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**AN INVESTIGATION ON GLYCEMIC INDEX OF LOCAL FOODS AND USE
IN MANAGEMENT OF DIABETES MELLITUS: A STUDY IN KISHI AND
HOMA-BAY DISTRICT HOSPITALS. //**

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**A RESEARCH THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE (FOODS,
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*An investigation on
glycemic index of*



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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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Dedication

To my parents,

The late Mr. Emmanuel Munga and Mrs. Marceline Adhiambo Munga

You set me forth in to the struggles of this life
and set foundations for my academic dreams.

Acknowledgement

I express my sincere gratitude to almighty God for granting me the strength and determination to carry on and accomplish this work.

I wish to thank my supervisors, Professor Judith Waudo and Doctor Hudson Nyambaka for their guidance and advice at all stages of my work. Despite their engrossed office and teaching duties, they could always attend to me whenever I consulted them. Their encouragement and fruitful suggestions have made the entire work possible. I am grateful to the MOH of Kisii and Homa-Bay district Hospitals for allowing me to carry out my research in their respective stations. My gratitude goes to Nutritionists Stella and Joyce together with the nurses and laboratory technicians in the respective hospitals for making my data collection possible.

I am greatly indebted to my entire family; Husband Ambrose and children, Calvin, Agnes, Winnie and Mercy for their invariable physical and emotional support that provided solace and impetus towards the success of this work. Lastly, am grateful to each and every person whom I may not have mentioned here but contributed in one way or another towards the completion of this work.

Abstract

Diabetes mellitus is a clinically and genetically heterogeneous disorder characterized by elevated blood glucose levels. Non-Insulin dependent diabetes mellitus (NIDDM) occurs because insulin produced by beta cells of pancreas is either insufficient or not used properly by target tissues. Nutrition services have become quite vital in management of NIDDM. However, the choice of type and amount of food is always not an easy task. Glycemic index (GI) is widely used to select various foodstuffs for use by NIDDM diabetics, though; little has been done regarding Kenyan foods. This study investigated the suitability of locally available foodstuffs in the management of NIDDM by determining their GI. The study was carried out in Homa-Bay and Kisii District Hospitals in Nyanza Province-Kenya, on 116 NIDDM diabetics. A descriptive cross sectional study was used to collect data on GI, demographic information, medical history, physical activity and meal planning. An interview schedule was used to collect verbal information while blood glucose levels were determined before and 2 hours after consuming a selected local foodstuff. The results were averaged and compared to test food (white bread) to determine their GI. Data collected were coded in Microsoft word and Microsoft excel computer software. Frequencies were done on the SPSS statistical computer software to determine percentages and GI of 10 selected foodstuffs using the formula $(x/3.1 \times 100)$. The results of the study revealed that NIDDM diabetics have not exhaustively used locally available foods in the management of the disorder due to low education and income levels respectively. The GI of the tested foods point to the potentiality of their usefulness in management of NIDDM. Mixed meals yielded high GI compared to individual foods consumed singly. Application of GI policy in meal planning and management of NIDDM makes locally available foodstuffs appropriate in management of NIDDM. The patients were found not to have exhaustively utilized nutrition as a means of management of NIDDM but majorly relied on drugs. The study recommends use of locally available foods by NIDDM diabetics for both cost effectiveness and conveniences and GI of various foods to be considered in meal planning to enhance continued enjoyment of favorite foodstuffs before the onset of NIDDM. The study generally concludes that locally available foodstuffs are appropriate in the management of NIDDM.

Abbreviations

NIDDM	-Non-insulin dependent diabetes Mellitus.
GI	-Glycemic Index.
ADA	-American diabetes association.
WHO	-World health organization.
IGT	-Impaired glucose tolerance.
GDM	-Gestational diabetes mellitus
GOK	-Government of Kenya.

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CHAPTER ONE

INTRODUCTION

1.1 Background Information

Diabetes mellitus is a clinically and genetically heterogeneous disorder characterized by elevated blood glucose levels. It occurs because insulin which is produced by the beta cells of the pancreas is either absent, insufficient or not used properly by target tissues (Herold et al, 1997). As a result, the body is unable to normally metabolize macronutrients such as carbohydrates, protein and fat in foods (Zimmet, 1997). When insulin is absent or ineffective, the body cannot convert glucose into energy such that the level of glucose in the blood increases. This implies that glucose fails to get into cells and remains high for abnormally long time (Whitney, 1995)

Diabetes is now one of the most common non-communicable diseases globally. It is the fourth leading cause of death in most developed countries and developing nations including Kenya (WHO, 1994). Diabetes is a leading cause of blindness in adults as well as amputation (WHO, 2004). There are four classes of Diabetes mellitus; Insulin dependent diabetes (Type 1 diabetes), Non-Insulin dependent diabetes mellitus (Type II diabetes), Impaired glucose tolerance (IGT) and Gestational diabetes mellitus (GDM) (Herold et al, 1997).

In type I diabetes the patient produces little or no insulin and usually occurs before 30 years of age. This type affects 5-10% of the diabetes while 90-95% falls under type two which appears after the age of 40 years (American Diabetes Association (ADA) 1995).

