EFFECT OF USING MOBILE PHONE COMMUNICATION IN THE MANAGEMENT OF TYPE 2 DIABETES MELLITUS AMONG ADULT PATIENTS ATTENDING KITUI COUNTY REFERRAL HOSPITAL, KENYA

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Effect of using mobile phone communication in the management of Type 2 Diabetes Mellitus among adult patients attending Kitui County Referral Hospital, Kenya

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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This thesis has been submitted for examination with our approval as University Supervisors.

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DEDICATION

This work is dedicated to my husband Amos, my children Austin, Westin and Alana for their support and words of encouragement throughout this study.

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ABBREVIATIONS AND ACRONYMNS

ADA	American Diabetes Association
aHR	Adjusted hazard ratio
AIDS	Acquired Immune Deficiency Syndrome
ASFs	Animal Source Foods
BP	Blood Pressure
CG	Control Group
CHD	Coronary Heart Disease
CME	Continuous Medical Education
CrP	Trivalent chromium
CVD	Cardio Vascular Disease
DLF	Diabetes Leadership Forum
DM	Diabetes Mellitus
DSME	Diabetes Self-Management Education
EFAs	Essential Fatty Acids
ESRD	End-Stage Renal Disease
FAO	Food and Agriculture Organization
FBS	Fasting Blood Sugar
FGD	Focus Group Discussion
FP	Family Planning
GI	Glycemic Index
GSMA	Global System for Mobile Communications Association
HbA1c	Glycated haemoglobin
HDL	High Density Lipoprotein
HIV	Human Immuno Deficiency Virus
ICT	Information, Communication and Technology
IDF	International Diabetes Federation

IG	Intervention Group
Kcal	Kilo calories
KCRH	Kitui County Referral Hospital
KDHS	Kenya Demographic and Health Survey
KII	Key Informant Interview
KNH	Kenyatta National Hospital
KNH-UON ERC	Kenyatta National Hospital/ University of Nairobi Ethics and Research Committee
LCD	Low Carbohydrate Diets
LCKD	Low Carbohydrate Ketogenic Diets
LDL	Low Density Lipoprotein
LMICs	Low and Middle Income Countries
MCCR	Moderate-carbohydrate, calorie-restricted, low-fat diet
Mcg	Micro gram
MDGs	Millennium Development Goals
MUFA	Mono Unsaturated Fatty Acids
NACOSTI	National Commission for Science, Technology and Innovation
NEI	Net Effect of Intervention
OADs	Oral Anti-diabetes Drugs
OGTT	Oral Glucose Tolerance Test
OHAs	Oral Hypoglycemic Agents
OPD	Out Patient Department
PSI	Population Services International
PUFA	Poly Unsaturated Fatty Acids
RBS	Random Blood Sugar
RCT	Randomized Control Trial
RDA	Recommended Dietary Allowance

RE	Retinol Equivalents
RR	Relative Risk
SEP	Socio-Economic Position
SFA	Saturated Fatty Acids
SMBG	Self-Monitoring of Blood Glucose
SSA	Sub-Saharan Africa
TB	Tuberculosis
T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
TFAs	Trans Fatty Acids
USA	United States of America
VLCKD	Very Low Carbohydrate Ketogenic Diet
VLDL	Very Low Density Lipoprotein
WHO	World Health Organization

OPERATIONAL DEFINITION OF TERMS

Adherence to dietary practices	Is an observable action or behavior of whether dietary practices are as per recommendations from health authorities
BP diastolic	The measure of the pressure in the blood vessels when the heart rests between beats
BP systolic	The measure of pressure in the arteries during the contraction of the heart muscle
Co morbidity	The presence of one or more additional disorders (or diseases) co-occurring with a primary disease or disorder
Controlled blood pressure	Is the blood pressure below 140/90 and this does not lead to complications
Controlled blood sugar	Is persistently lower blood glucose and glycated haemoglobin levels < 7%
Drug adherence	Refers to whether patients take their medications as prescribed by the doctor
Dyslipidemia	Abnormally high amount of lipids (e.g. triglycerides, cholesterol and/ or fat phospholipids) in the blood
Glycemic control	Refers to control of blood glucose and glycated haemoglobin levels
Glycemic index	A relative ranking of carbohydrate in foods according to how they affect blood glucose levels when consumed
Health seeking behavior	This is any action undertaken by individuals who perceive themselves to have a health problem or to

	be ill for the purpose of finding an appropriate remedy
High glycemic index	These are foods that are digested and absorbed into the bloodstream quickly and cause rapid increase in blood sugar levels
Ketogenic diet	It is a high-fat, adequate-protein, low-carbohydrate diet. The diet forces the body to burn fats rather than carbohydrates
Low glycemic index	These are foods that are digested and absorbed into the bloodstream slowly which causes slow changes in blood sugar levels and, therefore call for less insulin
Macro vascular diseases	Are diseases of large blood vessels including the coronary arteries aorta and arteries in the brain and limbs
mHealth	Mobile health, a term used for the practice of medicine and public health supported by mobile devices
Micro vascular diseases	Are conditions where the small arteries in the heart become narrowed
Mobile phone communication	Is the use of electronic device to pass information
Morbidity	Is the level of health and well-being of an individual
M-Pesa	It is a mobile banking service by Safaricom that allows users to store and transfer money through their mobile phones
Nutrition status	It is the balance between the intake of nutrients by a person and the expenditure of these in the processes

	of growth, reproduction, and health maintenance
Poor glycemic control	Persistently elevated blood glucose and glycated haemoglobin levels > 7%
Resistance training	Any exercise that causes the muscles to contract against an external resistance with the expectation of increases in strength, tone, mass, and/ or endurance
Uncontrolled blood pressure	Is the blood pressure above 140/90 and this is likely to lead to complications

ABSTRACT

The incidence and prevalence of Diabetes Mellitus has been rising globally, Kenya included and it is estimated that by 2030, the number of cases will almost double. The current interventions focus mainly on group health talks, which are not individualized, and have limited influence on adherence to health seeking behavior, drugs, and diet. In addition, there is limited information on the effectiveness of using mobile phone communication in diabetes management. The aim of the study was to determine the effect of mobile phone communication in the management of T2DM among patients attending Kitui Referral Hospital. The study design was longitudinal with qualitative and quantitative components. Consecutive sampling was used where every eligible and consenting Type 2 Diabetes Mellitus (T2DM) patients that came to the hospital in the month of March and April 2017 were selected and assigned to the intervention and control group until the required number of subjects for the study were achieved. One hundred and thirty eight (138) respondents participated in the study; 67 in intervention group (IG) and 71 in the control group (CG). By use of the mobile phone, key nutrition messages on health seeking behavior, drug adherence and dietary practices were developed and sent to the IG for six months. Descriptive statistics were used in describing the socio demographic and economic characteristics, while inferential statistics included odds ratio and logistic regression analysis for morbidity, health seeking behavior, drug and dietary practices. Net Effect of Intervention (NEI) analysis was used to determine the impact of intervention with level of significance set at $p<0.05$. There was no significant difference in the socio-economic characteristics of the IG and the CG. The proportion of respondents with controlled blood pressure (BP) increased from 44.8% to 49.3% in IG compared to a decline from 53.5% to 47.9% in the CG after six months. The NEI was significant ($p=0.046$). The proportion of respondents who conducted self-monitoring of blood glucose (SMBG) increased from 32.8% to 41.8% in IG while it reduced from 39.4% to 31% in CG. The NEI was significant ($p=0.047$). The proportion of respondents who took their drugs at specific times increased from 58.2% to 74.6% in the intervention group (IG) compared to a decrease of 47.9% to 46.5% in the control group (CG). The NEI was significant ($p=0.007$). The proportion of respondents who followed a meal plan increased in intervention group (IG) from 47.8% to 59.7% compared to a decrease in CG from 49.3% to 45.1%. The NEI (16.1%) increase was statistically significant ($p=0.021$). The proportion of respondents with increased frequency of meals increased from 41.8 to 47.8% in the IG compared to a reduction in the CG from 52.1% to 45.1% after six months. The NEI (13%) increase was statistically significant ($p=0.032$). In conclusion, use of mobile phone communication improved adherence to key management practices in the management of T2DM. It is recommended that there should be increased use of mobile phone communication in the management of T2DM.

CHAPTER ONE

INTRODUCTION

1.1 Background information

The term Diabetes Mellitus (DM) describes a metabolic disorder of multiple etiologies characterized by chronic hyperglycemia with disturbances of carbohydrate, fat and protein metabolism (Yigazu & Desse, 2017). The condition may result from defects in insulin secretion, insulin action, or both (Ngugi et al., 2015). The most common form of DM is Type 2 Diabetes Mellitus (T2DM) that accounts for over 90% of diabetes (Animaw & Seyoum, 2017). Diabetes is one of the most common metabolic disorders in the world and its prevalence in adults has been increasing in the last decades (Guariguata, Whiting, Hambleton & Beagley, 2013).

The World Health Organization (2016a) estimated that about 400 million adult people in the world had diabetes in the year 2016 with 1.5 million deaths attributed to it. Data published in 2013 by the International Diabetes Federation (IDF) indicate a global diabetes prevalence of 8.3% (382 million people) with an expected 55% increase (to 592 million people) by 2035 if current trends persist (Nordström, Hadrévi, Olsson, Franks & Nordström, 2016). In 2017, the estimated global prevalence had risen to 425 million people (Mohamed et al., 2018). Africa is expected to witness the greatest increase, rising from 19.8 million people with diabetes in 2013 to 41.4 million in 2035 (Mbanya, Assah, Saji & Atanga, 2014). Nigeria has the highest number of people living with diabetes in Africa (Chinenye & Ogbera, 2013).

Diabetes mellitus (DM) contributes to increasing burden of diseases in developing countries Kenya being one of them (Animaw & Seyoum, 2017). Diabetes incidence is increasing rapidly and it is estimated that by 2030, the number of cases will almost

double (Mwangi & Gitonga, 2014; Oti, van de Vijver, Agyemang & Kyobutungi, 2013). Previous studies in Kenya have found a prevalence of 3.5–5% (Mohamed et al., 2018) with higher prevalence (12.2%) reported in urban areas (Maina, Ndegwa, Njenga & Muchemi, 2011).

Type 2 Diabetes Mellitus (T2DM) is one of the world's most prevalent, costly, and fatal chronic conditions (Mattei et al., 2015). Complications from diabetes, such as stroke, diabetes neuropathy, amputations, renal failure and blindness lead to disability, reduced life expectancy and enormous health costs for virtually every society (Tabish, 2007). Data on the condition of people with diabetes in Sub-Saharan Africa (SSA) and the complications of diabetes that they suffer is very scarce (Tamirat, Abebe & Kirose, 2014). However, by 2014 it was estimated that at least 4.5 million had eye complications. Of these, 2.2 million needed dialysis because of kidney damage while 907,500 had cardio vascular disease (CVD) while about 423,000 were blind because of diabetes. In addition, about 400,000 have cerebro vascular disease and 169,000 had lost a foot because of amputation (Tamirat et al., 2014).

These diabetes cases account for 80% in Low and Middle Income Countries (LMICs) as noted by International Diabetes Federation (2013). Recent reports illustrate steep increases in the global prevalence of T2DM over the past few decades, and these trends are projected to keep rising over the next 20-40 years (Mattei et al., 2015).

At the population level, two factors have been proposed as major reasons for the rapid increase in diabetes worldwide: an epidemiologic transition where communicable diseases have decreased as the major causes of death and a concurrent nutrition transition characterized by increasingly unhealthy dietary habits, combined with lower levels of physical activity (Mattei et al., 2015).

Randomized control trials has shown that early interventions and maintaining the glucose levels leads to improved management of T2DM, prevents frequent morbidity, mortality and loss of body functions (Schulz et al., 2014). By achieving adequate glycemic control, complications are greatly reduced (Ahmad, Islahudin & Paraidathathu, 2014; Philis-tsimikas, 2009). Despite a number of therapies being available for patients with T2DM, some patients do not achieve glycemic control (Polonsky & Henry, 2016). Oral Anti Diabetes (OADs) are normally introduced to achieve glycemic control adequately. Use of Oral Anti Diabetes drugs (OADs) reduces glycated haemoglobin (HbA1c) from 0.5% to 2% (Philis-tsimikas, 2009). However, the use of OADs has side effects and their use is limited by their mechanisms of action which address symptoms of diabetes rather than underlying patho-physiology (Philis-tsimikas, 2009). Further, some OADs lead to hypoglycemia, Gastro Intestinal (GI) problems and weight gain (Ganesan & Sultan, 2019; Philis-tsimikas, 2009). These side effects can lead to hospitalization and mortality (Polonsky & Henry, 2016; Lau & Nau, 2004). In addition, poor adherence to the medication because of misleading reports from the public and media, emotional and behavioral issues may impede their treatment (Lebovitz, 2011). According to Free et al. (2013), the amount of information, encouragement and support that can be conveyed to individuals during face-to-face consultations or through traditional media such as leaflets is limited. New technologies such as mobile phones have the potential to transform the delivery of health messages (Free et al., 2013).

Management of T2DM should begin with an individualized regimen of diet, physical activity, and medical counseling targeted to reduce body weight, maintain ideal glycemic control hence reduction of co morbidities (Ohn et al., 2015). One way of achieving this is to develop a reminder system by use of telecommunication. Mobile technologies are mobile and popular as many people carry their mobile phone wherever they go (Free et al., 2013).

Mobile phones were licensed in Kenya in 1999 (Oteri, Kibet & Ndung'u, 2015). Since then, use of mobile telephone has experienced tremendous growth in the SSA. By 2004, there were over 700 million mobile phone connections in the region. According to Global System for Mobile Communications Association (GSMA, 2012), this is equivalent to 68% penetration rate. This can be attributed to economic growth and increasing affordability of the mobile services

In Kenya, the mobile phone penetration continues to soar from 75.4% reported in 2012 (i Hub Research and Research Solutions Africa, 2012) to 88.1% in 2015 (Communications Authority of Kenya, 2016). Consumers are rapidly using mobile phones in the region not just as a basic communication tool but also use it for accessing information (GSMA, 2012). This view is supported by Aker & Mbiti (2010) who noted that the mobile phones can transform lives through innovative applications and services. Further, use of mobile phones can facilitate access to medical care especially for the low socio-economic populations hence address their socio problems (GSMA, 2012). As technology evolves, networks are being upgraded to higher speed connectivity (InfoDev and World Bank, 2013). As such the use of mobile phones is moving from calls and SMS to advanced apps and services (InfoDev and World Bank, 2013). Consequently, this study is designed to explore the use of telecommunication in management of T2DM in patients attending hospitals.

1.2 Statement of the problem

According to El-busaidy, Dawood, Kasay, Mwamlole & Koraya (2014) over 50% of adult hospital admissions and 55% of hospital deaths in Kenya are as a result of Non-Communicable Diseases (NCDs), and diabetes is the leading cause of this. Mwavua, Ndungu, Mutai & Joshi (2016) noted that there is poor patient attendance at diabetes clinics in Kenya. Mungai (2016) reports that there are high cases of T2DM patients attending Kitui County Referral Hospital for diabetes clinic. On average, the hospital

treats close to 50 patients every week. This is because of the low doctor patient ratio (Ministry of Health, 2015) short consultation times (Gill, Mbanya, Ramaiya & Tesfaye, 2009) and not educating patients on DM management (Mwavua et al., 2016). Other reasons include inadequate monitoring and evaluation for the complications of diabetes, lack of infrastructure to support the services, unaffordable medicines and transportation, unskilled health care providers and inequality in the distribution of healthcare facilities (Mwavua et al., 2016; Park et al., 2015). Some patients resort to use of herbal formulations, whose active ingredients are not well understood (Mwangi & Gitonga, 2014).

There are also the risk of drug interactions between conventional medicines and herbal formulations (Chege, Okalebo, Guantai, Karanja & Derese, 2015; Mwangi & Gitonga, 2014). The management of DM is complex and good control significantly reduces the risk of complications yet studies from around the world concisely demonstrate inappropriate variations in care (Buowari, 2013). Currently, health care systems in developing countries, Kenya included, tend to focus on acute problems of communicable diseases like HIV and AIDS or malaria as noted by Mwavua et al. (2016). The current interventions are delivered as group health talks and have low impact resulting in poor adherence to health seeking behavior, drugs and diet. This leads to hyperglycemia and long-term complications, increased morbidity and premature mortality, ultimately increasing costs of health care. Use of mobile phone communication presents an opportunity of targeting messages to individuals, unlike health talks delivered to groups. It is also easy to monitor the delivery of messages. Further there is widespread ownership of phones by most patients. However, there is limited information on the effectiveness of this approach in the management of DM in the Kenyan setting.

1.3 Justification

Sustainable Development Goal (SDG) Number 3 aims at achieving good health and well-being of individuals (Davies, 2015). The achievement of this SDG is complicated

by the recent increase in the burden of NCDs, including T2DM. This calls for innovative interventions to manage the conditions. The rates of non-adherence to diet plan and physical activity recommendations among T2DM range from 35 to 75% and 70 to 81%, respectively (Ganiyu, Mabuza, Malete, Govender & Ogunbanjo, 2013). Studies have reported that despite the increase in Information and Communications Technology (ICT) application, mobile phones as a management tool in health issues still remain largely underutilized (Ajuwon & Rhine, 2008). This study has availed information in DM management for priority areas of intervention such as health seeking behavior, drug and dietary adherence to manage the problem of diabetes in Kitui County backed by scientific evidence based on need for innovative methods to ensure proper adherence.

The findings of this study can also be used by dieticians and nutritionists to improve and expand their services in ways geared to empowering the T2DM patients on the management of their condition. The study will provide information on the effectiveness of utilization of mobile phones in communication on health issues with T2DM. The information will help inform policy in respect to management of T2DM. The information will help inform policy in respect to improvement in the management of T2DM through use of mobile phone communication in increasing adherence to health seeking behavior, drugs and dietary practices.

1.4 Objectives

1.4.1 General objective

To determine the effect of using mobile phone communication in the management of outcomes of Type 2 Diabetes Mellitus among adult patients aged 20-70 years attending the diabetes clinic at Kitui County Referral Hospital (KCRH).

1.4.2 Specific objectives

1. To establish the socio demographic and socio-economic characteristics of T2DM patients at KCRH.
2. To determine the effect of using mobile phone communication on morbidity and nutrition status of T2DM patients at KCRH.
3. To determine the effect of using mobile phone communication on health seeking behavior of T2DM patients at KCRH.
4. To determine the effect of using mobile phone communication on drug adherence of T2DM patients at KCRH.
5. To determine the effect of using mobile phone communication on dietary practices of T2DM patients at KCRH.

1.5 Hypothesis

The null hypothesis was:

Use of mobile phone communication has no effect on the management of outcomes of Type 2 Diabetes Mellitus patients at KCRH.

This hypothesis was further broken down into the following sub hypothesis for ease of data analysis and interpretation:

Ho_1: Use of mobile phone communication has no effect on morbidity and nutrition status of T2DM patients at KCRH.

Ho_2: Use of mobile phone communication has no effect on health seeking behavior of T2DM patients at KCRH.

Ho_3: Use of mobile phone communication has no effect on drug adherence of T2DM patients at KCRH.

Ho_4: Use of mobile phone communication has no effect on dietary practices of T2DM patients at KCRH.

1.6 Conceptual framework

The conceptual framework (Figure 1.1) was modified from Brown et al. (2004).

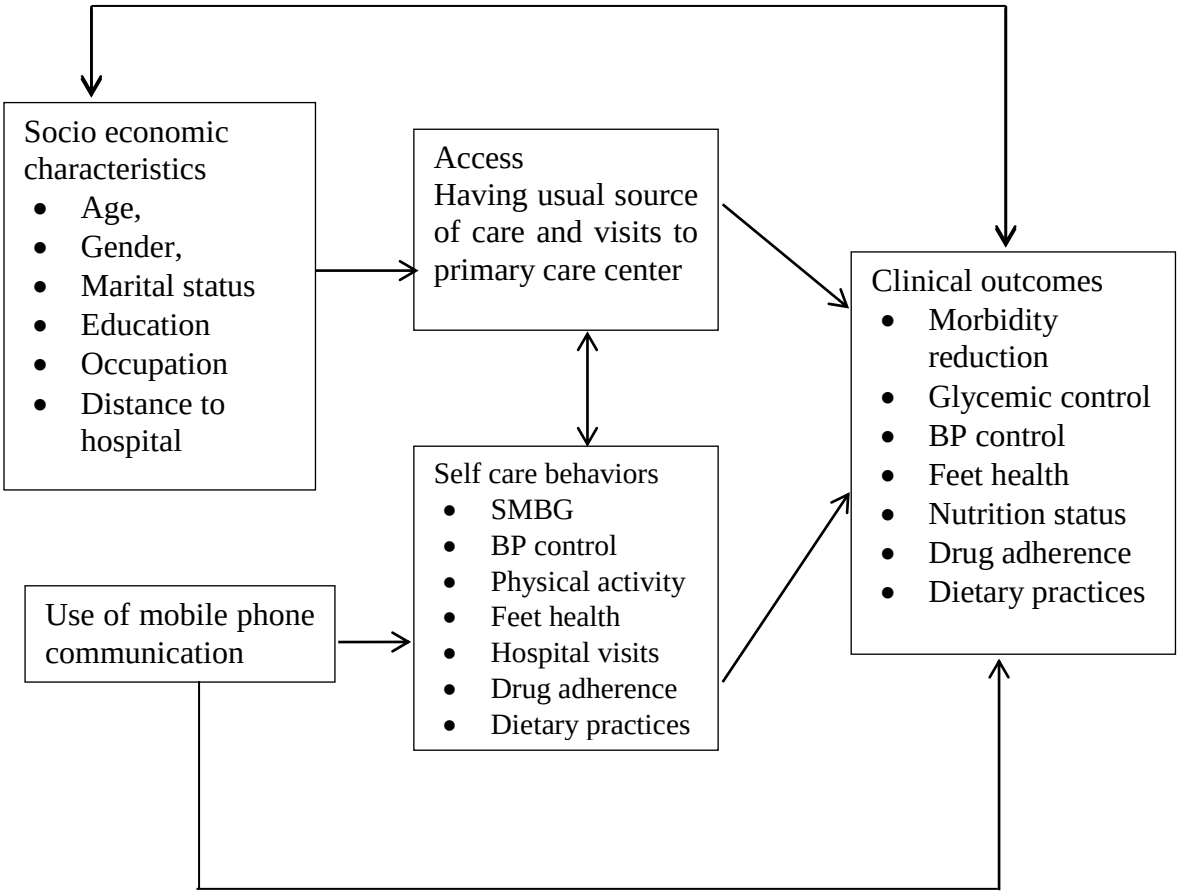


Figure 1.1: Conceptual frame work modified from Brown et al. (2004)

The conceptual framework (Figure 1.1) shows the relationship between socio-economic and demographic factors, health outcomes, and the association between self-care behaviors, access to primary care centre and improved health outcomes of the patient. Socio demographic and economic characteristics such as gender and level of income can have a direct effect on clinical outcome of diabetes. On the other hand, neighborhood may play a role in health status for example availability and distance of health facilities. This in turn leads to better clinical outcomes such as BP control and drug adherence. Use of mobile phone communication has a direct effect on self-care behaviors such as self-monitoring of blood glucose (SMBG) and feet health.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Type 2 Diabetes Mellitus

Diabetes is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both (American Diabetes Association, 2014). Type 2 Diabetes Mellitus (T2DM) is caused by a combination of factors among them changes in lifestyle factors such as obesity, genetics (Chen et al., 2015), a diet high in fat, sugar and carbohydrate, lack of physical activity (Madeline, 2012), stress and age between 45 and 55 years (Mwangi, Githinji & Githinji, 2011). The symptoms of T2DM are polyuria, polydipsia, polyphagia, weight loss, fatigue, blurred vision, and candidiasis (Bastaki, 2015), otherwise raised values on two occasions, of either fasting plasma glucose (FPG) ≥7.0mmol/L (126mg/dl) or with an oral glucose tolerance test (OGTT), two hours after the oral dose a plasma glucose ≥11.1mmol/L (200mg/dl) (Olokoba, Obateru & Olokoba, 2012).

2.2 Diabetes diagnosis

In the majority of people presenting with the classical symptoms of diabetes as explained above, the diagnosis of diabetes is straightforward. However, it may pose a problem for those with a minor degree of hyperglycemia, and in asymptomatic subjects (Ministry of Public Health and Sanitation, 2010). As such, a fasting capillary whole blood glucose >6.1 mmol/L or more confirms the diagnosis of diabetes. Fasting is defined as no energy intake for at least 8 hours. The problem with this test is that it is affected by stress, illness and feeding. The other test is random blood sugar (RBS) of ≥11.1 mmol/l (in patients with classic symptoms of hyperglycemia or hyperglycemic crisis) (American Diabetes Association, 2013).

Since Fasting Blood Sugar (FBS) and RBS are affected by stress, illness and feeding, glycated haemoglobin (HbA1c) tests are desirable standard tests (Ministry of Public Health and Sanitation, 2010). It is also the most commonly accepted measurement of long-term glycemic control (Bonora & Tuomilehto, 2011). According to the current recommendations HbA1c should be checked at least every 6 months if the patient is controlled (HbA1c $\leq$ 7%) and on a stable oral anti-hypoglycemic regimen, otherwise every 3 months (University of Michigan, 2014).

This test is advantageous because it does not require fasting like other methods of testing, which may increase the likelihood that a patient will undergo testing for T2DM and have appropriate diagnosis and treatment (Bonora & Tuomilehto, 2011). Glycated haemoglobin (HbA1c) also measures chronic glucose exposure over a two- to three-month period and is less influenced by factors such as eating, stress and illness than FBS (Kilpatrick & Atkin, 2014). Glycated haemoglobin (HbA1c) is useful in assessing the effectiveness of therapy and guiding the therapeutic decisions (Masoud, 2011). However, it is expensive and is presently unavailable in most of the primary and secondary health facilities in Kenya (Ministry of Public Health and Sanitation, 2010). In addition, there is incomplete correlation between HbA1c and average glucose in certain individuals and HbA1c levels may vary with patients' race/ethnicity (American Diabetes Association, 2013).

2.3 Diabetes in Africa

According to International Diabetes Federation (2015) the prevalence of diabetes in Africa was 425 million in 2015 while future projections are 642 million by the year 2040. The population of SSA is set to grow from around 860 million in 2010 to more than 1.3 billion by 2030. People aged 45-59 years are 8.5 times more likely to develop

diabetes than those aged 15-29 years; and those above the age of 60 are 12.5 times more likely to develop diabetes (Diabetes Leadership Forum, 2010).

The age of onset of T2DM is decreasing in SSA (Diabetes Leadership Forum, 2010). Peak occurrence of T2DM is between the ages of 20 and 44, already 40 years lower than the peak age of occurrence in high-income countries, and it is predicted to fall further (Diabetes Leadership Forum, 2010). This shows that diabetes mainly affects the productive age-group implying that its socio-economic consequences and complications could possibly bankrupt the economies of many developing nations including countries in SSA (Mbanya et al., 2014).

2.4 Diabetes in Kenya

Diabetes is now emerging as an epidemic of the 21st Century and it threatens to overwhelm the health care system in the near future (Alramadan et al., 2018; Maina et al., 2011). Since 1960 there has been a steady increase in the number of known diabetics (Mwangi & Gitonga, 2014). As early as 1966 the magnitude of DM had become sizeable enough necessitating starting of diabetic clinic at Kenyatta National Hospital (KNH) wholly devoted to diabetes (Mwangi & Gitonga, 2014). By the year 2000, diabetic clinic (at KNH) was booking a minimum of 60 patients every week (Kebaso, 2003). Kenyatta National Hospital clinic (KNH) is only one of the clinics dealing with diabetes. There are many such clinics spread all over Kenya including one based in Kitui County Referral Hospital where this study was conducted.

According to Mogre, Abanga, Tzelepis, Johnson & Paul (2017), Kenya and many countries in SSA can not cope with the double burden of chronic non communicable diseases (NCDs) and communicable diseases (CDs). This rise in incidence and prevalence of diabetes is associated with demographic and social pattern changes that are primarily driven by globalization and urbanization (Kibachio et al., 2013). These

changes include an ageing population, excessive consumption of alcohol and cigarettes, consumption of unhealthy diets, physical inactivity and overreliance on motorized transport (Mbanya et al., 2014; Kibachio et al., 2013).

Currently diabetes has no cure but patients can be managed and live a relatively normal life free of complications (Mwangi & Gitonga, 2014). Diabetes can be managed using insulin, oral hypoglycemic agents and diet combined with exercises (Mwangi & Gitonga, 2014). The National Clinical Guidelines for Management of Diabetes Mellitus, used by healthcare workers in Kenya, recommends specific self-care practices which patients are advised on (Ministry of Public Health and Sanitation, 2010). Such include diet, exercise and pharmacological management.

Studies indicate that treatment and control of diabetes can be highly cost effective because medical care expenditures are avoided when therapy defers or delays the development of complications (Mwavua et al., 2016). Abdulrehman, Woith, Jenkins, Kossman & Hunter (2016) noted that illiteracy, poverty, lack of diabetes policies/guidelines, and inadequate medical resources impede people's management of diabetes in Kenya. In addition, poor access to medications, finances, transportation and lack of skilled health care providers trained in DM management is a barrier that contributes to poor outcomes for patients with DM in Kenya (Park et al., 2015).

Kitui County Referral Hospital (KCRH) is the host to about 2400 patients with diabetes each year (Mungai, 2016). Most of them attending the diabetes clinic for the diabetes services or may be hospitalized to receive inpatient care. Despite the disease burden of communicable Diseases (CDs) health status has stagnated due partly to the increase of Non communicable Diseases (NCDs) (Jones, 2013). The double demand from CDs and NCDs has hindered Kenya's progress towards achieving the Millennium Development

Goals (MDGs) (Jones, 2013). The Kenyan Ministry of Health estimates the prevalence of diabetes to be around 10% (3.5 million people) (Mwangi et al., 2011).

The number of diabetes cases is estimated to rise dramatically in the near future in most developing and intermediate societies, affecting particularly urbanizing societies and the middle-aged population (Hussain et al., 2012). In addition, the prevalence of impaired glucose tolerance is equally high (8.6% in the rural population, and 13.2% in the urban population) (Maina et al., 2011). Further, up to 50% of diabetes cases in Kenya are undiagnosed (Mwangi et al., 2011).

2.5 Management of T2DM

In SSA, evidence indicates that much of the death and disability related to diabetes can be prevented with cost effective interventions (Mwavua et al., 2016). Healthy eating patterns, regular physical activity, and often pharmacotherapy are key components of diabetes management (Evert et al., 2013). According to Mwavua et al. (2016), emphasis in care has been on drug therapy, but omitting components such as education, nutrition counseling and psychosocial support. These challenges are compounded by regionally unique social, cultural and economic issues (Mwavua et al., 2016). Early education intervention can halt or even reverse the progression of the disease (Philis-tsimikas, 2009). Poor glycemic control as a result of poor diet and exercise adherence have been associated with micro vascular complications; 68.5% neuropathy, 56.1% nephropathy and 31.4% of retinopathy respectively (Ali et al., 2013). According to the writers, recent evidence indicates that aggressive glycemic control in T2DM is associated with a 25% lower incidence of micro vascular end points (Ali et al., 2013).

2.5.1 Diabetes education

Several studies have reported that knowledge about diabetes is poor among patients with diabetes in both the developed and developing countries (Islam et al., 2014). Effective diabetes education leads to better control of the disease, and is widely accepted to be an integral part of comprehensive diabetes care and management (Islam et al., 2015). Studies have shown that recommended glycemic goals are achieved by less than 50% of patients, which may be associated with decreased adherence to therapies (Garcı´a-Pe´rez, A´lvarez, Dilla, Gil-Guille´n & Orozco-Beltra´n, 2013).

Diabetes self-management education (DSME), the process of teaching individuals to manage their diabetes has been considered an important part of diabetes management (Divya & Nadig, 2015). According to Shrivastava, Shrivastava & Ramasamy (2013), there is a fourfold increase in diabetes complications for those individuals with diabetes who have not received formal education concerning self-care practices.

Past research show that patients who do self-monitoring techniques for example monitoring of the food intake, physical activity, and glucose levels, have better control of their diabetes (Charity et al., 2015). A meta-analysis in China on T2DM by Choi, Davidson, Walker, Lee & Palermo (2016) reported a pooled effect of HbA1c reduction of 1.19% larger than what has been previously reported within Western literature of 0.76% (Norris, Lau, Smith, Schmid & Engelgau, 2010) indicating the importance of diabetes education.

In this meta-analysis, glycemic improvement among intervention groups was twice that of control groups (usual care or no education). Diabetes education have shifted away from giving didactic instructions to a facilitative collaborative education based on ‘empowerment models’ (Naik, Teal, Rodriguez & Haidet, 2012) that promote greater patient participation and collaboration (Norris et al., 2010).

In developing countries, the focus is on acute disease management but little patient follow up coupled with sub-standard care and the complications of diabetes are often not screened for, recognized or treated (Grant, 2013). Grant (2013) further observed that among the problems associated to T2DM is access to health education on diet and lifestyle modification. Diabetes patients should receive individual, ongoing nutritional advice from a registered dietitian and this has been shown to help in achieving treatment goals (Liu, Zhang, Wu, Wang & Li, 2015) hence prevent the risk of CVDs, and maintain the glycemic levels (Kassahun, Eshetie & Gesesew, 2016).

It is also essential that persons with diabetes attend follow up visits by health care professionals in order to manage diabetes (Hawkins, 2015; Mukhopadhyay, Paul, Das, Sengupta & Majumder, 2010). Dieticians handling diabetes have the role of education on weight management, diet and combinations of drugs and diet in the management of T2DM and as a result, this is associated with lower HbA1c and a better quality of life (Trento et al., 2008). Culturally appropriate health education is more effective in the management of diabetes (Attridge, Creamer, Ramsden, Cannings-John & Hawthorne, 2015).

According to Diabetes Australia (2016), patients with diabetes and lower literacy or numeracy skills are at greater risk for poor diabetes outcomes. Al Sayah, Majumdar, Williams, Robertson & Johnson (2013) in their systematic review on DM patients showed that higher levels of health literacy were associated with better glycemic control. According to the writers, low levels of health literacy are more prevalent in minority populations, among persons for whom English is a second language, people with low levels of income and education, and people with a compromised health status and elder communities - the very same populations that carry the greatest burden of chronic conditions for example diabetes (Al Sayah et al., 2013). The same view is supported by

Al-Rasheedi (2014) that low educational status has been associated with negative effect on glycemic control.

In a study of patients with T2DM who underwent an in-patient, Structured Intensive Diabetes Education Programme (SIDEP) versus hospitalized patients aiming for glycemic control without intensive education, the group receiving intensive education had significantly improved HbA1c levels, less frequent subsequent hospitalizations and better self-care behavior (Philis-tsimikas, 2009). A meta-analysis on DM by Norris et al. (2010) showed that self-management education improves HbA1c levels at immediate follow up, and increased contact time increases the effect. However, the benefit declines 1–3 months after the intervention ceases suggesting that learned behaviors change over time (Norris et al., 2010).

2.5.2 Dietary management of T2DM

Insulin is the mainstay for patients with Type 1 Diabetes Mellitus (T1DM) while diet and lifestyle modifications are considered the cornerstone for the treatment and management of T2DM (Bastaki, 2005). For many individuals with diabetes, the most challenging part of the treatment plan is determining what to eat (Evert et al., 2014).

2.5.2.1 Carbohydrates

Carbohydrate foods, which are rich in fiber and have a low energy density are the basis of the eating plan (Ajala, English & Pinkney, 2013; Amod et al., 2012) and it is recommended that they contribute up to 45–65% of the total energy intake (Slavin & Carlson, 2014; Amod et al., 2012). However, this approach is often challenged because a high-carbohydrate diet exacerbates hyperglycemia (Feinman et al., 2015) and dyslipidemia (Ko, Kalantar-Zadeh, Goldstein-Fuchs & Rhee, 2017; Larsen, Mann, Maclean & Shaw, 2011). For the management of T2DM, a high-fiber, low-glycemic-

index sources of carbohydrate in the diet, such as fruit, vegetables, whole grains and pulses are recommended (Evert et al., 2014; Eswaran, Muir & Chey, 2013).

A ten to 12 day-dietary therapy with Low Carbohydrate Diet (LCD) on T2DM patients was shown to improve blood glucose profile (Bando, Ebe, Muneta, Bando & Yonei, 2017). In the study, patients with high HbA1c could be safely treated by LCD (Bando et al., 2017). In another study by Westman, Yancy, Mavropoulos, Marquart & Mcduffie (2008) on the effect of a low-carbohydrate, ketogenic diet (LCKD) versus a low-glycemic index diet on glycemic control in T2DM patients, a low-glycemic index, reduced-calorie diet and a LCKD led to improvement in glycemic control, diabetes medication elimination/ reduction, and weight loss in adherent overweight and obese individuals with T2DM over a 24-week period.

The diet lower in carbohydrates, the LCKD, was most effective for improving glycemic control. In this study, for patients taking insulin, the effects were often quite powerful. For example, participants taking from 40 to 90 units of insulin before the study were able to eliminate their insulin use, while also improving glycemic control. However, since this effect occurs immediately upon implementing the dietary changes, individuals with T2DM who are unable to adjust their own medication or self-monitor their blood glucose should not make these dietary changes unless under close medical supervision (Westman et al., 2008).

Hussain et al. (2012) compared a Very Low Carbohydrate Ketogenic Diet (VLCKD) with a low-calorie diet over a 24-wk period in 102 diabetes and 261 non-diabetes individuals. In the end, blood glucose dropped more dramatically in the VLCKD group than in those given the low-calorie diet (Hussain et al., 2012). Another study in USA on T2DM patients by Thomas, Elliott & Naughton (2009) found similar results. In the study, participants in the LCK group evidenced greater reductions in HbA1c and weight

than did participants in the moderate-carbohydrate, calorie-restricted, low-fat diet (MCCR) group.

In addition, the greater reductions in HbA1c in the LCK group occurred despite greater reductions in glucose lowering medications (Saslow et al., 2017). Use of modified plate method containing portion-controlled carbohydrates is recommended for illiterate patients (Lynch et al., 2014). Patients should be advised to refrain from intake of carbohydrates containing added fats, sugars and sodium (Evert et al., 2014; Lynch et al., 2014).

