did not allow interaction between the presenters and the listeners (Valkenburg et al., 2016). The system allowed the participants to leave an alert message for the nurse in case of an emergency. The message was sent to the nurse who called the participant and provided help. This was important to help the participants who were in emergency situations. This was unique to the system because earlier interventions did not provide a feature for emergency services (Ministry of Devolution and Planning, 2017). The system delivered the diarrhoea information effectively, which led to increase in diarrhoea awareness.The increase in diarrhoea awareness led to improved diarrhoea prevention practices and consequently reduced diarrhoea prevalence.This was a benefit to the community.

1.6.2 Contribution of the study to healthcare givers

The health intervention developed was used to educate the mothers on diarrhoea, which reduced the burden on healthcare givers who walk to the villages to conduct health education sessions. The villages are far apart and it takes long to move from one village to another (Narok County Government, 2018). Sometimes the villagers go out grazing making it hard to find them and thus wasting time for the healthcare givers. With increased diarrhoea awareness the diarrhoea rates reduced and their workload reduced, enabling them to focus more on other critical tasks.

1.6.3 Contribution of the study to health informatics

The study is a significant contribution to health informatics because it developed a framework that can be used in diarrhoea intervention in resource constrained environments such as Narok County (Narok County Government, 2018). Researchers can adopt the framework and use it for other diseases which can be intervened through awareness. Researchers can also modify the framework to work in other environments which are resource constrained but are different from the environment of the case study e.g. slums in urban areas.

1.6.4 Contribution of the study to information communication technology.

The study made a significant contribution to ICT in that a feasible mhealth prototype was designed, developed and implemented in resource constrained environments. The prototype was used in diarrhoea information dissemination and was found effective in raising diarrhoea awareness. The prototype can be adopted and modified to educate people on different issues such as women rights, children rights etc. (Njoroge et al., 2017).

1.6.5 Contribution of the study to the Government

Other stakeholders that can benefit from the study is the Narok county government and the Kenya national government because they can use the developed prototype in other disease interventions especially cholera which occurs often in the region (Narok County Government, 2018). Another possible area of application is mitigating malnutrition upon which the national and county governments spent large sums of money in health education but have proved to be ineffective (Kenya Ministry of Health, 2016). Since people in rural Narok have low levels of literacy the government can adopt the prototype to educate them on benefits of schooling and challenges of nomadism. The national government and county governments can educate people against vices such as female genital mutilation and early girl marriages which are rampant in the area.

1.6.6 Contribution of the study to the Non –Governmental organizations

There are many non-governmental organizations that conduct disease interventions in resource constrained environments such as Narok (Kenya Ministry of Health, 2016).The prototype developed can be more rapidly and cheaply deployed to achieve their aims.

1.7 STRUCTURE OF THE THESIS

This section presents the summary of the contents of the thesis by chapter.

Chapter 1: Introduction

The chapter covers the context of the study, the research problem, the aim and the objectives of the study, the contributions of the study are shown and finally the structure of the thesis is provided.

Chapter 2: Literature Review

The chapter critically reviews the relevant literature on diarrhoea intervention in resource constrained areas. The literature review includes literature on health and diseases, health and awareness, ICTs in health, mobile phones in health, mobile phones in health information dissemination, frameworks used in health interventions and finally presents a conceptual framework.

Chapter 3: Methodology

The chapter describes the research approach adopted, the research design used, the population of the study, the methods used to develop the prototype, the instruments of data collection, data collection process, data analysis and ethical considerations observed.

Chapter 4: Results

The chapter presents the data collected together with the analysis and the results of the prototype.

Chapter 5: Discussion

The chapter discusses the results of the study in relation to the objectives set at the beginning of the study. It also presents a discussion of the framework developed.

Chapter 6: Conclusions\Recommendations\Limitations

The chapter presents the conclusion of each objective, the study achievements, the limitations of the study and the recommendations for further research.

1.8 CONCLUSION OF THE CHAPTER

The chapter presented the background of the research, the research problem, and the objectives of the study and the significant contribution of the study to different stakeholders. The chapter concluded by presenting the structure of the thesis.

CHAPTER 2: LITERATURE REVIEW

The chapter starts by discussing health and diseases worldwide and in Kenya. In the next section diarrhoea prevalence worldwide and in Kenya is discussed. Thereafter the Kenya health structure is discussed and how it came to be and its operations. The levels of economic development for countries are discussed because the research is carried out in a resource-constrained environment in a developing country. Health awareness is also discussed because the study focuses on enhancing health awareness, followed by a discussion on information communication technologies (ICTs) which explains how ICTs have evolved up to the current state. The next section critically reviews the use of information communication technologies in the health sector. The literature on the use of mobile phones in health sector is also reviewed. The chapter concludes by presenting a proposed conceptual framework.

An extensive literature review was conducted on Kenya National Government and Narok County government reports, World Health Organisation reports, UNICEF reports, UNESCO reports, United Nations reports, World Bank reports and reports from other authors which were relevant to the objectives of the study. Relevant literature was also reviewed from books, Journals and conference proceedings. The researcher reviewed literature published not more than five years before the time of the study except in cases where such literature was not available. The literature was identified using Google scholar, Google, MEDLINE (Medical Literature Analysis and Retrieval System Online) and evidence search. The following keywords were included in the search; health, diseases, Kenya health structure, ICT, ICT in health sector, Mobile phones, mhealth, Mobile phones in health information dissemination, health promotion frameworks, disease intervention frameworks and diarrhoea intervention frameworks among others.

2.1 HEALTH AND DISEASES

According to African Medical and Research Foundation (2017), health is the ability of the body to adjust itself to new infirmities and threats. According to Kenya Ministry of Health (2016), health is a state of fulfilled psychological, social, mental and social needs. According to Atallah, Khalifa and Househ (2018), health is a condition where the physical and the emotional well-being of a living organism is complete. Kebbede (2018) defines health as social, physical and mental wellbeing and a resource to support fulfilled living. According to the World Health Organisation (2019), health is a state of complete mental, social and physical well-being and not just the absence of a disease (WHO, 2019). From the definitions given by the different authors, health can be summarised as a condition where an organism is living a fulfilled life. Although health is not just the absence of disease, diseases are the major contributors to poor health and therefore in order to achieve a healthy society it is important to prevent and control them (Kenya Ministry of Health, 2017).

According to the World Health Organisation (2017), a disease is a condition of a living plant, animal or part of its body that impairs normal functioning and is expressed by unique signs and symptoms. A disease is an anomalous condition that negatively affects the function or structure of an organism or part of it which is not caused by an external injury (AMREF, 2015). According to the Kenya Ministry of Health (2017), a disease is a medical condition that includes a pathological process related to particular signs and symptoms. In summary a disease can be viewed as an abnormal condition that negatively affects the functioning of a living organism.

Globally the top deadliest diseases are Ischemic heart disease, stroke, lower respiratory infection, chronic obstructive pulmonary disease, lung cancer, dementias and diarrhoea. Diseases account for more than 85% of all deaths worldwide (WHO, 2018). According to the World Health Organization report (2018),

the top deadliest diseases in Kenya are diarrhoea diseases, influenza and pneumonia, HIV/AIDS, stroke and coronary heart disease. Diseases account for over 90% of all deaths in Kenya. In Narok the top diseases include diseases of the respiratory system, malaria, pneumonia, diarrhoea, diseases of the skin and eye conditions (Narok County Government, 2018). Diseases are the major causes of death in Narok County accounting for over 90% of all deaths hence the need for adequate prevention and control (Narok County Government, 2018). Diarrhoea is one of the top diseases globally, in Kenya and in Narok County and most of its victims are children under five years of age (Clasen et al., 2015; WHO, 2017; AMREF, 2015; UNICEF, 2017). Therefore, this study focuses on diarrhoea disease in children under five years of age.

2.2 DIARRHOEA DISEASE

Diarrhoea is the passage of three or more loose or liquid stools per day and is usually as a result of the intestinal tract infection, it is spread through contaminated water sources, food or person to person due to unhygienic conditions (WHO, 2017). According to Bosomprah et al. (2018) diarrhoea is passing of looser and more repeated stools than normal, it usually affects anyone but children under five years of age are the major victims. According to Darvesh et al. (2017) diarrhoea is abnormal passing of watery or loose stools, yearly about two billion diarrhoea cases are reported globally and over 500,000 diarrhoea related deaths of children under five years of age. Most of the deaths are found in rural areas of developing countries.

According to the World Health Organization report (2019), every year about 1.7 billion cases of childhood diarrhoea are reported globally. Annually diarrhoea disease causes approximately 525, 000 deaths in children under five years of age globally. For every nine deaths of children, the diarrhoea disease causes one. It is

the leading cause of child mortality and morbidity and the second cause of deaths in children below the age of five years worldwide (WHO, 2019).

The under five years of age children are the most vulnerable because diarrhoea is a hygiene disease and that age bracket is the most exposed to poor hygiene (UNICEF, 2017).

In Kenya diarrhoea prevalence for children below the age of five years is about 16% and over 20% of mortality for children in that age bracket is caused by diarrhoea. Severe diarrhoea has a fatality rate of 21% (Dioso and Elmi, 2017; Kenya Ministry of Health, 2016). According to UNICEF (2017), in Kenya, diarrhoea disease is the second leading cause of death in children aged below five years after upper respiratory infections. These findings are supported by findings of the World Health Organisation (WHO, 2017). According to African Medical and Research Foundation (2015), diarrhoea prevalence in Kenya among children below the age of five years is approximately 16.5% and about 21% of the deaths for that age bracket are caused by diarrhoea which is in agreement with Dioso and Elmi (2017).

Diarrhoea prevalence among children below five years of age in Narok County is documented at 20%, which is higher than the national average, it is a major cause of morbidity and mortality for that age group (AMREF, 2015). These findings are supported by Tankoi, Asito and Adoka (2016). The high diarrhoea prevalence has resulted in reduced productivity, high mortality and high treatment costs in Narok (Narok County Government, 2018). When a child falls sick, due to the scarcity of health facilities, it takes long to access treatment; this delayed treatment is one of the causes of high childhood mortality (Nduba et al,. 2015). Often the dispensaries run out of drugs, this forces the guardians to seek for alternative drug sources, which are usually in major towns. These movements are a waste of time, which leads to reduced productivity of the people and increased treatment costs (Okeyo et al., 2019). According to literature, Narok has high diarrhoea prevalence

especially for the children below the age of five years, which has resulted to high mortality for children in that age bracket (UNICEF, 2017). Mortality comes with grieve and loss of lives which is a cost to the community. The Kenyan government has initiated a few measures to control diarrhoea such as providing water storage tanks in the health facilities and schools, digging boreholes in the shopping centers and providing drugs in the health facilities.These measures have not been successful because of lack of resources from the government to suistain such initiatives (AMREF, 2015).

Diseases including diarrhoea have presented enormous socioeconomic challenges in Narok, Kenya and the world as a whole. In order to address the challenges, United Nations in its sustainable development goals (SDGs) identified “ensuring healthy lives and promoting well –being at all ages” as her third goal among the 17 sustainable development goals (Ministry of Devolution and Planning, 2017). Countries that are members of the United Nations (UN) need to align their development agenda to the sustainable developments goals, which are a guide to achieving a better world in the future. Kenya being a member of the United Nations has mapped its vision 2030 to the 17 SDGs within the second medium term plan (Ministry of Devolution and Planning, 2017). In order to achieve the third SDG, Kenya restructured her health system as discussed in the next section.

2.3 HEALTH STRUCTURE IN KENYA

In her efforts to solve many of her challenges including healthcare, Kenya adopted a new constitution in 2010. The new constitution created 47 units of governance called counties. In the new constitution, some of the functions of the national government were devolved to the county governments; among the devolved functions are the health functions (Ministry of Devolution and Planning, 2017). This was done because Kenyans felt that healthcare is important to them and needed to be managed at a local level where the members of public would be more involved. They also felt that each county has its own unique health challenges,

which would best be addressed by the county itself. The county governments manage the health facilities except two national referral hospitals that are managed by the national government (Kenya Ministry of Health, 2015).

In Kenya there are health facilities at different levels. At the basic level there are mobile community health volunteers (CHVs) who have no permanent settings, they work on volunteer basis. They are trained by the Ministry of Health on basic health knowledge. The CHVs work with people in the very remote areas where hospitals are poorly spread, this level is known as level 1 (Kenya Ministry of Health, 2015). At the second level are dispensaries, which are headed by a clinical officer or a nurse. Most of them have one or two health workers i.e. a clinical officer and a nurse. Dispensaries use clinical symptoms for most disease diagnoses due to inadequate testing tools, in case of severe illness; patients are referred to bigger health facilities.

In the next level are health centres, which have several clinical officers and nurses. These centres have testing equipment but only basic ones, they are classified as level 3. Above the health centres, there are sub-county hospitals which have a doctor who is a general practitioner (GP). Sub-county hospitals are classified as level 4(Kenya Healthcare Federation, 2018). In every county there is a county hospital, which has general practitioners and specialists. The county hospitals are classified as level 5.

At the top, are level 6 hospitals, which are the national referral hospitals; these are managed by the national government. They deal with cases that cannot be addressed at lower levels, these hospitals have nurses, clinical officers, general practitioners and specialists. Most patients attended to at the referral hospitals are referred from lower level hospitals (AMREF, 2015).

It has been eight years since the government of Kenya restructured her health system, although few improvements are visible especially in the number of health workers, disease prevalence still remains a big challenge (Narok County

Government, 2018). This is an indication that restructuring the health system alone cannot solve Kenya's health problems. High disease prevalence is caused by many factors including inadequate health facilities, shortage of health workers, poorly trained health workers, poor health policies and lack of disease awareness which are common in developing countries (Institute of Economic Affairs Kenya, 2018). This study focuses on resource constrained environments which are largely found in developing countries. The next discussion is on levels of economic development of countries.

2.4 LEVELS OF ECONOMIC DEVELOPMENT

According to International Economic Development Council "economic development is an activity that seeks to improve the economic well-being and quality of life for a community, by creating and/or retaining jobs" (Greechie, 2016). There are over 2000 indicators that can be used to measure economic development but the most common ones are: economic policy and debt, financial sector, poverty, private sector and trade, public sector, infrastructure, health, environment, education and labour (Greechie, 2016).

Countries can be classified into three levels of development: Developed countries, newly industrialized countries and developing countries **(**Dufferin-Peel Catholic District School Board, 2016).

Developed countries are characterized by a well-developed education system, banking system, transport system, healthcare system and high adoption of information technologies (World Bank, 2018). The economy is mostly based on service sector and less on manufacturing and industrial services. Examples of such countries are United States of America, Canada, Australia, Japan and Western Europe (World Bank, 2018).

Newly industrializing countries are countries that are going through the process of becoming developed. The economic development of these countries is

transitioning from manufacturing and industrial to service sectors. Education, transportation, information technologies, healthcare and banking are developing. Examples of such countries are China, Brazil, Chile and Malaysia (Greechie, 2016). Developing countries have economies that are majorly based on agriculture, the citizens are poor and majority of the people live in the rural areas and are marked by big socioeconomic equality difference due to corruption (Gbadamosi, 2019). In these countries, governance, healthcare, education, information communication technologies, banking and transportation are poorly developed because of lack of resources and corruption. These countries majorly rely on foreign aid for social development and any money the government collects is channelled to repayment of loans. **(**Dufferin-Peel Catholic District School Board, 2016). Examples of these countries are African countries excluding South Africa (World Bank, 2018).

Although Kenya is striving to achieve the sustainable development goals especially in the health sector, disease prevalence is still high due to lack of healthcare resources and health awareness (Institute of Economic Affairs Kenya, 2018).

Increasing awareness of a disease has been shown to enhance prevention practices, which leads to reduced prevalence (CDC, 2019). Prevention of a disease is cheaper than treatment and therefore countries with scarce resources like Kenya can focus on raising health awareness to sensitize people to adopt disease prevention practices which can lead to reduced prevalence and consequently reduced disease burden (Jennings et al., 2016).

2.5 HEALTH AWARENESS

According to the World Health Organisation (2017), health awareness is having an understanding of one's health needs and the possibility to be vulnerable to repeated episodes of an illness. Health awareness is having health related

knowledge that can be used to identify, prevent and cure diseases (Abrams et al., 2019). Disease awareness is highly associated to health awareness because the main causes of poor health is the presence of diseases (AMREF, 2015). Health awareness increases the likelihood to adopt disease prevention practices and health promoting behaviours (Kenya Ministry of Health, 2016).

Health awareness campaigns have shown effectiveness in promoting sexual health, physical activity and tobacco control. Campaigns focused on health risks, availability of health services, risks associated with sexual behaviours, sedentary lifestyles and smoking have resulted to positive changes in behaviour. Health campaigns seems to achieve best results when they are well-focused on the targeted population (Stead, Angus and Langley, 2019).

A study conducted by Ortmann et al.(2016) on chronic disease prevention showed that increasing health awareness contributes to disease control and prevention. The study focused on school-based programs, work place health promotions, public health awareness campaigns, community health education and others. The health awareness was on health issues such as attending disease screening, living healthy lifestyles i.e. quitting smoking, eating healthy food, exercising, washing hands after a toilet visit etc. At the end of the study, there was a significant reduction of smokers and consumers of junk food. Most of the study participants exercised at least three times a week. A study conducted by Kheir and Ali (2014) in Sudan on the importance of awareness in prevention and control of acute rheumatic fever and rheumatic heart disease showed that awareness leads to health seeking behaviours which results to improved prevention and control of the disease. The same research showed that communities with low levels of literacy and low levels of awareness were the most affected by the disease. The study recommended adoption of appropriate technologies in raising health awareness within communities with low literacy levels. The World Health Organization

attributes reduction in tobacco and alcohol use, better nutrition, improved exercise and increased breast-feeding to increased health awareness (WHO, 2018).

Yuan et al. (2015) did a study in western China from July 2011 to April 2012 to find out whether health awareness could be used to control lifestyle diseases. The study was done in 8 counties, 24 towns and 72 villages involving 1466 rural residents. The study observed that people with low levels of awareness had more lifestyle diseases. After the awareness was increased, the management of the diseases improved and new cases reduced. Yuan et al. (2015) noted that higher education levels were associated with information seeking behaviours, which increased disease awareness and led to reduced disease prevalence. The study by Yuan et al. (2015) concluded that in order to increase the awareness on lifestyle diseases for rural residents, a suitable technology that addressed the challenges of rural settings should be adopted. According to a report by Centre for Disease Control and Prevention (2019), 15% of the American population lives in rural areas and they are likely to die prematurely from the five leading chronic diseases. One of the main causes of high disease prevalence in rural America is low levels of education, which has led to low health information seeking behaviours. The low health information seeking behaviour has led to low disease awareness and consequently to high disease prevalence. The report recommends adoption of appropriate technologies in raising disease awareness among the rural communities in order to address their unique challenges.

A report by Kenya Ministry of health (2016) shows that creating awareness was an important measure in stopping the spread of HIV /AIDS in Kenya. The report shows that increased awareness led to adoption of the HIV/AIDS prevention measures such as avoiding unprotected sex amongst unmarried people, avoiding extra-marital affairs and increased voluntary counselling and testing (VCT) visits. Many health awareness campaigns have been conducted in rural Narok to reduce

diarrhoea prevalence but results show that the impact has not been significant (UNICEF, 2017).

One of the main causes of high diarrhoea prevalence in Narok County is poor sanitation. The costs of reduced productivity, early deaths and high treatment costs due to poor sanitation are 8.6 million US dollars per year (Okeyo et al., 2019). Over 88% of diarrhoea related deaths in Narok can be attributed to drinking contaminated water, poor hygiene and poor waste disposal (Narok County Government, 2018). These deaths can be reduced by adopting feasible practices such as cleanliness, proper use of toilets, proper waste disposal and boiling drinking water if awareness is created (Clasen et al., 2015).

Nduba et al. (2015) working for African Medical and Research Foundation (AMREF) did a study in rural areas of Narok to find out why diarrhoea was very prevalent.The study found out that the community had certain wrong perceptions about diarrhoea that hindered its prevention. Nduba and associates classified the perceptions into causes, prevention and treatment. Under causes, the study found out that the community believed that diarrhoea is caused by eruption of milk teeth, breast-feeding when a woman is pregnant and having too much sex while breast-feeding. Having too much sex while breast-feeding was believed to contaminate the baby's milk. On the perception related to treatment, the community believed that when diarrhoea sick children are given herbs mixed with milk cream or goat's blood, they are cured of the disease. On the prevention, the community believed that herbs such as *emunak Ololoto, Sama- gurure*i could prevent diarrhoea (Nduba et al., 2015).

Nduba et al. (2015) concluded that the community held such beliefs because they lacked the correct information concerning diarrhoea. According to Nduba and associates the lack of awareness was due to the use of unsuitable strategies and technologies in diarrhoea information dissemination. Okeyo et al. (2019) in a study

conducted in rural areas of Narok reported that the high levels of diarrhoea were due to low levels of the disease awareness. Tankoi, Asito and Adoka (2016) in a study done in rural Narok found out that the area has low levels of literacy, its resource constrained and has low diarrhoea awareness. The study observed that the strategies and technologies used to raise diarrhoea awareness do not address the challenges that limit the people from benefiting in health awareness promotions.

Njomo et al. (2016) did a study to find out the reasons for high trachoma prevalence in rural Narok, it was concluded that the high prevalence was due to low levels of awareness, which was caused by the use of wrong strategies and technologies in raising awareness. Although the study was on trachoma, the same applies for diarrhoea because similar strategies and technologies are used to raise diseases awareness in the area. The following are the strategies and technologies used by Governments and relevant organizations to raise diarrhoea awareness in rural Narok: Public gatherings, posters, seminars, televisions and radios (Narok County Government, 2015).

2.5.1 Public gathering

Public gatherings are events or functions that are held in open places mostly in markets, inside campuses or other government owned institutions (Rosenberry and Vicker, 2017). During heath interventions through public gatherings, health officers invite members of the public either to the markets or dispensaries and take them through educational programs on diarrhoea.

Public gatherings have advantages such as; attracting big crowds, can be done in the preferred language of the audience, translators can also be engaged if need be and are cheap to organize (Ilana, 2017). The disadvantage of public gatherings is that only limited questions can be asked due to the number of people in attendance. Another disadvantage is that they are prone to distractions. Since the

people are many some may engage in different activities that distract the other participants. Due to the unavailability of presenters, the meetings are rarely held, this makes them ineffective as a means of disseminating health information. Public gatherings are held in centres, which are mostly far from the villages, the long distance discourages the villagers from attending the meetings (Stead, Angus and Langley, 2019). Villagers in rural Narok are pastoralists and therefore most times they are busy with their livestock which makes it difficult for them to get time to attend the gatherings (Okeyo et al., 2019). Due to these disadvantages, public gatherings are not suitable in disseminating diarrhoea information in the area. A report by Narok County government (2015) shows that public gatherings are not effective in raising disease awareness in the rural areas of Narok County.

2.5.2 Poster

A poster is a piece of paper with information intended for promotion of a product or an event. It can also be used to pass information for mass consumption. Posters are mainly displayed in public places (Valkenburg, Peter and Walther, 2016).

Posters have the following advantages; they can reach a large audience because they do not require a presenter who is limited by time, they can be displayed in many places increasing their reach and they can be used to reach people who have a hearing impairment (Rosenberry and Vicker, 2017).

Posters have the following disadvantages; they are inflexible, once printed and displayed, it is not easy to make corrections unless the poster is re-done. Preparing a poster takes time and posters require reduced content in order to attract attention. This limits the amount of information that can be displayed. Other disadvantages of posters are that they require reading skills, they are also expensive to display due to the cost of printing and they are prone to untimely removal (Rosenberry and Vicker, 2017). In rural areas, the levels of literacy are very low, since posters require reading skills this is a limitation to their use in health

information dissemination (AMREF, 2015). Governments lack resources which can be used to produce enough posters for display in all the relevant places in rural areas which is also a limitation to the use of posters. Since posters can easily be removed and is not possible to secure them in rural areas, they are limited in delivering health information. Posters can only display limited information; this is a limitation since health information can be massive (Ministry of Public Service, Youth and Gender Affairs, 2016). These disadvantages make posters unsuitable means of disseminating diarrhoea information in resource constrained areas. According to Kenya Ministry of Health (2017) posters have not been effective in disease information dissemination in rural areas due to low levels of literacy and the other disadvantages mentioned above.

2.5.3 Seminar

A seminar is a meeting which brings together a small group of people for a training or discussion on a particular subject (Ilana, 2017). The following are the advantages of seminars; the presenters have a wealth of knowledge which is compressed and shared in a short period of time, since the groups are small, individuals can interact and share knowledge. The groups are also controlled therefore chances of distraction are minimal (Ilana, 2017).The following are the disadvantages of seminars; they are expensive because of the cost of materials needed, food, hiring the venue and facilitation of trainers. Most seminars run for a whole day and may consume a lot of time. Another disadvantage of seminars is that most presenters are busy people who are hard to find (Valkenburg, Peter and Walther, 2016). Due to the high cost of running seminars, governments find it difficult to conduct them regularly and due to time constraints on the communities, the attendance to the seminars is normally poor. Therefore seminars are not conducted regularly in rural areas and when conducted only a few people attend (Kenya Ministry of Health, 2015). Due to these limitations, seminars are not a suitable strategy for diarrhoea information dissemination in rural environments. A

study conducted in rural areas of Narok by Nduba et al. (2015) reported that strategies such seminars were not effective in raising diarrhoea awareness.

2.5.4 Television

A television is an electronic device that receives radio signals or other forms of signals and converts them to sounds and pictures that are displayed on the screen (Ilana, 2017). The following are the advantages of televisions; televisions can be used to reach a large audience and since televisions display images, they are interesting to watch. The disadvantages of televisions are that they are expensive and most programs are broadcasted in the national languages. Televisions are complex to operate, bulky to carry and require reliable power supply (Rosenberry and Vicker, 2017). Communities living in the rural areas in Narok cannot afford television sets, they also lack reliable sources of power to support televisions and majority of them are illiterate to understand the languages used in communication. The communities are always on the move that makes bulky devices unsuitable for them (Narok County Government, 2015). These disadvantages of the televisions make them unsuitable for disseminating health information in rural Narok. Bloom et al. (2017) reported that televisions are not a suitable technology for health information communication in rural areas of low income countries due to their unaffordability and lack of supporting infrastructure.

2.5.5 Radio

A radio is an electronic device that receives radio waves and converts them to sound waves (Ilana, 2017). The following are the advantages of a radio; they are cheaper and lighter than the televisions, easier to carry around and some radio stations broadcast in vernacular languages. Radios have the following disadvantages; although they are cheaper than televisions, they are still expensive for the rural communities, radios are lighter than the televisions but still not light enough to be carried around by pastoralist (Valkenburg, Peter and Walther, 2016).

Although the vernacular channels are available on the radio stations, most health information communication is done using the national languages because they have a wider audience. Health campaigns done through the radios are conducted at a specific time of the day and only at specific periods e.g. during disease outbreaks (Kenya Ministry of Health, 2015). This is because radios are used for many other communications especially advertisements (Kumar, 2016). These times of the day and periods are not always known to the audience in advance and sometimes even when they are known, people in rural areas are too busy and often miss out on the campaigns. Most radio presentations are one way where the presenter speaks and the audience listen. This makes the radio a non-interactive device (Ministry of Public Service Youth and Gender Affairs, 2016). This is a limitation of the radio because listeners are often left without clear understanding of the health information being presented.

In the rural settings, power source is a challenge, radios lack long power retention, in order to use them, an external power source is required which is an extra cost (Okeyo et al., 2019). The power source problem presents another challenge to the adoption of radios in health promotion in these areas. Due to these limitations, radios are not suitable for dissemination of diarrhoea information in rural settings of Narok. Kumar (2016), in a study conducted on the use of mass media in India reported that radios were not a suitable technology for disease information dissemination in resource constrained areas.

Odorume (2015) did a study to find out the effectiveness of mass media for health information communication in Nigeria. The technologies assessed were radios and televisions, the strategies assessed were seminars, posters and public gatherings. The study concluded that the technologies and strategies were effective in urban areas but not in the rural settings due to the limitations discussed.

The failures of the previously used technologies and strategies in dissemination of diarrhoea information presents a need to explore other technologies that can be

employed in disseminating diarrhoea information successfully in resource constrained areas in order to raise diarrhoea awareness and consequently reduce its prevalence.

2.6 INFORMATION COMMUNICATION TECHNOLOGY

Anderson and Perrin (2017) define information communication technology (ICT) as a branch of engineering that deals with the use of telecommunication equipment and computers to manipulate, retrieve, store and transmit data. Information communication technology is the range of resources and technological tools used to create, manage and communicate information (Aceto, Persico and Pescape, 2018). According to Bedekar and Busc(2015), information communication technology is a technical way of inputting ,processing and outputting information through technology.

Information communication technologies (ICTs) mostly abbreviated as IT refers to communication devices or applications, encompassing: radio, television, computer, cellular phones, satellite systems, software and hardware, etc. as well as the various applications and services associated with them (Aikins and Arthur-Nyarko, 2019). From the above definitions information communication technologies (ICTs) can be summarised as communication devices and the applications and services associated with them.

ICT can be divided to software and hardware; the hardware are devices and the software are information processing systems (Casey, 2015).

Over the last few decades ICT has been growing exponentially, computer functionalities have increased, speeds have increased and sizes have reduced. This has allowed the emergence of technologies such as smartphones that are able to do the same jobs that full size computers do (Adekunle, 2016).

ICT hardware, with their accompanying software, have led to the automation of many tasks that used to be manual (Hoffer et al., 2016). New devices such tablets and mobile phones are hosting various applications that traditionally operated on computers, this has made them more relevant not only in communication but also in other fields including healthcare (Kebbede, 2018).

The growth of information communication technology has resulted to their increased availability, usability and reduction in cost which has augmented their application in many sectors including health (Zimmermann, 2017).

2.7 INFORMATION COMMUNICATION TECHNOLOGIES (ICTs) IN HEALTH SECTOR

The health sector faces many challenges such as storage of medical records, medical errors, diagnoses, communication between patients and health workers and communication between health workers. These challenges in the health sector among others can be addressed using ICTs (CDC, 2019). According to Alper and Yurdagül (2015), ICT is being applied in health education, health research ,hospital management and health data management. According to the World Health Organisation (2016), ICT is making a positive impact in public health information, remote diagnoses and treatment, communication and collaboration among health workers, sharing of health research findings, monitoring of disease outbreaks and administration of health facilities.

Beaulac et al. (2019) observe that ICT use is increasing in various areas of the health sector including those for health promotion, delivery of health services, decision-making and health knowledge transfer. A study conducted to analyse ICT use in rural Kenya showed that ICT is useful in improving access to health information but there exists challenges in its adoption such as poor infrastructure,

lack of access, low levels of literacy and high costs. The study concluded that most of the challenges can be overcome by entrants of new ICTs such as mobile phones (Njoroge et al., 2017).

According to Kiberu, Mars and Scott (2017), the government of Uganda identifies ICT as a suitable platform to enhance healthcare provision by allowing doctors to access patient's health records, diagnose and consult remotely, provide disease surveillance information and facilitate sharing of research findings. Kiberu, Mars and Scott argue that ICT solutions can provide access to improved healthcare and decrease healthcare costs as long as there exists a good infrastructure. The trio highlight challenges that exist in the implementation of ICTs in healthcare in Uganda as ICT illiterate health workers, internet connectivity failure, intermittent power failures and high cost of ICTs. These findings are echoed by findings of Achampong and Keney (2018) in a study done in Ghana.

A study conducted in rural Zambia explored how ICTs play a role in the development of rural areas. The results showed that challenges in implementation of ICTs in rural areas included low levels of ICT literacy, poor power connectivity, and high cost of ICTs and lack of proper ICT infrastructure (Tunen, 2017). Although the study identified the challenges of deployment of ICTs for development, the same challenges would be experienced in the deployment of ICTs for health intervention (Bajaj and Ali, 2019; Bardosh et al., 2017).

A study done by Kajirunga and Kalegele (2015) on the use of ICTs in healthcare in Tanzania observed that integration of ICT with healthcare has numerous benefits but challenges exists in the adoption of ICTs. The study highlighted key challenges as lack of ICT infrastructure, inadequate power supply, high cost of ICTs, use of unsuitable ICTs in the context areas and lack of ICT skills among health workers. The study observed that since Tanzania is resource constrained, it needs to explore different ICTs with a focus to identify particular ICTs that can bypass the

recognised challenges. Such ICTs should be affordable, easy to use, and available to the people and should be able to use the already existing infrastructure.

In the recent past there has been international discussions focusing on the potential of ICTs in improving the health and wellbeing of the poor in underserved communities. It has been noted that effective use of ICTs has the potential to increase the flow of health information and dissemination of health knowledge which can consequently empower communities (Bajaj and Ali, 2019). Despite their potential, ICTs have not been significantly exploited to advance equitable access to healthcare in developing countries (UNESCO, 2018). Studies have shown that in developing countries and specifically in the rural areas most of the health professionals and communities have not been introduced to use of ICTs in disseminating health information which has delayed the realization of the benefits that are being witnessed in developed countries (Sanchez et al., 2019).

Aceto, Persico and Pescape (2018) broadly classified the areas of applications of ICTs in healthcare into health information systems, delivery of healthcare and communication about health.

2.7.1 Health information systems

A health information system is a system that collects data, compiles, analyses to suitable quality and converts it to information for decision making within healthcare settings (UNESCO, 2018). Jorgenson and Vu (2016) define a health information system as a system used to collect , process, store and transmit information to the relevant levels in the health sector for decision making and planning. Marufu and Maboe (2017) define a health information system as a system that is used to manage healthcare data. From the definitions, a health information system can be said to be a system that is used to convert health-related data to information that is used in health sector.

Most healthcare data is exacerbated by complexity and size of medical terms, classification of health intervention and conditions and codification of biomedical findings which bring about various data requirements and specification challenges (Adekunle, 2016). A health information system is used to capture such data, store it, and present it in an organized manner. Examples of health information systems include hospital administrative systems, drugs ordering and patients billing systems and patient's records and management systems (Aceto, Persico and Pescape, 2018). Advantages of using health information systems are; errors are reduced, there is no requirement for storage space for files, easy access of records because they are well organized and billing of patients is faster and accurate (Gole et al., 2017). The disadvantages of using health information systems are; initial investment to establish a good infrastructure is costly, computer literacy is required and since computer systems can break down there is need for regular data backup (Adekunle, 2016). The benefits of health information systems outweigh the shortcomings and therefore there is need to adopt them (Aceto, Persico and Pescape, 2018).

2.7.2 Delivery of healthcare

Healthcare applications are diverse in functions and include continuing online training of health workers, biomedical literature search and retrieval through the web, remote diagnostic support and telemedicine, diagnostic imaging, epidemiology and disease surveillance systems (Kenya Ministry of Health, 2016).

Several benefits have been realized when ICTs are integrated into delivery of healthcare (Gole et al., 2017). The benefits include; Use of telemedicine in disease diagnosis and patient care, professional development of health workers and sharing of research findings and extended coverage and reach of health care. The disadvantages include high cost of initial investment to establish the infrastructure and requirements of ICT literacy (Basri et al., 2018). The benefits of ICTs in

healthcare delivery outweigh the disadvantages and hence the need for their adoption.

2.7.2.1 Use of Telemedicine in disease diagnosis and patient care

Telemedicine is diagnosis and treatment of patients remotely using telecommunication technology (Mila, 2018). Telemedicine has been implemented successfully in pilot studies in a number of countries and it has been found useful in improving health care delivery, diagnosis and treatment of various conditions (Carol and Kurt, 2018). In South Africa, teleophthalmology has been found to reduce the burden of eye diseases by availing treatment in many health facilities. Teleconsultations has been applied in cyto-pathology, dermatology, laboratory, cardiology and radiology and the results have been positive (Barron et al., 2017). Telemedicine is a useful tool but it requires high bandwidth and expensive infrastructure that makes it unsuitable for the poor countries (Carol and Kurt, 2018).

2.7.2.2 Professional development of health workers and sharing of research findings through easy health information access

Access to health information is important for attainment of the SDGs as evidenced in developed countries. In developing countries lack of access to health information is still a major impediment to achieving a healthcare that is knowledge based (Bloom et al., 2017). ICTs can be used in sharing of health information between consultant doctors and nurses where health workers are inadequate, they can also be used in sharing new research findings between health workers (Ahamed et al. 2017).

2.7.2.3 Extended coverage and reach of health care.

Hackett et al. (2018) points out that it is important that ICTs use in health care reaches out to the poor communities and that ICTs are designed with a strong focus on linking remote, rural and underserved environments with cities which have

more health resources. Approximately 75 percent of the world's poorest live in rural areas where health conditions are poor and access to supplies, services and health information is scarce, implementing relevant ICT initiatives would be a major milestone in reaching the world's majority and consequently meeting the SDGs (Kher, 2016).

2.7.3 Communication about health

This includes using ICTs for communication between health workers and the public and communication between health workers (Agarwal et al., 2016). This is done through health promotion using ICTs, feedback on patient information using ICTs, interactive communication between patients and health workers using ICTs and health information dissemination and advocacy using ICTs (Bliss, 2015). Information communication technologies provide various opportunities that can be tapped into to improve the delivery of health information to the general population; they are desirable channels by health workers for sharing information on disease outbreaks, prevalence and possible interventions (Modi et al., 2017). Information communication technologies provide an enabling platform for doctors to share research findings amongst themselves and specialists to provide assistance to nurses in areas where health workers are limited (Marufu and Maboe, 2017). It is unfortunate that with all the enormous benefits of ICTs in healthcare communication, access is still minimal in the rural areas of developing countries (Bliss, 2015).This minimal access is due to lack of a good ICT infrastructure, high costs of ICT devices, low levels of ICT literacy, unreliable sources of power and complexity of most ICT devices such as computers (Bloom et al., 2017;Bliss, 2015; Hackett et al., 2018).

According to Ling, Poorsat and Chib (2018) ICTs are not widely applied in the health sector in developing countries because of the following factors: Content, connectivity, skilled labour and capital. Content factors are to do with the language

used to present health information. The language used should be understandable by the consumers of the information (Ahamed et al., 2017). Most health information presented through ICTs is in national official languages because they have a wide audience (Ministry of Devolution and Planning, 2017). The national languages are often not understood by the rural people who use their local vernacular languages which often are not considered official. This hinders the adoption of ICTs in health information communication in rural areas (Mila, 2018). With connectivity, there are issues such as lack of access to electricity, high costs of alternative sources of power such as solar, low personal computer ownership, and poor Internet connectivity (Bloom et al., 2017).

Concerning skilled labour, an ICT personnel is important for the effective use of ICTs in the health sector (Alper and Yurdagul, 2017).The most successful implementation of ICTs in the health sector have occurred in developed countries where there is good education and research institutions (Sanchez et al., 2019). According to Bloom et al. (2017) one of the major reasons for the wide implementation of ICT in urban areas is the availability of skilled labour. ICT literacy is low in the developing countries and especially in the rural areas that limits their adoption (Adekunle, 2016).

Capital has to do with the amount of money invested in ICTs for the health sector. Developing countries lack resources to buy ICT equipment such as computers, switches, routers and connecting cables, they also lack resources to buy software required to support healthcare , hence slowing down the implementation of ICTs in healthcare of poor countries (Kenya Ministry of Health, 2016). According to a study conducted by Adekunle (2016) on implementation of ICTs in health sector in Nigeria, lack of capital was identified as a major challenge.

Although the factors highlighted by Ling, Poorsat and Chib (2018) are not exhaustive they are an indicator of the challenges that an ICT based health system should address in order to be succeessfully adopted in resource contrained

areas(Jennings et al., 2016). Jennings et al. (2016) observed that for any healthcare ICT based system to be effective in resource constrained areas it must be affordable because the people are poor, be available to the people, easy to use and should use understandable language because illiteracy is high. It should have long power rention due to power source challenges and should be able to use the available infrastructure .The characteristics mentioned by Jennings and associates can be found in a mobile phone (Latiff et al., 2017; Alhaidari et al., 2017; Barron et al., 2017; Biemba et al., 2017).

2.8 MOBILE PHONE TECHNOLOGIES

2.8.1 Introduction

Mobile phone technologies refer to wireless communication networks, mobile devices and applications that enable interaction between two participants in different locations (Beaulac et al., 2019). The first mobile phone was by Martin Cooper of Motorola in 1973 with a cost of 10,000 dollars and a weight of 1.1 kg, today mobile phones are available for as low as 10 dollars with a weight of less than 0.1kg, hence increasing their affordability and portability (Elliot, 2018). In addition to its affordability and portability most of the present mobile phones support many of services including voice, text, cameras, clocks, torches, internet and money transfer services among others. These myriad of services have made mobile phones popular and have increased their penetration to the communities living in the rural areas (Khormaee et al., 2019).

2.8.2 Generations of mobile phones

Since the invention of mobile phones, they have evolved from first generation to fifth generation (Alhaidari et al., 2017).

First generation

First generation also referred to as 1G is a set of wireless standards developed in the 1980's, which were only used for voice communication using analog radio signals (Vora, 2015).

Second generation

Second generation wireless telephone technology (2G) was designed for digital voice calls and supplementary data such as time and date (Agarwal et al., 2016).

Third generation

Third generation wireless telephone technology, also known as 3G supports the following characteristics among others; circuit-switched and packet-switched data transmission, wireless voice telephony, broadband wireless data and video calls all in a mobile environment and improved spectral efficiency. Third generation also supports high-Speed Packet Access (HSPA) data transmission capabilities (Nitesh and Kakkar, 2016).

Fourth generation

Fourth generation wireless telephone technology also known as 4G refers to all-IP packet-switched networks, multi-carrier transmission and a mobile ultra-broadband access (Agarwal et al., 2016). It is an extension of 3G technology with more bandwidth and services, its architecture is designed to allow seamless integration and communication between heterogeneous mobile devices (Kher, 2016).

Fifth generation

3rd Generation Partnership Project (3GPP) defines 5G as a wireless communication without limitations; it is a high capacity and high-speed generation (Vora, 2015).

Most mobile phones in the Kenyan market today are third and fourth generation, those generations are capable of supporting voice messages which can be used in disseminating diarrhoea information in the rural areas (Ggita et al., 2018).

2.8.3 Mobile phone use in Kenya

One of the most effective means of communication in Kenya is a mobile phone (Communication Authority of Kenya, 2018). According to Njoroge et al. (2017) most Kenyans communicate by mobile phones through voice calls, texting and through internet services such as WhatsApp, Facebook and Twitter. Mobile phones are portable, affordable, available and easy to use for majority of Kenyans including the people in the rural areas (Elliot, 2018). According to the Communications Authority of Kenya report of July to September 2018 the mobile phone subscription was at 46.6 million which was 100.1% penetration, in rural areas the penetration was at 60.5% (Communications Authority of Kenya, 2018). This level of penetration in the rural areas is sufficient for mhealth intervention (Ggita et al., 2018). Mhealth is application of mobile devices such as mobile phones in healthcare (Khormaee et al., 2019). A study done by Oteri, Kibet and Ndung'u (2015) showed that some of the reasons for the high mobile phone penetration in Kenya are a good mobile phone communication infrastructure in most parts of the country including rural areas and high demand for mobile money services.

The high penetration of mobile phones in the rural areas provides a suitable platform for a mhealth intervention for communities living in those areas (Kumar and Arya, 2015).

2.8.4 Use of mobile phones in healthcare

The use of mobile phones in health also known as mhealth is a new area that is growing rapidly to harvest the full capabilities of mobile phones (Fournet et al., 2018). Mhealth applications have successfully been used in areas like

enhancement of health awareness, management of chronic diseases like diabetes and high blood pressure, training of health care givers, prescription reminders and appointment reminders (Gray et al., 2018). Following are examples of some mhealth interventions that have been done.

Saunders et al. (2018) conducted a study in Callao Peru among tuberculosis patients to see the impact of mobile phones text reminders on drug adherence. The study was conducted between 2007 and 2017 on 2584 patients. Saunders and associates observed that mobile phones improved tuberculosis drug adherence in Peruvian population, although it was also noted that the population of the tuberculosis patients who had mobile phones was lower than the national average due to their economic status, it was pointed out that if accessibility to the phones was increased the adherence would have improved. The advantages of the intervention was that it used an available and affordable technology to the Peruvians and the disadvantage is that it used text messages which made it impossible for the illiterate to benefit from the intervention (Elliot, 2018).

In a dog vaccination campaign conducted by the Haiti Ministry of Agriculture during the yearly mass dog vaccination, a mobile phone-based system was used to send text messages to dog owners reminding them to bring their dogs for the rabies vaccination (Cleaton et al., 2018). The vaccination was done from May 20th to June 5th 2017. By the end of the campaign 91.9 % of the dog owners who received the messages said that the messages were helpful and 86.6% indicated that they were willing to receive the messages during future campaigns. The dog owners who received the messages were twice likely to take their dogs for the vaccination compared to the ones who did not receive the messages. The advantage of the intervention is that it used a pervasive technology among the Haitians. The disadvantage of the system is that it used text messages, which require reading skills. Haiti has a literacy level of 61%, which implies that some of the people were

not able to read the messages, and therefore they either got a translator or never participated in the campaign (Khormaee et al., 2019).

In Iran, mobile phones were applied in healthcare education for self-care in three fields; self-care for health maintenance, self-care in chronic diseases and self-care in acute diseases management (Moghaddasi and Sajjad, 2016). A mobile phone-based system was used to send text messages to patients educating them on self-care (e-self-care) depending on the field they registered under. Self-care in health maintenance resulted in better nutrition, improved physical exercise, faster weight reduction and mothers paying more attention to their baby's health. Self-care in chronic diseases resulted in improved management of diabetes, cancer and depression and greater patient's satisfaction. Self-care in acute diseases resulted in significant improvement in management of heartbeats and ECG, reduction in disease re-emergence and lower hospital care expenses. The advantages of the intervention are that it used mobile phones which are affordable and available to majority of Iranians and it used Persian language which is understandable by the people. The disadvantage of the system was that although the messages were in a language understandable by the people, they were in text form which is a limitation to the illiterate. Another disadvantage of the system was that it was not interactive and therefore the participants relied on the information received but could not ask questions. This limited the participants on how much they benefited from the education messages (Zhuang et al., 2016).

Since 2008 India has made significant improvement in mobile health (mhealth) (Ahamed et al., 2017). Examples of mhealth interventions that have been done in India include; *NIKSHAY*. The word means eradicate tuberculosis in Hindu. The system is web-enabled and helps in monitoring access to Tuberculosis (TB) patient's data and facilitates the healthcare providers in the grass-root level to track all the TB patients. The government of India in 2012 introduced the system and it utilizes text messages to provide drug adherence alerts to tuberculosis patients.

The system provides information related to TB on social and epidemiological impacts. Since the launch of the system, India has witnessed reduced TB treatment dropouts and reduced mortality resulting from TB infections. The advantages of the system are that it sends messages in the local language of the people and uses mobile phones which are highly available in India. A disadvantage of the system is that it provides information in text messages which limits the usability of the system by the illiterate. Another disadvantage of the system is that it is not interactive and therefore the users are not able to contact a healthcare provider for any assistance. (Marufu and Maboe, 2017)

Mother and child tracking system is a mobile phone-based system developed and launched by the government of India in 2009 (Kumar and Arya, 2015). The system covers the whole India with an aim to track all the pregnant women from conception to forty-two days after delivery and all new-born children until the age of five years. The system sends text messages to mothers in their local languages reminding them of their antenatal and postnatal clinic visits. The system also educates mothers on the importance of delivering in the hospital. Since its launch in 2009 India has recorded improved antenatal and postnatal care, increased hospital deliveries and improved children immunization adherence (Adekunle, 2016). The advantages of the intervention are that it is done in the local language that the people understand and it uses a pervasive technology among the people. The disadvantage of the system is that although the system sends messages in the local languages, the illiterate mothers require assistance to read the messages. Another disadvantage of the system is that it does not allow participants to interact with it and with the healthcare providers which limits its impact in the intervention (Gera et al., 2015).