In type II diabetes, the insulin level may be normal, depressed or elevated. When insulin level is high, it indicates decreased tissue sensitivity or responsiveness to Insulin referred to as insulin resistance. Low Insulin levels often develop as Non insulin dependent diabetes mellitus (NIDDM) progresses. Gestational diabetes mellitus describes a situation when glucose intolerance is detected during pregnancy, especially during the second and third trimester (ADA, 1995) while Impaired glucose tolerance describes when plasma glucose levels are higher than normal but lower than those considered diagnostic for diabetes mellitus (ADA, 1995)

The primary goal for patients with NIDDM is to achieve and maintain near normal blood glucose levels (ADA, 2000). Optimal nutrition achieved by consumption of proper types and amounts of proteins, fat and carbohydrates is an important aspect in diabetes management (ADA, 1995).

1.2 Statements of the Problem and Justification

It is acknowledged that diabetes not only affects prosperous nations, but often reaches its highest frequency in poor and disadvantaged communities, who least can afford the heavy burden of its costly long-term complications and diet (WHO, 2000). Diabetic patients are more often than once advised to reduce their carbohydrates and fats intake yet if this is followed; it results in tissue protein breakdown to produce energy and depletion of protein reserves (Whitney, 1995; Heaton, 1998)

The ultimate aim of nutritional management is to improve or maintain health and quality of life. Physical and Physiological fitness together with stable nutritional status among

diabetic patients improve glycemic control in addition to balancing food intake with endogenous and/or exogenous insulin levels (Walberg, 1995)

No one nutrition prescription will work for all people with diabetes since physical and physiological status are not similar in individuals. An individually developed nutrition prescription based on metabolic, nutrition and lifestyle requirements replaces a simple calculated caloric prescription that may have not considered glycemic index (GI) of the foods (Herold et al. 1997). This has been proved to be more practical in management of blood sugar levels within the normal range. This would enhance modification of usual individual diet rather than abandoning their usual eating habits for other foods that may have been considered "diabetically correct" (Herold , 1997). With the knowledge of GI of various foods, one may regulate the quantity of carbohydrates taken in a meal and continue eating previously enjoyed foods within a safe range.

There is therefore need to explore the GI of local foods for diets that would be appropriate in the management of diabetes mellitus on the basis of their availability and GI. This study investigated GI of local foods and their use in the management of non-insulin dependent diabetes mellitus (NIDDM).

1.3 Purpose of the Study

The purpose of this study was to investigate the glycemic index of local foods and their use in the management of non- insulin dependent diabetes mellitus.

1.4 Objectives of the Study

The objectives of the study were:

1. To determine socio-economic characteristics of diabetic patients in Kisii and Homa-Bay District Hospitals.
2. To determine the glycemic index of various local foods
3. To investigate nutrition patterns in management of NIDDM by patients in Kisii and Homa-Bay districts.

1.5 Hypothesis

H₁: Locally available foods are appropriate in the management of non-insulin dependent diabetes mellitus.

1.6 Rationale of the Study

The use of locally available foods in management of non-insulin dependent diabetes mellitus will help cut down on costs of expensive meals provided by the exchange lists, “diabetic food labels” and dependence on treatment. Based on glycemic index of various foods an individual does not have to go out of his/her way looking for diabetically correct foods which come with additional costs and may be consumed excessively under assumption of their harmlessness resulting into medical consultation. An individual will

therefore be encouraged to continue using locally available foods that he/she may have grown in the family farm and had been enjoying before the onset of the disorder.

1.7 Significance and Expected Output of the Study

The results of this study will be used by health professionals in providing cost effective nutritional advice based on the available foods within a patient's environment. Nutritionists will use this information to prescribe less costly and realistic diet to diabetic patients. The results will also be used by policy makers in promotion of local Kenyan foods especially among the subsistence farmers to enhance nutrition security.

1.8 Limitations of the Study

This study focused on non-insulin dependent diabetes mellitus (NIDDM). Some patients were not willing to co-operate especially when drawing blood from them to determine the glucose levels. An explanation was given by the researcher on the aim of the study and relevance of the results to them. Some patients traveled long distances to the Hospitals and had to be provided with bus-fare to come for the clinics as frequently as requested.