2.5.2.2 Dietary fiber

Low glycemic index (GI) diets may reduce HbA1c up to 0.5 per cent compared to intake of high GI foods according to Chiavaroli et al. (2016) In a meta-analysis on T2DM patients by Ajala et al. (2013), data from the 3 studies that compared low-GI with other diets showed a 20.1% decrease in HbA1c in subjects who consumed low-GI compared with control diets (95% CI: -0.23%, -0.03%; p= 0.008). Fiber rich foods such as cereals, whole grains, fruits and vegetables should be consumed to meet > 50g of fiber/ day to have a decrease in HbA1c (Evert et al., 2014). Fiber intake has a beneficial effect on serum cholesterol levels and other CVD risk factors such as BP (Evert et al., 2013).

There has been documented evidence that high fiber diet contributes to weight loss (Chandalia et al., 2000). However, Chandalia et al. (2000) demonstrated that patients' weight did not change with high fiber diet. This could be because the degree of reduction in absorption of fats was insignificant and fiber improves glycemic control by delaying absorption of carbohydrates (Chandalia et al., 2000). Despite the beneficial properties of consuming dietary fiber in T2DM patients, there is substantial barriers for example un palatability, gastrointestinal side effects and consumer preference for refined products (Eswaran et al., 2013).

2.5.2.3 Proteins

Protein and/ or amino acid co-ingestion has been shown to increase postprandial insulin responses 2-4 fold, thereby increasing blood glucose disposal and lowering the postprandial rise in blood glucose concentration (Manders et al., 2014). The role of protein in the management of hyperglycemia in T2DM has also been investigated since glucose can be derived from the constituent amino acids through gluconeogenesis (Gannon, Nuttall, Saeed, Jordan & Hoover, 2003). Furthermore, proteins do not have GI and in those with controlled T2DM, dietary protein does not raise plasma glucose concentration right after a meal (Meyer, 2009; American Diabetes Association, 2008). However, there may be an association between high-protein diets and the risk of developing diabetes nephropathy (Ko et al., 2017; Larsen et al., 2011).

Other studies have shown that substituting a protein for carbohydrate improves glycemic control in the short-term (Gannon & Nuttall, 2004). Further, an increase in protein content in the diet particularly if associated with a decrease in carbohydrate content would result in a decrease in the integrated glucose concentration (Gannon & Nuttall, 2004). Such a diet could be useful for controlling blood glucose in persons with T2DM, provided it does not result in any adverse effects. In the study on T2DM patients, HbA1c decreased 0.8% and 0.3% after 5 week of the high-protein and control diets, respectively; the difference was significant ($p<0.05$) (Gannon et al., 2003).

Larsen et al. (2011) demonstrated that the contrary happens in the long-term. In their RCT done to determine the effect of high-protein, low-carbohydrate diets in the treatment of T2DM for 12 months, there was no superior long-term metabolic benefit of a high-protein diet over a high-carbohydrate in the management of T2DM. In this study, HbA1c decreased in both groups over time, with no significant difference between

groups (mean difference of the change at 12 months; 0.04 [95% CI −0.37, 0.46]; p=0.44) (Larsen et al., 2011).

2.5.2.4 Fat intake

Good quality fat is important in the management of T2DM. High-fat intake (>37% of total energy) worsen insulin resistance due to the interference with the binding of insulin to its receptors and accumulation of triglycerides in the skeletal muscle (Weickert, 2012). The primary dietary fat goal in persons with diabetes is to limit saturated fat and dietary cholesterol intake (Gray, 2015). Mono Unsaturated Fatty Acids (MUFA) and Omega-3 fatty acids help to achieve glycemic control and reduce the risk of CVDs (Evert et al., 2014).

Diets high in MUFA are also associated with improved peripheral insulin sensitivity control (Imamura et al., 2016) and triglyceridemia (Meyer, 2009). Imamura et al. (2016) in their meta-analysis on glucose-insulin homeostasis found that replacing 5% energy from carbohydrate with Saturated Fatty Acids did not have significant effect on fasting glucose (+0.02mmol/L 95% CI = -0.01, +0.04; n trials = 99). In the same meta-analysis, the most consistent favorable effects were seen with Poly Unsaturated Fatty Acids (PUFA) which was linked to improved glycemia, insulin resistance, and insulin secretion capacity.

Consumption of trans unsaturated fatty acids has similar adverse effect to that of saturated fatty acids on Low Density Lipoprotein (LDL) and, in addition lowers High Density Lipoprotein (HDL) (World Health Organization, 2016b). However, de Souza et al. (2015); Accurso et al. (2008) have argued that total fat in the diet is not associated with an increase in CVDs. Having explored the pros and cons of dietary fat, the following recommendations should be followed: Restriction of total fat the total fat to < 35% of total energy per day, reducing Saturated Fatty Acids (SFAs) to < 7% of total

energy per day, MUFAs to < 10% of total energy per day, while PUFAs intake should be < 10% of the total energy intake per day, and Trans Fatty Acids (TFAs) to < 1% of total energy, and < 300mg of total dietary cholesterol per day (Evert et al., 2013; Amod et al., 2012).

2.5.2.5 Sugars and sweeteners

Sweeteners provide a useful means of reducing energy intake in addition to making food palatable (Goldfein & Slavin, 2015). Sugar alcohols or polyols sweeten with less energy per gram, averaging 8.4 kilojoules per gram (2kcal/g), because they are not fully absorbed from the gut and thus less available for energy metabolism (Meyer, 2009; American Diabetes Association, 2008). Studies have also shown that under certain circumstances, mono- and disaccharides do not deteriorate glycemic control or elevate lipid levels (Bastaki, 2005). An example of such sweeteners is sorbitol and fructose which has been widely recommended for diabetes in the past (Bastaki, 2015). These sugar alcohols cause less hyperglycemia than naturally occurring sugars and may also decrease the risk of dental caries (Bastaki, 2015). The sugar alcohols are only partially absorbed from the intestinal tract and therefore may lead to diarrhea or gastrointestinal discomfort, especially if consumed in higher amounts (Grembecka, 2015).

Fructose may increase fasting triglycerides and Very Low Density Lipoprotein (VLDL) (in levels above 12%) energy) (Gray, 2015), and can cause gastrointestinal disturbances when taken in large amounts (Bastaki, 2005). High fructose consumption also leads to obesity, insulin resistance, dyslipidemia and hypertension and high risk for T2DM and CVDs (Bastaki, 2015). It has been recommended that sucrose plus other added sugars provide no more than 10% of total energy requirement (World Health Organization, 2018a; Bastaki, 2015).

Rapidly absorbable carbohydrates such as sucrose or high-fructose corn syrup and large amounts of sweetened beverages should be avoided to lower the risk of weight gain (Evert et al., 2014), BP, insulin sensitivity, and de novo lipogenesis in overweight and obese (Gray, 2015; Ley, Hamdy, Mohan & Hu, 2014). Sucrose has also been shown to have the same impact as starch on glycemic control (Fowler, 2007). In addition, it may cause less postprandial hyperglycemia, but there is some evidence suggesting that it may also lead to or worsen hyper lipidemia (Fowler, 2007). However, foods that contain naturally occurring fructose, such as fruits, do not need to be avoided (Fowler, 2007; Franz et al., 2004) because of their relatively slow digestion and absorption unless consumed in an excess amount (>10% of energy) (Ley et al., 2014).

According to Fowler (2007), patients should exercise caution whenever introducing artificial sweeteners into the diet or decreasing their carbohydrate consumption. Making these changes without adjustment in diabetes medications could cause hypoglycemia, especially in patients using insulin. Short-term studies have shown that replacing added sugar with nonnutritive sweeteners reduces body weight and improves glycemic control, but the long-term effects need to be investigated (Ley et al., 2014).

2.5.2.6 Vitamins and minerals in T2DM patients

Diabetes patients should be informed about the importance of acquiring daily vitamin and mineral requirements through a well-balanced diet because uncontrolled diabetes leads to micro nutrient deficiencies (Ley et al., 2014). It is recommended that meal plans should contain optimal nutrients to meet the recommended dietary allowance (RDAs) or dietary reference intake for all micronutrients (DRIs) (American Diabetes Association, 2013). Diabetes patients with uncontrolled hyperglycemia, especially those on chronic diuretic therapy are prone to develop deficiencies in some minerals, notably potassium, magnesium, and zinc.

There is no evidence to support routine supplementation with vitamins and minerals, as well as use of herbal products in patients with T2DM who do not have the underlying deficiencies (American Diabetes Association, 2013). However, the elderly, pregnant or lactating women, vegetarians and those on energy-restricted diets, a multivitamin supplement may be necessary (American Diabetes Association, 2013). Specifically, micronutrient deficiencies of iron and zinc are recognized worldwide as of public health concern (Ministry of Health, 2011). In addition, chromium and magnesium are discussed in this chapter because of their role in diabetes management.

2.5.2.6.1 Iron

According to Leenstra et al. (2004), anemia remains one of the most prevalent and enfeebling morbidities suffered by individuals in the developing world and is a critical comorbid factor contributing to the excess mortality in these regions. Chronic anemia, especially when associated with severe micronutrient deficiencies, may affect lead to fatigue and hence affect physical work capacity (Ming & Rahman, 2002).

2.5.2.6.2 Zinc

People with uncontrolled diabetes have increased zinc losses in the urine and these losses are counter balanced by enhanced zinc absorption in the gut (Cruz, de Oliveira & Kyria, 2015). The other benefit of zinc is in healing skin ulcerations that are likely to occur in T2DM because of decreased immunity (Chehade, Sheikh-Ali & Mooradian, 2009). High serum zinc has been shown to be protective against the development of CVD and also play the roles of anti-oxidant, synthesis, storage and secretion of insulin (Sarmento, Silva, Sbruzzi, Schaan & de Almeida, 2013). According to Chehade et al. (2009), zinc deficiency, especially in high-risk patients such as those with prolonged glycosuria and diuretic therapy can be given supplementation of zinc sulfate, 220mg three times daily. Because prolonged zinc supplementation may inhibit copper

absorption and adversely affect lipid profiles, this should be initiated for no more than 3 months (Chehade et al., 2009).

2.5.2.6.3 Chromium

Chromium acts as a co factor for insulin action (Costello, Dwyer & Bailey, 2016; Dey, Attele & Yuan, 2002). Trivalent chromium (CrP), or chromium 3, is found in foods and dietary supplements (Costello et al., 2016) and is more bio available compared to chromium chloride (CrCl3) (Cefalu & Hu, 2004). Supplemental chromium has been shown to decrease fasting glucose levels, improve glucose tolerance, lower insulin levels, and decrease total cholesterol and triglycerides, while increasing HDL cholesterol in T2DM patients and without chromium, insulin's action is blocked and glucose levels are elevated (Matheka & Alkizim, 2012).

A large clinical study involving 180 diabetes patients as they continued their medication, they were placed in 3 groups (placebo, 100 micro gram (mcg) chromium picolinate twice daily and 500mcg chromium picolinate twice daily) (Dey et al., 2002; Anderson et al., 1997). There was a significant dose and time dependent decrease in HbA1c, FBS and two-hour postprandial insulin values and total cholesterol, particularly in the 500mcg twice daily group (Dey et al., 2002; Anderson et al., 1997). However, another study did not yield positive results. In a controlled six-month study to determine the effect of 200mcg/day chromium picolinate on individuals with T2DM, there was a decrease in triglycerides but no statistical difference between control and chromium- treated subjects with respect to measured parameters of glucose control (Dey et al., 2002).

2.5.2.6.4 Magnesium

There is some evidence that higher dietary intake of magnesium may help prevent T2DM in people at risk of developing the disease (Gray, 2015). Hypomagnesemia is

common in patients with diabetes (Cheng, 2013), especially those with glycosuria, ketoacidosis, and excess urinary magnesium losses (Yeh, Eisenberg, Kaptchuk & Phillips, 2003). Deficiency of magnesium can potentially cause states of insulin resistance. Magnesium is also important in prevention of diabetes complications (Yeh et al., 2003). It may increase insulin secretion and/ or improve insulin sensitivity and peripheral glucose uptake (Matheka & Alkizim, 2012). Magnesium is needed for cardio vascular system and skeletal muscles and hence deficiency, readily detectable because of low serum levels (Chehade et al., 2009). Increased magnesium intake can be achieved through diet without the use of supplements. Foods rich in magnesium include whole grains, green vegetables, nuts and many bean varieties (Gray, 2015; Matheka & Alkizim, 2012).

2.5.3 Exercises and weight loss in T2DM patients

Physical activity includes all movement that increases energy use, whereas exercise is planned, structured physical activity and it is recommended that diabetes patients receive at least 150 min/ week of physical activity (Colberg et al., 2016). Exercises improve insulin sensitivity that has been reported to persist for up to 48 hours following a single bout of exercise (Van dijk, Tummers, Stehouwer, Hartgens & Loon, 2012). Knowledge of the effects of exercises in T2DM patients can not be overlooked since T2DM patients have an increased risk of morbidity and mortality rates from CVDs two to four fold higher compared to the ones without diabetes (Khunti et al., 2015). Though there is need to manage weight in T2DM as studies have shown, regular, moderate physical activity reduces HbA1c and this is independent of weight loss in T2DM (Fowler, 2007; Pastors, Warshaw, Daly, Franz & Kulkarni, 2002).

One of the goals in nutritional therapy is to achieve and maintain body weight (Evert et al., 2013). Obesity especially abdominal obesity is associated with insulin resistance,

hyperinsulinemia, hyperglycemia, dyslipidemia and hypertension that are associated with T2DM complications (Jung & Choi, 2014; Boule´, Haddad, Kenny, Wells & Sigal, 2001). According to Gaal & Scheen (2015), weight loss can be brought about by a reduction of calorie intake of about 600 calories to 475 calories per day that result to a weight loss of 0.5kg a week.

A weight loss of 5–10% of body weight can improve fitness, reduce HbA1c levels, improve CVD risk factors, and decrease use of diabetes, hypertension, and lipid-lowering medications (Gaal & Scheen, 2015). Sustained weight loss of approximately 5kg is associated with a reduction in HbA1c levels of approximately 0.5–1% (Diabetes Australia, 2016). Exercises also have the benefit of low cost and they have non-pharmacological nature (Boule´ et al., 2001). However, the disadvantages of exercises are sustainability and minor musculoskeletal injuries and potential problems that are associated with neuropathy such as foot trauma and ulcers as a result of increased activity (Thomas et al., 2009).

In a meta-analysis on T2DM patients by Boule´ et al. (2001), exercises have been shown to reduce HbA1c by approximately 0.66%. This amount is significantly able to reduce the risk of diabetes complications. In addition, exercise training decrease hepatic and muscle insulin resistance and increase glucose disposal through a number of mechanisms that would not necessarily be associated with weight changes (Boule´ et al., 2001). An example of such a mechanism is exercise bring changes in muscle composition favoring increased glucose disposal (Röhling, Herder, Stemper & Müssig, 2016). Resistance training may be beneficial as an adjunct to standard care in this patient population according to Castaneda et al. (2002). In their Randomized Control Trial (RCT) of resistance exercise training to improve glycemic control in older adults with T2DM, there was improvement in glycemic control with resistance training; however,

this was independent of insulin use, years of diabetes, the change in diabetes medications, and the change in spontaneous physical activity (Castaneda, et al., 2002).

In a review done by Thomas et al. (2009) on T2DM patients, there was a significant lowering in plasma triglycerides in the exercise group compared with the control group though there was no significant difference between groups in total cholesterol and BP. According to Colberg et al. (2016), mild to moderate exercises rather than high intensity exercises that are hard to sustain are recommended. It is important to wear correct footwear when exercising especially if there is neuropathy, vascular disease, or foot ulcers (Colberg et al., 2016). Further, patients should look out for blisters and areas of redness after exercises and should consider delaying exercise if their blood glucose is > 250mg/dl and ketones are present or if their blood glucose level is > 300mg/dl (Fowler, 2007). They should monitor blood glucose before and after physical activity and be cautious about hypoglycemia, which can develop during or even several hours after exercise (Fowler, 2007). They should have carbohydrate sources available and consume them as necessary to avoid hypoglycemia (Colberg et al., 2016; Fowler, 2007).

Bariatric surgery may be considered in adults with Basal Mass Index (BMI) above 40kg/m2, and those with BMI > 35kg/m2 with co morbidities such as T2DM (Lebovitz, 2011). Bariatric surgical procedures, such as roux-en-Y gastric bypass (rYGB) and biliopancreatic diversion, caused striking improvements in hyperglycemia in severely obese patients with T2DM within days or weeks of the procedure and before the patients had experienced any notable weight loss (Lebovitz, 2011). However, it is only considered in those unable to lose weight with conventional therapy and those without contraindications for surgery (Larsen, Kronenberg, Melmed & Polonsky, 2003). Lack of motivation, physical problems such as injuries and weather conditions are the prominent barriers to adherence to exercises. Again, weight loss can only be achieved and maintained over a long period of time (García-Pérez et al., 2013).

2.5.4 Use of insulin and oral hypoglycemic agents

The ultimate goal in DM therapy is to achieve glycemic control (Vervloet et al., 2012) and this involves an interplay of self-management measures, including medication schedules (Waari, Mutai & Gikunju, 2018). Type 1 Diabetes Mellitus (T1DM) patients require life-long administration of insulin (Iqbal, Novodvorsky & Heller, 2018). Lifestyle modification can improve glycemic control in T2DM (Diabetes Australia, 2016; Charity et al., 2015).

However, lifestyle modification for example diet is not enough to achieve glycemic control and must be combined with pharmacological agents (one or more oral agents, and eventually insulin therapy) (Cavaiola & Pettus, 2017). All of the hypoglycemic agents, except metformin bring about weight gain while the use of insulin therapy brings about hypoglycemia and weight gain (Home et al., 2014). Studies have demonstrated that there is an inverse association between taking a prescribed Oral Hypoglycemic Agents (OHAs) and HbA1c level, with each 10% increase in OHA adherence associated with a decrease of 0.1% in HbA1c ($p<0.001$) (García-Pérez et al., 2013).

2.5.5 Use of alternative therapies in T2DM management

Alternative treatments for diabetes have become increasingly popular in the last several years, including medicinal herbs, nutritional supplementation, acupuncture, and hot tub therapy (Kibiti & Afolayan, 2015; Dey et al., 2002). It has been reported that 75-90% of the populations in developing countries rely on traditional remedies for treatment of various diseases (Chege et al., 2015). Complementary and/ or alternative medicine is cheaper than conventional medicine, safe and with no side effects, acceptable and effective (Ngugi et al., 2015).

2.5.5.1 Physical interventions in T2DM

2.5.5.1.1 Acupuncture

This can help relieve the pain associated with diabetes neuropathy by stimulation of certain points (Mwangi & Gitonga, 2014). Acupuncture can act on the pancreas to enhance insulin synthesis, increase the number of receptors on target cells, and accelerate the utilization of glucose; resulting in lowering of blood sugar (Matheka & Alkizim, 2012). In addition, acupuncture has been shown to have anti-obesity effect which is the most modifiable risk factor for T2DM (Matheka & Alkizim, 2012). However, a qualified practitioner should be consulted (Mwangi & Gitonga, 2014).

2.5.5.1.2 Hydrotherapy (Hot tub therapy)

This complementary and alternative therapy (CAT) increases blood flow to skeletal muscles and has been recommended in diabetes patients who are unable to exercise (Kibiti & Afolayan, 2015; Matheka & Alkizim, 2012). It is also suitable for weight management, mean plasma glucose level and mean HbA1c (Kibiti & Afolayan, 2015). One study reported that eight patients were asked to sit in a hot tub for 30 minutes daily for three weeks. During the study period, patients' weight, mean plasma glucose level and mean HbA1c decreased. Caution must be exercised especially with patients with neuropathy as they may not realize they are burning when they have diabetes neuropathy (Matheka & Alkizim, 2012).

2.5.5.2 Herbal medicine in T2DM

According to Mwangi & Gitonga (2014), people on all continents have used hundreds to thousands of indigenous plants for treatment of ailments since prehistoric times. In their study on perceptions and use of herbal remedies, 12.4% of those interviewed admitted to

having used herbal remedies (Mwangi & Gitonga, 2014). Herbal remedies are preferred because they have no side effects and are less costly (Maina et al., 2015).

Although there is no herbal substitute for insulin, some herbs may help adjust blood sugar levels or manage other diabetes symptoms. For example, gingko (*Gingko biloba*) may maintain blood flow to the retina, helping to prevent diabetes retinopathy (Mwangi & Gitonga, 2014). *Momordica charantia* (Linn/Family: Cucurbaceae) whose fruit is known as Karela/corilla, or bitter gourd juice has been shown to treat symptoms of diabetes (Kibiti & Afolayan, 2015; Bastaki, 2005). In one study using *M. charantia*, urinary excretion of sugar was reduced and insulin injections were stopped (Bastaki, 2005).

Animal studies on the use of *M. charantia* in diabetes have yielded contradictory results. For example, no effect was observed by Rao, Kesavulu & Apparao (2001) in a study on streptozotocin-induced diabetes rats. Another study done by Maina et al. (2015) on hypoglycemic effect of ethanoic extract of a herbal drugs formulation used by Kenyan herbalists showed that the highest dose of the extract lowered the blood glucose level from a peak 373.5± 13.6mg/dl to 167.4± 11.4mg/dl. The decrease was found to be comparable to the conventional drug, which lowered the blood glucose levels from the peak 344.7 ± 11.5mg/dl to 144.0 ± 78.9mg/dl (Maina et al., 2015). The problem with herbal remedies is that their use is not regulated and some may cause interactions with contemporary medicines (Mwangi & Gitonga, 2014).

2.6 Challenges facing diabetes management

2.6.1 Ignorance in T2DM

Maina et al. (2011) cited knowledge as the greatest weapon in the fight against DM. It is knowledge that motivates patients to seek proper treatment and care and inspires them to

take charge of the disease. Maina et al. (2011) in the study on diabetes found that only 49% of the population had positive attitude towards the disease. Among the challenges facing T2DM is poor health seeking behavior that results in late diagnosis. Majority of patients come to facilities with complications (Idemyor, 2010). As a result of economic costs (Mwavua et al., 2016; Maina et al., 2011), and lack of confidence on biochemical models, some DM patients seek alternative therapy such as herbal remedies (Mwangi & Gitonga, 2014; Idemyor, 2010).

2.6.2 Influence of socio-economic status on T2DM management

According to Brown et al. (2004), T2DM disproportionately affects socially and materially disadvantaged adults. Effective therapies are available for managing diabetes and preventing or treating its complications but these therapies are underutilized, particularly among persons of low socio-economic status (Brown et al., 2004). With Kenya's per capita Gross Domestic Product (GDP) estimated at $1200 a year, most diabetes patients even with subsidies are unable to afford diabetes health care, that is, the cost of drugs, transportation and laboratory tests (Mwavua et al., 2016). Peripheral public health facilities where the majority of the affected Kenyan population seek health care services continue to be sub-optimally equipped and not geared to non-communicable disease care (Mwavua et al., 2016).

Studies on diabetes in Kibera, Viwandani and Korogocho slums showed that there was a high prevalence of diabetes yet little is done to provide diabetes drugs, for optimal long-term glycemic control, and provide quality comprehensive care to the T2DM patients (Mwavua et al., 2016; Ayah et al., 2013).

One study conducted in India found that 40% of the respondents lived below the poverty line and could not afford the minimum standard care and therapy (Shah, Kamdar & Shah, 2009). According to Brown et al. (2004), lower individual Socio-Economic

Position (SEP), as measured by individual or household income, education, employment, occupation, or living in an underprivileged area, has been associated with poorer physical or emotional health, all-cause mortality or higher rates of fatal and nonfatal CVD, poorer glycemic control, and increased risk of micro vascular disease. In Europe, educational attainment and diabetes are inversely related, in terms of both morbidity and mortality rates according to Espelt et al. (2008).

Brown et al. (2004) described how socio-economic factors influence health among persons with diabetes through community factors (e.g. availability of healthy foods, availability of places to exercise), health behaviors (e.g. diet, physical activity), access to healthcare and processes of diabetes care (e.g. measurement of HbA1c, smoking cessation) (Espelt et al., 2008). At the same time, non-adherence to treatment is a major problem leading to loss of treatment benefits, extra visits to the doctor, hospitalization, and further medical prescriptions (Clark, 2004).

Closer home, Abdulrehman et al. (2016) noted that illiteracy, poverty, nursing shortages, lack of diabetes policies/ guidelines, and inadequate medical resources impede people's management of diabetes in Kenya. In their study conducted in the Coastal town of Lamu, economic factors such as poverty and the high cost of biomedical care appeared to have more influence in self-management behavior than socio cultural and educational factors do.

2.7 Health issues in diabetes patients

2.7.1 Co morbidities in diabetes patients

Uncontrolled diabetes leads to short-term and long-term micro vascular and macro vascular complications (Sontakke, Jadhav, Pimpalkhute, Jaiswal & Bajait, 2015). The long-term complications are the result of uncontrolled hyperglycemia that causes end

organ damage and can present itself as peripheral or autonomic neuropathy, micro or macro vascular disease, and kidney dysfunction that can progress into end stage renal disease or poor wound healing (Liu, Fu, Wang & Xu, 2010).

Micro vascular complications are specific to DM and do not occur in non-diabetes individuals. They involve the small blood vessels and include nephropathy and retinopathy (Meyer, 2009). Macro vascular complications involve diseases of large blood vessels. They are not specific to DM, but arise at an earlier age in those with diabetes than in non-diabetes individuals (Meyer, 2009).

2.7.1.1 Diabetes nephropathy

A common feature of T2DM is chronic hyperglycemia, leading to micro vascular complication such as diabetes nephropathy (Hadjadj, Cariou, Fumeron & Gand, 2016). The prevalence of nephropathy in diabetes patients in Malawi is 34.7% (Msyamboza, Mvula & Kathyola, 2014). Nephropathy is the leading cause of end-stage renal disease (ESRD) in Europe, Japan and the US, accounting for 25-30% of cases. However, it is the third leading cause of ESRD in Nigeria, accounting for up to 4% of patients (Andeyaba, Thacher, Aboi & Agaba, 2014) and leading cause of renal failure in the United States according to Hadjadj et al. (2016). It is defined by proteinuria above 300mg in 24 hours in the setting of diabetes (Hadjadj et al., 2016).

According to Gross et al. (2005), 7% of patients with T2DM may already have micro albu-minuria at the time they are diagnosed with diabetes. In order to prevent this, patients are treated to the lowest safe glucose level that can be obtained to prevent or control diabetes nephropathy. Screening for diabetes nephropathy or micro albu-minuria may be accomplished by either a 24-hour urine collection or a spot urine measurement of micro albumin (Gross et al., 2005).

2.7.1.2 Diabetes retinopathy

This may be the most common micro vascular complication of diabetes (Sayin, Kara & Nihat, 2015). Uncontrolled diabetes causes visual impairment through cataract and diabetes retinopathy (Bastawrous et al., 2017). For instance, it is responsible for ~ 10,000 new cases of blindness every year in the United States alone (Fong et al., 2004). The incidence of diabetes retinopathy (DR) is related primarily to duration and control of diabetes and is related to hyperglycemia, hypertension, hyperlipidemia, pregnancy, nephropathy, and anemia (Sayin et al., 2015). In Nakuru County, diabetes retinopathy has been shown to affect 36% of diabetes patients aged above 50 years according to a study conducted by Bastawrous et al. (2017). According to Hajar, Hazmi, Wasli, Mousa & Rabiu (2015), approximately 2% of diabetes patients become blind after 15 years, and about 10% develop severe visual impairment.

2.7.1.3 Diabetes neuropathy

According to Bansal et al. (2014), diabetes peripheral neuropathy (DPN) is a micro vascular complication of T2DM attributed to chronic hyperglycemia, and is defined as the presence of peripheral nerve dysfunction in diabetes after exclusion of other causes. Diabetes peripheral neuropathy (DPN) leads to further infections, increasing the risk of foot ulcers and non-traumatic amputations (International Diabetes Federation, 2017). Estimates of foot infections in T2DM range from a lifetime risk of 4–7% annually (Bansal et al., 2014). A cross sectional study in East Africa found that neuropathy was found in 78% of diabetes patients (Ahmed, Algamdi, Algurashi, Abdulelah & Khalid, 2014). Studies in Kenya have suggested that the prevalence of foot ulcers was found to be a significant complication at tertiary clinics like Kenyatta National Hospital (Ahmed et al., 2014; Nyamu, Otieno, Amayo & Mcligeyo, 2003). However, the risk factors

attributed to the ulcers are modifiable and manageable (Ahmed et al., 2014; Nyamu et al., 2003).

2.7.1.4 Cardio vascular conditions in T2DM

Cardio vascular disease (CVD) is the most significant cause of death in the diabetes population (Shah et al., 2015) and account for 70% to 80% of deaths in diabetes patients (Bastaki, 2015). The kinds of CVD that accompany diabetes include angina, myocardial infarction (heart attack), stroke, peripheral artery disease, and Congestive Heart Failure (Shah et al., 2015). According to the writers, for T2DM patients, the risk of CVDs associated with the presence of T2DM was highest for those with an HbA1c $\geq$ 7·5% (Shah et al., 2015).

Blood pressure (BP) levels are on average higher among patients with diabetes and increased BP is a well-established risk factor for people with diabetes (Emdin et al., 2015). In a Korean study, the prevalence of hypertension was 62.5% in patients with T2DM and 16.9% in patients without diabetes indicating that the prevalence of hypertension was notably higher in subjects with diabetes (Noh, Han, Ko, Ko & Park, 2017). Reviews have shown that aggressive BP control in diabetes patients leads to reduced risk for micro vascular events such as decreased vision and end stage renal disease (Cooper-dehoff et al., 2010; Choe et al. (2005). The normal BP levels are 135/80mmHg (Vijan & Hayward, 2003). Diabetes patients are advised to restrict sodium intake to lower than 2300 mg/day (Evert, et al., 2013).

According to Idemyor (2010), T2DM is associated with a cluster of dyslipidemias such as elevated triglycerides, reduced high-density lipoprotein cholesterol (HDL-C), smaller and low-density lipoprotein cholesterol (LDL-C). All these have been associated with an increased risk of CVD (Idemyor, 2010).

2.7.2 Infectious diseases in T2DM

As reported by Casqueiro, Casqueiro & Alves (2012), DM has negative consequences for certain infectious diseases, other than non-communicable diseases. Although under debate, DM has been associated with increased rates of infections which may be partially explained by a decreased T cell–mediated immune response. Impaired neutrophil function associated with diabetes has also been documented (Casqueiro et al., 2012; Muller et al., 2005). Some studies have shown that both common and rare infections are more prevalent among patients with diabetes than among the general population, whereas other studies have not observed such an association (Casqueiro, et al., 2012).

Patients with diabetes appeared to have an increased risk of asymptomatic bacteriuria, urinary tract infection, skin and mucous membrane infections, including *Candida* infections and infections of the foot (Muller et al., 2005). There exists an association between DM and tuberculosis (TB). About 10% deaths in the world that are related to TB cases are linked to diabetes (García-Elorriaga & Del Rey-Pineda, 2014). In the early 20^{th} century, diabetes patients who did not die in a coma were likely to die from TB. Even after the introduction of insulin therapy, TB was reported three times more often among diabetes patients than among non-diabetes patients (Ayah et al., 2013; Alisjahbana et al., 2006). According to Samad et al. (2017), people living with Human Immuno Deficiency Virus (HIV) have a higher incidence of DM relative to the general population.

One of the reasons could be prolonged Anti-Retroviral Therapy (ART) especially those People Living With HIV/AIDS (PLWH) who received older antiretroviral treatments, experienced peripheral fat atrophy, visceral fat accumulation, and metabolic co morbidities, including dyslipidemia and impaired glucose homeostasis, which can lead

to increased risk for CVD and other related morbidities (Samad et al., 2017; Kalra, Kalra, Agrawal & Unnikrishnan, 2011). People Living With HIV/AIDS (PLWH) aged ≥ 50 years have been shown to have a DM incidence of 1.39 times higher than men in the general Canadian population of similar age (Samad et al., 2017).

2.7.3 Diabetes dyslipidemia

According to Wu & Parhofer (2014), diabetes dyslipidemia is characterized by elevated fasting and postprandial triglycerides, low HDL-cholesterol, elevated LDL-cholesterol and the predominance of small dense LDL particles. These lipid changes represent the major link between diabetes and the increased cardio vascular risk of diabetes patients (Wu & Parhofer, 2014). The lipid abnormalities are prevalent in DM because insulin resistance or deficiency affects key enzymes and pathways in lipid metabolism (Dixit et al., 2014; Taskinen, 2002). Dixit et al. (2014) proposed aggressive lifestyle changes, such as weight reduction and physical exercise and lipid lowering drugs.

In a Korean study on trends in the pervasiveness of T2DM by Noh et al. (2017), the prevalence of dyslipidemia, was 49.5% in patients with T2DM which was 5.1 times higher than in non–diabetes cases (total 9.7%, men 8.5%, women 10.8%).

In their study, the prevalence of dyslipidemia had an explosive increase of 78% from 2006 (27.8%) to 2013 (49.5%, $p<0.001$). The rates of controlled dyslipidemia were 45.3% when defined as LDL-cholesterol <100mg/dl, 55.2% when defined as triglycerides < 150mg/dl, and 68.3% when defined as HDL-cholesterol ≥ 40 in men and ≥ 50mg/dl in women. Only 18.8% of diabetes subjects met all target goals for controlled dyslipidemia (Noh et al., 2017).

2.8 Unhealthy practices in T2DM

2.8.1 Smoking

Studies have shown that smokers tend to have a higher HbA1c concentration compared to non-smokers (Sari, Sari, Darlan & Prasetya, 2018). Cigarette smoking greatly increases the risk of Coronary Heart Disease (CHD) in diabetes patients (Koda et al., 2016). In one study by Al-Delaimy, Willett, Manson, Speizer & Hu (2001), the Relative Risk (RR) for CHD across categories of smoking was 1.21 for past smokers, 1.66 for current smokers of 1-14 cigarettes/ day and 2.68 for current smokers with more than 15 cigarettes/ day. The RR for women who had stopped smoking for more than 10 years was similar to women who had never smoked. According to Bastaki (2005), smoking cessation can have an important effect on CHD risk reduction in diabetes patients and clinical trials in diabetes patients who lowered their cholesterol levels achieved a 25-55% reduction in risk of major CHD events (Bastaki, 2005).

A study in Japan on T2DM patients by Ohkuma et al. (2015) showed that active smoking was dose-dependently associated with increased levels of HbA1c compared with never smoking habits in Japanese male patients with T2DM. Moreover, HbA1c levels decreased in former smokers as the years since quitting smoking increased, in comparison with current smokers (Ohkuma et al., 2015). Other studies have demonstrated that the insulin resistance and fasting serum glucose levels of current smokers and non-smokers do not differ significantly (Koda et al., 2016; Soulimane et al., 2015).

2.8.2 Alcohol use in T2DM

Heavy drinking is associated with higher risks of cardio vascular events and all-cause mortality (Martín-Timón, Sevillano-Collantes, Segura-Galindo & del Cañizo-Gómez,

2014). According to Blomster et al. (2014), moderate alcohol consumption has been shown to have fewer cardio vascular events (adjusted hazard ratio [aHR] 0.83; 95% CI 0.72–0.95; p= 0.008), less micro vascular complications (aHR 0.85; 95% CI 0.73–0.99; p= 0.03), and lower all-cause mortality (aHR 0.87; 96% CI 0.75–1.00; p= 0.05). The benefits were particularly evident in participants who drank predominantly wine (cardio vascular events aHR 0.78, 95% CI 0.63–0.95, p= 0.01; all-cause mortality aHR 0.77, 95% CI 0.62–0.95, p= 0.02) (Blomster et al., 2014).

Another study by Gepner et al. (2015) showed red wine significantly increased HDL level by 0.05 mmol/l (2.0mg/dl) (95% CI, 0.04 to 0.06mmol/l [1.6 to 2.2mg/dl]; p< 0.001). Blomster et al. (2014) reported that heavy alcohol consumption (defined as >1.9 standard drinks per day) was associated with a more than doubling of the risk of incident of retinopathy. It should also be noted that alcohol has the potential danger of causing hypoglycemia (Amod et al. 2012; Bastaki, 2005), hepatic complications, and certain cancers (Blomster et al., 2014), hyperglycemia (Evert, et al., 2013) and hypertension and dyslipidemia (Heianza et al., 2013).

2.9 Diabetes and economic impact

According to Maina et al. (2011), T2DM threatens to overwhelm the health care system unless interventions are put in place. Majority of the population affected by T2DM in developing countries are within the productive age of 45-64 years and these are the individuals expected to drive the economy forward to achieve economic goals (Maina et al., 2011). At the same time, T2DM results to high economic burden in health care expenditure leading to further economic loss (Seuring, Archangelidi & Suhrcke, 2015; Maina et al., 2011). Good health of the workforce is a major factor in economic development; the burden of illness caused by diabetes and the reduction in life expectancy in SSA will hinder the region's economic growth (Tamirat et al., 2014). As

diabetes presents during the peak income-earning period in an individual's life, those affected are often the breadwinners of their family. Loss of primary income in households can lead to despair and poverty (Tamirat et al., 2014).

2.10 Overview of use of telecommunication in management of diseases

Mobile phones were first introduced in Kenya in 1992 but affordable services started in 1999 (Manica & Vescovi, 2009). At that time, there were 2 main mobile operators, Safaricom that was launched in 1997 and Celtel that is currently called Airtel that was launched in 2000. Other additional mobile phone providers are Orange and Yu (Communications Authority of Kenya, 2016; Oteri et al., 2015). Mobile phone communication especially text messaging is simple, cheap and wide spread and it can therefore be an appropriate intervention for a variety of health behavior changes (Sarabi, Sadoughi, Orak & Bahaadinbeigy, 2016). Text messages is a notable practice world wide both in developing and developed countries and Kenya is noted among countries where it is widely used (Communications Authority of Kenya, 2016).

In the whole world, around 350 billion text messages are exchanged daily (Jones, Lekhak & Kaewluang, 2014). The mobile phone subscriptions reached 46.6 million, while the number of short message service (SMS) rose from 816.887 million during the April-June 2018 quarter to 974.569 million during the July to September 2018 quarter in Kenya (Communications Authority of Kenya, 2019).