Alhaidari et al. (2017) conducted a study in Iraq to find out the acceptability and feasibility of text messages in supporting prenatal care for women in Iraq. The study was conducted in May 2010 to October 2011. One hundred women were

recruited in the experimental group and 150 in the control group. The experimental group received weekly text messages in Arabic language, which varied in content depending on the week of gestation. At the end of the study about 85% of the women in the experimental group indicated that they gained from the program and were willing to recommend the program to their friends. The clinical visits improved from a median of two to four per pregnancy. The advantages of the intervention was that it used the most available communication technology to the people in Iraq and used an understandable language by the people (Bajaj and Ali, 2019). A disadvantage of the system was that it used text messages and although they were in Arabic, which is the local language of the people, the mothers who were illiterate could not benefit from the intervention. Another disadvantage is that the system was not interactive which limited the mothers on the amount of information they could get from the intervention (Bloom et al., 2017).

Biemba et al. (2017) developed a community health management information system (C-HMIS) that provides integrated community case management services to community health workers. The project was implemented from February to mid-July 2016 in Chipata and Chadiza districts of Zambia where 40 community health workers (CHWs) and 20 community health worker's supervisors were recruited in the program (Bajaj and Ali, 2019). Using mobile phones, the CHWs submitted data on medical and diagnostic supplies received and dispensed and the supervisors tracked the CHWs submitted reports on drug consumption using their mobile phones. The system sent text messages reminders to the supervisors to organize mentorship sessions. By the end of the study it was observed that the CHWs used the mobile phone- based system to send weekly reports to their supervisors on medical commodities consumed and disease caseloads and made requisitions on drug and medical supplies (Kumar and Arya, 2015). The supervisors used the system to provide case outcomes to the CHWs on patient's referrals and got SMS reminders to organize monthly mentorship meetings. The study reported timely report submissions by the CHWs, efficient communication between the CHWs and

their supervisors and timely delivery of medical resources by the supervisors to the CHWs. There were better interactions between the district health staff, the CHWs and the supervisors by the end of the study. The advantage of the system is that it used the most pervasive and affordable technology for Zambians and therefore it was easily adopted. The disadvantage of the system is that it required reading skills, hence could only be used by the literate (Alhaidari et al., 2017).

Mobile phones have successfully been applied in various areas in Kenya health system; examples of some applications are Kenya's Mobile Post Exposure Prophylaxis (mPEP) (Gera et al., 2015). The mPEP was developed by the Kenya government in partnership with Centre for Disease Control and Prevention (CDC) and launched in 2013. Mobile Post Exposure Prophylaxis is used to assist people on HIV treatment or those who have been exposed by tracking their testing and sending drug adherence reminders (Sanchez et al., 2019). It copies the correspondence between the system and the patient to healthcare providers so that they can monitor their patients. Mobile Post Exposure Prophylaxis has another functionality where the system notifies blood donors when donation is required and in which part of the country it is required. After the blood has been screened the donors are notified in case their blood has an infectious disease and advised to seek medical assistance (Mwangi and Mukanya, 2017). Since the launch of mPEP, improved blood donation has been reported and many HIV patients have been recruited into the program and are receiving better management. The advantage of the system is that it uses mobile phones, which are highly available and affordable in Kenya. The disadvantage of the system is that the information is presented in English and Kiswahili, which majority of the people in the rural areas do not understand. The information is also sent in text message form that limits the illiterate in accessing the services of mPEP. Another disadvantage of the system is that it does not allow for interaction between the system and the users and interaction between the users and healthcare providers.This limits the users on how much they can benefit from the system (Kenya Ministry of Health, 2017).

2.8.5 Use of mobile phones in health awareness through information dissemination

Mobile phones have been used in health awareness through information dissemination. Below are some examples.

Zhuang et al. (2016) conducted a study in Shenzhen city in China in the year 2012 to increase health literacy using short messaging service, health education messages were sent from a group sending system once a week for one year. The messages were sent to 3,205 participants, the results showed 2% increase in health literacy .The higher the level of education of the participants, the higher was the increase in health literacy, implying that the educated people had the capacity to grasp information faster than the less educated (Adekunle, 2016). The advantage of the system is that mobile phones are highly available and affordable to the Chinese population and therefore the system had a wide reach. Another advantage is that it used Chinese language which is understood by the participants. The disadvantage of the system is that it used text messages, although it was used in the city where literacy levels are high, the system could not be used by the illiterate who are mostly in the rural areas. Another disadvantage is that the system was not interactive and therefore the participants were limited on the health education information they received (Biemba et al., 2017).

Bobrow et al. (2016) conducted a study in Cape Town South Africa with hypertensive patients from November 2012. The patients received text educational messages on behavioural change and drug adherence reminders. After twelve months the blood pressure reduced slightly and there was a marked improvement in clinic attendance on the intervention group. The study findings suggested that the intervention benefitted most of the patients who previously had breaks from taking drugs due to different stressful situations such as job losses and poverty (Sanchez et al., 2019). The advantages of the system in that it used devices that are highly available and affordable to the people in the city where the intervention

was done. Another advantage is that it used text messages, which are understandable by majority of the city dwellers since they are educated (Latiff et al., 2017). The disadvantage of the intervention is that it was conducted in the city where literacy levels are high and the recipients could read text messages. In South Africa about 35% of the population live in rural areas where literacy levels are low which makes the system unsuitable for that population. Another disadvantage is that the system was not interactive and therefore the participants were limited on the health education information they received (UNICEF, 2017).

Sema doc (Hello Doc) is a mobile application that was launched on 31st August 2015 in Nairobi, Kenya (Kosgei, 2018). It was developed by Kenya Ministry of Health, Safaricom, Commercial bank of Africa and Hello Doc Company. Subscribers pay 3 dollars per month to get an account where they can save for medical expenses, get medical loans and receive 50 dollars hospital cash benefit. Once registered in the application, the subscribers are able to have one on one interaction with a doctor where they receive any health information and assistance they may need. The interactions with the doctor are not charged. Sema Doc has enabled many Kenyans to be able to take care of their treatment costs and get early diagnosis, which assists in getting better treatment. Sema Doc has made Kenyans more informed concerning their health which has led to adoption of healthier lifestyles like exercises, and reduced smoking (Kenya Ministry of Health, 2017). The advantage of the system is that Kenya has a high mobile penetration and the application can be accessed by most Kenyans. The disadvantage of the system is that it can only be used by the literate because the interactions with the system are done in English and Kiswahili in text message form only. Another disadvantage of the system is that doctors interact with patients in English and Kiswahili unless the doctor understands the patient's mother tongue which rarely happens. This limits the illiterate, who are largely from the rural communities, from interacting with the Sema Doc application (Zhuang et al., 2016).

Kenya Red Cross app is a mobile application launched by the Kenya Red Cross society on 6th April 2016 in Nairobi. The app is available on both android and iOS platforms and was developed by Connectik technologies limited through sponsorship by Willful capital, Red Crescent Societies and the International Federation of Red Cross (Kenya Red Cross, 2016). The application has three main functionalities; ability to find blood donation points, ability to get emergency news and alerts and ability to get emergency services. The functionality for blood donations shows the users, various blood donation points and their proximity to users (Hackett et al., 2018). The functionality for emergency news and alerts provides real time and lifesaving information on emergencies and crisis situations. The functionality for emergency services allows users to take a picture of the situation, briefly describe the incident such as whether the person is conscious, unconscious, or dead and request for an ambulance. It allows the users to indicate the location of the incident. Users seeking first aid information in emergency situations before getting help can also use the functionality. The Kenya Red Cross application also has a functionality where the users can donate to Red Cross or support it by using their hotels or buying their merchandise. First Aid app has resulted to increased blood donations; improved response during disasters and more Kenyans are participating in community-based programs. Kenyans who have used the application are more informed about first aid measures in case of emergencies (Kenya Red Cross, 2016). The advantage of the application is that it uses mobile phones, which are portable, usable and available for most Kenyans, which makes the application effective in emergency situations (Hackett et al., 2018). The disadvantage of the application is that it uses smartphones and its services are offered in English and Kiswahili. Smartphones are expensive to the poor and the illiterate don't understand English and Kiswahili. Another disadvantage of the application is that the information is in text form, which is a limitation to the illiterate. These disadvantages limits the use of the application by

most Kenyans who live in the rural areas where illiteracy levels are high (Kenya Ministry of Health, 2016).

Abaza and Marschollek (2017) conducted a study from 21st march 2017 for 12 consecutive weeks to find out the impact of short message service (SMS) education on diabetic patients in Egypt. The education messages were on self-management practices and glycaemic control. The study involved 34 patients from experimental group and 39 patients from the control group. The study was conducted in Misr University for Science and Technology hospital in Cairo-Egypt (Sanchez et al., 2019). In the twelve weeks of intervention, text messages were sent every day and by the end of the study every patient received 97 messages, of which 12 were reminder messages, 84 educational and one welcome message. By the end of the study the intervention group achieved 1% drop in the HbA1c. Other secondary results were 61-mg/dl decrease in blood glucose and 1.3 kg decrease in body weight. There was considerable improvement in medication adherence, treatment adherence and patient's confidence in their ability to manage diabetes. Patient's knowledge on diabetes increased among the experimental group compared to the control group. During the intervention period four patients in the control group were admitted to the emergency room but none from the experimental group. The number of patients attending weekly check -up increased and regular exercise improved with at least 30 minutes of walk per day being recorded by 13 patients from the experimental group. The participants expressed high satisfaction with the program and said that they would recommend it to other diabetic patients (Bajaj and Ali, 2019).

The advantage of the system was that it used mobile phones which are highly available in the Egyptian communities. The disadvantage of the system is that it used text messages which could not be read by the illiterate who are mostly the rural communities. Another disadvantage is that the intervention was not

interactive and therefore the participants were limited on the health education information they received (Zhuang et al., 2016).

Pitaloka (2017) conducted a study in Kembangarum and Selojajar villages located near Magelang in central Java province of Indonesia to find the preferred mode of health information communication among diabetic patients. The study involved 30 women and was conducted for 8 months in 2016. In the study the women had constant communication with mantra (a male health practitioner) who provided diabetes support information in Javanese language through SMS messages. With time the texting became embedded in the women lifestyle and they were able to manage their daily work together with their healthcare routines. At the end of the study women showed improved diabetic self-care practices and all of them approved the mobile phone mode of communication for management of diabetes (Latiff et al., 2017). The advantage of the intervention was that it was through mobile phones which are highly available to Indonesians even the rural communities. The disadvantage of the intervention were that although it used Javanese language which is the local language of the people, the messages were in text form which was a limitation to the illiterate (UNICEF, 2017).

Kim et al. (2015) conducted a study from June 2012 to August 2013 to find out the effects of health education through a short messaging service on adherence of antiretroviral therapy (ART). The study was conducted among the HIV positive patients in rural Jinja Uganda. In the study 895 participants with a median age of 44 years were enrolled who received SMS messages for a period of 14 months educating them on the importance of adhering to antiretroviral therapy and reminding them to take their medication (Bardosh et al., 2017). By the end of the study, 91% of the respondents reported improved ARV drugs adherence. The study concluded that a mobile phone-based support system for ART adherence had the potential to benefit people living in rural Uganda. The advantage of the mobile phone-based system was that mobile phones are available in Uganda even

in the rural areas. The disadvantage of the intervention is that it used text messages, which require the ability to read. This kind of intervention is limited to the literate since they possess the reading skills but does not benefit the illiterate who are largely found in rural areas. Another disadvantage of the system was that it was not interactive and therefore the participants were limited on the health education information they received (Mwangi and Mukanya, 2017).

Hackett et al. (2018) did a study in Iramba and Singida districts of Tanzania in 2014 to find out the impact of mobile phone-based education in enhancing hospital deliveries. The two districts are found in the rural and resource constrained areas with many women delivering their new-borns at home. The women in Iramba district received educational messages but the ones in Singida did not. The mobile phone-based system registered the mothers to the system from the second trimester of their pregnancy and send them weekly text messages on antenatal care, importance of hospital delivery and expected dates of delivery. At the end of the study, in Iramba district (experimental group), 89.6% of the women delivered on their way or at a health facility compared to 48.3% of the women in the Singida district (control group) (Bardosh et al., 2017). There was increased uptake of antenatal care and improved maternal care in Iramba district after the intervention. The advantages of the system is that it used mobile phones which are highly available and affordable in rural Tanzania and the messages were presented in Kiswahili language which is generally understood by all Tanzanians. The disadvantage of the system is that it used text messages, which can only be read by the literate, this limited the use of the system to the literate. Another disadvantage is that the system was not interactive and therefore the participants were limited on the health education information they received (Alhaidari et al., 2017).

Wazazi nipendeni (parents love me) is a mobile phone application in Tanzania that is used to empower pregnant women and their partners through education (Modi

et al., 2017). The application sends text messages with information on how to take care of the pregnancy and ensure safe delivery. It encourages mothers to attend pre-natal clinics by sending reminders on clinic dates. The system also encourages mothers to deliver in health facilities. The application was developed by Johns Hopkins Bloomberg School of Public Health Centre for Communication Programs and launched in November 2012 in Tanzania. Five months after its launch it had registered 100,000 mothers and sent four million text messages. *Wazazi nipendeni* initiative has resulted to reduced perinatal mortality among the participants and many mothers recommend the application to their friends (K4Health, 2019). The advantages of the *Wazazi nipendeni* system is that it uses mobile phones which are highly available in Tanzania and uses the Kiswahili language which is widely understood. The disadvantage of the system is that the information is in form of text messages which limits its use to the literate. Another disadvantage of the system is that it is not interactive and therefore the participants are limited on the health education information they receive (Mwangi and Mukanya, 2017).

On 19th December 2014 the International Telecommunication Union (ITU), launched the Ebola information sharing mobile application in Geneva, Switzerland. The mobile application operates on an android platform (Basri et al., 2018). The application was developed based on information from organizations that are involved in fighting Ebola in the affected countries. The mobile application is used by these organizations to share Ebola information with the public. The application has two main features; News and maps and contacts and interactive forum. The news and maps component provides latest news about Ebola to the public (Biemba et al., 2017). The map shows the location of health facilities and allows the users to mark location areas with infected people. Based on the inputs, the maps are updated continuously (Khormaee et al., 2019). Contacts and interactive forum component is used by organizations to interact, exchange information about Ebola and share important contacts. The application has been designed to operate online

and also offline, it is available in French and English languages (The Mother and Child Health and Education Trust, 2015). The advantage of the application is that it uses mobile phones, which are highly available in the Ebola prone countries. The disadvantage is that it uses smartphones, which are expensive and not common in the rural areas of Ebola prone countries. Another disadvantage of the application is that information is in English and French and in text form which limits its use to the literate people (Biemba et al., 2017).

2.8.6 Advantages and disadvantages of mobile phones in dissemination of health information in rural communities

The examples discussed show that mobile phones can be applied in health promotion through information dissemination. Some of the successful applications discussed are in rural areas of developing countries. Examples of such applications are in rural Indonesia, rural areas of Ebola prone countries, rural Uganda and rural Tanzania,

The following are the strengths of a mobile phone-based system for health information dissemination deployed in rural communities:

1. It can use the language the users are comfortable with.
2. Mobile phone penetration is high even in the rural areas and therefore many users can use the system.
3. It can either use voice or text messages depending on the levels of literacy of the users.
4. It is user friendly such that the users can interact with it comfortably.
5. Mobile phones are portable devices, therefore easy to carry hence convenient for rural communities who are involved in a lot of movement.
6. Mobile phones are affordable to rural communities and therefore many people can afford to use the system.

7. The information can be customized so that it is specific to the needs of the users.
8. Mobile phones have a long charge retention which makes them suitable in areas with challenges of source of power. Therefore, a mobile phone-based system can be available to the users most of the times.

(Abaza and Marschollek, 2017; Ggita et al., 2018; Barron et al., 2017; Anderson-Lewis et al., 2018)

The following are the weakness of a mobile phone-based system for health information dissemination deployed in rural communities; mobiles are portable and therefore they are easy to loose and mobile phone communications are normally charged and therefore there is a cost implication (Beaulac et al., 2019; Bardosh et al., 2017; Bassi et al., 2018).

The advantages of mobile phone-based systems for health information dissemination in rural communities outweighs the disadvantages, which is a motivation to their adoption in dissemination of health information (Bassi et al., 2018; Beaulac et al., 2019).

It was shown in section 2.5 that one of the reasons people in rural areas have low levels of disease awareness is low levels of literacy. In order to overcome that challenge, dissemination of health information can be done through mobile phone voice messages as opposed to text messages (Kenya Ministry of Health, 2016; Barron et al., 2017; Kebbede, 2018).

2.8.7 Advantages and disadvantages of voice and text messages

A discussion on text messages is presented below and thereafter a discussion on voice messages

Advantages and disadvantages of text messages

Text messages have advantages such as; they are cheap to send and can be stored for future reference. Another advantage is that in case the receiver is experiencing poor network connection, he/she can still receive the messages once a connection is established. The disadvantages of text messages are; the receiver should be able to read and write in order to communicate through text messages, writing and reading text messages is cumbersome because of the small screen and keyboards. Other disadvantages are that text messages have a limit on the number of characters that can be sent at a time, which limits the amount of information that can be communicated at a time and the interaction between the sender and the receiver in a mobile phone is slow because it takes long to type and read a text message (Ahamed et al., 2017; Abaza and Marschollek, 2017; Alhaidari et al., 2017).

Advantages and disadvantages of voice messages

The advantages of voice messages are; they do not require the ability to read and write and therefore even the illiterate can communicate, they can be used to relay a lot of information at a go and they provide fast interaction between the communicator and the listener as opposed to texting. A disadvantage of voice message is that it is more expensive to send compared to a text message although in terms of the volume of information being communicated, the difference may be insignificant. Another disadvantage is that voice messages are not delivered if the receiver does not receive the call (Gray et al., 2018; Ggita et al., 2018;Kamis et al., 2015). Considering that health information messages are long and require interaction to be effective and majority of the rural communities are illiterate, health information dissemination would be more effective in rural settings if delivered in form of voice messages (Jennings et al., 2016;Hackett et al., 2018;Barron et al., 2017).

2.9 FRAMEWORKS USED IN HEALTH INTERVENTION

In order to identify frameworks that are relevant to diarrhoea intervention in resource constrained environments, frameworks in health promotion and disease intervention were reviewed. The health promotion framework identified as relevant was the rural health framework. This framework was identified because diarrhoea is a health problem and rural areas are resource constrained. The disease intervention frameworks identified as relevant were cholera intervention framework and pneumonia and diarrhoea intervention framework. The cholera intervention framework was selected because the prevention practices of diarrhoea and cholera are similar (WHO, 2017). The pneumonia and diarrhoea framework was selected because the problem being addressed is a diarrhoea problem and currently, according to the reviewed literature there is no framework that addresses diarrhoea intervention independently. The frameworks are discussed in the subsequent sections.

2.9.1 Rural health framework

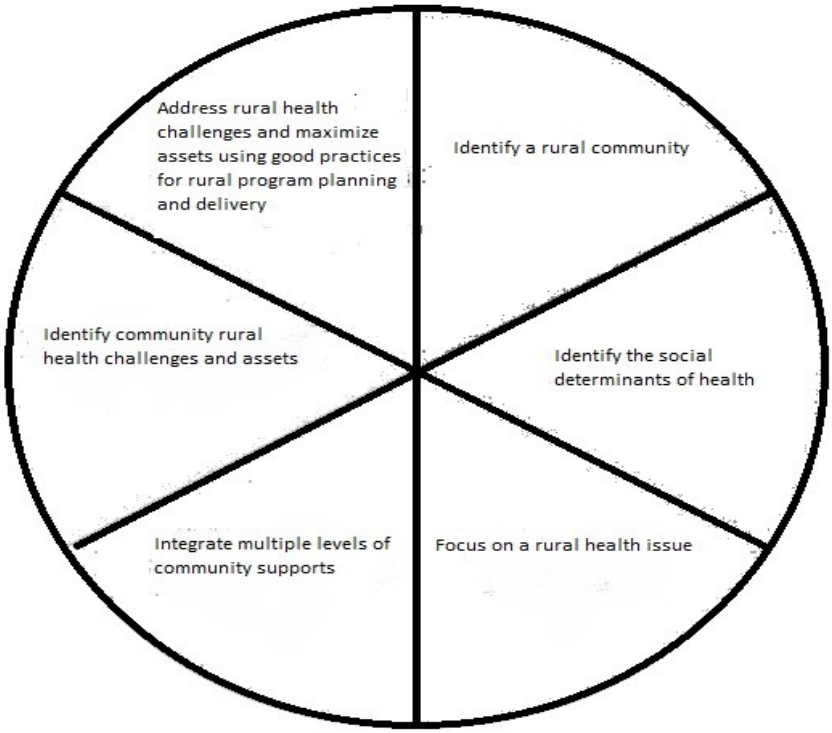

Figure 2.1: Rural health framework (Deanna, 2013)

The rural health framework was developed by Deanna White in 2013 to guide rural health program service planning and policy (Barron et al., 2017). In order to test it, Haldimand–Norfolk Health Unit (HNHU) applied it to influenza immunization to help healthcare providers increase the uptake of the vaccine among the rural people in Canada (Deanna, 2013). The framework is made of six key elements; identify a rural community, identify the social determinants of health, focus on a rural health issue, integrate multiple levels of community support, identify community rural health challenges and assets, address rural health challenges and maximize assets using good practices for rural program planning and delivery (Deanna, 2013).

Strengths of the framework

An advantage of the rural health framework is that one of its element is “focus on a rural health issue” (Dioso and Elmi, 2017). This element helps the health interveners to focus on the rural health issues, which leads to proper resource utilization. Another advantage of the framework is that it integrates multiple levels of community support, which brings all the stakeholders together. This is important because all the efforts of the stakeholders are combined which results in increased productivity. Integrating multiple levels of community support reduces chances of having competing projects, which can lead to wastage of resources (Dioso and Elmi, 2017).

Shortcomings of the framework

In the rural health framework, the third element emphasizes that for an effective health intervention, it is important to determine the health of the population with evidence and determine whether the health is improving or worsening. For countries like Canada greater resources are available to monitor the health of rural people; however, in developing countries, like Kenya such as monitoring requirement is not always feasible (Njoroge et al., 2017).

A second weakness of the framework is that it does not address the issue of health awareness, which has been shown to be a major cause of high disease prevalence in rural communities (Clasen et al., 2015). A third weakness of the framework is that it does not address the issue of using suitable technologies in providing rural communities with health information yet studies have shown that the major cause of poor health in rural communities is the lack of health awareness which is due to the utilization of the wrong technologies in dissemination of health information (Ling, Poorsat and Chip, 2018).

The shortcomings of the rural health framework make it unsuitable for diarrhoea intervention in rural settings of poor countries.

2.9.2 Cholera intervention framework

Preparedness	Response	Preparedness
Prepositioning of necessary supplies and capacity building in identified hotspots	Delivery of a timely ,Epidemiological-driven, targeted multi-sectorial (health,WASH,C4D,Nutrition) response, including co-morbidity	Improvement of preparedness measures based on lessons learned from past outbreaks and new epidemiological data
Prevention	**Prevention**	**Prevention**
Implementation of WASH and C4D activities in hotspots during pre-outbreak season	Containment of outbreak to avoid spread beyond hotspots and across borders	Improvement of overall WASH, Health, Nutrition and social/behaviour conditions in hotspots
CROSSCUTTING ACTIONS		
Elaboration of national cholera prevention plans Improvement of surveillance and epidemiological basin/hotspot mapping Public advocacy and awareness raising to prioritize an end to cholera through citizen voice and actions and calls for prioritization and the need for increased funding Regional coordination and cross-border collaboration		

Figure 2.2: The United Nations International Children Emergency Fund (UNICEF) strategic framework for cholera in Eastern and Southern Africa (UNICEF, 2017)

The most current cholera intervention framework is the UNICEF strategic framework for cholera in Eastern and Southern Africa 2018-2022, it was developed

by UNICEF in 2017**.** The framework is made of seven elements i.e. preparedness, response, preparedness, prevention, prevention, prevention and cross-cutting actions (UNICEF, 2017).

Strengths of the framework

One of the components of the framework is preparedness, which makes the framework useful in responding to outbreaks promptly minimizing their effects on the area of concern. The seventh element is crosscutting action, which involves public advocacy in raising awareness. This is important because from section 2.5, it was shown that when disease awareness is increased, people tend to adopt prevention practices, which largely controls the disease.

Shortcomings of the framework

The second element of the framework is response which deals with delivery of a timely, epidemiologically –driven, targeted multi-sectorial response including co-morbidity (UNICEF, 2017). For timely delivery of health intervention there is need to have a good road infrastructure, availability of healthcare providers and health facilities which lack in resource constrained environments (Narok County Government, 2018).

A second weakness of the framework is in the seventh element, which is crosscutting actions. This element takes into consideration public advocacy in raising awareness to prioritize an end to cholera through citizen's voices. The element does not take into consideration the technologies being used in the public advocacy in order to raise cholera awareness. From section 2.5 it was shown that the national government and Narok County government have been conducting diarrhoea awareness campaigns in the rural areas of Narok but diarrhoea prevalence is still high, implying that the awareness campaigns have not been effective. Although the framework identifies awareness as an important element in

disease intervention, it fails to address the reasons the disease awareness interventions have failed.

The shortcomings of the UNICEF strategic framework for cholera in Eastern and Southern Africa 2018-2022 make it unsuitable for diarrhoea intervention in resource constrained environments.

2.9.3 Diarrhoea and pneumonia intervention framework

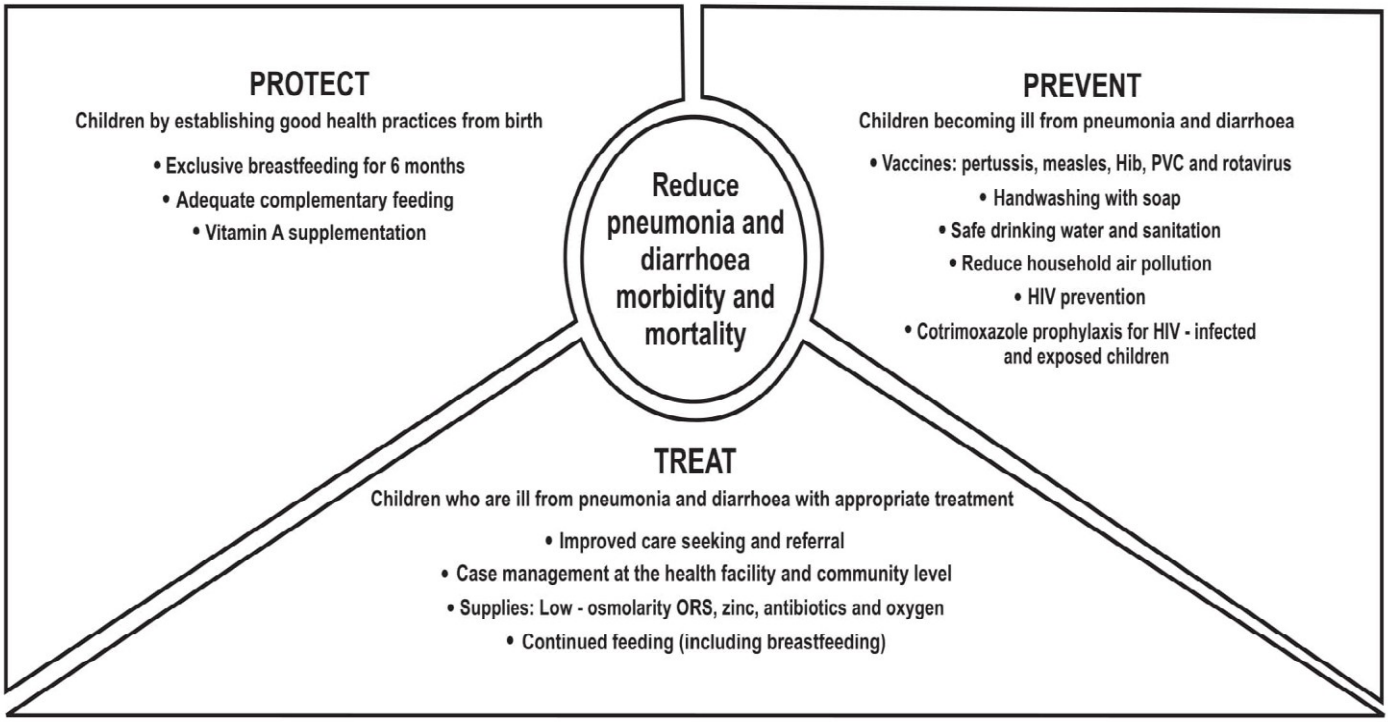

Figure 2.3: Prevent, Treat, Protect Framework (WHO and UNICEF, 2013)

The integrated global action plan for the prevention and control of pneumonia and diarrhoea (GAPPD) also known as prevent, treat and protect framework was developed by the United Nations International Children's Emergency Fund (UNICEF) and World Health Organization (WHO). Launched in 2009, the framework has three segments; prevent, treat and protect (WHO and UNICEF, 2013). The framework proposes an integrated approach to reduce diarrhoea and pneumonia and end preventable deaths resulting from diarrhoea and pneumonia.

Strengths of the framework

One of the elements of the framework is prevent. Prevention is cheaper and easier than treatment and one of the challenges of poor countries in healthcare is lack of resources to establish a good healthcare system (Adekunle, 2016). When the framework is adopted, it can be useful in preventing pneumonia and diarrhoea and consequently reduce the cost of treatment and reduce the deaths resulting from the diseases. Another advantage of the framework is the protect aspect. Children are vulnerable to many diseases because of their low levels of immunity and therefore they need to be protected from infections (Nyamtema et al., 2017).

Shortcomings of prevent, treat, protect framework

The integrated global action plan for the prevention and control of pneumonia and diarrhoea (GAPPD) developed the prevent, treat and protect framework which combines the intervention of diarrhoea and pneumonia (WHO and UNICEF, 2013). Although the developers of the framework argue that the two diseases mostly affect children under five years of age and a single framework can be used for their intervention, research shows that the causes of the two diseases are different (Fuller et al., 2014; WHO, 2019). Diarrhoea is majorly a hygiene disease, which affects mostly the poor because of poor hygiene while pneumonia affects mostly people with a weak immune system like the old, children and people living with HIV (WHO, 2019). Hygiene can easily be improved through awareness unlike low immunity, which sometimes is an age factor. Since the two diseases have different pre-disposing factors, the same framework may not be effective in their intervention, it is therefore necessary to have a diarrhoea specific intervention framework.

The second weakness of the framework is in the prevent element. The framework points out some of the methods of diarrhoea prevention as vaccines. In resource-constrained environments where health resources are limited, vaccines may not

be available. Other methods of prevention of diarrhoea identified in the framework are washing hands with soap and safe drinking water. These practices are helpful in prevention of diarrhoea but from section 2.5 it was shown that people in rural settings of poor countries are not aware that such practices can be adopted to prevent diarrhoea. Therefore the framework fails to address the issue of awareness, which was shown to be the main cause of high diarrhoea prevalence in rural settings. Since the framework does not address the issue of diarrhoea awareness, it also fails to address the issue of suitable technologies used in raising diarrhoea awareness, which was shown to be the main cause of low diarrhoea awareness and consequently high diarrhoea prevalence.The shortcomings of the prevent, protect, treat framework make it unsuitable for diarrhoea intervention in resource constrained environments.

The rural health framework, the UNICEF strategic framework for cholera in eastern and southern Africa and the prevent, protect, treat framework which are currently the most relevant frameworks in diarrhoea intervention in rural settings fail to address the challenges faced by rural communities in poor resource settings in reducing diarrhoea prevalence. Therefore, a conceptual framework is proposed.

2.10 CONCEPTUAL FRAMEWORK

In section 2.9 it was shown that currently there is no diarrhoea intervention framework that addresses the needs of the rural communities especially in poor resource countries. In section 2.5 it was shown that diarrhoea prevalence is high in rural areas, which is due to low awareness caused by use of poor diarrhoea information dissemination strategies and technologies. The frameworks discussed in section 2.9 address the issue of disease awareness but fail to address the issue of the suitability of technologies used in raising awareness which is the main contributor to the low levels of diarrhoea awareness in rural areas. In order to

overcome the shortcomings of the discussed frameworks, a conceptual framework was proposed.

The framework has one independent variable, a moderating variable and a dependent variable. The dependent variable was drawn from the three discussed frameworks, the moderating variables were drawn from literature review and the independent variable is the researcher's contribution to the diarrhoea intervention framework for resource-constrained environments. The independent variable which is use of suitable ICT for the context environment was measured by the following indicators; affordability of the technology, availability of the technology, usability of the technology, portability of the technology, interactivity of the technology, information understandability, information availability, long charge retention and reliability of the technology.These indicators are suitable characteristics of a technology that can be successfully applied in diarrhoea awareness in resource constrained environments according to section 2.5 and 2.7. The dependent variable which is enhance diarrhoea intervention was measured by the following indicators; raising diarrhoea awareness, adoption of diarrhoea prevention practices and reduction of diarrhoea prevalence.

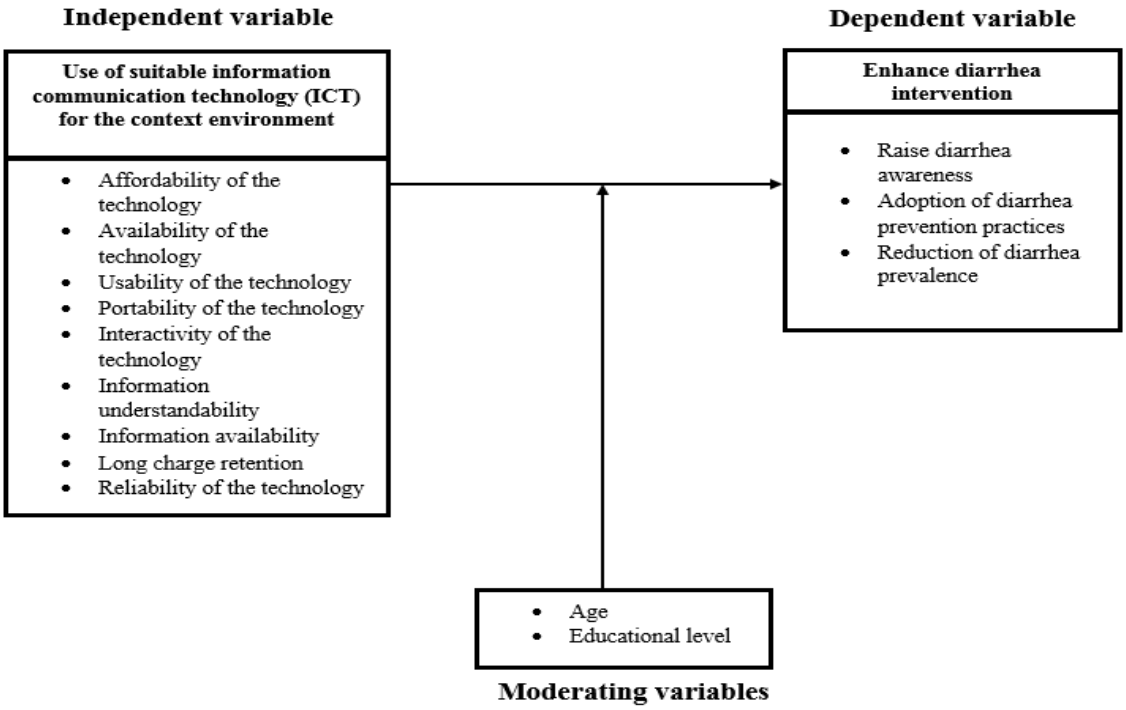

Figure 2.4: Conceptual framework for diarrhoea intervention in resource constrained environments

2.10.1 Operationalization of the variables

Table 2.1: Operationalization of variables

Variable	Measurement	Source	Collection tool	Analysis method
Use of suitable information communication technology (ICT) for the context environment	Affordability of the technology	Mothers and community health volunteers	Questionnaire	Proportional analysis & Chi-square test
	Availability of the technology	Mothers and community health volunteers	Questionnaire	Proportional analysis & Chi-square test
	Usability of the technology	Mothers and community health volunteers	Questionnaire	Proportional analysis & Chi-square test

	Portability of the technology	Mothers and community health volunteers	Questionnaire	Proportional analysis & Chi-square test
	Interactivity of the technology	Mothers and community health volunteers	Questionnaire	Proportional analysis & Chi-square test
	Information understandability	Mothers and community health volunteers	Questionnaire	Proportional analysis & Chi-square test
	Information availability	Mothers and community health volunteers	Questionnaire	Proportional analysis & Chi-square test
	Long charge retention	Mothers and community health volunteers	Questionnaire	Proportional analysis & Chi-square test
	Reliability of the technology	Mothers and community health volunteers	Questionnaire	Proportional analysis & Chi-square test
Age	Number of completed years (for mothers)	Mothers	Questionnaire	Descriptive statistics and t-test
Educational level	Education Level completed	Mothers	Questionnaire	Proportional analysis & Chi-square test
Enhance diarrhoea intervention	Raise diarrhoea awareness	Mothers	Questionnaire	Proportional analysis & Chi-square test
	Adoption of diarrhoea prevention practices	Mothers	Questionnaire and Observation	Proportional analysis & Chi-square test
	Reduction of diarrhoea prevalence	Dispensary data for children below the age of five years.	Clinical data	Descriptive statistics and t-test

2.10.2 Relationship between the variables

The diarrhoea intervention conceptual framework is made of one independent variable, two moderating variables and one dependent variable. The independent variable, which is use of suitable information communication technology (ICT) for the context environment affects directly the dependent variable, which is enhance diarrhoea intervention. There are two moderating variables which are age and educational level. If the use of suitable ICT and educational level are kept constant and age is varied, the enhance diarrhoea intervention varies. If the use of suitable ICT and age are kept constant and the educational level is varied, enhance diarrhoea intervention varies. If the use of suitable ICT is kept constant and age and educational level are varied, the enhance diarrhoea intervention varies. If the age and educational level are kept constant and the use of suitable ICT is varied, the enhance diarrhoea intervention varies.

2.11 CONCLUSION OF THE CHAPTER

The chapter begins with an introduction of the literature review, defines health, diseases and diarrhoea disease.The chapter presents the health structure in Kenya and proceeds to explain levels of economic development and how Kenya fares in terms of economic development. The chapter discusses health awareness, information communication technology and use of information communication technology in the health sector. The different generations of mobile phone technologies are discussed, within information technology, because the intervention uses mobile phones and understanding the technology level of the participants is crtical in understanding the feasibility of the intervention .The chapter proceeds to present a detailed analysis of frameworks that have been developed for health intervention in resource contrained environments, their strengths and weakness and concludes by presenting a proposed conceptual framework of the study and how it was operationalised .

CHAPTER 3: METHODOLOGY

The chapter starts with an introduction which explains how the study was conducted. A description of the study population is presented followed by the research approach and research design. The next section presents a description of the chart review followed by a description of the prospective interventional study. Thereafter the methods used to develop the prototype are explained. The procedure followed to collect data from the mothers is detailed followed by information on the post and during intervention chart review. The next section is on the study of the community health volunteers which is followed by a description on how data analysis was carried out. The chapter concludes with a discussion of the ethical considerations observed.

3.1 INTRODUCTION

In this chapter the techniques and methods used to achieve the aim and objectives of this study are described. The research methodology is described in detail to allow duplication of the study. The tools used for data collection, screening, analysis and validation are detailed in order to ensure that the findings are reliable. This quantitative study was conducted in three parts concurrently. Part one consisted of a retrospective chart review of records of children under the age of five years who suffered from diarrhoea. The records were from two dispensaries in two sub-locations in a Kenyan county. One of the sub-location was a control group and the other was an experimental group. This part helped to determine the prevalence of diarrhoea among children below the age of five years in the two sub-locations before and after the interventional study. Part two consisted of the pre-test post-test experimental study as described below. Part three conducted concurrently with parts one and two was a cross sectional survey on community health volunteers in the dispensaries. This part served to validate through

triangulation the data collected from parts one and two. The findings from all parts of the study formed the basis for the development of a framework that could be used for diarrhoea intervention in resource constrained settings. The framework can be adopted by the Kenya government to assist in fighting diseases that can be prevented through dissemination of information hence accelerate her momentum in achieving the sustainable developments goals.

3.2 STUDY LOCATION

Kenya has 47 counties. Narok County was chosen purposively due to its high rates of diarrhoea, homogenous populace and being one of the counties with most of its population living in resource constrained areas (Narok County Government, 2018). Narok County has four sub-counties, Narok East sub-county was chosen purposively due to its high rates of diarrhoea. Narok East sub-county has ten locations and two locations were chosen i.e. Oletukat and Mosiro purposively because they have similar diarrhoea rates to allow a comparison in the experimental study (Narok County Government, 2018). These locations are distant enough to prevent data contamination. From Oletukat location, Enkorika sub-location was chosen as the experimental group purposively due to high diarrhoea rates. From Mosiro location, Mosiro sub location was chosen as the control group purposively, due to high diarrhoea rates. The intent was to have two sub-locations who have similar pre-intervention (baseline) characteristics. According to the Kenya National Bureau of Statistics (2017), Enkorika sub-location has a population of 807 males, 834 females and 307 households. It covers an area of 153.1 km square and has a population density of eleven people per square kilometre. Mosiro sub-location (control) has a population of 587 males, 738 females and 290 households. It covers an area of 64.4 km square and has a population density of 20 people per square kilometre (Kenya National Bureau of Statistics, 2017). Enkorika and Mosiro sub- locations are 100 kilometres apart and are separated by

hills and valleys, making it difficult for the two groups to interact (Narok County Government, 2018). Saturation sampling within the loci allowed all inhabitants in each loci to participate in the study. Multistage sampling was used to choose the locations, sub locations and participants.

Research approach:

The approach was quantitative. The first part consisted of a retrospective chart review both before and after the interventional study. The second part of the study was a pre-test post-test experimental study. Data was collected primarily from the mothers who are the caregivers of children under the age of five years. A third part of the study was a cross-sectional survey of community health volunteers.

3.3 RESEARCH DESIGN

The first part of the study was a retrospective chart review. This part of the study required a review of clinical records from the dispensaries that served each of the two selected communities. This was done to determine the prevalence of diarrhoea in the area before the intervention. The first objective of the study was achieved through this study. The second part of the study was a two-group pre-test post-test experimental study. The third part of the study was a prospective cross-sectional survey which was conducted using questionnaires on the community health volunteers (CHVs). The retrospective and the prospective studies were used to achieve the objectives of the study. Following is a description for each part of the study.

3.4 PART 1: CHART REVIEW

The retrospective chart review was conducted before and after the study to determine the diarrhoea rates before and after the intervention. It involved use of clinical records from the dispensaries in the chosen sub-locations. The first chart review was conducted a week before the commencement of the intervention in

order to determine the prevalence of diarrhoea before the intervention. The second chart review was conducted at the end of the intervention in order to determine the incidences of diarrhoea that occurred during the intervention in the study locations.

3.4.1 Study population

Anonymous patient's records of children under five years of age who suffered from diarrhoea in the two selected dispensaries in the study areas were reviewed. Narok County in Kenya was purposively chosen as a study site due to its high rates of diarrhoea and homogenous populace (Narok County Government, 2018; UNICEF, 2017). Mosiro sub-location had 465 children who were under five years of age and Enkorika sub-location had 490 children under five years of age (Narok County Government, 2018).

3.4.2 Inclusion criteria

Registers that contained data not more than one year old from the date of data collection were included. It was observed that within a year, new health facilities may have come up which would have changed the catchment area for the dispensaries.

3.4.3 Exclusion criteria

Registers containing data that was more than a year old from the date of data collection were excluded. Data that was more than a year before the time of the study was viewed as old with the danger that it could give a wrong impression about the population and health facilities and therefore it was excluded. Data of children who were not from the study area and the data of children who were more than five years old was excluded. Incomplete data was also excluded.

3.4.4 Sampling

Each of the study areas was served by a single dispensary. The Mosiro dispensary served the Mosiro sub-location and Oletukat dispensary served the Enkorika sub-location (Narok County Government, 2018). The two dispensaries were chosen through purposive sampling since they were the only sources of clinical data for the study locations. Purposive sampling is a technique that relies on the purpose of the study and is often beneficial when there are limited sources of primary data which was the case in this study (Palinkas et al., 2015). Diarrhoea data for the children who were under five years of age was accessed. Diarrhoea was chosen because the effects of its intervention could be visible within a short duration such as occurs during a PhD study period, and the children under five year of age were chosen because they are the most affected by diarrhoea and therefore the effect of the intervention would be visible within 3 months (WHO, 2017).

The data for the period between April 2018 and March 2019 were reviewed for the first retrospective chart review. One year was chosen as a sufficient period to demonstrate a clear trend of the diarrhoea prevalence in the area. The second chart review was conducted at the end of the interventional study to determine the diarrhoea prevalence trend from the time the intervention started until the end.

3.4.5 Study instruments

In order to capture the clinical data, a data sheet shown in appendix XVII was developed. The pre-recorded patient's records by the time of the study were reviewed. The chart reviews were used because they have several advantages such as they can be accomplished within a short duration of time, charts are readily available, they are cheap to conduct because they do not require specialized equipment's and they are not disposed to loss of follow up during the study (Baumann et al., 2018).

The data sheet was based on the objectives of the study and review of related literature. To ensure validity and reliability of the data sheet, it was piloted in a dispensary different from the study area but in an area with similar characteristics to the study area. Piloting is important in any research process for reasons such as strengthening the instruments of study, providing new clues, approaches and insights. It creates an opportunity to confirm the analytical and statistical tools to be used in the study, providing the researcher with an opportunity to try alternative methods and select the most suitable ones (Vogel and Draper-Rodi, 2017). From the outcome of the piloting the researcher modified the data sheet to include sections that only focused on the objectives of the study. This study adopted the chart reviews because the researcher was time constrained and the chart provided the data immediately. The researcher was also financially constrained and the charts provided data at a low cost. The study was done on the children through the mothers therefore any details that could identify the children were removed.

3.4.6 Data collection procedure

Ethical clearance was obtained from Durban University of Technology Institutional Research Ethics Committee, Kenyatta University Ethics Committee and National Commission of Science, Technology and Innovation (NACOSTI). Permissions were also obtained from Narok County Commissioner, Narok County Director of Health and Narok County Director of Education. Before the study, the participants were required to give informed consent in order to participate in the study.The participants were also informed that the information collected was to be used only for academic purposes and it was to be kept anonymous. A pilot study was conducted in Ewaso-Nyiro dispensary to verify the validity and reliability of the data sheet. Based on the findings of the pilot study the researcher improved the data sheet to be consistent with the study objectives.

The dispensaries in the study area offer outpatient services only. Patients who require further treatment are referred to Narok County hospital which is the closest

referral hospital. The dispensaries keep two registers, one for children under five years of age and the second one for people who are five years old and above. Each register keeps data for all the diseases for the respective age bracket. Each patient brings his/her own book where the nurse makes notes regarding the diagnoses and treatment given. In order to review the diarrhoea data for the children who are under five years of age, the outpatient register for that age bracket was accessed. The register contains daily diseases summaries and monthly diseases summaries. Since the researcher was interested in the diarrhoea data for a year, the daily diarrhoea summaries were found to be too many and therefore the monthly diarrhoea summaries were obtained. The parameters captured from the register were: the name of the dispensary, the month which the diarrhoea cases occurred and the number of diarrhoea cases recorded. The diarrhoea data captured was from April 2018 to March 2019.The data sheet used to capture the diarrhoea data is shown in appendix XVII.

3.4.7 Data analysis

Before analysing the data, data preparation was done to enhance the quality of the data. This allowed the data to be analysed using Statistical Package for Social Scientist (SPSS) version 25 to find relationships between variables, Excel 2013 was used to calculate the effect sizes.

The differences in diarrhoea prevalence was found significant if the p-values were less than or equal to 0.05.The effect was found small if the effect size was less than or equal to 0.2, medium when the effect size was greater than 0.2 and less than 0.8.The effect was found to be large when the effect size was greater than 0.8 (Vogel and Draper-Rodi, 2017).

3.5 PART 2: PROSPECTIVE INTERVENTIONAL STUDY

The interventional study was used to answer objectives two to eight.

3.5.1 Design

This phase was conducted concurrently with the retrospective chart review. The prospective pre-test survey was conducted on the mothers with children under five years of age since the children are not capable of responding to questions accurately. The pre-test study was used to measure the level of diarrhoea awareness, adoption of diarrhoea prevention practices and to find out the mother's opinion on the current's technologies/strategies used in diarrhoea information dissemination. The mothers also suggested the characteristics of a suitable diarrhoea information dissemination technology that could be adopted in the area. The study was also used to elicit requirements for the development of the prototype.