1.9 Conceptual Framework

Independent variables of particle size, fiber content, and fat content, cooking methods of food affect Glycemic index (GI). The G.I. in turn determines the level of glucose in the blood. On the other hand eating well-spaced meals and increased physical activity increases glucose take up by the Insulin receptor cells in the body. These factors can be summarized in an equation as;

$$BG = (P + F + \text{Fat} + C + K)$$

Where- BG = blood glucose

P= particle size

F= fiber content

Fat= fat content of food

C= cooking method

K= composed disturbance term

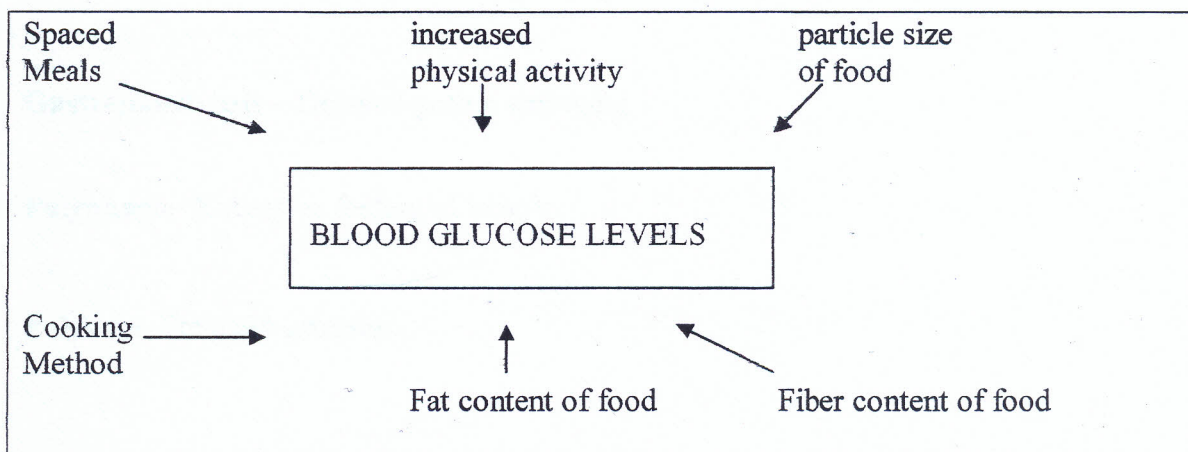


Figure 1. Conceptual Framework: Relationship between various factors and blood glucose levels.
Source: American Diabetes Association (1994)

1.10 Operational definition of terms

Diabetes mellitus- This is a metabolic disorder characterized by decreased or complete inability of the body tissues to utilize carbohydrates.

Glycemic Index – A measure of how much blood glucose rises in two to three hours after eating.

Hyperglycemia – An abnormally high blood glucose concentration.

Hypoglycemia- An abnormally low blood glucose concentration.

Oral hypoglycemic agents- Drugs taken by mouth to enhance insulin action, stimulate insulin secretion or delay carbohydrate absorption in order to maintain normal glucose levels in the blood.

Gastroparesis – Delayed gastric emptying

Polyphagia- Excessive feeling of hunger.

Polyuria- Frequent urination.

Polydipsia- Frequent feeling of thirst.

Glycosuria- Presence of glucose in the urine.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the review of related literature on non-insulin dependent diabetes mellitus and the contribution of food to the management of the disorder. This literature review showed the extent of knowledge and the gap to be filled in management of NIDDM. The literature was reviewed under the following sub-headings;

The spread of non- insulin dependent diabetes mellitus (NIDDM), Causes of NIDDM, Symptoms of NIDDM, Complications of NIDDM, Nutrition management of NIDDM and Glycemic index.

2.2 Prevalence of Non-Insulin Dependent Diabetes Mellitus (NIDDM)

Globally, diabetes is one of the most common non-communicable diseases. It is the fourth leading cause of death in many developed countries and there is substantial evidence that it is epidemic in many developing and newly industrialized nations (WHO, 1998). Significant number of people in the world (151 million) suffer from diabetes mellitus, of which 85-95% is non-insulin dependant diabetes mellitus cases (WHO, 1998). A higher percentage of NIDDM cases found in developed countries. NIDDM accounts for even a higher percentage in developing countries. WHO (1994) and Mc Carty (1994) estimated that global burden of diabetes was 110 million in 1994 and was to double by the year 2010.

The African region has a population of 525 million inhabitants, with the diabetic population estimated at 102, 000 who are Insulin dependent and 2.5 million non-insulin dependent diabetes mellitus (Diabetes Atlas, 2000). From the current trends, African diabetic population is set to increase dramatically over the next few decades.

The prevalence of NIDDM is high in Indian immigrants, Muslim and Hindu communities in Tanzania and South Africa. NIDDM is also higher in the urban than in the rural area due to type of lifestyle and diet (Diabetes Atlas 2000). Most urbanites spend most of their time in offices and are not engaged in exercises. This together with the high fat and refined diets consumed leads to overweight which may predispose one to NIDDM disorder.

Epidemiological evidence suggests that without effective prevention and control programmes, diabetes is likely to continue to increase globally (WHO, 1994). In Kenya, the last randomized/stratified preliminary survey (Mngola, 2001) suggested that diabetes was common in both rural and urban populations with a greater prevalence in urban areas. Today prevalence has increased rapidly as 3-5 new cases are treated weekly at the diabetes clinic at Kenyatta National Hospital.

2.3 Causes of NIDDM

The increase of NIDDM is observed in all regions where traditional lifestyles and dietary patterns are giving way to a sedentary lifestyle with consumption of high fat diet. Obesity, which is increasing in prevalence as well, is a significant risk factor for diabetes. Aging is also a risk factor for NIDDM as the majority of the cases are the elderly, usually over 40 years old (ADA, 1994). Stress and trauma in an individual are also risk factors of NIDDM.