2.10.1 Use of mobile phone products in health

Millennium Development Goals (MDG) Number 5 aims at improving maternal health (World Health Organization, 2019b). Through a project dubbed "WE CARE Solar'', the health workers and midwives are provided with mobile phones and reliable lighting to ensure safer deliveries (GSMA, 2012). The use of mobile phone is also demonstrated in

Tanzania where by use of Mobile for Reproductive Health (M_4RH), clients can get information on contraceptive use and clinic locations where they can get the Family Planning (FP) services hence lower the risk of maternal mortality (L'Engle, Plourde & Zan, 2017). This system is also replicated in Democratic Republic of Congo (DRC) where in partnership with Vodacom, the Population Services International (PSI) has established a hotline, 'The Ligne Verte' that gives FP information to the community (GSMA, 2012; Corker, 2010).

The Bozza project uses the mobile phones to raise awareness on HIV transmission, condom use and also creates job opportunities in Kenya, South Africa Nigeria and Tanzania. The Praekelt Foundation in South Africa uses SMS to alert patients on adherence to medication and remind them to pick medicine from hospitals (GSMA, 2012). Mobile telephone text reminders were used as the only intervention in 73% in a systematic study by Kannisto, Koivunen & Välimäki (2014). In their study, the SMS reminders were sent to different patient groups: patients with HIV/AIDS (15%, 9/60) and diabetes (13%, 8/60) being the most common groups. From these studies, about three quarters of the studies (77%, 46/60) reported improved adherence to medication. No emphasis on diet, exercise and overall wellness of the diabetes patient is laid out in this review. In yet another systematic review on use of text messaging, it was shown that text reminders can increase behavior change in patients with chronic diseases (Cole-Lewis & Kershaw, 2010).

In the review, it was found that there was a greater decrease in HbA1c levels in adolescents and obese and non-obese adult diabetes patients. The use of text reminders resulted in increased frequency of blood glucose monitoring when compared with e-mail reminders. The same meta-analysis displayed significant positive effect on weight loss and smoking cessation (Cole-Lewis & Kershaw, 2010). In a study by Cho, Lee, Lim, Kwon & Yoon (2009), HbA1c levels of both groups had decreased significantly from

7.6% to 6.9% for the internet group and from 8.3% to 7.1% for the phone group ($p<0.01$).

2.10.2 Potential use of telecommunication in diabetes management

A growing body of literature suggests that information technology (IT), such as computer, internet and mobile phone technology, holds great promise in enhancing diabetes care (Faridi et al., 2008). Information technology based interventions such as text messages have been associated with HbA1c decrease when compared to the usual care alone as demonstated in a systematic review on T2DM by Riazi, Larijani, Langarizadeh & Shahmoradi (2015). Haddad et al. (2014) in their study on managing DM by use of ICT found that HbA1c concentrations decreased from baseline levels though it is not possible to attribute this effect to the intervention because the study lacked a control group. Mobile phones have the potential of transforming opportunities so as to improve health care outcomes.

Nevertheless, to date, there is little evidence on their use in Low and Middle Income Countries (LMICs) like Kenya (Hall, Fottrell, Wilkinson & Byass, 2014). One of the benefits of the text messages is low costs, quick delivery, safety issues, and reduced intrusiveness compared to phone calls (Kannisto et al., 2014). In a review done to assess the management of diabetes by use of mobile phones, 85% reported improvement in HbA1c while no significant changes were found on Body Mass Index (BMI).

Table 2.1 summarizes the use of mobile phone in hospitals by the health system, physician and the patient in diabetes care.

Table 2.1: Use of mobile phone in diabetes care

Domain	Application of mobile phone
Health system	Development of real time diabetes registries
	Screening diabetes and diagnosis of diabetes
	Health promotion tool using SMS
	Monitoring patients in remote settings
Physician	Reference tool
	A tool for conducting Continuous Medical Education (CME)
Patient	Patient education
	Self-management of diabetes and reminder for drug intake

Source: Ajay & Prabhakaran, 2011

2.11 Gaps in knowledge

Though mobile phone technology is increasingly being recognized in Africa as whole and Kenya specifically, this technology has not been used in the management of diseases and more specifically in T2DM. Rajput et al. (2012) explored the use of mobile phone in health management in Kenya and found out that the users felt it was easy to use and it facilitated their work. World-wide, Kenyans far exceed their counterparts in their use of mobile money transfer services where 60.3% of all Kenyans send or receive mobile money, compared to Tanzania's 14.1%, Nigeria's 0.5%, and South Africa's 3.2% usage (i Hub Research and Research Solutions Africa, 2012). However, use of mobile phone has not been applied in management of diseases the way M-Pesa has been.

A study on use of mobile phone in Kenya to educate people on contraceptive use has been done by Harrington, Drake, Matemo & Ronen (2019). In the study there was

increased postpartum contraceptive use by the SMS use. However this was a two-way SMS with a nurse and the patient. In another study, an SMS contraceptive education scheme in Kenya suggested improved contraceptive knowledge and use, but suffered from a sample size that was too small, with no control group (Vahdat, L'Engle, Plourde, Magaria & Olawo, 2013). This then reduced the ability to draw firm conclusions.

An RCT study in Peru using educational SMS to reduce the risks of contracting dengue fever, hinted at improved educational equity via SMS but showed no statistically significant improvement over alternative educational schemes (Dammert, Galdo & Galdo, 2014). On drug adherence, retrospective analysis of an intervention in South Africa using SMS reminders sent to 18 tuberculosis (TB) patients who delayed in opening their wireless pill bottles showed improved health compared to 72 control patients who received no SMS reminder (Broomhead & Mars, 2012). A pre post intervention study in South Africa by Rotheram-Borus, Tomlinson & Gwegwe (2012) on mHealth-based peer-support group for women suffering from DM showed significant change in health over a 6-month period. However, the sample size was very small (N=22).

In yet another RCT in India by Ramanchandran et al. (2013), use of text messages reduced the incidence of T2DM in Indian Asian men with impaired glucose tolerance. In the trial, one group at risk of T2DM was randomly assigned to receive text messages with educational and motivational advice to help them to adopt a healthier lifestyle over a 3-year period. On the other hand, the control group received only standard lifestyle modification advice at the start of the trial. At the end of the trial, 18% of participants in the intervention group had developed T2DM compared with 27% in the control group (Ramanchandran et al. 2013).

A study in Kenya showed that conditional cash transfers by use of mobile phone, and SMS reminders, improved child vaccination rates in rural areas (Wakadha et al., 2013). From these studies, it is clear that mobile phone communication has been embraced in health management. However, none of such studies has been done on the management of T2DM specifically in Kenya. From the literature review, it is clear that T2DM can be managed in patients to help them achieve their treatment goals. However, the current diabetes care focuses on management of patients at the health facility with no proper follow up at their homes. In addition, there are still high cases of T2DM admissions and mortality because of poorly controlled diabetes. Health care professionals can not manage T2DM alone and hence the need to manage it jointly by promoting self-care and management (Idemyor, 2010).

CHAPTER THREE

METHODOLOGY

3.1 Study site

The study was carried out at Kitui County Referral Hospital (KCRH) in Kitui County, Kenya. It is a level five hospital and its catchment area includes the whole population of Kitui County. The county is located about 160km east of Nairobi County and is the 6th largest county, covering an area of 30,496.51km^2 (including 6,302.7km^2 occupied by Tsavo East National park) (Kitui County, 2013). The county borders Machakos and Makueni counties to the west, Tana River County to the east and south-east, Taita Taveta County to the south, Embu to the north-west, and Tharaka-Nithi and Meru counties to the north. It is located between latitudes 0°10' and 3°0' South and longitudes 37°50' and 39°0' East (Kitui County, 2013).

There are over 255 health facilities spread across the county. On average, the distance to the nearest health centre is 10.2km while the doctor to population ratio is 1:22,005. The main Non Communicable Diseases (NCDs) include cancer, diabetes, and hypertension among others. The percentage of population with the ability to read and write is 77.3% (Kitui County, 2013).

3.2 Study design

This was a longitudinal study with qualitative and quantitative components. The study participants were assigned to either the intervention or control group. Data was collected at baseline and six months after intervention with text messaging. This design is useful in assessing if the intervention had a significant impact on morbidity and nutrition status, health seeking behavior, drug adherence and dietary practices. The findings from the

intervention and control group at the baseline and after six months were compared to determine change.

3.3 Study variables

The dependent variables in this study were morbidity and nutrition status, health seeking behavior, drug adherence and dietary practices while the independent variable was use of mobile phone communication. The study variables are described in Table 3.1.

Table 3.1: Study variables

Socio demographic and socio-economic characteristics	Independent variable	Dependent variables
Gender	Use of the mobile phone	**Morbidity and nutrition status**
Age		Morbidity status
Marital status		Side effects of drugs
Number of dependents		Glycemic control
Education level		Blood pressure control
Occupation		Nutrition status
Distance to the health facility		**Health seeking behavior**
		Seeing the health worker when unwell
		DM clinic attendance
		SMBG
		Feet health
		Drug adherence
		Specific time for drugs
		No missed doses
		Travelling with drugs
		Using unprescribed drugs
		Absconding drugs
		Dietary practices
		Use of meal plan
		Frequency of meals
		Frequency of snacks
		Fruits intake
		Vegetable intake
		Dietary diversity (DDS)
		Intake of macro and micro nutrients

3.4 Study population

Based on the national rural prevalence of 3.5% (Mwangi & Gitonga, 2014) in rural Kenya, it can be assumed that the target population for T2DM adult patients based on Kitui county population is 30, 501 (Kitui County, 2013). As per the hospital records, the accessible T2DM patients is 200 per month (Kitui County Referral Hospital, 2017).

3.5 Inclusion and exclusion criteria

Consenting T2DM patients visiting the Out Patient Department (OPD) diabetes clinic and aged 20-70 years diagnosed with T2DM at least one year before this study were included in the study while patients without mobile phones were excluded from this study.

3.6 Sampling and sample size determination

3.6.1 Sampling procedure

Consecutive sampling was used where every eligible and consenting T2DM patient that came to the diabetes clinic at Kitui County Referral Hospital was selected and assigned to the intervention and control group until the required number of subjects for the study were achieved. Efforts were made to match the two groups in respect to sex and age. It took two months to achieve the required sample size.

3.6.2 Sample size determination

The sample size for this study was determined using Krejcie & Morgan (1970) method. This method was chosen because it is relevant for selecting samples from populations as small as 10 and as large as 100,000 where the population of patients suffering from

T2DM seen at Kitui County Referral Hospital lies. The formula for this method is as stated below:-

$s= \chi^2NP (1-P)/d^2 (N-1) + \chi^2P (1-P)$

Where:

s = required sample size

χ^2= the table value of Chi-square for 1 degree of freedom at the desired confidence level. In our case we will use 95% confidence level which yields χ^2= (1.96) (1.96) = 3.841

N = the population size

P = the population proportion (This was assumed to be 0.50 since this would provide the maximum sample size)

d = the degree of accuracy expressed as a proportion (0.05).

The population for this study was taken as N=200 who were the T2DM patients on follow up for the previous one month (Kitui County Referral Hospital, 2017). Using the above formula the sample size for the study was calculated as below,

3.841(200) (0.5) (1-0.5)/ (0.05) (0.05) (200-1) + 3.841 (0.05) (1-0.05)

s=132

To cater for attrition (Jones et al., 2014), the calculated sample size was increased by 10% hence

s= 145

3.7 Respondents

A total of 250 T2DM patients were screened for eligibility. Of this, 191 met the eligibility criteria (90 in the intervention group and 101 from the control group). Out of this, 16 participants in intervention group and 21 in control group refused to consent. Therefore, one hundred and fifty four (154) respondents participated at the baseline. After the six months, 6 participants in the intervention group and 9 in the control group did not consent to participate while 1 respondent in the intervention group died. The number of respondents who completed the two phases of data collection were 138 (67 in the intervention and 71 in the control group) as shown in Figure 3.1.

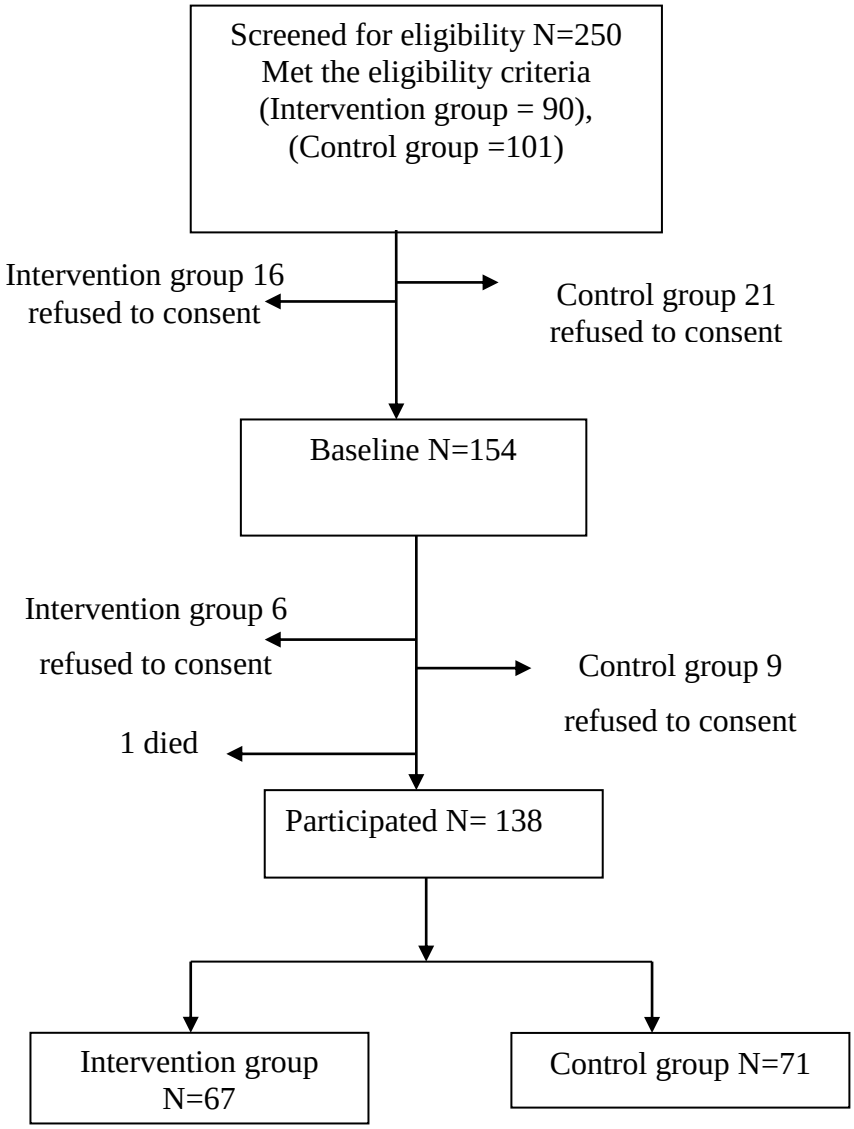


Figure 3.1: Flow diagram on the enrolment of the study participants

3.8 Description of the intervention

Respondents were selected and assigned to intervention and control group. Base line data was collected from the groups on socio-economic status, morbidity and nutrition status, health seeking behavior, drugs and dietary intake and compared to data after the intervention. By use of mobile phones, the researcher developed and sent key nutrition messages every day for five days in a week to the intervention group. The messages were on morbidity and health seeking behavior, SMBG, feet health, drug adherence and

dietary practices as recommended in diabetes management (Appendix 2, 3 & 4). Information on portion sizes was clarified to the intervention group before the start of the intervention.

This intervention took a period of six months. On the other hand, the control group did not receive any messages. However, the group received the standard diabetes care provided in the diabetes clinic at the hospital. This includes health talks on the management of diabetes. However, after completing the second phase of the study, the messages on morbidity, health seeking behavior, drugs and dietary practices were sent to the control group.

Baseline data collection was conducted in March and April 2017 while data after intervention was collected in November and December 2017. To minimize 'contamination' of information across the study groups, the purpose of the study was explained to the intervention and control groups. In addition, respondents in the intervention group were called on several occasions to remind them the purpose of the study. This is because changes in knowledge, attitude and practice of an individual may influence others close to them to do the same, for instance through sharing of the text messages, thus influencing the study outcome (Machin, Campbell & Walters, 2007).

3.9 Formulation of the text messages

The SMSs were formulated based on recommendations by the Ministry of Public Health and Sanitation (2010) and Ministry of Medical Services (2010). The messages were formulated in English and Kamba language. Each SMS had a maximum of 160 characters per message. The formulated messages were evaluated by the hospital physician, nurse and a nutritionist. The messages were sent in the morning at 0500–0800 hours. Each patient provided a mobile phone number on which they preferred to receive

the messages to enhance diabetes related knowledge. Respondents were called on weekends to ensure that SMSs had been received and understood.

3.10 Data collection instruments

3.10.1 Questionnaire

A structured questionnaire was used to collect primary data from the T2DM patients. Data was collected on socio demographic and socio-economic status, morbidity and anthropometry, health seeking behavior, drug adherence and dietary habits.

3.10.1.1 Morbidity and nutrition status

Morbidity patterns

Data on morbidity patterns was determined by physical and clinical examination form. The physical examination was carried out in the hospital and was performed concurrently with face to face interview. Trained and registered nurses and clinical officers as part of the research team carried out the examination. An enquiry on when the patient was last sick was made. The main morbidities that were assessed were common cold, pneumonia, fever, malaria, headache, hyperglycemia and hypoglycemia. These were assessed and recorded during physical and clinical examination.

Nutrition status

Weight and height measurement

Nutrition status was determined using anthropometry. Weight was determined using a Seca weighing scale. The scale was placed on a flat, hard surface and participants were measured in light clothes, without shoes (Mokhehle, 2014). Weight measurements were taken after emptying the bladder and before a meal. The subjects were asked to stand in

the middle of the scale and to look ahead, unassisted and relaxed. The readings obtained were recorded to the nearest 0.1 kg and used to calculate the BMI. To ensure reliability the scale was calibrated before use and after weighing every 10th patient. The zero reading was checked periodically and each time the scale was moved (Mokhehle, 2014). Three readings were taken and the averages of the readings were used if the readings were more than 1kg apart (Gibson, 2005).

Height was measured to the nearest 0.5cm using a stature meter. Participants were requested to stand upright on a flat surface without shoes, with the back of the heels on the stadiometer (Gibson, 2005). Participants were asked to take a deep breath, relax and stand tall to aid the straightening of the spine. The headboard was lowered until it reached of the crown the head and height was taken at maximum inspiration, with the researcher's eyes level with the headboard to avoid parallax errors (Gibson, 2005). To ensure reliability two readings were taken to the nearest mm, and the average of the readings was used if the readings were greater than 1mm apart (Gibson, 2005).

After recording both measurements, the Body Mass Index (BMI) was calculated using the formula Weight/Height^2. Body Mass Index (BMI) <18.5kg/m^2 was recorded as underweight, 18.6-24.9kg/m^2 as normal, 25–30.0 kg/m^2 as overweight and BMI above 30.0 kg/m^2 was classified as obesity (World Health Organization, 2019a).

Biochemical measurements

Determination of glycated haemoglobin

Glycated haemoglobin (HbA1c) was determined onsite using CERA-STAT^{TM} 2000 HbA1C.Eag machine. This is a portable, easy-to-use device capable of providing HbA1c results in 5 minutes. After cleaning the tip of the middle finger, 5µℓ of blood sample was collected with a capillary tube and then dropped into R1 reagent and incubated, shaken well for 5 seconds, and from this, 25 µℓ was collected, then R2 reagent was dropped into the cartridge and the sample was analyzed by the machine and results recorded immediately. Glycated haemoglobin (HbA1c) <7% was classified as controlled while >7% was classified as poorly controlled (Ministry of Public Health and Sanitation, 2010; Monnier & Colette, 2009).

Determination of fasting blood sugar level

Fasting blood sugar (FBS) was collected by a certified laboratory technologist after ascertaining that the respondents had fasted 8 hours. The FBS was determined onsite using Gluco Dr Auto Model Agm 4000 machine. After preparing the kit, the patient's hands were washed and dried. A test strip was inserted and the middle finger was pricked at the tip. A blood drop was applied to the side edge of the yellow window of the test strip. The sample was analyzed instantly and recorded immediately. Fasting blood sugar (FBS) <7mmols/L was classified as controlled while >7mmols/L was classified as poorly controlled (Ministry of Public Health and Sanitation, 2010).

Blood pressure measurement

After ensuring that the subject had been seated for at least fifteen minutes, a mercury sphygmomanometer was used to take the BP. This was repeated two more additional times, waiting a few minutes between measurements. The mean of the three measurements was recorded. Systolic BP below 140mmHg was classified as controlled

while above 140mmHg was classified as poorly controlled. Diastolic BP below 90mmHg was classified as controlled while above 90mmHg was classified as poorly controlled (World Health Organization, 2019c).

3.10.1.2 Health seeking behavior

Health seeking behavior was determined by assessment of self-monitoring of blood glucose (SMBG), diabetes clinic attendance, seeing the doctor promptly when required and feet care. Self-monitoring of blood glucose (SMBG) was assessed by determining whether the patients carried out daily SMBG either at home or in the nearest health facility (Abbas, Al Fares, Jabbari, El Dali & Al Orifi, 2015) while feet care was assessed by whether respondents checked their feet daily for cuts, sores, blisters, redness, calluses or other problems (Hassan, 2017).

3.10.1.3 Drug adherence

This was determined by occurrence of delayed and missed doses, travelling with drugs, use of un prescribed medicine and not absconding drugs (Worku, Abebe & Wassie, 2015). Delayed dose was defined as not taking medication as prescribed regarding timing or dosage, but taking the medicine within 6 hours. Missed dose was described as participants going for half period without the diabetes medicine (Huang et al., 2013). Drug abscondance was described as participants going for over 60 days without diabetes drugs (Polonsky & Henry, 2016).

3.10.1.4 Dietary practices

Following of the meal plan

This was determined by respondents' ability to follow the meal plan prepared and provided by the hospital nutritionist upon diabetes diagnosis on a daily basis (Badedi et al., 2016).

Frequency of meals and snacks consumed

Respondents who took more than three meals and more than three snacks in a day were categorized as meeting the recommended number of meals and snacks respectively (American Diabetes Association, 2008). Those who took less than three meals and less than three snacks were categorized as not meeting the recommended number of meals and snack per day.

Fruit and vegetable intake

Fruit intake was assessed on whether respondents took 2-4 servings of fruits daily while vegetable intake was assessed on whether one took 3-5 servings of vegetables daily (Ministry of Public Health and Sanitation, 2010).

Dietary diversity score

A dietary diversity score (DDS) based on 10 food groups was used where the cut-off was set at ≥5 food group (FAO, 2010). Respondents consuming foods from five or more food groups have a greater likelihood of meeting their micro nutrient needs than those consuming foods from fewer food groups (Ngala et al., 2015). A food frequency table was used to establish the frequency of consumption of selected foods. This was assessed

by listing all the commonly consumed food items and asking the respondents to state the frequency of consumption.

Dietary intake: Twenty four (24) hour dietary recall

Dietary intake of macro and micro nutrients was determined by a single 24-hour dietary recall method. The subjects were interviewed to find out the actual food intake during the immediate past 24 hours (Gibson, 2005). A detailed description of foods on list was provided. The respondent was asked to clarify the description and preparation of foods on the list. The interviewer reviewed the data collected, probed for additional eating occasions and clarified food portion sizes using household dishes and measures (Chacko & Begum, 2016). Information from 24-hour dietary recalls was coded and entered into a modified version of Nutri Survey software.

The package calculated energy and nutrient intakes per person where Recommended Dietary Allowance (RDA) for energy was 2000kcal. The fat RDA was 70g while protein intake of 0.8-1.0g/kg per day was within the recommended intake (Evert et al., 2013). Intakes of <0.8g/kg/day and >1.0g/kg/day were below and above the recommended intake respectively. Vitamin A, iron and zinc RDA was determined by 600 Retinol Equivalents (RE), 15mg and 15mg respectively (American Diabetes Association, 2013).

3.10.2 Key Informant Interview (KII) Guides

Key Informant Interview (KII) Guides were administered to the County Nutrition Officer, the clinician at the Out Patient diabetes clinic and the Nurse in- Charge. These gave information on feeding practices, challenges in diabetes management, coping mechanisms and perceptions of the patients in management of the T2DM (Appendix 5 & 20).

3.10.3 Focus Group Discussion (FGD) Guides

These were used during Focus Group Discussions (FGDs) to collect qualitative information of T2DM patients. The FGDs were administered to the intervention and control group to get an in-depth understanding on how the respondents manage diabetes. Information on feeding practices, perceptions, challenges and coping mechanisms were sought. Two FGDs were held for the T2DM patients (both in the intervention and control group) and community members that comprised of 8-10 participants each with discussions lasting between 60 and 90 minutes (Appendix 6, 7, 21 & 22).

3.11 Pretesting the instruments

The questionnaires were pretested at Muthale Mission Hospital in Kitui County. Thirty (30) T2DM patients with similar characteristics to the sample were interviewed and this group was not included in the main study. The information gathered was used to rectify and update the tools. The rectified questionnaires were used to conduct interviews with the patients.

3.12 Validity and reliability of research instruments

3.12.1 Validity

To ensure validity of the research instruments, a standard previously validated questionnaire by the World Health Organization (2018b) was modified accordingly and used for this study. These questionnaires were evaluated by the study supervisors who are experts in the subject area.

3.12.2 Reliability

To ensure reliability, research assistants were trained and the research tools were pretested. During training and pretesting, standardization of data collection procedures was done. Two research assistants were trained to take anthropometry measurements and record appropriately (Appendix 10). Certified laboratory technologists were recruited and trained for three days for collection, analysis and recording of biochemical measurements (Appendix 11). Discussions with enumerators were done on daily basis to identify encountered problems and how to address them.

The field assistants and laboratory technologists were trained on ethical and human rights issues. Such involved the need to explain to the respondents the objectives of the study, the contents of the questionnaire and the expected outcomes. The training was conducted for three days prior to pretesting period. Three (3) repeated measures of anthropometric and biochemical tests were done and an average calculated. To avoid contamination of the blood samples, onsite analysis and recording at the hospital was done.

In addition to the above step, the research instrument was subjected to a reliability test. The study used Cronbach's alpha to test reliability of the study instruments. This was analyzed through SPSS version 24. According to the test, an instrument is deemed reliable if it meets the cut-off point of 0.7 (Field, 2005). Reliability tests conducted on the instrument showed a reliability score of 0.768 which confirms the reliability of the study instrument.

3.13 Data management and analysis

Data processing was done using SPSS software Version 24. The data was entered into the computer software and cleaned before analysis. Descriptive statistics were

specifically frequencies used in describing the socio demographic and economic characteristics while inferential statistics included Chi-square analysis and bivariate logistic regression analysis for morbidity, health seeking behavior, drug and dietary practices. The Net Effect of Intervention (NEI) analysis was used to determine the impact of the intervention at 95% confidence level. This was achieved by the change (±) in percentage obtained from intervention group compared with the change obtained from control group. Statistical significance was set at $p<0.05$ with the cutoff for accepting or rejecting the hypothesis as $p= 0.05$ while data was presented in tables.

3.14 Ethical issues

Ethical clearance was obtained from the Kenyatta National Hospital/ University of Nairobi Ethics and Research Committee (KNH-UON ERC) (Appendix 14 & 15) while authority to carry out the study was sought from Kitui County Referral Hospital administration and National Commission for Science, Technology and Innovation (NACOSTI) (Appendix 16, 18 & 19). Scientific merit, equitable selection of subjects, seeking informed consent, confidentiality, and avoidance of coercion were considered while conducting the research. Written and oral consent to take part in the study was obtained from the respondents. There was no compensation for participation in the study in form of money or any other gift.

CHAPTER FOUR

RESULTS

4.1 Response rate

In this study, 154 participants were recruited at baseline and 138 of them completed the two phases of data collection (67 in intervention and 71 in control group). This gives a response rate was 90%. This is excellent and is considered good to make conclusions for the study.

4.2 Socio demographic and socio-economic characteristics of respondents

At baseline, majority of the respondents were female (65.7% in the intervention group and 62% in the control group). The highest proportion of the respondents was aged above 40 years (92.5% in the intervention group and 88.7% in the control group). Majority of the respondents were married (74.6% in the intervention group and 84.5% in the control group) as shown in Table 4.1. More than a quarter (26.9%) in the intervention group and 31% in the control group lived within 5km of a health facility. Majority of participants (46.3% in the intervention and 45.1% in the control group lived more than 10km away from the nearest health facility. Thirty eight percent (38.8%) in the intervention group and 38% in the control group were unemployed. Participants in business were 29.9% in the intervention group and 22.5% in the control group (Table 4.1).

No significant differences were observed between the study groups in terms of gender, age, marital status, number of dependents, education, occupation and distance to health facility. Hence any differences in the dependent variables can not be attributed to differences in these characteristics.

Table 4.1: Socio demographic and socio-economic characteristics based on Chi-square test

Characteristic	Intervention group (n=67) n (%)	Control group (n=71) n (%)	Chi-square; P value
Gender			0.651
Male	23(34.3)	27(38.0)	
Female	44(65.7)	44(62.0)	
Age (years)			0.444
<40	5(7.5)	8(11.3)	
>40	62(92.5)	63(88.7)	
Marital status			0.343
Married	50(74.6)	60(84.5)	
Single/separated	7(10.4)	4(5.6)	
Widow/widower	10(14.9)	7(9.9)	
Number of dependents			0.40
<3	34(50.7)	32(45.1)	
>3	33(49.3)	39(54.9)	
Education level			0.349
No formal education	21(31.3)	13(18.3)	
Primary	23(34.3)	27(38.0)	
Secondary	13(19.4)	18(25.4)	
Tertiary	10(14.9)	13(18.3)	
Occupation			0.510
Unemployed	26(38.8)	27(38.0)	
Employed	21(31.3)	28(39.4)	
Business	20(29.9)	16(22.5)	
Distance to health facility			0.848
<5km	18(26.9)	22(31.0)	
5-10km	18(26.9)	17(23.9)	
>10km	31(46.3)	32(45.1)	

4.3 Effect of using mobile phone communication on morbidity (and its related components) and nutrition status of T2DM patients at KCRH

Table 4.2 shows morbidity and its related components and nutrition status of the participants. The proportion of participants reporting sickness in the previous month decreased from 35.8% to 22.4% in the intervention group and 31% to 29.6% in the

control. The Net Effect of Intervention (NEI) (-12%) decrease was statistically significant (OR= 0.48 (95% CI= 0.27-0.85), p= 0.012) as shown in Table 4.2.

There were no significant differences in the proportion of respondents who had suffered side effects of medicine used in diabetes management. In addition, there were no significant differences in the proportion of respondents who had controlled glycated haemoglobin (HbA1c) as shown in Table 4.2.

The proportion of respondents with controlled BP increased from 44.8% to 49.3% in the intervention group and decreased from 53.5% to 47.9% in the control group. The NEI (10.1%) increase was statistically significant (OR=1.63(95% CI =1.01-2.63), p= 0.046). However, there were no significant differences in the proportion of respondents within the normal BMI as shown in Table 4.2.

Table 4.2: Effect of intervention on morbidity (and its related components) and nutrition status of respondents

	Intervention group			Control group					
	Baseline	Six months		Baseline	Six months				
	n (%)	n (%)	% change	n (%)	n (%)	% change	NEI* %	Odds(95% CI)	P value
Morbidity status	24(35.8)	15(22.4)	-13.4	22(31.0)	21(29.6)	-1.4	-12	0.48(0.27-0.85)	0.012
Side effects of diabetes management	10(14.9)	9(13.4)	1.5	8(11.3)	6(8.5)	2.8	-1.3	1.1(0.53-2.49)	0.718
Glycated haemoglobin	39(58.2)	42(62.7)	4.5	37(52.1)	34(47.9)	-4.2	8.7	1.58(0.98-2.56)	0.061
Fasting Blood Sugar	37(55.2)	44(65.7)	10.5	34(47.9)	41(57.7)	9.8	0.7	1.06(0.61-1.81)	0.834
Blood pressure	30(44.8)	33(49.3)	4.5	38(53.5)	34(47.9)	-5.6	10.1	1.63(1.01-2.63)	0.046
Good nutrition status	23(34.3)	26(38.8)	4.5	27(38.0)	28(39.4)	-1.4	5.9	1.50(0.93-2.44)	0.095

*NEI: Net effect of Intervention

4.4 Health seeking behavior of respondents

The proportion of respondents who contacted the health worker when unwell increased from 37.3% to 50.7% in the intervention group and 36.6% to 40.8% in the control group. The NEI (9.2%) increase was not statistically significant (OR=1.24(95% CI =0.77-2.01), p= 0.372) as shown in Table 4.3. The proportion of respondents who conducted self-monitoring of blood glucose (SMBG) increased from 32.8% to 41.8% in the intervention group and decreased from 39.4% to 31% in the control group. The NEI (17.4%) increase was statistically significant (OR= 1.65(95% CI= 1.01-2.73), p= 0.047) (Table 4.3). There were no significant differences in the proportion of respondents who monitored their feet condition as shown in Table 4.3.

Table 4.3: Effect of intervention on health seeking behavior of respondents

	Intervention group			Control group					
	Baseline	Six months		Baseline	Six months				
	n (%)	n (%)	% change	n (%)	n (%)	% change	NEI* %	Odds(95% CI)	P value
Contacted health worker when unwell	25(37.3)	34(50.7)	13.4	26(36.6)	29(40.8)	4.2	9.2	1.24(0.77-2.01)	0.372
Diabetes clinic attendance	41(61.2)	53(79.1)	17.9	43(60.6)	49(69.0)	8.4	9.5	1.52(0.93-2.50)	0.099
Self-monitoring of blood glucose	22(32.8)	28(41.8)	9.0	28(39.4)	22(31.0)	-8.4	17.4	1.65(1.01-2.73)	0.047
Feet health monitoring	41(61.2)	48(71.6)	10.4	41(57.7)	43(60.6)	2.9	7.5	1.41(0.88-2.28)	0.158

*NEI: Net effect of Intervention

4.5 Drug adherence of the respondents

The proportion of respondents who adhered to specific drug time increased from 58.2% to 74.6% in the intervention group compared to a decrease from 47.9% to 46.5% in the control group. The NEI (17.8%) increase was statistically significant (OR=1.94, 95% CI=1.19-3.14, p= 0.007) as shown in Table 4.4. The proportion of respondents who did not have missed doses increased from 65.7% to 79.1% in the intervention group and decreased from 63.4% to 54.9% in the control group. The NEI (21.9%) increase was statistically significant (OR=2.74, 95% CI=1.68-4.58, p= 0.001. There were no significant differences in the proportion of respondents who travelled with drugs, those who used un prescribed drugs and those who absconded diabetes drugs as shown in Table 4.4.

Table 4.4: Effect of intervention on drug adherence of respondents

	Intervention group			Control group					
	Baseline	Six months		Baseline	Six months		NEI*		
	n (%)	n (%)	% change	n (%)	n (%)	% change	%	Odds(95% CI)	P value
Specific time for taking drugs	39(58.2)	50(74.6)	16.4	34(47.9)	33(46.5)	-1.4	17.8	1.94(1.19-3.14)	0.007
No missed doses	44(65.7)	53(79.1)	13.4	45(63.4)	39(54.9)	-8.5	21.9	2.74(1.68-4.58)	0.001
Travelling with drugs	37(55.2)	45(67.2)	12.0	42(59.2)	43(60.6)	1.4	10.6	1.29(0.88-2.09)	0.29
Using un prescribed drugs	29(43.3)	17(25.4)	-17.9	26(36.6)	19(26.8)	-9.8	-8.1	1.12(0.68-1.86)	0.64
Absconding drugs	9(13.4)	1(1.5)	-11.9	5(7.0)	6(8.5)	1.5	-13.4	1.57(0.88-0.89)	0.12

*NEI: Net effect of Intervention

4.6 Dietary practices of the respondents

4.6.1: Dietary practices

The proportion of respondents who used a meal plan increased from 47.8% to 59.7% in the intervention group and decreased from 49.3% to 45.1% in the control group. The NEI (16.1%) increase was statistically significant (OR= 1.77(95% CI= 1.09-2.87), p= 0.021) (Table 4.5). The proportion of respondents who increased the frequency of meals increased from 41.8% to 47.8% in the intervention group and decreased from 52.1% to 45.1% in the control group. The NEI (13%) increase was statistically significant (OR= 1.69(95% CI= 1.04-2.74), p= 0.032).

The proportion of respondents who increased the frequency of snacks increased from 20.9% to 32.8% in the intervention group and decreased from 14.1% to 9.9% in the control group. The NEI (16.1%) increase was statistically significant (OR= 2.04(95% CI= 1.10-3.76), p= 0.023). There were no significant differences in the proportion of respondents who ate the recommended portion of fruits and vegetables as shown in Table 4.5. In addition, there were no significant differences in the proportion of respondents who were within ≥5 dietary diversity score (Table 4.5).

Table 4.5: Effect of intervention on dietary practices of the respondents

	Intervention group			Control group					
	Baseline	Six months		Baseline	Six months				
	n (%)	n (%)	% change	n (%)	n (%)	% change	NEI* %	Odds(95% CI)	P value
Meal plan	32(47.8)	40(59.7)	11.9	35(49.3)	32(45.1)	-4.2	16.1	1.77(1.09-2.87)	0.021
Frequency of meals	28(41.8)	32(47.8)	6.0	37(52.1)	32(45.1)	-7.0	13.0	1.69(1.04-2.74)	0.032
Frequency of snacks	14(20.9)	22(32.8)	11.9	10(14.1)	7(9.9)	-4.2	16.1	2.04(1.10-3.76)	0.023
Fruit intake	9(13.4)	14(20.9)	7.5	10(14.1)	16(22.5)	8.4	-0.9	0.74(0.38-1.44)	0.382
Vegetable intake	12(17.9)	17(25.4)	7.5	14(19.7)	15(21.1)	1.4	6.1	1.71(0.89-3.28)	0.103
Dietary diversity score	33(49.3)	37(55.2)	5.9	34(47.9)	32(45.1)	-2.8	8.7	0.49(0.24-1.04)	0.064

*NEI: Net effect of Intervention

4.6.2 Proportion of respondents within the RDAs

Table 4.6 shows the proportion of respondents who were within the RDA for macro and micro nutrients. When proteins were expressed per kg body weight, there was an increase of the proportion of respondents within 0.8-1.0g/kg/day from 25.4% to 32.8% in the intervention group and a decrease from 18.3% to 16.9% in the control group. The NEI (8.8%) increase was statistically significant (OR=1.87(95% CI =1.15-3.04, p= 0.012).