3.5.2 Population: Mothers/caregivers

According to Narok County Government (2018), Narok County is predominantly Maasai and the Maasai people have the same culture making the population homogenous. For this reason, homogenous purposive sampling was used to come up with the sample. Homogenous purposive sampling is a common sampling technique that is used in health research especially where high costs are involved and the population is homogenous (Hickey et al., 2018). Purposive sampling was used because there was no data for all the people in the study area who met the inclusion criteria to allow for randomization. This technique involved purposively choosing two sub-locations and then purposively choosing participants who met the inclusion criteria from the two groups.

3.5.3 Inclusion/exclusion criteria

A screening questionnaire shown in appendix XII was used for recruiting mothers using inclusion/exclusion criteria described below.

Inclusion criteria

In selection of participants for the research the requirements were; access to a mobile phone, mothers with children under five years of age and availability of mobile phone network in the homestead of the participant. Access to a mobile phone and availability of mobile phone network were important because voice messages were received through a mobile phone and therefore access to the device and network for transmission of messages were required. From the literature review about rural Narok, diarrhoea is most common in children under five years of age and therefore the intervention was on that age bracket. According to a study done in Narok by Matanda et al. (2014), mothers in Maasai culture are the caregivers for the children and this makes them most suitable to protect the children from diarrhoea infections. For this reason, the mothers were used in the intervention.

Exclusion criteria

Mothers who had any form of disability that could affect their performance in the study were excluded. The disabilities considered were deafness, blindness, etc. Mothers with health training background were not included in the study because they already knew about diarrhoea from their professional training and therefore the intervention was not necessary for them. Men in Maasai culture do not tend the young children and therefore they were excluded from the study (Matanda et al., 2018).

Other exclusion criteria were mothers with children above five years of age because children of that age are not very vulnerable to diarrhoea and therefore the results of the intervention would not have been visible within three months. Men and women with no access to a mobile phone and mobile phone network were excluded because the intervention was done through a mobile phone.

3.5.4 Sample size calculation

The sample size was computed using the survey system available on http://www.surveysystem.com/sscalc.htm.

The computation is as follows
Sample Size (SS)

$SS= (Z^2*(p)*(1-p))/C^2$

Z = Z value. This is the measure of how far an observation is from the mean of the group. A 95% is the most used confidence level in statistics and it has a z-value of 1.96.
p = percentage picking a choice, expressed as decimal, p is the level of significance. It is the probability that the outcome will be due to chance but not the intervention. The value of 0.5 was used because it is the one that gives the largest possible sample size incases where the sample size is not known.
c = confidence interval, expressed as decimal. It is the range of values we are sure our true value lies. The value of 0.05 is the margin of error.

$= ((1.96)^2* (0.5)*(1-0.5)/ (0.05)^2 =384.16$

With a finite population new SS= (SS)/ (((SS-1)/pop) +1)

Where new SS is the corrected sample where a finite population exists and pop is the population.
New SS = (384.16)/ (((384.16-1)/307) +1)
=171

With a population of 307 households in the test group and a confidence level of 95% which is the most used confidence level in recent health researches and a confidence interval of 5% which is acceptable for a very homogeneous group like our population, a sample size of 171 participants was required to achieve statistical power (Onwuegbuzie and Collins, 2017). The sample size was increased to 175 participants in each group to take care of drop outs. The participants were chosen through purposive sampling.

3.5.5 Instrument

The pre-test questionnaire is shown in appendix XIV. The pre-test and the post-test questionnaires were similar but the post-test questionnaire had an extra section which sought the opinion of the participants on the mobile phone in diarrhoea information dissemination. Based on the outcome of the pilot study, this section was removed from the pre-test questionnaire but retained in the post-test questionnaire. The questionnaires for the mothers were in English and Maasai languages. The English version was for the researcher. The translation of the questionnaire from English to Maasai language was done by one of the Maasai nurses. The researcher used the Maasai version to collect data from the mothers. A questionnaire is a research instrument consisting of a set of questions aimed at eliciting information from respondents (Sugimoto and Lariviere, 2018). Questionnaires were used because they are suitable for large groups of people such as our target population and are easy to analyse (Williamson and Johanson, 2019). The pre-test questionnaire was used to elicit information on diarrhoea awareness, adoption of diarrhoea prevention practices, technologies/strategies previously used in disseminating diarrhoea information and the characteristics of a suitable diarrhoea information dissemination technology for the study area. It was also used to elicit user requirements for the prototype.

The validity of the questionnaires was checked by letting the supervisors go through them and also by doing a pilot study before the study. The reliability was checked using Cronbach's alpha index, the reliability of the questionnaires was improved to a value of 0.811 which was above the acceptable minimum value of 0.7 (Goforth, 2015).

In order to strengthen the instruments of the study, a pilot study was done. The pilot study is described below.

3.5.5.1 Pilot study

The pilot study was conducted in Majimoto sub-location which is in Narok south, chosen conveniently because it has characteristics similar to the study area. Majimoto is 50 kilometres from the experimental area and 150 kilometres from the control area. The purpose of the pilot study was to identify the misunderstandings and the ambiguities of the questions, to check the acceptability of the questionnaire and to find out any other challenges that respondents would have encountered in the study.

Several reports have suggested different methods of determining the size of a pilot study. Machin et al. (2018) suggest sample sizes of 10 to 30 participants in order to overlook weak treatment effects and take advantages of easy calculations, ability to test hypothesis and simplicity of sampling. This view is supported by other investigators (Sorzano et al., 2018). Viechtbauer at al. (2015) suggest the use of 10% of the main sample size for the pilot study. The sample size of the study was 175 participants and therefore a sample size of 18 participants for the pilot study was found to be acceptable. This is within 10 to 30 range and is about 10% of the main sample size complying with the views of most authors. Out of the 18 questionnaires that were given out, 16 were returned which was 89% response rate.

Modifications were done on the questionnaire based on the pilot study responses. Question one which asked about the name of the village was modified to give options because the names of the villages in the research areas are known. Question two that asked about the occupation was modified to give the options of the common occupations within the area. In cases where the occupation of the participant was not in the option, the participant was allowed to specify under others, this made the answering of the question easier. Question 18 which asked what could be done to assist a child with diarrhoea brought a new option by the respondents which was giving herbal medicine. Since it was a common response it was included as one of the options in the responses.

Question 19 that asked whether there was any diarrhoea intervention information dissemination that had been done or was being done in the area was not well understood. The researcher determined so because some respondents gave a “no” answer, yet in the subsequent question, they gave names of some of the organizations that had conducted interventions. The respondents also indicated strategies/technologies that had been used. From the outcome, the researcher conducted a more rigorous training on the community health volunteers to help them understand the questions well so that they could explain clearly to the respondents and avoid conflicting responses. Question 23 was a yes or no answer, many respondents answered that the interventions previously/presently used were effective but in question 25 they answered that better strategies were required for diarrhoea intervention, this was a conflict of responses. The researcher viewed the cause of the conflicting responses could have been that the strategies were effective to some extent. The researcher viewed that if the question was modified to provide more options that would evaluate the level of effectiveness of the interventions, the responses would improve. The question was modified to read “what is your opinion on the present/previous diarrhoea intervention being conducted/have been conducted in your area if any? a. very effective b. effective c. not sure d. ineffective e. very ineffective”

Questions in part G focused on use of suitable diarrhoea information dissemination technologies/strategies. The questions were supposed to evaluate the respondent's perception on the use of mobile phones in diarrhoea information dissemination. Most of the respondents answered that they were not sure. These responses were viewed by the researcher to imply that since the respondents had not used mobile phones for diarrhoea intervention information dissemination before, they did not have a way of comparing them with previously used strategies/technologies. The researcher found it necessary to remove part G from the pre-test questionnaire since the responses received did not add any value to the study, part G was maintained in the post-test questionnaire.

After the adjustments on the questionnaires, they were ready to be used in the study with a Cronbach's alpha of 0.811.

3.5.6 Intervention: Prototype development

During the pre-test phase of the study, the mothers suggested the characteristics of a suitable diarrhoea information dissemination technology in their context environment. The next phase of the study involved development of the prototype which was based on the characteristics proposed by the mothers and supported by the community health volunteers during the pre-test study.

In order to develop a suitable, effective, and feasible software prototype for this m-health intervention, design science methodology was adopted.

3.5.7 Design Science

Design science is the design and investigation of artefacts in context, it is an outcome methodology that offers specific guidelines for evaluation and iteration within research projects (Wieringa, 2014). Design science methodology was selected because it allows the development of a software to be done iteratively until the desired outcome is reached. Studies have shown that many technologies,

which have been used in health information dissemination in rural areas fail because of lack of sufficient evaluation by the users (Barron et al., 2017). Design science involves rigorous iteration between user requirements, design and evaluation (Baskerville et al., 2018). In order to overcome the failures experienced by the earlier technologies, the researcher adopted design science where after developing the prototype, it was taken to the stakeholders for evaluation. After the evaluation, the stakeholders gave their feedback and their suggestions were incorporated into the new designs and development. The iterations between the evaluation, definition of requirements, design and development and demonstration continued until the stakeholders were satisfied with the software. The steps followed to develop the prototype are shown in Figure 3.1

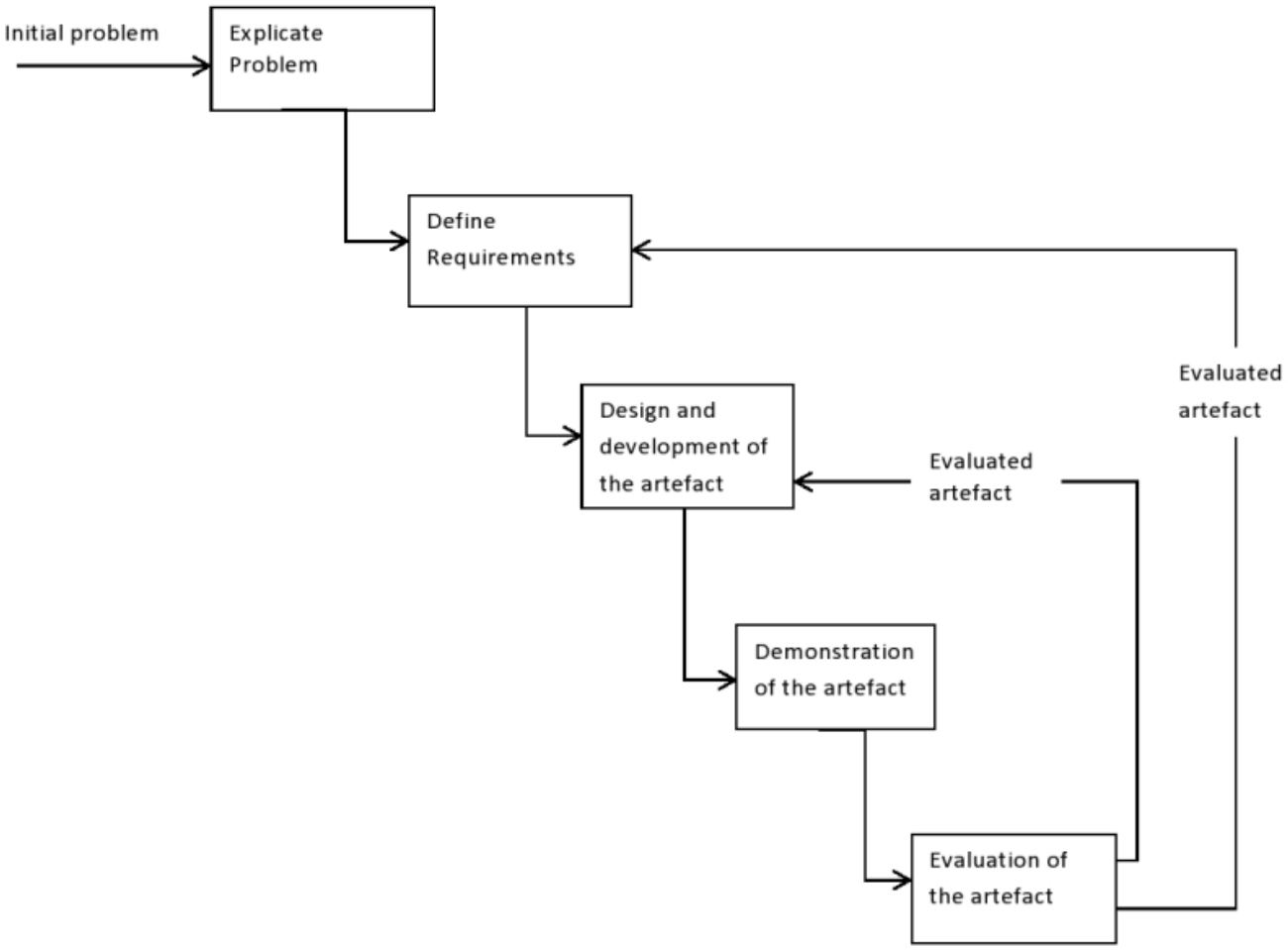

Figure 3.1: Rahman H. (2015) DSRM adopted for the Prototype development

Following is a discussion of the steps of design science that were followed to develop a prototype that met the user requirements.

3.5.7.1 Explicate the problem

In order to find out the problem, a background survey was done in the area of study. The researcher achieved this by visiting the area and observing the condition of the roads, availability of health facilities, availability of schools, and lifestyle of the people. Other information that the researcher sought to find through observations was availability of toilets in the homes and market places, and

economic status of the people. The researcher reviewed literature on Narok County in relation to levels of literacy, common diseases, major causes of morbidity and mortality and current methods used in disease interventions and their weakness. The literature reviewed was from National government reports, Narok County government reports, non-governmental organizations reports and other relevant authors. The researcher reviewed studies which were less than five years old in order to obtain current information.

3.5.7.2 Define requirements

In order to elicit user requirements for the prototype, multiple methods for different groups of stakeholders were used in order to obtain a fuller set of user requirements and provide a form of validation through a type of triangulation of data sources. The pre-test questionnaire shown in appendix XIV was used to get information from the mothers. The same questionnaire was used in the main study. The information sought from the mothers regarding the prototype requirements was: preferred language of communication, preferred mode of mobile phone communication i.e. text messages or voice messages and the telephone numbers. The preferred language was to be used in disseminating diarrhoea information and the telephone numbers were to allow diarrhoea information to be delivered to the mothers. A preferred mode of communication was sought to determine how the diarrhoea information would be delivered.

Questionnaires were also used to elicit information from the community health volunteers. The information from the community health volunteers was to complement that from the mothers. The questionnaire used to elicit information from the community health volunteers is shown in appendix XVI which is the same questionnaire used in the main study. Interviews were used to elicit diarrhoea information from the nurse, this information was sent to the mothers. The nurse gave the information and suggested how it should be structured for the mothers to easily follow. The nurse gave his/her personal details such as mobile telephone

number that was used to reach him/her in case of an emergency. The interview sheet for the nurse is shown in appendix XXI.

Literature reviews were also used to elicit requirements. The literature reviews were conducted on studies done in Narok, studies done on disease intervention through information dissemination in rural areas similar to rural Narok and studies done on mobile phone-based systems that have been used in disease information dissemination. The reviews were on literature not older than five years. This was because information older than five years may not be currently valid since ICT and health are active fields where information changes often. The literature reviews on studies done in rural Narok were to find out the following;

a. The economic status of the people
b. The population distribution in the study area
c. The mobile phone penetration in the area
d. Mobile phone network coverage
e. The common language of communication in the area.

This information was important for us to know whether mobile phones penetration was sufficient to be adopted for the intervention in the area. The information was also used to give insight on the mode of communication to use i.e. whether text or voice messages and the language to use for the intervention.

Literature reviews done on disease interventions through information dissemination in rural communities were to find out the following;

a. Whether any interventions had been implemented through information dissemination in rural communities.
b. The diseases that the interventions were used to control.
c. Whether the interventions were successful.
d. In case they were successful, the reason for their success

e. If they failed, the causes of the failures.
f. Whether ICTs had been used in disease intervention in rural communities.
g. In case the ICTs had been used, whether they were successful and the reasons for their success.
h. In case they had failed, the causes of the failures.

It was important to establish whether there were earlier interventions and the reasons for their failures in order to overcome them. The information also was useful to help build on the reasons of their success in order to design a successful intervention.

Literature reviews on mobile phone-based systems that had been used in disease information dissemination were to find out the following;

a. The environments where they had been used.
b. The diseases they were intervening.
c. Whether they used voice or text messages.
d. Whether they were successful or not.
e. In case they were successful, the reasons for their success.
f. In case they failed, the causes of the failures.

Since we were developing a mobile phone-based system, it was important to find out other mobile phone-based systems that had been used in disease information dissemination. This information was helpful to find out whether mobile phone-based systems had been used in environments similar to rural Narok and in diseases similar to diarrhoea and whether they were successful or not.

Avoiding the causes of their failures and adopting the reasons for their success helped us design a successful prototype for this study's intervention.

Use case diagrams were used to model the prototype requirements.

A use case diagram is a graphical illustration of how the elements in the system interact with one another, they are used in system modelling to show the functions of the system according to the requirements (Hoffer et al., 2016; Kendall, Kendall and Mathew, 2019). Use case diagrams are demonstrated because they show the functional requirements of the system and describe how the users interact with the system (Hoffer et al., 2016).

3.5.7.3 Design and development of the prototype

In the design phase, the requirements identified in the previous phases were transformed into systems models in order to visualize the functionalities of the prototype. The methodology adopted in the design and development of the prototype was design science and the method used in the development was evolutionary prototyping which are both iterative. Both of them were used in order to strengthen the development of the prototype. Evolutionary prototyping is a method of designing a software where the initial prototype is improved iteratively based on the user's feedback until an acceptable version is obtained (Dennis, Wixom and Roth, 2018). The evolutionary prototyping was used because it allowed changes dictated by socio-technical design science (socio-technical as this prototype was both technical and filled a social need) to be more easily adapted (Kendall, Kendall and Mathew, 2019). Based on design science, a simple prototype was developed which was improved through design science iterations until an acceptable version was obtained.

From the literature, it was found out that earlier technologies used in diarrhoea information dissemination had failed because of lack of user engagement (Biemba et al., 2017). In order to avoid the failures, the researcher engaged the users from the requirements gathering to the deployment stage of the software. Another reason for using design science is that the researcher is a PhD student who is time

constrained and since this method ensures fast software delivery it was a preferred choice. A third reason for using design science was because it has high chances of meeting user requirements which was important in this study to overcome the challenges of earlier interventions (Baskerville et al., 2018). Based on the user requirements a preliminary design of the prototype was done and modelled using flowcharts, dataflow diagrams and system architecture.

A flowchart is a graphical representation of a workflow, a logic sequence or similar formalized structure, its purpose is to analyse, design, document and manage projects or processes (Dennis, Wixom and Roth, 2018). The flowchart was chosen for demonstration because it assists the stakeholders to understand the relationship between different elements in the system (Hoffer et al., 2016).

A data flow diagram (DFD) is defined as a graphical representation of how information flows in an information system, DFDs are also used in visualization of data processing (Kendall, Kendall and Mathew, 2019) .The data flow diagrams were used by the programmer to encapsulate certain flows within objects and in proper manipulation of data as required (Kendall, Kendall and Mathew, 2019).

A system design architecture is the basic structure of a software comprising of the components that make the system and how they relate to each other (Hoffer et al., 2016). The system design architecture was used to show how the components of the prototype relate with each other.

3.5.7.4 Evaluation phase

The methods used in the evaluation of the prototype were observations, interviews, document reviews and questionnaires.

The observations were used by the researcher to see the challenges the mothers experienced when using the system. The challenges the researcher sought to find out were whether the mothers were able to pick calls, whether they were able to

leave a comment or post a question and whether they were able to leave an alert message for the nurse.

Interviews help a researcher to get an in depth and full range of information. The interviews were done to elicit views of the county health officers and community health volunteers on the suitability of the information, clarity and whether the functionalities available were sufficient for maximum benefit of the participants. The interview for the nurse was to find out whether the flow of the information was as expected and determine whether the diarrhoea information was accurate. The interview sheet for the community health volunteers and the county health officers is shown in appendix XXIII. The interview sheet for the nurse is shown in appendix XXIV.

The researcher used the questionnaire shown on appendix XXII to find out from the mothers the challenges they were experiencing while using the system and the improvements they preferred. Questionnaires were used because they are cheap to administer, easy to analyse, enable collection of a lot of data and measure patterns within data (Russell, 2015).

The researcher used document reviews to find out whether the requirements that were initially provided had been met by the system.

In order to conduct a proper evaluation of the prototype, the following consideration were made:

1. The prototype was made available to mothers, nurses, community health volunteers and county health officers to get their reactions in terms of system usability, availability of the necessary functionalities, system response time, information quality and clarity.
2. Areas to be tested were carefully identified and tools to be used for the evaluation developed.

3. The participants for the evaluation were identified. The participants were mothers, community health volunteers, the nurses and the county health officers. The mothers, nurses, community health volunteers and the county health officers suggested any improvements that they preferred and pointed out what was not necessary.

Using the feedback from the evaluations, the requirements were redefined and the designs modified to include the suggestions given. The prototype was improved until a refined version was obtained. The refined version was used for the intervention. The prototype developed is discussed in chapter four.

3.5.8 Procedure for data collection from the mothers

Ethical clearance was obtained from Durban University of Technology Institutional Research Ethics Committee where the researcher is a student. Permissions from Kenyan institutions where the study was being conducted were obtained. These institutions included National Commission for Science, Technology and Innovation (NACOSTI), Narok County Commissioner, Narok County director of health and Narok County director of education.

Invitations to participate in the study were done by the researcher through visiting the primary schools in the two sub-locations and requesting the head teachers to pass the invitations to the mothers through their children. The researcher also visited the dispensaries and requested the nurses to invite the mothers for the study. The researcher displayed posters in the market places and in the dispensaries inviting the mothers for the study.

Screening was done using the questionnaire shown in appendix XII to select the mothers who met the inclusion and exclusion criteria. Study participants gave consent in order to participate in the study. The study was voluntary and withdrawal from the study was allowed at any stage by informing the researcher.

After selecting the mothers, the purpose of the study was explained and the mothers were informed that the information collected was to be kept confidential. The community health volunteers assisted in administering the questionnaires during the pre-test and post-test phases of the study. The researcher translated the questionnaires from English to Maasai language for easy administration. The Maasai versions are attached next to the English versions. Before the pre- test, the community health volunteers were trained on how to administer the questionnaires. A pre-test was administered using the questionnaire shown in appendix XIV.

After the pre-test, a prototype was developed based on the characteristics of a suitable diarrhoea information dissemination technology proposed during the pre-test. The prototype was used in diarrhoea intervention through information dissemination.

Before the intervention, the mothers and the community health volunteers were trained on how to interact with the prototype. Although the community health volunteers never received the intervention, they were trained so that they could assist the mothers whenever they were faced with challenges during their interaction with the prototype. The mothers from the control group were never trained because they never used the prototype.

A training schedule for both the mothers and the community health volunteers was developed. The training schedule for the mothers is shown in appendix XIX and the training schedule for the community health volunteers is shown in appendix XX. The training for both groups was conducted by the researcher in the dispensaries.

The training schedule shows the steps that were followed in the training and what the participants were trained on. The training was done at different times for the two groups depending on the availability of the respondents. The training of the

mothers was on interaction with the prototype. The training of the CHVs was on interaction with the prototype and on how to administer the questionnaires.

The training of the mothers was done in one day from nine o'clock in the morning to four o'clock in the evening. The researcher assessed the success of the training by observing the mother's interactions with the prototype and asking them questions regarding their interactions with the prototype. The mothers were also allowed to ask questions on issues that were not well understood.

The training of the CHVs was done in one day from nine o'clock in the morning to three o'clock in the afternoon. The training of the CHVs took a shorter period of time than the mothers because they were able to grasp ideas faster than the mothers since they were educated. The researcher assessed the success of the training by observing the CHVs's interaction with the prototype and asking them questions regarding their interactions with the prototype. The CHVs were also allowed to ask questions on issues that were not well understood regarding the prototype and the questionnaires.

The experimental group was exposed to voice messages in Maasai language educating them on diarrhoea signs and symptoms, causes, prevention measures and first aid measures. The participants were allowed to leave a question or a comment if they had any. If the comment or question was on the functionality of the prototype, the system administrator addressed it. If the comment or question was on diarrhoea information, the system administrator consulted the nurse and the diarrhoea information was improved to address the comments or questions. In case a participant had an emergency, she left an alert message which was sent to the nurse by the system. The nurse received the alert message and called the participant. The messages were sent at ten o'clock in the morning because it was the most convenient time for the mothers according to their suggestions in the pre-test.

Messages were sent four times a week on Mondays, Wednesdays, Fridays and Saturdays for three months. Four days were found sufficient in order to give the mothers breaks in between the week and three months were found sufficient time to observe the impact of the diarrhoea education. The sample size required for the study was 171 participants but it was increased to 175 to take care of drop outs, although no drop outs were reported. On average each time the 175 messages were sent, there were ten failed messages which was 5.7% default rate. In total 48 messages were sent to each mother and 8400 messages were sent in total. Each message was 156 seconds long.

After the intervention, a post-test was conducted on both the experimental and control groups using a structured questionnaire shown in appendix XV. The post-test was used to determine the new level of diarrhoea awareness, the level of adoption of diarrhoea prevention practices and the opinion of the mothers on the prototype used.

3.5.9 Post and during intervention chart review

A chart review was used to collect data from the dispensaries on the diarrhoea cases reported for children under five years of age during the intervention and by the end of the intervention. The chart review is shown in appendix XVIII. The same procedure as described in the retrospective pre-test chart review was followed.

3.5.9.1 Inclusion/exclusion criteria

Inclusion criteria

Registers containing diarrhoea data for children under five years of age following three months of intervention were included. The data was required to show the

impact of the intervention on diarrhoea prevalence for the children under five years of age in the study area. It was viewed that the data for the three months was necessary in order to show the trend of the diarrhoea prevalence unlike data at the end of the intervention which would only show the prevalence at an instance.

Exclusion criteria

Registers containing data that was more than three months old were excluded since the intervention was only done for three months.

3.6 PART 3: COMMUNITY HEALTH VOLUNTEERS STUDY

The purpose of the study on the community health volunteers (CHVs) was to complement the responses from the mothers. It was viewed that since the CHVs work with the community, they observe the challenges that the mothers face during disease interventions. Therefore, they could identify the challenges of the previous diarrhoea information dissemination technologies/strategies and propose characteristics of a suitable diarrhoea information dissemination technology. The information that was sought from the CHVs was on the weakness of the previously used diarrhoea information strategies/technologies and characteristics of suitable diarrhoea information dissemination technologies that can be used in the study area. The CHVs also gave their views on the requirements of the prototype that was developed.

3.6.1 Design

A cross sectional survey was conducted using community health volunteers in the two sub-locations.

3.6.2 Population of the community health volunteers

According to Narok County Government report (2018), Mosiro and Enkorika sub locations each had 20 community health volunteers.

3.6.3 Inclusion/exclusion criteria

Inclusion

The community health volunteers (CHVs) needed to have a mobile phone or access to a mobile phone in order to be selected, this helped in communication with the mothers and the researcher .The community health volunteers had to be fluent in English and Maasai language in order to communicate with the researcher who did not understand the Maasai language and to communicate with the mothers who did not understand English. They needed to know how to read and write in both Maasai and English languages in order to read the questionnaires for the mothers and to write any required communication to the researcher. The CHVs had to be available and willing to participate in the study in order for them to be selected, this was important for the study to be successful.

Exclusion criteria

Community health volunteers who had a disability that could not allow them to participate in the study were excluded. Disabilities considered included crippled, deafness and blindness. Community health volunteers (CHVs) who did not participate in the training were excluded from the study. The CHVs who did not have a mobile phone or access to a mobile phone were excluded. Community health volunteers who were not available or willing to participate in the study were also excluded.

3.6.4 Sample

Fifteen community health volunteers were chosen by convenience sampling to participate in the study. Fifteen community health volunteers were chosen because from the background study it was found out that one community health volunteer attended to an average of 12 people per day, since the participants were 175 per group the required number of the community health volunteers was 15 per group.

3.6.5 Instrument

A screening questionnaire was developed, the questionnaire is shown in appendix XIII. The screening questionnaire was used to determine qualifying community health volunteers. The questionnaire requested information such as ownership of a mobile phone, availability of mobile phone network and availability and willingness to participate in the study.

Training schedule was developed. The training schedule is shown in appendix XX. The schedule indicates the steps that were followed in the training and what the CHVs were trained on. The CHVs were trained on how to interact with the prototype and how to administer the questionnaires to the mothers.

A pre-test questionnaire was developed. The questionnaire is shown in appendix XVI. The pre-test questionnaire was used to elicit information on the weakness and characteristics of a suitable diarrhoea information dissemination technology. It was also used to elicit information on the requirements of the prototype such as mode of mobile phone communication for the mothers i.e. text messages or voice messages and the suitable language for the diarrhoea information communication for the mothers.

3.6.6 Procedure for data collection from the community health volunteers.

An invitation to participate in the study was sent to the experimental and control sub-locations. The information was passed to the community health volunteers by the nurses verbally during their weekly meetings. Text messages were also sent by the nurses to the CHVs who had mobile phones. The researcher visited the dispensaries and passed the information to the nurses verbally. A screening questionnaire was used to determine qualifying community health volunteers using inclusion and exclusion criteria. The screening questionnaire is shown in appendix XIII.

The community health volunteers who qualified for the study were selected and trained. A pre-test questionnaire was administered.

3.7 DATA ANALYSIS

Before analysing the data, it was cleaned to enhance its quality. The process of data analysis followed the steps below:

1. Checking the questionnaire: The questionnaires were checked and those found incorrectly filled or incomplete were discarded.
2. Response coding: A code book was developed to code the responses to numerical values. This allowed the data to be analysed using Statistical Package for Social Scientist (SPSS).
3. Transcription: The codes were translated from the questionnaires to prepare data that was analysed using SPSS.
4. Cleaning: Partial least squares (PLS) data validator and SPSS were used to inspect the dataset for any occurring inconsistencies, missing and outlier values. For any data that required transformation, statistical adjustments were done

After data cleaning and coding were carried out, descriptive statistics such as mean, p-values, effect sizes, standard deviation, minimum, maximum and proportions were used to capture the general outcome of the research. The descriptive statistics were displayed using tables and bar graphs.

In order to compare the groups before and after the intervention, assess the effect of the intervention and prove similarity in all the study aspects for the experimental and control groups, various statistical tests were used. Statistical tests such as independent t-test and paired sample t-test were used to test the difference in diarrhoea awareness and diarrhoea prevalence. The independent sample t-test was used to determine whether the change was significant between the groups.

The paired sample t-test was used to determine whether the change was significant within the groups.The t-test is used to compare the means of two groups. It is interpreted together with the p-value. If the p-value is less than 0.05, the means of the two groups are significantly different. Chi-square test was used to check the existence of relationship between variables and if the distributions were similar or different for both the experimental and control groups. Chi-square is interpreted together with the p-value.The p-value is set to be 0.05. If the p-value is below 0.05, it is concluded that there is an association between the variables. The effect size is used to measure how strong a relationship is between two variables, the greater the difference between the two variables, the bigger the effect size. The effect was found small if the effect size was less than or equal to 0.2, medium when the effect size was greater than 0.2 and less than 0.8.The effect was found to be large when the effect size was greater than 0.8 (Vogel and Draper-Rodi, 2017). The effect size was used to measure the relationship between the diarrhoea wareness before and after the intervention. If the difference in diarrhoea awareness before and after the intervention was big then the intervention caused a big effect on diarrhoea awareness.

Using the data collected from the study, partial least squares (PLS) structural equation modelling was used to develop a diarrhoea intervention framework for resource constrained environments based on the proposed conceptual framework.

The framework coefficients that showed the existence of a relationship between the latent variables were tested for their significant difference using the Hoteling's T-test. This was done to check if each relationship in the framework was significant. All the tests in the study were carried out at 95% level of confidence.

3.8 ETHICAL CONSIDERATIONS

Ethical approvals for the study were obtained from Durban University of Technology Institutional Research Ethics Committee (IREC), Kenyatta University

Ethics Committee and National Commission of Science, Technology and Innovation (NACOSTI). Permissions were also obtained from Narok County Commissioner, Narok County Director of Health and Narok County Director of Education. Patient's records were kept confidential and the participants gave informed consent before participating in the study. The study process subscribed to the international standards in research ethics to which the Durban University of Technology IREC subscribes to. All data was pooled to ensure anonymity. Outcomes of the study were shared with the participating community.

3.9 CONCLUSION OF THE CHAPTER

In this chapter an introduction to the methodology used in the research was done, this was followed by a discussion on the research design used in the study. The study was done in three parts and each part is discussed including the population, the sampling, the inclusion and exclusion criteria, and the analysis. A discussion is also presented on how design science was used in the development of the prototype that was used in the intervention.The chapter concludes with the ethical considerations followed during the study.

CHAPTER 4: RESULTS

This chapter presents the results of the study in a series of sections. The study was done in three parts which are chart review, the interventional study on the mothers and a study on community health volunteers.The first section is the results of the chart review, followed by the interventional study and lastly the study on the community health volunteers. In the chart review section, the data on diarrhoea cases from the two dispensaries in the two study locations is presented. The interventional study section begins by highlighting the adjustment done on the sample size before the actual study. The next section is the presentation of the demographics of the respondents from both the control and the experimental groups showing a comparison between the two groups. Next section presents the results on dissemination of diarrhoea intervention information technologies/strategies, including data on previous technologies/strategies that have been used and their weakness. In the next section the results of the prototype are presented followed by the results of the diarrhoea intervention which include results of diarrhoea awareness, diarrhoea prevention practices and diarrhoea prevalence.In the next section an evaluation of the mobile phone as an alternative technology for diarrhoea intervention through information dissemination in the study area is presented. The last section presents the results of the community health volunteers.

4.1 CHART REVIEW RESULTS

The chart review results were used to to determine the diarrhoea prevalence before and after the intervention.

4.1.1 Diarrhoea prevalence

The summary of the diarrhoea prevalence among children below the age of five years three months before the intervention and three months of the intervention for both the experimental and control groups is shown in table 4.1 below.

Table 4.1: Pre-intervention and post-intervention diarrhoea prevalence from the dispensary records for both the experimental and control groups.

Month	Experimental area N=490	Control area N= 465
Pre-intervention		
April 2018	11	12
May 2018	12	11
June 2018	9	10
July 2018	11	9
August 2018	11	12
September 2018	12	12
October 2018	11	10
November 2018	10	9
December 2018	10	10
January 2019	11	11
February 2019	12	10
March 2019	12	11
During intervention		
April 2019	10	10
May 2019	8	11
June 2019	6	12
3 months	**Prevalence**	**P-value**
Experimental Pre-study	6.93	0.441
Control Pre-study	6.89	
Experimental Post -study	4.89	0.040
Control Post-study	7.09	
Experimental Pre-study	6.93	0.002
Experimental Post -study	4.89	
Control Pre-study	6.89	0.557
Control Post-study	7.09	

The dispensary diarrhoea records accessed were from April 2018 to June 2019.The pre-intervention data considered was from April 2018 to March 2019. The intervention started in April 2019 and was done for three months. In order to find out if the intervention had an impact on the diarrhoea prevalence, the data

considered was for the three months before intervention and the three months of intervention. The three months before intervention were January, February and March 2019 and the three months during intervention were April, May and June 2019. The three months were found necessary in order to show the trend of the diarrhoea prevalence over a period of time. It was viewed that considering diarrhoea prevalence just before intervention and just after the intervention may not have given a clear picture of the impact of the intervention. The comparison between the control and experimental groups in diarrhoea prevalence according to the dispensary data shows that there was no significance difference before the intervention (p=0.441). The post–intervention comparison of the diarrhoea prevalence from the dispensary data shows that there was a significant difference between the two groups (p=0.040). The comparison between the diarrhoea prevalence before and after the intervention for the control group shows that there was no significant difference (p=0.557). The comparison between the diarrhoea prevalence in the experimental group before and after the intervention shows that there was significant difference (p=0.002).

4.2 INTERVENTIONAL STUDY

The interventional study was done on the children through their mothers. The results are as presented.

4.2.1 Response rate

The original sample size of 171 people who met the inclusion and exclusion criteria was increased to 175 participants for both the experimental and control groups. The slight increase in sample size allowed the investigator to accommodate missing responses. The response rate for both the control and experimental groups was 100%.

4.2.2 Demographic profile

The demographic information captured by the researcher included level of education, occupation, marital status, age, number of children, access to communication media and how information is accessed by the respondents. The data are presented below.

4.2.2.1 Highest level of education

The level of education of the respondents in the control and experimental groups is shown in Figure 4.1

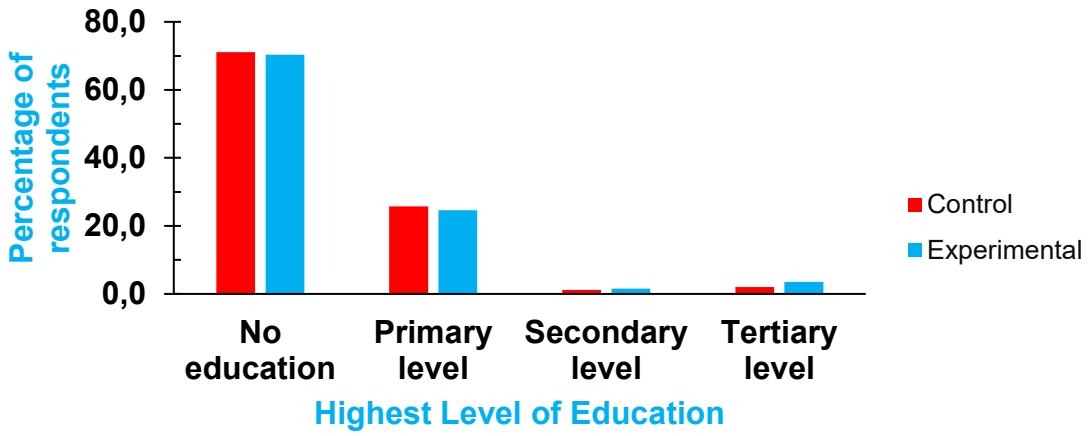

Figure 4.2: Level of education for participants in both the experimental and control groups

In both the experimental and control groups the largest proportion of the respondents were not educated. Very few participants had attained tertiary education**.** The level of education in the experimental group was not significantly different from that of the control group (p=0.403).

4.2.2.2 Occupation of the respondents

The occupations of the respondents are shown in Figure 4.2

Figure 4.3: Respondent's occupation

Majority of the respondents from both groups were livestock farmers. There was no significant difference in the occupation of the respondents between the experimental and control groups (p=0.873).

4.2.2.3 Marital status

The marital status of both groups is shown in Figure 4.3.

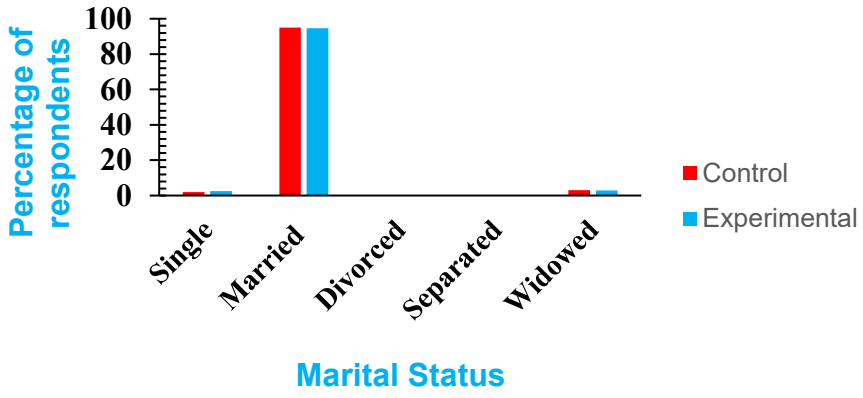

Figure 4.4: Respondent's marital status

Majority of the respondents from both groups were married, and there were no divorce or separated cases in any of the groups. There was no significant difference in the marital status between the groups (p=0.065).

4.2.2.4 Age of the respondents in years

The age distribution of the respondents is shown in Figure 4.4

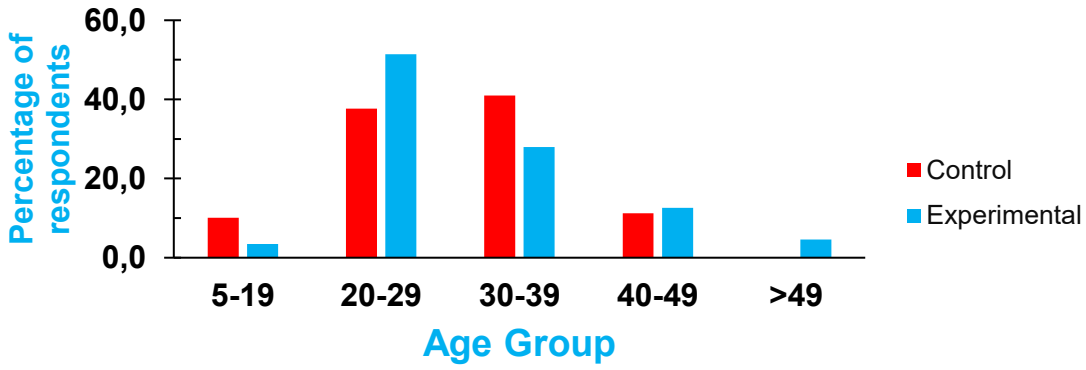

Figure 4.5: Distribution of respondents by age category

Majority of the respondents were between 20-29 years of age in the experimental group and 30-39 years in the control group. The mean age for the experimental group was 30.67 ±9.026 years, while the mean age for the control group was 29.58± 8.712 years. The mean age of the respondents from the experimental group was slightly higher than that of respondents from the control group (p=0.042).

4.2.2.5 Number of children per responding mother

Figure 4.5 shows the number of children that each mother had from both groups.

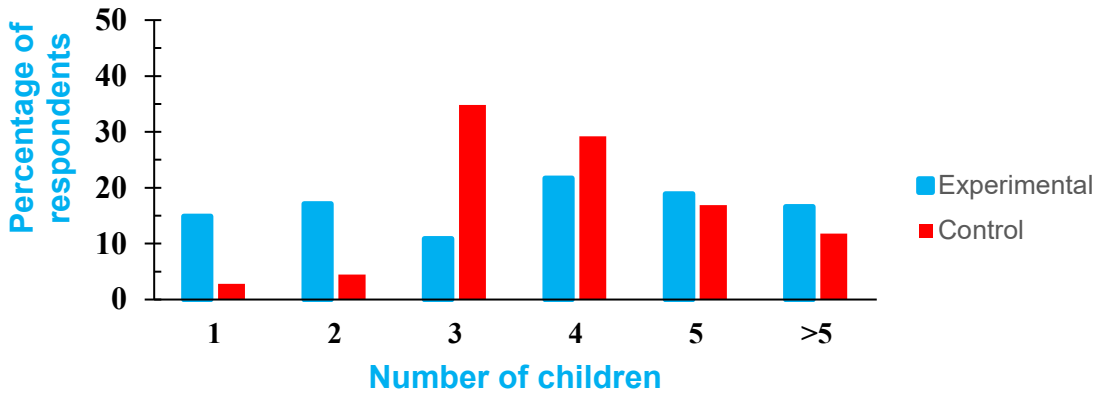

Figure 4.6: Number of children per responding mother

Most of the respondents in the experimental group had four children while in the control group they had three children. The average number of children in the experimental group was 3.62 ± 1.69, and 3.88±1.69 in the control group. There was no significant difference between the control and experimental groups regarding the number of children per mother (p=0.097).

4.2.2.6 Access to communication media

Figure 4.6 shows the respondents (%) access to communication media by group and media

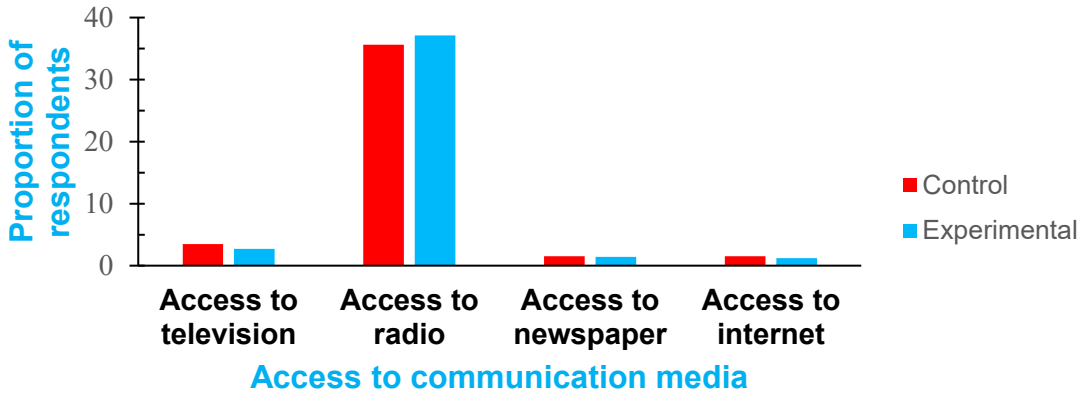

Figure 4. 7: Access to communication media by group and media (%)

The most accessed communication media by the respondents from both the experimental and the control groups was a radio. There was no significant difference between the groups in the access to a communication media (p=0.603).

4.2.2.7 How the respondents access information

Figure 4.7 shows the manner in which the respondents access information.

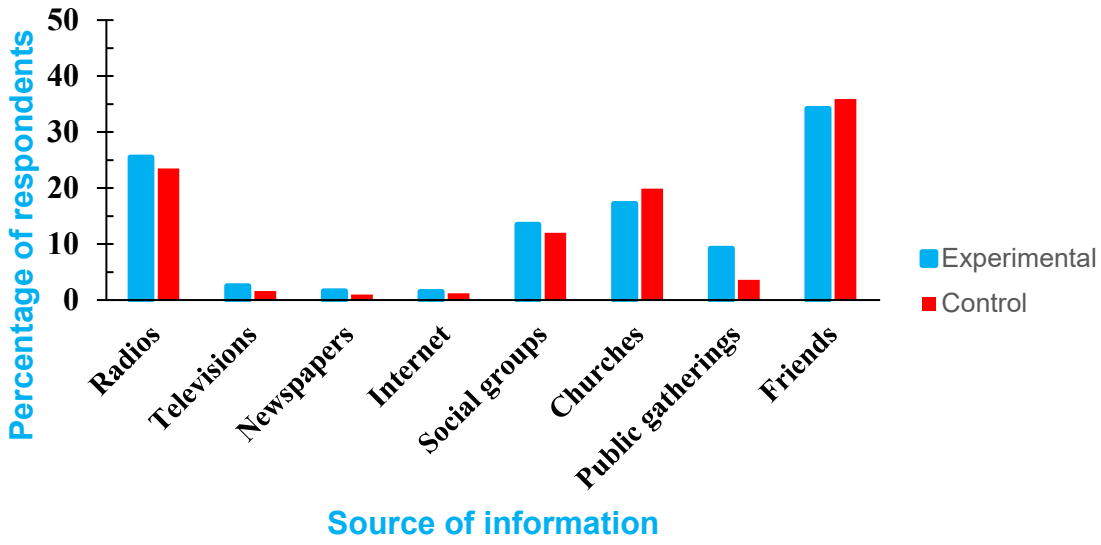

Figure 4. 8: Respondent's access to information by source

Majority of the respondents from both groups said that they mostly accessed information from friends. There was no significant difference in the source of information between the groups (p=0.60).

4.2.3 Diarrhoea intervention information dissemination technologies /strategies prior to the study.

In order to get information concerning diarrhoea intervention strategies/ technologies that had previously been used, respondents were asked questions on the organizations that conducted the interventions, technologies/strategies used by the organizations, whether the interventions had been effective, the

weakness of the previous interventions, if a better technology/strategy in diarrhoea information dissemination was required , characteristics of technologies/strategies that can be feasible in diarrhoea intervention information dissemination and if a mobile phone would be a better technology compared to the existing technologies/strategies. The results are shown in the subsequent sections.

4.2.3.1 Previous diarrhoea intervention information dissemination conducted

About 65% of the respondents in the experimental group had previously been exposed to diarrhoea intervention information dissemination compared to 71% in the control group. There was no significant difference between the groups (p= 0.202).

4.2.3.2 Frequency of diarrhoea interventions

The table 4.2 shows the opinions of the respondents on frequency of the diarrhoea intervention.