NIDDM has the characteristics of Insulin resistance (diminished tissue sensitivity to insulin) and impaired beta-cell function (delayed or inadequate Insulin release). The defective Insulin –Secretion response of the beta cells of the pancreas results in slow and ineffective suppression of glucose conversion in the liver and decreases glucose uptake by the peripheral tissues. This result, in high blood glucose level (hyperglycemia) and provides constant stimulation for insulin secretion in the pancreas (ADA, 2000). The resultant chronic high insulin levels in the blood (hyperinsulinemia) causes insulin resistance in the peripheral tissues in two ways:

- 1) Since insulin receptors are regulated by ambient insulin level, high circulatory level of insulin cause “down regulation” of Insulin receptors referred to as the ‘binding defect.’
- 2) Chronic hyperinsulinemia can lead to post-binding defects in the metabolism of glucose. This occurs in the peripheral tissues, where uptake of glucose occurs and in the liver where insulin fails to decrease hepatic glucose production.

These defects result in elevated glucose levels despite apparently normal or higher than normal insulin levels. Prolonged chronic hyperglycemia may further impair insulin secretion and function leading to glucose toxicity (ADA, 1994)

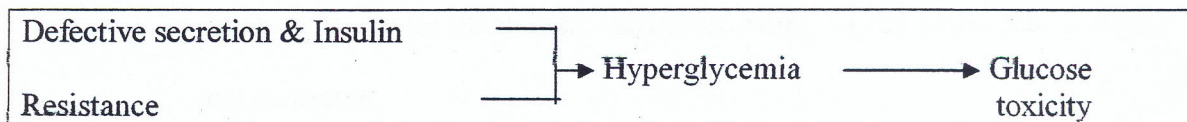


Figure 2: Glucose toxicity flow chart

Source; American Diabetes Association (ADA, 1994)

2.4 Symptoms of NIDDM

The following are some of the known symptoms of NIDDM (Franz, Horton and Bantle, 1994)

Hyperglycemia- (abnormally high blood glucose levels); this is due to resistance in the insulin receptor cells. Glucose cannot be taken up into the cells causing the blood sugar level to shoot up.

Glycosuria- (presence of glucose in urine); Due to high levels of glucose in the blood there tends to be high levels of glucose in the glomerular filtrate resulting to low concentration gradient between the two areas. The re-absorption rate of glucose from renal fluid will be lowered leading to presence of glucose in the urine.

Polyuria- (frequent urination); The compromised re-absorption of glucose within the renal tubule will lead to retention of water in the tubule due to high osmotic potential in the renal fluid. The water will then be frequently eliminated from the body as long as the glucose level remains high. The body cells on the other hand will lose water to the blood that is highly concentrated.

Dehydration;- High amounts of water will be lost due to polyuria and dehydration occurs.

Polydipsia- (excessive thirst); Low volumes of water in the blood and dehydration effect will induce a feeling of thirst so that the individual can drink water as a corrective mechanism.

Polyphagia- (excessive hunger); Due to insulin resistance in the receptor cells, glucose enters the cell very slowly and the cells will be undersupplied with glucose and this message will be conveyed by the cells in form of hunger.

Overweight- Frequent messages conveyed on hunger will keep the individual eating as a corrective mechanism to the imbalance leading to increased fat deposits and weight gain.

These symptoms can be summarized in a flow chart for the metabolic consequences of unmanaged NIDDM as follows:

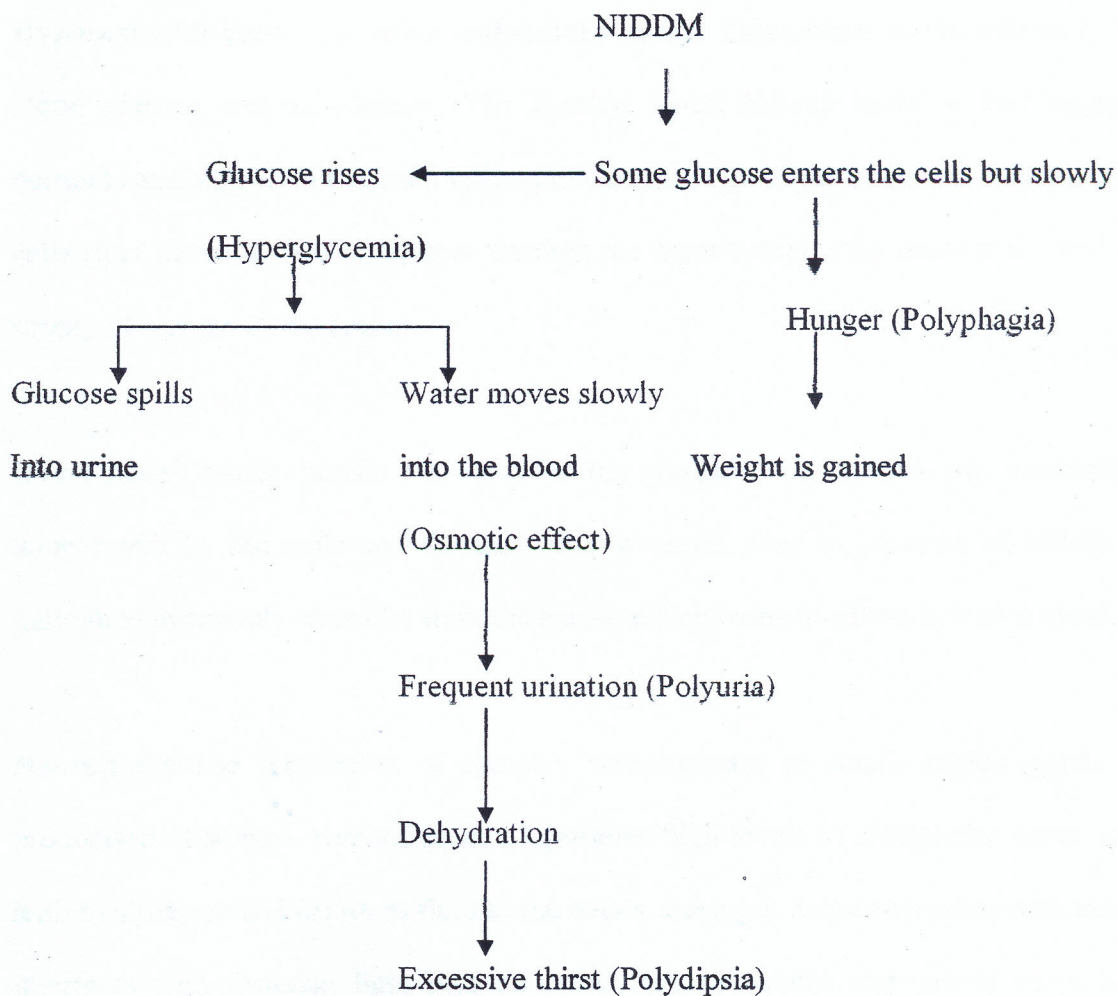


Figure 3. Flow cart on metabolic consequences of poorly managed NIDDM.

Source; Wolever (2004)

2.5 Complications of NIDDM.

People with NIDDM usually suffer the following complications according to Herold, (1997);

Hyperosmolar-Hyperglycaemic non-ketotic coma- This occurs due to extremely high blood glucose and dehydration. The reduced blood volume leads to low supply of nutrients and oxygen to the brain leading to a coma. High sugar levels make the red blood cells rigid hence unable to squeeze through the narrow capillaries leading to inefficient supply of oxygen to the brain.

Overeating-Chronic insulin resistance in the receptor cells results into messages of hunger sent by the cells and the individual overeats. Due to presence of insulin, the individual eventually stores fat from the excess energy consumed and becomes obese.

Neuropathy-The breakdown of complex carbohydrates to simple sugars results into production of sobitol. Hyperglycemia represents high levels of sobitol that settle on the lenses of the eye and draws in fluid to the lenses making it bulge beyond normal and this interferes with focusing light rays on retina. Excess sobitol may get to nerve lining bringing with it excess fluid that causes nerve lining to rupture. The myelin sheath of the nerve fibre is interfered with and messages cannot be sent to the brain leading to pins and needles, numbness, pain burning sensation and coldness from inside.

Infections-High blood sugar environment inactivates the white blood cells giving microbes time to multiply and worsen the infection. High sugar environment causes

sticky effect on the platelets that stick to the walls of blood vessels and promotes sticking of cholesterol on the walls narrowing the vessels further resulting into poor blood circulation. This coupled with rich glucose in blood and urine provides favorable breeding ground for pathogens. Infections may go undetected due to impaired nerve function and gangrene may follow.

Cardiovascular disease-Long term diabetes results in storage of collagen and calcium on the walls of the vessels that make the vessels rigid, thick and inflexible. This may lead to hypertension. Obesity aggravates the risk of atherosclerosis that can lead to heart attacks and stroke.

Nephropathy-Disorders of the capillaries may also develop and lead to loss of kidney function.

Retinopathy-Degeneration of retina may occur due to nephropathy and neuropathy leading to loss of vision.

Constipation-Poor nerve function can slow the stomach's action and delay gastric emptying. This makes it more difficult to control blood glucose as by the time glucose is absorbed, insulin may not be available to enhance entry of glucose into the cells.

2.6 Nutritional Management of NIDDM

The primary goal for patients with NIDDM is to achieve and maintain near normal blood glucose levels (ADA, 2000). Making healthy food choices, especially modifying calorie intake (250-500 calories less than the average daily intake) can be beneficial and increase

in physical activity may lead to improved weight control. Weight loss increases Insulin sensitivity and normalizes hepatic glucose production (ADA, 1995).

Optimal nutrition achieved by consumption of the proper types and amounts of proteins, fat and carbohydrates is an important aspect in diabetes management (ADA, 1995). This study helped identify the proper types of proteins, fat and carbohydrate sources that would assist the NIDDM patients in management of their conditions.