The proportion of respondents who were within the fat RDA increased from 41.8% to 47.8% in the intervention group and 35.2% to 47.9% in the control group. The NEI (-6.7%) decrease was statistically significant (OR= 1.68(95% CI =1.03-2.71, p= 0.037). There were no significant differences in the proportion of respondents who were within the RDA for energy, vitamin A and iron (Table 4.6)

Table 4.6: Effect of intervention on proportion of respondents within the RDAs nutrients

	Intervention group			Control group					
	Baseline	Six months		Baseline	Six months				
	n (%)	n (%)	% change	n (%)	n (%)	% change	NEI* %	Odds(95% CI)	P value
Energy RDA	51(76.1)	56(83.6)	7.5	47(66.2)	53(74.6)	8.4	-0.9	1.76(0.45-1.27)	0.296
Protein RDA	17(25.4)	22(32.8)	7.4	13(18.3)	12(16.9)	-1.4	8.8	1.87(1.15-3.04)	0.012
Fat RDA	28(41.8)	32(47.8)	6.0	25(35.2)	34(47.9)	12.7	-6.7	1.68(1.03-2.71)	0.037
Vitamin A RDA	33(49.3)	37(55.2)	5.9	34(47.9)	36(50.7)	2.8	3.1	1.39(0.85-2.25)	0.171
Iron RDA	28(41.8)	31(46.3)	4.5	29(40.8)	32(45.1)	4.3	0.2	1.12(0.69-1.81)	0.646
Zinc RDA	34(50.7)	40(59.7)	9.0	32(45.1)	34(47.9)	2.8	6.2	1.61(0.99-2.60)	0.053

*NEI: Net effect of Intervention

CHAPTER FIVE

DISCUSSION

5.1: The socio demographic and socio-economic characteristics of respondents

Epidemiological studies have repeatedly confirmed the inverse association between T2DM and some aspects of socio-economic status (Grintsova, Maier & Mielck, 2014). There were more women (66% in intervention and 62% control) than men in this study. These results are similar to those of other studies in Kenya: in a study carried out in Murang'a District on T2DM patients, female were 64% (Mwangi & Gitonga, 2014) while another study involving Kenyatta National Hospital (KNH) and Thika District Hospital (TDH) found 67% of respondents were female (Mwavua et al., 2016). Fewer studies have reported lower number of females compared to men (Umeh & Nkombua, 2018; Ganiyu et al., 2013). A higher percent (72%) of women compared to men in a diabetes study was also observed in Ghana by Mogre et al. (2017). However, a study by Houle et al. (2016) reported an equal number of males and females in the diabetes clinic.

The higher prevalence of females compared to males attending the clinics in many studies has been attributed to better health seeking behavior by women (Kautzky-Willer, Harreiter & Pacini, 2016; Hilawe, Yatsuya, Kawaguchi & Aoyama, 2013; Lawson, 2004). In addition, the most prominent risk factor, which is obesity, is more common in women as noted by Kautzky-Willer et al. (2016). Women were two times more likely to have chronic diseases compared to men after adjusting for other variables being studied (Lee, 2010).

Majority of respondents in this study were aged above forty years (93% in intervention and 89% in control). This is expected as the risk for T2DM increases with age (International Diabetes Federation, 2015). Given the fact that older patients with

diabetes are at increased risk of having diabetes-related complications, and to present with co morbid conditions such as hypertension (American Diabetes Association, 2014), this makes it more probable that it is the older rather than the younger who seek medical attention. It is therefore important to educate the population on need for T2DM screening.

Majority of respondents (75%) in intervention and 85% in control in this study were married. This is consistent with another study in Coastal Kenya on T2DM patients by Abdulrehman et al. (2016) where 77% of the respondents were married and another in Tripoli, Libya where 76.9% were married (Ashur, Shah, Bosseri, Fah & Shamsuddin, 2016). The results are lower than a study in India by Chacko & Begum (2016) on T2DM where 98.7% of the respondents were married while another study in Ethiopia by Angamo, Melese & Ayen (2013) showed 65.1% as married. Although marital status has not been studied as a risk factor for morbidity, marital function has been suggested to be a significant factor in mental and physical health (Lee, 2010).

Increased risk of diabetes has been associated with low socio-economic status and low education status (Hosseinpoor et al., 2012). This study had 31% in the intervention group (IG) and 18% in the control group (CG) with no formal education. Mandewo, Dodge, Chideme-munodawafa & Mandewo (2014) in their study on T2DM showed 8.7% and an equivalent 8.7% did not have formal education. A higher level (24.2%) of illiteracy was reported by Zaki & Mohamed (2014) while an illiteracy of 47% was reported by Islam et al. (2014). A 30% illiteracy was reported by Déré et al. (2016) in a study on diabetic and hypertensive patients. More than a third (34%) in intervention group and 38% in control group had attained primary education. Similar results on T2DM patients have been reported Musee, Omondi & Odiwuor (2016) where 35.4% had primary education. Lower primary education was reported in Botswana by Ganiyu et al.

(2013) with 22.1%. The results are lower than the ones reported in Murang'a District by Mwangi & Gitonga (2014) where 53.1% had primary education.

This study found that 19% in intervention and 25% in control group had secondary education. Al Bimani, Khan & David (2015) in their study on T2DM patients reported that 17% of respondents had attained secondary education while Arcury et al. (2006) reported that 20.8% had secondary education. A study by Nduati, Karanja, Njenga & Muthami (2016) on T2DM patients reported 42.3% with secondary education. A low percent (15%) of respondents in intervention group and 18% in control in our study had attained tertiary education. Arcury et al. (2006) in their study on diabetes patients found that 14.2% of respondents had attained higher education. A lower level of tertiary education (8.7%) was reported by Nduati et al. (2016) while a higher level (57.4%) was reported in Malaysia by Ahmad, Ramli, Islahudin & Paraidathathu (2013).

Over one third (39% in the IG and 38% in the CG) in this study were unemployed. This implies that the respondents were predominantly of a low socio-economic status. A study among diabetes patients in Cote d'Ivoire reported a slightly lower proportion (31%) of unemployed respondents (Déré et al., 2016). These results are lower than a study in Libya to assess glycemic control status among T2DM patients where the unemployed comprised 72.8% (Ashur et al., 2016). The results are similar to a study by Mwangi & Gitonga (2014) on T2DM patients where 13% were in salaried employment. The reason for high unemployment among respondents could be the study setting as most of the population came from rural areas and therefore opportunities are limited as noted by Maez, Erickson & Naumuk (2014).

The distance patients must travel in order to obtain treatment has long been recognized as a primary determinant of the utilization of health care facilities (Titus, Adebisola & Adeniji, 2015). Majority of the population (46% in the intervention group and 45% in

the control group) in this study lived more than 10km away from the nearest health facility. Another study on T2DM patients showed that 50% lived within 5km of a health facility while 50% lived more than 5km away (Patil, Deshmukh & Patil, 2017). A study in Finland on T2DM patients showed that 70% of the population was living within a radius of 5km from the health facility (Toivakka, Laatikainen, Kumpula & Tykkyläinen, 2015).

5.2: Effect of using mobile phone communication on morbidity and nutrition status of respondents

Our study noted that there was a significant reduction on morbidity prevalence among respondents. This reduction in morbidity prevalence in the intervention group compared to the control group could be because the mobile phone intervention led to improvement in self-care practices that led to better management of the T2DM patients hence decreased morbidity. Use of the mobile phone may lead to early identification of complications and enhance patient's adoption of healthy lifestyles that in the long run lead to reduced morbidity (Huang et al., 2013).

This study also noted that there was no significant effect of the mobile phone intervention on side effects of diabetes medicine. Medication side effects among T2DM patients have been reported in other studies (Mandewo et al., 2014; Kamuhabwa & Charles, 2014). Such side effects can have a negative impact on patient's adherence to treatment, resulting in uncontrolled diabetes and increased hospitalization and mortality (Philis-tsimikas, 2009). Therefore, it is important to adhere to prescribed drugs to minimize possible side effects. Mobile phone communication was used to monitor medication side effects following treatment in cancer patients in a study by Weaver et al. (2007).

The proportion of subjects with controlled HbA1c was relatively low in both the intervention and control groups. In addition, mobile phone communication did not have a significant effect in HbA1c control. This raises concern as poorly controlled diabetes puts the patients at risk of complications (Nduati et al., 2016). Studies on T2DM by Waari et al. (2018), Nduati et al. (2016) and Musenge, Michelo, Mudenda & Manankov (2016) on T2DM patients have reported even a lower proportion of patients with controlled HbA1c.

The results on the effect of mobile phone communication on diabetes management in this study are similar to those made in other studies (Istepanian et al., 2009; Newton, Wiltshire, Fracp & Elley, 2009; Turner, Larsen, Tarassenko, Neil & Farmer, 2009; Benhamou et al., 2007; Kim, 2007) where mobile phone communication did not have a significant effect. However, significant reduction in HbA1c after mobile phone intervention was reported in other diabetes studies (Franklin, Waller, Pagliari & Greene, 2006; Kim, 2005).

This study found that there was no significant effect of the mobile phone intervention on FBS among the respondents. This is similar to a study by Kim (2007) that found non-significant reduction in FBS in the intervention and control group ($p>0.05$) after mobile phone intervention. Liu, Yeh, Lee & Li (2005) in their study on diabetes patients found a significant reduction ($p<0.05$) in intervention versus control group after mobile phone intervention. As A common practice in the hospital, respondents are instructed to fast 8 hours prior to FBS test and this may have affected the results.

Blood pressure (BP) control in T2DM patients is important as it also prevents cardio vascular complications (Parati, Bilo & Ochoa, 2011). This study observed that there was a significant BP control after mobile phone communication. Significant improvement in BP after mobile phone intervention have been reported in diabetes studies by Holbrook

et al. (2009) and Yoo et al. (2009) while no significant effect on BP have been reported by Newton et al. (2009) and Hurling et al. (2007) after mobile phone intervention.

Since it has been noted that most diabetes patients are overweight or obese, it is important to lose weight as weight reduction is associated with a significant reduction of HbA1c levels and improvement in several other cardio vascular risk factors (Wilding, 2014). Less than 40% of respondents in this study had good nutrition status. A similar prevalence of overweight and obesity (61%) was reported among slum residents in Nairobi by Ettarh, Vijver & Oti (2013).

According to Maina et al. (2011), the prevalence of overweight and obesity was 22.6% in women and 10% in men in rural areas. This shows that obesity is a rising epidemic worldwide and continues to be a major health problem (Maric-Bilkan, 2013). Khattab, Khader, Al-khawaldeh & Ajlouni (2010) in their study on T2DM patients found that 91% had poor nutrition status. There was no significant effect of the mobile phone intervention on nutrition status among the respondents. Studies on T2DM patients by Newton et al. (2009) and Hurling et al. (2007) have reported no significant difference in BMI between intervention and control group after mobile phone intervention ($p>0.05$).

5.3: Effect of using mobile phone communication on health seeking behavior of T2DM patients at KCRH

Good health seeking behavior is important as it helps to prevent serious long-term complications associated with diseases such as diabetes (Mandewo et al., 2014; Siddiqui, Sohag & Siddiqui, 2011). There was no significant effect of the mobile phone intervention on the proportion of patients who attended the hospital when unwell in this study.

Diabetes should be aggressively managed by regular clinic attendance (Jones, 2013). This study also observed that there was no significant effect of the mobile phone intervention on clinic attendance. Other studies on T2DM patients reported a higher adherence to clinic attendance at 85% and 87% (Mwavua et al., 2016; Mwangi & Gitonga, 2014). However, a study carried out in United Kingdom (UK) on T2DM patients reported a very low adherence to doctor's appointment of 35% (Cheng, 2013). Mobile phone communication have been shown to have an increase in rate of diabetes clinic attendance in a study by Avdal, Kizilci & Demirel (2011) where the rate of attending health check visits increased in the intervention group ($p<0.05$). Use of mobile phone significantly increased ($p<0.05$) rate of clinic attendance in epileptic patients in Malaysia (Sarkar, Sivashankar & Seshadri, 2015).

Self-monitoring of blood glucose (SMBG) is important as it promotes better awareness of glucose levels, leading to improvements in diet and lifestyle (Young et al., 2017). Lower rates of SMBG of 34% and 19% have been shown in other diabetes studies (Mwavua et al., 2016; Charity et al., 2015). However, higher rates of SMBG (49%) have been reported in other studies (Badedi et al., 2016; Sontakke et al., 2015). There was a significant increase in SMBG after mobile phone communication in this study. Durso et al. (2003) in their study on T2DM patients reported an increase in SMBG in intervention group compared to control group after mobile phone messaging. However, no significant difference in SMBG was observed between intervention and control group after mobile phone intervention in a study on T2DM (Benhamou et al., 2007).

Feet health is an important component in diabetes as it prevents diabetes foot ulcers (DFUs) that are associated with foot amputations (Ekore, Ajayi, Arije & Ekore, 2010). This study found that less than 75% of respondents had daily feet health monitoring. Another study on diabetes reported an even lower proportion (20%) of patients that

monitored their feet (Ekore et al., 2010), while a study in Lamu, Kenya, showed that 37% of DM patients checked their feet regularly (Abdulrehman et al., 2016).

However, another study reported that over half (58%) of respondents checked their feet (Saleh, Mumu, Ara, Hafez & Ali, 2014). The reason for poor feet checks in this population could be because of poor knowledge on its importance indicating the need for more education on importance of daily feet check. Our study noted that there was no significant increase in feet health monitoring after mobile phone communication. A previous study on T2DM patients by Hassan (2017) reported a significant difference in feet health ($p<0.05$) after mobile phone messaging.

5.4: Effect of using mobile phone communication on drug adherence of T2DM patients at KCRH

Drug adherence has been shown to be a significant predictor of HbA1c, indicating that improved adherence results in better glycemic control (Garcı´a-Pe´rez et al., 2013) and this reduces the risk of diabetes complications (Angamo et al., 2013).

This study found that >40% of T2DM patients were not adherent to specific drug times at baseline. This proportion is higher compared to a study in Palestine on T2DM patients by Elsous, Radwan, Al-Sharif & Mustafa (2013) that found 11% did not adhere to specific drug times. Sontakke et al. (2015) in their study on T2DM found that 35% of respondents did not adhere to specific drug times. This study also found that 34% in intervention group and 37% in control group forgot to take their diabetes drugs. These findings are similar to a study by Elsous et al. (2013) where 34% forgot to take their medicine. Hernández-ronquillo, Téllez-zenteno, Garduño-espinosa & González-acevez (2003) reported that a lower proportion (13%) of patients missed doses while Sajith, Pankaj, Pawar, Modi & Sumariya (2014) showed that 41% had missed doses. A study in Zimbabwe on T2DM found that 63% of respondents had missed the diabetes drugs

(Ponesai et al., 2015) while Alqarni, Alrahbeni, Al Qarni & Al Qarni (2019) found that 54% missed their diabetes drugs.

Our study found that mobile phone communication led to significant effect on adherence to specific time for taking drugs. These results are similar to other studies that found that intervention with SMS significantly decreased ($p<0.05$) incidences of delayed doses (Huang et al., 2013; Vervloet et al., 2012). Vervloet et al. (2012) in their study on T2DM noted that there was a significant difference ($p<0.05$) between the intervention and control groups in regard to adhering to standardized time windows. The reasons for non-adherence in this study as reported in Focus Group Discussion (FGD) were side effects of medication, forgetfulness and travelling away from home which are similar to those reported in other studies (Mandewo et al., 2014; Ahmad et al., 2013).

The proportion of respondents who did not travel with DM drugs was high (>40% in intervention and in control group). This is higher compared to studies on T2DM patients in Cameroon (Aminde et al., 2019) and Mexico (Hernández-Ronquillo et al., 2003) where 27% and 13% did not travel with their diabetes drugs respectively. This is lower compared to a study on DM by Mandewo et al. (2014) that found that 55% of respondents did not travel with their drugs.

There was low proportion (<50%) of respondents using un prescribed drugs in both groups at baseline and after six months, probably because of fear of being reprimanded by the health workers. Sontakke et al. (2015) in their study on T2DM patients found that 45% of respondents took additional non prescribed medicine. Some diabetes drugs have been associated with diabetes treatment failure (Bagonza, Rutebemberwa & Bazeyo, 2015) while some patients believe that diabetes is curable as reported by Shah et al. (2009).

Consequently patients may resort to use of herbal remedies (Mwangi & Gitonga, 2014) and use of over the counter medicine (May & Schindler, 2016). The use of herbal remedies and over the counter medicine may lead to drug interactions that further lead to pharmacologic inefficacy and side effects (May & Schindler, 2016). Given that diabetes mainly affects populations aged above 40 years, this leads to a decline in immune function (Montecino-Rodriguez, Berent-Maoz & Dorshkind, 2013) that in the long run calls for more pharmacology and this is likely to lead to adverse drug interaction (May & Schindler, 2016). It is for this reason that use of un prescribed drugs in T2DM patients should be discouraged.

In addition, treatment failure may lead T2DM patients to abscond diabetes drugs as shown in this study. Other studies (Aminde et al., 2019; Polonsky & Henry, 2016; Iglay et al., 2015; Sontakke et al. 2015; Elsous et al., 2013) reported that 5%-60% of T2DM patients absconded diabetes drugs. This may be because after a long duration of treatment, patients feel better while some give up treatment. Poor drug adherence in this population is a worrying trend given the high rates of diabetes in Africa and more so in Kenya (Waari et al., 2018). Similar high rates of non-adherence to DM drugs have been reported in Cameroon (54%) (Aminde et al., 2019) while lower rates have been reported in Uganda (16.7%) (Bagonza et al., 2015). This might imply that inadequate attention is given to diabetes or it might be attributed to forgetfulness by some patients.

As majority (46% in the IG and 45% in the CG) of patients in this study lived more than 10km away from the nearest health facility this might be another possible reason for the poor drug adherence. Poor cognition that is common with advancing age could also be a potential reason, considering that over 85% of respondents in this study were aged over forty years of age. This in turn may lead to poor drug adherence (Smaje, Davis, Ranjana, Mine & Rawle, 2018).

The high prevalence of unemployment could also be a factor since socio-economic factors are related to medication adherence (Elsous et al., 2013). Given that diabetes patients in Kenya pay for their medicines, this may lead to poor drug adherence as drug costs and affordability are recognized challenges to controlling chronic diseases like diabetes especially in low income settings (Aminde et al., 2019; Abdulrehman et al., 2016). Poor drug adherence could also be attributed to poor knowledge (Maina et al., 2011). From the FGD, most respondents cited forgetfulness as one patient stated, '*I work away from home and most drug times I am away and sometimes I forget to travel with the medication*'. Another patient cited financial constraints. '*I live far from home and sometimes I miss bus fare to go to the hospital and buy the drugs*'.

Non adherence to medication is a common problem associated with sub-optimal clinical outcomes and increased health-care costs (Sarkar et al., 2015). The acceptable cutoff point for adherence rate is 80% or higher (Alqarni et al., 2019). The present study is in agreement with WHO report that adherence to long-term therapy for chronic illnesses in developed countries is 50% and is even lower in developing countries (World Health Organization, 2003). This study relied on patients' recall, the actual and true prevalence of drug adherence could be lesser than the reported proportions. It is important to motivate patients to take the medications as prescribed by the doctor.

The use of Short Message Service (SMS) can offer a promising intervention in diabetes and this can go a long way in managing the high cases of drug non adherence that is associated with sub-optimal clinical outcomes as stated above. This has also been demonstrated by other studies (Sarkar et al., 2015; Haddad et al., 2014; da Costa et al., 2012; Khwankhom, 2007). In the Thai study by Khwankhom (2007), patients with tuberculosis who received daily SMS reminders improved drug adherence to over 90%.

Though other studies (Boker, Feetham, Armstrong, Purcell & Jacobe, 2012; Iribarren, Chirico, Echevarrria & Cardinali, 2012; Vervloet et al., 2012) have demonstrated that the use of SMS did not lead to improved drug adherence our study showed positive results. More specifically, use of mobile phone communication improved adherence to the time for taking diabetes drugs and with no missed doses. Bearing in mind that forgetfulness has been cited as one of the reasons leading to poor drug adherence in T2DM patients (Aminde et al., 2019), use of mobile phone communication in diabetes clinics is recommended since it resulted in improved adherence to drugs.

5.5: Effect of using mobile phone communication on dietary practices of T2DM patients at KCRH

According to Musee et al. (2016), T2DM can be controlled and prevented through lifestyle changes with a focus on diet management and studies have shown that diet management, reduce the complications associated with T2DM (Sami, Ansari, Butt & Ab Hamid, 2017; Gutschall, Miller, Mitchell & Lawrence, 2009). Despite this, the extent to which patients follow the recommended dietary regime is below optimal in most cases, ranging from 22% to 70% (Musee et al., 2016).

Dietary habits have been shown to improve after the mobile phone intervention (Cole-Lewis & Kershaw, 2010). While it might be hard to place a direct association of diet and glycemic control, diabetes management by mobile phone with dietary theme have been shown to lead to improved glycemic control. For example, Haddad et al. (2014) and Tamban, Isip-Tan & Jimeno (2013) in their studies on DM have shown improved glycemic control after the mobile phone management. At the same time dietary practices are greatest predictors of weight loss in overweight and obese patients (Haapala, Barengo, Biggs, Surakka & Manninen, 2009).

A simple meal plan emphasizing guidelines for healthy food choices is effective in producing changes in glycemic control in T2DM patients (Yannakoulia, 2006). Results of this study show that less than 60% in the intervention and the control group followed a meal plan. The results are higher compared to a study in Saudi Arabia on T2DM where 19% used a meal plan (Badedi et al., 2016). The results are lower compared to a study by Kamuhabwa & Charles (2014) where 69% DM patients followed a meal plan. A study on adherence to and factors associated with self-care behaviors in T2DM in Ghana showed that less than one-third followed a healthy eating plan daily (Mogre et al., 2017).

This study found that mobile phone communication had a significant increase on use of meal plan among the respondents. One of the reasons why respondents were not following the meal plan in this study could be the perceived barriers for example lack of time following a meal plan and poor education status as a large percent (31% in the intervention group and 18% in the control group did not have formal education). Living in rural settings (Mogre et al., 2017), non-availability of fruits and vegetables and the high cost of foods (Worku et al., 2015) have been identified by other studies as barriers to following meal plan.

Frequent meals in T2DM patients reduce post-prandial insulin secretion and enhance insulin sensitivity in diabetes patients (Mohamed, Almajwal, Saeed & Bani, 2013) and prevent hypoglycemia (Meyer, 2009). Respondents who adhered to the recommended number of meals in this study were 42% at baseline in the intervention and 52% in the control group. Brown, O'Connor & Savaiano (2014) in their study on college students found that 18% adhered to the correct number of meals while a higher number of meals have been reported by Chacko & Begum (2016) and Mohamed et al. (2013) of 58% and 64% respectively. A study on dietary patterns in Kitui, Bondo and Trans Mara Districts found that those meeting the required number of meals were 73%, 82% and 88% respectively (Hansen et al., 2011).

Use of mobile phone communication significantly increased frequency of meals among the respondents in this study. Tamban et al. (2013) found a significant increase in the number of meals by diabetes patients in the SMS group compared to control group (p= 0.02). Studies by Senadheera, Ekanayake & Wanigatunge (2016) and Årsand, Tatara, Østengen & Hartvigsen (2010) on T2DM patients found an increase in frequency of meals after mobile phone intervention.

This study found a low snack intake (<3) among respondents (<35%) in the intervention and the control group at baseline and after six months. Hansen et al. (2011) in their study on dietary practices found that 1%, 3% and 4% of respondents were taking recommended snacks in Kitui, Bondo and Trans Mara Districts respectively. A study conducted in Saudi Arabia on T2DM patients found that 23% took the recommended daily snacks (Mohamed et al., 2013). This low intake of meals and snacks in this study could be explained by lack of knowledge on the number of meals and snacks and poor socio-economic status and poor dietary practices (Mohamed et al., 2013; Hansen et al., 2011).

According to Senadheera et al. (2016), consumption of vegetables contributes to intake of certain vitamins and antioxidants and thus combats deficiencies that could arise with diabetes. Vegetables and fruits also improve bowel function, slow rates of glucose and lipid absorption from the small intestine, and lower blood lipids (Eswaran et al., 2013).

There was a low fruit intake (<30% in the intervention and in control group) in this study. Olielo (2013) in his study on food security problems in various income groups in Kenya found low fruit intake (26%). Senadheera et al. (2016) found that consumption of fruits by a Sri Lankan population was 46% while Mokhehle (2014) found that 32% were within the recommended fruit intake. The National Micro Nutrient Survey report of

1999 in a study done in five districts in Kenya found that only 10% consumed fruits (GOK/UNICEF, 1999).

Lower fruit intakes in T2DM patients (<20%) have been reported by Mogre et al. (2017) and Musee et al. (2016). Tiew, Chan, Lye & Loke (2014) found a similar trend of fruit intake by T2DM patients (29%). An even lower fruit intake (2.1%) was reported in a Sri Lankan study by Jayawardena, Byrne, Soares, Katulanda & Hills (2012). Meyer (2009) in a South African study found that only a third took fruits in a day. This study shows that fruit intake in the population is low. This study found that mobile phone communication did not have a significant effect on fruit intake among respondents.

Elbert, Dijkstra & Oenema (2016) and Brown et al. (2014) reported a significant increase ($p<0.05$) in fruit consumption in the intervention group compared to the control group after mobile phone intervention. Studies by Spring et al. (2018) and Partridge et al. (2015) found an increased fruit intake after mobile phone intervention. However, this was not significant at $p>0.05$. Fifty eight percent (58%) reported increased daily intake of fruits and vegetables after mobile phone intervention in a study by Årsand et al. (2010). The reason for the low fruit intake in this population could be seasonality of the fruits. Another reason could be perception that the population has on fruits as an interview conducted on one respondent remarked '*How can I consume fruits which have a lot of sugar? You want me to have high sugar levels?*' Another study by Tiew et al. (2014) found that fruits were defined as '*too sweet'* by the respondents. The other factor could be cost since socio demographic determinants are important in shaping fruit and vegetable intake patterns (Msambichaka et al., 2018).

This study also noted that there was low vegetable consumption (<30%) in the intervention and the control group. Low vegetable consumption in T2DM patients have also been reported by Musee et al. (2016), Mohamed et al. (2013) and Jayawardena et al.

(2012) of 10%, 18.5% and 11.6% respectively. Higher amounts of vegetable intake have been reported by Senadheera et al. (2016), Worku et al. (2015) and Tiew et al. (2014) in their studies on T2DM patients of 45.5%, 67.2% and 51% respectively. This study found that mobile phone communication did not have a significant effect on vegetable intake among the respondents. Spring et al. (2018), Elbert et al. (2016), Mummah, Mathur, King, Gardner & Sutton (2016), Partridge et al. (2015) and Brown et al. (2014) reported a significant increase in consumption of vegetables after mobile phone communication.

The two periods of data collection (March and April 2017 and November and December 2017) coincided with the rainy seasons. The low intake of vegetables could be attributed to lack of knowledge on the importance of vegetable intake. Similar observations have also been made by Worku et al. (2015) and Mohamed et al. (2013). Majority of respondents (>70%) were not within the recommended fruit (2-4) and vegetable (3-5) intake in this study. This puts respondents at risk of complications such as uncontrolled BP (over 50% in the intervention and over 40% in the control group had uncontrolled BP). Therefore, there is need for reminders by use of mobile phone communication to increase intake of fruits and vegetables.

Studies have argued that diverse diets reflect nutrient adequacy (Labadarios, Steyn & Nel, 2011). Lack of dietary diversity is particularly a considerable problem among poor populations of developing world as their diets are predominantly based on starchy staples (Ngala et al. 2015; Rathnayake, Madushani & Silva, 2012) and our study is no different with less than half (49% in the intervention and 48% in the control group) within the recommended DDS at baseline. Tiew et al. (2014) in their study found that 35% of respondents were within the DDS. Kiboi, Kimiywe & Chege (2017) in their study in Laikipia, Kenya found that 37% were in medium diversity category (4–5 food

groups). A study in South Africa by Labadarios et al. (2011) found that 38.2% of respondents in Limpopo and 40.4% in Eastern Cape were within the DDS of 4.

A higher percent (79%) of respondents who were within the DDS was reported in diabetic and hypertensive patients in Cote d'Ivoire by Déré et al. (2016). The reason for a low DDS in this study could be because of the agricultural practices with majority cultivating cereals and pulses. There was a perception by the study participants that a diabetes diet is a special diet from the FGD conducted on the T2DM patients and this was likely to have led to low DDS. Similar observations have been reported on T2DM patients by Meyer (2009).

Improved glycemic control has been associated with caloric restriction (Mason et al., 2019; Sathananthan et al., 2015). This study found that less than 15% of respondents in the intervention and the control group were not within the RDA for energy. This is despite the fact that more than half (>60%) of respondents in the two groups were overweight or obese. In addition, >40% at baseline had poorly controlled HbA1c. Ming & Rahman (2002) in their study on dietary intake of T2DM patients found similar results where 72% of respondents were within the RDA for energy despite majority of them being overweight and obese. The discrepancy in this study may have been brought about by underreporting which is a disadvantage of recall method.

Kolahdooz, Spearing & Sharma (2013) in their study on dietary adequacies in South Africa found that majority of respondents exceeded the RDA for energy. These findings indicate lack of knowledge among respondents on food intake and healthy eating among diabetes patients. This study found that mobile phone communication did not have significant effect on energy intake of respondents. No significant difference in energy intake was reported after mobile phone intervention in studies by Casperson et al. (2015) and Haapala et al. (2009). A study by Ambeba et al. (2016) on energy and fat intakes

showed there was significant improvement in energy intake for both groups ($p<0.05$) after mobile phone intervention.

Nutritional recommendation includes reducing protein intake to 0.8-1.0g/kg body weight per day in individuals with diabetes (American Diabetes Association, 2013). Protein intake in T2DM patients is known to augment postprandial insulin release and attenuate the postprandial rise in glucose concentration in T2DM patients (Manders et al., 2014). Less than 35% of respondents were within the protein RDA (0.8-1.0g/kg body weight). This is similar to a study in Sri Lanka on food consumption where 36.2% of respondents were within the RDA for protein (Jayawardena et al., 2012).

The results are higher compared to a study in South Africa by Mokhehle (2014) on T2DM where 20% had sufficient protein intake. Studies in South Africa and Saudi Arabia by Kolahdooz et al. (2013) and Mohamed et al. (2013) found that >70% and 59.2% met the recommended protein level respectively. This study found that mobile phone communication had a significant effect on protein intake. There was increase in consumption of protein foods in the intervention group compared to the control group after mobile phone intervention in a study by Vakili, Abedi, Afshari & Kaboli (2015). However, this was not significant at $p>0.05$. Bearing in mind that there is high cultivation of pulses in this population, this raises the question of underreporting.

Fats provide energy, essential fatty acids (EFAs) that are precursors of hormone-like substances that influence and regulate key physiological functions (Smuts & Wolmarans, 2013). There was low fat intake (<70g) with majority (>50%) in intervention and control not within the RDA. This is despite over half (>50%) of the population being overweight or obese. Again, this raises suspicion of underreporting. Mohamed et al. (2013) in their study on dietary practices among patients with T2DM in Saudi Arabia found that less than 50% of respondents were within the RDA for fat. This

study found that mobile phone communication had significant effect on fat intake of respondents. Haapala et al. (2009) in their study found that there was reduced fat intake after mobile phone intervention. However, this was not significant ($p>0.05$). A study by Ambeba et al. (2016) on use of mHealth showed there was significant improvement in total fat intake for both groups ($p<0.05$) after mobile phone intervention. Having explored the negative consequences of high-fat consumption, it is important to educate this population on the reduction of fat intake and how to make healthy food choices.

Type 2 Diabetes Mellitus (T2DM) is characterized by significant losses of important micro nutrients due to metabolic basis of the disease and its complications (Kaur & Henry, 2014). Micronutrient deficiencies of vitamin A, iron and zinc are discussed in this chapter as they are recognized worldwide as of public health concern (Ministry of Health, 2011). Less than 60% of respondents in this study were within the RDA for vitamin A. This is despite the fact that data collection coincided with the two rainy seasons. This could be attributed to low intake of fruits and vegetables as shown above and lack of knowledge on the importance of vitamin A. In addition, vitamin A is more bioavailable from Animal Source Foods (ASFs) and affordability by populations in low socio-economic status is a limitation.

A study by Kolahdooz et al. (2013) on dietary adequacies found that more than 80% of respondents were not within the RDA for vitamin A. This study found that mobile phone communication did not have significant effect on vitamin A intake among respondents. Non-significant adherence to vitamin regimen was reported in a study on text messaging by Cocosila, Archer, Haynes & Yuan (2009) after mobile phone intervention. The consumption of vitamin A rich fruits significantly increased in the intervention group compared to the control group ($p<0.001$) in a study on mobile phone intervention (Vakili et al., 2015).

This study found that less than 50% were within the RDA for iron. Kolahdooz et al. (2013) in their study on dietary adequacies among South African adults found that >70% of their respondents were within the iron RDA while Qin et al. (2009) found 3.4% with insufficient iron intake. The low iron intake could be explained by the fact that respondents had low vegetable intake. This study noted that there was no significant effect of the mobile phone intervention on iron intake among the respondents. Mann et al. (2015) in their study found that there was an increase in iron intake in pregnant women after mobile phone intervention.

Zinc improves the oxidative stress in diabetes patients by reducing chronic hyperglycemia (Cruz et al., 2015). Less than 60% of the respondents were within the zinc RDA of 15mg daily in this study. This is despite the cultivation of cereals which are rich in micro nutrients such as zinc. Similar findings have been reported by Briefel et al. (2000) in their study on zinc intake of the USA population where 55.6% had adequate zinc intake. A study conducted in China on dietary intake of zinc by Qin et al. (2009) had lower intake (22.9%) of zinc while Kolahdooz et al. (2013) found that more than 40% of respondents consumed adequate RDA for zinc. The low zinc intake in this study could be attributed to underreporting, a disadvantage of recall method. This study found that mobile phone communication had a significant effect on zinc intake. Ali, Silvioli, Rajai & Aslam (2017) in their study on feasibility of use of a mobile application for nutrition assessment found that more than 90% of respondents were within the limits of zinc intake after use of mobile phone intervention.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Majority of the respondents were above forty years, married, with low education status, unemployed and travelled over 10km to access the nearest health facility.

Use of mobile phone communication was associated with significantly reduced morbidity, though it had no effect on the nutrition status of T2DM patients.

Use of mobile phone communication improved health seeking behavior in respect to increased self-monitoring of blood glucose (SMBG) among the T2DM patients in this study.

Use of mobile phone communication was also associated with improved drug adherence practices, specifically adherence to the time for taking diabetes drugs, and not missing doses.

Use of mobile phone communication was associated with improved adherence to recommended dietary practices in respect to use of meal plans, and increased frequency of meals.

These findings therefore disprove the hypothesis that use of mobile phone communication has no effect on the management of outcomes of T2DM patients at KCRH. The hypothesis was thus rejected.

All the study hypotheses were therefore rejected as indicated below:

Ho_1: Use of mobile phone communication has no effect on morbidity and nutrition status of T2DM patients at KCRH was rejected

Ho_2: Use of mobile phone communication has no effect on health seeking behavior of T2DM patients at KCRH was rejected

Ho_3: Use of mobile phone communication has no effect on drug adherence of T2DM patients at KCRH was rejected and

Ho_4: Use of mobile phone communication has no effect on dietary practices of T2DM patients at KCRH was rejected

6.2 Recommendations

Based on the study findings and conclusions, the following recommendations were made:

- Health care workers should promote mobile phone communication in aspects of morbidity and health seeking behavior to control BP and enhance self-monitoring of blood glucose (SMBG). There should also be use of mobile phone to remind patients to take drugs at specific time and to reduce missed doses.

- Health care workers should also promote mobile phone communication in improving adherence to recommended dietary practices, specifically the use of meal plan and to increase the frequency of meals.

- The County Government of Kitui should target females as there is a higher prevalence of diabetes among females in the current study. Equally, the programmes should target patients in low socio-economic and low education status as most T2DM patients are found with these characteristics.

- The Kitui County should explore ways of improving the nutrition status of T2DM patients, including improvement of their knowledge on the importance of having sufficient intake of vitamin A, iron, and zinc in their diet.

- This study proposes further research that includes use of mobile phone communication in T2DM patients in specific age groups and use of mobile phone communication in physical activity and exercises.

- This study also proposes further research on patients' perception of use of mobile phone communication in diabetes management.

REFERENCES

se. *The National Medical Association*, *102*(7), 650–653.

Abbas, B., Al Fares, A., Jabbari, M., El Dali, A., & Al Orifi, F. (2015). Effect of mobile phone short text messages on glycemic control in type 2 diabetes. *International Journal of Endocrinology and Metabolism*, *13*(1). https://doi.org/10.5812/ijem.18791.

Abdulrehman, M., Woith, W., Jenkins, S., Kossman, S., & Hunter, G. (2016). Exploring cultural influences of self-management of diabetes in Coastal Kenya: An ethnography. *Global Qualitative Nursing Research*, *3*. https://doi.org/10.1177/2333393616641825.

Accurso, A., Bernstein, R., Dahlqvist, A., Draznin, B., Feinman, R., Fine, E., … Vernon, M. (2008). Dietary carbohydrate restriction in type 2 diabetes mellitus and metabolic syndrome. *Nutrition & Metabolism*, *5*(9). https://doi.org/10.1186/1743-7075-5-9.

Ahmad, N., Islahudin, F., & Paraidathathu, T. (2014). Factors associated with good glycemic control among patients with type 2 diabetes mellitus. *Diabetes Investigation*, *5*(5), 563–569.

Ahmad, N., Ramli, A., Islahudin, F., & Paraidathathu, T. (2013). Medication adherence in patients with type 2 diabetes mellitus treated at primary health clinics in Malaysia. *Patient Preference and Adherence*, *7*, 525–530.

Ahmed, A., Algamdi, S., Algurashi, A., Alzhrani, A., & Khalid, K. (2014). Risk factors for diabetic foot ulceration among patients attending primary health care services. *Diabetic Foot Complications*, *6*(2), 40–47.