Table 4.2: Frequency of the diarrhoea intervention

GROUP	how often are the interventions						P-value	Chi-Square
	At least once a week	At least once a month	At least once in three months	At least once in six months	At least once a year	Less than once in a year		
Control	21.5%	21.5%	3.8%	12.3%	33.1%	7.7%	0.545	
Experimental	14.2%	25.8%	1.7%	14.2%	37.5%	6.7%		4.03

Most respondents from both the experimental and control groups said that the interventions were done once in a year that is at 37.5% and 33.1% respectively. Chi-square test was used to generate the p-value. The Chi-square test of association between the groups and the frequency of intervention showed that

there was no association (p =0.545), implying that there was equal frequency of diarrhoea intervention in the areas.

4.2.3.3 Organizations that conduct the diarrhoea intervention

Table 4.3 shows the organizations that previously/currently conducted diarrhoea intervention information dissemination.

Table 4.3: Organizations that conduct diarrhoea intervention

Group	Organizations that conducted the intervention				P-value	Chi-Square
	Narok County government	Government of Kenya	NGOs	Churches		
Control	24.7%	24.7%	17.5%	33.1%	0.071	7.032
Experimental	29.8%	13.7%	25.2%	31.3%		

Most respondents from both the experimental and control groups said that the interventions were conducted by churches at 31.3% and 33.1% respectively. Chi-square test was used to generate the p-value. The Chi-square test of association between the groups and the intervening organization showed that there was no association between the groups and the organizations conducting the intervention (p=0.071), implying that there was equal intervention by different organizations in both the control and experimental areas.

4.2.3.4 Strategies/technologies used by the organizations

Table 4.4 shows the strategies/technologies that have previously been used in diarrhoea intervention information dissemination as reported by the mothers.

Table 4.4: Diarrhoea intervention strategies/technologies as reported by the mothers

Group	strategies/technologies used by the organizations						P-value	Chi-Square
	Radio	Television	Public gathering	Display information in health facilities	Seminars	Newspapers		
Control	36.2%	7.8%	18.3%	11.5%	24.3%	1.8%	0.955	1.09
Experimental	33.0%	8.0%	20.0%	14.0%	23.0%	2.0%		

Both the experimental and control groups said that the most used strategies/ technologies by organizations in diarrhoea information dissemination were radios with 33.0% and 36.2% respectively. Chi-square test was used to generate the p-value. The Chi-square test of association between the groups and the strategy /technology used in diarrhoea intervention showed that there was no association (p=0.955), implying that there were similar intervention strategies/technologies being used in the two areas.

4.2.3.5 Opinion on present/previous diarrhoea interventions strategies /technologies

Respondent's opinion on the present/previous diarrhoea intervention information disseminations are shown in table 4.5

Table 4.5: Opinion on effectiveness of present/previous diarrhoea intervention strategies/ technologies

Group	Effectiveness					P-value	Chi-Square
	Very effective	Effective	Not sure	Ineffective	Very Ineffective		
Experimental	5.1%	3.4%	1.1%	60.1%	30.3%	0.99	0.31
Control	6.2%	3.9%	1.1%	59.0%	29.8%		
Mean	5.6%	3.7%	1.1%	59.6%	30.1%		

Most respondents from both the experimental and control groups said that the interventions were ineffective at 60.1% and 59.0% respectively. Chi-square test was used to generate the p-value. The Chi-square test of association between the groups and the opinions on the effectiveness of the strategy/technology used in diarrhoea intervention showed that there was no association (p=0.99).This means that the opinions on the effectiveness of the strategy/technology was not depended on the group and therefore since each group viewed the strategies/technologies as ineffective, then they were inefective.

4.2.3.6 Weakness of the diarrhoea intervention strategies/technologies used

Table 4.6 shows the weaknesses of the previous/present diarrhoea strategies /technologies that were identified by the respondents.

Table 4.6: Weaknesses of the present/previous diarrhoea intervention strategies/technologies

Weaknesses	Experimental	Control	Mean
Strategies/ technologies used are expensive	90.5%	92.9%	91.7%
Strategies/ technologies used are not available	57.1%	64.7%	60.9%
Strategies/technologies used are not portable	85.2%	81.3%	83.3%
Do not understand intervention language	90.8%	95.9%	93.4%
Intervention time not convenient	77.4%	74.0%	75.7%
Technologies/strategies not interactive	85.1%	82.1%	83.6%
Technologies lack long charge retention	87.2%	93.9%	90.6%
Long distance to the intervention place (public gathering, seminars)	65.2%	78.3%	71.8%
Nature of work therefore no time(nomads)	76.2%	78.5%	77.4%
Strategies or technologies are not easy to use	52.4%	46.6%	49.5%
Mean value of the weaknesses	**76.7%**	**78.8%**	**77.8%**
T-test value	**-1.092**		
P -value	**0.152**		

The mean value for the weaknesses for the experimental group was 76.7% and 78.8% for the control group. The t-test was used to generate the p-value.The t-test

for the means of weakness of technologies/ strategies for the experimental and control groups showed that there was no significant difference in the rating of the weaknesses (p=0.152). This means that the weaknesses of the previous technologies were rated the same by the two groups.

4.2.3.7 Characteristics of an effective diarrhoea intervention information dissemination strategy/technology

Table 4.7 shows the characteristics of a suitable diarrhoea intervention information dissemination that were identified by the mothers.

Table 4.7: Characteristics of feasible technologies/strategies in diarrhoea information dissemination

Characteristic	Experimental	Control	Mean
Affordable	96.63%	94.94%	95.6%
Technology available	89.44%	87.75%	88.6%
Portable	91.01%	95.51%	93.3%
Information is always available	95.51%	96.63%	96.1%
Allow interaction	80.34%	80.63%	80.5%
Information is available in understandable language	100.00%	100.00%	100%
Have long charge retention	94.94%	93.82%	94.4%
Easy to use	96.07%	98.88%	97.5%
Reliable	74.04%	94.94%	84.5%
Mean on the characteristics	90.8%	93.7%	92.25%
T-test value	-0.86		
P-value	**0.38**		

The respondents from the experimental and control groups approved the characteristics shown in table 4.6 as necessary for a suitable ICT for diarrhoea information dissemination with a mean of 90.8% and 93.7% respectively. The t-test was used to generate the p-value. The t-test for the means of characteristics of effective technologies/ strategies for the experimental and control groups

showed that there was no significant difference in the ratings of the characteristics (p=0.38). This result means that the rating of the characteristics of feasible strategies/technologies by the two groups was the same.

4.2.3.8 Opinion on a mobile phone as a better strategy/technology for diarrhoea intervention information dissemination

The mothers were asked their opinions on mobile phones as a better strategy/technology for diarrhoea information dissemination compared to previously used technologies/ strategies, the responses are shown in table 4.8.

Table 4.8: Opinion on mobile phones as a better strategy/technology for diarrhoea information dissemination

Group	use of mobile phone as a better technology/strategy for diarrhoea information dissemination						Chi-Square Test value
	Strongly Agree	Agree	Not sure	Disagree	Strongly disagree	p-value	
Experimental	40.2%	40.4%	8.3%	9.6%	1.5%	0.918	.947
Control	38.5%	43.0%	10.6%	6.7%	1.2%		
Mean	39.4%	41.7%	9.5%	8.2%	1.4%		

On the opinion about the mobile phone being a better technology than the previous used technologies/strategies in diarrhoea information dissemination, 40.2% and 38.5% of the respondents from the experimental and control groups strongly agreed, 40.4% and 43.0% from experimental and control group respectively agreed. The Chi-square test was used to generate the p-value.The Chi-square test for distribution of proportion showed that there was no significant difference in the distribution of proportions on the views regarding use of mobile phones as a diarrhoea intervention information dissemination technology (p =0.918).

4.2.4 Results of the prototype

The results of the prototype that was developed using design science are shown in this section.

4.2.4.1 Results of the prototype first iteration

The results of the first interation are presented below.

4.2.4.1.1 Explicate the problem

In this step the problem was analysed. The study was conducted in rural Narok County and from the literature review it was found to have high diarrhoea prevalence especially among children under five years of age (UNICEF, 2017).

The high diarrhoea prevalence is attributed to the low levels of diarrhoea awareness which is caused by poor diarrhoea information dissemination strategies/ technologies (Okeyo et al., 2019). Rural Narok is characterized by poor road infrastructure, inadequate resources, low levels of literacy and nomadic lifestyle (Narok County Government, 2018). Because of these factors the currently used technologies/strategies in diarrhoea information dissemination such as public gatherings, seminars, display of information in the health facilities, radios and televisions have been ineffective (Tankoi, Asito and Adoka, 2016). The problem being addressed is high diarrhoea prevalence caused by low levels of awareness due to utilization of poor information dissemination strategies and technologies in the context environment.

4.2.4.1.2 Define requirements

Mobile phone penetration in rural Narok is over 60%, this high penetration in a rural setting is because the mobile phones are affordable, portable, available and easy to use and that there exists a mobile phone communication infrastructure

(Communication Authority of Kenya, 2019). Due to their high penetration, mobile phones can be a suitable channel for diarrhoea information dissemination in the area.

From the interviews conducted on the nurses, they gave the diarrhoea information and translated it into the Maasai language. They also gave their views on how the information should be structured in order for it to be comprehensive. They proposed that the message should start with an introduction which should state the aim of the message, message source and that the message is free to the participants. The message introduction should be followed by a definition of diarrhoea, signs and symptoms of diarrhoea, diarrhoea causes, diarrhoea prevention practices, diarrhoea first aid and the importance of visiting a health facility when a child suffers from diarrhoea. In terms of message density, the nurses proposed that the messages should be short in order to catch the attention of the listener. In terms of message content, they proposed that the keywords should be well selected to make the message short but clear and informative. In terms of tone it was proposed that the messages should be polite and of advisory nature to interest the listeners.

The pre-test questionnaire (Appendix XIV) was used to elicit prototype requirements from the mothers. The questionnaire was used to find out how conversant the mothers were with mobile phones, to get their contact numbers in order to receive the messages and to find out their preferred language to be used in the messages. The mothers also suggested the most suitable time to receive the messages and the form they preferred the message to be in.

It was found out that all the mothers were familiar with the procedures of taking calls but were unable to write or read text messages due to illiteracy. The mothers indicated that they preferred the diarrhoea messages to be in the Maasai language because it is the language they best understood and to be in voice form due to illiteracy. The mothers also suggested that the messages should be sent at ten

o'clock in the morning since during that time they are less occupied. The mothers gave their mobile phones numbers which were used to send the diarrhoea information messages. The user requirements are demonstrated using a use case diagram.

Use case diagram of the diarrhoea intervention healthcare system

In the initial design there were two actors who are the system administrator and the participant. This is because it was only the system administrator and the participants who interacted with the system in the initial design.

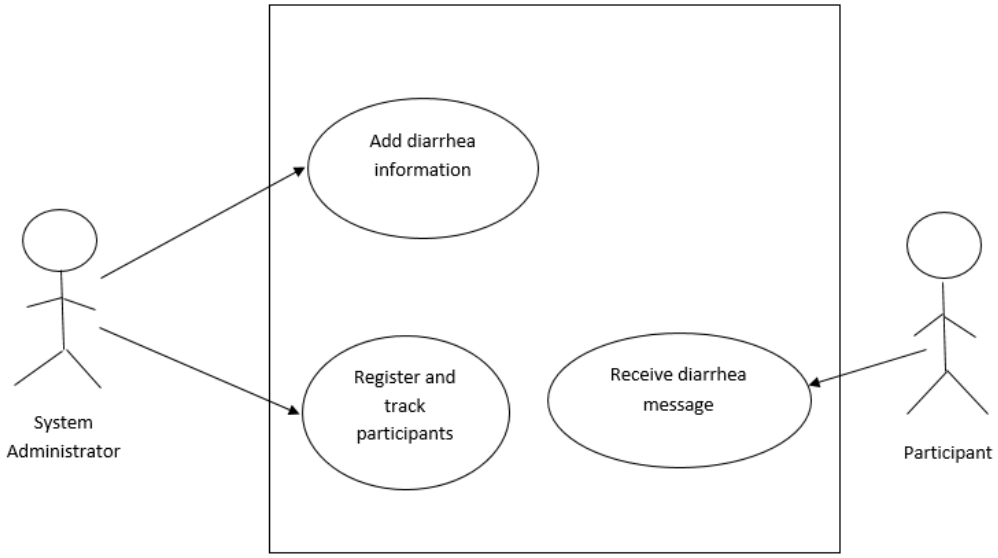

Figure 4.9: Use case diagram for diarrhoea intervention healthcare system in the first iteration

The working of use case diagram

Figure 4.8 shows the use case diagram for the initial design. The system administrator was responsible for the management of the system. The system administrator got diarrhoea information from the nurse and uploaded it into the diarrhoea intervention healthcare system. The system administrator also

registered the participants and tracked them using call logs to see whether they were receiving the messages. The participants received the diarrhoea information in the form of voice messages.

4.2.4.1.3 Design and development of the artefact

From the requirements gathering, it was observed that mobile phones were pervasive in the study area and that the mothers were conversant with picking of calls. It was also found that the Maasai language was the most spoken language and the language of choice for dissemination of diarrhoea information. From those requirements a mobile phone-based system was designed which disseminated information in form of voice messages in the Maasai language. This made the system unique because earlier technologies used the English or Kiswahili languages to disseminate diarrhoea information which are scarcely understood by the locals (Narok County Government, 2018).

Another uniqueness of the system was that it used voice messages which overcame the challenges of low levels of literacy. The system was designed to be easy to use and required minimal knowledge by the users to obtain information, such as being able to pick a call. This minimal user involvement was a motivation to the mothers to use the system. The minimal involvement and subsequent motivation provided a uniqueness to the system that other, more complex systems lacked.

The nurses gave the diarrhoea information and translated it to the Maasai language. They suggested the structure and the tone of the messages for the diarrhoea information. Their recommendation was incorporated in the design of the messages.

Using design science method, a preliminary design was made and modelled using flowcharts, data flow diagrams and system architecture as shown below.

4.2.4.1.3.1 Flowchart of the diarrhoea intervention healthcare system

The flowchart of the diarrhoea intervention healthcare system is shown in Figure 4.9. The system administrator logs into the system and enters the diarrhoea information collected from the nurse, this is the information that is sent to the participants. The system administrator checks whether a participant is registered if not she is registered, after registration the participants receive diarrhoea intervention information.

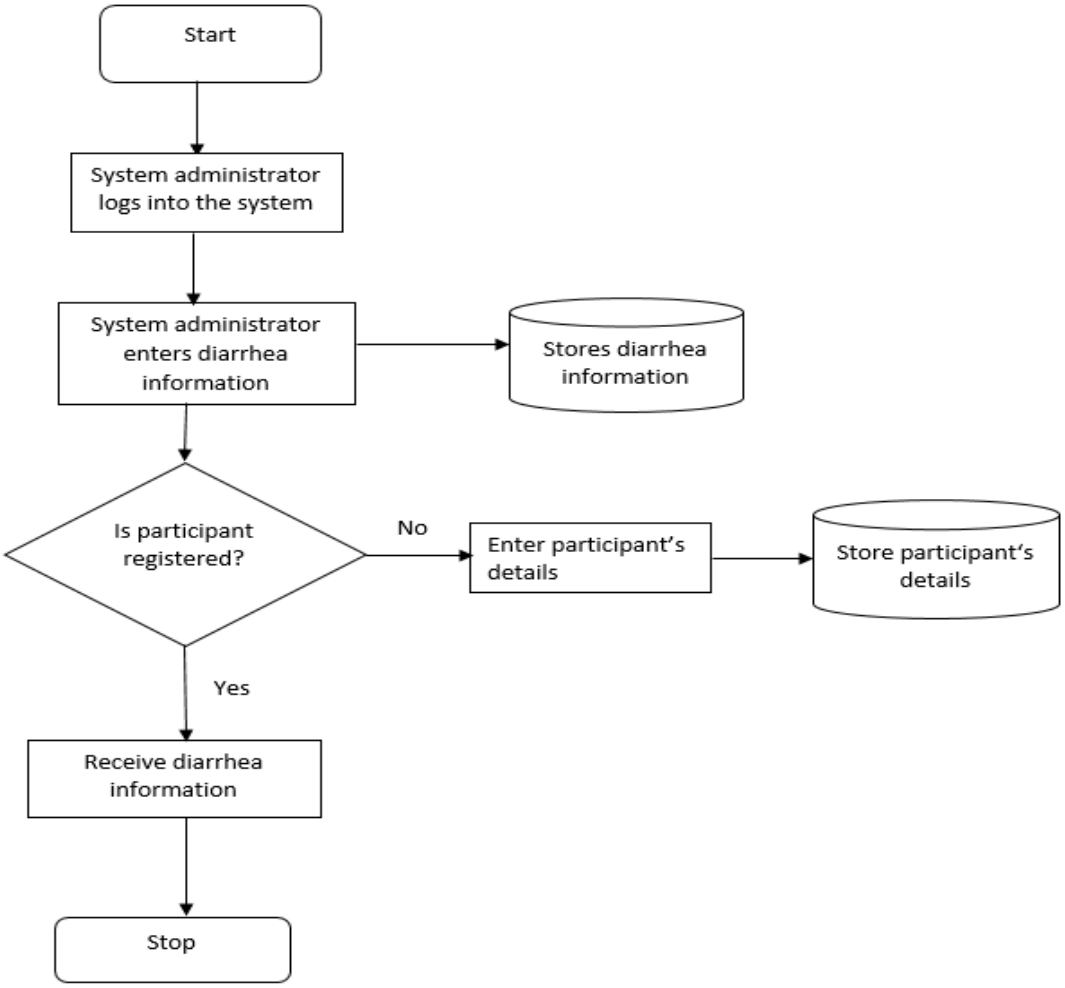

Figure 4. 10: Flowchart diagram of the diarrhoea intervention healthcare system in the first iteration

4.2.4.1.3.2 Data flow diagram of the diarrhoea intervention healthcare system

At the basic of a data flow diagram(DFD) is the context diagram which is also called level 0 data flow diagram, the processes can be exploded to higher levels depending on the details required in the demonstration (Kendall , Kendall and Mathew , 2019). The context diagram of the mobile phone-based system developed is shown in figure 4.10. Although many proceses were used to uncover our requirements, only the first level of DFDs is presented because the details are sufficient for the demonstration.

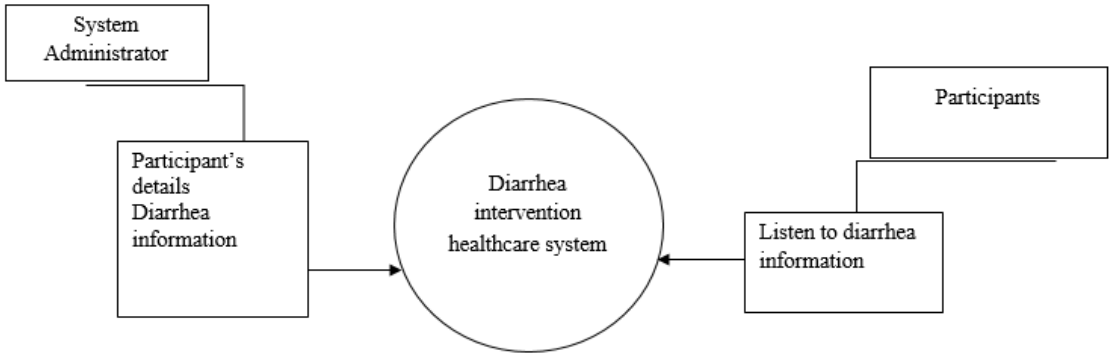

Figure 4.11: Context diagram of the diarrhoea intervention healthcare system in the first iteration

In the preliminary design of the system, the system was designed to only send messages to all the participants at ten o'clock in the morning. For the participants to receive the messages, they needed to be registered in the system and the diarrhoea information needed to be uploaded into the system for dissemination. The system administrator registered the participants and uploaded the diarrhoea information into the system.

4.2.4.1.3.3 System design architecture of the diarrhoea intervention healthcare system

A system design architecture is the basic structure of a software comprising of the components that make the system and how they relate to each other (Hoffer et al., 2016). Figure 4.11 below shows the preliminary design of the diarrhoea intervention healthcare system

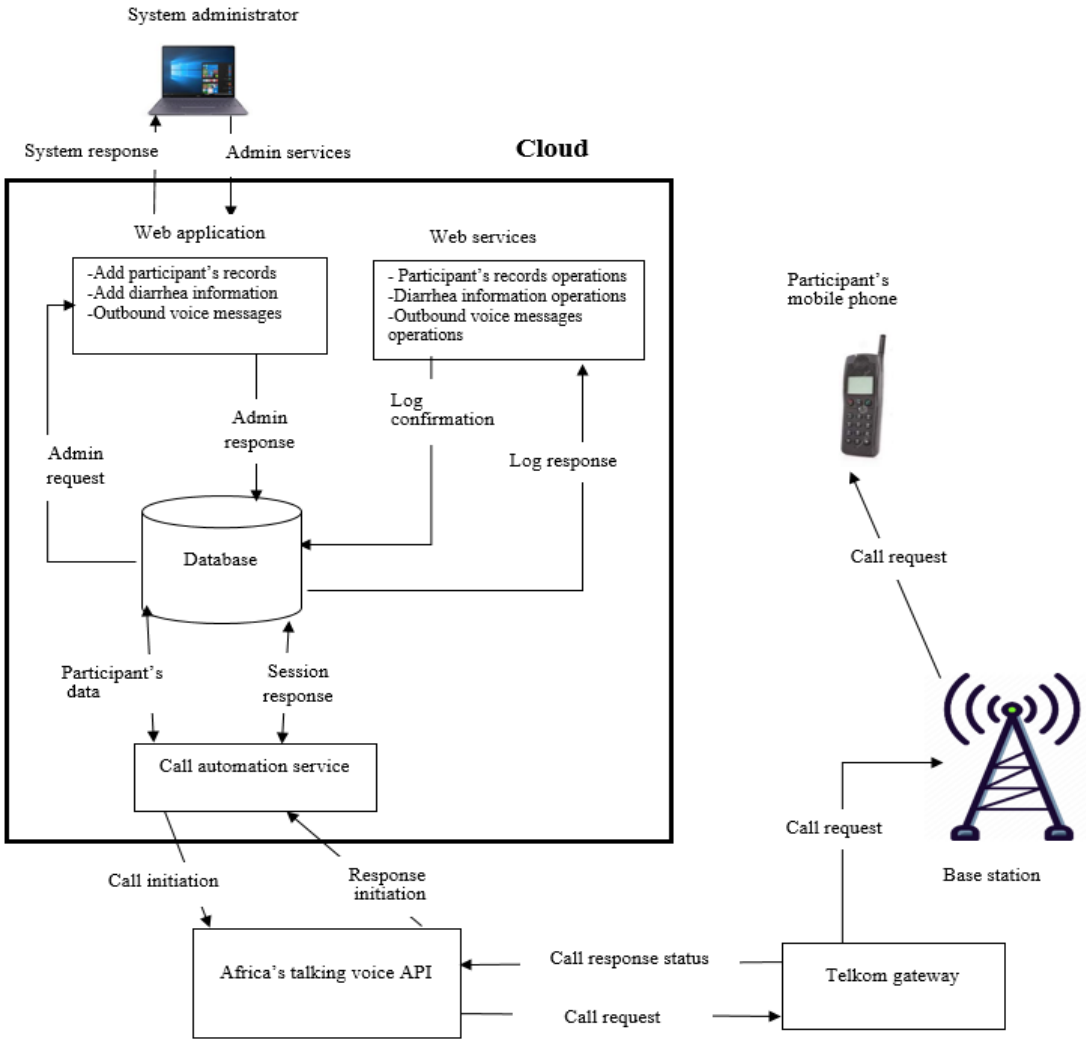

Figure 4.12: System design architecture of the diarrhoea intervention healthcare system in the first iteration

The system was hosted in the cloud, the system administrator interacted with the web application through the cloud and with the database which was in the cloud through the web application. The system was hosted in the cloud because the interaction between the telecommunication company and our application required that the system be online in order for it to be available to the users, which would not have been possible on a locally hosted machine .The web application was used to add participant's data, enter diarrhoea information and send outbound messages. Based on the newly-entered information such as user's phone number and pre-determined voice content, web services performed standardised operations such as initiating the call while maintaining records of the call being initiated and received. The database contained information such as the diarrhoea information and participant's mobile phone numbers. The participants interacted with the system through Africa's talking voice API. The Africa's talking voice API were selected because of the reasons explained in section 4.5.1.3.3.a.

When a diarrhoea information message was sent from the database, a call was initiated from the Africa's talking voice API which sent a call request through the telecom's gateway. The call request went through the base station to the participant's mobile phone. The participants received the call and listened to the voice message, the system indicated whether the call was received by sending an initiation response, if the call was not received; the system terminated the call and showed that the call was not received. This was done through the call response status. This aided in assessing the reliability of the system in delivering the diarrhoea information. The participants were not charged for the calls. The administrator's services included entering and updating diarrhoea information and registering participants.

After designing the prototype, it was developed based on the design. The following technologies were used in this phase to build the prototype:

a. Africa's Talking Voice Services gateway.

Africa's talking voice services gateway is a premium rates services provider (PRSP). In order to send bulk voice messages to a third party it is a requirement in Kenya to use a PRSP, otherwise a license has to be obtained for one's own system which is expensive. Since Africa's talking voice services gateway is already licensed, easy to use and cheap, it was used for the voice messages interactions. The gateway allowed mass calling to be done to the participants which would not have been possible without the gateway.

b. Visual Studio 2015 Community Edition.

This is an integrated non-licensed IDE by Microsoft used to develop web applications, web services and windows services. The IDE was used to develop the web application that stored different voice files, contacts and participant's data. Visual Studio 2015 Community Edition was used because it is free, supports .NET framework and PHP developments which were used to develop the prototype (Reynders, 2018). Visual Studio 2015 Community Edition supported the writing of C# code and ASP. NET applications that were used to maintain the list of participants, to initiate the calls, maintain call status and alert messages. It also allowed writing of PHP code that communicated with Africa's talking API to receive call status information and responses from the telecommunication companies in order to ensure reliability of messages sent.

c. Microsoft SQL 2016 Express Edition: Microsoft SQL server express is a free Microsoft's primary relational database management system; it was used to store diarrhoea information data. Microsoft SQL Express Edition has the advantages of being free, it is scalable and has high levels of security, and it also has an option of free online backup (Ben-Gan, 2016).

d. SQL Server Management Studio.

This is a software tool used for configuring, managing and administering all the components within Microsoft SQL server, it includes graphical tools and scripts

editors which work with objects and features of the server (Ben-Gan, 2016). SQL Server Management Studio provides a GUI for MS SQL that is needed for easier management of queries, scripts, and database objects (Ben-Gan, 2016).

Server–side Implementation

ASP.NET and C# were used to develop the web application that held the data for the prototype. ASP. NET was chosen because it is easy to use therefore saving on development time. C# was chosen because it has pre-existing libraries that allowed easy communication with MS-SQL database saving the researcher coding time. C# is fully supported for all ASP.NET web application development which made it easy to work with both.

Client-side Implementation

To make the system responsive to different devices for ease of management, twitter bootstrap and jQuery were used. Twitter bootstrap and jQuery allowed the use of pre-existing libraries to manage the look and feel of the user interface, this use saved on the time that would otherwise be used to develop the interface. Twitter bootstrap and jQuery are easy to use and support ASP.NET applications, which was another reason for their selection.

Data validation was done using AjaxControlKit and JavaScript to protect the system from SQL injections and malicious attacks and to ensure that data input such as mobile phone numbers and dates were in the correct format ensuring a degree of data validity. The client side was a web application. This was to allow broad and easy accessibility and easy interaction with the other services and applications that interacted with it since they were web based.

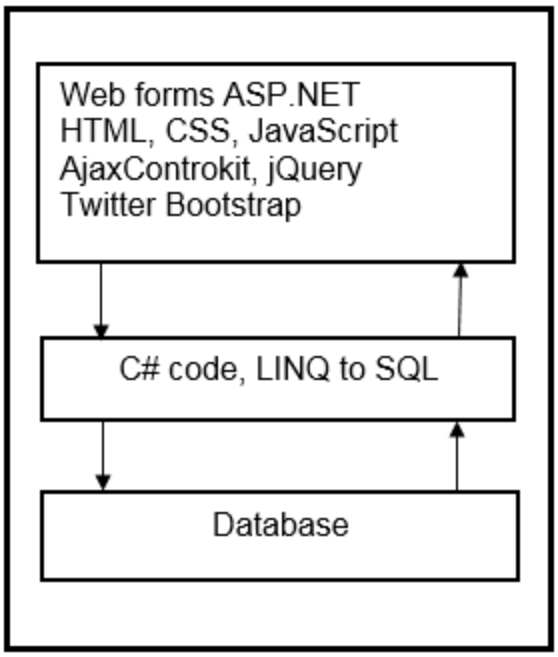

Figure 4. 13: Client-side design

LINQ to SQL is a component of .NET Framework that provides a run-time infrastructure for managing relational data as objects (Reynders, 2018). It provides for an easy way to manipulate database objects such as tables, stored procedures, views and functions. LINQ was used to minimize the lines of code written to access database objects which reduced the development time and integration time. C#, ASP .NET and MySQL being products of Microsoft, are already designed to work together with a large pool of pre-existing classes and functions which made development easy and faster (Reynders, 2018). Client-side design of the system is shown in Figure 4.12. The functionalities of the client side were to input participant's data, to input diarrhoea information and to listen to the diarrhoea information messages.

Automated services.

Windows services were developed to automate scheduling mass calls and reminders by using timers within the windows service.

Hosting server

Web services and web application were hosted on IIS server with support for PHP hosting. IIS stands for Internet Information Server; it can be used to host different services and applications. Since we were using ASP.NET it was the most suitable server as it was the most compatible with ASP.NET

4.2.4.1.4 Demonstration of the prototype

After the development of the prototype, it was demonstrated to the stakeholders consisting of county health officials, the nurses, the CHVs and the mothers. The stakeholders were shown how calls were received in order to listen to the diarrhoea information. The mothers listened to the diarrhoea information messages in order to evaluate the clarity of the messages. The nurses listened to the messages in order to evaluate the accuracy of the information. The mothers, nurses, CHVs and the county health officers interacted with the system in order to evaluate its usability. The demonstration was conducted in various venues as per the convenience of the stakeholders.

4.2.4.1.5 Evaluation of the prototype

Using the methods discussed in section 3.5.7, evaluation of the prototype was conducted by the stakeholders. The following were the results of the evaluation.

1. The participants requested that the information be made clear, in some parts of the message, the nurse was not loud enough and in other areas the speech was too fast. The nurse made the improvements and the changes were incorporated into the recorded message.

2. The participants requested to be allowed to ask questions and make comments if there were blurred issues. The researcher incorporated a functionality that could be used by the participants to leave a question or comment.
3. The participants requested to access the message any other time if they missed the 10.a.m time. A functionality was incorporated to allow the participants to press a certain key on the mobile phone to listen to the message at the participant's convenience.
4. The Narok County health officials and the CHVs requested that a functionality be included where the participants could leave an alert message in case of an emergency and a nurse functionality to be included where the alert message could be sent to the nurse and the nurse could call the participant.

Design science methodology which was used in the prototype development requires that a software be improved iteratively until a refined state is achieved (Baskerville et al., 2018). Using the results of the evaluation, the requirements were expounded to incorporate the new suggestions. The design of the system was modified as shown in the next section.

4.2.4.2 Second iteration

4.2.4.2.1 Redefine requirements

From the first evaluation the requirements were redefined as follows.
The Narok County health officials and the CHVs requested a functionality be included to allow the participants to leave an alert message. They also requested that a functionality for the nurse be added so that in case of an emergency the participants could call the nurse. The participants requested to be allowed to leave a comment/question in case they required further clarification. Below is the new requirements modelled by a use case diagram.

Use case diagram of the system in the second iteration

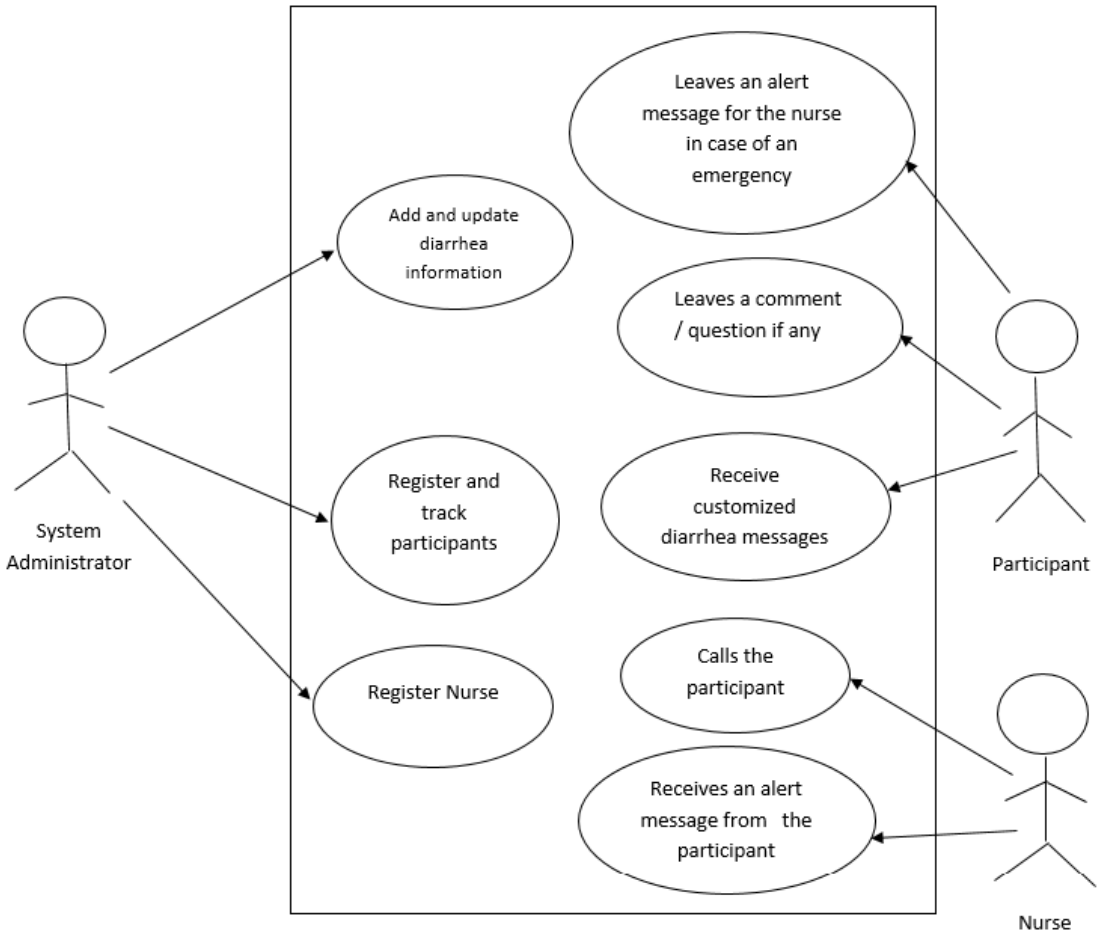

Figure 4.14: Use case diagram for the diarrhoea intervention healthcare system in the second iteration

Figure 4.13 shows the use case diagram after the first evaluation. A nurse was added as an actor. The nurse functions were also added and the participants were allowed to interact with the system.

4.2.4.2.2 Design and development of the artefact

Using the new requirements an improved design was made and modelled using flowcharts diagrams, data flow diagrams and system architecture diagrams as shown below.

4.2.4.2.2.1 Flowchart of the system in the second iteration

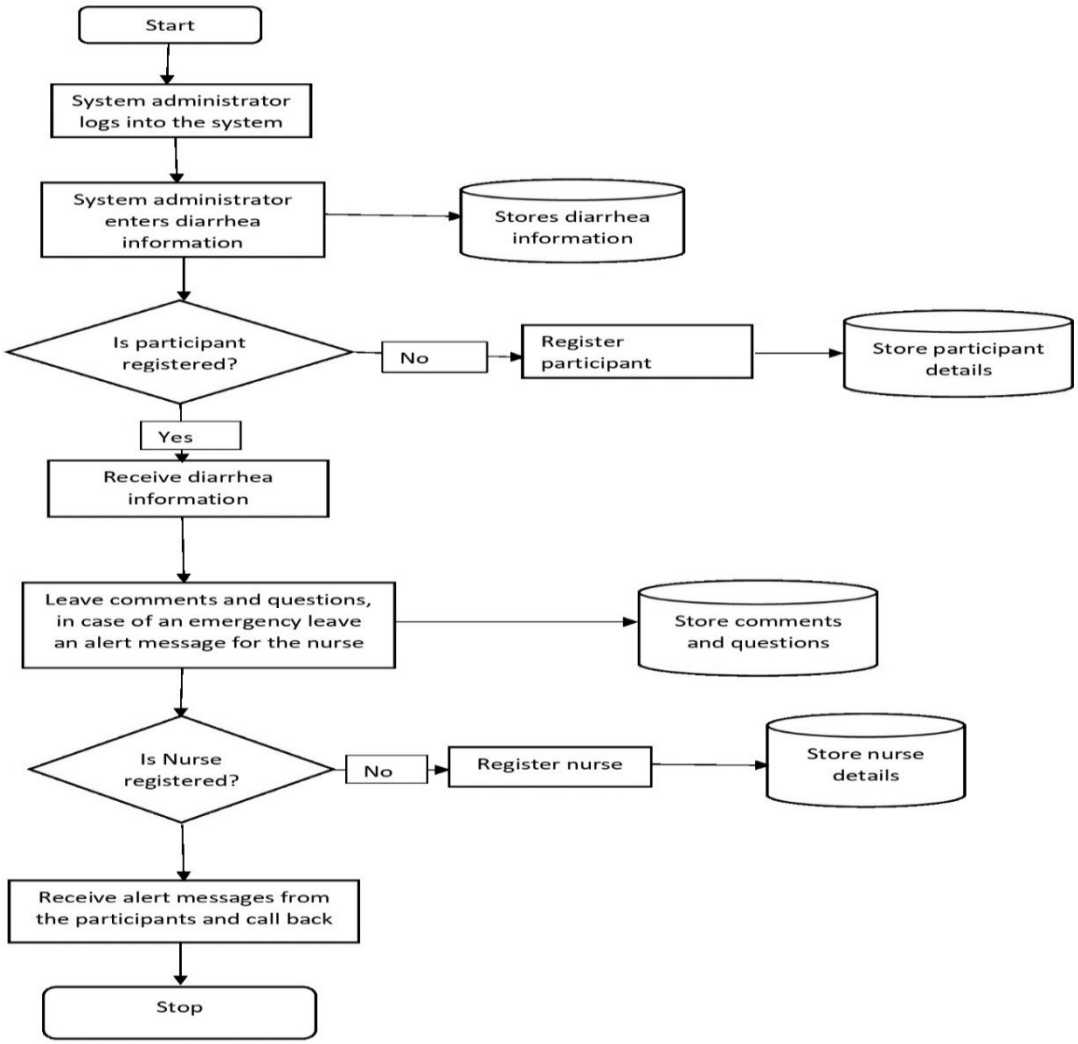

Figure 4.15: Flowchart diagram of the diarrhoea intervention healthcare system in the second iteration

Figure 4.14 shows the new flowchart diagram with the modifications after the first evaluation.The modifications done on the system after the first evaluation were that after entering the diarrhoea information from the nurse to the system, the system administrator registered the nurse if not yet registered. The participants received the diarrhoea information, they left a question or a comment in case they had any. In case a participant had an emergency, she left an alert message which was sent to the nurse by the system, after receiving the alert message the nurse called the participant. This functionality made the system unique because earlier technologies that were used in diarrhoea information dissemination did not provide for interaction with a health worker and there were no provisions for emergency services (Dioso and Elmi, 2017).

4.2.4.2.2.2 Context diagram of the system in the second iteration

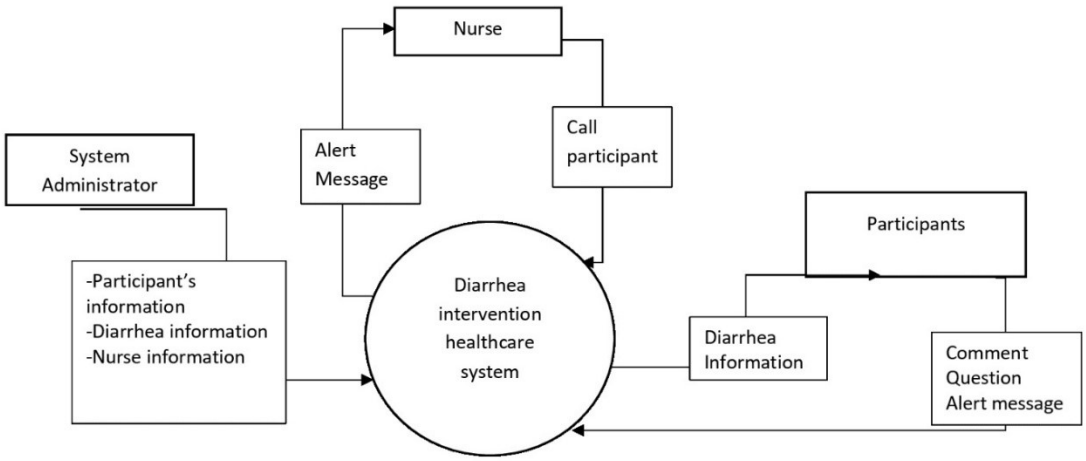

Figure 4.16: Context diagram for the diarrhoea intervention healthcare system in the second iteration.

Figure 4.15 shows the context diagram after the first evaluation. A functionality for a nurse was added and the participants were provided with a functionality to leave

a question/comment/alert message. The alert message was sent to the nurse and the nurse called the participant.

4.2.4.2.2.3 System design architecture of the system in the second iteration

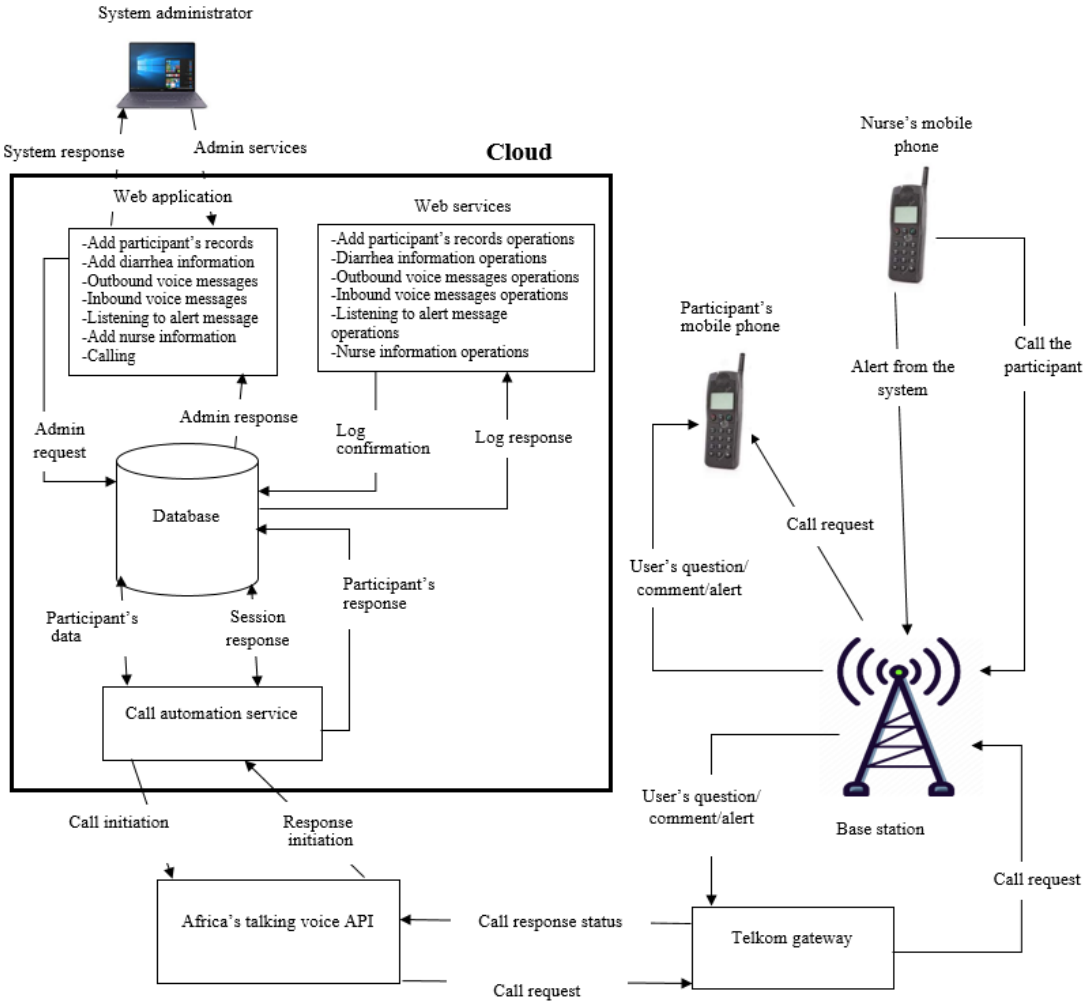

Figure 4. 17: System design architecture of the diarrhoea intervention healthcare system in the second iteration

The design of the system in the second iteration is shown in Figure 4.16.

In the second iteration more functions were added to the web application which were to receive inbound messages, add nurse details, sent alert messages and

call the participants who left alert messages. The web services were added accordingly. The database was modified to store the added information. The system design was modified to allow the participants to leave a question/comment or an alert message and to include a nurse who received the alert messages and made calls to the participants.

The system was developed according to the new design using the same tools that had previously been used.

4.2.4.2.3 Demonstration of the prototype

After the prototype was improved, it was demonstrated to the stakeholders. The mothers listened to the diarrhoea information messages in order to evaluate the clarity of the messages. The nurses listened to the messages in order to evaluate the accuracy of the information. The mothers, nurses, CHVs and the county health officers interacted with the system in order to evaluate its usability. The demonstration was conducted in various venues as per the convenience of the stakeholders.

4.2.4.2.4 Evaluation of the prototype

The system was evaluated again by the stakeholders who were the participants, the nurses, the county health officers and the CHVs. The steps followed in the first evaluation were followed in the second evaluation.

The results of the second evaluation gave the following feedback.

1. The participants requested that the information be expounded where it was not clear.
2. The Narok County health officers, requested that the data on diarrhoea for the children under five years of age from the dispensary be added into the system and that they should receive periodic and on demand reports on diarrhoea cases in order to determine the impact of the intervention.

4.2.4.3 Third iteration

4.2.4.3.1 Redefine requirements

After the first evaluation the county health officers requested that the data on diarrhoea for the children under five years of age from the dispensary be incorporated into the system and that they should receive periodic and on demand reports on diarrhoea cases in order to determine whether the intervention was having an impact. This was added in the new requirements. The participants requested that the diarrhoea information be expounded where it was unclear, the nurses made the improvements and the changes were incorporated in the recorded message.

The requirements were modelled using a use case diagram as shown below.