Studies have proved that any single type of food consumed in excess and in absence of other foods could appear to be toxic (Herald et al, 1997). A mixed diet that includes all types of foods (carbohydrates, proteins, vitamins, minerals, fats, roughage and water) will keep an individual healthy and active. Most plants and animals used as food sources are primarily made up of the six nutrients (Herald et al, 1997). The energy nutrients to be considered include carbohydrates, fat and protein.

Carbohydrates and NIDDM

Dietary carbohydrates from cereals, beans, legumes, vegetables, fruits, dairy products and added sugars should provide 50-60% of the individual energy requirements (Wolever et al, 2004). Classification of carbohydrates using the terms simple and complex should not be used to classify carbohydrates since factors in food that influence blood glucose are not predicted by chemical composition alone but food form, ingested portion size, starch

structure and cooking methods all influence the carbohydrates absorption rate from the small intestine and the resultant blood glucose response (Wolever et al, 2004).

Although various carbohydrates produce different glycemic responses, from a clinical perspective, the total amount of carbohydrates consumed is more important than the source of the carbohydrates (Hollen et al, 1985). The daily total and distribution should be individualized and based on each patient eating habits and blood glucose levels (Hollen et al, 1985). This would encourage consumptions of the meals one enjoyed before the onset of NIDDM.

Protein and NIDDM

Wolever et al (1981) indicates that people with diabetes have similar protein requirements to those of the general population. Excessive intake should be avoided as it may contribute to the pathogenesis of diabetic nephropathy.

Fat and NIDDM

Fat does not raise blood sugar directly, as very little of it actually breaks down into blood sugar (Lee, 1998). Fats need to be watched as high fat diet predisposes one to heart disease. The recommended calories from fat depend on desired blood glucose, lipid levels and weight outcomes (Herold et al, 1997). Saturated fats should be reduced to decrease the risk of developing heart disease under normal weight diabetes. In obese NIDDM

patients, reduction in dietary fat combined with increased physical activity is recommended (ADA, 1994).

Fibre and NIDDM

Both soluble and insoluble fibres have been associated with improved outcomes in people with diabetes (National Research Council, 1999). Soluble fibres e.g. pectins, gums and mucilage associated with reductions in serum cholesterol improve blood glucose control. ADA (1995) recommendations for dietary fibre intake for persons with diabetes are the same as recommendations for the general public of $\approx 20\text{-}35$ g/day. Dietary fibre may be beneficial in maintaining normal Gastrointestinal function as speed of digestion and absorption is reduced resulting into steady entry of glucose into the bloodstream. Fibre also helps in treating or preventing several gastrointestinal disorders and colon cancer. Including more food combinations that combine cereal fibre with low Glycemic Index may be helpful in optimizing healthy outcomes for people with diabetes or at risk for diabetes (Wolever et al, 2004)

2.7 Glycemic Index.

2.7.1. Introduction.

Glycemic index (GI) of a food represents the magnitude of the increase in blood glucose that occurs after ingestion of food (Brand miller, 1994). GI indicates how high ones blood sugar rises after consuming the substance and determines the affect of each food on blood sugar level two hours after ingestion.

Foods with a high GI produce a higher peak in post prandial blood glucose and greater overall blood glucose response during the first two hours after ingestion than do foods with a low GI (WHO, FAO, 1997). A committee of experts brought together by food and Agriculture organization and world Health organization to review available research evidence regarding the importance of carbohydrates in human nutrition and health endorsed the use of GI method for classifying carbohydrates. They recommended use of GI value of foods in conjunction with information about food composition to guide food choices. Canadian diabetes Association and Dietitians association of Australia have also recommended high fibre, low GI foods for individuals with diabetes as a means of improving postprandial glycemic and weight control.

The GI is especially useful to people with diabetes who want to plan their diets to minimize the incidence of high blood sugar. It measures how fast the carbohydrate of a particular food is converted to glucose and enters the blood stream. The lower the number, the lower the action (Rick, 2002).

A study carried out on voluntary caloric intake increased 53% after a moderately high glycemic meal as compared to a low glycemic index meal (Rick, 2002). This proves that low glycemic meal has got low urge to eat more in the individuals reducing polyphagia and overeating thus results in weight gain. Low GI foods when consumed provide steady flow of glucose into the blood increasing use of fatty acids as a source of fuel and in return reduce cholesterol and triglyceride levels as well as reducing changes of long-range complications in NIDDM individuals (Rick, 2002).

2.7.2. Factors affecting Glycemic Index.

Factors affecting glycemic Index include; Biochemical structure of the carbohydrate, absorption process, size of food particle, the degree of thermal processing, contents and timing of the previous meal and co-ingestion of fat, fibre or protein (Guezenec, 1995).