Ajala, O., English, P., & Pinkney, J. (2013). Systematic review and meta-analysis of different dietary approaches to the management of type 2 diabetes. *American Journal of Clinical Nutrition*, *97*(3), 505–516.

Ajay, V., & Prabhakaran, D. (2011). The scope of cell phones in diabetes management in developing country health care settings. *Diabetes Science and Technology*, *5*(3), 778–783.

Ajuwon, G., & Rhine, L. (2008). The level of internet access and ICT training for health information professionals in Sub-Saharan Africa. *Health Information and Libraries Journal*, *25*(3), 175–185.

Aker, J., & Mbiti, I. (2010). Mobile phones and economic development in Africa. *Economic Perspectives*, *24*(3), 207–232.

Al Bimani, Z., Khan, S., & David, P. (2015). Evaluation of T2DM related knowledge and practices of Omani patients. *Saudi Pharmaceutical Journal*, *23*(1), 22–27.

Al Sayah, F., Majumdar, S., Williams, B., Robertson, S., & Johnson, J. (2013). Health literacy and health outcomes in diabetes. *General Internal Medicine*, *28*(3), 444–452.

Al-Delaimy, W., Willett, W., Manson, J., Speizer, F., & Hu, F. (2001). Smoking and mortality among women with type 2 diabetes. *Diabetes Care*, *24*(12), 2043–2048.

Ali, A., Farrukh, I., Taj, A., Iqbal, Z., Joher, M., & Iqbal, Q. (2013). Prevalence of microvascular complications in newly diagnosed patients with type 2 diabetes. *Pak Journal of Medical Science*, *29*(4), 899–902.

Ali, Z., Silvioli, R., Rajai, A., & Aslam, T. (2017). Feasibility of use of a mobile application for nutrition assessment pertinent to age-related macular degeneration (MANAGER2). *Translational Vision Science and Technology*, *6*(1). https://doi.org/10.1167/tvst.6.1.4.

Alisjahbana, B., Crevel, R., Sahiratmadja, E., Heijer, M., Maya, A., Istriana, E., … Meer, J. (2006). Diabetes mellitus is strongly associated with tuberculosis in Indonesia. *International Journal of Tuberculosis and Lung Disease*, *10*(6), 696–700.

Alqarni, A., Alrahbeni, T., Al Qarni, A., & Al Qarni, H. (2019). Adherence to diabetes medication among diabetic patients in the Bisha governorate of Saudi Arabia. *Patient Preference and Adherence*, *13*, 63–71.

Alramadan, M., Afroz, A., Hussain, S., Batais, M., Almigbal, T., Al-Humrani, H., … Billah, B. (2018). Patient-related determinants of glycaemic control in people with type 2 diabetes in the Gulf Cooperation Council Countries. *Journal of Diabetes Research*, *2018*. https://doi.org/10.1155/2018/9389265.

Al-Rasheedi, A. (2014). The role of educational level in glycemic control among patients with type II diabetes mellitus. *International Journal of Health Sciences*, *8*(2), 177–187.

Ambeba, E., Ye, L., Sereika, S., Styn, M., Acharya, S., Sevick, M., … Burke, L. (2016). The use of mHealth to deliver tailored messages reduces reported energy and fat intake. *Cardiovascular Nursing*, *30*(1), 35–43.

American Diabetes Association. (2008). Nutrition recommendations and interventions for diabetes. *Diabetes Care*, *31*(1), S61–S78.

American Diabetes Association. (2013). Standards of medical care in diabetes-2013. *Diabetes Care*, *36*(1), S11–S66.

American Diabetes Association. (2014). Diagnosis and classification of diabetes mellitus. *Diabetes Care*, *37*(1), S81–S90.

Aminde, L., Tindong, M., Ngwasiri, C., Aminde, J., Njim, T., Fondong, A., & Takah, N. (2019). Adherence to antidiabetic medication and factors associated with non-adherence among patients with type-2 diabetes mellitus in two regional hospitals in Cameroon. *BMC Endocrine Disorders*, *19*(39). https://doi.org/10.1186/s12902-019-0360-9.

Amod, A., Ascott-Evans, B., Berg, G., Blom, D., Brown, S., Carrihill, M., … May, W. (2012). The 2012 SEMDSA guideline for the management of type 2 diabetes. *Endocrinology, Metabolism and Diabetes of South Africa*, *17*(2), S1–S95.

Anderson, R., Cheng, N., Bryden, N., Polansky, M., Cheng, N., Chi, J., & Feng, J. (1997). Elevated intakes of supplemental chromium improve glucose and insulin variables in individuals with type 2 diabetes. *Diabetes*, *46*, 1786–1791.

Andeyaba, R., Thacher, T., Aboi, M., & Agaba, E. (2014). Control of risk factors for nephropathy among Nigerian outpatients with type 2 diabetes mellitus. *Jos Journal of Medicine*, *8*(3). Retrieved from https://www.ajol.info/index.php/jjm/article/view/138958.

Angamo, M., Melese, B., & Ayen, W. (2013). Determinants of glycemic control among insulin treated diabetic patients in Southwest Ethiopia. *Open Access*, *8*(4). https://doi.org/10.1371/journal.pone.0061759.

Animaw, W., & Seyoum, Y. (2017). Increasing prevalence of diabetes mellitus in a developing country and its related factors. *PLoS ONE*, *12*(11). https://doi.org/10.1371/journal.pone.0187670.

Arcury, T., Bell, R., Snively, B., Smith, S., Skelly, A., Wetmore, L., & Quandt, S. (2006). Complementary and alternative medicine use as health self-management: Rural older adults with diabetes. *Gerontology*, *61*(2), S62–S70.

Årsand, E., Tatara, N., Østengen, G., & Hartvigsen, G. (2010). Mobile phone-based self-management tools for type 2 diabetes. *Diabetes Science and Technology*, *4*(2), 328–336.

Ashur, S., Shah, S., Bosseri, S., Fah, T., & Shamsuddin, K. (2016). Glycaemic control status among type 2 diabetic patients and the role of their diabetes coping behaviours. *Libyan Journal of Medicine*, *11*(October 2017). https://doi.org/10.3402/ljm.v11.31086.

Attridge, M., Creamer, J., Ramsden, M., Cannings-John, R., & Hawthorne, K. (2015). Culturally appropriate health education for people in ethnic minority groups with type 2 diabetes mellitus. *Cochrane Database of Systematic Reviews*, (11), 1–608.

Avdal, D., Kizilci, S., & Demirel, N. (2011). The effects of web-based diabetes education on diabetes care results. *Computers, Informatics, Nursing*, *9*(2), 101–106.

Ayah, R., Joshi, M., Wanjiru, R., Njau, E., Otieno, C., Njeru, E., & Mutai, K. (2013). A population-based survey of prevalence of diabetes and correlates in an urban slum community in Nairobi, Kenya. *BMC Public Health*, *13*(371). https://doi.org/10.1186/1471-2458-13-371.

Badedi, M., Solan, Y., Darraj, H., Sabai, A., Mahfouz, M., Alamodi, S., & Alsabaani, A. (2016). Factors associated with long-term control of type 2 diabetes mellitus. *Diabetes Research*, *2016*. https://doi.org/10.1155/2016/2109542.

Bagonza, J., Rutebemberwa, E., & Bazeyo, W. (2015). Adherence to anti diabetic medication among patients with diabetes in eastern Uganda. *BMC Health Services Research*, *15*(168). https://doi.org/10.1186/s12913-015-0820-5.

Bando, H., Ebe, K., Muneta, T., Bando, M., & Yonei, Y. (2017). Effect of low carbohydrate diet on type 2 diabetic patients and usefulness of M-Value. *Diabetes Research*, *3*(10), 9–16.

Bansal, D., Gudala, K., Muthyala, H., Esam, H., Nayakallu, R., & Bhansali, A. (2014). Prevalence and risk factors of development of peripheral diabetic neuropathy in type 2 diabetes mellitus in a tertiary care setting. *Diabetes Investigation*, *5*(6), 714–721.

Bastaki, S. (2005). Diabetes mellitus and its treatment. *International Journal of Diabetes & Metabolism*, *13*, 111–134.

Bastaki, S. (2015). Pharmacotherapy of nonnutritive sweeteners in diabetes mellitus. *International Journal of Diabetes and Metabolism*, *23*, 11–22.

Bastawrous, A., Mathenge, W., Wing, K., Bastawrous, M., Rono, H., Weiss, H., … Kuper, H. (2017). The incidence of diabetes mellitus and diabetic retinopathy in a population-based cohort study of people age 50 years and over in Nakuru,

Kenya. *Endocrine Disorders*, *17*(19). https://doi.org/10.1186/s12902-017-0170-x.

Benhamou, P., Melki, V., Boizel, R., Perreal, F., Quesada, J., Bessieres-Lacombe, S., … Hanaire, H. (2007). One-year efficacy and safety of web-based follow-up using cellular phone in type 1 diabetic patients under insulin pump therapy. *Diabetes and Metabolism*, *33*(3), 220–226.

Blomster, J., Zoungas, S., Chalmers, J., Li, Q., Chow, C., Woodward, M., … Hillis, G. (2014). The relationship between alcohol consumption and vascular complications and mortality in individuals with type 2 diabetes. *Diabetes Care*, *37*, 1353–1359.

Boker, A., Feetham, H., Armstrong, A., Purcell, P., & Jacobe, H. (2012). Do automated text messages increase adherence to acne therapy? *The American Academy of Dermatology*, *67*(6), 1136–1142.

Bonora, E., & Tuomilehto, J. (2011). The pros and cons of diagnosing diabetes with A1C. *Diabetes Care*, *34*(2), S184–S190.

Boule´, N., Haddad, E., Kenny, G., Wells, G., & Sigal, R. (2001). Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus. *American Medical Association*, *286*(10), 11–15.

Briefel, R., Bialostosky, K., Kennedy-Stephenson, J., McDowell, M., Ervin, R., & Wright, J. (2000). Zinc intake of the U.S. population. *American Society for Nutritional Sciences*, *130*(5), 1367s-1373s.

Broomhead, S., & Mars, M. (2012). Retrospective return on investment analysis of an electronic treatment adherence device piloted in the Northern Cape Province. *Telemedicine and E-Health*. https://doi.org/https://doi.org/10.1089/tmj.2011.0143.

Brown, A., Ettner, S., Piette, J., Weinberger, M., Gregg, E., Shapiro, F., … Arbor, A. (2004). Socioeconomic position and health among persons with diabetes mellitus. *Epidemiologic Reviews*, *26*, 63–77.

Brown, O., O'Connor, L., & Savaiano, D. (2014). Mobile MyPlate: A pilot study using text messaging to provide nutrition education and promote better dietary choices in college students. *American College Health*, *62*(5), 320–327.

Buowari, O. (2013). Diabetes mellitus in developing countries and case series. In O. Oguntibeju (Ed.), *Diabetes Mellitus – Insights and Perspectives* (pp. 131–149). Intech.

Casperson, S., Sieling, J., Moon, J., Johnson, L., Roemmich, J., & Whigham, L. (2015). A mobile phone food record app to digitally capture dietary intake for adolescents in a free-living environment. *Medical Internet Research*, *3*(1). https://doi.org/10.2196/mhealth.3324.

Casqueiro, J., Casqueiro, J., & Alves, C. (2012). Infections in patients with diabetes mellitus. *Indian Journal of Endocrinology and Metabolism*, *16*(7), S27–S36.

Castaneda, C., Layne, J., Munoz-Orians, L., Patricia, L., Gordon, P., Walsmith, J., … Nelson, M. (2002). A randomized controlled trial of resistance exercise training to improve glycemic control in older adults with type 2 diabetes. *Diabetes Care*, *25*(12), 2335–2341.

Cavaiola, T., & Pettus, J. (2017). *Management of type 2 diabetes: Selecting amongst available pharmacological agents* (R. Henry, ed.). USA: MDText.com, Inc., South Dartmouth (MA).

Cefalu, W., & Hu, F. (2004). Role of chromium in human health and in diabetes. *Diabetes Care*, *27*(11), 2741–2751.

Chacko, M., & Begum, K. (2016). Dietary practices among type 2 diabetic patients. *International Journal of Health Sciences & Research*, *6*(4), 370–377.

Chandalia, M., Garg A., Lutjohann, D., Von Bergmann K., Grundy, S., & Brinkley, L. (2000). Beneficial effects of high dietary fibre intake in patients with type 2 diabetes mellitus. *The New England Journal of Medicine*, *342*(19), 1392–1398.

Charity, K., Kumar, A., Hinderaker, S., Chinnakali, P., Pastakia, S., & Kamano, J. (2015). Do diabetes mellitus patients adhere to self-monitoring of blood glucose

(SMBG) and is this associated with glycemic control? *Diabetes Research and Clinical Practice*, *2*, 37–43.

Chege, I., Okalebo, F., Guantai, A., Karanja, S., & Derese, S. (2015). Management of type 2 diabetes mellitus by traditional medicine practitioners in Kenya-key informant interviews. *Pan African Medical Journal*, *22*(1). https://doi.org/10.11604/pamj.2015.22.90.6485.

Chehade, J., Sheikh-Ali, M., & Mooradian, A. (2009). The role of micronutrients in managing diabetes. *Diabetes Spectrum*, *22*(4), 214–218.

Chen, R., Ji, L., Chen, L., Chen, L. Cai, D., Feng , B., … Zou, D. (2015). Glycemic control rate of T2DM outpatients in China. *Medical Science Monitor*, *21*, 1440–1446.

Cheng, C. (2013). *Diabetes: An old disease, a new insight* (S. I. Ahmad, ed.). Retrieved from https://link.springer.com/book/10.1007%2F978-1-4614-5441-0.

Chiavaroli, L., Mirrahimi, A., Ireland, C., Mitchell, S., Sahye-Pudaruth, S., Coveney, J., … Berger, A. (2016). Low-glycaemic index diet to improve glycaemic control and cardiovascular disease in type 2 diabetes. *BMJ Open Access*, *6*(7). https://doi.org/10.1136/bmjopen-2016-012220.

Chinenye, S., & Ogbera, A. (2013). Socio-cultural aspects of diabetes mellitus in Nigeria. *Social Health and Diabetes*, *1*(1), 15–21.

Cho, J., Lee, H., Lim, D., Kwon, H., & Yoon, K. (2009). Mobile communication using a mobile phone with a glucometer for glucose control in Type 2 patients with diabetes. *Telemedicine and Telecare*, *15*(2), 77–82.

Choe, H., Mitrovich, S., Dubay, D., Hayward, R., Krein, S., & Vijan, S. (2005). Proactive case management of high-risk patients with type 2 diabetes mellitus by a clinical pharmacist. *The American Journal of Managed Care*, *11*(4), 253–260.

Choi, T., Davidson, Z., Walker, K., Lee, J., & Palermo, C. (2016). Diabetes education for Chinese adults with type 2 diabetes. *Diabetes Research and Clinical Practice*, *116*, 218–229.

Clark, M. (2004). Adherence to treatment in patients with type 2 diabetes. *Diabetes Nursing*, *8*(10), 386–391.

Cocosila, M., Archer, N., Haynes, R., & Yuan, Y. (2009). Can wireless text messaging improve adherence to preventive activities? *International Journal of Medical Informatics*, *78*(4), 230–238.

Colberg, S., Sigal, R., Yardley, J., Riddell, M., Dunstan, D., Dempsey, P., … Tate, D. (2016). Physical activity/exercise and diabetes: A position statement of the American Diabetes Association. *Diabetes Care*, *39*(November), 2065–2079.

Cole-Lewis, H., & Kershaw, T. (2010). Text messaging as a tool for behavior change in disease prevention and management. *Epidemiologic Reviews*, *32*(1), 56–69.

Communications Authority of Kenya. (2016). *First quarter sector statistics report for the financial year 2015/2016* (Vol. 2016). Retrieved from http://www.ca.go.ke/images/downloads/STATISTICS/Sector Statistics Report Q1 2015-16.pdf.

Communications Authority of Kenya. (2019). *First quarter sector statistics report for the financial year 2018/2019* (Vol. 2019). Retrieved from https://ca.go.ke/wp-content/uploads/2018/12/Sector-Statistics-Report-Q1-2018-2019.pdf.

Cooper-dehoff, R., Handberg, E., Bavry, A., Denardo, S., Bakris, G., & Pepine, C. (2010). Tight blood pressure control and cardiovascular outcomes among hypertensive patients with diabetes and coronary artery disease. *American Medical Association*, *304*(1), 61–68.

Corker, J. (2010). "Ligne Verte" toll-free hotline: Using cell phones to increase access to family planning information in the Democratic Republic of Congo. *Cases in Public Health Communication & Marketing*, *III*, 23–37.

Costello, R., Dwyer, J., & Bailey, R. (2016). Chromium supplements for glycemic control in type 2 diabetes. *Nutrition Reviews*, *74*(7), 455–468.

Cruz, K., de Oliveira, A., & Kyria, D. (2015). Antioxidant role of zinc in diabetes mellitus. *World Journal of Diabetes*, *6*(2), 333–337.

da Costa, M., Barbosa, B., e Costa, D., Marin, H., Filho, A., & Pisa, I. (2012). Results of a randomized controlled trial to assess the effects of a mobile SMS-based intervention on treatment adherence in HIV/ AIDS-infected Brazilian women and impressions and satisfaction with respect to incoming messages. *International Journal of Medical Information*, *81*(4), 257–269.

Dammert, A., Galdo, J., & Galdo, V. (2014). Preventing dengue through mobile phones: Evidence from a field experiment in Peru. *Journal of Health Economics*, *35*, 147–161.

Davies, R. (2015). *The sustainable development goals as a network of targets. Monitoring and Evaluation NEWS* (Vol. 1). Retrieved from http://www.un.org/esa/desa/papers/2015/wp141_2015.pdf.

de Souza, R., Mente, A., Maroleanu, A., Cozma, A., Ha, V., Kishibe, T., … Anand, S. (2015). Intake of saturated and trans unsaturated fatty acids and risk of all cause mortality, cardiovascular disease, and type 2 diabetes. *BMJ Open Access*, *351*. https://doi.org/10.1136/bmj.h3978.

Déré, K., Djohan, Y., Koffi, K., Manhan, K., Niamké, A., & Tiahou, G. (2016). Individual dietary diversity score for diabetic and hypertensive patients in Cote d'Ivoire. *International Journal of Nutrition*, *2*(1), 38–47.

Dey, L., Attele, A., & Yuan, C. (2002). Alternative therapies for type 2 diabetes. *Alternative Medicine Review*, *7*(1), 45–58.

Diabetes Australia. (2016). *General practice management of type 2 diabetes: 2016-2018* (E. Deed, G. & Ackermann, ed.). Retrieved from https://static.diabetesaustralia.com.au/s/fileassets/diabetes-australia/5d3298b2-abf3-487e-9d5e-0558566fc242.pdf.

Diabetes Leadership Forum. (2010). Diabetes: The hidden pandemic and its impact on Sub-Saharan Africa. Johannesburg, South Africa.

Divya, S., & Nadig, P. (2015). Factors contributing to non-adherence to medication among type 2 diabetes mellitus in patients attending tertiary care hospital in South India. *Asian Journal of Pharmaceutical Clinical Research*, *8*(2), 8–10.

Dixit, A., Dey, R., Suresh, A., Chaudhuri, S., Panda, A., Mitra, A., & Hazra, J. (2014). The prevalence of dyslipidemia in patients with diabetes mellitus of Ayurveda Hospital. *Diabetes and Metabolic Disorders*, *13*(58). Retrieved from http://www.jdmdonline.com/content/13/1/58.

Durso, S., Wendel, I., Letzt, A., Lefkowitz, J., Kaseman, D., & Seifert, R. (2003). Older adults using cellular telephones for diabetes management. *Medical-Surgical Nursing*, *12*(5), 313–317.

Ekore, R., Ajayi, I., Arije, A., & Ekore, J. (2010). Knowledge of and attitude to foot care amongst type 2 diabetes patients attending a university-based primary care clinic in Nigeria. *African Journal of Primary Health Care & Family Medicine*, *2*(10). https://doi.org/10.4102/phcfm.v2i1.175.

Elbert, S., Dijkstra, A., & Oenema, A. (2016). A mobile phone app intervention targeting fruit and vegetable consumption. *Medical Internet Research*, *18*(6). https://doi.org/10.2196/jmir.5056.

El-busaidy, H., Dawood, M., Kasay, A., Mwamlole, C., & Koraya, N. (2014). How serious is the impact of type II diabetes in rural Kenya? *The Open Diabetes Journal*, *7*. Retrieved from https://pdfs.semanticscholar.org/8adb/81f65d05618e860448bab5dc9ba13813a1d6.pdf.

Elsous, A., Radwan, M., Al-Sharif, H., & Mustafa, A. (2013). Medications adherence and associated factors among patients with type 2 diabetes mellitus in the Gaza Strip, Palestine. *Frontiers in Endocrinology*, *8*(100). https://doi.org/10.3389/fendo.2017.00100.

Emdin, C., Rahimi, K., Neal, B., Callender, T., Perkovic, V., & Patel, A. (2015). Blood pressure lowering in type 2 diabetes. *American Medical Association*, *313*(6), 603–615.

Espelt, A., Borrell, C., Roskam, A., Rodríguez-Sanz, M., Stirbu, I., Dalmau-Bueno, A., … Kunst, A. (2008). Socioeconomic inequalities in diabetes mellitus across Europe at the beginning of the 21st century. *Diabetologia*, *51*(11), 1971–1979.

Eswaran, S., Muir, J., & Chey, W. (2013). Fiber and functional gastrointestinal disorders. *American Journal of Gastroenterology*, *108*(5), 718–727.

Ettarh, R., Vijver, S., & Oti, S. (2013). Overweight, obesity, and perception of body image among slum residents in Nairobi, Kenya, 2008–2009. *Preventing Chronic Disease*, *10*(4). https://doi.org/10.5888/pcd10.130198.

Evert, A., Boucher, J., Cypress, M., Dunbar, S., Franz, M., Mayer-davis, E., … Urbanski, P. (2014). Nutrition therapy recommendations for the management of adults with diabetes eating patterns. *Diabetes Care*, *37*(1), 120–143.

Evert, A., Boucher, J., Cypress, M., Dunbar, S., Franz, M., Mayer-davis, E., … Yancy, W. (2013). Nutrition therapy recommendations for the management of adults with diabetes. *Diabetes Care*, *36*(11), 3821–3842.

FAO. (2010). *Guidelines for measuring household and individual dietary diversity*. Retrieved from http://www.fao.org/fileadmin/user_upload/wa_workshop/docs/FAO-guidelines-dietary-diversity2011.pdf.

Faridi, Z., Liberti, L., Shuval, K., Northrup, V., Ali, A., & Katz, D. (2008). Evaluating the impact of mobile telephone technology on type 2 diabetic patients' self-management. *Evaluation in Clinical Practice*, *14*(3), 465–469.

Feinman, R., Pogozelski, W., Astrup, A., Bernstein, R., Fine, E., Westman, E., … Worm, N. (2015). Dietary carbohydrate restriction as the first approach in diabetes management. *Nutrition*, *31*. https://doi.org/10.1016/j.nut.2014.06.011.

Field, A. (2005). *Discovering statistics using SPSS* (2nd ed.). London: Sage Publishers.

Fong, D., Aiello, L., Gardner, T., King, G., Blankenship, G., Cavallerano, J., … Klein, R. (2004). Retinopathy in diabetes. *Diabetes Care*, *27*(1), S84–S87.

Fowler, M. (2007). Diabetes treatment, Part 1: Diet and exercise. *Clinical Diabetes*, *25*(3), 105–109.

Franklin, V., Waller, A., Pagliari, C., & Greene, S. (2006). A randomized controlled trial of sweet talk, a text-messaging system to support young people with diabetes. *Diabetic Medicine*, *23*(12), 1332–1338.

Free, C., Phillips, G., Galli, L., Watson, L., Felix, L., Edwards, P., … Haines, A. (2013). The effectiveness of mobile-health technology-based health behaviour change or disease management interventions for health care consumers. *PLoS Medicine*, *10*(1). https://doi.org/10.1371/journal.pmed.1001362.

Gaal, L., & Scheen, A. (2015). Weight management in type 2 diabetes: Current and emerging approaches to treatment. *Diabetes Care*, *38*, 1161–1172.

Ganesan, K., & Sultan, S. (2019). *Oral hypoglycemic medications*. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK482386/.

Ganiyu, A., Mabuza, L., Malete, N., Govender, I., & Ogunbanjo, G. (2013). Non-adherence to diet and exercise recommendations amongst patients with type 2 diabetes mellitus attending Extension II Clinic in Botswana. *African Journal of Primary Health Care & Family Medicine*, *5*(1). https://doi.org/10.4102/phcfm.v5i1.457.

Gannon, M., & Nuttall, F. (2004). Effect of a high-protein, low-carbohydrate diet on blood glucose control in people with type 2 diabetes. *Diabetes*, *53*(9), 2375–2382.

Gannon, M., Nuttall, F., Saeed, A., Jordan, K., & Hoover, H. (2003). An increase in dietary protein improves the blood glucose response in persons with type 2 diabetes. *The American Journal of Clinical Nutrition*, *78*(4), 734–741.

Garcı´a-Pe´rez, L., A´lvarez, M., Dilla, T., Gil-Guille´n, V., & Orozco-Beltra´n, D. (2013). Adherence to therapies in patients with type 2 diabetes. *Diabetes Therapy*, *4*, 175–194.

García-Elorriaga, G., & Del Rey-Pineda, G. (2014). Type 2 diabetes mellitus as a risk factor for tuberculosis. *Mycobacterial Diseases*, *4*(2). https://doi.org/10.4172/2161-1068.1000144.

Gepner, Y., Golan, R., Harman-Boehm, I., Henkin, Y., Schwarzfuchs, D., Shelef, I., … Shai, I. (2015). Effects of initiating moderate alcohol intake on cardiometabolic risk in adults with type 2 diabetes. *Annals of Internal Medicine*, *163*(8). https://doi.org/10.7326/M14-1650.

Gibson, R. (2005). Anthropometric assessment. Principles of nutritional assessment (2nd ed.). USA: Oxford University Press.

Gill, G., Mbanya, J., Ramaiya, K., & Tesfaye, S. (2009). A sub-Saharan African perspective of diabetes. *Diabetologia*, *52*(1), 8–16.

GOK/UNICEF. (1999). *National Micronutrient Survey report: Anemia and status of iron, vitamin A and zinc in Kenya*. Retrieved from https://static1.squarespace.com/static/56424f6ce4b0552eb7fdc4e8/t/57491e882eeb81625aeed64b/1464409865033/Kenya_Micronutrient+Survey_1999.pdf.

Goldfein, K., & Slavin, J. (2015). Why sugar is added to food: Food science 101. *Comprehensive Reviews in Food Science and Food Safety*, *14*(5), 644–656.

Grant, P. (2013). Management of diabetes in resource-poor settings. *Clinical Medicine*, *13*(1), 27–31.

Gray, A. (2015). *Nutritional recommendations for individuals with diabetes* (B. A. Feingold KR, Anawalt B, ed.). South Dartmouth, USA.

Grembecka, M. (2015). Sugar alcohols- Their role in the modern world of sweeteners. *European Food Research and Technology*, *241*. https://doi.org/10.1007/s00217-015-2437-7.

Grintsova, O., Maier, W., & Mielck, A. (2014). Inequalities in health care among patients with type 2 diabetes by individual socio-economic status (SES) and regional deprivation. *International Journal for Equity in Health*, *13*(43). https://doi.org/10.1186/1475-9276-13-43.

Gross, J., De Azevedo, M. Silveiro, S., Canani, L., Caramori, M., & Zelmanovitz, T. (2005). Diabetic nephropathy: Diagnosis, prevention, and treatment. *Diabetes Care*, *28*(1), 164–176.

GSMA. (2012). *Sub-Saharan Africa mobile observatory 2012*. Retrieved from https://www.gsma.com/publicpolicy/wp-content/uploads/2012/03/SSA_FullReport_v6.1_clean.pdf.

Guariguata, L., Whiting, D., Hambleton, I., & Beagley, J. (2013). Global estimates of diabetes prevalence for 2013 and projections for 2035. *Diabetes Research and Clinical Practice*, *103*(2), 137–149.

Gutschall, M., Miller, C., Mitchell, D., & Lawrence, F. (2009). A randomized behavioural trial targeting glycaemic index improves dietary, weight and metabolic outcomes in patients with type 2 diabetes. *Public Health Nutrition*, *12*(10), 1846–1854.

Haapala, I., Barengo, N., Biggs, S., Surakka, L., & Manninen, P. (2009). Weight loss by mobile phone. *Public Health Nutrition*, *12*(12), 2382–2391.

Haddad, N., Istepanian, R., Philip, N., Khazaal, F., Hamdan, T., Pickles, T., … Gregory, J. (2014). A feasibility study of mobile phone text messaging to support education and management of type 2 diabetes in Iraq. *Diabetes Technology & Therapeutics*, *16*(7), 455–458.

Hadjadj, S., Cariou, B., Fumeron, F., & Gand, E. (2016). Death, end-stage renal disease and renal function decline in patients with diabetic nephropathy in French cohorts of type 1 and type 2 diabetes. *Diabetologia*, *59*, 208–216.

Hajar, S., Hazmi, A., Wasli, M., Mousa, A., & Rabiu, M. (2015). Prevalence and causes of blindness and diabetic. *Saudi Medical Journal*, *36*(4), 449–455.

Hall, C., Fottrell, E., Wilkinson, S., & Byass, P. (2014). Assessing the impact of mHealth interventions in low- and middle-income countries what has been shown to work? *Global Health Action*, *7*. https://doi.org/10.3402/gha.v7.25606.

Hansen, A., Christensen, D., Larsson, M., Eis, J., Christensen, T., Friis, H., … Tetens, I. (2011). Dietary patterns, food and macronutrient intakes among adults in three ethnic groups in rural Kenya. *Public Health Nutrition*, *14*(9), 1671–1679.

Harrington, E., Drake, A., Matemo, D., & Ronen, K. (2019). An mHealth SMS intervention on postpartum contraceptive use among women and couples in Kenya. *American Journal of Public Health*, *109*(6), 934–941.

Hassan, Z. (2017). Mobile phone text messaging to improve knowledge and practice of diabetic foot care in a developing country. *International Journal of Nursing Practice*, *23*. https://doi.org/10.1111/ijn.12546.

Hawkins, J. (2015). Social determinants of diabetes self-management, and diabetes health care utilization in African American and Latino men with type 2 diabetes (The University of Michigan, USA). Retrieved from https://pdfs.semanticscholar.org/4176/6f69d19645586095f2bdba00f68ecc5b86ec.pdf.

Heianza, Y., Arase, Y., Saito, K., Tsuji, H., Fujihara, K., Hsieh, S., … Sone, H. (2013). Role of alcohol drinking pattern in type 2 diabetes in Japanese men: The Toranomon Hospital Health Management Center Study 11. *The American Journal of Clinical Nutrition*, *97*(3), 561–568.

Hernández-ronquillo, L., Téllez-zenteno, J., Garduño-espinosa, J., & González-acevez, E. (2003). Factors associated with therapy noncompliance in type-2 diabetes patients. *Salud Publica Mexico*, *45*(15), 191–197.

Hilawe, E., Yatsuya, H., Kawaguchi, L., & Aoyama, A. (2013). Differences by sex in the prevalence of diabetes mellitus, impaired fasting glycaemia and impaired glucose tolerance in sub-Saharan Africa. *Bulletin of the World Health Organization*, *91*(9), 671-682D.

Holbrook, A., Thabane, L., Keshavjee, K., Dolovich, L., Bernstein, B., Chan, D., … Gerstein, H. (2009). Individualized electronic decision support and reminders to improve diabetes care in the community. *Canadian Medical Association*, *5*(181), 37–44.

Home, P., Riddle, M., Cefalu, W., Bailey, C., Bretzel, R., Prato, S., … Raz, I. (2014). Insulin therapy in people with type 2 diabetes. *Diabetes Care*, *37*(6), 1499–1508.

Hosseinpoor, A., Bergen, N., Mendis, S., Harper, S., Verdes, E., & Kunst, A. (2012). Socioeconomic inequality in the prevalence of noncommunicable diseases in low- and middle-income countries. *BMC Public Health*, *12*(474). Retrieved from http://www.biomedcentral.com/1471-2458/12/474 RESEARCH.

Houle, J., Lauzier-Jobin, F., Beaulieu, M., Meunier, S., Coulombe, S., Côté, J., … Lambert, J. (2016). Socioeconomic status and glycemic control in adult patients with type 2 diabetes. *BMJ Open Diabetes Research & Care*, *4*(e000184). https://doi.org/10.1136/bmjdrc-2015-000184.

Huang, H., Li, Y., Chou, Y., Hsieh, Y., Kuo , F., Tsai, W., … Chuang, C. (2013). Effects of and satisfaction with short message service reminders for patient medication adherence. *BMC Medical Informatics and Decision Making*, *13*(127). https://doi.org/10.1186/1472-6947-13-127.

Hurling, R., Catt, M., De Boni, M., Fairley, B., Hurst, T., Murray, P., … Sodhi, J. (2007). Using internet and mobile phone technology to deliver an automated physical activity program. *Medical Internet Research*, *9*(2). https://doi.org/10.2196/jmir.9.2.e7.

Hussain, T., Mathew, T., Dashti, A., Asfar, S., Al-Zaid, N., & Dashti, H. (2012). Effect of low-calorie versus low-carbohydrate ketogenic diet in type 2 diabetes. *Nutrition*, *28*(10), 1016–1021.

i Hub Research and Research Solutions Africa. (2012). *Mobile Phone Usage at the Kenyan Base of the Pyramid*. Retrieved from

https://blogs.worldbank.org/ic4d/files/ic4d/mobile_phone_usage_kenyan_base_pyramid.pdf.

Idemyor, V. (2010). Diabetes in Sub-Saharan Africa: Health care perspectives, challenges, and the economic burden of disease. *The National Medical Association*, *102*(7), 650–653.

Iglay, K., Cartier, S., Rosen, V., Zarotsky, V., Rajpathak, S., Radican, L., & Tunceli, K. (2015). Meta-analysis of studies examining medication adherence, persistence, and discontinuation of oral antihyperglycemic agents in type 2 diabetes. *Current Medical Research and Opinion*, *31*(7), 1283–1296.

Imamura, F., Micha, R., Wu, J., Otto, M., Otite, F., Abioye, A., & Mozaffarian, D. (2016). Effects of saturated fat, polyunsaturated fat, monounsaturated fat, and carbohydrate on glucose-insulin homeostasis. *PLoS Medicine*, *13*(7). https://doi.org/10.1371/journal.pmed.1002087.

InfoDev and World Bank. (2013). Mobile Usage at the Base of the Pyramid: Research Findings from Kenya and South Africa. Retrieved from http://www.infodev.org/mbopsummary.

International Diabetes Federation. (2013). *IDF Diabetes Atlas*. Retrieved from https://www.idf.org/e-library/epidemiology-research/diabetes-atlas/19-atlas-6th-edition.html.

International Diabetes Federation. (2015). *IDF Diabetes Atlas*. Retrieved from https://www.oedg.at/pdf/1606_IDF_Atlas_2015_UK.pdf.

International Diabetes Federation. (2017). IDF Clinical Practice Recommendations on the Diabetic Foot – 2017. Brussels, Belgium.

Iqbal, A., Novodvorsky, P., & Heller, S. (2018). Recent updates on type 1 diabetes mellitus management for clinicians. *Diabetes Metabolism*, *42*. https://doi.org/10.4093/dmj.2018.42.1.3.

Iribarren, S., Chirico, C., Echevarrria, M., & Cardinali, D. (2012). A parallel design randomized control pilot study to evaluate acceptance and feasibility of a patient-

driven mobile phone based intervention to support adherence to TB treatment. *Mobile Technology in Medicine, 1*, 23–24.

Islam, F., Chakrabarti, R., Dirani, M., Islam, M., Ormsby, G., Wahab, M., … Finger, R. (2014). Knowledge, attitudes and practice of diabetes in rural Bangladesh: The Bangladesh Population based Diabetes and Eye Study (BPDES). *Open Access*, *9*(10). https://doi.org/10.1371/journal.pone.0110368.

Islam, S., Niessen, L., Seissler, J., Ferrari, U., Biswas, T., Islam, A., & Lechner, A. (2015). Diabetes knowledge and glycemic control among patients with type 2 diabetes in Bangladesh. *SpringerPlus*, *4*(284). https://doi.org/10.1186/s40064-015-1103-7.

Istepanian, R., Zitouni, K., Harry, D., Moutosammy, N., Sungoor, A., Tang, B., & Earle, K. (2009). Evaluation of a mobile phone telemonitoring system for glycaemic control in patients with diabetes. *Telemedicine and Telecare*, *15*(3), 125–128.

Jayawardena, R. Byrne, N., Soares, M., Katulanda, P., & Hills, A. (2012). Food consumption of Sri Lankan adults. *Public Health Nutrition*, *16*(4), 653–658.

Jones, K., Lekhak, N., & Kaewluang, N. (2014). Using mobile phones and short message service to deliver self-management interventions for chronic conditions. *Worldviews on Evidence-Based Nursing*, *11*(2), 81–88.

Jones, T. (2013). Diabetes Mellitus: The increasing burden of disease in Kenya. *South Sudan Medical Journal*, *6*(3), 60–64.

Jung, U., & Choi, M. (2014). Obesity and its metabolic complications: The role of adipokines and the relationship between obesity, inflammation, insulin resistance, dyslipidemia and nonalcoholic fatty liver disease. *International Journal of Molecular Sciences, 15*, 6184–6223.

Kalra, S., Kalra, B., Agrawal, N., & Unnikrishnan, A. (2011). Understanding diabetes in patients with HIV/AIDS. *Diabetology & Metabolic Syndrome*, *3*(2). https://doi.org/10.1186/1758-5996-3-2.

Kamuhabwa, R., & Charles, E. (2014). Predictors of poor glycemic control in type 2 diabetic patients attending public hospitals in Dar es Salaam. *Drug, Healthcare and Patient Safety*, *6*, 155–165.

Kannisto, K., Koivunen, M., & Välimäki, M. (2014). Use of mobile phone text message reminders in health care services. *Medical Internet Research*, *16*(10). https://doi.org/10.2196/jmir.3442.