Use case diagram of the system in the third iteration

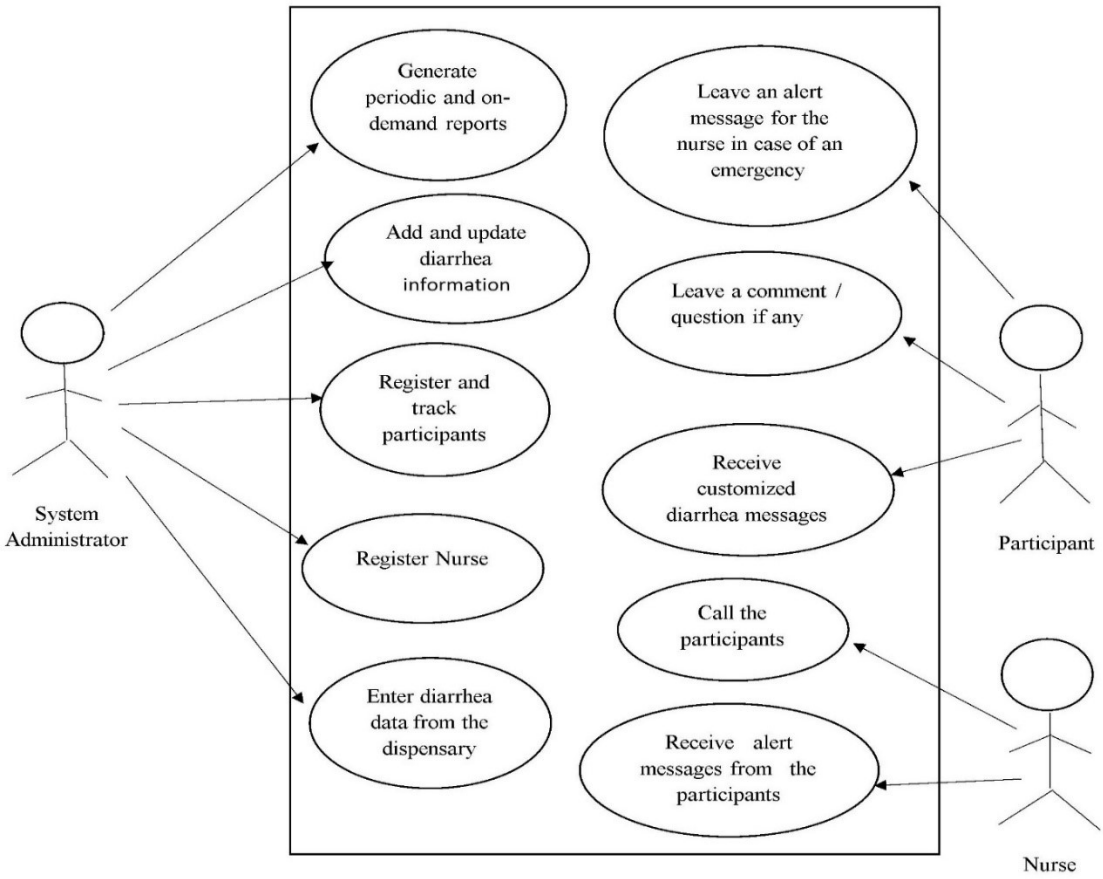

Figure 4. 18: Use case diagram for the diarrhoea intervention healthcare system in the third iteration

Figure 4.17 shows the use case diagram after the second evaluation. The system administrator was added other duties which were to add the diarrhoea data for children under five years of age from the dispensary into the system and produce periodic and on demand reports. The system was modified accordingly.

4.2.4.3.2 Design and development of the prototype

Using the new requirements an improved design was made and modelled using flowcharts, data flow diagrams and system architecture as shown below

4.2.4.3.2.1 Flowchart diagram of the system in the third iteration

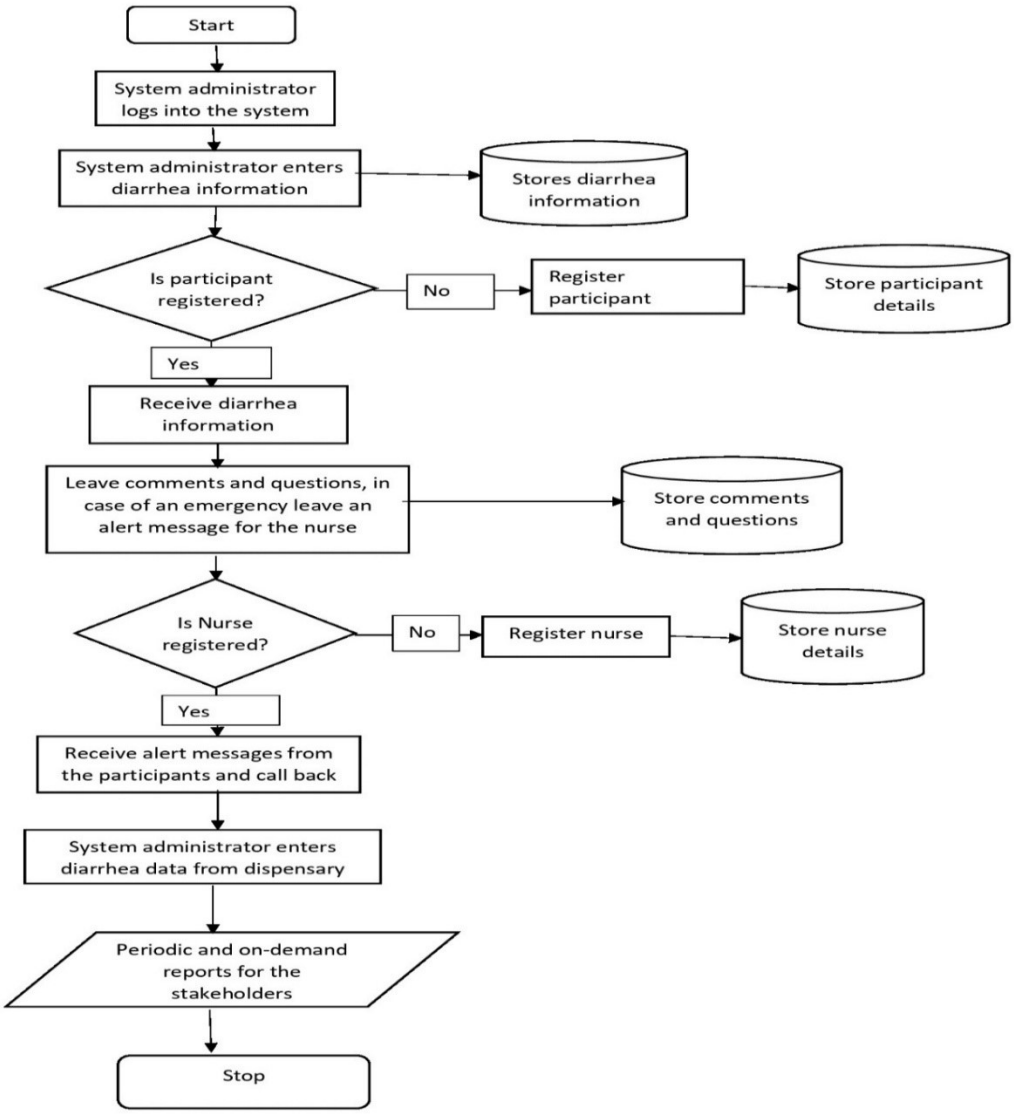

Figure 4.19: Flowchart diagram for the diarrhoea intervention healthcare system in the third iteration

Figure 4.18 shows the flow chart of the redefined diarrhoea intervention healthcare system. The improvements done were that the system administrator collected diarrhoea data for the children under five years of age from the dispensary for the intervention period and added it into the system. This information was used to determine the impact of the intervention. The system produced periodic reports and reports on demand on different issues including the diarrhoea messages sent, diarrhoea messages delivered and not delivered. It also produced reports on the questions asked, the comments given, alert messages posted, alert messages responded to and the ones not responded to and diarrhoea cases reported in the dispensary during the intervention period. The reports on diarrhoea cases were given to the Narok County health officers to see the impact of the intervention. They were also used by the researcher to determine the impact of the intervention. The other reports were used by the researcher to find out whether the system was working according to the requirements.

4.2.4.3.2.2 Context diagram of the system in the third iteration

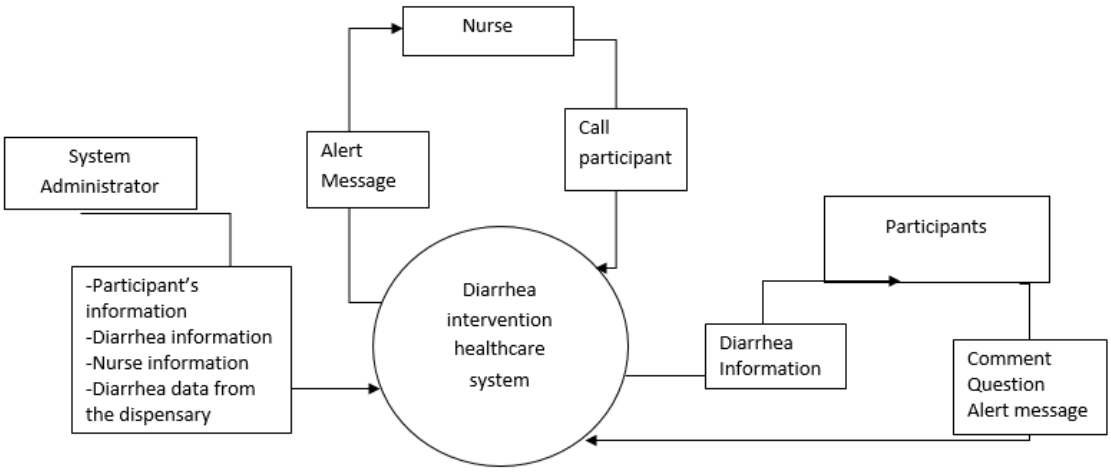

Figure 4.20: Context diagram for the diarrhoea intervention healthcare system in the third iteration

Figure 4.19 shows the context diagram after the second evaluation. The improvement done was that the system administrator was able to add diarrhoea data for children below the age of five years from the dispensary to the system.

4.2.4.3.2.3 System design architecture of the system in the third iteration

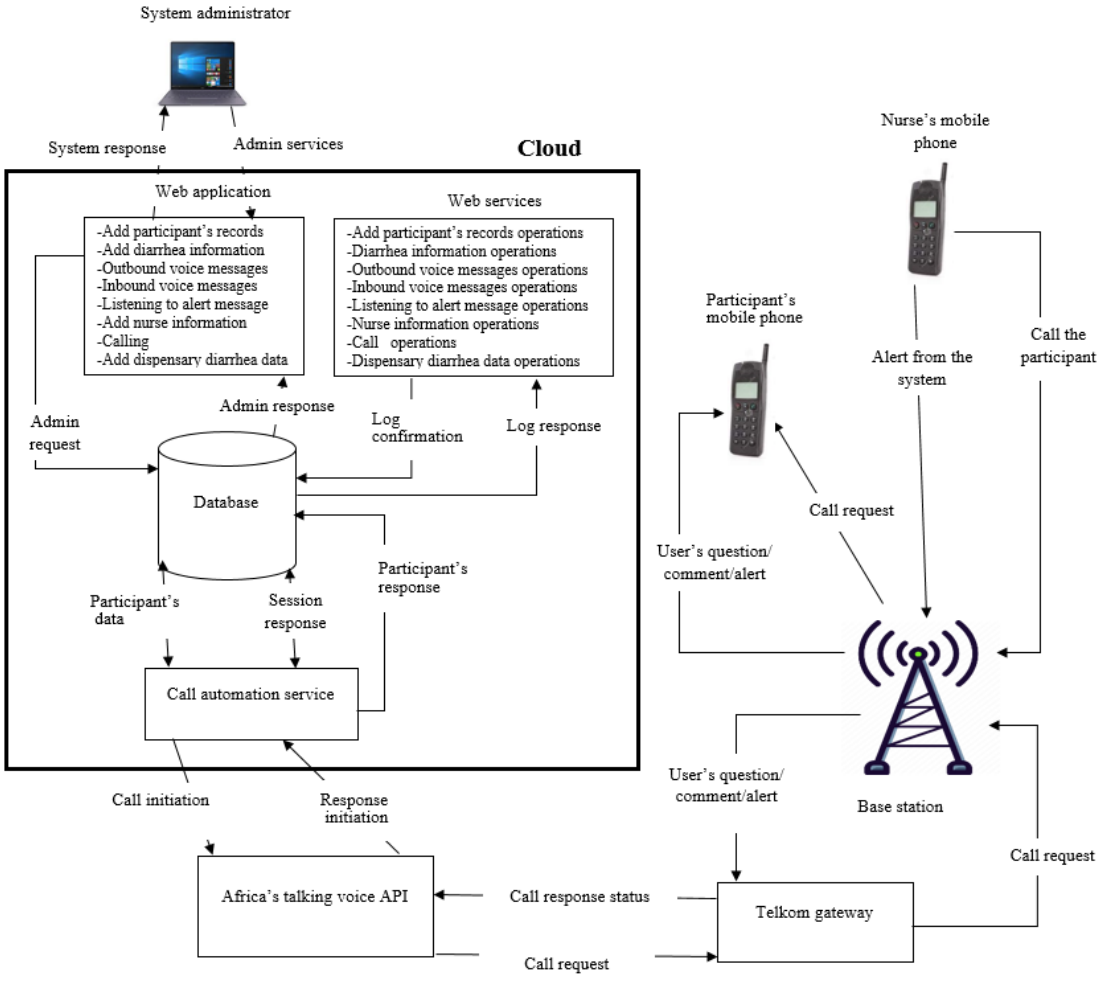

Figure 4.21: System design architecture of the diarrhoea intervention healthcare system in the third iteration

Figure 4.20 shows the system design architecture in the third iteration. The improvements done on the system was that the web application allowed entry of diarrhoea data from the dispensary by the system administrator. In the web services, addition of the dispensary diarrhoea data operations was done. The database was modified to allow the storage of the dispensary diarrhoea data.

4.2.4.3.2.4 Physical database design of the diarrhoea intervention healthcare system

Figure 4.21 shows the physical database design of the diarrhoea intervention healthcare system. Physical database design is a translation of the logical database into SQL statements that define the database, it demonstrates the base relations, file organizations and indexes used for data access (Hoffer et al., 2016). The system adminstrator's table relates to nurse's table, participant's table, diarrhoea information's table, report's table, comment's table and participant's diarrhoea data from the dispensary table. The participant's table relates to the diarrhoea information table, participant's diarrhoea information data from the dispensary table, alert message table, system adminstator's table, question table, comment table and call table. The diarrhoea information table relates to the participant's table and the system administrator's table. The participant's diarrhoea data from the dispensary table relates to the participant's table and the system administrator's table. The table for the nurse relates to call's table, alert messages table and system administrator's table. The questions table relates to participants and the system administrator's tables. Alert messages table relates to the nurse's and the participant's tables. The calls table relates to the nurse's and the participant's tables. The comments table relates to the participant's and the system administrator's tables. The report table relates to the system administrator's and the stakeholder's tables. The stakeholders table relates to the report's table.

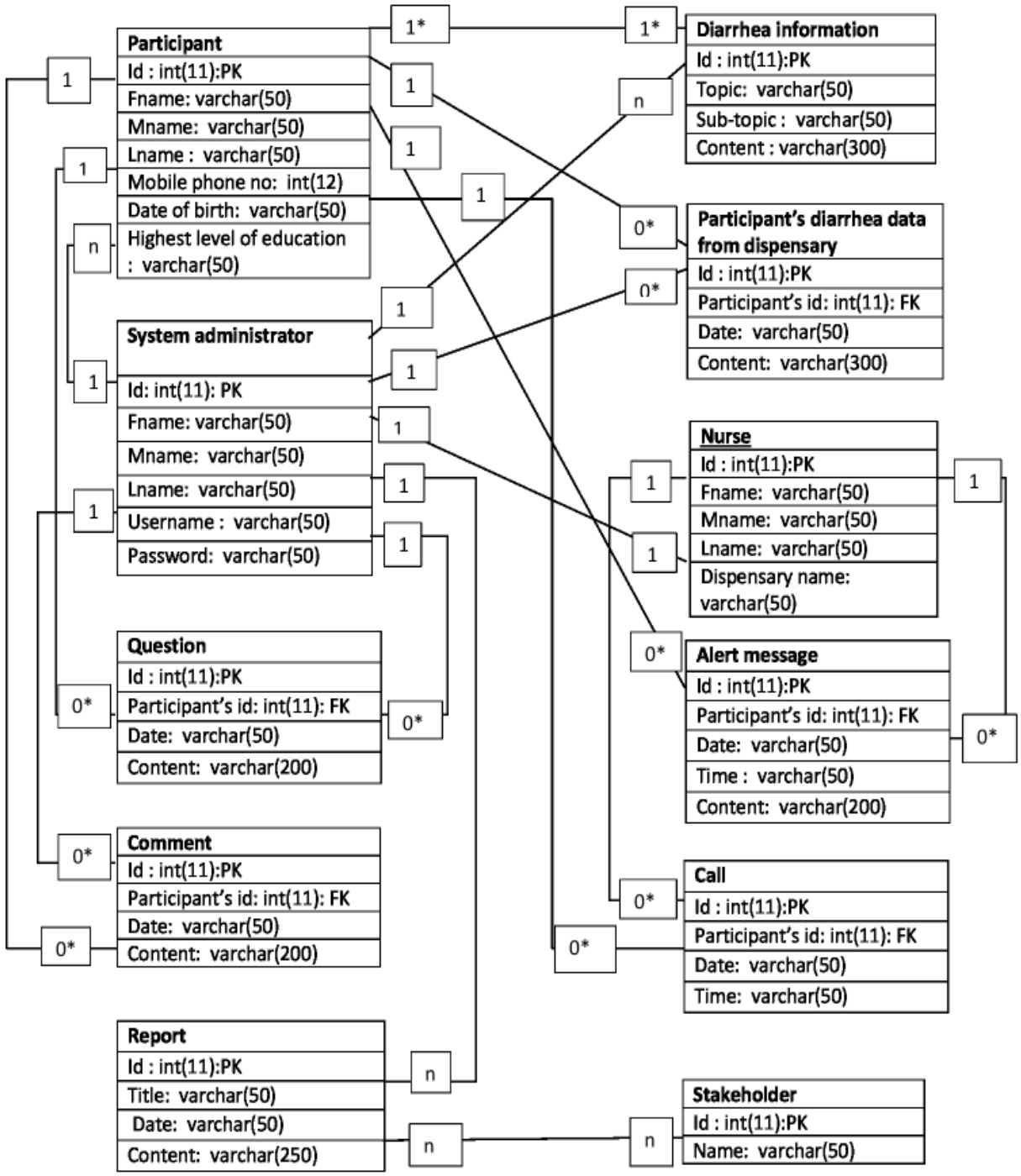

Figure 4.21: Physical database design of the diarrhoea intervention healthcare system

4.2.4.3.2.5 Main window of the diarrhoea intervention healthcare system

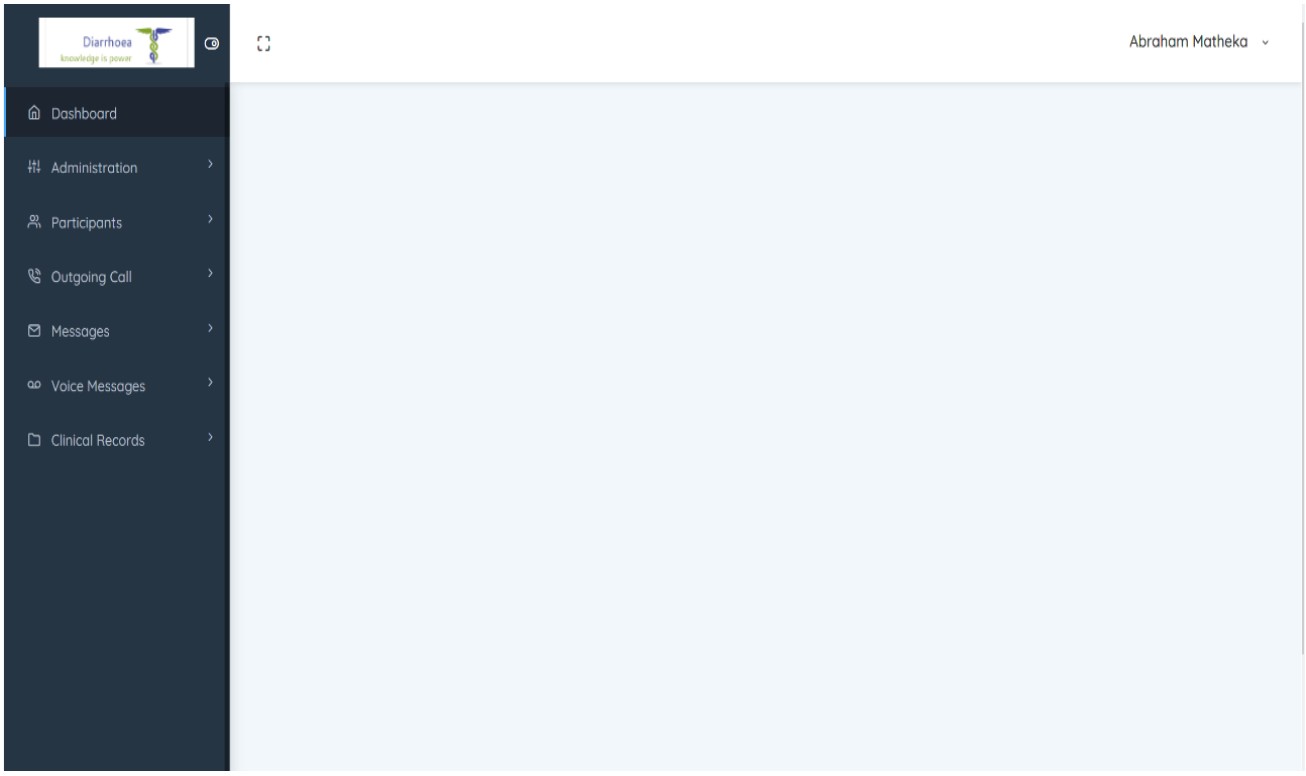

Figure 4.22: Main window of the diarrhoea intervention healthcare system

The main window consists of the main menu of the system. It is provides links to the administration, partipants, outgoing calls, text messages, voice messages and clinical records.

4.2.4.3.2.6 Login screen for the administrator

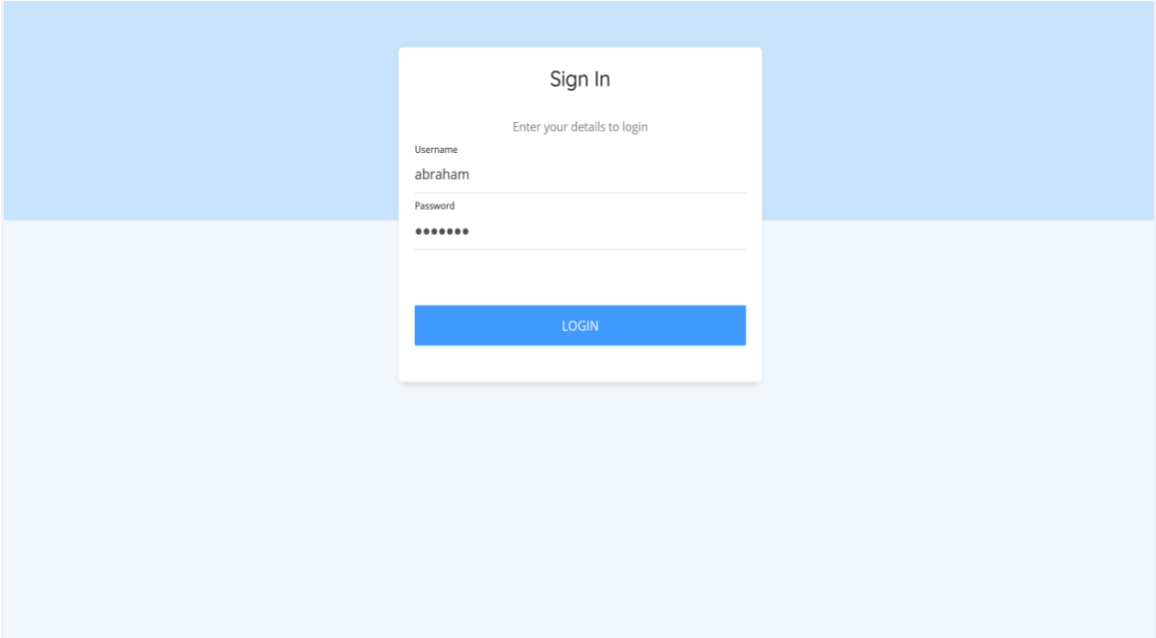

Figure 4.23: Login screen for the administrator

The login screen of the administrator shows the interface that the administrator uses to login into the system. This screen requests the user's login and password.

4.2.4.3.2.6 Participants registration screen

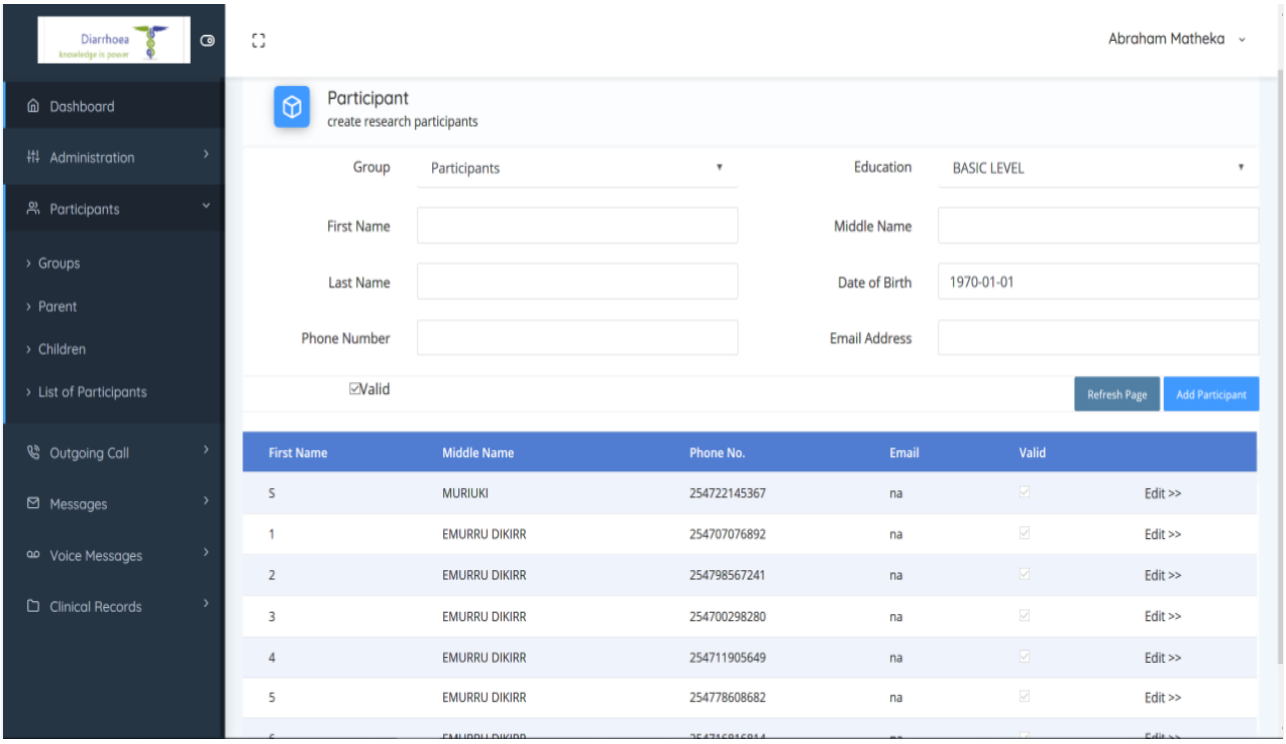

Figure 4.24: Participants registration screen

The participant's registration screen is the interface that is used to register the participants to the system. It is used to capture the participant's details such as names, telephone number, date of birth, level of education and email address. The information is stored in the system.

4.2.4.3.3 Demonstration of the prototype

After the prototype was improved, it was demonstrated to the stakeholders. The mothers listened to the diarrhoea information messages in order to evaluate the clarity of the messages. The nurses listened to the messages in order to evaluate the accuracy of the information. The mothers, nurses, CHVs and the county health officers interacted with the system in order to evaluate its usability. The demonstration was conducted in various venues as per the convenience of the stakeholders.

4.2.4.3.4 Evaluation of the prototype

The system was evaluated again by the stakeholders who were the participants, the nurses, the Narok County health officers and the CHVs. The steps followed in the third iteration were the same ones followed in the previous iterations.

The results of the third iteration was that all of the stakeholders were satisfied with the system. The researcher used the refined system to conduct the diarrhoea intervention.

The flowchart diagrams, dataflow diagrams, system design architecture diagrams and the use case diagrams were used to show how the system was iterated into the final version.

Uniqueness of the system

The prototype developed, through several iterations of design science, had unique features that other technologies used previously did not have. Below are the features;

i. The information was delivered in the local language which the participants were able understand.
ii. The information was in voice messages which enabled the participants who did not know how to read and write to understand.
iii. The system used a technology that was pervasive in the area.
iv. The diarrhoea information was customized to the participants according to the comments they made and the questions they asked which made it more effective in diarrhoea intervention.
v. Mass forwarding of diarrhoea voice messages was done at a convenient time for participants as per local context.

vi. The system allowed the participants to get the diarrhoea information at any time they wanted in case they missed the ten o'clock scheduled time for the mass forwarding.
vii. The system allowed the participants to ask questions and make comments.
viii. The system allowed the participants to interact with the nurse in case of an emergency

From the results of the pre-test, a prototype was developed using design science and the results of the prototype developed using methods discussed in section 3.5.7 have been discussed in the previous section. The prototype was used in diarrhoea intervention through information dissemination for three months. The results of the diarrhoea intervention are discussed in the next section.

4.2.5 Diarrhoea intervention

The diarrhoea intervention was measured using diarrhoea awareness, diarrhoea prevention practices and diarrhoea prevalence.

4.2.5.1 Diarrhoea awareness

The diarrhoea awareness was measured by evaluating knowledge of signs and symptoms of diarrhoea, causes of diarrhoea, prevention of diarrhoea and diarrhoea first aid measures. The results are presented for the pre-intervention and post-intervention diarrhoea awareness for both experiment and control groups.

The comparison between the pre-intervention and post-intervention diarrhoea awareness for both groups is shown in table 4.9

Table 4.9: Pre-intervention and post-intervention comparison of diarrhoea awareness

Group	Study period	Diarrhoea signs and symptoms	Diarrhoea causes	Diarrhoea prevention	Diarrhoea first aid	General diarrhoea awareness
Control	Pre - intervention	32.48%	51.84%	50.29%	35.66%	42.58%
	Post Intervention	32.20%	51.70%	51.30%	34.90%	41.35%
	Mean difference	-0.28%	-0.14%	1.01%	-0.76%	-1.23%
	Effect Size	**-0.021**	**-0.007**	**0.093**	**-0.044**	**-0.101**
	P-value	**0.889**	**>0.999**	**>0.999**	**>0.999**	**>0.999**
Experimental	Pre - intervention	33.77%	47.14%	53.31%	36.52%	42.69%
	Post Intervention	91.22%	79.45%	91.04%	86.70%	87.10%
	Mean difference	57.45%	32.31%	37.73%	50.18%	44.41%
	Effect Size	**0.892**	**0.683**	**0.712**	**0.823**	**0.81**
	P-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Control vs Experimental Pre-intervention	Mean difference	1.29%	-4.70%	3.02%	0.86%	0.11%
	P -value	0.606	0.127	0.304	0.629	0.074
	Effect sizes	**0.063**	**0.072**	**0.149**	**0.051**	**0.201**
	T-test for equality of means	**-1.432**	**-1.528**	**-1.029**	**-0.483**	**-1.793**
Post-intervention Control vs Experimental	Mean difference	59.02%	27.75%	39.74%	51.60%	45.75%
	P -value	<0.001	<0.001	<0.001	<0.001	<0.001
	Effect sizes	**0.830**	**0.535**	**0.622**	**0.732**	**0.703**
	T-test for equality of means	**72.973**	**30.754**	**45.600**	**53.124**	**78.631**

The t -test is used to test for difference in means of samples where the p-value is used to make conclusion for the test, a p-value greater than 0.05 shows no significant difference in the means of two samples whereas a p-value less than or equal to 0.05 shows a significant difference in the means of the two samples (Smith, 2018).

The pre-intervention general diarrhoea awareness was 42.69% for the experimental group and 42.58 % for the control group. There was no significance difference in the general diarrhoea awareness between the two groups before the intervention (p=0.074).

The post-intervention general diarrhoea awareness was 87.10% for the experimental group and 41.35% for the control group. There was a significance difference in the general diarrhoea awareness between the two groups after the intervention (p<0.001).

In general, the diarrhoea awareness after intervention for the experimental group increased by 44.41% and decreased by 1.23% for the control group. The intervention caused a large increase in diarrhoea awareness on the experimental group (Effect size= 0.81) but there was no significant change in the control group (p>0.999).

4.2.5.2 Diarrhoea prevention practices

The diarrhoea prevention practices are those actions that are done to prevent new infections and spread of diarrhoea. The respondents were asked whether they observed those practices. When need be, the CHVs validated the responses e.g. by checking whether there was a toilet in the homestead. The diarrhoea intervention practices were classified under sanitary hygiene, water hygiene and food hygiene. The pre-intervention and post- intervention results comparison for the experimental and control groups are shown in table 4.10.

Table 4.10: Pre-intervention and post -intervention comparisons of diarrhoea prevention practices

Sanitary hygiene	Group	Good Practices		Mean Difference	P-value
		Pre-intervention	Post - intervention		
Having a toilet	Experimental	41.8%	43.3%	1.5%	0.886
	Control	48.9%	49.4%	0.5%	1.000

Sanitary state of the toilet	Experimental	17.3%	62.0%	44.7%	<0.001
	Control	13.3%	16.0%	2.7%	0.547
Washing hands after toilet	Experimental	38.4%	61.0%	22.6%	<0.001
	Control	37.9%	40.0%	2.1%	0.772
Mean sanitary hygiene	**Experimental**	32.5%	55.5%	23%	<0.001
	Control	33.4%	35.1%	1.7%	0.77
P- values		**0.963**	**0.004**		
Effect sizes		**-0.045**	**0.583**		
Chi-square test		**0.002**	**8.08**		
Water hygiene					
Boil water	Experimental	44.0%	55.0%	11.0%	<0.001
	Control	27.0%	29.0%	2.0%	0.753
Covering water container	Experimental	51.7%	71.0%	19.3%	0.006
	Control	51.4%	54.0%	2.6%	0.671
Sanitary state of water storage container	Experimental	68.8%	90.0%	21.2%	<0.001
	Control	71.7%	71.0%	-0.7%	0.876
Sanitary state of the water drawing container	Experimental	4.5%	34.7%	30.2%	<0.001
	Control	6.8%	5.0%	-1.8%	0.552
Mean water hygiene	**Experimental**	42.3%	62.7%	20.4%	0.003
	Control	39.2%	39.8%	0.6%	0.89
P-values		**0.742**	**0.001**		
Effect sizes		**0.193**	**0.632**		
Chi-square test		**0.021**	**10.59**		
Food hygiene					
Boiling of milk before giving to children	Experimental	56.6%	99.0%	42.4%	<0.001
	Control	56.9%	55.0%	-1.9%	0.776
Boiling of food before giving to children	Experimental	61.6%	99.0%	37.4%	<0.001
	Control	64.5%	65.0%	0.5%	0.924
Washing hands before feeding children	Experimental	35.0%	94.0%	59.0%	<0.001
	Control	35.6%	35.0%	-0.6%	0.883
Cleaning Utensils	Experimental	44.9%	97.0%	52.1%	<0.001
	Control	53.4%	47.0%	-6.4%	0.396
Mean food hygiene	**Experimental**	49.5%	97.3%	47.8%	<0.001
	Control	52.6%	50.5%	-1.9%	0.722
P- values		**0.125**	**<0.001**		
Effect sizes		**-0.13**	**0.784**		
Chi-square test		**0.32**	**55.97**		
General diarrhoea prevention practices	Experimental	36.9%	73.0%	36.1%	<0.001
	Control	37.5%	42.0%	4.5%	0.526
P-values		**0.838**	**0.045**		

Effect sizes		**-0.234**	**0.643**		
Chi-square test		**0.008**	**19.67**		

In general, the pre-intervention diarrhoea prevention practices were observed at 36.9% in the experimental group and 37.5% in the control group. Chi-square test was used to generate the p-value. The Chi-square test of distribution of proportions showed that there was no significant difference in the general diarrhoea prevention practices within the two groups (p=0.838), implying that the observations of general diarrhoea prevention practices were similar in the two groups.

In general, the post-intervention diarrhoea prevention practices were observed at 42.0% in the control group and 73.0% in the experimental group. The Chi-square test for the distribution of proportions for diarrhoea prevention practices in the experimental and control groups after the intervention showed that there was a significant difference in the practices (p=0.045). The general hygiene practices were better in the experimental group than in the control group after the intervention.

The mean value of general diarrhoea prevention practices increased by 36.1% in the experimental group and 4.5% in the control group after the intervention. The Chi-square test for effect of the intervention showed that there was a medium improvement in diarrhoea prevention practices in the experimental group (Effect size=0.643) however there was no significant change for the control group (p=0.526).

4.2.6 Mobile phone as a suitable technology for diarrhoea intervention information dissemination

The technology that was used for the diarrhoea information dissemination during the intervention was a mobile phone. At the end of the intervention the respondents were asked to evaluate the mobile phone technology in its suitability for diarrhoea

intervention information dissemination as compared to previous strategies/technologies. The results are shown in table 4.11 below.

Table 4.11: Use of mobile phone as a suitable technology for diarrhoea intervention information dissemination

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
Diarrhoea information received on mobile phone is much clear and in language I best understand compared to other technologies/strategies	82.6%	14.0%	0.0%	2.2%	1.1%
I can access diarrhoea information from a mobile phone any time I want unlike other technologies	65.1%	26.3%	8.0%	0.6%	0.0%
Mobile phone is a more reliable means of diarrhoea information communication compared to other technologies	63.8%	28.8%	5.1%	2.3%	0.0%
Mobile phones are portable so I can get information from wherever I am.	60.3%	33.3%	0.0%	0.0%	0.0%
Mobile phones are the most affordable technologies that I can use to get diarrhoea education information	69.9%	21.5%	4.1%	1.7%	0.0%
Mobile phones keep charge for long compared to other technologies	60.6%	23.7%	13.5%	2.2%	0%
Mobile phone is the most available technology for diarrhoea information communication	57.3%	38.8%	2.2%	0.6%	1.1%
Mobile phone is the most user-friendly device for communication for me	70.2%	27.0%	.6%	1.7%	.6%
Mobile phones are interactive allowing me to ask questions and get responses	51.1%	37.3%	6.5%	3.6%	1.5%
Mean	**64.54%**	**27.86%**	**4.44%**	**1.66%**	**0.48%**

In general, 64.54% of the respondents strongly agreed that a mobile phone is the most suitable technology/strategy in diarrhoea intervention information dissemination compared to the previously used technologies/strategies. In general, the participants in the experimental group approved the use of mobile phones for diarrhoea information dissemination at 92.4%.

4.3 COMMUNITY HEALTH VOLUNTEERS (CHVs) RESULTS

The data from the community health volunteers was to complement the data that was collected from the mothers on strategies/technologies that have been previously used in diarrhoea intervention information dissemination, their weaknesses and characteristics of a suitable diarrhoea intervention information dissemination technology. The information was important because it was the main focus of the study. The CHVs did not receive any intervention but assisted the researcher in administering the questionnaires. Fifteen CHVs were chosen from each group through purposive sampling. The results are classified under demographics profile and diarrhoea intervention information dissemination technologies/strategies.

4.3.1 Demographics profile

The demographic information that was collected was on level of education and years of experience.

4.3.1.1 Level of education

Sixty percent of the CHVs had acquired tertiary education and forty percent had secondary education.

4.3.1.2 Years of service

About 60% of the CHVs had 0-5 years of experience and 40% had 6-10 years of experience.

4.3.2 Diarrhoea intervention information dissemination technologies/ strategies

Under the diarrhoea intervention information dissemination technologies/ strategies, the results provided are on strategies/ technologies that had previously

been used, weaknesses of the strategies/ technologies, characteristics of effective strategies/technologies that can be used for diarrhoea intervention information dissemination and whether a mobile phone can be a better technology in diarrhoea intervention information dissemination compared to the previously used strategies /technologies.

4.3.2.1 Strategies/technologies that had previously been used by the organizations in diarrhoea intervention information dissemination

Table 4.12 shows the strategies/technologies previously used in diarrhoea information dissemination as reported by the CHVs.

Table 4.12: Strategies/ technologies used in diarrhoea information dissemination as reported by CHVs

	Strategies/technologies used by the organizations					
Group	Radio	Television	Public gathering	Display information in health facilities	Seminars	Newspapers
Experimental	39.1%	2.8%	18.2 %	15.2%	24.0%	0.7%
Control	37.3%	3.4%	20.1%	16.1%	22.0%	1.1%

From both the experimental and control groups, the CHVs said that the most used strategies/technologies by organizations in diarrhoea intervention information dissemination were radios with a mean of 39.1 % and 37.3% respectively. The information from the CHVs was similar to what the mothers gave increasing the reliability of the mother's responses.

4.3.2.2 Opinion on effectiveness of present/previous diarrhoea intervention information dissemination strategies/technologies

Table 4.13 shows the opinions of the CHVs on the effectiveness of the previously used strategies/technologies in diarrhoea intervention information dissemination.

Table 4.13: Opinions of the CHVs on effectiveness of strategies/technologies used for diarrhoea intervention information dissemination

Group	Effectiveness				
	Very effective	Effective	Not sure	Ineffective	Very Ineffective
Experimental	0%	0%	5.0%	55.0%	40.0%
Control	0%	0%	2.0%	68.0%	30.0%
Mean	0%	0%	3.5%	61.5%	35.0%

About 61.5% of the CHVs said that the strategies/technologies that had been used before were ineffective with 35% viewing them as very ineffective. The information supported the views of the mothers who had similar opinions indicating that there was a need for a better technology/strategy.

4.3.2.3 Weakness of the present/previous strategies/technologies used in diarrhoea intervention information dissemination.

The CHVs were asked to state the weakness of the previous/current diarrhoea intervention information dissemination strategies/technologies. This information was necessary in complementing what the mothers had given, the results are shown in the table below.

The CHVs identified the same weakness identified by the mothers at percentages shown in table 4.14

Table 4.14: Weakness of strategies/technologies used in diarrhoea intervention- CHVs

Weaknesses	Experimental group	Control group	Mean
Strategies/technologies are expensive	87.2%	88.9%	88.1%
Strategies/technologies are not available	60.1%	66.5%	63.3%
Strategies/technologies are not portable	90.5%	87.9%	89.2%
Do not understand intervention language	92.6%	95.4%	94.0%
Intervention time not convenient	67.4%	70.0%	68.7%
Technologies/strategies not interactive	80.1%	83.8%	82.0%

Technologies lack long charge retention	84.8%	88.6%	86.7%
Far distance to the intervention place	85.3%	86.8%	86.1%
Nature of work therefore no time	82.1%	80.4%	81.3%
Strategies or technology are not easy to use	71.2%	74.2%	72.7%
Mean value of the weaknesses	**80.13%**	**82.25%**	**81.2%**
P-value	**0.062**		

The CHVs were asked to state the weakness of the previous/current diarrhoea intervention information dissemination strategies/technologies, the information was necessary in complementing what the mothers had given. On average 81.2% of the community health volunteers identified the weakness shown in the table 4.14. The t-test for the difference between the means of the weakness given by the respondents from the two groups shows that there was no significant difference between the various weaknesses listed and therefore the weaknesses identified were similar (p=0.062).

4.3.2.4 Characteristics of a suitable technology for diarrhoea information dissemination in the area.

The CHVs identified similar characteristics with the mothers as shown in table 4.15

Table 4. 15: Characteristics of a suitable technology for diarrhoea information dissemination in the area as identified by CHVs

Characteristic	Experimental group	Control group	Mean
Technology affordable	90.63%	94.10%	92.37%
Technology available	92.44%	88.75%	90.60%
Technology portable	93.15%	96.31%	94.73%
Information is always available	94.12%	90.31%	92.22%
Technology allows interaction	78.32%	78.34%	78.33%
Information is available in the language I best understand	94.55%	91.43%	92.99%
Technology has long charge retention	79.56%	81.40%	80.48%
Technology is easy to use	89.45%	94.99%	92.22%

Technology is reliable	91.45%	92.77%	92.11%
Mean on the characteristics	**89.30%**	**89.82%**	**89.56%**

On the characteristics of a suitable technology for diarrhoea information dissemination in the area, about 89.56% of the CHVs proposed the same characteristics identified by the mothers.

4.3.2.5 Use of a mobile phone as a better strategy/technology for diarrhoea information dissemination

Table 4.16 shows the opinions of the community health volunteers on the use of a mobile phone as a suitable technology for diarrhoea intervention information dissemination.

Table 4.16: Opinions of the CHVs on use of mobile phone for diarrhoea intervention information dissemination

Group	Strongly agree	Agree	Not sure
Experimental	48%	42%	10%
Control	45.4%	43%	11.6%
Mean	46.7%	42.5%	10.8%

On suitability of a mobile phone in diarrhoea information dissemination 46.7% of the CHVs strongly agreed that a mobile phone was suitable and 42.5% agreed.

4.4 CONCLUSION OF THE CHAPTER

The chapter begins with an introduction, response rate and the demographics of the respondents are shown. The results of the study before and after the intervention are presented using tables and figures. The results are on the response rate, the demographics, access of health information, previously used technologies in health information dissemination and opinion on use of mobile phones in health information communication. The development of the prototype is discussed in detail and how design science was used to develop the prototype in iterations. Data on diarrhoea prevalence before and after the intervention is presented. The chapter concludes with the results of the evaluation of the prototype by the participants on its suitalbility in diarrhoea information dissemination.

CHAPTER 5: DISCUSSION

This chapter presents a discussion of the results of the study presented in chapter four. It starts with an introduction, followed by a discussion in terms of the objectives of the study.

5.1 INTRODUCTION

Diseases have become an issue of concern the world over due to rising costs of treatment and high mortality they cause (WHO, 2018). In order to confront this challenge, the United Nations, in its sustainable development goals (SDGs) identified “ensure healthy lives and promote wellbeing for all at all ages” as the third of her goals. Efforts are being made to reduce disease prevalence through different approaches. One approach being increased disease awareness. Increased disease awareness has been shown to cause improved disease prevention practices; these prevention practices have been shown to be cheaper than treatment and lead to reduction in disease prevalence (Nduba et al., 2015). The Kenya government, being a member of the United Nations, has adopted the SDGs and consequently as part of its attempt to implement these SDGs, efforts are being made through the national government and county governments to increase disease awareness in order to reduce disease prevalence. This study aimed to identify the most suitable technology that can be used to raise diarrhoea awareness, a prevalent disease, in marginalized areas specifically rural Narok. Below is a discussion of the results of the study according to the objectives.

5.2 FIRST OBJECTIVE OF THE STUDY

The first objective of the study was to determine the current diarrhoea rates in resource constrained environments and specifically Narok County.

The study was on diarrhoea rates for the children under five years of age because they are the most affected by diarrhoea (WHO, 2017). A disease rate is the proportion of a population who have experienced the disease in a given period and it is computed as the total number of disease cases that have occurred in that period divided by the total population (National Institute of Mental Health, 2017). Diarrhoea rate is also referred to as diarrhoea prevalence (Clasen et al., 2015).

In this study, a mobile phone-based system was developed and used to disseminate diarrhoea information through voice messages in the study area. In order to determine the impact of the intervention, the diarrhoea prevalence was determined before and after the intervention through the use of a quasi-experimental trial with a control and an experimental group. Data was collected from the dispensaries where the respondents got treated. Each participating sub-location had one dispensary.

Before the intervention the diarrhoea prevalence for the children under five years of age for both the experimental and control groups was about 28% which is above the national prevalence which is 16% (Kenya Ministry of Health, 2016). The high diarrhoea prevalence in the areas can be explained by several factors one of them being lack of clean drinking water. Studies have shown that rural areas of Narok depend on water from the ponds which is shared between people and animals (UNICEF, 2017). From this study, it was found out that about half of the population lack toilets and the bush is the main area for defecation. During the rainy seasons, defecates are swept to the ponds making the water unsuitable for human consumption. Other factors are eating unclean food, eating with dirty hands and using dirty utensils among others (National Drought Management Authority, 2019).

After the intervention, the diarrhoea prevalence in the experimental group decreased to 19.6% but there was no significant change in the control group. The 19.6% was an improvement although it was still higher than the national average. Although the intervention was implemented for only three months, the results

showed reduced diarrhoea prevalence by about eight percent. From these results, it can be inferred that if the intervention was sustained for a longer period of time, diarrhoea prevalence may have reduced further. Because awareness interventions involve behaviour change, they are known to take a long period of time before the impact is realized. Consequently, studies showing eight percent reduction in a disease prevalence within three months is significant (Beaulac et al., 2019).

5.3 SECOND OBJECTIVE OF THE STUDY

The second objective of the study was to determine the level of diarrhoea awareness in the study area before and after the intervention.