The contribution of these factors to GI has been discussed as follows;

2.7.2.1. Biochemical Structures;

Biochemically, most carbohydrate foods can be classified as monosaccharide, disaccharides and polysaccharides. Monosaccharides are the simplest carbohydrate forms that are linked together with a chemical bond to form disaccharides. Glucose, fructose and galactose are the forms of monosaccharide and when linked in combinations of two molecules form disaccharides such as sucrose, maltose and lactose. Polysaccharides are made up of hundreds or thousands of linked monosaccharide for example starches found in plant foods (Guezenec, 1995).

There are two forms of starch, amylose that is a straight chain of repeating glucose molecules and amylopectin that is a branched chain of glucose molecules. Glucose raises GI faster than fructose while carbohydrate sources made of amylopectin raise GI faster than amylose.

2.7.2.2 Digestion and Absorption.

All carbohydrate foods are mostly broken down to their consistent monosaccharide during digestion. Digestion of some carbohydrates begins in the mouth through the action of enzymes in the saliva and most occurs in the small intestines. Enzymes released from the pancreas in the gut split the larger carbohydrates into fructose and mostly glucose.

Absorption of this monosaccharide happens in the intestinal mucosal cells where glucose and galactose are actively transported with a carrier protein to help them cross the membrane against concentration gradient. However, it is difficult for fructose to be absorbed against a concentration gradient for it depends on diffusion for its absorption. A high level of fructose in the blood slows down absorption of fructose (Murray et al, 1989).

Because fructose is absorbed from the small intestine more slowly than glucose and metabolized mainly by the liver, fructose ingestion has little immediate effect on blood glucose concentration; thus foods high in fructose content have a relatively low GI (Guezennec, 1995).

Guezennec et al (1993) studied the difference in carbohydrate oxidation during exercise when amylose and amylopectin were consumed. Amylopectin was oxidized faster during exercise than amylose. The blood glucose response to amylopectin is more rapid than for amylose because the digestive enzymes more rapidly break down the branched structure of the amylopectin. Full carbohydrate content of a high amylose food may not be readily available to the body resulting in low GI.

2.7.2.3. Food Processing.

Mechanical or thermal processing of food breaks it down into smaller particles that make it more susceptible to the actions of the digestive enzymes. This increases the glycemic index of the food. For example, making flour from wheat will increase the glycemic index relative to ingesting wheat Kernels. The particles of wheat Kernels are much bigger than those of flour hence less susceptible to actions of the digestive enzymes.

Two different brands of same type of food such as plain cookie may look and taste almost the same but different in type of flour used moisture content and cooking time, which result in differences in starch gelatinization and consequently GI values. Guezennec et al (1993) fed crude and gelatinized forms of both amylose and amylopectin to subjects prior to exercise. Gelatinization involves the bonding of water molecules to the starch structure, increasing its viscosity and bioavailability. The gelatinized forms of each starch were more quickly oxidized than was the crude form.

Kirwan et al (1996) also tested metabolic effects of different processing forms of the same food. Whole grain oats and oat flour was fed to individuals and after two hours, those who consumed whole oats had low GI compared to oat flour.

2.7.2.4. Co- Ingestion of Fat, Fiber and Protein;-

Zawadzki et al (1992) tested a combination of carbohydrate with protein and found that the mixture caused a greater increment in blood glucose and insulin than did either carbohydrate or protein mixture alone. The carbohydrate protein mixture contributed to a higher rate of glycogen synthesis for the mixture than for either of the macronutrients ingested separately. The carbohydrate plus protein treatment provided more than three times the energy as the protein trial and about a third more than the carbohydrate trial.

Burke et al (1995) tested addition of GI- lowering fat and protein to a high carbohydrate diet. The results showed that addition of fat reduced the glycemic response and increased the plasma fatty acid concentration.

Honowitz and Coyle (1993) added fat to carbohydrate sources of potato, rice and sucrose. The addition of fat reduced the GI of the carbohydrate sources. Presence of insoluble fiber in the diet slows down movement of food in the alimentary canal. This results in reduced digestion and absorption process of nutrients including glucose, hence low increase in blood sugar level.

Summary of literature review.

Diabetes is epidemic in many developing and newly industrialized nations with 85-95% of entire population suffering from NIDDM. In Africa, by the year 2000 population of NIDDM had risen to 2.5 million and was expected to increase. Risk factors of NIDDM were found to be; stress, trauma, obesity, aging and sedentary lifestyle as well as consumption of highly refined food with high fat content. Nutrition contributes tremendously to management and prevention of NIDDM. GI has been highly researched on in the developed countries and applied in healthy diets for both NIDDM and healthy individuals.

CHAPTER THREE

RESEARCH DESIGN and METHODOLOGY

3.1 Introduction

This chapter gives a description of the study area, research design, study population, sample size, sampling procedures, data collection instrument, and data analysis and presentation.

3.2 Study Design.

A descriptive cross-sectional study design was used to collect and analyze data that addressed the objectives of the study. A questionnaire was used to collect data on socio-economic characteristics and nutrition patterns of NIDDM patients in Kisii and Homa-bay districts. Glycemic index of selected local foods like maize, green bananas, millet, sorghum, sweet potatoes and beans were determined.