Kassahun, T., Eshetie, T., & Gesesew, H. (2016). Factors associated with glycemic control among adult patients with type 2 diabetes mellitus. *BMC Research Notes*, *9*(78). https://doi.org/10.1186/s13104-016-1896-7.

Kaur, B., & Henry, J. (2014). Micronutrient status in type 2 diabetes. *Advances in Food and Nutrition Research*, *71*, 55–100.

Kautzky-Willer, A., Harreiter, J., & Pacini, G. (2016). Sex and gender differences in risk, pathophysiology and complications of type 2 diabetes mellitus. *Endocrine Reviews*, *37*(3), 278–316.

Kebaso, J. (2003). Prevalence, major complications of diabetes mellitus and compliance in diabetic patients seeking treatment at Kenyatta National Hospital (Kenyatta University, Kenya). Retrieved from https://ir-library.ku.ac.ke/handle/123456789/4948?show=full.

Khattab, M., Khader, Y., Al-khawaldeh, A., & Ajlouni, K. (2010). Factors associated with poor glycemic control among patients with type 2 diabetes. *Diabetes and Its Complications*, *24*(2), 84–89.

Khunti, K., Davies, M., Majeed, A., Thorsted, B., Wolden, M., & Paul, S. (2015). Hypoglycemia and risk of cardiovascular disease and all-cause mortality in insulin-treated people with type 1 and type 2 diabetes. *Diabetes Care*, *38*, 316–322.

Khwankhom, A. (2007, January). Phoned pill reminders make inroads against TB. *The Nation (Bangkok)*. Retrieved from http://listmanager.bpslmit.com/read/messages?id=49295.

Kibachio, J., Omolo, J., Muriuki, Z., Juma, R., Karugu, L., & Ng'ang'a, Z. (2013). Risk factors for diabetic foot ulcers in type 2 diabetes: A case control study, Nyeri, Kenya. *African Journal of Diabetes Medicine*, *21*(1). Retrieved from https://www.africanjournalofdiabetesmedicine.com/articles/AJDM MAY 20-23.pdf.

Kibiti, C., & Afolayan, A. (2015). Herbal therapy: A review of emerging pharmacological tools in the management of diabetes mellitus in Africa. *Pharmacognosy Magazine*, *2*. https://doi.org/10.4103/0973-1296.166046.

Kiboi, W., Kimiywe, J., & Chege, P. (2017). Determinants of dietary diversity among pregnant women in Laikipia County, Kenya. *BMC Nutrition*, *3*(12). https://doi.org/10.1186/s40795-017-0126-6.

Kilpatrick, E., & Atkin, S. (2014). Using haemoglobin A1c to diagnose type 2 diabetes or to identify people at high risk of diabetes. *British Medical Journal*, *348*(g2867). https://doi.org/10.1136/bmj.g2867.

Kim, H. (2005). Effects of web-based diabetic education in obese diabetic patients. *Korean Academy of Nursing*, *35*(5), 924–930.

Kim, H. (2007). A randomized controlled trial of a nurse short-message service by cellular phone for people with diabetes. *International Journal of Nursing Studies*, *44*(5), 687–692.

Kitui County Referral Hospital. (2017). *Kitui County Referral Hospital Records*. Kitui County, Kenya.

Kitui County. (2013). First County Integrated DKitui County. (2013). First County Integrated Development Plan 2013- 2017: Planning for sustainable socio-economic growth and development. Retrieved from http://www.kituicountyassembly.org/userfiles/KITUI COUNTY INTEGRATED DEVELOP. Retrieved from http://www.kituicountyassembly.org/userfiles/KITUI COUNTY INTEGRATED DEVELOPMENT PLAN July 2014(1).pdf.

Ko, G., Kalantar-Zadeh, K., Goldstein-Fuchs, J., & Rhee, C. (2017). Dietary approaches in the management of diabetic patients with kidney disease. *Nutrients*, *9*(824). https://doi.org/10.3390/nu9080824.

Koda, M., Kitamura, I., Okura, T., Otsuka, R., Ando, F., & Shimokata, H. (2016). The associations between smoking habits and serum triglyceride or hemoglobin A1c levels differ according to visceral fat accumulation. *Epidemiology*, *26*(4), 208–215.

Kolahdooz, F., Spearing, K., & Sharma, S. (2013). Dietary adequacies among South African adults in rural KwaZulu-Natal. *Open Access*, *8*(6). https://doi.org/10.1371/journal.pone.0067184.

Krejcie, R., & Morgan, D. (1970). Determining sample size for research activities. *Education and Psychological Measurement*, *38*(30), 607–610.

L'Engle, K., Plourde, K., & Zan, T. (2017). Evidence-based adaptation and scale-up of a mobile phone health information service. *MHealth*, *3*(11). https://doi.org/10.21037/mhealth.2017.02.06.

Labadarios, D., Steyn, N., & Nel, J. (2011). How diverse is the diet of adult South Africans? *Nutrition Journal*, *10*(33). Retrieved from http://www.nutritionj.com/content/10/1/33.

Larsen, P., Kronenberg, H., Melmed, S., & Polonsky, K. (2003). *Williams textbook of endocrinology* (10th ed.; Elsevier, Ed.). Williams Textbook of Endocrinology.

Larsen, R., Mann, N., Maclean, E., & Shaw, J. (2011). The effect of high-protein, low-carbohydrate diets in the treatment of type 2 diabetes. *Diabetologia*, *54*(4), 731–740.

Lau, D., & Nau, D. (2004). Nonadherence and subsequent hospitalization among individuals with type 2 diabetes. *Diabetes Care*, *27*(9), 2149–2153.

Lawson, D. (2004). Determinants of Health Seeking Behaviour in Uganda. *Economic Literature*, *111*(118). Retrieved from

http://unpan1.un.org/intradoc/groups/public/documents/NISPAcee/UNPAN018976.pdf.

Lebovitz, H. (2011). Type 2 diabetes mellitus—current therapies and the emergence of surgical options. *Nature Reviews Endocrinology*. https://doi.org/10.1038/nrendo.2011.10.

Lee, K. (2010). Sociodemographic status and self-reported BMI-related morbidity in Koreans. *Yonsei Medical Journal*, *51*(2), 171–177.

Leenstra, T., Kariuki, S., Kurtis, J., Oloo, A., Kager, P., & ter Kuile, F. (2004). Prevalence and severity of anemia and iron deficiency. *European Journal of Clinical Nutrition*, *58*(4), 681–691.

Ley, S., Hamdy, O., Mohan, V., & Hu, F. (2014). Prevention and management of type 2 diabetes: Dietary components and nutritional strategies. *Lancet*, *383*(9933), 1999–2007.

Liu, C., Yeh, Y., Lee, T., & Li, Y. (2005). Observations on online services for diabetes management. *Diabetes Care*, *28*(11), 2806–2812.

Liu, H., Zhang, M., Wu, X., Wang, C., & Li, Z. (2015). Effectiveness of a public dietitian-led diabetes nutrition intervention on glycemic control in a community setting in China. *Asia Pacific Journal of Clinical Nutrition*, *24*(3), 525–532.

Liu, Z., Fu, C., Wang, W., & Xu, B. (2010). Prevalence of chronic complications of type 2 diabetes mellitus in outpatients. *Health and Quality of Life Outcomes*, *8*(62). Retrieved from http://www.hqlo.com/content/8/1/62.

Lynch, E., Liebman, R., Ventrelle, J., Keim, K., Appelhans, B., Avery, E., … Fogelfeld, L. (2014). Design of the Lifestyle Improvement through Food and Exercise (LIFE) study. *Contemporary Clinical Trials*, *39*(2), 246–255.

Machin, D., Campbell, M., & Walters, S. (2007). *Medical Statistics* (4th ed.). UK: John Wiley & Sons, Ltd, UK.

Madeline, J. (2012). *Nutrition and Diabetic Management in Urban Kenya*. Retrieved from

http://digitalcollections.sit.edu/cgi/viewcontent.cgi?article=2411&context=isp_collection.

Maez, L., Erickson, L., & Naumuk, L. (2014). Diabetic education in rural areas. *Rural and Remote Health*, *14*(2742). Retrieved from http://www.rrh.org.au/publishedarticles/article_print_2742.pdf.

Maina, J., Kareru, P., Gatebe, E., Rotich, H., Njonge, F., Kimani, D., & Mutembei, J. (2015). Hypoglycemic effect of ethanoic extract of a herbal drugs formulation used by Kenyan herbalists. *Natural Sciences Research*, *5*(9), 60–65.

Maina, W., Ndegwa, Z., Njenga, E., & Muchemi, E. (2011). Knowledge, attitude and practices related to diabetes among community members in four provinces in Kenya. *African Journal of Diabetes Medicine*, *19*(1), 15–18.

Manders, R., Hansen, D., Zorenc, A., Dendale, P., Kloek, J., Saris, W., & van Loon, L. (2014). Protein co-ingestion strongly increases postprandial insulin secretion in type 2 diabetes patients. *Medicinal Food*, *17*(7), 758–763.

Mandewo, W., Dodge, E., Chideme-munodawafa, A., & Mandewo, G. (2014). Non-adherence to treatment among diabetic patients attending outpatients clinic at Mutare Provincial Hospital, Manicaland Province, Zimbabwe. *International Journal of Scientific & Technology Research*, *3*(9), 66–86.

Manica, L., & Vescovi, M. (2009). *Mobile telephony in Kenya … is it " Making the life better "?* Retrieved from https://it46.se/projects/UNITN_ict4sd/assignments/ICT4SD_manica_vescovi.pdf.

Mann, D., Riddell, L., Lim, K., Byrne, L., Nowson, C., Rigo, M., Szymlek-Gay, E., & Booth, A. (2015). Mobile phone app aimed at improving iron intake and bioavailability in premenopausal women. *Medical Internet Research*, *3*(3). https://doi.org/10.2196/mhealth.4300.

Maric-Bilkan, C. (2013). Obesity and diabetic kidney disease. *The Medical Clinics of North America*, *97*(1), 59–74.

Martín-Timón, I., Sevillano-Collantes, C., Segura-Galindo, A., & del Cañizo-Gómez, F. (2014). Type 2 diabetes and cardiovascular disease. *World Journal of Diabetes*, *5*(4), 444–470.

Mason, A., Saslow, L., Moran, P., Kim, S., Abousleiman, H., Hartman, A., … Hecht, F. (2019). Examining the effects of mindful eating training on adherence to a carbohydrate-restricted diet in patients with type 2 diabetes (The DELISH Study). *Medical Internet Research*, *8*(2). https://doi.org/10.2196/11002.

Masoud, S. (2011). *Quality of glycemic control among insulin treated ambulatory patients with diabetes mellitus at Kenyatta National Hospital* (University of Nairobi). Retrieved from http://erepository.uonbi.ac.ke/bitstream/handle/11295/9348/DR._SALIM_RASHID_MASOUD_M.MED_CLINICAL_MED_2012.pdf?sequence=1.

Matheka, D., & Alkizim, F. (2012). Complementary and alternative medicine for type 2 diabetes mellitus. *Diabetes and Endocrinology*, *3*(4), 44–56.

Mattei, J., Malik, V., Wedick, N., Hu, F., Spiegelman, D., Willett, W., & Campos, H. (2015). Reducing the global burden of type 2 diabetes by improving the quality of staple foods. *Globalization and Health*, *11*(23). https://doi.org/10.1186/s12992-015-0109-9.

May, M., & Schindler, C. (2016). Clinically and pharmacologically relevant interactions of antidiabetic drugs. *Therapeutic Advances in Endocrinology and Metabolism*, *7*(2), 69–83.

Mbanya, J., Assah, F., Saji, J., & Atanga, E. (2014). Obesity and type 2 diabetes in Sub-Sahara Africa. *Current Diabetes Reports*, *14*(501). https://doi.org/10.1007/s11892-014-0501-5.

Meyer, C. (2009). The development of recommendations for the implementation of nutrition therapy for coloured women with type 2 diabetes attending CHCs in the Cape Metropole (University of Cape Town, South Africa). Retrieved from

https://open.uct.ac.za/bitstream/handle/11427/3267/thesis_hsf_2009_meyer_cm.pdf?sequence=1.

Ming, M., & Rahman, S. (2002). Anthropometry and dietary intake of type 2 diabetes patients attending an outpatient clinic. *Malaysian Journal of Nutrition*, *8*(1), 63–73.

Ministry of Health. (2011). *The Kenya national micronutrient survey*. Nairobi, Kenya.

Ministry of Health. (2015). Kenya Health Workforce Report: The status of healthcare professionals in Kenya. Nairobi, Kenya.

Ministry of Medical Services. (2010). *Clinical nutrition and dietetics reference manual*. Nairobi, Kenya.

Ministry of Public Health and Sanitation. (2010). *National clinical guidelines for management of diabetes mellitus*. Nairobi, Kenya.

Mogre, V., Abanga, Z., Tzelepis, F., Johnson, N., & Paul, C. (2017). Adherence to and factors associated with self-care behaviours in type 2 diabetes patients in Ghana. *BMC Endocrine Disorders*, *17*(20). https://doi.org/10.1186/s12902-017-0169-3.

Mohamed, B., Almajwal, A., Saeed, A., & Bani, A. (2013). Dietary practices among patients with type 2 diabetes in Riyadh, Saudi Arabia. *Food Agriculture & Environment*, *11*(2), 110–114.

Mohamed, S., Mwangi, M., Mutua, M., Kibachio, J., Hussein, A., Ndegwa, Z., … Kyobutungi, C. (2018). Prevalence and factors associated with pre-diabetes and diabetes mellitus in Kenya. *BMC Public Health*, *18*(3). https://doi.org/10.1186/s12889-018-6053-x.

Mokhehle, M. (2014). Nutritional status, glycemic control and barriers to treatment compliance among patients with type 2 diabetes attending diabetes clinics in Maseru, Lesotho (University of the Free State Bloemfonte, South Africa). Retrieved from http://scholar.ufs.ac.za:8080/xmlui/handle/11660/1896.

Monnier, L., & Colette, C. (2009). Targets for glycemic control. *Diabetes Care*, *32*(2), 5199 – 5204.

Montecino-Rodriguez, E., Berent-Maoz, B., & Dorshkind, K. (2013). Causes, consequences, and reversal of immune system aging. *Clinical Investigation*, *123*(3), 958–965.

Msambichaka, B., Eze, I., Abdul, R., Abdulla, S., Klatser, P., Tanner, M., … Probst-Hensch, N. (2018). Insufficient fruit and vegetable intake in a low- and middle-income setting. *Nutrients*, *10*(222). https://doi.org/10.3390/nu10020222.

Msyamboza, K., Mvula, C., & Kathyola, D. (2014). Prevalence and correlates of diabetes mellitus in Malawi: Population-based national NCD STEPS survey. *BMC Endocrine Disorders*, *14*(41). https://doi.org/10.1186/1472-6823-14-41.

Mukhopadhyay, P., Paul, B., Das, D., Sengupta, N., & Majumder, R. (2010). Perceptions and practices of type 2 diabetics. *International Journal of Diabetes in Developing Countries*, *30*(3), 143–149.

Muller, L., Gorter, K., Hak, E., Goudzwaard, W., Schellevis, F., Hoepelman, A., & Rutten, G. (2005). Increased risk of common infections in patients with type 1 and type 2 diabetes mellitus. *Clinical Infectious Diseases*, *41*(3), 281–288.

Mummah, S., Mathur, M., King, A., Gardner, C., & Sutton, S. (2016). Mobile technology for vegetable consumption. *Medical Internet Research*, *4*(2). https://doi.org/10.2196/mhealth.5146.

Mungai, J. (2016). Face to face interview with Kitui County Referral Hospital physician held on 28th November 2016. Kitui County.

Musee, C., Omondi, D., & Odiwuor, W. (2016). Dietary adherence pattern in the context of type 2 diabetic management within clinical setting, Kenya. *International Journal of Diabetes Research*, *5*(2), 26–34.

Musenge, E., Michelo, C., Mudenda, B., & Manankov, A. (2016). Glycaemic control and associated self-management behaviours in diabetic outpatients: A hospital based observation study in Lusaka, Zambia. *Diabetes Research, 2016*. https://doi.org/10.1155/2016/7934654.

Mwangi, J., & Gitonga, L. (2014). Perceptions and use of herbal remedies among patients with diabetes mellitus in Murang'a North District, Kenya. *Open Journal of Clinical Diagnostics*, *4*, 152–172.

Mwangi, M., Githinji, G., & Githinji, F. (2011). Knowledge and awareness of diabetic retinopathy amongst diabetic patients in Kenyatta National Hospital, Kenya. *International Journal of Humanities and Social Science*, *1*(21), 140–146.

Mwavua, S., Ndungu, E., Mutai, K., & Joshi, M. (2016). A comparative study of the quality of care and glycemic control among ambulatory type 2 diabetes mellitus clients, at a tertiary referral hospital and a regional hospital in Central Kenya. *BMC Research Notes*, *9*(12). https://doi.org/10.1186/s13104-015-1826-0.

Naik, A., Teal, C., Rodriguez, E., & Haidet, P. (2012). Methods of diabetes education. *Patient Education and Counselling*, *85*(3), 383–389.

Nduati, J., Karanja, S., Njenga, E., & Muthami, L. (2016). Factors associated with glycemic control among type 2 diabetes patients attending Mathari National Teaching Hospital, Nairobi Kenya. *Endocrinology and Diabetes*, *3*(6). https://doi.org/10.15226/2374- 6890/3/6/00162.

Newton, K., Wiltshire, E., Fracp, C., & Elley, R. (2009). Pedometers and text messaging to increase physical activity. *Diabetes Care*, *32*(5), 813–815.

Ngala, S., Souverein, O., Tembo, M., Mwangi, A., Kok, F., & Brouwer, I. (2015). *Evaluation of dietary diversity scores to assess nutrient adequacy among rural Kenyan women*. https://doi.org/ISBN 978-94-6257-423-6.

Ngugi, P., Kimuni, N., Ngeranwa, N., Orinda, O., Njagi, M., Maina, D., … Njagi, E. (2015). Antidiabetic and safety of Lantana rhodesiensis in Alloxan induced diabetic rats. *Developing Drugs*, *4*(1). https://doi.org/10.4172/2329-6631.1000129.

Noh, J., Han, K., Ko, S., Ko, K., & Park, C. (2017). Trends in the pervasiveness of type 2 diabetes, impaired fasting glucose and co-morbidities during an 8-year-follow-

up of nationwide Korean population. *Scientific Reports*, *7*. https://doi.org/10.1038/srep46656.

Nordström, A., Hadrévi, J., Olsson, T., Franks, P., & Nordström, P. (2016). Higher prevalence of Type 2 diabetes in men than in women is associated with differences in visceral fat mass. *Clinical Endocrinology & Metabolism*, *101*(10), 3740–3746.

Norris, S., Lau, J., Smith, S., Schmid, C., & Engelgau, M. (2010). Self-management education for adults with type 2 diabetes. *Diabetes Care*, *25*(7), 1159–1171.

Nyamu, P., Otieno, C., Amayo, E., & Mcligeyo, S. (2003). Risk factors and prevalence of diabetic foot ulcers at Kenyatta National Hospital, Nairobi. *East African Medical Journal*, *80*(1), 36–43.

Ohkuma, T., Iwase, M., Fujii, H., Kaizu, S., Ide, H., Jodai, T., … Kitazono, T. (2015). Dose- and time-dependent association of smoking and its cessation with glycemic control and insulin resistance in male patients with type 2 diabetes mellitus. *Open Access*, *10*(3). https://doi.org/10.1371/journal.pone.0122023.

Ohn, J., Lee, J., Hong, E., Koo, B., Kim, S., Yi, K., & Moon, M. (2015). Subjective assessment of diabetes self-care correlates with perceived glycemic control but not with actual glycemic control. *Diabetes and Metabolism Journal*, *39*(1), 31–36.

Olielo, T. (2013). Food security problems in various income groups of Kenya. *African Journal of Food, Agriculture, Nutrition and Development*, *13*(4). Retrieved from https://www.ajol.info/index.php/ajfand/article/view/94584.

Olokoba, A., Obateru, O., & Olokoba, L. (2012). Type 2 diabetes mellitus: A review of current trends. *Oman Medical Journal*, *27*(4), 269–273.

Oteri, O., Kibet, L., & Ndung'u, E. (2015). Mobile subscription, penetration and coverage trends in Kenya's telecommunication sector. *International Journal of Advanced Research in Artificial Intelligence*, *4*(1). Retrieved from

https://thesai.org/Downloads/IJARAI/Volume4No1/Paper_1-Mobile_Subscription_Penetration_and_Coverage_Trends.pdf.

Oti, S., van de Vijver, S., Agyemang, C., & Kyobutungi, C. (2013). The magnitude of diabetes and its association with obesity in the slums of Nairobi, Kenya. *Tropical Medicine and International Health*, *18*(12), 1520–1530.

Parati, G., Bilo, G., & Ochoa, J. (2011). Benefits of tight blood pressure control in diabetic patientswith hypertension: Importance of early and sustained implementation of effective treatment strategies. *Diabetes Care*, *34*(2). https://doi.org/10.2337/dc11-s243.

Park, P., Wambui, C., Atieno, S., Egger, J., Misoi, L., Nyabundi, J., … Kamano, J. (2015). Improving diabetes management and cardiovascular risk factors through peer-led self-management support groups in Western Kenya. *Diabetes Care*, *38*, e110–e111.

Partridge, S., McGeechan, K., Hebden, L., Balestracci, K., Wong, A., Denney-Wilson, E., … Allman-Farinelli, M. (2015). Effectiveness of a mHealth lifestyle program with telephone support (TXT2BFiT) to prevent unhealthy weight gain in young adults. *Medical Internet Research*, *3*(2). https://doi.org/10.2196/mhealth.4530.

Pastors, J., Warshaw, H., Daly, A., Franz, M., & Kulkarni, K. (2002). The evidence for the effectiveness of medical nutrition therapy in diabetes management. *Diabetes Care*, *25*(3), 608–613.

Patil, S., Deshmukh, J., & Patil, C. (2017). Social factors influencing diabetes mellitus in adults attending a tertiary care hospital in Nagpur. *International Journal of Research in Medical Sciences*, *5*(11), 4988–4992.

Philis-tsimikas, A. (2009). *Type 2 Diabetes: Limitations of current therapies*. Retrieved from imaging.ubmmedica.com/consultantlive/supplements/0907Con_Diabetes_Philis.pdf.

Polonsky, W., & Henry, R. (2016). Poor medication adherence in type 2 diabetes: Recognizing the scope of the problem and its key contributors. *Open Access*, *10*, 1299–1307.

Ponesai, N., Anderson, C., Mufuta, T., Notion, G., Lucia, T., & Donewell, B. (2015). Risk factors for diabetic complications among diabetic patients, Chirumanzu District, Zimbabwe. *Austin Journal of Public Health and Epidemiology*, *2*(2), 1021.

Qin, Y., Melse-Boonstra, A., Shi, Z., Pan, X., Yuan, B., Dai, Y., … Zhou, M. (2009). Dietary intake of zinc in the population of Jiangsu Province, China. *Asia Pacific Journal of Clinical Nutrition*, *18*(2), 193–199.

Rajput, Z., Mbugua, S., Amadi, D., Chepngeno, V., Saleem, J., Anokwa, Y., … Were, M. (2012). Evaluation of an Android-based mhealth system for population surveillance in developing countries. *Journal of the American Medical Informatics Association*, *19*(4), 655–659.

Ramanchandran, A., Snehalatha, C., Ram, J., Selvam, S., Simon, M., Nanditha, A., … Johnston, D. (2013). Effectiveness of mobile phone messaging in prevention of type 2 diabetes by lifestyle modification in men in India. *Diabetes and Endocrinology*, *1*(3), 191–198.

Rao, B., Kesavulu, M., & Apparao, C. (2001). Antihyperglycemic activity of Momordica cymbalaria in alloxan diabetic rats. *Ethnopharmacology*, *78*(1), 67–71.

Rathnayake, K., Madushani, P., & Silva, K. (2012). Use of dietary diversity score as a proxy indicator of nutrient adequacy of rural elderly people in Sri Lanka. *BMC Research Notes*, *5*(469). https://doi.org/10.1186/1756-0500-5-469.

Riazi, H., Larijani, B., Langarizadeh, M., & Shahmoradi, L. (2015). Managing diabetes mellitus using information technology. *Diabetes & Metabolic Disorders*, *14*(49). https://doi.org/10.1186/s40200-015-0174-x.

Röhling, M., Herder, C., Stemper, T., & Müssig, K. (2016). Influence of acute and chronic exercise on glucose uptake. *Diabetes Research*, *2016*. https://doi.org/10.1155/2016/2868652.

Rotheram-Borus, M., Tomlinson, M., & Gwegwe, M. (2012). Diabetes buddies: Peer support through a mobile phone buddy system. *The Diabetes Educator*, *3*(38), 357–365.

Sajith, M., Pankaj, M., Pawar, A., Modi, A., & Sumariya, R. (2014). Medication adherence to antidiabetic therapy in patients with type 2 diabetes mellitus. *International Journal of Pharmacy and Pharmaceutical Sciences*, *6*(2), 564–570.

Saleh, F., Mumu, S., Ara, F., Hafez, A., & Ali, L. (2014). Non-adherence to self-care practices & medication and health related quality of life among patients with type 2 diabetes. *BMC Public Health*, *14*(431). https://doi.org/10.1186/1471-2458-14-431.

Samad, F., Harris, M., Puskas, C., Ye, M., Chia, J., Chacko, S., … Guillemi, S. (2017). Incidence of diabetes mellitus and factors associated with its development in HIV-positive patients over the age of 50. *BMJ Open Diabetes Research & Care*, *5*(1). https://doi.org/10.1136/bmjdrc-2017-000457.

Sami, W., Ansari, T., Butt, N., & Ab Hamid, M. (2017). Effect of diet on type 2 diabetes mellitus. *International Journal of Health Sciences*, *11*(2), 65–71.

Sarabi, R., Sadoughi, F., Orak, R., & Bahaadinbeigy, K. (2016). The effectiveness of mobile phone text messaging in improving medication adherence for patients with chronic diseases. *Iranian Red Crescent Medical Journal*, *18*(5). https://doi.org/10.5812/ircmj.25183.

Sari, M., Sari, N., Darlan, D., & Prasetya, R. (2018). Cigarette smoking and hyperglycaemia in diabetic patients. *Macedonian Journal of Medical Sciences*, *6*(4), 634–637.

Sarkar, S., Sivashankar, P., & Seshadri, H. (2015). Mobile SMS reminders for increasing medication adherence. *International Journal of Pharmaceutical Sciences Review and Research*, *32*(38), 228–237.

Sarmento, R., Silva, F., Sbruzzi, G., Schaan, B., & de Almeida, J. (2013). Antioxidant micronutrients and cardiovascular risk in patients with diabetes. *Arquivos Brasileiros de Cardiologia*, *101*(3), 240–248.

Saslow, L., Daubenmier, J., Moskowitz, J., Kim, S., Murphy, E., Phinney, S., … Hecht, F. (2017). Twelve-month outcomes of a randomized trial of a moderate-carbohydrate versus very low-carbohydrate diet in overweight adults with type 2 diabetes mellitus or prediabetes. *Nutrition and Diabetes*, *7*(304). https://doi.org/10.1038/s41387-017-0006-9.

Sathananthan, M., Shah, M., Edens, K., Grothe, K., Piccinini, F., Farrugia, L., … Vella, A. (2015). Six and 12 weeks of caloric restriction increases β cell function and lowers fasting and postprandial glucose concentrations in people with type 2 diabetes. *Nutrition*, 2046–2051.

Sayin, N., Kara, N., & Nihat, G. (2015). Ocular complications of diabetes mellitus. *World Journal of Diabetes*, *6*(1), 92–108.

Schulz, L., Bennett, P., Ravussin, E., Kidd, J., Kidd, K., Esparza, J., … Eisenbarth, G. (2014). IDF Diabetes Atlas. *Diabetes Care*, *383*(1), 69–82.

Senadheera, S., Ekanayake, S., & Wanigatunge, C. (2016). Dietary habits of type 2 diabetes patients: Variety and frequency of food intake. *Nutrition and Metabolism*, *2016*. https://doi.org/10.1155/2016/7987395.

Seuring, T., Archangelidi, O., & Suhrcke, M. (2015). The economic costs of type 2 diabetes. *PharmacoEconomics*, *33*(8), 811–831.

Shah, A., Langenberg, C., Rapsomaniki, E., Denaxas, S., Pujades-Rodriguez, M., Gale, C., … Hemingway, H. (2015). Type 2 diabetes and incidence of cardiovascular diseases: A cohort study in 1·9 million people. *Diabetes and Endocrinology*, *3*, 105–113.

Shah, V., Kamdar, P., & Shah, N. (2009). Assessing the knowledge, attitudes and practice of type 2 diabetes among patients of Saurashtra region, Gujarat. *International Journal of Diabetes in Developing Countries*, *29*(3), 118–122.

Shrivastava, S., Shrivastava, P., & Ramasamy, J. (2013). Role of self-care in management of diabetes mellitus. *Diabetes & Metabolic Disorders*, *12*(14). https://doi.org/10.1186/2251-6581-12-14.

Siddiqui, S., Sohag, A., & Siddiqui, K. (2011). Health seeking behavior of the people. *Professional Medical Journal*, *18*(4), 623–631.

Slavin, J., & Carlson, J. (2014). Carbohydrates. *Advances in Nutrition*, *5*(6), 760–761.

Smaje, A., Davis, D., Ranjana, M., Mine, R., & Rawle, M. (2018). Factors associated with medication adherence in older patients. *Aging Medicine*, *1*, 254–266.

Smuts, C., & Wolmarans, P. (2013). The importance of the quality or type of fat in the diet. *South African Journal of Clinical Nutrition*, *26*(3), 87–99.

Sontakke, S., Jadhav, M., Pimpalkhute, S., Jaiswal, K., & Bajait, C. (2015). Evaluation of adherence to therapy in patients of type 2 diabetes mellitus. *Young Pharmacists*, *7*(4), 462–469.

Soulimane, S., Simon, D., Herman, W., Lange, C., Lee, M., Colagiuri, S., … Magliano, D. (2015). HbA1c, fasting and 2-hour plasma glucose in current-, ex-, and non-smokers. *Diabetologia*, *57*(1), 30–39.

Spring, B., Pellegrini, C., McFadden, H., Pfammatter, A., Stump, T., Siddique, J., … Hedeker, D. (2018). Multicomponent mHealth intervention for large, sustained change in multiple diet and activity risk behaviors. *Medical Internet Research*, *20*(6). https://doi.org/10.2196/10528.

Tabish, S. (2007). Is diabetes becoming the biggest epidemic of the twenty-first century? *International Journal of Health Sciences*, *1*(2), V–VIII.

Tamban, C., Isip-Tan, I., & Jimeno, C. (2013). Use of short message services (SMS) for the management of type 2 diabetes mellitus. *ASEAN Federation of Endocrine Societies*, *28*(2), 143–149.

Tamirat, A., Abebe, L., & Kirose, G. (2014). Prediction of physical activity among type-2 diabetes patients attending Jimma University specialized Hospital, Southwest Ethiopia. *Science Journal of Public Health*, *2*(6), 524–531.

Taskinen, M. (2002). Diabetic dyslipidemia. *Atherosclerosis Supplements*, *3*, 47–51.

Thomas, D., Elliott, E., & Naughton, G. (2009). *Exercise for type 2 diabetes mellitus* (Cochrane, Ed.). John Wiley & Sons, Ltd.

Tiew, K., Chan, Y., Lye, M., & Loke, S. (2014). Factors associated with dietary diversity score among individuals with type 2 diabetes mellitus. *International Journal of Health Population and Nutrition*, *32*(4), 665–676.

Titus, O., Adebisola, O., & Adeniji, A. (2015). Health-care access and utilization among rural households in Nigeria. *Development and Agricultural Economics*, *7*(5), 195–203.

Toivakka, M., Laatikainen, T., Kumpula, T., & Tykkyläinen, M. (2015). Do the classification of areas and distance matter to the assessment results of achieving the treatment targets among type 2 diabetes patients? *International Journal of Health Geographics*, *14*(27). https://doi.org/10.1186/s12942-015-0020-x.

Trento, M., Basile, M., Borgo, E., Grassi, G., Scuntero, P., Trinetta, A., … Porta, M. (2008). A randomised controlled clinical trial of nurse-, dietitian- and pedagogist-led group care for the management of type 2 diabetes. *Endocrinological Investigation*, *31*, 1038–1042.

Turner, J., Larsen, M., Tarassenko, L., Neil, A., & Farmer, A. (2009). Implementation of telehealth support for patients with type 2 diabetes using insulin treatment. *Innovation in Health Informatics*, *17*(1), 47–53.

Umeh, A., & Nkombua, L. (2018). A study of the knowledge and practice of lifestyle modification in patients with type 2 diabetes mellitus in Middelburg sub-district of Mpumalanga. *South African Family Practice*, *60*(1), 26–30.

University of Michigan. (2014). *Management of Type 2 Diabetes Mellitus*. Retrieved from http://www.med.umich.edu/1info/FHP/practiceguides/diabetes/dm.pdf.

Vahdat, H., L'Engle, K., Plourde, K., Magaria, L., & Olawo, A. (2013). There are some questions you may not ask in a clinic: Providing contraception information to young people in Kenya using SMS. *International Journal of Gynecology and Obstetrics*, *123*, e2–e6.

Vakili, M., Abedi, P., Afshari, P., & Kaboli, N. (2015). The effect of mobile phone short messaging system on healthy food choices among Iranian postmenopausal women. *Midlife Health*, *6*(4), 154–159.

Van dijk, J., Tummers, K., Stehouwer, C., Hartgens, F., & Loon, L. (2012). Exercise therapy in type 2 diabetes: Is daily exercise required to optimize glycemic control? *Diabetes Care*, *35*, 948–954.

Vervloet, M., van Dijk, L., Santen-Reestman, J., van Vlijmen, B., van Wingerden, P., Bouvy, M., & de Bakker, D. (2012). SMS reminders improve adherence to oral medication in type 2 diabetes patients who are real time electronically monitored. *International Journal of Medical Informatics*, *81*(9), 594–604.

Vijan, S., & Hayward, R. (2003). Treatment of hypertension in type 2 diabetes mellitus: Blood pressure goals, choice of agents, and setting priorities in diabetes care. *Annals of Internal Medicine*, *138*, 593–602.

Waari, G., Mutai, J., & Gikunju, J. (2018). Medication adherence and factors associated with poor adherence among type 2 diabetes mellitus patients on follow-up at Kenyatta National Hospital, Kenya. *Pan African Medical Journal*, *29*(82). https://doi.org/10.11604/pamj.2018.29.82.12639.

Wakadha, H., Chandir, S., Were, E., Rubin, A., Obor, D., Levine, O., … Feikin, D. (2013). The feasibility of using mobile-phone based SMS reminders and conditional cash transfers to improve timely immunization in rural Kenya. *Vaccine*, *31*, 987–993.

Weaver, A., Young, A., Rowntree, J., Townsend, N., Pearson, S., Smith, J., … Tarassenko, L. (2007). Application of mobile phone technology for managing

chemotherapy associated side effects. *Annals of Oncology*, *18*(October), 1887–1892.

Weickert, M. (2012). What dietary modification best improves insulin sensitivity and why? *Clinical Endocrinology*, *77*(4), 508–512.

Westman, E., Yancy, W., Mavropoulos, J., Marquart, M., & Mcduffie, J. (2008). The effect of a low-carbohydrate, ketogenic diet versus a low-glycemic index diet on glycemic control in type 2 diabetes mellitus. *Nutrition & Metabolism*, *5*(36). https://doi.org/10.1186/1743-7075-5-36.

Wilding, J. (2014). The importance of weight management in type 2 diabetes mellitus. *International Journal of Clinical Practice*, *68*(6), 682–691.

Worku, A., Abebe, S., & Wassie, M. (2015). Dietary practice and associated factors among type 2 diabetic patients. *Springer Open Journal*, *4*(15). https://doi.org/10.1186/s40064-015-0785-1.

World Health Organization. (2003). *Adherence to long term therapies*. Geneva, Switzerland.

World Health Organization. (2016a). *Diabetes infographic*. Geneva, Switzerland.

World Health Organization. (2016b). Effects of trans- fatty acid intake on blood lipids and lipoproteins. Geneva, Switzerland.

World Health Organization. (2018a). *Reducing free sugars intake in children and adults*. Geneva, Switzerland.

World Health Organization. (2018b). *WHO STEPS Instrument*. Geneva, Switzerland.

World Health Organization. (2019a). *Global Health Observatory (GHO) data*. Geneva, Switzerland.

World Health Organization. (2019b). *Millennium Development Goals (MDGs)*. Geneva, Switzerland.

World Health Organization. (2019c). *Q & As on hypertension*. Geneva, Switzerland.

Wu, L., & Parhofer, K. (2014). Diabetic dyslipidemia. *Metabolism: Clinical and Experimental*, *63*, 1469–1479.

Yannakoulia, M. (2006). Eating behavior among type 2 diabetic patients: A poorly recognized aspect in a poorly controlled disease. *The Review of Diabetic Studies*, *3*(1), 11–16.

Yeh, G., Eisenberg, D., Kaptchuk, T., & Phillips, R. (2003). Systematic review of herbs and dietary supplements for glycemic control in diabetes. *Diabetes Care*, *26*(4), 1277–1294.

Yigazu, D., & Desse, T. (2017). Glycemic control and associated factors among type 2 diabetic patients at Shanan Gibe Hospital, Southwest Ethiopia. *BMC Research Notes*, *10*(597). https://doi.org/10.1186/s13104-017-2924-y.

Yoo, H., Park, M., Kim, T., Yang, S., Cho, G., Hwang, T., … Choi, K. (2009). A ubiquitous chronic disease care system using cellular phones and the internet. *Diabetic Medicine*, *26*(6), 628–635.

Young, L., Buse, J., Weaver, M., Vu, M., Mitchell, C., Blakeney, T., … Trial, M. (2017). Glucose self-monitoring in non–insulin-treated patients with type 2 diabetes in primary care settings. *JAMA Internal Medicine*, *177*(7), 920–929.

Zaki, S., & Mohamed, I. (2014). Concerns regarding diabetes mellitus among adult patients in Minia University Hospital. *Biology, Agriculture and Healthcare*, *4*(7), 53–67.

APPENDICES

Appendix 1: Patient's questionnaire

Date_____/_____/_____

1.0 Identification

Id code/ OPD file number …….