5.3.1 Introduction

A diseases awareness is building an understanding of a person's health requirements and the potential to be vulnerable to repeated infections by the diseases (WHO, 2019). High disease prevalence is highly attributed to low levels of the disease awareness (Bassi et al., 2018)**.** People in the developed countries have longer life expectancy than in developing countries due to low disease prevalence in developed countries compared to developing countries (Crixell et al., 2018). Although developed countries have better healthcare systems, the low disease prevalence is highly attributed to high levels of diseases awareness (Latiff et al., 2017). A report by the World Health Organization (2019) showed that increasing acquired immune deficiency syndrome (AIDS) awareness has led to reduced prevalence worldwide. Because preventing a disease is cheaper than treating, this has led to many governments and other organizations to invest substantially in raising awareness especially of those diseases with high levels of morbidity and mortality (Ye et al., 2019)**.**

This study applied a diarrhoea intervention through disease awareness to a sample of the population. In order to find out whether the intervention worked it was

necessary to measure the pre-intervention and the post-intervention diarrhoea awareness of the control and experimental groups (Luby et al., 2018). A diarrhoea awareness involves being able to recognize its signs and symptoms, causes, prevention and treatment (WHO, 2017). Diarrhoea can easily be controlled through raising awareness and that is why the researcher chose the strategy for the intervention (Kawakatsu et al., 2017). The intervention focused on children under five years of age because they are the most affected and the intervention was through their mothers who are the care givers (Darvesh et al., 2017; Narok County Government, 2015).

5.3.2 Awareness of diarrhoea signs and symptoms

The findings of the study showed that all the respondents both in the experimental and control groups were aware of the diarrhoea disease. This is in agreement with other studies conducted in Narok that showed that most people were aware of the diarrhoea disease (AMREF, 2015). The respondents were asked whether they were aware of signs and symptoms of diarrhoea. Before the intervention, the awareness on signs and symptoms among the respondents was about 33% .This low levels of awareness could be a contributing factor to the high mortality rate in children under five years of age in the area which is above 40% (Kenya Ministry of Health, 2015). After the intervention, the awareness increased to 91.2% in the experimental group but remained the same in the control group. This high increase in awareness can be explained by the fact that diarrhoea signs and symptoms are few and easy to understand when clearly explained (Clasen et al., 2015). Knowledge of the signs and symptoms of a disease is important in order to identify the disease a child is suffering from before it is out of control (Darvesh et al., 2017). Some signs and symptoms such as fever and vomiting are common in most diseases; thus, in order to differentiate a diarrhoea infection from other disease infections, it is necessary to be aware of its signs and symptoms (AMREF, 2015).

The next aspect of diarrhoea awareness that was measured was the causes.

5.3.3 Awareness of diarrhoea causes

Diarrhoea disease can be caused by many things, and for better control of the disease it is necessary to be aware of its causes. The study findings showed that the knowledge on the diarrhoea causes was about 50% before the intervention. The average awareness on the causes can be associated to previous interventions that were done by the local churches (Narok County Government, 2018). The results are in agreement with findings of other studies done in rural Narok that showed that people in the area, on average are aware that dirt can cause diarrhoea (UNICEF, 2017). After the intervention the knowledge on diarrhoea causes increased to 79.45% in the experimental group but remained about the same in the control group. The findings show that the tool used was effective in raising awareness on causes of diarrhoea.

5.3.4 Awareness of diarrhoea prevention practices

Practices such as boiling drinking water, washing hands before breast feeding, using toilets for waste disposal, covering drinking water and washing hands after visiting the toilet have been shown to reduce diarrhoea infections (Bosomprah et al., 2016). These practices are important in the study area because the main sources of water are dirty ponds and rivers, toilets are few and sharing of houses with animals is common (National Drought Management Authority, 2019). The results of the study showed average knowledge on diarrhoea prevention practices on both groups before the intervention which is consistent with findings of African Medical and Research Foundation (AMREF, 2015). After the intervention, the awareness of diarrhoea prevention practices improved to 91.04% for the experimental group but remained average for the control group. Saunders et al. (2018) in a study done where mobile phones were used to raise awareness on tuberculosis observed that mobile phones improved the awareness on the prevention practices, and these findings are consistent with the findings of our study.

5.3.5 Awareness of diarrhoea first aid

The diarrhoea first aid awareness has been found to be important in diarrhoea intervention (Bosomprah et al., 2016). The first aid awareness was measured by asking the respondents what could be done to a child when it gets infected by diarrhoea. This was found important because each sub-location in the study area has only one dispensary which is closed over the weekends. Some areas in the sub-location are more than ten kilometres from the dispensary, and in such cases, if a child is infected, first aid knowledge can be useful in saving the child's life (Narok County Government, 2015). Diarrhoea first aid measures such as giving a patient extra water, giving a sugar solution and giving a salt solution were considered (WHO, 2017).

The pre-intervention awareness on diarrhoea first aid was about 36% for both groups which was below average. The low values can be attributed to the poor technologies/strategies that have previously been used in raising the disease awareness in the area (Eze, Gleasure and Heavin, 2016). After the intervention, the level of diarrhoea awareness on first aid improved to 86.70% for the experimental group but remained almost the same for the control group. These findings show that when the right technology is used in raising diarrhoea first aid awareness, the awareness is improved which is in agreement with previous studies done on raising disease awareness (Bosomprah et al., 2016).

5.3.6 Conclusion on diarrhoea awareness

Disease interventions through awareness have been implemented with great success in developed countries. Clasen et al. (2015) points out that such success is due to high availability of communication tools and high levels of literacy. The tools provide the means for the information dissemination and literacy empowers the user to interact with the tools (Aikins and Arthur-Nyarko, 2019).

When information is passed in the language that people understand, the language barrier is overcome and when a tool that is easy to use is adopted, the technology barrier is removed. These are the greatest impediments to the availability of diarrhoea information for the rural people in developing countries (Eze, Gleasure and Heavin, 2016).

The mobile phone is an important device to the rural people of Narok because it is used for many functions such as a torch, a clock, a camera, sending and receiving money but most importantly communication. Many of the functionalities are easy to use and can be operated by the illiterate (Evans et al., 2018). Due to the myriad uses and low cost, the mobile phone is highly available in rural Narok (Elliot, 2018).

The study developed a mobile phone-based system that provided diarrhoea information in the local language through voice messages. This was done to overcome the technological barrier because the people know how to use the mobile phone to make calls and to overcome the illiteracy barrier because the people understand the local language. These challenges have been shown to be the greatest obstacles to diarrhoea awareness in rural Narok. The study findings show that the general diarrhoea awareness improved by 44.4% in the experiment group after the intervention but there was no significant change in the control group. The findings concur with the findings of other studies done to raise disease awareness using information dissemination (Ahamed et al., 2017; Hackett et al., 2018; Kim et al., 2015).

The findings show that a mobile phone is a suitable technology for raising diarrhoea awareness in resource constrained environments. The government of Kenya in line with the United Nations sustainable development goals aims to improve the health of the people (Ministry of Devolution and Planning, 2017). Literature has shown that diarrhoea is one of the common causes of morbidity and mortality in Kenya and is widely spread in the rural areas (Darvesh et al., 2017; Institute of Economic Affairs Kenya, 2018). If the government can adopt mobile

phones for raising diarrhoea awareness, it would be a significant step towards achieving the third SDG.

5.4 THIRD OBJECTIVE OF THE STUDY

The third objective of the study was to determine the current strategies including ICTs being used for diarrhoea intervention through information dissemination in resource constrained environments specifically Narok County in Kenya.

Application of information communication technologies (ICTs) in healthcare dates back to 1920s, where computers were used to store patient's data, but they were not fully adopted until 1950s (Brooks, 2015). In the early days of ICTs (1950s to 80s), computers were expensive and complex and only computer experts used them which slowed down their adoption in most sectors including the health sector (Basri et al., 2018). Over the last few decades, ICTs has witnessed exponential growth which has increased their affordability, usability and availability (Aceto, Persico and Pescape, 2018). The increased ICT affordability, availability and usability has brought about a wider and increased ICT adoption in many areas including the health sector (Eze, Gleasure and Heavin, 2016).

One of the main applications of ICTs in the health sector is communication. This includes communication among the healthcare providers, communication between patients and healthcare givers and communication to raise health awareness to the public by relevant institutions (Mila, 2018). In the world over, organizations and governments have used different strategies and technologies including ICTs in raising diarrhoea awareness (Dioso and Elmi, 2017). Such strategies include putting posters in health facilities, conducting diarrhoea education seminars, using public gatherings to educate people on sanitation and diseases, using radios and televisions to provide health education and using mobile phones to send health information (Eze, Gleasure and Heavin, 2016). In this study, the researcher sought

to find out which strategies/technologies the Kenya government, Narok County government and other relevant organizations use for disseminating diarrhoea information in rural Narok.

The researcher started by finding out whether any diarrhoea intervention information dissemination had been conducted previously. About 65% of the respondents from the experimental and control groups agreed that interventions had been done. On the frequency of the interventions, the majority of respondents from both the experimental and control groups said that the interventions were done once in a year. Most respondents from both experimental and control groups said that the interventions were conducted by churches. The findings were similar to the findings of a study done by the Narok county government which showed that churches conducted most of the disease interventions in rural Narok (Narok County Government, 2018).

On the strategies/technologies used by organizations and governments, 34.7% said that radios were the most used and about 38% of the community health volunteers supported the observation. According to a report by the Ministry of Public Service, Youth and Gender Affairs (2016) over 80% of Kenyans own radios with over 90% listening to a radio at least once a week.The radio has the widest reach in Kenya among the traditional media, making it the most adopted for dissemination of diarrhoea intervention information. Jennings et al. (2016) in a study done on HIV intervention in Kenya showed that radios were the most used devices for disease intervention in rural areas due to their wide spread adoption. The findings of Jennings and associates are in support of our study findings.

5.5 FOURTH OBJECTIVE OF THE STUDY

The fourth objective of the study was to identify the weakness of the current/previous strategies/technologies including ICTs being used for diarrhoea intervention through information dissemination in Narok County.

5.5.1 Introduction

In order to establish the weaknesses, the researcher started by finding out whether the previous/current technologies/strategies were effective. Most respondents from the experimental and control groups said that the interventions were ineffective at 60.1% and 59.0% respectively. This observation was supported by 96.5% of the community health volunteers. This is in agreement with other studies that have shown that the high prevalence of diarrhoea in rural settings is due to lack of awareness which is attributed to ineffective awareness raising technologies/ strategies (Kenya Ministry of Health, 2016; Bosomprah et al., 2016; Bloom et al., 2017).

The respondents were asked to state the weaknesses of the previous/current diarrhoea information dissemination strategies/technologies. The weaknesses identified were; unaffordability, unavailability, non-portability and inability to understand the language. Other weaknesses identified were: inconvenient times, non-interactive, short charge retention, long distance to intervention places (i.e public gatherings) and not easy to use. In the next section, a discussion of each weakness is presented.

5.5.2 Discussion of the weakness of the previous /current strategies/ technologies

Both in the experimental and the control groups about 91% of the respondents of the survey felt that the strategies/ technologies were expensive which was supported by 88.1% of the community health volunteers (CHVs). In the study area, the main economic activity is pastoralism. Pastoralism is not reliable especially with the frequent rain failures in Kenya. These unreliable rains lead to loss of pasture and death of the livestock in masses. The loss of livestock has made the pastoralists poor and therefore tools like radios and televisions are unaffordable to them (World Bank, 2018). Gole et al. (2017) points high costs as a major challenge

in implementation of ICTs for poor resource settings which supports the findings of our study.

In both the experimental and control groups about 60% of the respondents cited unavailability of the devices as a weakness. This is because traditional technologies such as radios and televisions are only found in main towns where majority of the participants do not visit (UNDP, 2018). Kamis et al. (2015) in a study done to increase drug adherence using ICTs showed that the reason why the adoption of ICTs was slow in rural areas was unavailability of the devices, and these findings are in agreement with findings of our study.

About 83% of the respondents from the experimental and control groups respectively identified non-portability as a major challenge in use of ICTs. This was supported by 89.2% of the CHVs. This is because the lives of nomads involve a lot of movement which makes carrying heavy devices like televisions and most radios unsuitable for their communication (Aceto, Persico and Pescape 2018). Similar studies done for disease interventions in rural areas identified non-portability as a challenge (Bloom et al., 2017; Luby et al., 2018; Basri et al., 2018). These studies agree with the findings of our study.

Language was identified by about 92% of the respondents as a barrier. The views of the mothers were supported by 94.0% of the CHVs. The high values show that language is a big impediment in dissemination of diarrhoea information. Although there are two vernacular radio stations which broadcast in Maasai, the local language in the area, most of the stations in Kenya, both radio and television broadcast in English or Kiswahili which are the official and national languages respectively (Ministry of Public Service, Youth and Gender Affairs, 2016; Basri et al., 2018). With the majority of the stations using English or Kiswahili, any diarrhoea information dissemination through radio or television tends to be broadcasted in either of the languages. This lack of use of Maasai language in the broadcasts creates a language barrier in health information dissemination. The

challenge of language barrier has been cited by other authors who did health information dissemination using ICTs in similar environments (Gole et al., 2017; Bloom et al., 2017; Jorgenson and Vu, 2016). Their findings correlate with our study findings.

Time inconvenience was identified as a weakness by 75.7% of the mothers and supported by 68.7% of the CHVs. Time is a big challenge for nomads because of their movements. Previous interventions that used radios, televisions, seminars and public gatherings were time specific. Given that nomadic people are always on the move and are not used to specific times, these interventions set at specific times are both inconvenient and difficult to attend, consequently, many miss out on them (Bosomprah et al., 2016). Hackett et al. (2018) in a study done in rural Tanzania on health education through ICTs, pointed out that one of the challenges of reaching the rural communities was intervention time. Kenya has similar conditions as Tanzania; therefore, Hackett and associate's findings are consistent with the findings of our study.

Interactivity is important in providing information more so in healthcare, because it allows clarification of ambiguous and complex information (WHO, 2019). Lack of interactivity was cited by 83.6% of the mothers and supported by 82.0% of the CHVs as a weakness of the previous technologies. These views suggest that the participants preferred to interact with presenters for better understanding (Fournet et al., 2018; Aceto, Persico and Pescape, 2018; Jorgenson and Vu, 2016). Except for the seminars and the public gatherings, the other strategies/technologies used in diarrhoea information dissemination in the area are not interactive. This limits their effectiveness (Kenya Ministry of Health, 2016). The findings of this study are supported by a study done by Moghaddasi and Sajjad (2016) on using technology in disease intervention in rural Iran that showed that lack of interactivity was a challenge with the traditional technologies.

ICT devices require electrical energy to operate with some having inbuilt batteries and others requiring external batteries for support (Adekunle, 2016; Pagalday-olivares et al., 2017). The high cost of external batteries has resulted in over reliance on direct sources of electrical power which are inadequate in poor settings (Jorgenson and Vu, 2016). This over-reliance on direct power sources has forced people to seek for alternative sources such as solar power which is expensive in the initial investment (Ministry of Devolution and Planning, 2017). In the study area, electricity is available only in the market places, the dispensaries and in the primary schools which are all located in the same area. Only a few people have small solar panels, implying that getting a reliable power source is a challenge (Narok County Government, 2015). With the power supply being a challenge, technologies with short power retention are unsuitable, and this led to 90.6% of the mothers to identify short charge retention as a weakness of the existing technologies. The views of the mothers were supported by 86.7% of the CHVs. The findings of this study correlate with findings of a study done in Haiti were short power retention was cited as a challenge in use of ICTs in poor resource settings (Cleaton et al., 2018; Basri et al., 2018; Bosomprah et al., 2016).

The study area is sparsely populated, most of the people live in villages and land ownership is communal. Each sub –location has only one market centre with a few shops and animal trade is the main economic activity (Narok County Government, 2015). The public gatherings regarding disease interventions are held in the market places which are far especially for those living in the edges of the sub-locations, this makes it difficult for the people to attend them (Narok County Government, 2015). The challenge of distance to the intervention area was cited by 71.8% of the mothers and supported by 86.1% of the CHVs. A study conducted by Dioso and Elmi (2017) on diarrhoea intervention in rural areas of East Africa showed that most people do not attend diarrhoea education seminars due to long distances to the education centres. These findings of Dioso and Elmi (2017) show that long

distances in the rural areas is a challenge. These findings are in agreement with our study findings.

Usability of a technology is a major motivation to its adoption. A good technology which the users are unable to interact with is likely to fail (Crixell et al., 2018; Ling, Poorsat and Chib, 2018). Operating a television or a radio is not an easy task for the illiterate, and this led to 49.5% of the respondents to cite usability as a weakness of previous technologies. This view was supported by 72.7% of the CHVs. This average value was an indication that some respondents may have known how to operate radios and televisions while many did not. The high value for the CHVs may have been a result of many of them having used the traditional technologies which caused them to be familiar with their challenges. Kamis et al. (2015) in a study done in rural Bolivia identified usability as a challenge with the most ICTs. The findings by Kamis and associates are consistent with the findings of our study.

5.5.3 Conclusion of the weakness of the previous/current strategies/ technologies

In general, 77.8% of the mothers identified unaffordability, unavailability, non-portability and inability to understand the language as some of the weaknesses. Other weaknesses identified were time inconvenience, non-interactivity, short charge retention, long distance to intervention places (public gatherings) and not easy to use. Their views were supported by 81.2% of the community health volunteers.

A study conducted by Bloom et al. (2017) on implementation of health interventions through information dissemination in rural settings identified high costs of devices, language barrier, poor usability of the devices, poor power infrastructure, lack of portability, lack of interactivity and time inconvenience as the main barriers. The authors suggested that future health interveners should address these barriers if

they are to realize success in the interventions. Gray et al. (2018) in their studies focusing on improving healthcare in the rural settings using ICTs got similar findings. The findings of Gray et al. (2018) and Bloom et al. (2017) correlate with our study findings.

5.6 FIFTH OBJECTIVE OF THE STUDY

The fifth objective of the study was to identify the most feasible strategies, including ICTs, for diarrhoea information dissemination within Narok County.

5.6.1 Introduction

Many studies have shown that diarrhoea disease can largely be reduced by creating awareness which can be achieved through information dissemination (Bosomprah et al., 2016; Kawakatsu et al., 2017; Luby et al., 2018). Several technologies and strategies have been used in dissemination of disease information in different parts of the world some with significant success and others with no success. This difference in outcome has been brought about by the suitability of the technology/strategy in the context environment (Beaulac et al., 2019; Crixell et al., 2018).

Developing countries especially in the rural areas are faced with challenges that make use of technologies in health information dissemination difficult (Ye et al., 2019). The traditional disease information dissemination strategies such as seminars, public gatherings and newspapers have failed in rural areas of poor countries (Kawakatsu et al., 2017; Gole et al., 2017).

Technologies such as radios and televisions have been used for a long time in dissemination of disease information but literature shows that in poor countries,

they have only been effective in the urban areas where reach, infrastructure, resources, literacy and convenience is not a challenge (Bedekar and Busc, 2015). Gole et al. (2017) suggest that in order to implement an effective dissemination of diarrhoea information, it is necessary to get the views of the recipients regarding the characteristics of a technology they would prefer because the suitability of the technology is highly determined by the context environment.

The researcher sought the views of the respondents both from the experimental and control groups concerning the characteristics of a diarrhoea intervention information dissemination technology that they would find suitable. The respondents identified affordability, availability, portability, availability of information, interactivity, use of understandable language, long charge retention, easy to use and reliability as their preferred characteristics. About 90% of the community health volunteers were in agreement with the mothers regarding the characteristics of a suitable technology. Following is a discussion of each characteristic.

5.6.2 Characteristics of the most feasible ICT

The respondents had mentioned high cost as one of the weakness of the previous technologies, 95.6 % of the mothers preferred a technology that is affordable. The opinions of the mothers were supported by 92.37% of the CHVs. Cost is a major factor in determining adoption of a technology, many good technologies have failed because they were not affordable to the users (Agarwal et al., 2016; Jorgenson and Vu, 2016).

Unavailability had been identified as a weakness of the previous technologies, 88.6% of the mothers said that the technology should be available. Their opinions were supported by 90.60% of the community health volunteers. This proposal by the respondents was because they live in rural settings where radios and

televisions are not sold which makes them prefer devices that are easily found (Ministry of Devolution and Planning, 2017).

Portability was proposed by 93.3% of the mothers and supported by 94.73% of the community health volunteers. This high proposal showed the interest the respondents had on a portable device due to their lifestyle.

Time inconvenience had been identified by the participants as a weakness of the previous technologies. When asked the characteristics of suitable technologies, 96.1% of the respondents said that they would prefer a technology where information is always available. The proposal was supported by 92.22% of the CHVs.

Non- interactivity had been mentioned as one of the weakness of the previous technologies/ strategies. When respondents were asked about the characteristics of a suitable technology for diarrhoea information dissemination, about 80% of the respondents preferred an interactive technology. The views of the mothers were supported by 78.33% of the community health volunteers.

All the respondents preferred to get information in the Maasai language which is their local language. This was because of the low levels of literacy which barred them from benefitting from previous interventions that were conducted in English and Kiswahili languages (UNICEF, 2017; Aceto, Persico and Pescape, 2018).

The study area is remote and has poor electricity connection which poses a challenge in device charging (Narok County Government, 2018). This limitation made the respondents to prefer a technology that keeps charge for a long time with 94.4% of them proposing long charge retention as a preferred characteristic.

Usability is a major motivation for technology adoption. Based on the people's level of literacy a technology should be designed such that it fits them (Gole et al., 2017; Yugi and Buesseler, 2016). Studies have shown that a good technology should be

usable by its consumers who in this case are community members in poor resource settings (UNICEF, 2017). About 97 % of the respondents said that they preferred an easy to use technology. These findings are in agreement with UNESCO report on use of ICTs in health education (UNESCO, 2018).

A technology is said to be reliable if the probability of its failure is low in a long time (Hoffer et al., 2016; Luby et al., 2018). Devices that are reliable are preferred in the rural settings because of the harsh environment, about 85% of the respondents preferred a reliable technology.

5.6.3 Conclusions on the characteristics of the most feasible ICT in the study area.

In general, 92.25% of the respondents proposed affordability, availability, portability and availability of information as the preferred characteristics. Other characteristics proposed were interactivity, use of understandable language, long charge retention, easy to use and reliability. These were the preferred characteristics of a technology that would be suitable for diarrhoea information dissemination. This high proposal made the researcher consider those characteristics in designing the diarrhoea information dissemination system.

Aceto, Persico and Pescape (2018) argue that many ICTs that have been successful in different settings have been designed with characteristics that fit the environment. Gray et al. (2018) observe that rural settings of poor countries have unique characteristics that should not be overlooked when implementing health interventions. Bloom et al. (2017) proposes affordable, available, portable, information always available, interactive, understandable language, long charge retention, easy to use and reliable as necessary characteristics to be considered when designing and deploying diarrhoea information dissemination technologies in rural settings. The proposal is supported by Eze, Gleasure and Heavin (2016)

findings. The findings of these authors are consistent with the findings of our study.

Based on the characteristics identified, the researcher asked the respondents to give their opinions on suitability of a mobile phone as a technology for diarrhoea intervention information dissemination in the study area. About 81% of the respondents agreed that a mobile phone was a better technology in diarrhoea intervention information dissemination compared to the previously used technologies/strategies. The CHVs supported the mother's opinion with 89.2% being in agreement. The researcher interpreted the findings to mean that a mobile phone was the most feasible technology for diarrhoea information dissemination in rural Narok County. These findings correlates with findings of other studies where a mobile phone was proposed as a suitable technology for health information dissemination in poor resource settings (Ggita et al., 2018; Khormaee et al., 2019; Kulathinal et al., 2019).

The researcher used the proposals of the respondents supported by the findings of the other authors to develop a diarrhoea intervention information dissemination ICT prototype that was based on a mobile phone.

5.7 SIXTH OBJECTIVE OF THE STUDY

The sixth objective of the study was to develop and implement an ICT prototype that overcomes the weakness of the current strategies/ technologies that are being used for diarrhoea intervention information dissemination in the study area.

In the previous sections, the weakness of the previous/current technologies/ strategies were identified and the characteristics of a feasible technology suggested, a mobile phone-based system was proposed, developed and implemented. The methods used in developing the prototype were discussed in

the methodology chapter and the prototype developed discussed in the results chapter. The prototype was used to raise diarrhoea awareness through information dissemination in the rural Narok for three months. By the end of the study, the diarrhoea awareness was found to have increased and diarrhoea prevalence to have reduced. This shows that the prototype was suitable for the context environment.

Mobile phones have become an important tool for raising disease awareness, examples are in cancer awareness where they have been used in smoking cessation and sun safety (Anderson-Lewis et al., 2018; Aikins and Arthur-Nyarko, 2019). In Bangladesh a mobile phone-based system was employed to raise nutrition awareness, the results showed reduced cases of malnutrition in young children, decreased number of pre-mature births and reduced number of reported disease incidences for the children under five years of age (Uddin et al., 2017; Kamis et al., 2015).

Mobile phones have the ability to enhance disease awareness in under-developed areas in an effective and efficient manner due to their portability, usability, availability, affordability, interactivity, reliability, long charge retention ,information availability and they can use an understandable language to the local community (Bassi et al., 2018; Pagalday-olivares et al., 2017). These characteristics mirror the characteristics proposed by the respondents in this study and overcome the weaknesses identified by the respondents. From the background study and literature review, it was observed that there were no diarrhoea information dissemination systems based on mobile phones that had been developed targeting the resource constrained areas. This led the researcher to develop a mobile phone-based system for diarrhoea information dissemination.

5.8 SEVENTH OBJECTIVE OF THE STUDY

The seventh objective of the study was to evaluate the effectiveness of the ICT prototype developed.

5.8.1 Introduction

In order to evaluate the effectiveness of the mobile phone-based system, the researcher considered its impact on diarrhoea intervention and the opinions of the respondents on the prototype. The impact of the diarrhoea intervention was measured by assessing the change in diarrhoea awareness, the change in diarrhoea prevention practices and the change in diarrhoea prevalence. The opinions of the respondents on the prototype were determined through a questionnaire after the intervention.

5.8.2 Impact of the ICT prototype on diarrhoea intervention

Korn et al. (2016) proposed two main consideration to make when evaluating the effectiveness of a disease intervention which are; having an experimental group and a control group and conducting a pre-test and post-test evaluation in the two groups. The pre-test and the post –test comparison show whether there was any change after the intervention and the experimental and control group comparison shows whether the change occurred only on the experimental group.

The study involved an experimental and a control group, a pre-test evaluation was done, diarrhoea intervention was conducted for three months and a post-test administered to evaluate the effectiveness of the intervention.

5.8.2.1 Impact of the ICT prototype on diarrhoea awareness

The diarrhoea awareness was measured and the findings discussed under the second objective in section 5.3. The findings showed that the diarrhoea awareness increased for the experiment group but there was no significant change in the

control group implying that the mobile phone- based system was effective in raising diarrhoea awareness. These findings are supported by a study done in USA where mobile phones were used in promoting cancer screening and physical activity. After several months of promotion campaigns, results showed that the awareness on benefits of cancer screening and physical activity increased (Coughlin et al., 2016).The results of the study are in agreement with our study findings.

5.8.2.2 Impact of the ICT prototype on diarrhoea prevention practices

The diarrhoea prevention practices were measured to show whether there was change in behaviour after the awareness intervention. Other studies have shown that in order to measure the impact of a disease intervention campaign, behavioural change is a good indicator of the impact (Duplaga, 2019; Aceto, Persico and Pescape, 2018; Muljo et al., 2016). The diarrhoea prevention practices were measured by looking at sanitary hygiene, water hygiene, and food hygiene which are the avenues for diarrhoea infections (WHO, 2017).

The sanitary hygiene was measured using parameters such as having a toilet, washing hands after toilet and cleanliness of the toilet. Before the intervention, the sanitary hygiene was about 33% for both groups, after the intervention it improved to 55.5% for the experimental group but remained almost the same for the control group. Some sanitary hygiene practices such as installing toilets take long to implement, although the respondents got informed of their importance, it required more time to implement. Consequently the sanitary hygiene was still average even after the intervention (WHO, 2019). The general sanitary hygiene was very low before the intervention with about half of the population lacking a toilet which was a major contributor to the high diarrhoea prevalence in the area (WHO, 2019).The health promotion intervention showed a significant improvement in sanitary hygiene in the study area. These results are supported by other studies done in disease interventions (Aceto, Persico and Pescape, 2018; Muljo et al., 2016).

The food hygiene practices were about 50% for both groups before the intervention, after the intervention, they improved to 97.3% for the experimental group but changed insignificantly for the control group to 50.5%. This great improvement for the experimental group may be explained by the fact that food hygiene practices such as covering food, boiling food and washing utensils before use are easy to implement. Previous studies done on disease interventions through health promotion campaigns showed that simple hygiene practices such as food hygiene are highly adopted after the campaigns (Greenland et al., 2016; Khormaee et al., 2019). The findings of Greenland and associates are consistent with our study findings.

The water hygiene practices were measured by parameters such as covering drinking water, storing water in clean containers and boiling drinking water. Before the intervention, the practices were at about 40%. This low levels of water hygiene practices may be explained by the low levels of knowledge on the dangers of poor water hygiene (Fuller et al., 2014). After the intervention, the water hygiene practices improved to 62.5% for the test group but dropped to 39.8% for the control group which was an insignificant drop. The improvement showed that the intervention had an impact even though the change was not big but it was significant.

The general diarrhoea prevention practices were at about 37% for the two groups before the intervention, they improved to 72% for the intervention group after the intervention but changed insignificantly for the control group. The improvement in diarrhoea prevention practices showed that using suitable technology raised diarrhoea awareness as shown in section 5.3, which led to improved diarrhoea prevention practices. These findings are consistent with findings of a study done in Nyanza province in Kenya which showed that using a mobile phone-based system raised HIV awareness which improved HIV prevention practices (Jennings et al., 2016). Joshua (2016) observed that when a mobile phone-based system

was used to raise awareness of prostate cancer in Kenya, cancer screening practices improved. A study done by Muljo et al. (2016) in Malaysia showed that raising breast cancer awareness improved cancer check-up seeking behaviour for women. A study done in Los- Angeles showed that black young men who have sex with men adopted safe sex methods after getting awareness messages through mobile phones, although the change was not 100% but it was significant. The study findings of these researchers are in support of the findings of our study.

5.8.2.3 Impact of the ICT prototype on diarrhoea prevalence

The next parameter that the researcher used to evaluate the impact of the diarrhoea intervention was the prevalence. Discussion of the first objective of the study showed that the diarrhoea prevalence reduced in the experimental group but there was no significant change in the control group after the intervention (5.2). The findings of this study are supported by a study done in china on men who have sex with men. The men accounted for 3% of the male population but accounted for 25.5% of new HIV reported cases. A mobile phone- based system was used to raise HIV awareness amongst them, the results showed that there was a significant drop in the reported new HIV cases (Zhang et al., 2019). Uddin et al. (2017) did a study in Bangladesh to determine the association between health promotion awareness through mobile phone and health practices related to care of the mother, neonates and childbirths. The results showed that the intervention delayed first baths after birth by 48 hours. This delay in first baths led to reduced child mortality. The findings of Uddin et al. and Zhang and colleagues correlate with the findings of our study.

5.8.3 Opinions of the respondents on the ICT prototype used in diarrhoea information dissemination

One of the considerations in evaluating the effectiveness of the prototype was to get the opinion of the users on its suitability in diarrhoea information dissemination.

The opinions were sought from the experimental group because they were the ones who used the system. User evaluation of a software is important because it allows the users to give their views on the likes and dislikes regarding the software (Hoffer et al., 2016).

The users were asked to evaluate the software based on the characteristics of a suitable technology that they had proposed. The characteristics that the software was evaluated against were understandable language, availability of the information, reliability, portability, affordability, and long charge retention. Other characteristics were availability of the mobile phone device, usability and interactivity.

The respondents received diarrhoea information in form of voice messages through mobile phones in Maasai language which is their local language for three months. After the intervention, 96.6% of the respondents were in agreement that the mobile phone was suitable because it delivered messages in a language they understood. The high approval of a mobile phone being able to give information in the local language infers that the people were not comfortable with the previous interventions that used other languages. This made our diarrhoea intervention unique compared to the previous ones. The small proportion that disagreed may have been literate and, thus, had no problem with other languages being used in diarrhoea interventions. A study conducted in Ethiopia on implementation of ICTs in rural settings found out that mobile phones were highly accepted because they could deliver messages in the preferred language of the people. The findings of the study are consistent with our findings (Kebbede, 2018; Muljo et al., 2016).

About 91% of the respondents said that the mobile phone-based system was suitable because they could access diarrhoea information anytime from a mobile phone. The mobile phone-based system allowed the respondents to listen to the information any time they wished by dialling a certain key. Radios and televisions do not allow the recipients to listen to the information later once they miss it. This

led the respondents to appreciate that functionality (Evans et al., 2018). Zhuang et al. (2016) did a study in china to increase health literacy, the results showed that one of the reasons the respondents preferred a mobile phone as a channel for health education was that they could access the information anytime. Zhuang's findings are in agreement with findings of our study.

Reliability is an important requirement in software development. A technology which is reliable has wide acceptability and is adopted much faster. A major indicator of mobile phone reliability is its wide penetration worldwide and more so in the poor settings in comparison with other technologies (ITU, 2018). The feelings of the respondents concurred with the world view, with 92.6% agreeing that a mobile phone is reliable (Bardosh et al., 2017). Lu et al. (2018) in a study done in China where mobile phones were used in healthcare promotion observed that one of the contributions of its success was reliability. These findings support the findings of this research.

About 94% of the respondents agreed that they preferred a mobile phone as a tool for information dissemination because it is portable. On average the weight of a mobile phone is 200 grams which is comfortable to carry around either by hand, pocket or handbag (Communication Authority of Kenya, 2018). The traditional information dissemination technologies such as radios and televisions are heavy making them less convenient compared to mobile phones. The findings of this study correlate with the findings of a study done in Uganda on tuberculosis intervention using mobile phones that found out that portability was highly approved by the respondents as one of the advantages of mobile phones over other technologies (Ggita et al., 2018).

In Kenya, mobile phones costs as low as 10 USD which is much lower than other technologies (Communication Authority of Kenya, 2018). About 91 % of the respondents agreed that a mobile phone is the most affordable technology compared to the rest. Yugi and Buesseler (2016) in a study conducted in rural

South Sudan where a mobile phone-based system was used in disease surveillance showed that its wider acceptability was due to the low cost of the device, although the intervention was on disease surveillance the findings are consistent with our study findings.

Power infrastructure is poor in the study area posing a challenge of energy source to support electronic devices. A diarrhoea information dissemination technology would need to be powered if it is to be successful (Gray et al., 2018). About 84% of the respondents preferred a mobile phone because it has long charge retention, 13.5% were not sure. The ones who were not sure may not have used other technologies in order to do a reliable comparison. Power infrastructure in developing countries possess a challenge in adoption of electronic devices. Currently some mobile phones can store charge for more than three days which makes them suitable in areas where power source is a challenge. This is as opposed to the traditional technologies which have shorter power retention (Ahamed et al., 2017). The findings correlate with those of a study done in Burundi on adoption of mobile phones in the rural areas by Ndayizigamiye and Mahara (2016) which showed that long charge retention was a major advantage of mobile phones.

Mobile phones in Kenya are sold in most small towns as opposed to televisions, radios and computers, this is partly because they are cheap, light and they have a wide market (Communication Authority of Kenya, 2018). About 96 % of the respondents agreed that mobile phones are more available than other devices used in diarrhoea information dissemination. Hackett et al. (2018) conducted a study in Tanzania where mobile phones were used to persuade mothers to deliver in health facilities, 74% in the experimental group delivered in the health facilities as opposed to 63% in the control group, Harriet and associates pointed availability as a key characteristics of a mobile phone that accelerated its adoption. Hackett and colleagues' findings are consistent with our study findings.

Marufu and Maboe (2017) conducted a study in Zimbabwe to find out the effectiveness of a mobile phone as a tool used by doctors to manage patients with chronic disease in the rural areas. The findings showed good rates of success, the authors identified usability of a mobile phone as a key factor to its success. In this study 97.2% of the respondents agreed that the mobile phone is more user friendly than other technologies, the few who were of a different opinion may not have used the other technologies to base their comparison on. The findings of Marufu and Maboe are in agreement with the findings of our study.

The researcher asked the respondents their opinions on mobile phones in terms of interactivity, 88.4% were in agreement that it is more interactive than the technologies previously used. The mobile phone-based system that was developed in this study allowed the participants to leave a comment/question in case there was a need. The responses were incorporated in the message and send back. The system also allowed the participants to leave an alert message in case of an emergency, the alert message was sent to the nurse. The nurse would call the participants. These functionalities of the system made it interactive and unique compared to the earlier used technologies. Mobile phones were used in Thailand to improve patient's referral, the doctors interacted with patients in the rural areas through a mobile phone-based system. The findings showed that the referrals improved (Ling, Poorsat and Chip, 2018). Ling and associates observed that mobile phones were well adopted in the intervention because of their interactivity power, these findings are in support of the findings of the researcher in this study.

5.8.4 Conclusion of the evaluation of the effectiveness of the ICT prototype developed.

In general, 64.54% of the respondents strongly agreed that the mobile phone was the most suitable technology in diarrhoea information dissemination for the study environment compared to the previous technologies/strategies. About 28%

agreed, 4.44% were not sure, 1.66% disagreed, and 0.48% strongly disagreed. Before the intervention was done, the respondents were asked to give their opinions on the suitability of a mobile phone in diarrhoea information dissemination in their environment, 39.4% strongly agreed. About 41 % agreed, 9.5% were not sure, 8.1% disagreed and 1.3% strongly disagreed. After using the mobile phone-based system, those who were in agreement increased, and those who were not sure or had initially disagreed decreased. This shows that after using the mobile phone-based system, the respondents were persuaded that it was better than the previously used technologies/strategies. Many authors who have done studies on the use of mobile phones in healthcare interventions through information dissemination in resource constrained environments have realized results similar to the findings of our study (Hackett et al., 2018; Ling, Poorsat and Chib, 2018; Marufu and Maboe, 2017; Ndayizigamiye and Mahara, 2016; Yugi and Buesseler, 2016).

5.9 EIGHTH OBJECTIVE OF THE STUDY

The eighth objective of the study was to develop a framework for diarrhoea intervention in resource constrained environments using the outcome of the diarrhoea intervention.

5.9.1 Introduction

The results of the study showed that diarrhoea intervention can be enhanced in rural settings of poor countries by raising awareness using a suitable information dissemination technology. A framework was developed from the findings of the study. The framework can be used by health care implementers in curbing diarrhoea through awareness.

5.9.2 Framework development

The framework was developed using partial least squares (PLS) structural equation modeling. Partial least squares (PLS) structural equation modeling was selected because it works well with any size of data and it is suitable when a proposed conceptual framework already exists (Olya, 2017; Hair et al., 2017). In chapter two, a proposed conceptual framework was presented as shown in Figure 2.4. The diarrhoea intervention framework was developed based on the conceptual framework proposed.

The framework developed is shown in Figure 5.1

The framework coefficients that show the existence of a relationship between the latent variables were tested for their significant difference from zero using the Hotelling's T-test. This was to assist in checking if each relationship in the framework was significant at 95% level of confidence. The Hotelling's T-test results for the framework coefficients are shown in Figure 5.2

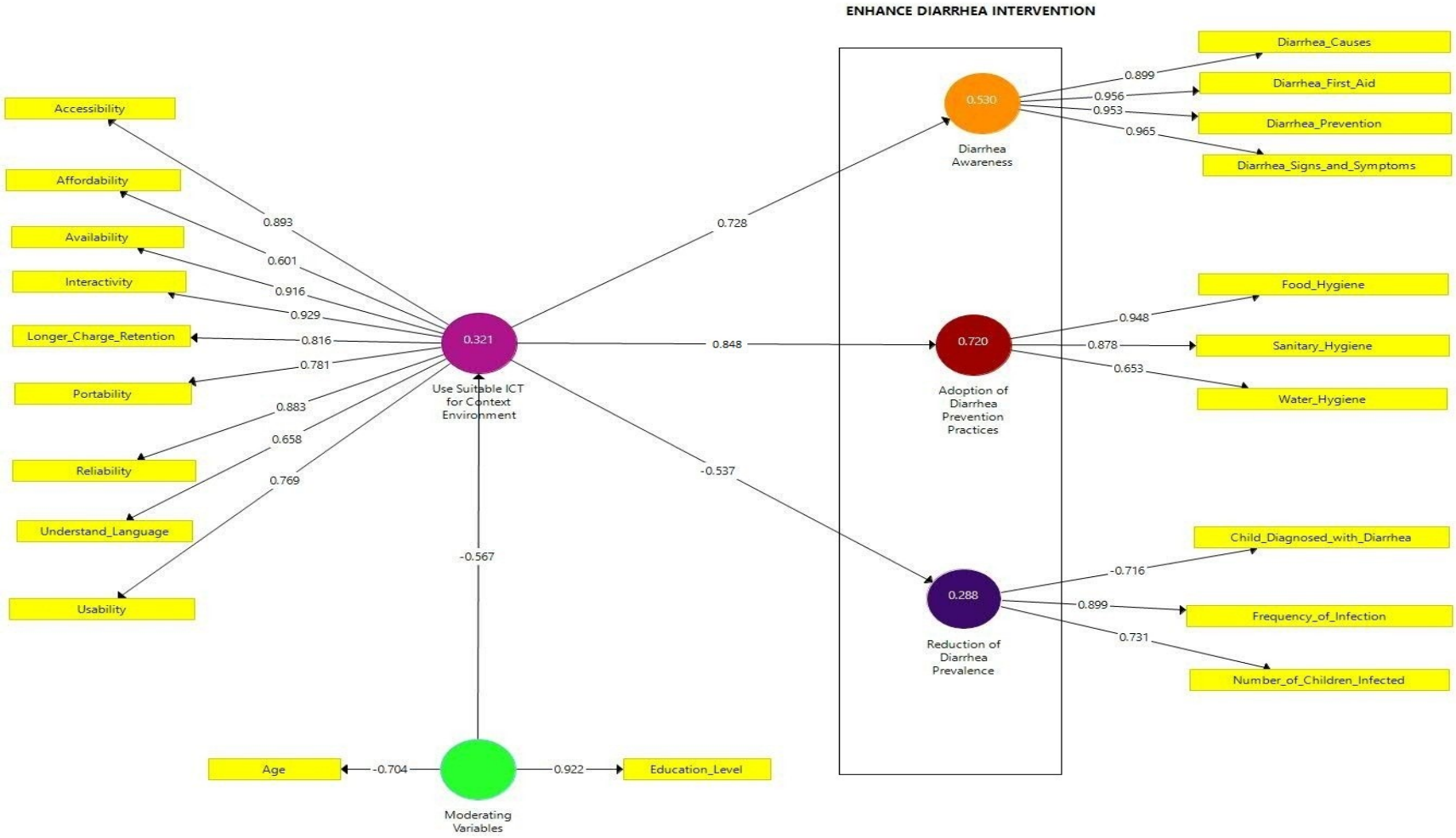

Figure 5.22: Diarrhoea intervention framework for resource constrained environments

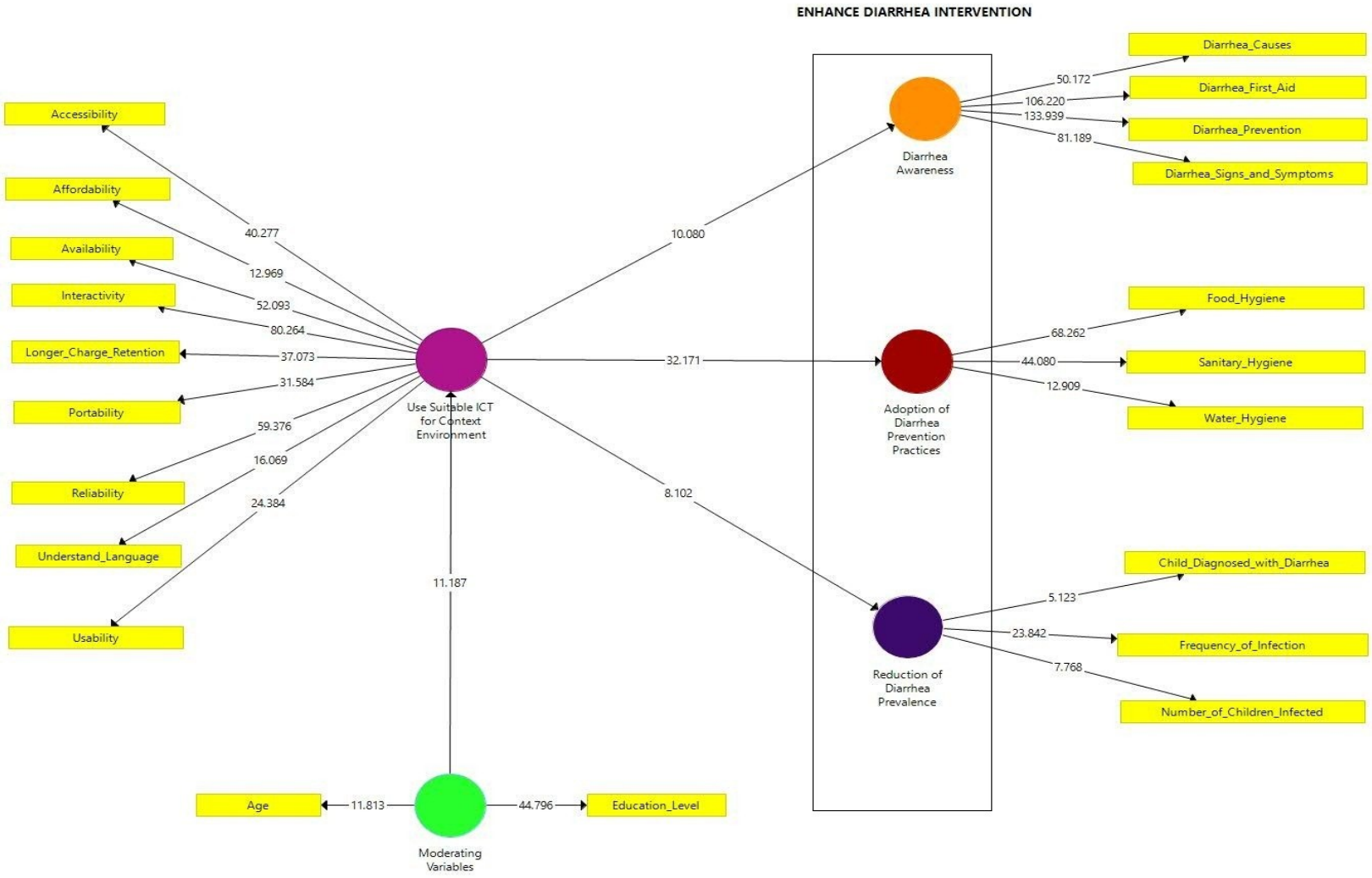

Figure 5.2: The Hotelling's T-test results for the diarrhoea intervention framework coefficients.

The use of a suitable ICT for context environment was determined to have a significant effect on diarrhoea awareness based on Hotelling's T- test for the path coefficient ($p<0.001$). Thus, use of suitable ICT increased the average diarrhoea awareness by 72.8%.

The use of a suitable ICT for the context environment was determined to have a significant effect on adoption of diarrhoea prevention practices ($p<0.001$). Thus, use of suitable ICT increased the adoption of diarrhoea prevention practices by 84.8%.

The use of suitable ICT for context environment was determined to have a significant effect on reduction of diarrhoea prevalence ($p<0.001$). Thus, use of suitable ICT for the context environment reduced diarrhoea prevalence by 53.7%.

Individually age had a negative effect on adoption of a suitable ICT for the context environment ($p<0.001$), thus, the older the mothers were, the lesser was the likelihood of adopting the ICT. On the other hand, the level of education attained was determined to have a positive effect on adoption of suitable ICT for the context environment ($p<0.001$), thus, the higher the level of education attained, the more the likelihood of adopting suitable ICT. Both age and education combined were determined to negatively affect the adoption of suitable ICT in enhancing diarrhoea intervention ($p<0.001$). Thus, the two intervening variables were determined to jointly reduce the likelihood of adoption of a suitable ICT by 56.7%.

The framework is made up of one independent variable, one dependent variable and two moderating variables. The independent variable is "use of a suitable information communication technology (ICT) for the context environment", the dependent variable is "enhance diarrhoea intervention". The moderating variables are education level and age.

The independent variable that is "use of suitable ICT for the context environment "is the contribution of the researcher. Through literature review the researcher proposed the variable and conducted a study to find out the characteristics of a suitable ICT for diarrhoea information dissemination in a resource constrained environment.

The dependent variable "enhance diarrhoea intervention" includes raising diarrhoea awareness, adoption of diarrhoea prevention practices and reduction of diarrhoea prevalence. Raising diarrhoea awareness leads to adoption of diarrhoea prevention practices which leads to reduction in diarrhoea prevalence.

The variable “raise diarrhoea awareness” was adopted from the UNICEF strategic framework for cholera in Eastern and Southern Africa (UNICEF, 2017). Although the variable in the framework is raising cholera awareness, cholera and diarrhoea have similar causes and therefore the variable was adopted but as raise diarrhoea awareness. According to the World Health Organization, diarrhoea awareness involves being able to recognize diarrhoea signs and symptoms, its causes, prevention and treatment (WHO, 2017; Ndayizigamiye and Mahara, 2016). These parameters were used to measure diarrhoea awareness. The researcher considered that the respondents may not know how to treat diarrhoea and they are not allowed to treat themselves thus; treatment was replaced with first aid measures. Therefore, the diarrhoea awareness was measured by awareness on; signs and symptoms, causes, prevention and first aid measures.

The variable” adoption of diarrhoea prevention practices” was adopted from the Prevent, Treat, Protect Framework” for pneumonia and diarrhoea prevention (WHO and UNICEF, 2013). According to the World Health Organization (2017) diarrhoea can be prevented mainly by observing good sanitary hygiene, water hygiene and food hygiene. The three parameters were used to measure the diarrhoea prevention practices.

The variable “reduction of diarrhoea prevalence” was adopted from the Prevent, Treat, Protect Framework” for pneumonia and diarrhoea prevention (WHO and UNICEF, 2013). Although in the framework the variable is reduce diarrhoea mortality and morbidity, the researcher argued that when diarrhoea prevalence is reduced, morbidity and mortality resulting from the disease reduces.

According to a study done by Anderson and Perrin (2017) age affects adoption of a technology. Therefore, the researcher adopted age as a moderating variable. According to a study done by Riddel and Song (2017) education level affects adoption of a technology and therefore age and educational level were adopted as the moderating variables in the framework.

The researcher conducted a pre-test where the characteristics of a suitable ICT for the context environment were determined. The characteristics proposed were; affordability, availability of information, availability of the device, usability, portability, and interactivity. Other characteristics identified were ability to understand information, long charge retention and reliability.

The pre-test was also used to determine the level of diarrhoea awareness and the level of adoption of diarrhoea prevention practices. The researcher also conducted a retrospective chart review where the diarrhoea prevalence was determined.

Based on the characteristics proposed during the pre-test, a mobile phone-based system was developed. The system was used in diarrhoea information dissemination in a resource constrained environment for three months after which data was collected. Using the data collected, partial least squares (PLS) structural equation modeling was used to develop the diarrhoea intervention framework based on the proposed conceptual framework.

5.10 CONCLUSION OF THE CHAPTER

The chapter begins with an introduction. A discussion of the results of the study is presented on how the research answered each objective. The chapter concludes with a discussion on the statistical framework that was developed from the results of the study. The framework is based on the proposed conceptual framework presented in chapter 2.

CHAPTER 6: CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS

The chapter presents the conclusions drawn from the results of the study, the limitation of the study, and recommends areas for further research.

6.1 INTRODUCTION

The researcher conducted a rigorous literature review which can be used by other researchers to appreciate the current status of knowledge in the field of health informatics. The objectives of the study guided the research process from the beginning to the end. The study had eight objectives. In this chapter the conclusions for each objective are narrated.

This study was conducted in two sub-locations of Narok County in Kenya. These sub-locations were chosen based on the high prevalence of diarrhoea in children below the age of five years, resource constraints and the pastoral nature of the communities that dwell in these areas. It provided an opportunity to test an intervention using a technology that is pervasive to address gaps in existing interventions used to reduce diarrhoea prevalence in keeping with the third UN sustainable development goal.

The conclusions below are based on the objectives and as gleaned from the results of the study.

6.2 CONCLUSIONS IN RELATION TO THE OBJECTIVES

OBJECTIVE 1: ***To determine the current rates of diarrhoea among the populace in resource constrained environments specifically Narok County in Kenya****.*

The study findings showed a decrease in diarrhoea incidences in the experimental group ($p<0.001$) but no significant change in the control group ($p=0.530$) implying that the technology enhanced diarrhoea intervention leading to reduced diarrhoea incidences. Since the pre-test and post-test diarrhoea rates were determined and compared, the objective was met.

OBJECTIVE 2: ***To determine the level of diarrhoea awareness in the community before and after the intervention.***

In order to determine the level of diarrhoea awareness, awareness was measured using four different variables which are: signs and symptoms of diarrhoea, causes of diarrhoea, prevention of diarrhoea and first aid on a diarrhoea infected child. The intervention group showed a significant increase in diarrhoea awareness compared to the control group ($p<0.001$) after the intervention, suggesting that the intervention was effective. Since the level of diarrhoea awareness before and after the intervention were determined and compared, the objective was met.

OBJECTIVE 3: ***To determine the current strategies including ICT technologies being used for diarrhoea intervention through information dissemination in resource constrained environments specifically Narok County in Kenya*****.**

The study findings showed that churches conducted most of the diarrhoea intervention information dissemination followed by Narok County Government. Radio was the most common technology/strategy used in diarrhoea intervention information dissemination followed by seminars. The respondents said that the technologies/strategies were ineffective suggesting that a better technology/strategy was required. This outcome of the study shows that the objective was met.

OBJECTIVE 4: ***To identify the weaknesses of the previous/current strategies/ technologies including ICTs being used for diarrhoea intervention information dissemination in Narok County****.*

The weakness of the current technologies/strategies are; unaffordability, unavailability, non-portability and inability to understand the language. Other weaknesses identified were; time inconvenient, non-interactive, short charge retention, long distance to intervention places (public gatherings) and not easy to use. The findings from the mothers collaborated with those from the CHVs suggesting the need for a technological solution to diarrhoea awareness and consequently diarrhoea prevalence in the area. Since the study identified the weakness of the strategies and technologies the objective was met.

OBJECTIVE 5: ***To identify the most feasible strategy including ICTs for diarrhoea information dissemination in Narok County.***

A significant proportion of respondents from both the control and experimental groups believed that for any technology/strategy to be effective in disseminating diarrhoea information, it should

be affordable, available, easy to use, portable, have long charge retention, information should always be available, information should be in an understandable language, be interactive and should be reliable. On average, those characteristics were proposed by 92.25% of the respondents from both the experimental and control groups and supported by 89.56% of the community health volunteers. Based on the characteristics, respondents were asked their opinions on using a mobile phone as a technology for dissemination of diarrhoea intervention information. More than 80% of the respondents in all groups agreed that a mobile phone is a preferred technology for dissemination of diarrhoea information due to its characteristics. The fifth objective of the study was met.

OBJECTIVE 6: ***To develop and implement an ICT prototype that overcomes the weaknesses of the current strategies/technologies including ICTs that are currently used for diarrhoea intervention through information dissemination in the study population.***

The researcher developed and implemented a prototype with the characteristics that addressed the weaknesses highlighted by the mothers and supported by the community health volunteers.The characteristics proposed as suitable for a diarrhoea information dissemination technology were incorporated in the prototype. The ICT prototype developed was a mobile phone-based system that delivered diarrhoea information to the participants in form of voice messages and therefore the objective was met.

OBJECTIVE 7: ***To evaluate the effectiveness of the ICT prototype developed for diarrhoea intervention through information dissemination.***

The ICT prototype developed was evaluated by comparing the pre-test and post-test level of diarrhoea awareness, diarrhoea prevention practices and diarrhoea prevalence. The experimental group also evaluated the prototype because they used it.

The findings of the study showed that the ICT prototype developed was able to enhance diarrhoea intervention by promoting diarrhoea awareness, diarrhoea prevention practices and reducing diarrhoea prevalence. About 92% of the respondents from the experimental group approved the prototype, which is a strong evidence that mobile phones are suitable for

diarrhoea intervention through information dissemination in resource constrained areas. These findings show that the objective was met.

OBJECTIVE 8: ***To develop a framework for diarrhoea intervention in resource constrained environments based on the outcome of the study.***

Using the data from the study, the researcher developed a framework for diarrhoea intervention in resource constrained environments. The framework was based on the conceptual framework shown in Figure 2.4. The conceptual framework was developed through rigorous literature review by surveying frameworks that have been used in health promotion and disease interventions in resource constrained environments. The survey outcomes showed that there were no frameworks that have been developed for diarrhoea intervention that have been effective in resource constrained environments similar to the study area. Therefore the objective was met.

6.3 CONTRIBUTIONS OF THE RESEARCH TO HEALTHCARE IN RESOURCE CONSTRAINED ENVIRONMENTS.

The major contribution of the study was a framework for diarrhoea intervention in resource constrained environments. The framework was developed through literature review and data from the study. The developed framework is a contribution to the body of knowledge and especially in the field of health informatics. It is an ideal chance for researchers in health informatics to critique, enhance and even undertake further studies to modify the framework to fit other environments.

Since the majority of Kenyans live in rural areas which are resource constrained and have high levels of disease prevalence, the framework can be adopted by the Kenya Government and the County Governments to promote health in those areas. This can accelerate the momentum of the government towards achieving the third UN sustainable development goal (SDG).

Another contribution of the study was development of a prototype. A prototype was developed that was used in diarrhoea information dissemination. The prototype was unique in that it sent diarrhoea information to the participants in their preferred language and in voice messages in order to overcome the illiteracy barrier. The messages were customized to the needs of the participants and the system allowed interactions with a health worker. Another uniqueness of

the prototype was that the participants were allowed to access diarrhoea information any time of the day in case they missed the scheduled time. The prototype used the most pervasive technology in the area .It can be adopted and used in other environments similar to the study area for diarrhoea information dissemination. The prototype can also be used in interventions of diseases that can be controlled through awareness. The prototype can be used in advocacy to promote awareness on social issues such as female genital mutilation (FGM) and early girl marriages which are often rampant in rural areas of developing countries.

6.4 RESEARCH LIMITATIONS

The prototype developed was only tested in the two sub-locations of Narok County. It was not tested in other resource constrained environments to find out the outcome. There are other resource constrained environments which have high rates of diarrhoea but have different characteristics from the study area. Areas that are war torn like Somalia, although they are resource constrained, they lack telecommunication network for mobile phone communication. In these areas the prototype may not be applicable.

The researcher paid for the voice messages which costed 0.13 dollars per message. This is expensive for rural communities to fund. For the intervention to cover large populations, donor funding or government subsidy may be required.

The diarrhoea intervention was done through the mothers because the children were too young to participate in an awareness promotion and therefore the impact of the intervention on diarrhoea prevalence was not measured directly on the participants but on their children. The intervention through intermediaries may have reduced the impact of the intervention on diarrhoea prevalence.

6.5 RECOMMENDATIONS

6.5.1 Recommendations to governments

The study showed that increasing awareness of a disease can reduce its prevalence. The study also showed that when the right technology is adopted in raising diarrhoea awareness, the prevelence can significantly be reduced. Developing countries bear the greatest disease burden due to lack of resource for interventions. The study also showed that mobile phone technology is pervasive in developing countries.The study developed a mobile phone based

system that was used in diarrhoea information dissemination in a developing country and the results showed that diarrhoea prevalence reduced significantly. Governments in developing countries including Kenya can adopt the system and use it to raise disease awareness which can lead to reduced disease prevalence and consequently reduced disease burden. The framework developed from the study can guide governments in launching disease interventions in different environments.

6.5.2 Recommendations to organisations involved in disease interventions

Many non-governmental organisations (NGOs) are involved in healthcare interventions in resource limited areas. The healthcare interventions include family planning, maternal care and disease interventions. The healthcare interventions mainly involve health information dissemination. The health information dissemination is always limited by the available channels that can effectively be used to reach communities in the rural areas. The system developed takes advantage of the wide penetration of mobile phones in the rural areas and can be adopted by these organisations to implement the desired interventions.

6.5.3 Recommendations to mothers

The mothers can use the mobile phone based system to get diarrhoea information any time they need it. The system can be modiefied to provide health information on other diseases which can also benefit the the mothers.

6.5.4 Recommendations to healthcare workers

The mobile phone based system can be used by healthcare workers to provide health information to communities that are far from their reach.

6.5.5 Recommendations for further research

Since the framework was shown to work in the case study which is Narok County in Kenya, it can be tried in other resource constrained environments and if need be it can be modified to fit those environments. The framework can be tried with other diseases that can be prevented through awareness. The framework can also be used to raise awareness on other issues such as social-economic, governance and environmental issues in areas with high mobile phone penetration but have limited resources. Diarrhoea was chosen by the researcher because its intervention can be realized within a short duration of time such as PhD studies. It is also

possible to largely control diarrhoea through awareness as opposed to many other diseases such chronic diseases.

6.6 CONCLUSION OF THE CHAPTER

The chapter begins with an introduction followed by a conclusion on each of the objectives of the study. The contributions of the study are presented and the limitations. The chapter concludes with recommendations for further research.

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APPENDICES

APPENDIX I: GATEKEEPER PERMISSION FROM DURBAN UNIVERSITY OF TECHNOLOGY

7/6/2018

Head of Research Office

Durban University of Technology

41/43 M L Sultan Rd, Greyville, Durban, 4001, South Africa

Request for Permission to Conduct Research

Dear Sir/Madam,

My name is Abraham Matheka Mutua, a PhD in information Technology student at the Durban University of Technology. The research I wish to conduct for my Doctoral thesis titled "Using ICT for diarrhoea intervention in resource constrained environments: a case study of Narok County in Kenya "

I am hereby seeking your consent to conduct Research in Narok rural community.

I have provided you with a copy of my proposal which includes copies of the data collection tools and consent and/ or assent forms to be used in the research process, as well as a copy of the approval letter which I received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me on +254 722317623, email: abumutua@yahoo.com. Thank you for your time and consideration in this matter.

Yours sincerely,

Abraham Matheka Mutua

Durban University of Technology

APPENDIX II: GATEKEEPER PERMISSION IN KENYA

7/6/2018

National Commission for Science Technology and Innovation

Off Waiyaki Way, Upper Kabete

P. O. Box 30623, 00100. Nairobi, KENYA.

Land line: +254 020 4007000

Request for Permission to Conduct Research

Dear Sir/Madam,

My name is Abraham Matheka Mutua, a PhD in information Technology student at the Durban University of Technology. The research I wish to conduct for my Doctoral thesis is titled " Using ICT for diarrhoea intervention in resource constrained environments : a case study of Narok county in Kenya"

I am hereby seeking your consent to conduct Research in Narok rural community.

I have provided you with a copy of my proposal which includes copies of the data collection tools and consent and/ or assent forms to be used in the research process, as well as a copy of the approval letter which I received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me on +254 722317623,email:abumutua@yahoo.com. Thank you for your time and consideration in this matter.

Yours sincerely,

Abraham Matheka Mutua

Durban University of Technology

APPENDIX III: LETTER OF INFORMATION AND CONSENT IN ENGLISH

LETTER OF INFORMATION

Title of the Research Study: Using ICT for diarrhoea intervention in resource constrained environments : a case study of Narok county in Kenya

Principal Investigator/s/researcher: Abraham Matheka Mutua, PhD in Information Technology

Co-Investigator/s/supervisor/s: Professor Richard C. Millham (PhD) and Professor Threethambal Puckree (PhD)

Brief Introduction and Purpose of the Study:

Diarrhoeais a major disease worldwide with 1.7 billion cases and 525 deaths reported yearly for under five year old children making it the second biggest deadliest disease for that age bracket. In Kenya diarrhoea is the leading cause of morbidity for children in that age group and in Narok county diarrhoea contributes to over 40% of under five year old child mortality and morbidity . The research aims to develop a framework for diarrhoea intervention using ICTs in resource constrained environments. The research will involve a case study of Narok County, Narok County was chosen because it is resource constrained and some ICTs like mobile phones are available.

Outline of the Procedures:

RESPONSIBILITIES OF THE PARTICIPANT

Participation will involve training on how to interact with the application through a mobile phone, how to receive the voice messages and how to respond. You will be required to participate in a pre-test diarrhoea awareness questionnaire, you will receive voice messages on diarrhoea awareness for three months and participate in a post-test questionnaire. Your participation in this research is completely voluntary. If you choose not to take part, you will continue to receive all of the services that you usually get in your community and nothing will change.

CONSULTATION/INTERVIEW/SURVEY DETAILS, VENUE DETAILS

The participants will be trained in the nearest dispensary and the will receive voice messages in their mobile phones from anywhere, the participants will respond to the questionnaires from their homes. The sample size for the study is 171 participants.

INCLUSION CRITERIA

Access to a mobile phone, mothers with children of ages 5 years and below and availability of mobile phone network in the homestead of the participants will be the requirements.

EXCLUSION CRITERIA

Participants who will not participate in the pre-test training , participants that have any form of disability that may affect their performance in the experiment , health workers ,Men, mothers with children above five years of age and Men and women with no access to a mobile phone and mobile phone network.

EXPLANATION OF TOOLS AND MEASUREMENT OUTCOMES

Mobile phones will be used to receive voice messages and questionnaires will be used to measure the level of diarrhoea awareness before and after the treatment. The responses from the questionnaires will be able to inform us whether the treatment increased diarrhoea awareness or not, if the intervention is seen to be effective then it can be used in similar environments for diarrhoea awareness.

ANY FOLLOW-UPS, ANY PLACEBO OR NO TREATMENT

There will be no follow ups or placebo

TIME REQUIRED OF PARTICIPANT

The treatment will run for 3 months.

WHAT IS EXPECTED OF PARTICIPANTS

The participants will be expected to participant in the pre-treatment training, respond to the pre-treatment questionnaire, listen to voice messages and respond to post-treatment questionnaire.

RANDOMIZATION/ GROUP ALLOCATION

The participants will be chosen randomly and they will not work in groups.

Risks or Discomforts to the Participant:

There will be no risks or discomforts to the participants

Benefits:

The participants will benefit from diarrhoea information because it will assist them in taking care of themselves and their children against diarrhoea infections .The researcher will benefit by publishing papers from the study outcomes.

Reason/s why the Participant May Be Withdrawn from the Study

The participant will be withdrawn from the study if she does not participate in the training, pre-test questionnaire and treatment. The participants can withdraw because of a sickness or any other reason if she wishes by informing the researcher. If you are withdrawn or you chose to withdraw from the study, there will be no other consequences apart from not getting the intervention messages.

Remuneration:
The participants will not receive any monetary of other types of remuneration

Costs of the Study:
The participants will not be expected to cover any costs towards the study

Confidentiality:
The information collected is purely for academic purpose and may not be used for any other purpose. All answers will be kept confidential and your anonymity will be preserved.

Research-related Injury:
The researcher will bear the cost of any injury or adverse reaction that may occur on the participant as a result of the treatment, therefore in case of adverse reaction or injury please contact the researcher

Persons to Contact in the Event of Any Problems or Queries:

In case of any problems or queries please contact Abraham Matheka Tel no.0722317623 email abumutua@yahoo.com, Professor Richard at email :Richardm1@dut.ac.za,Professor Puckree at email: Puckreet@gmail.com or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the Director: Research and Postgraduate Support, Prof S Moyo on 031 373 2577 ormoyos@dut.ac.za

CONSENT

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Abraham Matheka Mutua , about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: _____,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

Full Name of Participant	Date	Time	Signature / Right Thumbprint

I, Abraham Matheka Mutua herewith confirm that the above participant has been fully Informed about the nature, conduct and risks of the above study.

Full Name of Researcher	Date	Signature
Abraham Matheka Mutua	7/6/2018	

Full Name of Witness (If applicable)	Date	Signature

Full Name of Legal Guardian (If applicable)	Date	Signature

APPENDIX IV: LETTER OF INFORMATION AND CONSENT IN MAASAI LANGUAGE

EMPALAI NALIMU ENAIPIRTA ENA KISUMA

Enkisuma: Nkoitoi naarareki emoyian elototo oo nkushuaa te Kaunti e Narok.

Enkipirta ena kisuma

Ore emoyian elototo oo nkoshuaa neitamyamala iltungak kumok oleng ten kop. Eitanyamala oleng nkera kutiti naata ilarin imiet nedoyio. Ore Kaunti e Narok neibunga nkera kutiti naabaya iip are o tomon. Ore enkipirta ena kisuma, naa kejo peingoruni eneikoni tenetumi ewaoleta te nkoitoi oo simui oo nkaik. Te Kaunti e Narok eesi ena kisuma.

ENEIKUNARI ENA KISUMA

ILTUNGANAK OOIPIRIEKI

Ore iltunganak ooipirieki ena kisuma naa keng'as aatum enkisuma naitayiolo ninche eneiko teneishoru iwaleta te nkoitoi oo simui oo nkaik. Keishaakino neyiolou eneiko te nelimu imbaa nayiolo ninche naipirta elototo oo nkoshuaa oo nkera kutiti. Ore kulo tunganak naa kekilikuanishoreki te nyorrata enye. Meerakini metolimu naa teniany ninche nemeata eneitaasi.

EWEJI NEESIEKI ENA KISUMA

Ore sii kulo tunganak naa ketum enkitengena te sipitali nataaniki ninche. Keikilikuanishoreki sii too nkangitie enye. Ore ena kisuma neyieu neipirie iltunganak oobay iip nabo o ntomoni naapishan obo.

LOOIPIRIEKI ENKISUMA

Ntomonok naata nkera kutiti –Ilarini imiet nedoyio. Eishaakino neeta kuna tomonok isimui oo nkaik.

LEMEIPIRIEKI ENKISUMA

Iltunaganak lemeidim ate, loosisho te sipitali, ilpayiani, ntomonok naata nkera botorok- ilarin imiet neilep oltunganak lemeeta isimui oo nkaik.

ENEIKUNARI ENA KISUMA

Isimui oo nkaik etumieki ilkiliku teneoshi aaikilikuanishore ntomok metolimu enetabayie elototo oo nkoshuaa too neeti ninche. Ore sii kulo kiliku neidim aatolimu tenaa keyiolo kuna tomonok imbaa pooki naaipirta elototo oo nkoshuaa . Tenejo keyiolo nepuoi aaisumisha likae orere too nkulie wuejitin.

OO EIPAKI ENKISUMA

Meitokini aasujaki iltunganak ooidipaki aaikilikuanishore..

ERISHATA E NKISUMA

Ore embaata ena moyian elototo oo nkoshuaa naa keya lapaitini oobaya okuni.

ILOOPIRIEKI

Ore iltunganak ooipirieki ena kisuma naa kengasi aaitengen, neikilikuanishoreki, neneing ilikiku too simui oo nkaikneishooyo iwaleta enye.

KAJI EIKONI TENEINGORUNI ILTUNGANAK

Ore iltunganak ooikilikuanishoreki naa ketumi tiatua olorere kumok, nedumuni moobo.

ESIDANO ENA KISUMA

Ketum iltunganak engeno naipirta elototo oo nkoshuaa naret ntomonk naata nkera kutiti. Ore sii oloasita ena kisuma naa keiger imbukui alikioo mbaa naanoto tena kisuma.

EITAYUNI OLTUNGANI TENA KISUMA

Elo naaji neitayuni oltungani tena kisuma teneeny elimu iwaleta enyenak. Tenemoyu sii oltungani naa keidim atupuku kake meeta eneitaasi ele tungani tenepuku.

IROPIYANI

Meeta iropiyani naalakini oltungani teneishoru iwaleta enyenak..

IROPIYANI NAAITALAKUNI

Meeta sii iropiyani naaitalakuni oltngani to oltungani oishoru iwaleta enyenak.

MELIKIORI

Ore engeno natumi tena kisuma naa ene nkisuma ake. Ore iwaleta pooki nemelikini likae tungani. Melimuni sii ajo keningae oishorua aa waleta.

EMOYIAN

Tenemoyu oltungani eesita ena kisuma naa oloitasheiki ena kisuma oitasheiki.

KAING'AE IOSHOKI ESIMU

Teniaata entoki niyie ninkilikuanu, ng'oru Abraham Mutua te simu -0722-317623 ashu irriwaki E-mail - abumutua@yahoo.com, ashu Professor Richard :Richardm1@dut.ac.za,Profe̱ssor Puckree email: Puckreet@gmail.com ashu Institutional Research Ethics Administrator te simu: 031 373 2375.

ORUSA

ATONYORRAIYIE AAS ENA KISUMA:

- Atonyorraiyie aas ena kisuma naatolikio Abraham Matheka Mutua pookin naaipirta ena kisuma
- Aisuma sii pooki naaishaa nayiolou ten a kisuma.
- Anoto sii empalai nalimu pooki naishaakino nayiolou anaa oloipirta ena kisuma.
- Kayiolo sii ajo ore pooki nalimu ten a kisuma anaa imbaa pooki naaipirta nanu, ilarin laainei, olari laatoiwuoki oe moyian naata nemelikiori.
- Ore sii pooki wolet naishooyo naa ketaas oloigira aitasheiki ena kisuma pooki nayieu.
- Kaidim sii terrishata pooki atupuku tena kisuma.
- Anoto erishata sidai naikilikuanishore oloitasheiki naa kayieu naas ena kisuma.
- Kayiolo sii ajo ore pooki naishooyo ten kisuma na kaishori sii nanu.

Full Name of Participant	**Date**	**Time**	**Signature / Right Thumbprint**

I, Abraham Matheka Mutua herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Abraham Matheka Mutua	7/6/2018	
Full Name of Researcher	**Date**	**Signature**
Full Name of Witness (If applicable)	**Date**	**Signature**
Full Name of Legal Guardian (If applicable)	**Date**	**Signature**

APPENDIX V: ETHICAL APPROVAL FROM DURBAN UNIVERSITY OF TECHNOLOGY

DUT DURBAN UNIVERSITY OF TECHNOLOGY

FACULTY OF ACCOUNTING & INFORMATICS

Faculty Research Office
Durban University of Technology 9
1 November 2018

Mr A. Mutua
Student Number: **21855624**
Degree: PhD IT

Email: abumutua@yahoo.com

Dear Mr A. Mutua

ETHICAL APPROVAL: LEVEL 2

Your email correspondence in respect of the above refers.
I am pleased to inform you that the Faculty Research Committee (FRC) following its round-robin approval on 31 October 2018, has granted preliminary permission for you to conduct your research ***"Using ICT for diarrhea intervention in resource constrained environments: a case study of Narok county Kenya"***

You are required to present the letter at your research site for permission to gather data at your research site. Please also note that your questionnaires and interviews must be accompanied by the letter of information and the letter of consent for each participant, as per your research proposal.

A summary of your key research findings may be submitted to the FRC on completion of your studies.

Kindest regards.
Yours sincerely

DURBAN UNIVERSITY OF TECHNOLOGY
DUT
DURBAN UNIVERSITY OF TECHNOLOGY
DATE RECEIVED
07 -11- 2018
FACULTY RESEARCH OFFICE
FACULTY OF ACCOUNTING AND INFORMATICS
P O BOX 1334 DURBAN 4000

Dr Delene Heukelman
Faculty Research Coordinator (Acting)

APPENDIX VI: ETHICAL APPROVAL FROM KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE

KENYATTA UNIVERSITY
ETHICS REVIEW COMMITTEE

Fax: 8711242/8711575
Email: kuerc.chairman@ku.ac.ke
kuerc.secretary@ku.ac.ke
Website: www.ku.ac.ke

P. O. Box 43844,
Nairobi, 00100
Tel: 8710901/12

Our Ref: **KU/ERC/ APPROVAL/VOL.1** (241) Date: 13th February, 2019

Abraham Matheka Mutua
P.0 Box 43844-00100
Nairobi

Dear Abraham,

APPLICATION NUMBER: PKU/944/E/87: USING ICT FOR DIARRHEA INTERVENTION IN RESOURCE CONSTRAINED ENVIRONMENTS: A CASE STUDY OF NAROK COUNTY IN KENYA

1. IDENFICATION OF THE PROTOCOL

The application before the committee is with a research topic **"Using ICT for diarrhea intervention in resource constrained environments: A case study of Narok county in Kenya**" received on 9th September,2018 and discussed on 12th February ,2019

2. **APPLICANT**
Abraham Matheka Mutua

3. **SITE**

Narok County In Kenya

4. **DECISION**

The committee has considered the research protocol in accordance with the Kenyatta University Research Policy (section 7.2.1.3) and the Kenyatta University Ethics Review Committee Guidelines and **APPROVED that the research may proceed for a period of ONE year from 12th February, 2019**

5. ADVICE/CONDITIONS

i. Progress reports are submitted to the KU-ERC every six months and a full report is submitted at the end of the study.
ii. Serious and unexpected adverse events related to the conduct of the study are reported to this committee immediately they occur.
iii. Notify the Kenyatta University Ethics Committee of any amendments to the protocol.
iv. Submit an electronic copy of the protocol to KUERC.

When replying, kindly quote the application number above.
If you accept the decision reached and advice and conditions given please sign in the space provided below and return to KU-ERC a copy of the letter.

KENYATTA UNIVERSITY CHAIRMAN
15 FEB 2019
P.O. BOX 43844 - 00100 NAIROBI

PROF. JUDITH KIMIYWE
CHAIRMAN ETHICS REVIEW COMMITTEE

I ...Abraham Matheka Mutua... accept the advice given and will fulfill the conditions therein.

Signature... .. Dated this day of...15/02/2019..... ~~2018.~~

cc.
DVC-Research Innovation and Outreach

APPENDIX VII: ETHICAL APPROVAL FROM NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471,
2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/19/41454/28340** Date: **27th February, 2019**

Abraham Matheka Mutua
Maasai Mara University
P.O. Box 861
NAROK.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on "**Using ICT for diarrhea intervention in resource constrained Environments: A case study of Narok county in Kenya**". I am pleased to inform you that you have been authorized to undertake research in Narok County for the period ending **27th February 2020**

You are advised to report to **the County Commissioner, the County Director of Education and the County Director of Health Services, Narok County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Narok County.

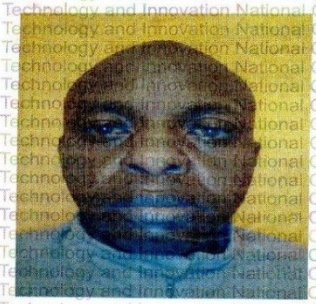
The County Director of Education
Narok County.

The County Director of Health Services
Narok County.

APPENDIX VIII: NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION PERMIT

THIS IS TO CERTIFY THAT:
MR. ABRAHAM MATHEKA MUTUA
of MAASAI MARA UNIVERSITY,
18873-100 NAIROBI,has been permitted
to conduct research in *Narok County*

Permit No : NACOSTI/P/19/41454/28340
Date Of Issue : 27th February,2019
Fee Recieved :Ksh 2000



on the topic: "Using ICT for diarrhea intervention in resource constrained Environments: A case study of Narok county in Kenya".

for the period ending:
27th February,2020

Applicant's Signature

.....
Director General
National Commission for Science, Technology & Innovation

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014.

CONDITIONS

1. The License is valid for the proposed research, location and specified period.
2. The License and any rights thereunder are non-transferable.
3. The Licensee shall inform the County Governor before commencement of the research.
4. Excavation, filming and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
5. The License does not give authority to transfer research materials.
6. NACOSTI may monitor and evaluate the licensed research project.
7. The Licensee shall submit one hard copy and upload a soft copy of their final report within one year of completion of the research.
8. NACOSTI reserves the right to modify the conditions of the License including cancellation without prior notice.

National Commission for Science, Technology and innovation
P.O. Box 30623 - 00100, Nairobi, Kenya
TEL: 020 400 7000, 0713 788787, 0735 404245
Email: dg@nacosti.go.ke, registry@nacosti.go.ke
Website: www.nacosti.go.ke

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH LICENSE

Serial No.A 23356

CONDITIONS: see back page

APPENDIX IX: PERMISSION FROM NAROK COUNTY COMMISSIONER

OFFICE OF THE PRESIDENT
MINISTRY OF INTERIOR AND
COORDINATION OF NATIONAL GOVERNMENT

Telegram: **"narok@go.ke"**, Narok
Telephone: Narok [050] 22433
Fax: [050] 22588
If calling or telephoning ask for the undersigned.
When replying please quote;
RE:CC/NRK/L&O.17/11 VOL II/94

County Commissioner
Narok County
P.O. Box 4 – 20500
NAROK
5th March, 2019,

DEPUTY COUNTY COMMISSIONERS
NAROK COUNTY

RE: RESEARCH AUTHORIZATION – ABRAHAM MATHEKA MUTUA

Mr Abraham Matheka from Maasai Mara University has been authorized to conduct research on "**Using ICT for diarrhea intervention in resource constrained environments: A case study of Narok County in Kenya**" for the period ending 27th February,2020

This is, therefore, to request you to give him necessary support.

GEORGE NATEMBEYA, MBS
COUNTY COMMISSIONER
NAROK COUNTY

COUNTY COMMISSIONER
NAROK COUNTY
05 MAR 2019
P. O. Box 4 - 20500
NAROK

APPENDIX X: PERMISSION FROM NAROK COUNTY DIRECTOR OF EDUCATION

REPUBLIC OF KENYA

MINISTRY OF EDUCATION

State Department of Early Learning and Basic Education

FAX NO. 050-22391
When replying please quote;

Ref. CDE/NRK/RES/VOL1/173

COUNTY DIRECTOR OF EDUCATION
NAROK COUNTY
P.O BOX 18
NAROK

DATE: 5TH MARCH, 2019

TO WHOM IT MAY CONCERN

RE: RESEARCH AUTHORIZATION – ABRAHAM MATHEKA MUTUA .

The above mentioned is a student of Durban University of Technology, South Africa. He has been authorized to carry out research on ***"Using ICT for diarrhea intervention in resource constrained Environments: A case study of Narok county in Kenya"***

Please accord him the necessary assistance.

COUNTY DIRECTOR OF EDUCATION
05 MAR 2019
NAROK COUNTY
Box 18-20500 NAROK

ANTONY M. MAKORI
FOR: COUNTY DIRECTOR OF EDUCATION
NAROK COUNTY

C.C

- The County Commissioner – **Narok**
- Abraham Matheka Mutua.

APPENDIX XI: PERMISSION FROM NAROK COUNTY DIRECTOR OF HEALTH

NAROK COUNTY GOVERNMENT
DEPARTMENT OF HEALTH AND SANITATION

Telegrams: "HEALTH", Narok
Telephone: Narok 22300 and 22308
Fax: (050) 22394
Email: *countyhealthdirectornarok@gmail.com*

COUNTY DIRECTOR OF HEALTH
NAROK COUNTY
P.O. BOX 11- 20500
NAROK

When replying please quote our Ref and date

OUR REF: DIR/NRK CNTY/MOH/60/ [156] **5th March, 2019**

The SCMOH
Narok East Sub County

RE: RESEARCH AUTHORIZATION FOR MR. ABRAHAM MATHEKA MUTUA – PERMIT NO. NACOSTI/P/19/41454/28340

Reference is made to the National Commission for Science, Technology and Innovation Letter Ref.No NACOSTI/P/19/41454/28340 dated 27th February, 2019 copied to this office.

Authority is hereby granted to the named to carry out research in Narok County for period ending 27th February 2020 on topic "**Using ICT for diarrhea intervention in resource constrained Environments: A case study of Narok county in Kenya**". The research should be carried out in conformity with the study protocol and ethics.

Kindly accord the researcher the information and cooperation that he may require.

COUNTY DIRECTOR OF HEALTH
NAROK COUNTY GOVERNMENT
05 MAR 2019
P. O. Box 11-20500,
NAROK

Dr. Francis K. Kiio
County Director of Health
NAROK COUNTY

C.C. Abraham Matheka Mutua
Maasai Mara University
P.O. Box 861
NAROK

APPENDIX XII: SCREENING QUESTIONNAIRE FOR MOTHERS

Good day ladies,

My name is Abraham Matheka Mutua a PhD student in Information Technology at Durban University of Technology in South Africa.

This questionnaire is intended to determine eligibility for the study. The study is aimed to determine the levels of diarrhoea awareness in the community. The information collected is purely for academic purposes and may not be used for any other purpose. All answers will be kept confidential and anonymity will be preserved.

Please tick appropriate answers or fill in where appropriate.

Household No. … …..

Date of filling the questionnaire……....

Mother's mobile number ……

	Respondents General Information
1.	Do you have any child/children under five years of age a. Yes b. No
2.	Do you own/ have constant access to a mobile phone? a. Yes b. No
3.	How would you rate mobile phone network coverage in your homestead? a. Very good b. Good c. Poor d. very Poor e. not available
4.	Do you have any training on human health? a. Yes b. No
5.	Are you are you available to participate in the study? a. Yes b. No
6.	Are you willing to participate in the study? a. Yes b. No

Thank you for participating in the questionnaire.

Abraham Matheka Mutua

Mobile phone number: 0722317623

Email: abumutua@yahoo.com

MAASAI TRANSLATION OF THE SCREENING QUESTIONNAIRE FOR MOTHERS

Imaswalini nagel ntomonok naiput ena ardasi

Entasupa nomama

kaji Abraham Matheka Mutua, aasita PhD tenkisuma oolomon letekinologi te Durban University of Technology natii South Africa.

Ore ena ardasi a keji pitodolu eneba engeno naata ntunganak lele oshi tenkipirta emoyian elototo oo nkoshuak. Ore ilomon likinchisho naa ilenkisuma ake nemeitumiai tonkule koitoi nimishaa. Ore ikimwalat muj nikimchosho aa kisudori nimipiti enkarna oltungani.

Tikira ashu imput aitobiraki

Enkaji namba. … …..

Ntarikini nimputa ena ordasi…….....

Enamba e mama esimu…….

	Ilomon lorarikioloni
1.	Iyata enkerai/inkera naa abori ilarin imiet? a. Eeh b. A ah
2.	Iyata esimu enkaina? a. Eeh b. A ah
3.	Kejaa enetiwak osimuyi enkang ino? a. Kisiai oleng b. kisidai c. sisuji d. kisuji oleng e. metii pi
4.	Iyata engeno naipirta esiriani oltunganak tenkirpirta imoyiaritin? a. Eeh b. A ah
5.	Itii sawa tiniro enkutuk e maa a. Eeh b. A ah
6.	Iyata eyeunoti nijazayie enaardasi? a. Eeh b. A ah

Ashe tenkata ino.

Abraham Matheka Mutua
Namba esimu: 0722317623
Email: abumutua@yahoo.com

APPENDIX XIII: SCREENING QUESTIONNAIRE FOR COMMUNITY HEALTH VOLUNTEERS

Hallo ladies and gentlemen.

My name is Abraham Matheka Mutua a PhD student in Information Technology at Durban University of Technology in South Africa.

This questionnaire is intended to determine eligibility for the study. The study is aimed to determine the levels of diarrhoea awareness in the community. The information collected is purely for academic purposes and may not be used for any other purpose. All answers will be kept confidential and anonymity will be preserved.

Please tick appropriate answers or fill in where appropriate.

Household No. … …..

Date of filling the questionnaire…….....

Mobile phone number ……

	Respondent's General Information
1.	Do you own or have a reliable access to a mobile phone? c. Yes d. No
2	Do you have a reliable mobile phone network? a. Yes b. No
3.	Are you available to participate in the study c. Yes d. No
4.	Are you willing to participate in the study a. Yes b. No

Thank you for participating in the questionnaire.

Abraham Matheka Mutua

Mobile phone number: 0722317623

Email: abumutua@yahoo.com

APPENDIX XIV: PRE-TEST QUESTIONNAIRE FOR THE MOTHERS

Good day ladies

My name is Abraham Matheka Mutua, a PhD student in Information Technology at Durban University of Technology in South Africa.

This questionnaire is intended to determine the levels of diarrhoea awareness and the diarrhoea information dissemination strategies and technologies used in the community. The information collected is purely for academic purpose and may not be used for any other purpose. All answers will be kept confidential and anonymity will be preserved.

Please tick appropriate answers or fill in where appropriate.

Household No. …….....

Mobile phone No……

Date ……..

Part A	RESPONDENT'S GENERAL INFORMATION
1.	What is the name of your village? a. Oresimu b. Oletukat c. Orkutoto d. Olorien e. Ilemeck f. Ilmirisho g. Iltumtum h. Emurru dikirr i. Enkoreroi j. Enkorika k. Enaramatishoreki l. Olguiri m. Empurputia n. Irrigation o. Oloikukuri
2.	What is your occupation? a. Farmer b. Housewife c. Teacher d. Shopkeeper e. Social worker f. Other, specify
3.	What is your level of Education? a. No education b. Primary level c. Secondary level d. Tertiary level
4.	What is your marital Status? a. Single b. Married c. Divorced d. Separated e. Windowed

5.	What is your age in years? a. 5-19 b. 20-29 c. 30-39 d. 40-49 e. >49
6.	How many children do you have? a. 1 b. 2 c. 3 d. 4 e. 5 f. >5
7.	How many children under five years of age are there in your household? a. Girls ……. b. Boys …….
8.	Do you own a TV? a. Yes b. No
9.	Do you own a Radio? a. Yes b. No
10.	Do you have access to newspapers? a. Yes b. No
11.	Do you have internet access? a. Yes b. No
12.	How do you get information? a. Radio b. TV c. Newspapers d. Internet e. Social groups f. Churches g. Public gatherings h. From friends
Part B	**Diarrhoea Awareness**
13.	Do you know of a disease known as diarrhoea? a. Yes b. No
14.	If yes in 13, what do you think are the main signs and symptoms of diarrhoea in young children? a. Three or more loose stools within a day b. Abdominal pain c. Vomiting d. Cramps e. Nausea f. Blood in stool g. Fever h. General body weakness i. Thirst j. Others, specify k. I don't know
15.	What do you think are the causes of diarrhoea in young children? a. Indigestible foods b. Worm infection c. Germ infection

	d. Dirty water e. Poor sanitation f. Poor hygiene g. Others, specify h. I don't know
16.	How do you think diarrhoea is spread in young children? a. Through contaminated drinking water b. Through contaminated food c. From person to person when one of them is infected d. When a child touches infected areas and puts the fingers in the mouth e. When mothers breastfeed their children without washing hands after touching infected areas. f. Food allergy or sensitivity to medicine g. By houseflies h. Poisoning
17.	State the ways you think are used to prevent diarrhoea in young children a. Boiling drinking water b. Washing hands before breastfeeding c. Keeping the environment clean d. Avoid giving children too much juice e. Washing dishes after use f. Preserving cooked food well g. Using toilets for defecation and urination h. Good waste disposal i. Washing hands after toilet j. Avoid sharing houses with animals k. Others ,specify l. I don't know
18.	What do you think can be done to assist a child with diarrhoea a. Give extra water. b. Give salty water. c. Give water with sugar. d. Give easily digestible foods, such as rice cereal, breads, cooked beans, mashed potatoes, cooked carrots and bananas e. Take the child to the hospital f. Give herbal medicine g. Others ,specify h. I don't know
Part C	**CURRENT DIARRHOEA INTERVENTION STRATEGIES**
19.	Is there any diarrhoea intervention information dissemination that has been done or is being done in your area? a. Yes b. No
20.	If yes in 19, how often are the interventions? a. At least once a week b. At least once a month c. At least once every three months d. At least once every six months e. At least once a year f. Less than once a year
21.	Which organizations conduct the interventions? a. Narok county government b. Government of Kenya c. Non-governmental organizations d. Churches

	e. Others, specify
22.	What strategies/technologies do the organizations use to conduct the interventions? a. Radio b. Television c. Public gatherings d. Displaying information in the health facilities e. Seminars f. Newspapers g. Others, specify
23.	What is your opinion on the present/previous diarrhoea intervention being conducted/have been conducted in your area if any? a. very effective b. effective c. not sure d. ineffective e. very ineffective
24.	If no in 23, why do you think the interventions are not effective? a. The technologies/strategies used are expensive b. The technologies/strategies used are not available for buying c. The technologies/strategies used are not portable d. The information is not clear e. The time the intervention are done is not convenient for me f. I am not able to interact with the presenters of the intervention programme g. The intervention information is in a language that i don't understand h. I don't have power to charge my devices and so I can't listen to the programme i. The place where the interventions are conducted is far from my reach. j. I don't have time to listen to the intervention programme because of my nature of work k. The technologies/strategies used are not easy to use
25.	**State your opinion** I think a better strategy in diarrhoea information dissemination in my area is required A. strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
26.	What do you think are the characteristics of technologies/strategies that can be feasible in diarrhoea intervention information dissemination in your area……? a. Technology/strategy is affordable b. Technology/strategy is accessible c. Technology/strategy is available d. Technology/strategy is easy to use e. Technology/strategy is portable f. Can keep charge for long g. Information is always available h. Information is available in the language I best understand i. Technology/strategy allows interaction j. Technology should be reliable k. Any other, please suggest
27.	I think mobile phones would be a better strategy in diarrhoea information dissemination in my area compared to the existing strategies A. strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
Part D	**DIARRHOEA PREVENTION PRACTICES**
I.	**Water Supply and Quality**
28.	What is your main source of water? a. From the ponds b. Harvesting from the rains

	c. From boreholes d. From the rivers e. From wells
29.	Do you treat your water before drinking? a. Yes b. No
30.	If yes in 29, how do you treat your water before drinking? a. Allowing the water to settle b. Filtering c. Use of herbs d. Boiling e. Others, specify
31.	How long are water shortages? a. Less than a day b. Less than a week c. Less than a month d. More than a month
II.	**Food cleanliness**
32.	Do you wash fruits before giving to your children? a. Yes b. No
33.	Do you boil milk before giving to your children? a. Yes b. No
34.	Do you boil food before giving to your children? a. Yes b. No
III.	**Household hygiene**
35.	Is a toilet available in the homestead? a. Yes b. No
36.	If yes in 35, what is the sanitary state of the toilet? a. Very Clean b. Clean c. Dirty d. Very dirty
37.	If No in 35, how do you attend to the call of nature? a. Bush b. Neighbour's toilet c. Others ,specify
38.	If yes in 35, are children under five years able to use the toilet alone? a. Yes b. No
39.	If no in 38, how do they attend to the call of nature? a. Assisted to use the toilet b. Use children portable toilet c. Use toilet bags d. Use the bush e. Others, specify
40.	How are the feces disposed of? a. To the toilet b. To the bush
41.	In your own opinion, do you think the young children's feces are harmful in any way? a. Yes b. No
IV.	**Personal hygiene**
42.	I am aware of the importance of my personal hygiene in protecting child's health a. Yes b. No

43.	I always wash my hands after visiting the toilet a. Yes b. No
44.	I always wash my hands before feeding a child a. Yes b. No
45.	I always clean the utensils after use a. yes b. No
46.	I am aware that cleaning utensils with clean water is important for a child's health a. Yes b. No
47.	I am aware that the presence of disease causing insects in the house poses a health risk to the child a. Yes b. No
48.	I am aware that the presence of uncollected human waste in the compound poses a health risk to the child a. Yes b. No
49.	I am aware that sharing a room with animals poses a health risk to the child a. Yes b. No
50.	I am aware that a dirty toilet poses a health risk to my child a. Yes b. No
V.	**Household Water Storage**
51.	How do you store water in your house? a. Clay pot b. Calabash c. Plastic container d. Metallic container e. Other
52.	What is the containers/container's sanitary state? a. Clean b. Dirty
53.	Where is the water container kept? a. Inside the house b. Outside the house
54.	Is the water container covered? a. Yes b. No
55.	What is the sanitary state of the container used to draw water from the water container? a. Dirty b. Clean
56.	Is the water container used to store any other substance? a. Yes b. No
57.	If yes in 56, what substance? a. Milk b. Other, specify
58.	How often is the water container cleaned? a. Daily b. Weekly c. Fortnightly d. Monthly e. After a period longer than a month
Part E	**Diarrhoea incidences**

59.	Has any of your children under five years suffered diarrhoea in the last three months? a. Yes b. No
60.	If yes in 59, how many children suffered from diarrhoea? a. 1 b. 2 c. 3 d. 4 e. 5
61.	How often was the diarrhoea infection in the last three months? a. once b. twice c. thrice d. others, specify
Part F	**Use of mobile phones**
62.	What make of a mobile phone do you own/ use? a. Samsung b. Nokia c. Motorola d. Others
63.	On average how much do you spent on mobile phone per month? a. ≥0≤200 b. .>200≤500 c. >500≤1000 d. >1000
64.	How would you prefer to receive diarrhoea information from your mobile phone ? a. Voice b. Texting
65.	What language would you be comfortable with when receiving diarrhoea information though your mobile phone? a. Maasai b. English c. Kiswahili
66.	How conversant are you with your mobile phone? a. Very conversant b. Moderately conversant c. Not very conversant
67.	What time would you prefer to receive the diarrhoea information messages?, please suggest

Thank you for participating in the study

Abraham Matheka Mutua

Mobile phone number: 0722317623

Email:abumutua@yahoo.com

MAASAI TRANSLATION OF THE PRE-TEST QUESTIONNAIRE FOR THE MOTHERS

Imaswalini oo ntomonok

Entasupa na tomonok

kaji Abraham Matheka Mutua, aasita PhD tenkisuma oolomon letekinologi te Durban University of Technology natii South Africa.