Name of interviewer……

The researcher is conducting a study on 'Effect of using mobile phone communication in the management of Type 2 Diabetes Mellitus among adult patients attending Kitui County Referral Hospital, Kenya'. The information will help the researcher develop appropriate interventions for diabetes patients in the community. The information you provide will be treated with confidentiality and will not be used for any other purpose other than the objectives of this study.

Respondent's name.....**.....**

Respondent's age in years

1= 21-30 4= 51-60

2= 31-40 5= 61-70

3= 41-50

Detailed contact information

Phone number ……..…

Home area ……

Other contacts when not available ……..…

Location …….. Sub-location…….

Nearest church/ school……

2.0 Socio-economic and demographic data

(Tick appropriate responses)

2a. Gender	Marital status	Highest level of education	Primary occupation
1= Male	1= Married	1= No formal education	1= Unemployed
2= Female	2= Single/ separated	2= Primary	2= Employed
	3= Widow/ widower	3= Secondary	3= Business
		4= Tertiary	

2b. How many children do you have?

1= None
2= 1-3
3= 4-6
4= 6-9
5= >9

2c. How many people/ dependents live with you in this household?

1= None
2= 1-3
3= 4-6
4= 6-9
5= >9

2d. In your opinion is the distance from your home to hospital

1= Near
2= Far

2e. Which means do you use to the hospital?

1= Bicycle ride
2= Matatu ride
3= Walking
4= Motorcycles

2f. How much do you spend to and from the hospital in KSH?

1= 0
2= <50
3= 50-100
4=100-150
5= 150-200
6= >200

3.0 Anthropometric and biochemical measurements

I will take your measurements of height, weight and record

Measurement	Baseline	After six months
Height		
Weight		

HbA1c		
FBS		
Blood Pressure		

3.1 Have you been sick in the last one month?

1= Yes 2= No

3.2 If yes above, state the sickness/ hospitalization……

3.3 If yes above, what did you do?

1= Saw the doctor 4= Received spiritual healing
2= Used un prescribed drugs 5= Used herbal medication
3= Just did nothing 6= N/A

3.4 Do you suffer from side effects when you take your medicine?

1= Yes (State)…… 2= No

4.0 Health seeking behavior

4.1 Have you missed to attend diabetes clinic?

1= Yes 2= No

4.2 If yes above, why?

1= I did not have bus fare 4= I was unwell 7=N/A

2= I did not remember 5= I was not available

3= I did not see the importance 6= Others (Specify)……

4.3 According to your own view, do you find the clinic 'waiting time' too long?

1= Yes 2= No

4.4 Do you do self-monitoring of blood glucose?

1= Yes 2= No

4.5 If no above why?

1= I do not know the importance 4= Other reasons……

2= I can not afford the kit 5= N/A

3= I can not be able to use the kit

4.6 Do you contact your health care provider when unwell?

1= Yes 2= N

5.0 Feet health

5.1 Do you check your feet daily?

1= Yes 2= No

6.0 Drug adherence of the patients

6.1 Which anti diabetes drugs are you currently taking?

1= Metformin 3= Mixtard

2= Insulin 4= Others (Specify) ……

6.2 When do you take the drugs?

1= When I remember 3= When not feeling well

2= Specific times 4= No specific time

6.3 Did you forget to take anti diabetes drugs yesterday?

1= Yes 2= No

6.4 If yes above, what did you do later?

1= Fore go for the day 3= Take in combination with the later drug

2= Took at the time when I remembered 4= N/A

6.5 Do you take the drugs even if you are ill and unable to eat?

1= Yes 2= No

6.6 If yes above, about what percent of the time have you missed your medicines in the past one week?

1= About one day 4= More than three days

2= About two days 5= I can not remember the number of times

3= About three days 6= N/A

6.7 Have you gone without diabetes drugs for over two months?

1= Yes 2= No

6.8 If yes above, what were the reasons?

1= I received spiritual healing 4= Drug side effects 7= N/A

2= I took herbal remedies 5= Cost of drugs

3= I gave up taking medication 6= Others……

6.9 If yes above, what made you to go back to the drugs?

1= Progression of disease 5= Own initiative

2= Hospitalization 6= Change of drug

3= Talking to the relatives and friends 7= N/A

4= Health worker intervention

6.10 When you travel or leave home, do you bring your medicine along?

1= Yes 2= No

6.11 Have you ever taken un prescribed drugs in your diabetes state?

1= Yes 2= No

6.12 If yes above, why?

1= Felt drugs were not working

2= Un prescribed drugs work better

3= I was unwell

4= Cheaper than prescription drugs

5= N/A

6.13 If yes in 6.11 above, did your diabetes doctor know?

1= Yes 2= No 3= N/A

7.0 Dietary practices

7.1 Do you have a meal plan?

1= Yes 2= No

7.2 If yes above, do you follow the meal plan?

1=Yes 2= No 3= Sometimes 4= N/A

7.3 How many meals do you take in a day?

1= One 4= Three or more times

2= Two (Lunch and dinner) 5= Do not know

7.4 How many snacks do you take in a day?

1= One 3= Three or more times

2= Two 4= None

7.5 How many times do you eat fruits in a day?

1= <2 2= 2 - 4 times

7.6 How many times do you eat vegetables in a day?

1= <3 2= 3 - 5 times

8.0 To determine dietary patterns and dietary diversity I will ask you the questions that follow about food.

8.1 Adapted food frequency questionnaires

1. How many times did you eat the foods listed below in the last 7 days?
2. How much do you normally eat at one time especially over the last 7days?

List any others not provided in the list.

i) Grains, white roots and tubers, plantains

Food	Last 7 days	Portion size/ grams
Cereals and cereal products		
1=Brown ugali		
2=White ugali		
3= Brown rice		
4=White rice		
5=Brown chapatti		
6=White chapatti		
7=Brown bread		
8=White bread		
White roots, tubers, plantains		
1=Irish potatoes (White potatoes)		
2=Sweet potatoes		
3=Arrow roots		
4=Cassava		
5=Plantains		
Mixed foods		
1=Maize and beans (Muthokoi)		
2=Githeri (Maize and beans)		

ii) Pulses

Food	Last 7 days	Portion size/ grams
1=Beans		
2=Peas		
3=Lentils		
4=Chickpea		
5=Soy beans		
6=Pigeon peas		
7=Cow peas		
8=Dolichos (Njahe)		
9=Green grams		

iii) Nuts and seeds

Food	Last 7 days	Portion size/ grams
1=Macadamia		
2=Peanuts		
3=Groundnuts		
4=Sunflower seeds		
5=Pumpkin seeds		

iv) Dairy

Food	Last 7 days	Portion size/ grams
1=Milk		
2=Cheese		
3=Yogurt		
4=Ice cream		

v) Meat, poultry and fish

Food	Last 7 days	Portion size/ grams
1=Beef		
2=Poultry		
=Fish		

vi) Eggs

Food	Last 7 days	Portion size/ grams
1=Eggs		

vii) Dark green leafy vegetables

Food	Last 7 days	Portion size/ grams
Exotic vegetables		
1=Sukuma wiki		
2=Cabbages		
3=Spinach		
Traditional vegetables		

1=Black night shades (Managu)		
2=Amaranth (Terere)		
3=Cassava leaves		
4=Kunde		

viii) Vitamin A rich fruits

Food	Last 7 days	Portion size/ grams
1=Oranges		
2=Melon		
3=Pawpaw		
4=Apples		
5=Avocado		
6=Mangoes		

ix) Other vegetables

Food	Last 7 days	Portion size/ grams
1=Broccoli		
2=Cauliflower		
3=Others		

x) Other fruits

Food	Last 7 days	Portion size/ grams
1=		
2=		
3=		

8.2 Adapted 24 hour dietary recall

Please indicate the meals, food type, preparation methods, quantity and time eaten for the last 24 hours.

Name of respondent ……...Code……

Meals, preparation methods, time eaten	Food/ recipe name	Quantity/ Portions
Breakfast …….. …….. …….. ……..		
Mid-morning snack …….. …….. …….. ……..		
Lunch …….. …….. …….. …….. ……..		
Mid-afternoon snack …….. …….. …….. ……..		
Supper …….. …….. …….. ……..		
Midnight snack …….. …….. …….. ……..		
Total		

Appendix 2: Short Message Services (SMSs) sent to the patients

May 2017

Week 1

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Ensure you have 30 minutes of exercise daily
Self-monitoring of blood sugar	*Good morning.* Remember to monitor your blood sugar level daily
Feet health	*Good morning.* Check your feet daily for cuts, sores, blisters, redness, calluses, or other problems
Drug adherence	*Good morning.* Take only prescribed medication
Diet	*Good morning.* Eat a variety of foods including vegetables, fruits and carbohydrates

Week 2

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Seek prompt treatment if unwell
Self-monitoring of blood sugar	*Good morning.* Do daily self-monitoring of blood glucose either at home or in a health facility near you
Feet health	*Good morning.* Check your feet daily for bruises
Drug adherence	*Good morning.* Avoid self medication
Diet	*Good morning.* Ensure every meal has half of the plate green leafy vegetables such as kales to prevent diseases

Week 3

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Remember to attend monthly diabetes clinic
Self- monitoring of blood sugar	*Good morning.* Do self- monitoring of

	blood glucose levels
Feet health	*Good morning.* Check your feet daily for bruises
Drug adherence	*Good morning.* Adhere to set drug times and carry your diabetes drugs any time you travel away from home
Diet	*Good morning.* Take plenty of fruits such as oranges and melon

Week 4

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Brisk walking and running are forms of exercise that a diabetic can do 30 minutes everyday
Self- monitoring of blood sugar	*Good morning.* Do self- monitoring of blood glucose levels
Feet health	*Good morning.* Check your feet daily and if you can not see well, ask someone else to help
Drug adherence	*Good morning.* Do not discontinue with drugs unless on advise by the doctor
Diet	*Good morning.* Avoid sweets and biscuits and foods with added sugars

June 2017

Week 1

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Have a ready snack before exercising
Self- monitoring of blood sugar	*Good morning.* Test your blood glucose level before exercise
Feet health	*Good morning.* Please dry between the toes of your feet
Drug adherence	*Good morning.* If you forget to take diabetes drugs, take immediately you remember
Diet	*Good morning.* Avoid processed juices and other concentrated drinks such as sodas

Week 2

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Running and brisk walking are forms of exercise that a diabetic can do 30 minutes everyday
Self- monitoring of blood sugar	*Good morning.* Do self- monitoring of blood glucose after exercise
Feet health	*Good morning.* Wear comfortable shoes when exercising or after a physical activity
Drug adherence	*Good morning.* Do not stop diabetes drugs unless on advice by the doctor
Diet	*Good morning.* Avoid alcohol as this interferes with drug adherence and may lead to hypoglycemia

Week 3

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Do not just sit the whole day. Do something
Self- monitoring of blood sugar	*Good morning.* Do self- monitoring of blood glucose level
Feet health	*Good morning.* Check your feet for bruises after exercises or after a physical activity
Drug adherence	*Good morning.* Avoid un prescribed drugs
Diet	*Good morning.* Ensure foods taken are high in fiber and unrefined to help in weight management

Week 4

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Exercise helps burn fats in the body. So do your exercise 30 minutes everyday
Self- monitoring of blood sugar	*Good morning.* Do daily monitoring of blood sugar and record
Feet health	*Good morning.* Check your feet daily and pay attention to color changes of toes and

	soles of feet
Drug adherence	*Good morning.* Do not take un prescribed drugs
Diet	*Good morning.* Avoid animal fats as this leads to weight gain and heart diseases such as hypertension

July 2017

Week 1

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Exercise help to burn fats in the body. Do your exercise 30 minutes everyday
Self- monitoring of blood sugar	*Good morning.* Remember to do self-monitoring of blood glucose and record the results
Feet health	*Good morning.* Do not wear tight fitting shoes
Drug adherence	*Good morning.* Do not stop taking diabetes drugs when you feel well
Diet	*Good morning.* Eat balanced meals to include proteins such as beans and meat, vitamins such as fruits and vegetables and carbohydrates such as ugali and chapatti

Week 2

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* See the doctor when you feel unwell
Self- monitoring of blood sugar	*Good morning.* Do daily monitoring of the blood sugar and share the results with the doctor
Feet health	*Good morning.* Cut your nails short with a nail cutter, do not use a razor blade or bite them
Drug adherence	*Good morning.* Go to the doctor if you feel unwell. Avoid self medication
Diet	*Good morning.* Eat foods prepared with

	minimal oil to avoid weight gain

Week 3

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Eat properly, exercise daily and take your medications regularly to control blood pressure
Self- monitoring of blood sugar	*Good morning.* Self monitor blood sugar after exercise
Feet health	*Good morning.* Remember to check your feet daily for sores and bruises
Drug adherence	*Good morning.* Do not let anyone tell you to stop drugs unless your doctor
Diet	*Good morning.* Eat small meals at frequent intervals. Avoid large meals.

Week 4

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Regularly consult your doctor if you feel unwell or if you have any questions about your disease
Self- monitoring of blood sugar	*Good morning.* Do daily self- monitoring of the blood glucose
Feet health	*Good morning.* Check feet for foot infections such as fungal disease
Drug adherence	*Good morning.* Adhere to your doctor's prescription. Do not take less drugs
Diet	*Good morning.* Follow a meal plan provided by the nutritionist in the hospital. Ensure protein foods such as meat and beans are not more than quarter a plate.

August 2017

Week 1

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* If you feel dizzy while exercising, stop and take sweet or a sweet drink
Self- monitoring of blood sugar	*Good morning.* Monitor your blood sugar and record immediately
Feet health	*Good morning.* Check feet for cuts and bruises
Drug adherence	*Good morning.* Follow your doctors' advice on drugs. Stick to one health facility as they have all your records
Diet	*Good morning.* Eat healthy snacks between meals such as arrow roots and sweet potatoes

Week 2

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Regularly consult your doctor if you feel unwell
Self- monitoring of blood sugar	*Good morning.* Do daily self-monitoring of your blood glucose
Feet health	*Good morning.* Avoid tight fitting shoes
Drug adherence	*Good morning.* Take your diabetes drugs even when you feel ill
Diet	*Good morning.* Include foods with different methods of cooking in a day e.g fried, steamed and raw such as kachumbari

Week 3

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Other physical activities such as dancing and playing sports are good for you
Self- monitoring of blood sugar	*Good morning.* Do daily self- monitoring of the blood glucose
Feet health	*Good morning.* Always wear comfortable shoes when exercising
Drug adherence	*Good morning.* Do not stop diabetes medication unless the doctor advises
Diet	*Good morning.* Avoid junk foods as they contribute to weight gain such as chips and sausages

Week 4

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* When exercising, remember to keep hydrated
Self- monitoring of blood sugar	*Good morning.* Do daily self- monitoring of blood glucose
Feet health	*Good morning.* Do daily feet monitoring for bruises and sores
Drug adherence	*Good morning.* Remember to travel with your diabetes drugs
Diet	*Good morning.* Avoid processed foods for example sausages as they have added salt that may cause high blood pressure

September 2017

Week 1

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Avoid or quit smoking as it interferes with blood glucose control and may lead to cardio vascular diseases
Self-monitoring of blood sugar	*Good morning.* When you feel dizzy, do self- monitoring of blood glucose
Feet health	*Good morning.* Check feet immediately after exercise for redness and bruises
Drug adherence	*Good morning.* Adhere to you doctors' prescription on drugs
Diet	*Good morning.* Use minimal sugar in foods as it contributes to weight gain

Week 2

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* If you are going to have exercise for more than 1 hour, make sure you eat first
Self- monitoring of blood sugar	*Good morning.* Do self- monitoring of blood sugar and record
Feet health	*Good morning.* When indoors, remember to air your feet
Drug adherence	*Good morning.* Remember to travel with your diabetes drugs
Diet	*Good morning.* Always eat on time and avoid skipping meals

Week 3

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Other physical activities such as dancing and playing sports are good for you
Self- monitoring of blood sugar	*Good morning.* Do self- monitoring of the blood glucose
Feet health	*Good morning.* Check your feet for bruises and cuts daily
Drug adherence	*Good morning.* Remember to take your diabetes drugs in time
Diet	*Good morning.* Eat properly, exercise daily and take medication well to avoid blood pressure

Week 4

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* See your doctor any time you feel unwell
Self- monitoring of blood sugar	*Good morning.* Do daily self- monitoring of the blood glucose
Feet health	*Good morning.* Check your feet daily for sores and fungal disease
Drug adherence	*Good morning.* Avoid herbal remedies and they interfere with prescribed drugs
Diet	*Good morning.* Kidneys are damaged by high protein foods. Ensure protein foods such as meat and beans are not more than quarter a plate.

October 2017

Week 1

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Do your exercise 30 minutes daily as exercise helps lower blood sugar.
Self-monitoring of blood sugar	*Good morning.* Do daily self -monitoring of blood sugar and share results with the doctor
Feet health	*Good morning.* Do not walk bare feet in the house
Drug adherence	*Good morning.* Adhere to the doctors prescriptions on drug times
Diet	*Good morning.* Take minimal salt to avoid blood pressure control will help prevent complications

Week 2

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* So do your exercise 30 minutes daily as exercise helps reduced weight.
Self- monitoring of blood sugar	*Good morning.* Do daily self- monitoring of blood sugar and share results with the doctor
Feet health	*Good morning.* Do not wear open shoes to avoid cuts
Drug adherence	*Good morning.* See the doctor in case of side effects of diabetes medicine
Diet	*Good morning.* Eat plenty of vegetable for example sukuma wiki and spinach to prevent from infections

Week 3

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* Report any sickness to the

	doctor
Self-monitoring of blood sugar	*Good morning.* Ensure you do daily self-monitoring of the blood sugar
Feet health	*Good morning.* Do not wear plastic shoes as the feet do not air well
Drug adherence	*Good morning.* Avoid un prescribed drugs
Diet	*Good morning.* Use lean meat instead of fatty meat and avoid too much meat

Week 4

Topic of SMS	Message
Morbidity and health seeking behavior	*Good morning.* See the doctor if you are feeling unwell
Self- monitoring of blood sugar	*Good morning.* Record your daily blood sugar levels and share with your doctor
Feet health	*Good morning.* To not wear tightly fitting shoes
Drug adherence	*Good morning.* Do not take herbal remedies
Diet	*Good morning.* Honey and sweets can not be eaten freely as they cause rise in blood sugar

Appendix 3: Short Message Services (SMSs) sent to the patients in Kamba

May 2017

Week 1

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Ikiithya wii na ivinda ya kuthangaasya mwii (kwa kutembea kana kusemba) ndakika miongo itatu kila muthenya
Kwiithima sukali mwii	*Uvoo wa kyoko.* Lilikana kwiithima sukali mwiini kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Suva mauu kila muthenya wone kana wina utune, makundu kana itau
Kunywa ndawa	*Uvoo wa kyoko.* Nywa ndawa ila waandikiwe ni ndakitali syi syoka
Liu	*Uvoo wa kyoko.* Ya maliu ma kwongela mwii vinya, ma kwaka mwii na ma kusyiia mwii mowau

Week 2

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Utakwiwa nesa thii wonekane ni ndakitali
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini wii musyi kana kwa kliniki kila kii vakuvi naku kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Suva mauu kila muthenya wone kana wina itau
Kunywa ndawa	*Uvoo wa kyoko.* Ndukanywe ndawa utaandikiitwe ni ndakitali
Liu	*Uvoo wa kyoko.* Ikiithya nusu ya isaani ya kila liu ni mboka ta nyunyi, sukuma na makovisi

Week **3**

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Lilikana kuthi kliniki kya uwau wa kisukali kila mwei
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Suva mauu kila muthenya wone kana wina utune, makundu kana itau
Kunywa ndawa	*Uvoo wa kyoko.* Nywa ndawa nesa mavinda ala utavitwe ni ndakitali, kua ndawa isu ila utae musyi
Liu	*Uvoo wa kyoko.* Ya matunda maingi ta masungwa na mavavai

Week 4

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Kutembea na kusemba ni muthemba wa kuthangaasya mwii utonya kwikwa ni mundu wina uwau wa kisukali ndakika miongo itatu kila muthenya
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Suva mauu maku nesa kila muthenya, uketha utakwona nesa, tethwa ni mundu unge
Kunywa ndawa	*Uvoo wa kyoko.* Ndukaeke unywa ndawa utatavitwe ni ndakitali
Liu	*Uvoo wa kyoko.* Ekana na velemende, misukuti na maliu ala mongeletwe sukali mwingi

June 2017

Week 1

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Ya kaliu kanini utanambia kuthaangasya mwii
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini utanambia kuthaangasya mwii
Uiima wa maau	*Uvoo wa kyoko.* Ikiithya niwanyaasa kiwu katikati wa ítala sya mauu
Kunywa ndawa	*Uvoo wa kyoko.* Wolwa kunywa ndawa ivinda ila yailite, nywa ila walilikana
Liu	*Uvoo wa kyoko.* Ekana na njuisi ila sisovetwe na makambuni na masota

Week 2

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Kutembea na kusemba ni muthemba wa kuthangaasya mwii utonya kwikwa ni mundu wina uwau wa kisukali ndakika miongo itatu kila muthenya
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini wamina kuthaangasya mwii
Uiima wa maau	*Uvoo wa kyoko.* Ikiia syatu ngunike na itaukwete muno uuthangaasya mwii na wamina
Kunywa ndawa	*Uvoo wa kyoko.* Ndukaeke unywa ndawa utatavitwe ni ndakitali
Liu	*Uvoo wa kyoko.* Ekana na uki (karubu) niwanangaa kuthukuma kwa ndawa na uutuma sukali uthee nthakameni

Week 3

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Ndukatinde wiikalite muthenya muima, thukuma
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini

	wamina kuthaangasya mwii
Uiima wa maau	*Uvoo wa kyoko.* Suva kana mauu ni maumiite wamina kuthangaasya mwii
Kunywa ndawa	*Uvoo wa kyoko.* Ndukanywe ndawa ila utaandikiitwe ni ndakitali
Liu	*Uvoo wa kyoko.* Ikiithya wiya maliu ala matalikaa nthakameni mituke ta mukate wa brown na nduma, maliu aa matethasya kusuuvia wito wa mwii

Week 4

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Kuthangaasya mwii ni kutethasya kumina mauta mwiini. Thangaasya mwii ndakika miongo itatu kila muthenya
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya na ukwandika vandu
Uiima wa maau	*Uvoo wa kyoko.* Suva mauu kila muthenya wone kana vena tovauti ki-langi kwa syaa
Kunywa ndawa	*Uvoo wa kyoko.* Ndukanywe ndawa ila utaandikiitwe ni ndakitali
Liu	*Uvoo wa kyoko.* Ekana na mauta ma indo nundu mongelaa wito mwiini, mowau ma ngoo na kuambatya nthakame

July 2017

Week 1

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Kuthangaasya mwii ni kutethasya kumina mauta mwiini. Thangaasya mwii ndakika miongo itatu kila muthenya
Kwiithima sukali mwii	*Uvoo wa kyoko.* Lilikana kwiithima sukali mwiini kila muthenya na ukwandika vandu
Uiima wa maau	*Uvoo wa kyoko.* Ikiia syatu ngunike na itaukwete muno
Kunywa ndawa	*Uvoo wa kyoko.* Ndukaeke unywa ndawa utatavitwe ni ndakitali ona waiwa nesa
Liu	*Uvoo wa kyoko.* Ya maliu ala ma kwongela mwii vinya (ta maluu, ngima na musele), ma kwaka mwii (ta nzuu, matumbi, mboso na nyama) na ma kusyiia mwii na mowau (ta nyunyi na matunda

Week 2

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Utakwiwa nesa thii wonekane ni ndakitali
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya na ulilikane kuandika vandu ni kana wonie ndakitali
Uiima wa maau	*Uvoo wa kyoko.* Tila ngunyo na nailcutter, ndukatumie kawembe na ndukatile na maeo
Kunywa ndawa	*Uvoo wa kyoko.* Utakwiwa nesa thii wonekane ni ndakitali. Ndukanywe ndawa utaandikiitwe ni ndakitali
Liu	*Uvoo wa kyoko.* Ya liu uuitwe na mauta manini ni kana ndukaongele wito mituke

Week 3

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Ya nesa, thangaasya mwii na uunywa ndawa kila muthenya ni kana ndukaambatwe ni nthakame
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini wamina kuthangaaysa mwii
Uiima wa maau	*Uvoo wa kyoko.* Lilikana kusuva mauu kila muthenya wone kana wina utune, makundu kana itau
Kunywa ndawa	*Uvoo wa kyoko.* Ndukaitikile mundu unge akutavye wekane na ndawa teka ndakitali
Liu	*Uvoo wa kyoko.* Ya liu munini mavinda maatianisye. Taanisya na maliu maingi kwa ivinda imwe

Week 4

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Utakwiwa nesa thii wonekane ni ndakitali na ukulye maukulyo ala wina mo
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Suva mauu kila muthenya wone kana wina itau
Kunywa ndawa	*Uvoo wa kyoko.* Nywa ndawa nesa mavinda ala utavitwe ni ndakitali
Liu	*Uvoo wa kyoko.* Ya liu undu utavitwe kana waandikiitwe ni ndakitali wa liu vau sivitalini

August 2017

Week 1

Topic of SMS	Example
Mauwau na mwikalile wa kumantha	*Uvoo wa kyoko.* Wakwatwa ni nziuo

uiiti/uima wa mwii	uuthangaasya mwii, amba kweka na unywe kindu kiina muyo ta kasota
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya na ulilikane kuandika vandu
Uiima wa maau	*Uvoo wa kyoko.* Suva mauu kila muthenya wone kana wina itau
Kunywa ndawa	*Uvoo wa kyoko.* Atiia mawaidha ma ndakitali uunywa ndawa na ukwikiithya wendaa kwa sivitali umwe
Liu	*Uvoo wa kyoko.* Ya tuliu tunini tula tuseo kwa mwii (ta matunda na makwasye na nduma) katikati wa ivinda ya maliu manene

Week 2

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Utakwiwa nesa thii wonekane ni ndakitali
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Ikiia syatu ngunike na itaukwete muno
Kunywa ndawa	*Uvoo wa kyoko.* Nywa ndawa ila utavitwe ona utakwiwa nesa
Liu	*Uvoo wa kyoko.* Ikiithya maliu ala uya kila muthenya mauitwe kwa nzia tovauti ta kutheukya, kukaanga na angi matauitwe ta kachumbali

Week 3

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Mithemba ya kuthangaasya mwii ta kusunga na mathau ni nzeo kwaku
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Ikiia syatu ngunike na itaukwete muno uuthangaasya mwii

Kunywa ndawa	*Uvoo wa kyoko.* Ndukaeke unywa ndawa utatavitwe ni ndakitali
Liu	*Uvoo wa kyoko.* Ekana na maliu ala matatethasya mwii ta chips, ni matumaa wito wa mwii wongeleka

Week 4

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Uuthangaasya mwii, lilikiana kunwya kiwu kyaniie
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Suva mauu kila muthenya wone kana wina itau
Kunywa ndawa	*Uvoo wa kyoko.* Lilikana ukue ndawa syaku ila utae musyi
Liu	*Uvoo wa kyoko.* Ekana na maliu ala matatethasya mwii ta chips, ni matumaa wito wa mwii wongeleka

September 2017

Week 1

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Ekana na mbaki, niyanangaa kusuvia sukali nthakameni na niyetaa mowau ma ngoo
Kwiithima sukali mwii	*Uvoo wa kyoko.* Wakwatwa ni nziuo, ithime sukali mwiini
Uiima wa maau	*Uvoo wa kyoko.* Suva kana mauu ni maumiite wamina kuthangaasya mwii
Kunywa ndawa	*Uvoo wa kyoko.* Nywa ndawa undu utavitwe ni ndakitali
Liu	*Uvoo wa kyoko.* Tumia sukali munini vyu liuni, niwongelaa kwituva

Week 2

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Waenda kuthangaasya mwii kwa ivinda ivitite isaa imwe, ya liu utanambiia
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Wi nyumba, ndukaikie syatu ngunike ni kana mauu makwate nzeve
Kunywa ndawa	*Uvoo wa kyoko.* Lilikana ukue ndawa syaku ila utae musyi
Liu	*Uvoo wa kyoko.* Ikiithya ni waya mavinda ala mailite vatee ukila

Week 3

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Mithemba ya kuthangaasya mwii ta kusunga na mathau ni nzeo kwaku
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Suva mauu kila muthenya wone kana wina itau
Kunywa ndawa	*Uvoo wa kyoko.* Lilikana unywe ndawa syaku mavinda ala mailite
Liu	*Uvoo wa kyoko.* Ya nesa, thangaasya mwii kila muthenya na uunywa ndawa undu wailite ni kana ndukaambatwe ni nthakame

Week 4

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Utakwiwa nesa thii wonekane ni ndakitali
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Suva mauu kila muthenya

	wone kana wina itau
Kunywa ndawa	*Uvoo wa kyoko.* Ekana na ndawa sya musyi, nisyanangaa kuthukuma kwa ndawa ila ndakitali ukunengete
Liu	*Uvoo wa kyoko.* Ya nesa, thangaasya mwii kila muthenya na ukwekana na maliu mena munyu mwingi ni kana ndukaambatwe ni nthakame. Ndukaye nyama mbingi niyanyagaa kuthuuma kwa mbiu

October 2017

Week 1

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Thangaasya mwii ndatika miongo itatu kila muthenya ni kana sukali mwiini utheeye
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini na ukwandika vandu ni kana ndakitali aone
Uiima wa maau	*Uvoo wa kyoko.* Ndukatembee utee syatu nyumba
Kunywa ndawa	*Uvoo wa kyoko.* Nywa ndawa mavinda ala mailite, undu ndakitali ukutavitye
Liu	*Uvoo wa kyoko.* Ya liu wina munyu munini ni kana ndukaambatwe ni nthakame

Week 2

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Thangaasya mwii ndakika miongo itatu kila muthenya, ni kana wito unyive
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini na ukwandika vandu ni kana ndakitali aone
Uiima wa maau	*Uvoo wa kyoko.* Ikia syatu ngunike ni kana ndukaumiisye mauu

Kunywa ndawa	*Uvoo wa kyoko.* Ndawa sitaukwika nesa thii wonekane ni ndakitali
Liu	*Uvoo wa kyoko.* Ya mboka mbingi ta nyunyi, sukuma na makovisi

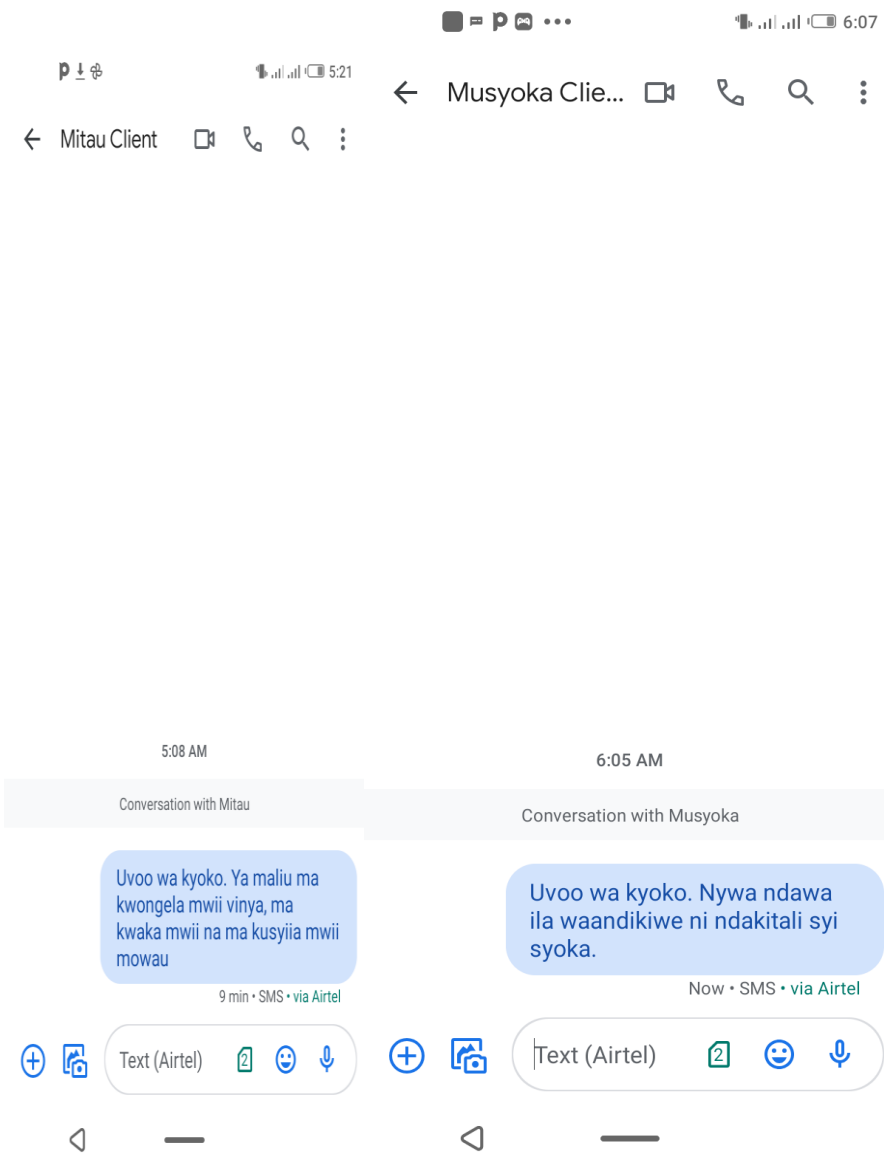
Week 3

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Utakwiwa nesa thii wonekane ni ndakitali
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini kila muthenya
Uiima wa maau	*Uvoo wa kyoko.* Ndukaikie syatu sya plastiki nundu syiilikasya nzeve nesa mauuni
Kunywa ndawa	*Uvoo wa kyoko.* Nywa ndawa ila waandikiwe ni ndakitali syi syoka
Liu	*Uvoo wa kyoko.* Ya nyama ila itena mauta maingi

Week 4

Topic of SMS	Example
Mauwau na mwikalile wa kumantha uiiti/uima wa mwii	*Uvoo wa kyoko.* Utakwiwa nesa thii wonekane ni ndakitali
Kwiithima sukali mwii	*Uvoo wa kyoko.* Ithime sukali mwiini na ukwandika vandu ni kana ndakitali aone
Uiima wa maau	*Uvoo wa kyoko.* Ikiia syatu ngunike na itaukwete muno
Kunywa ndawa	*Uvoo wa kyoko.* Ndukatumiie ndawa sya kuisovesya musyi
Liu	*Uvoo wa kyoko.* Ndukaye uki na velemende muno ni kana ndukaambatwe ni nthakame

Appendix 4: Sample of Short Message Services (SMSs) screen shots sent to the patients



Appendix 5: Key Informant Interview (KII) guide

1. Does the hospital carry out diabetes education?

   1= Yes 2= No

2. If yes above, how often?

   1= Per every diabetes clinic 2= On diagnosis

3. If yes in 1 above, how many patients per session

   1= Individual 2= Group

4. If no in 1 above, what could be the reason?..... …….

5. Do you use teaching aids in diabetes education?

   1= Yes 2= No

6. Why is there poor management of diabetes? ……...

7. How does your facility actively help in management of diabetes?.....

8. Apart from this health facility, what are the other sources of diabetes information in this county? ……...

9. Why do you think patients resort to this type of information?

   ……..

10. Do you think household counseling of family members is feasible in a health facility context?.....

11. Do you think group counseling has been effective?.....

12. Do you think a reminder system for drugs will be effective in diabetes management? .....
13. Do you think a reminder system for diet would/ has been effective in diabetes management? ……..
14. What patient related challenges do you encounter in diabetes management?
15. What are the challenges in drug management of T2DM?.....
16. What are the challenges in dietary management of T2DM?.....
17. What are the cultural beliefs about diabetes in Kitui County?.....

Appendix 6: Focus Group Discussion (FGD) guide for discussion held with T2DM patients

1. What was your reaction when you were diagnosed with diabetes?
2. What challenges did you encounter when you were diagnosed with diabetes?
3. What is dietary management of diabetes?
4. Do you think that dietary management of diabetes is beneficial?
5. What are the challenges facing use of diet in management of diabetes?
6. How do you think this can be solved?
7. What is drug management of diabetes?
8. Do you think that drug management of diabetes is beneficial?
9. What are the challenges facing use of drugs in management of diabetes?
10. How do you think this can be solved?
11. Do other family members provide adequate support for management of diabetes?
12. What and who are the major influences on the diabetes attitude towards management?
13. What are the sources of diabetes information in this area?
14. Do these sources actively involve other family members?
15. Should these sources actively involve other family members?
16. Do you think use of mobile phone reminders can help improve the diabetes management?

Appendix 7: Focus Group Discussion (FGD) guide for discussion held with community members

1. Do you know of diabetes?
2. If Yes above, what is it?
3. What are the causes of diabetes?
4. Do you think diabetes is a serious disorder in the community?
5. What are the challenges affecting diabetes management?
6. What are the current interventions in diabetes management?
7. Do you think the current interventions in diabetes management are effective?
8. Do you think the hospital has done enough in the management of diabetes?
9. What do you think of a reminder system for example use of text messages for diabetes management?

Appendix 8: Consent form

Study participation consent form for interviewees on effect of using mobile phone communication in the management of Type 2 Diabetes Mellitus among adult patients attending Kitui County Referral Hospital, Kenya

Questionnaire No……..

Principal Investigator: ALICE WAIRIMU THEURI

Introduction

Ms. Alice Wairimu Theuri, a PhD student at the Jomo Kenyatta University of Agriculture and Technology is conducting a survey on Effect of Using Mobile Phone Communication in the Management of Type 2 Diabetes Mellitus Patients in Kitui County. This study has been approved by the Kenyatta National Hospital/ University of Nairobi research and ethics committee (KNH/UON/ERC).

You have been selected by chance to participate in this study. This consent form is to give you information to help you decide to participate or not. Please read it carefully or listen as I read. You may ask questions on anything not clear to you on the purpose of the study, procedures, risks, benefits, compensation and your rights as a volunteer.

Purpose

The findings of this study can be used by mobile phone operators in collaboration with dieticians and nutritionist to improve and expand their services in ways geared to empowering the Type 2 Diabetes Mellitus patients on the management of their condition.