Ore enkipirta ena ardasi na pitodolu engeno niyata tonkoitoyi naitumiyai awal emoyian elotot enkoshoke tolosho. . Ore ilomon likinchisho naa ilenkisuma ake nemeitumiai tonkule koitoi nimishaa. Ore ikimwalat muj nikimchosho aa kisudori nimipiti enkarna oltungani.

Enkaji namba. … …..

Ntarikini nimputa ena ordasi…….....

Enamba e mama esimu…….……

intarikini ……..

Part A	ILOMON LIKIMPIRTA IYIE
1	Keji aa emurua nimanya? a. Oresimu b. Oletukat c. Orkutoto d. Olorien e. Ilemeck f. Ilmirisho g. Iltumtum h. Emurru dikirr i. Enkoreroi j. Enkorika k. Enaramatishoreki
2	Kaa siai iyasita? a. Airemisho b. Ene atua aji c. Ormalimui d. Amir olduka e. Olasiayani lolosho f. enkae, tolimu
3	Kaji itabaikia tenkisuma? a. Itu aisuma b. Pirimari c. Sikundari d. Sukuluni eshumata
4	Iyama ashu miyama? a. Mayama b. kayama c. kitugwaroto d. Kitorote e. Etua ormoruo
5	Kaja ilarin liyata? a. 5-19 b. 20-29

	c. 30-39 d. 40-49 e. >49
6	Kaja ilarin liyata? a. 1 b. 2 c. 3 d. 4 e. 5 f. >5
7	Kaja inkera nata abori larin imiet tenkaji ino? a. Intoyie ……. b. Inkayok …….
8	Iyata entelefishin? a. Ee kaata b. Maata
9	Iyata eredio? a. Ee kaata b. Maata
10	Itum oshi nkasetini? a. Eeh katum b. Matum
11	Indim aatijinga ormutandao? a. Yes b. No
12	Kaji itumie ilomon? a. Erendio b. Etelefishen c. Igasetini d. ormutandao e. iltururi lolosho f. Nkanisani g. Itumoritin olosho h. Imao
Part B	**Kainyoo iyolo emoyian elototo enkoshoke**
13	Iyolo emoyian elototo enkoshoke? a. Eeh kayolo b. Mayolo
14	Amaa tiniyolo nyoo irbulabul lemoyian elototo enkoshoke too nkera kutitik? a. Aosh enkoroti katitin uni ashu saidi tenkolong b. Emion e abori enkoshoke c. Elopa d. Emonira e. Aning elopa f. Inkik natii orsage g. enkiruwaj h. enchalan osesen i. enkure j. kulie, tolinu k. mayolo
15	Amaa teyie kainyoo nayau emoyian elototo enkoshoke? a. Endaa emeibibi osesen b. Nkalukan naitasurisho c. Induduyi naitasurisho d. Enkare chafu e. Ormanyara torono f. Olchafu

	g. Kulie , tolimu h. Mayolo
16	Amaa teyie nyoo naitamanaa emoyian elototo enkoshoke tonkera kutitik? a. Aimu enkare torono naoki b. Aimu endaa torono **c.** Itunganak kulie loota emoyian d. Tinibung enkera wejiting netii ina moyian enepik orkimojik enkutuk e. Enitanak intomonok inkera itu ituku nkaik naibunyie wejiting enetii ina moyian Indaiki ashu ikiek loiba osesen f. Aimu lojingak g. Enkeya osumu
17	Tolimu enikoni tiniboori emoyian elototo enkoshoke tonkera kutitik? a. Aitokitokie enkare naoki b. Aituku nkaik eton ituntanak enkerai c. Aitayu olchafu tormanyara d. Apal aisho nkera enjuis saapuk e. Aituku mpirbili f. Aisudoo endaa nayara aitobiraki g. Apuo enchoo tonkulak onkik h. Anangaa olchafu teweji sidai i. Aituku nkaik tinipuku techoo j. Aingua echula tonkajijik ongwesi k. kulie ,tolimu l. mayolo
18	Amaa teyie nyoo idimi ataas peretuni nkera naata emoyian elototo enkoshoke a. Aisho enkare. b. Isho enkare eshumbi. c. Aisho enkare esukari. d. Aishoo endaa nangamaa osesen anaa ormushele, bofulo, emaragwe nayara, enkum, karat nayiara ormaisurin e. Ayaa sipitali f. Aishoo irkiek lentim g. Kulie ,tolimu h. Mayolo
Part C	**Iwalat emoyian elototo enkoshoke**
19	Keetai ilomon lewalata emoyian elototo enkoshoke loishoyoki ashulonkirai aishooyo teweji nimanya? a. eeh b. a ah
20	Amaa tenetai kebaa enkata naya peesi? a. Enkolon nabo tewiki b. Enkolong nabo tolapa c. Enkolong nabo tolapaitin okuni d. Enkolong nabo tolapaitin ile e. Mara nabo tolari f. Miput olari
21	Kakwa tururi loyau iwalat? a. Sirkali e Narok county b. Sirkali e Kenya c. Irtururi leme ilesirikali d. nkanisani e. kulie, tolimu
22	Nyoo enkira lelo tururi aitumia aishorie nena walat? a. Erendio b. enkelefishen c. ntumoritin olosho

	d. naapiki sipitalini e. Seminani f. Igasetini g. Kulie , tolimu
23	Kaa induata ino iyie too walat natasaki teweji nimanya tentiaraki emoyian elototo enkoshoke tenaa ketai natasaki? a. Etaretuo oleng b. Etaretuo c. mayolo d. itu eretu e. etu eretu pii
24	Amaa tanaa a ah 23, idol anaa nyoo pemeretu nena walat? a. Kegoli ntokiting/nkoitoyi nangira aitumia b. Matumia ntokiting/nkoitoyi nangira aitumia teneji manyangu c. Menapayu ntokiting/nkoitoyi naingira aitumia d. Mewing ilomon lonkira alimu e. Ore isaayi nayauni lelo walat nemesidai tenanu f. Maata erishata natumore lelo loyau iwalat g. Ore ilomon lewalata naa kitumia ororei lemayolo h. Maata ositima lapikie entokiting enkima neeku maning ilomon i. Kelakwa eweji nishorieki ilomon maidim atabai. j. Maata erishata naininingie iwalat tentiaraki esiai naasita k. Kegol etumiaroto oo ntokiting/nkoitoyi naingirai aitumia
25	**Tolimu nduat inonok** Kajo keyeuni enkoitoi naikash nashorieki ilomon lemoyian elototo enkoshoke teweji namanya A. kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E. manyoraa pii
26	Amaa teyie idol anaa keyeu naa kaji etui inkoitoyi/intokiting naishorieki ilom lewalata emoyian elototo enkoshoke a. Nkoitiyi/ntokiting nalelek b. Nkoitiyi/ntokiting nabakinoyu c. Nkoitiyi/ntokiting natumoyu d. Nkoitiyi/ntokiting nalelek itumiai e. Nkoitiyi/ntokiting nanapayu f. Aingor enkadori g. Tenaa ketumoyu lomon anaa ake h. Ketumoyu ilomon tenkutuk naing aitibiraki i. Nkoitiyi/ntokiting nanyoraa orkiu j. Nkoitiyi naitegemayayu k. Kulie, tolimu
27	Kajo kiksh tinitumiai isimuyi onkaik ashoyo ilomon lewalata emoyian elototo enkoshoke teweji namanya alang nkoitoyi nangirai atumia saai A. kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E. manyoraa pii
Part D	**INKIBOROT EMOYIAN ELOTOTO ENKOSHOKE**
I.	**Enetumieki enkare wesidano enye**
28	Kaji itumie enkare? a. osilanga b. enkare enchan c. engumoto d. oreyet e. enchoro
29	Intoropil oshi enkare eton itu iwok? a. Eeh kaitoropil

	b. maitoropil
30	Amaa tenesipa no 29, kaji inko tinintoropil enkare ino eton itu iwok? a. Kaisho meraga olchafu b. kaji c. kapik irkiek lentim d. kaitokitokie e. kulie , tolimu
31	Kebaa enkata kiti enkare? a. Miput enkolong b. Miput ewiki c. Miput olapa d. Kedoyo olapa
II.	**Food cleanliness**
32	Intuku irmatunda eton itu incho nkera? a. Eeh kaituku b. Maituku
33	Intokitokie kule eton itu cho nkera? a. Eeh b. aah
34	Irowajie endaa eton itu icho nkera a. eeh b. a ah
III.	**Household hygiene**
35	Iyatata enchoo tiang? a. eeh b. a ah
36	Amaa tenaa eeh 35 kaji ekununo esidano? a. Kisafi oleng b. kisafi c. kichafu d. kichafu oleng
37	Amaa tenaa a ah 35, kaji oshi ilotie haja? a. Entim b. Enchoo c. kulie ,tolimu
38	Amaa tanaa eeh 35, kidim ikera o abori irin imet aitumia openy? a. Eeh b. A ah
39	Amaa tanaa eeh 38kaji iko tenepuo haja? a. Keretokini aitumia choo b. Kitumia enchoo naigut onkera c. Kitimia irbenia le choo d. Kitumia entim e. kulie, tolimu
40	Kaji epiki inkik? a. Kipiki choo b. Kioiki entim
41	Amaa tenduata ino kinyalisho inkik oo nkera kutitik a. Eeh b. A ah
IV.	**olsa**
42	Iyolo esidano enkuso ino teseriani enkera? a. eeh b. a ah
43	Kaituku oshiake inkaik enaidip ashomo echoo a. Yes b. No
44	Ituku oshi inkaik tinincho enkerai endaa? a. Yes

	b. No
45	Intuku oshiake ipirbili tinidip aitumia
46	Kayolo ajo enetipat tinitukuyeki impirbili enkare sidai teseriani enkerai a. Eeh b. A ah
47	Kayolo ajio teetii inkijingak nayau emoyian aji naa kidim ayau enyamali teseriani enkerai a. eeh b. aah
48	Kayolo ajo tenetii inkik nemedumuno ormanyara naa kidim ayau enyamali teseriani enkerai a. Eeh b. A ah
49	Kayolo ajo tinikishulakino aji ogwesi na kidim ayau enyamali teseriani enkerai a. Eeh b. A ah
50	Kayolo ajo kidim enchoo nimitukuo ayau enyamali teseriani enkerai a. Eeh b. A ah
V.	**Enkitisho enkare**
51	Kainyoo ishumie enkare? a. enyongo b. enkukuri c. ilduumi lempira d. ildumi lochuma e. kulie
52	Kaji entiu intokiting nishumie olchafu? a. kisafii b. kichafuyi
53	Kaji ipik ntokiting nishumie enkare? a. Atua aji b. Ongota
54	Kitemoro ntokiting nishumie enkare a. Eeh b. A ah
55	Kejaa enkuso oo ntokiting niwokunyie enkare a. Kisafii b. Kichafuyi
56	Kitumiyai nena tokiting nishumie enkare ashumie kulie tokiting? a. Eeh b. A ah
57	Amaa tanaa eeh 56, nyoo emukieki? a. Kule b. Kulie , tolimu
58	Kaa rishata iya pintuku ntokiting nimukie enkare? a. Kila enkolong b. Kila ewiki c. Kila wikii are d. Kila olapa e. Keya saidi olapa
Part E	**Emoyian elototo enkoshoke**
59	Ketae enkerai e abori ilarin imietnaibunga emoyian elototo enkoshoke toolapaitin akuni atulusoitie? a. Eeh b. A ah
60	Amaa tanaa eeh 59, kaja inkera naibunga? a. 1 b. 2 c. 3 d. 4

	e. 5
61	Mara aja ibunga ina moyian toolapatin okuni otulusoiteie a. nabo b. ware c. uni d. kulie, tolimu
Part F	**Emetuisi esimu**
62	Kaabila esimu niyata? a. esamsung b. enokia c. emotorola d. kulie
63	Amm tiningor aja ropiyani nitumia te simu tolapa? a. ≥0≤200 b. .>200≤500 c. >500≤1000 d. >1000
64	Kainyoo itumia esimu ino aitas? a. Awosh b. Ager ormesage c. Areu nangamaa ropiyani d. Ajing omutandao e. kulie
65	Kainyoo itumia esimu aitas oleeng? a. Awosh b. Aiger ormesag c. Areu nangamaa ropiyani d. Ajing ormutandau e. Kulie
66	Iyolo aitumia esimu? a. Kayolo oleng b. Kayolo penyo c. Mayolo oleng
67	Kaji iyieu nikinkunakini olkilikuai le lototo enkoshoke? a. Eoshoto e simu b. Olkilikuai
68	Tiaa kutuk iyieu ning'amu olkilikuai le lototo enkoshoke te simu? a. Kimaasai b. Enkutuk oo lashumba c. Kiswahili
69.	Iyiolo pooki toki naipirta esimu ino? a. Kayiolo oleng b. Kayiolo penyo c. Mayiolo
70	Kakua saai iyieu ningamu olkilikuai le lototo enkoshoke? Tolimu tenaa dama ashu kewarie.

Ashe tenkata ino

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APPENDIX XV: POST-TEST QUESTIONNAIRE FOR THE MOTHERS

Good day ladies,

My name is Abraham Matheka Mutua, a PhD student in Information Technology at Durban University of Technology in South Africa.

This questionnaire is intended to determine the levels of diarrhoea awareness and your opinion on the mobile based system that was used in diarrhoea information dissemination. The information collected is purely for academic purpose and may not be used for any other purpose. All answers will be kept confidential and anonymity will be preserved.

Please tick appropriate answers or fill in where appropriate.

Household No. …….....

Mobile Telephone No……

Date ……..

Part A	RESPONDENT'S GENERAL INFORMATION
1.	What is the name of your village? a. Oresimu b. Oletukat c. Orkutoto d. Olorien e. Ilemeck f. Ilmirisho g. Iltumtum h. Emurru dikirr i. Enkoreroi j. Enkorika k. Enaramatishoreki l. Olguiri m. Empurputia n. Irrigation o. Oloikukuri
2.	What is your occupation? a. Farmer b. Housewife c. Teacher d. Shopkeeper e. Social worker f. Other, specify
3.	What is your level of Education? a. No education b. Primary level c. Secondary level d. Tertiary level
4.	What is your marital Status? a. Single b. Married c. Divorced d. Separated e. Windowed

5.	What is your age in years? a. 5-19 b. 20-29 c. 30-39 d. 40-49 e. >49
6.	How many children do you have? a. 1 b. 2 c. 3 d. 4 e. 5 f. >5
7.	How many children under five years of age are there in your household? a. Girls ……. b. Boys …….
8	Do you own a TV? a. Yes b. No
9.	Do you own a Radio? a. Yes b. No
10.	Do you have access to newspapers? a. Yes b. No
11.	Do you have internet access? a. Yes b. No
12.	How do you get information? a. Radio b. TV c. Newspapers d. Internet e. Social groups f. Churches g. Public gatherings h. From friends
Part B	**Diarrhoea Awareness**
13.	Do you know of a disease known as diarrhoea? a. Yes b. No
14.	If yes in 13, what do you think are the main signs and symptoms of diarrhoea in young children? a. Three or more loose stools within a day b. Abdominal pain c. Vomiting d. Cramps e. Nausea f. Blood in stool g. Fever h. General body weakness i. Thirst j. Others, specify k. I don't know

15.	What do you think are the causes of diarrhoea in young children? a. Indigestible foods b. Worm infection c. Germ infection d. Dirty water e. Poor sanitation f. Poor hygiene g. Others, specify h. I don't know
16.	How do you think diarrhoea is spread in young children? a. Through contaminated drinking water b. Through contaminated food c. From person to person when one of them is infected d. When a child touches infected areas and puts the fingers in the mouth e. When mothers breastfeed their children without washing hands after touching infected areas. f. Food allergy or sensitivity to medicine g. By houseflies h. Poisoning
17.	State the ways you think are used to prevent diarrhoea in young children a. Boiling drinking water b. Washing hands before breastfeeding c. Keeping the environment clean d. Avoid giving children too much juice e. Washing dishes after use f. Preserving cooked food well g. Using toilets for defecation and urination h. Good waste disposal i. Washing hands after toilet j. Avoid sharing houses with animals k. Others ,specify l. I don't know
18.	What do you think can be done to assist a child with diarrhoea a. Give extra water. b. Give salty water. c. Give water with sugar. d. Give easily digestible foods, such as rice cereal, breads, cooked beans, mashed potatoes, cooked carrots and bananas e. Take the child to the hospital f. Give herbal medicine g. Others ,specify h. I don't know
Part C	**CURRENT DIARRHOEA INTERVENTION STRATEGIES**
19.	Is there any diarrhoea disease teachings that has been done or is being done in your area? a. Yes b. No
20.	If yes in 19, how often are the teachings done? a. At least once a week b. At least once a month c. At least once every three months d. At least once every six months e. At least once a year f. Less than once a year
21.	Which organizations conduct the teachings? a. Narok county government

	b. Government of Kenya c. Non-governmental organizations d. Churches e. Others, specify
22.	What strategies/technologies do the organizations use to conduct the teachings? a. Radio b. Television c. Public gatherings d. Displaying information in the health facilities e. Seminars f. Newspapers g. Others, specify
23.	What is your opinion on the present/previous diarrhoea teachings being conducted/have been conducted in your area if any? a. very effective b. effective c. not sure d. ineffective e. very ineffective
24.	If not very effective in 23, why do you think they are not very effective? a. The technologies/strategies used are expensive b. The technologies/strategies used are not available for buying c. The technologies/strategies used are not portable d. The information is not clear e. The time the intervention are done is not convenient for me f. I am not able to interact with the presenters of the intervention programme g. The intervention information is in a language that i don't understand h. I don't have power to charge my devices and so I can't listen to the programme i. The place where the interventions are conducted is far from my reach. j. I don't have time to listen to the intervention programme because of my nature of work k. The technologies/strategies used are not easy to use
25.	**State your opinion** I think a better strategy in diarrhoea disease teaching in my area is required A. strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
26.	What do you think are the characteristics of technologies that can be feasible in diarrhoea teachings in your area……? a. Technology/strategy is affordable b. Technology/strategy is accessible c. Technology/strategy is available d. Technology/strategy is easy to use e. Technology/strategy is portable f. Can keep charge for long g. Information is always available h. Information is available in the language I best understand i. Technology/strategy allows interaction j. Technology should be reliable k. Any other, please suggest
Part D	**DIARRHOEA PREVENTION PRACTICES**
I.	**Water Supply and Quality**
27.	What is your main source of water? a. From the ponds b. Harvesting from the rains c. From boreholes

	d. From the rivers e. From wells
28.	Do you treat water before drinking? a. Yes b. No
29.	If yes in 28, how do you treat the water? a. Allowing the water to settle b. Filtering c. Use of herbs d. Boiling e. Others, specify
30.	How long are water shortages? a. Less than a day b. Less than a week c. Less than a month d. More than a month
II.	**Food cleanliness**
31.	Do you wash fruits before giving to your children? a. Yes b. No
32.	Do you boil milk before giving to your children? a. Yes b. No
33.	Do you boil food before giving to your children? a. Yes b. No
III.	**Household hygiene**
34.	Is a toilet available in your homestead? a. Yes b. No
35.	If yes in 34, what is the sanitary state of the toilet? a. Very Clean b. Clean c. Dirty d. Very dirty
36.	If No in 34, how do you attend to the call of nature? a. Bush b. Neighbor's toilet c. Others ,specify
37.	If yes in 34, are children under five years able to use the toilet alone? a. Yes b. No
38.	If no in 37, how do they attend to the call of nature? a. Assisted to use the toilet b. Use children portable toilet c. Use toilet bags d. Use the bush e. Others, specify
39.	How are the feces disposed? a. To the toilet b. To the bush
40.	In your own opinion, do you think the young children's feces are harmful in any way? a. Yes b. No
IV.	**Personal hygiene**
41.	I am aware of the importance of my personal hygiene in protecting child's health a. Yes b. No
42.	I always wash my hands after visiting the toilet

	a. Yes b. No
43.	I always wash my hands before feeding a child a. Yes b. No
44.	I always clean the utensils after use a. yes b. No
45.	I am aware that cleaning utensils with clean water is important for a child's health a. Yes b. No
46.	I am aware that the presence of disease causing insects in the house poses a health risk to the child a. Yes b. No
47.	I am aware that the presence of uncollected human waste in the compound poses a health risk to the child a. Yes b. No
48.	I am aware that sharing a room with animals poses a health risk to the child a. Yes b. No
49.	I am aware that a dirty toilet poses a health risk to my child a. Yes b. No
V.	**Household Water Storage**
50.	How do you store water in your house? a. Clay pot b. Calabash c. Plastic container d. Metallic container e. Other
51.	What is the containers/container's sanitary state? a. Clean b. Dirty
52.	Where is the water container kept? a. Inside the house b. Outside the house
53.	Is the water container covered? a. Yes b. No
54.	What is the sanitary state of the container used to draw water from the water container? a. Dirty b. Clean
55.	Is the water container used to store any other substance? a. Yes b. No
56.	If yes in 55, what substance? a. Milk b. Other, specify
57.	How often is the water container cleaned? a. Daily b. Weekly c. Fortnightly d. Monthly e. After a period longer than a month
Part E	**Diarrhoea incidences**
58.	Has any of your children under five years suffered diarrhoea in the last three months?

	a. Yes b. No
59.	If yes in 58, how many children suffered from diarrhoea? a. 1 b. 2 c. 3 d. 4 e. 5 f. More than 5
60.	How often was the diarrhoea infection in the last three months? a. once b. twice c. thrice d. others, specify
Part F	**Use of mobile phones**
61.	What make of a mobile phone do you own/use? a. Samsung b. Nokia c. Motorola d. Others
62.	On average how much do you spent on mobile phone per month? a. ≥0≤200 b. >200≤500 c. >500≤1000 d. >1000
63.	What activities do you use your mobile phone on? a. Calling b. Texting c. Mobile money d. Internet access e. Others
64.	Which is the most common activity that you use your mobile phone for? a. Calling b. Texting c. Mobile money d. Internet access e. Others
65.	How conversant are you with your mobile phone? a. Very conversant b. Moderately conversant c. Not very conversant
Part G	**Use of suitable diarrhoea information communication technologies** To what extent do you agree with the following statements?
66.	The diarrhoea information received from a mobile phone is much clear and in language I best understand compared other technologies A. strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
68.	I can access diarrhoea information from a mobile phone any time i want unlike other technologies A. Strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
69.	A mobile phone is a more reliable means of diarrhoea disease teaching compared to other technologies A. Strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
70.	Because a mobile phone is portable I can always get diarrhoea information better than with other technologies A. Strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
71.	A mobile phone is the most affordable ICT that I can use to get diarrhoea disease teaching A. Strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
72.	I would prefer to receive diarrhoea information through mobile phones than other ICTs because it keeps charge for long and charging areas are scarce.

	A. Strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
73.	I would prefer to receive diarrhoea disease teachings through a mobile phone than other technologies because we are Nomads and it's easy to move with it. A. Strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
74.	The mobile phone is the most available ICT for me and therefore I would prefer to use it to get diarrhoea teachings. A. Strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
75.	The mobile phone is the most user friendly ICT for me and therefore I would prefer to use to get diarrhoea teachings. A. Strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
76.	I would prefer to receive diarrhoea teachings through a mobile phone than other ICTs because I can ask questions and get responses. A. Strongly agree B. Agree C. not sure D. disagree E. Strongly disagree

Thank you for participating in the study

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MAASAI TRANSLATION OF THE POST- TEST QUESTIONNAIRE FOR THE MOTHERS

Imaswalini oo ntomonok

Entasupa na tomonok

kaji Abraham Matheka Mutua, aasita PhD tenkisuma oolomon letekinologi te Durban University of Technology natii South Africa.

Ore enkipirta ena ardasi na pitodolu engeno niyata tonkoitoyi naitumiyai awal emoyian elotot enkoshoke tolosho. . Ore ilomon likinchisho naa ilenkisuma ake nemeitumiai tonkule koitoi nimishaa. Ore ikimwalat muj nikimchosho aa kisudori nimipiti enkarna oltungani.

Enkaji namba. … …..

Ntarikini nimputa ena ordasi…….....

Enamba e mama esimu…….

intarikini ……..

Part A	ILOMON LIKIMPIRTA OLARIKIOLONI
1	Keji aa emurua nimanya? a. Oresimu b. Oletukat c. Orkutoto d. Olorien e. Ilemeck f. Ilmirisho g. Iltumtum h. Emurru dikirr i. Enkoreroi j. Enkorika k. Enaramatishoreki
2	Kaa siai iyasita? a. Airemisho b. Ene atua aji c. Ormalimui d. Amir olduka e. Olasiayani lolosho f. enkae, tolimu
3	Kaji itabaikia tenkisuma? a. Itu aisuma b. Pirimari c. Sikundari d. Sukuluni eshumata
4	Iyama ashu miyama? a. Mayama b. kayama c. kitugwaroto d. Kitorote e. Etua ormoruo

5	Kaja ilarin liyata? a. 5-19 b. 20-29 c. 30-39 d. 40-49 e. >49
6	Kaja ilarin liyata? a. 1 b. 2 c. 3 d. 4 e. 5 f. >5
7	Kaja inkera nata abori larin imiet tenkaji ino? a. Intoyie ……. b. Inkayok …….
8	Iyata entelefishin? a. Ee kaata b. Maata
9	Iyata eredio? a. Ee kaata b. Maata
10	Itum oshi nkasetini? a. Eeh katum b. Matum
11	Indim aatijinga ormutandao? a. Yes b. No
12	Kaji itumie ilomon? a. Erendio b. Etelefishen c. Igasetini d. ormutandao e. iltururi lolosho f. Nkanisani g. Itumoritin olosho h. Imao
Part B	**Kainyoo iyolo emoyian elototo enkoshoke**
13	Iyolo emoyian elototo enkoshoke? a. Eeh kayolo b. Mayolo
14	Amaa tiniyolo nyoo irbulabul lemoyian elototo enkoshoke too nkera kutitik? a. Aosh enkoroti katitin uni ashu saidi tenkolong b. Emion e abori enkoshoke c. Elopa d. Emonira e. Aning elopa f. Inkik natii orsage g. enkiruwaj h. enchalan osesen i. enkure j. kulie, tolinu k. mayolo
15	Amaa teyie kainyoo nayau emoyian elototo enkoshoke? a. Endaa emeibibi osesen b. Nkalukan naitasurisho c. Induduyi naitasurisho d. Enkare chafu

	e. Ormanyara torono f. Olchafu g. Kulie , tolimu h. Mayolo
16	Amaa teyie nyoo naitamanaa emoyian elototo enkoshoke tonkera kutitik? a. Aimu enkare torono naoki b. Aimu endaa torono **c.** Itunganak kulie loota emoyian d. Tinibung enkera wejiting netii ina moyian enepik orkimojik enkutuk e. Enitanak intomonok inkera itu ituku nkaik naibunyie wejiting enetii ina moyian f. Indaiki ashu ikiek loiba osesen g. Aimu lojingak h. Enkeya osumu
17	Tolimu enikoni tiniboori emoyian elototo enkoshoke tonkera kutitik? a. Aitokitokie enkare naoki b. Aituku nkaik eton ituntanak enkerai c. Aitayu olchafu tormanyara d. Apal aisho nkera enjuis saapuk e. Aituku mpirbili f. Aisudoo endaa nayara aitobiraki g. Apuo enchoo tonkulak onkik h. Anangaa olchafu teweji sidai i. Aituku nkaik tinipuku techoo j. Aingua echula tonkajijik ongwesi k. kulie ,tolimu l. mayolo
18	Amaa teyie nyoo idimi ataas peretuni nkera naata emoyian elototo enkoshoke a. Aisho enkare. b. Isho enkare eshumbi. c. Aisho enkare esukari. d. Aishoo endaa nangamaa osesen anaa ormushele, bofulo, emaragwe nayara, enkum, karat nayiara ormaisurin e. Ayaa sipitali f. Aishoo irkiek lentim g. Kulie ,tolimu h. Mayolo
Part C	**INKOITOYI EWALATA EMOYIAN ELOTOTO ENKOSHOKE SAI**
19	Keetai ilomon lewalata emoyian elototo enkoshoke loishoyoki ashulonkirai aishooyo teweji nimanya? a. eeh b. a ah
20	Amaa tenetai kebaa enkata naya peesi? a. Enkolon nabo tewiki b. Enkolong nabo tolapa c. Enkolong nabo tolapaitin okuni d. Enkolong nabo tolapaitin ile e. Mara nabo tolari f. Miput olari
21	Kakwa tururi loyau iwalat? a. Sirkali e Narok county b. Sirkali e Kenya c. Irtururi leme ilesirikali d. nkanisani e. kulie, tolimu
22	Nyoo enkira lelo tururi aitumia aishorie nena walat? a. Erendio

	b. enkelefishen c. ntumoritin olosho d. naapiki sipitalini e. Seminani f. Igasetini g. Kulie , tolimu
23	Kaa induata ino iyie too walat natasaki teweji nimanya tentiaraki emoyian elototo enkoshoke tenaa ketai natasaki? a. Etaretuo oleng b. Etaretuo c. mayolo d. itu eretu e. etu eretu pii
24	Amaa tanaa a ah 23, idol anaa nyoo pemeretu nena walat? a. Kegoli ntokiting/nkoitoyi nangira aitumia b. Matumia ntokiting/nkoitoyi nangira aitumia teneji manyangu c. Menapayu ntokiting/nkoitoyi naingira aitumia d. Mewing ilomon lonkira alimu e. Ore isaayi nayauni lelo walat nemesidai tenanu f. Maata erishata natumore lelo loyau iwalat g. Ore ilomon lewalata naa kitumia ororei lemayolo h. Maata ositima lapikie entokiting enkima neeku maning ilomon i. Kelakwa eweji nishorieki ilomon maidim atabai. j. Maata erishata naininingie iwalat tentiaraki esiai naasita k. Kegol etumiaroto oo ntokiting/nkoitoyi naingirai aitumia
25	**Tolimu enduata ino** Kajo keyeuni enkoitoi naikash nashorieki ilomon lemoyian elototo enkoshoke teweji namanya A. kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E. manyoraa pii
26	Amaa teyie idol anaa keyeu naa kaji etui inkoitoyi/intokiting naishorieki ilom lewalata emoyian elototo enkoshoke a. Nkoitiyi/ntokiting nalelek b. Nkoitiyi/ntokiting nabakinoyu c. Nkoitiyi/ntokiting natumoyu d. Nkoitiyi/ntokiting nalelek itumiai e. Nkoitiyi/ntokiting nanapayu f. Aingor enkadori g. Tenaa ketumoyu lomon anaa ake h. Ketumoyu ilomon tenkutuk naing aitibiraki i. Nkoitiyi/ntokiting nanyoraa orkiu j. Nkoitiyi naitegemayayu k. Kulie, tolimu
27	Kajo kiksh tinitumiai isimuyi onkaik ashoyo ilomon lewalata emoyian elototo enkoshoke teweji namanya alang nkoitoyi nangirai atumia saai A. kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E. manyoraa pii
Part D	**INKIBOROT EMOYIAN ELOTOTO ENKOSHOKE**
I.	**Enetumieki enkare wesidano enye**
28	Kaji itumie enkare? a. osilanga b. enkare enchan c. engumoto d. oreyet e. enchoro

29	Intoropil oshi enkare eton itu iwok? a. Eeh kaitoropil b. maitoropil
30	Amaa tenesipa no 29, kaji inko tinintoropil enkare ino eton itu iwok? a. Kaisho meraga olchafu b. kaji c. kapik irkiek lentim d. kaitokitokie e. kulie , tolimu
31	Kebaa enkata kiti enkare? a. Miput enkolong b. Miput ewiki c. Miput olapa d. Kedoyo olapa
II.	**Edidano endaa**
32	Intuku irmatunda eton itu incho nkera? a. Eeh kaituku b. Maituku
33	Intokitokie kule eton itu cho nkera? a. Eeh b. aah
34	Irowajie endaa eton itu icho nkera a. eeh b. a ah
III.	**Enkuso enkaji namanyai**
35	Iyatata enchoo tiang? a. eeh b. a ah
36	Amaa tenaa eeh 35 kaji ekununo esidano? a. Kisafi oleng b. kisafi c. kichafu d. kichafu oleng
37	Amaa tenaa a ah 35, kaji oshi ilotie haja? a. Entim b. Enchoo c. kulie ,tolimu
38	Amaa tanaa eeh 35, kidim ikera o abori irin imet aitumia openy? a. Eeh b. A ah
39	Amaa tanaa eeh 38kaji iko tenepuo haja? a. Keretokini aitumia choo b. Kitumia enchoo naigut onkera c. Kitimia irbenia le choo d. Kitumia entim e. kulie, tolimu
40	Kaji epiki inkik? a. Kipiki choo b. Kioiki entim
41	Amaa tenduata ino kinyalisho inkik oo nkera kutitik a. Eeh b. A ah
IV.	**Enkuso oltungani makeon**
42	Iyolo esidano enkuso ino teseriani enkera? a. eeh b. a ah
43	Kaituku oshiake inkaik enaidip ashomo echoo a. eeh b. a ah

44	Ituku oshi inkaik tinincho enkerai endaa? a. eeh b. a ah
45	Intuku oshiake ipirbili tinidip aitumia a. eeh b. a ah
46	Kayolo ajo enetipat tinitukuyeki impirbili enkare sidai teseriani enkerai a. Eeh b. A ah
47	Kayolo ajio teetii inkijingak nayau emoyian aji naa kidim ayau enyamali teseriani enkerai a. eeh b. a ah
48	Kayolo ajo tenetii inkik nemedumuno ormanyara naa kidim ayau enyamali teseriani enkerai a. Eeh b. A ah
49	Kayolo ajo tinikishulakino aji ogwesi na kidim ayau enyamali teseriani enkerai a. Eeh b. A ah
50	Kayolo ajo kidim enchoo nimitukuo ayau enyamali teseriani enkerai a. Eeh b. A ah
V.	**Enkitisho enkare tiaji**
51	Kainyoo ishumie enkare? a. enyongo b. enkukuri c. ilduumi lempira d. ildumi lochuma e. kulie
52	Kaji entiu intokiting nishumie olchafu? a. kisafii b. kichafuyi
53	Kaji ipik ntokiting nishumie enkare? a. Atua aji b. Ongota
54	Kitemoro ntokiting nishumie enkare a. Eeh b. A ah
55	Kejaa enkuso oo ntokiting niwokunyie enkare a. Kisafii b. Kichafuyi
56	Kitumiyai nena tokiting nishumie enkare ashumie kulie tokiting? a. Eeh b. A ah
57	Amaa tanaa eeh 56, nyoo emukieki? a. Kule b. Kulie , tolimu
58	Kaa rishata iya pintuku ntokiting nimukie enkare? a. Kila enkolong b. Kila ewiki c. Kila wikii are d. Kila olapa e. Keya saidi olapa
Part E	**Emoyian elototo enkoshoke**
59	Ketae enkerai e abori ilarin imietnaibunga emoyian elototo enkoshoke toolapaitin akuni atulusoitie? a. Eeh b. A ah

60	Amaa tanaa eeh 59, kaja inkera naibunga? a. 1 b. 2 c. 3 d. 4 e. 5
61	Mara aja ibunga ina moyian toolapatin okuni otulusoiteie a. nabo b. ware c. uni d. kulie, tolimu
Part F	**Imatumisi esimu enkaina**
62	Kaabila esimu niyata? a. esamsung b. enokia c. emotorola d. kulie
63	Amm tiningor aja ropiyani nitumia te simu tolapa? a. ≥0≤200 b. .>200≤500 c. >500≤1000 d. >1000
64	Kainyoo itumia esimu ino aitas? a. Awosh b. Ager ormesage c. Areu nangamaa ropiyani d. Ajing omutandao e. kulie
65	Kainyoo itumia esimu aitas oleeng? a. Awosh b. Aiger ormesag c. Areu nangamaa ropiyani d. Ajing ormutandau e. Kulie
66	Iyolo aitumia esimu? a. Kayolo oleng b. Kayolo penyo c. Mayolo oleng

Part G **Ntokiting naitumiai alikio ilon loipirta emoyian elototo enkoshoke**

Tiaa kiroshi inyoraa kulo omon?

67 Ore ilomon loipirta emoyan elototo enkoshoke tenangamaa tesimu tororei layolo naa naa kewang alangu tinitumia kulie tokiting

B. Kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E.manyoraa pii

68 Katim ilomon loipirta emoyian elototo enkoshoke eimu esimu kila saa nayeu metiu anaa eimu kulie tokiting

A.Kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E.manyoraa pii

69 Ore esimu kitegemeyayu oleng etumieki ilomon lemoyian elototo enkoshoke tinintanyanyukie kulie tokiting

A.Kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E.manyoraa pii

70. Ore amu kenapaa esimu kadim anoto ilomon loipirta emoyan elototo enkoshoke aitobiraki kuliko kulie tokiting

B. Kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E.manyoraa pii

71 Ore esimu naa enkoitoi nalele naidim ainotie engeno naipirta emoyian elototo enkoshoke

B. Kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E.manyoraa pii

72 Kakashie esimu tenatumie ilomon lemoyian elototo enkoshoke kuliko kulie tokiting nalimu arorei amu ore nena kulie na keya enkata pejing enkima naa kikuti wejiting napikieki enkima.

A Kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E.manyoraa pii

73 Kaikashie esimu tenaningie ilomon lemoyian elototo enkoshoke amuu kira ilaramatak naa kelelek inapata enye.

A Kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E.manyoraa pii

74 Kaikashie esimu tenaningie nkitengenak emoyian elototo enkoshoke amu ninye adim ainoto teleleki

A. Kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E.manyoraa pii

75 Kaikashie esimu tekulie tokiting nalimu ilomon lemoyian elototo enkoshoke amu kelelek etumia ntunganak.

A. Kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E.manyoraa pii

76 I kaikashie rsimu tenatumie nkitengenak emoyian elototo enkoshoke amu kaidim aikilikwanu entoki natum ewalata.

A. Kanyoraa oleng B. kanyoraa C. mayolo D. manyoraa E.manyoraa pii

Ashe tenkata ino

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APPENDIX XVI: QUESTIONNAIRE FOR THE COMMUNITY HEALTH VOLUNTEERS

Good day ladies and gentlemen

My name is Abraham Matheka Mutua, a PhD student in Information Technology at Durban University of Technology in South Africa.

This questionnaire is intended to determine the strategies and technologies used in diarrhoea information dissemination in the area and their weakness and elicit information for the design and development of the prototype. The information collected is purely for academic purpose and may not be used for any other purpose. All answers will be kept confidential and your anonymity will be preserved.

Date……..

Time……

	Respondents General Information
1.	What is the name of your village? a. Oresimu b. Oletukat c. Orkutoto d. Olorien e. Ilemeck f. Ilmirisho g. Iltumtum h. Emurru dikirr i. Enkoreroi j. Enkorika k. Enaramatishoreki l. Olguiri m. Empurputia n. Irrigation o. Oloikukuri
2.	Which Dispensary/health center are you attached to? a. Oletukat b. Mosiro
3.	What is your level of Education? a. No education b. Primary level c. Secondary level d. Tertiary level
4.	What is your age? a. 5-19 b. 20-29 c. 30-39 d. 40-49 e. >49
5.	How many years of service as a health worker do you have? a. 0-5 b. 6-10 c. 11-15 d. 16-20 e. >20

6.	**QUESTIONS ON DIARRHOEA**
7.	How often is diarrhoea reported in the area you are in charge of? a. At least once a day b. At least once a week c. At least once fortnightly d. At least once in a month e. Less than once a month
8.	What do you think are the causes of diarrhoea in your area? a. Eating contaminated food b. Drinking contaminated water c. Poor hygiene d. Other, specify
9.	Are there any diarrhoea information dissemination interventions that have been done on diarrhoea in your area? a. Yes b. No
10.	If yes in 9, how often are the interventions? a. At least once a week b. At least once a month c. At least once every three months d. At least once every six months e. At least once a year f. Less than once a year
11.	Which organizations conduct the interventions? a. Narok county government b. Government of Kenya c. Non-governmental organizations d. Churches e. Others, specify
12.	What methods do the organizations use to conduct the interventions? a. Radio b. Television c. Public gatherings d. Displaying information in the health facilities e. Seminars f. Newspapers g. Others, specify
13.	How would rate the diarrhoea interventions being used/have been used if any A. Very effective b. Effective c. not sure c. Slightly effective d. not effective
14.	If not very effective in 13, why do you think so? a. The technologies/strategies used are expensive b. The technologies/strategies used are not available for buying c. The technologies/strategies used are not portable d. The information is not clear e. The time the intervention are done is not convenient for me f. I am not able to interact with the presenters of the intervention programme g. The intervention information is in a language that i don't understand h. I don't have power to charge my devices and so I can't listen to the programme

	i. The place where the interventions are conducted is far from my reach. j. I don't have time to listen to the intervention programme because of my nature of work. k. The technologies/strategies used are not easy to use
15.	What do you think are the characteristics of technologies/strategies that can be feasible in diarrhoea intervention information dissemination in your area……? a. Technology/strategy is affordable b. Technology/strategy is accessible c. Technology/strategy is available d. Technology/strategy is easy to use e. Technology/strategy is portable f. Can keep charge for long g. Information is always available h. Information is available in the language I best understand i. Technology/strategy allows interaction j. Technology should be reliable k. Any other, please suggest
16.	I think mobile phones would be a better strategy in diarrhoea information dissemination in my area compared to the existing strategies A. strongly agree B. Agree C. not sure D. disagree E. Strongly disagree
17.	Which is the best language to use to disseminate diarrhoea information to the mothers so that they can clearly understand? a. English b. Kiswahili c. Maasai d. Others, please specify
18.	What is the best mode of communication in a mobile phone for the mothers to understand the diarrhoea information? a. Text messages b. Voice messages

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APPENDIX XVII: RETROSPECTIVE CHART REVIEW

Year	Month	Name of the dispensary	Number of diarrhoea cases reported for children under five years of age
2018	April	Mosiro	
		Oletukat	
	May	Mosiro	
		Oletukat	
	June	Mosiro	
		Oletukat	
	July	Mosiro	
		Oletukat	
	August	Mosiro	
		Oletukat	
	September	Mosiro	
		Oletukat	
	October	Mosiro	
		Oletukat	
	November	Mosiro	
		Oletukat	
	December	Mosiro	
		Oletukat	
2019	January	Mosiro	
		Oletukat	
	February	Mosiro	
		Oletukat	
	March	Mosiro	
		Oletukat	

APPENDIX XVIII: PROSPECTIVE CHART REVIEW

Year	Month	Name of the dispensary	Number of diarrhoea cases reported for the children under five years of age
2019	April	Mosiro	
		Oletukat	
	May	Mosiro	
		Oletukat	
	June	Mosiro	
		Oletukat	

APPENDIX XIX: TRAINING SCHEDULE FOR MOTHERS

TIME	ACTIVITY
8 a.m. -9 a.m.	Arrival and assembly
9 a.m. -9.30 a.m.	Introduction of the participants, researcher and brief overview of what the research is all about.
9.30 a.m-10 a.m.	Training on navigation on the mobile phone for those who may not be very conversant with mobile phones.
10 a.m-10.30 a.m.	Tea break
10.30 a.m-1 p.m.	Training on the interaction of the prototype
1 p.m.-2 p.m.	Lunch break
2 p.m-3 p.m.	Training on the interaction of the prototype
3 p.m-4 p.m.	Questions, answers and comments
4 p.m-4.30 p.m.	Vote of thanks
4.30 p.m.	Disperse

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APPENDIX XX: TRAINING SCHEDULE FOR COMMUNITY HEALTH VOLUNTEERS

TIME	ACTIVITY
8 a.m. -9 a.m.	Arrival and assembly
9 a.m. -9.30 a.m.	Introduction of the participants, researcher and brief overview of what the research is all about.
9.30 a.m. -10 a.m.	Training on the interaction of the prototype
10 a.m-10.30 a.m.	Tea break
10.30 a.m. -12.00 a.m.	Training on the interaction of the prototype
12.00 a.m.-1 p.m.	Training on how to administer the questionnaires
1 p.m-2 p.m.	Lunch break
2 p.m-3 p.m.	Questions, answers and comments
3 p.m-3.30 p.m.	Vote of thanks
3.30 p.m.	Disperse

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APPENDIX XXI: INTERVIEW GUIDE FOR ELICITING PROTOTYPE REQUIREMENTS FROM THE NURSE

Hallo ladies /gentlemen

My name is Abraham Matheka Mutua a PhD student in Information Technology at Durban University of Technology in South Africa.

This interview is intended to elicit diarrhoea information to be used for education to the mothers through a mobile based system. The information collected is purely for academic purposes and may not be used for any other purpose. All answers will be kept confidential and anonymity will be preserved.

Date of interview……....

Mobile telephone number……..

Please provide the following information:

1. Definition of diarrhoea
2. Diarrhoeasigns and symptoms
3. Diarrhoeacauses
4. Diarrhoeaprevention practices
5. Diarrhoeafirst aid measures

Thank you for participating in the interview

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APPENDIX XXII: QUESTIONNAIRE FOR EVALUATION OF THE PROTOTYPE BY MOTHERS.

Hallo ladies

My name is Abraham Matheka Mutua a PhD student in Information Technology at Durban University of Technology in South Africa.

This questionnaire is intended to evaluate the prototype to be used in diarrhoea information dissemination in the area. The information collected is purely for academic purposes and may not be used for any other purpose. All answers will be kept confidential and anonymity will be preserved.

Date of questionnaire ……....

Mobile phone number……..

1. Did you have any challenges using the system? if yes, state the challenges
2. Was the information clear? If no, which areas did you find unclear?
3. What other functionalities do you think should be added to make the system more effective in diarrhoea information dissemination?

Thank you for participating in the study

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APPENDIX XXIII: INTERVIEW GUIDE FOR EVALUATION OF THE PROTOTYPE BY THE COMMUNITY HEALTH VOLUNTEERS AND COUNTY HEALTH OFFICERS

Hallo ladies and gentlemen

My name is Abraham Matheka Mutua a PhD student in Information Technology at Durban University of Technology in South Africa.

This interview is intended to evaluate the mobile phone-based system that will be used in diarrhoea information dissemination in the area. The information collected is purely for academic purposes and may not be used for any other purpose. All answers will be kept confidential and anonymity will be preserved.

Date of interview……....

1. What improvement can you suggest to be done on the system in order to make it more effective in delivering diarrhoea information to the mothers?
2. What other functionalities do you think should be added to make the system more effective in diarrhoea information dissemination?
3. What other information should be added to make the message more interesting to the participants?

Thank you for participating in the interview

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APPENDIX XXIV: INTERVIEW GUIDE FOR EVALUATION OF THE PROTOTYPE BY THE NURSE

Hallo Ladies /Gentlemen

My name is Abraham Matheka Mutua a PhD student in Information Technology at Durban University of Technology in South Africa.

This interview is for evaluating the prototype that is to be used in diarrhoea information dissemination. The information collected is purely for academic purposes and may not be used for any other purpose. All answers will be kept confidential and anonymity will be preserved.

Date of interview……....

Mobile telephone number……..

What improvements would you like to be done on the following sections?

1. Diarrhoeadefinition
2. Diarrhoeasigns and symptoms
3. Diarrhoeacauses
4. Diarrhoeaprevention practices
5. Diarrhoeafirst aid measures
6. Any other areas that should be improved? please suggest

Thank you for participating in the study

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APPENDIX XXV: MAP OF NAROK COUNTY