Procedure

If you agree to participate in the study you will be asked questions. The nature of the questions will be pertaining to your household, morbidity experience, health seeking practices, drug adherence and feeding practices. The interviewer will also draw a blood sample from you to check your blood glucose level. The initial interview will take approximately 30 minutes. Consent is sought when taking these measurements and to record them for study purposes. The investigator also seeks consent to obtain information on your morbidity status from the hospital health records. You will also be getting text messages at set times every day on your mobile phone on morbidity experience, health seeking practices, drug adherence and feeding practices which you are required to follow as you manage your condition.

If you consent to also participate in the follow-up for 6 months after today (Date……) then further questions will be asked on morbidity experience, health seeking practices, drug adherence and feeding practices then to have blood drawn for this study, weight and height will also be measured on dates of the interview and recorded.

Confidentiality

Your confidentiality will be maintained at all times. The filled questionnaires will be stored in a lockable filing cabinet only accessible to the principal investigator and research assistant. Electronic data will be stored in a password protected database accessible only through the principal investigator. Analysis and report of the study will only use the study numbers and no detail will be provided at any point that might identify an individual. There shall be no mention of names or identifiers in the report or publications which may arise from the study. The information obtained will be used only for the purpose of the study.

Risks/ discomfort

There are no risks involved in this study. The interviewee will experience a little pain/ discomfort as blood is drawn at the beginning of the study and at the end of six months. In addition, you will be asked questions which may cause psychological discomfort; you are free not to answer any such questions if you feel so. In addition, the questions will also be asked in a private environment and confidentiality will be assured at all times to ensure your comfort.

Benefits

The information obtained will be used to improve the quality of care for Type 2 Diabetes Mellitus patients in our communities through improvement of information given on drugs and diet. A copy of the report will be submitted to your health facility to be used for planning development strategies and interventions to address the findings.

Compensation

There will be no compensation for participation in the study in form of money or any other gift. However, the information you give will be highly appreciated.

Rights as a volunteer

Participation in the study is voluntary and will be highly appreciated. If you choose not to participate, you will not be denied any service. You will be free to withdraw from the study at any time.

For any questions/ clarification, contact the principal investigator on:

P.O. Box, 427-00902, Kikuyu, Kenya

Telephone number: 0721 264231

Email address: raliceke@yahoo.com

You can also contact my supervisor:

Prof. A.O. Makokha

P.O Box 62000-00200 Nairobi, Kenya

Phone: 0713 817436

Email: anmakokha@gmail.com

As well as the Chairman KNH/UON-ERC through:

P.O. Box 19676, Nairobi, Kenya

Tel. 726300-9 Extension 44102

Email: uonknh_erc@uonbi.ac.ke

PARTICIPANT'S STATEMENT

I Mr/Mrs/Ms/Miss.....being a person aged 18 years and over, having read/ been explained to the above and in the knowledge that it is voluntary, acknowledge that a thorough explanation of the nature of the study has been given to me. I hereby give consent to participate in this study. I understand that I have the right to withdraw from the research at any time, for any reason, without penalty or harm.

Patient's signature

.....

Date...../...../2017

Researcher/Assistant's signature

.....

Date...../...../2017

Appendix 9: Fomu ya idhini

Fomu ya idhini ya mgonjwa kushiriki katika utafiti wa athari ya kutumia mawasiliano ya simu za mkononi katika usimamizi wa aina ya 2 ya kisukari kati ya wagonjwa wazima wanaohudhuria hospitali ya Referral ya Kitui County, Kenya

Nambari.....

Mpelelezi Mkuu: ALICE WAIRIMU THEURI

Utangulizi

Bi. Alice Wairimu Theuri**,** mwanafunzi anayesomea daktari wa falsafa (PhD) anataka kufanya utafiti miongoni mwa wagonjwa wa aina 2 kisukari. Utafiti huu imekuwa kupitishwa na kamati ya Taifa ya Kenyatta Hospital/ Chuo Kikuu cha Nairobi utafiti na maadili (KNH/ UON/ ERC).

Wewe umepata kuchaguliwa kwa nafasi ya kushiriki katika utafiti huu. Fomu ya idhini ni kukupa habari ya kukusaidia kuamua kushiriki au la. Tafadhali pata kusoma kwa makini au kusikiliza nikikusomea. Unaweza kuuliza maswali juu ya kitu chochote usichokielewa kuhusu; makusudi ya utafiti huo, taratibu, hatari, faida, fidia na haki zako kama umejitolea.

Madhumuni

Madhumuni ya utafiti ni kutoa taarifa za kutumiwa na waendeshaji simu ya mkononi kwa kushirikiana na daktari wa lishe bora ili kuboresha na kupanua huduma zao kwa njia lengo la kuwawezesha wagonjwa wa aina 2 kisukari juu ya usimamizi wa hali yao.

Utaratibu

Kama utakubali kushiriki katika utafiti na utapata kuulizwa maswali na unaombwa kuyajibu kwa usahihi. Asili ya maswali itakuwa yanayohusu jamaa yako, mazoea ya huduma, uzoefu wa maradhi, utumiaji wa dawa za kisukari na lishe. Mtafiti atateka sampuli ya damu yako, kutathmini ufanisi na kuingilia kati. Utaweza pia kuwa nakupata ujumbe kwa nyakati kwenye simu yako ya mkononi juu ya uzingatiaji wa madawa za kisukari na chakula, ambayo unatakiwa kufuata kama wewe kusimamia hali yako. Mahojiano ya awali itachukua takriban dakika thelathini; kisha kutakuwa na mahojiano ya kufuatilia jinsi unavyoendelea baada ya miezi sita.

Ridhaa wakati wa kuchukua vipimo hivi na kurekodi kwa madhumuni ya utafiti itatoka kwako. Mpelelezi pia anataka kukubaliana na kupata taarifa juu ya maradhi yako sasa kutoka kumbukumbu za afya hospitalini.

Hii ni kama wewe umekubali na pia kushiriki katika kufuatilia kwa miezi 6 baada ya leo (Tarehe……). Uzito na urefu wako itapimwa wakati wa mahojia. Kisha maswali zaidi yataulizwa juu ya maradhi uzoefu, mazoea huduma, madawa ya kisukari, uzingatiaji na vitendo vya chakula kurekodiwa na kurudiwa baada ya miezi sita kutoka leo.

Usiri

Usiri wako utasimamiwa wakati wote. Maswali iliojazwa itakuwa inahifadhiwa katika kabati na kufungwa na kifuli na kuangaliwa na mtafiti mkuu na msaidizi wa utafiti pekee yake. Takwimu za elektroniki itahifadhiwa katika siri ya ulinzi na kupatikana kupitia tu mtafiti mkuu. Ripoti ya utafiti itatumia nambari ya siri ya utafiti na hakuna maelezo yatatolewa katika hatua yoyote ambayo inaweza kutambua mtu binafsi. Hakutakuwa na kutaja majina au vitambulisho vyovyote katika ripoti au machapisho

ambayo yanaweza kutokea kutokana na utafiti. Taarifa zitakazopatikana zitatumika tu kwa madhumuni ya utafiti.

Hatari/ usumbufu

Hakuna hatari ya kushiriki katika hii utafiti lakini utapata kidogo maumivu/ usumbufu kama damu inayotolewa katika mwanzo wa utafiti huu na baada ya miezi sita. Aidha, utakuwa unaulizwa maswali ambayo inaweza kusababisha usumbufu wa kisaikolojia; wewe ni huru si kujibu maswali yoyote kama wewe kujisikia hivyo. Aidha, maswali pia itaulizwa katika mazingira binafsi na usiri utakuwa na uhakika wakati wote ili kuhakikisha faraja yako.

Faida

Taarifa zilizopatikana zinaweza kutumika kuboresha huduma bora kwa wagonjwa wa kisukari katika jamii zetu kupitia uboreshaji wa taarifa iliyotolewa juu ya utumiaji wa madawa za kisukari na chakula. Nakala ya ripoti itawasilishwa kwa kituo chako cha afya na kutumiwa kwa ajili ya kupanga mikakati ya maendeleo na utekelezaji wa kushughulikia matokeo.

Fidia

Hakutakuwa na fidia kwa kushiriki katika utafiti katika mfumo wa fedha au zawadi nyingine yoyote, hata hivyo maelezo utakayotoa itakuwa yenye kukubaliwa.

Haki kama mwenye hiari

Kushiriki katika utafiti ni wa hiari na itakuwa yenye kukubaliwa. Kama utachagua kutoshiriki, huwezi kataliwa huduma yoyote. Pia utakuwa huru kuondoka kutoka utafiti wakati wowote.

Kwa maswali yoyote/ ufafanuzi, wasiliana mpelelezi mkuu kupitia:

Sanduku la barua: 427-00902, Kikuyu, Kenya

Nambari ya simu: 0721 264231

Barua pepe: raliceke@yahoo.com

Unaweza pia kuwasiliana na msimamizi wangu:

Prof. A.O. Makokha

Sanduku la barua: 62000-00200, Nairobi, Kenya

Nambari ya simu: 0713 817436

Barua pepe: anmakokha@gmail.com

Kama vile Mwenyekiti KNH/ UON-ERC kupitia:

Sanduku la barua: 19676, Nairobi, Kenya

Nambari ya simu 726300-9 Ugani was simu 44102

Barua pepe: uonknh_erc@uonbi.ac.ke

TAMKO LA USHIRIKI

Mimi Bibi/ Bi/ Bwana ..... kuwa mtu wenye umri wa miaka zaidi ya 18, baada ya kusoma/ kuelezwa na katika maarifa kwamba ni hiari, nakiri kwamba maelezo ya asili ya utafiti nimepewa. Ninatoa idhini ya kushiriki katika utafiti huu. Naelewa kwamba niko na haki ya kutoka utafiti wakati wowote, kwa sababu yoyote, bila adhabu au madhara.

Sahihi ya mgonjwa .....

Tarehe ..... /. ..... / 2017

Mtafiti Mkuu/ Msaidizi .....

Tarehe ..... /... ..... / 2017

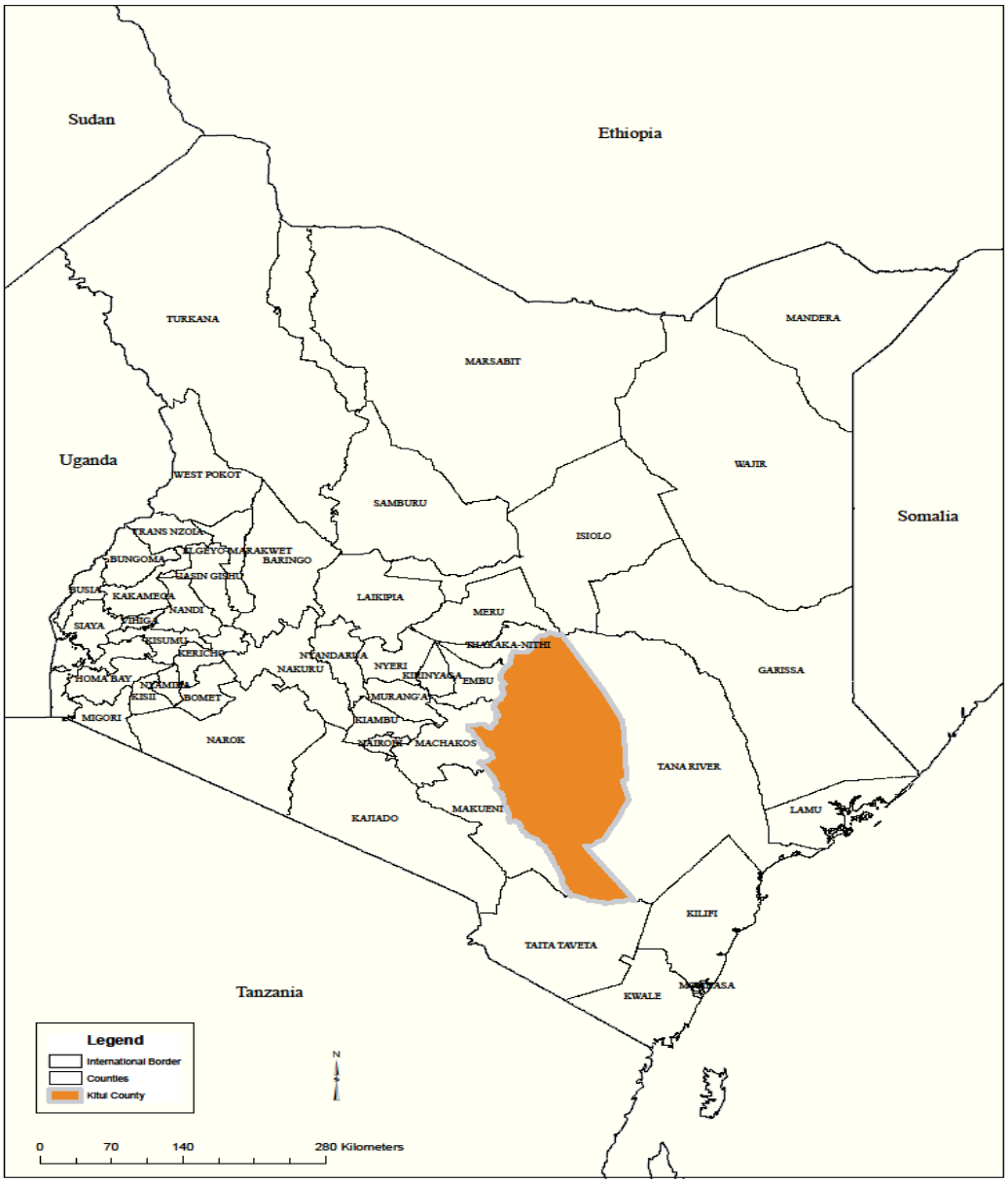
Appendix 10: Training curriculum for data collection

Day	Component
1	Introduction to study objectives Introduction to data collection tools How to use data collection tools Taking anthropometric measurements
2	Interview skills Filling the questionnaire
3	Assessment of each research assistant on all aspects learnt using role play

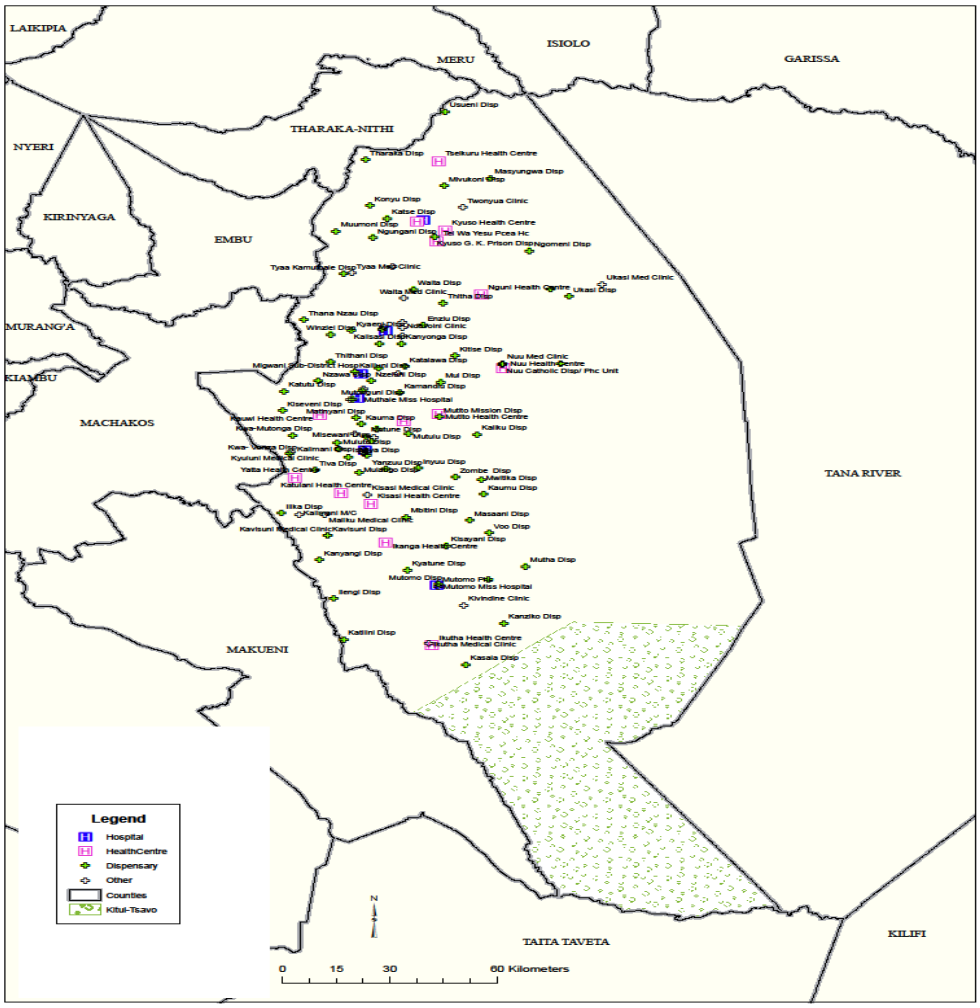
Appendix 11: Training curriculum for laboratory technologists

Day	Component
1	Introduction to study objectives
2	Collection of blood samples
3	Analysis and recording of HbA1c results

Appendix 12: Location map of Kitui County in Kenya



Appendix 13: Distribution of health facilities in Kitui County



Appendix 14: Research authorization- KNH-UON ERC

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
(254-020) 2726300 Ext 44355

KNH-UoN ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/ Mod&SAE/394

21st December, 2016

Ms. Alice Wairimu Theuri
P O Box 427 (00902)
KIKUYU

Dear Alice

Re: Approval of modifications study titled 'Development of a Telecommunication Tool for the management of Type II Diabetes Mellitus among adult patients aged 20-70 years at Kitui District Hospital (P785/12/2015)

Refer to your communication dated December 4 2016.

The KNH-UON Ethics and Research Committee has reviewed and approved the following:

1. Change of universities from University of Nairobi to Jomo Kenyatta University of Agriculture & Technology(JKUAT)
2. Change of research station from Kiambu District Hospital and Thika District Hospital to Kitui District Hospital and Mwingi District Hospital in Kitui county
3. Change of the working title to 'Development of a telecommunication tool for the management of Type 2 Diabetes mellitus among adult patients aged 21-70 years in Kitui District Hospital' but add Mwingi District Hospital in title too.

The approved period for the study is w.e.f. 28th June 2016 – 27th June 2017.

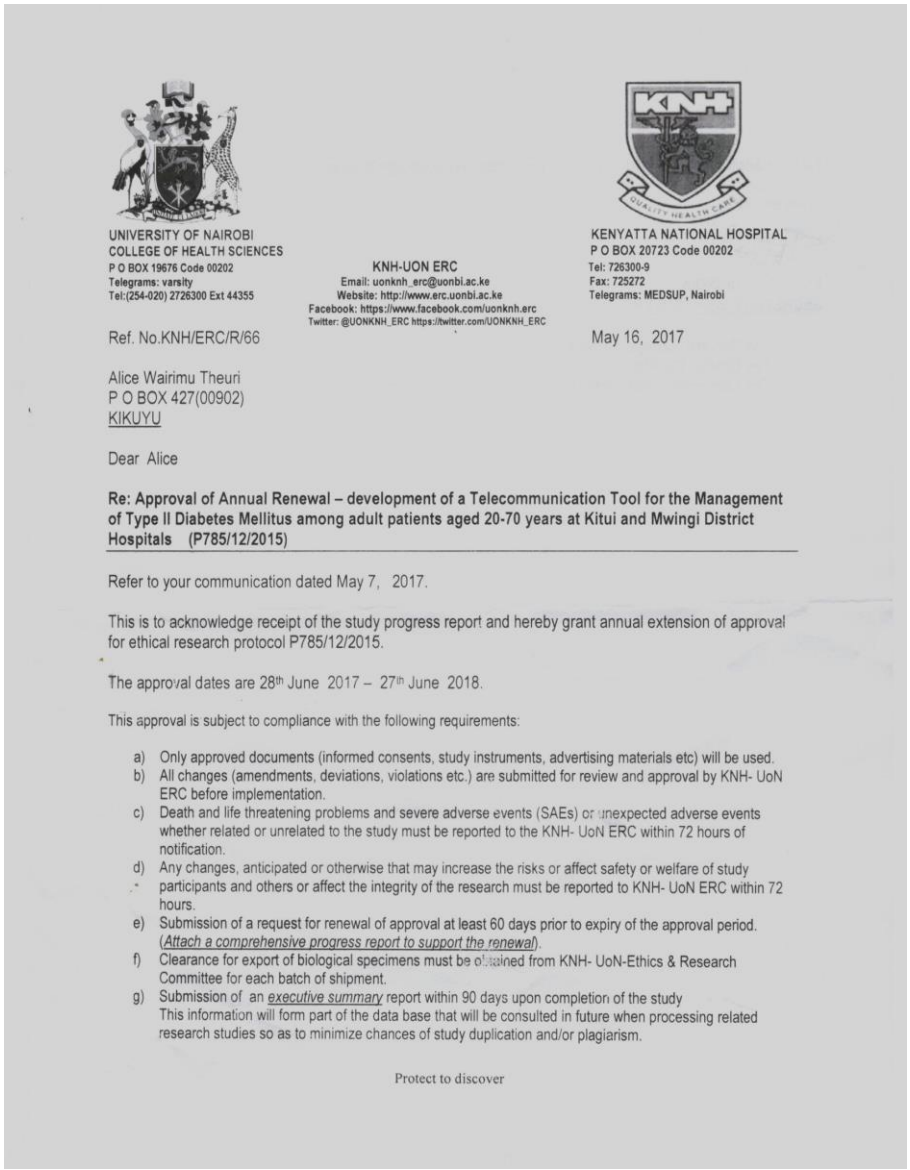
Yours sincerely,

PROF. M.L. CHINDIA
SECRETARY, KNH-UON ERC

c.c. The Principal, College of Health Sciences, UoN
The Deputy Director, CS, KNH
The Chair, KNH- UoN ERC

Protect to discover

Appendix 15: Research authorization renewal letter- KNH-UON ERC



UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
Tel:(254-020) 2726300 Ext 44355

KNH-UON ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref. No.KNH/ERC/R/66

May 16, 2017

Alice Wairimu Theuri
P O BOX 427(00902)
KIKUYU

Dear Alice

Re: Approval of Annual Renewal – development of a Telecommunication Tool for the Management of Type II Diabetes Mellitus among adult patients aged 20-70 years at Kitui and Mwingi District Hospitals (P785/12/2015)

Refer to your communication dated May 7, 2017.

This is to acknowledge receipt of the study progress report and hereby grant annual extension of approval for ethical research protocol P785/12/2015.

The approval dates are 28th June 2017 – 27th June 2018.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH- UoN ERC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH- UoN ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
f) Clearance for export of biological specimens must be obtained from KNH- UoN-Ethics & Research Committee for each batch of shipment.
g) Submission of an *executive summary* report within 90 days upon completion of the study
This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/or plagiarism.

Protect to discover

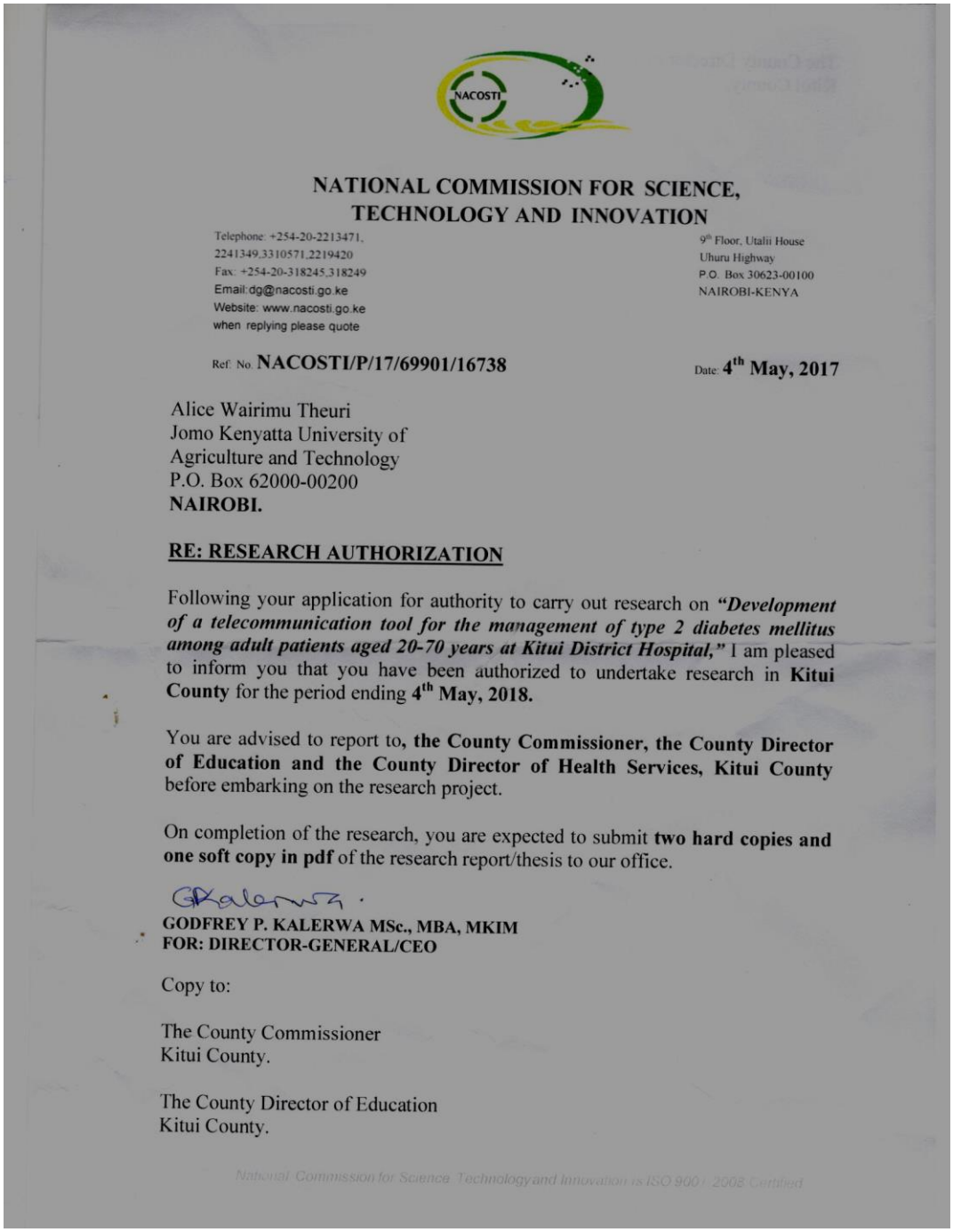
For more details consult the KNH- UoN ERC website **http://www.erc.uonbi.ac.ke**

Yours sincerely,

PROF. M.L. CHINDIA
SECRETARY, KNH-UON ERC

c.c. The Principal, College of Health Sciences, UoN
The Director CS, KNH
The Chairperson, KNH-UoN ERC

Appendix 16: Research authorization- NACOSTI



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

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/17/69901/16738**

Date: **4th May, 2017**

Alice Wairimu Theuri
Jomo Kenyatta University of
Agriculture and Technology
P.O. Box 62000-00200
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Development of a telecommunication tool for the management of type 2 diabetes mellitus among adult patients aged 20-70 years at Kitui District Hospital,"*** I am pleased to inform you that you have been authorized to undertake research in **Kitui County** for the period ending **4th May, 2018.**

You are advised to report to, **the County Commissioner, the County Director of Education and the County Director of Health Services, Kitui County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kitui County.

The County Director of Education
Kitui County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified

The County Director of Health Services
Kitui County.

Appendix 17: Permission to carry out research- JKUAT

JOMO KENYATTA UNIVERSITY
OF
AGRICULTURE AND TECHNOLOGY
P.O. BOX 62000-00200, NAIROBI, KENYA. TEL: 067-52711 FAX: 067-52164
e-mail: foodscience@agr.jkuat.ac.ke

DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

Our Ref: JKU/2/13/011/125

23rd November, 2016

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

REF: ALICE WAIRIMU THEURI – REG/NO. AGF411-5343/2016

This is to confirm that the above named person is our student at the Department of Food Science and Technology, Faculty of Agriculture, Jomo Kenyatta University of Agriculture and Technology. She is pursuing PhD in Food Science and Nutrition.

Her research title is "*Development of a telecommunication tool for the management of type II Diabetes Mellitus Patients in Kitui District Hospital.*

Kindly assist Theuri to carry out her research in your institution.

Thank you.

JOMO KENYATTA UNIVERSITY
OF
AGRICULTURE AND TECHNOLOGY
DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY
P. O. BOX 62000, NAIROBI, KENYA.

DR. ARNOLD N. ONYANGO
COD:FOOD SCIENCE AND TECHNOLOGY

ANO/mm

Appendix 18: Permission to carry out research- KCRH

COUNTY GOVERNMENT OF KITUI
MINISTRY OF HEALTH AND SANITATION

Email:dmsokitui@gmail.com
Mobile: 0724036822

PO BOX 22-90200,
KITUI

10 JAN 2017

KITUI COUNTY HOSPITAL

Ref : C.6/VOL.VII/372

Date: 1st December, 2016

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

RE: ALICE WAIRIMU THEURI – REG. NO. AGF411-5343/2016

The above named student can do her research work in our facility, on condition that she has the required documents.

We hope to benefit from the study as well.

Yours sincerely,

MEDICAL SUPERINTENDENT
KITUI DISTRICT HOSPITAL
P. O. KITUI
01 DEC 2016
TEL: 044 4422665
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Dr. Irene Makite
Medical Superintendent
Kitui County Referral Hospital

Accepted

Appendix 19: Permission to follow up patients- KCRH

ALICE WAIRIMU THEURI
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9/11/2017

TO THE MEDICAL SUPERINTENDENT
KITUI DISTRICT HOSPITAL
P.O BOX 22(90200)

Dear Sir

PERMISSION TO FOLLOW UP PATIENTS FOR MY RESEARCH AT YOUR FACILITY

I, Alice Wairimu Theuri, student Reg. No. AGF411-5343/2016 a student at Jomo Kenyatta University of Agriculture and Technology(JKUAT) hereby request for permission to follow up diabetes patients for my research so as to complete my data collection that started in April 2017 in your facility. This is to enable me complete my PhD research titled 'Development of a Telecommunication Tool for the Management of Type 2 Diabetes Mellitus among Patients Aged 20-70 Years Attending Kitui District Hospital'. While I undertake the research, I promise to adhere to the rules set by the KNH/ERC committee and also follow the rules of your facility. Attached, please find my JKUAT admission letter, JKUAT introduction letter and KNH/ERC ethical clearance letter and earlier authorization from your facility.

Thanking you in advance.

Yours Faithfully

Alice Wairimu Theuri

15/11/2017
Approved
Dr. [illegible]
J.N

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Appendix 20: Summary of findings from Key Informant Interview (KII) guide

The study established from the informants that: "The hospital carries out diabetes education but it is not consistent. There are times when the nutritionist is not there. This is because the hospital has only one nutritionist who is expected to be in many areas for example outpatient clinics, inpatient, Comprehensive Care Clinic (CCC) kitchen and community health'.

> Respondents noted that nutrition education is not often done as: 'This is mostly on diagnosis. After this, the nutrition education is not on a weekly basis because there is shortage of personnel'.
>
> Information from KII revealed that: 'The sessions are mostly in group that is comprised of many patients with different conditions. They are not arranged in terms of disease conditions since there is only one physician, one educator and one nurse to attend to all the patients in the clinic'.
>
> Teaching aids are used by the diabetes educators as: 'Yes, teaching aids are used in the nutrition diabetes education. However, teaching aids are not elaborated because of lack of time and the patients are too many to receive individualized care'.

Respondents revealed the causes of poor management as: 'There is poor management of diabetes because of shortage of personnel in the hospital. The hospital has one physician, and no endocrinologist, one nutritionist and no trained nurse on feet care. There is also no follow up to assess use of the nutrition messages and socio-economic factors such as cost of drugs and lack of bus fare and poor purchasing power'.

In addition, 'Most patients do not attend diabetes clinic regularly because of lack of bus fare, forgetfulness and being unwell'.

Asked whether the hospital actively helps in management of diabetes, the response was: *'I can not say that the facility actively helps in management of diabetes because of few personnel and poor socio-economic characteristics of the patients'.*

Other than Kitui County Referral Hospital, the other sources of diabetes information in the county were: *'The sources of information are many. For example some seek the services of a traditional healer believing the diabetes will disappear. Others receive spiritual healing while other rely on herbalists to prescribe for them herbal medication. Others rely on radio and their friends for information on diabetes management'.*

On why patients resort to other sources of information, the responses were: *'I think patients resort to this type of information because of desperation and poor information on the diabetes. For example some will start using herbal medication as they believe they have no side effects while others believe the herbalists will completely heal them. Others resort to this information because of lack of individualized care in the hospital and little or no follow up of their condition'.*

On whether household counseling of family members is feasible in the facility context the response was: *'No, household counseling of the family members would not be feasible in this study because major issue which is lack of personnel for nutrition counseling is not addressed'.*

Asked whether group counseling has been effective in diabetes management, the response was: *'Group counseling has not been effective because if there are many hospital admissions and diabetes. In addition, the clinic has very many cases of hyperglycemia'.*

On whether a reminder system for drugs will be effective in diabetes management: *'This would probably work given the fact that the hospital has few personnel to attend to the many patients'.*

The patient related challenges encountered in diabetes management were: *'The patient related challenges I encounter is lack of acceptance in diagnosis. The other factor is drug abscondance yet when the patients come to the hospital, they inform us that they have been adhering to the drug recommendations'.*

The challenges in drug management in diabetes were: *'The main challenge is social economic where the patients say they do not have the money for the diabetic diet. Some patients do not come to the hospital for their diabetes drugs because they come from far and are unable to get the busfare to come to the hospital. Another challenge is the ability to follow the guidelines given in terms of measures'. Since diabetes patients need to monitor their blood glucose, most do not do this because of non affordability of the SMBG kit. Others do not know how to use the kit because of illiteracy levels'.*

The cultural beliefs about diabetes in Kitui County were: *'The cultural beliefs do not really play out. However, a few believe that diabetes is a curse which makes them to reach out to the services of a traditional healer'.*

Appendix 21: Summary of findings from the Focus Group Discussion (FGD) held with T2DM patients

The FGD revealed that respondents did were in denial on diabetes diagnosis as: *'When I was diagnosed with diabetes, I was shocked. This is because no one in my family has diabetes. I was in denial for about five months. I went to be prayed for by my pastor then when my symptoms deteriorated, I had to go back to the doctor who prescribed the drugs that I have been taking'.*

On challenges with diabetes management: *'Mostly it is to get bus fare to the hospital. Then again, I take a combination of diabetes drugs which cost a lot of money. In addition, buying diabetes food is very expensive'.*

Dietary management of diabetes was defined as: *'It is eating foods that are recommended for diabetes patients. In this, unrefined foods and legumes such as beans and cabbage are recommended'.*

Members were of the opinion that dietary management of diabetes is beneficial as: '*Yes, dietary management is recommended so that drugs can we used well in the body'.*

Another response was: '*Dietary management is not as important as taking drugs because without drugs one can easily die of high blood sugar'*

Respondents identified the main challenges in diabetes management as:

'The main challenge is I do not know what to eat since I have not been advised on it. The other challenge is I do not have money to buy diabetes diet so I just eat what I can get'.

When respondents were asked how this can be solved, the response was: *'This can be solved by mainly by the government providing us with foods to manage our condition as money is the problem'.*

In their view on whether drug management of diabetes is beneficial, the response was: *'Yes it is very important as without drugs, one can easily die of complications of diabetes'.*

From the FGD, the challenges facing use of drugs in management of diabetes was:

'The main challenge facing use of drugs is that it is very expensive to buy them'.

'The other challenge is when they get finished; I have to go to the hospital to buy them'.

'Yet there are times I do not have bus fare. Another challenge is some of these drugs make one to feel dizzy and have headache'.

'Some make one to overeat yet getting food is a problem with me'.

Their view in regard to how this problem can be solved was: *'This can be solved by providing us with drugs free of charge'. 'The other way is by providing us with foods to eat so that we lessen the side effects of the drugs'.*

On whether other family members provide adequate support for management of diabetes, the responses were: *'Some family members do not provide us with support'. 'My husband left me when I was diagnosed with diabetes'. 'Other family members believe diabetes is a curse so do not want to associate with me while others believe I did something wrong for me to get diabetes'.*

The major influences on the diabetes attitude towards management: *'The major influence is the government as it can provide us with drugs which will help in managing and treating diabetes'.*

The main sources of diabetes information in the area were radio and Television as: *'The main source of information in my area is the radio. I listen to adverts on the radio on management. 'The other source is the Television as I watch how people get cured of the disease'.*

Respondents felt that these sources do not actively involve other family members as: '*No because I listen to the radio alone as the other family members are not interested as they do not have the disease'.*

Respondents were of the view that these sources should actively involve other family members as: *'Yes they should so that I can get support as other members are educated on how to handle me and so manage my disease'.*

On whether mobile phone reminders would help improve the diabetes management: *'Yes it will work as this will be a source of information on diabetes'.* Others said they were not sure of whether it will help as: *'I am not sure whether this will be of help to diabetes management because I have not used it before'.*

Appendix 22: Summary of findings from the Focus Group Discussion (FGD) held with community members

The FGDs held with the community members revealed that respondents had an understanding of what diabetes was. However, respondents felt that: *'It is a bad disease that has affected many people in my area. It makes one to eat a lot of food'.* They attributed the causes to*: 'It is caused by overeating and family curses'.*

The FGD revealed the challenges faced by diabetes patients which could provide some insight to improve diabetes management. Such included: *'The main challenge is lack of money to buy drugs and lack of bus fare to go and see the doctor'.* On whether diabetes is a serious disorder, the response was: *'Yes because it has killed people in my area. It has also led to other complications for example loss of sight and loss of limbs'.*

Respondents seemed not to know the current interventions in diabetes management as: *'I am not sure since diabetes cases are mainly seen in the hospital not in the community'.* However on further probing on whether the current interventions are effective, the responses were: *'I am not sure but I think the current interventions are not effective as there are many cases of deaths in the area'.* On whether the hospital has done enough in the management of diabetes the response was: *'Not really because they do not give free drugs to the diabetes patients'.* However, the community members were not sure whether mobile phone communication would work in diabetes management as: *'May be it will work in management of diabetes but I am not sure how it will be used'.*