3.3 Study Area.

This study was carried out in Kisii and Homa-Bay District Hospitals. The Hospitals were purposively selected since they are the largest in each of the Districts hence attend to a high population of patients with regular attendance than the dispensaries. Both Hospitals also run diabetes clinics weekly with regular patients that would be relevant to the study that require the subjects on more than one occasion. The NIDDM patients attending diabetes clinics were used to collect data.

3.3.1 Description of Kisii District.

Kisii District is one of the twelve Districts in Nyanza province. It shares a common border with Nyamira District to the east, Transmara District to the south, Migori District to the south west, Rachuonyo District to the north and Gucha District to the south west.

The District covers an area of 648.9 square kilometers that is further divided into seven divisions, thirty one locations and ninety sub-locations. The District is mainly hilly with three topographical zones; the first zone covers an area below 1500 meters above sea level, second zone covers an area that lies between 1500 and 1800 meters above sea level while the third zone covers an area above 1800 meters above sea level (GOK, 2002).

Kisii District has highland equatorial climate with an average of 1500 millimeters of rainfall per year and moderate temperatures. Crops grown include tea, coffee, pyrethrum, maize, beans, finger millet, potatoes, bananas and groundnuts. Economic activities include farming, brick making, pottery, manufacture of tiles, soapstone quarrying and carvings as well as household decorations from granite (GOK, 2002).

The District population distribution is greatly influenced by a number of factors namely; physical, historical, patterns of economic development and policies pertaining to land settlement. In 1999, population density was approximately 647 persons per square kilometer and was projected to reach 790 persons per square kilometer by the year 2008. More details in appendix 2 attached.

3.3.2 Description of Homa-Bay District.

Homa-Bay District is located in south west part of Kenya along Lake Victoria in Nyanza province. The District has 26 locations and 63 sub-locations. It covers an area of 1,160.4 square kilometers, of which 29.5 square kilometers is under water (GOK, 2002).

The District is divided into two main relief regions; lakeshore lowland that lies between 1,143 meters and 1,220 meters above sea level and upland plateau that rises from 1,220 meters to 1,560 meters above sea level. It has an inland equatorial climate with temperatures varying with altitude and proximity to the lake.

The District experiences low rainy seasons during long and short rain periods with average annual rainfall ranging between 500 and 1000 milliliters in the uplands and between 250 and 700 milliliters in low lands. Main food crops produced are maize, sorghum, millet and beans. Cash crops grown are cotton, pineapple, sugarcane, tobacco and sunflower (GOK, 2002).

Population in Homa-Bay District is 312,885 persons of whom 148,264 are males and 164,621 are females. Economic activities include small scale farming of cash crops, fishing, livestock farming, poultry farming and water transport. Other details found in appendix 3 attached (GOK, 2002).

3.4 Justification of Study Area.

Kisii and Homa-Bay District hospitals cater for people in and around the Districts that comprises of people from various ethnic origins and economic status. The District hospitals also run diabetes clinics on Tuesdays and Fridays every week making access to NIDDM patients very easy. Studies by Mngola, (2001) also reveal high frequency of NIDDM in Kisii District thus posing an interest in the area for this particular study.

3.5 Population.

The target population was NIDDM patients attending clinics at Homa-bay and Kisii District Hospitals. The two groups share a common problem of poor Insulin receptor cells leading to accumulation of glucose in the blood for a long time. The GI tests carried out on them with various foods were to help establish the suitable foods for their consumption.

3.6 Sampling and Sample Size.

Kisii District hospital diabetes clinic has a population of 250 NIDDM patients with regular attendance. Homa-Bay District hospital diabetes clinic has a population of 170 patients with regular attendance. Purposive sampling was used to select a sample of 200 NIDDM regular patients where each hospital had 100 patients from the sampled population. Simple random sampling was then applied to select a sample size of 116 NIDDM patients. More than 50% of the sample groups were considered to enhance validity of the deductions on GI of various foodstuffs.

A market survey was carried out in the Homa-Bay open air market, Rongo open air market and Kisii municipal markets to help identify the locally available foodstuffs within the two districts. The following foodstuffs were selected from the markets; sweet potatoes, millet, sorghum, maize, rice, green bananas and beans. The foodstuffs were majorly from carbohydrate sources since carbohydrate are the major sources of sugar in the blood that calls for regulation in NIDDM condition.

The identified foodstuffs were purchased with the help of the hospital nutritionists and prepared using boiling as a general overall cooking method for uniformity purposes. No spices were added to the foods.

3.7 Data Collection Instruments.

A researcher-assisted questionnaire was used as data collection instrument. The questions were read to the subjects and the response marked accordingly on the questionnaire. A set of questions, both closed ended and open ended were used to collect data from each respondent. This helped standardize the data collected since each respondent answered a similar question. The questionnaire was divided into five parts; demographic information, medical history, meal patterns, physical activity and glycemic index. Each part of the questionnaire has been discussed as follows;

PART 1: Demographic information

This section was used to solicit information on division and location of respondent, marital status, gender, age, education level and occupation. The respondent was expected to answer all the questions that addressed these areas.

PART 2: Medical history.

This section consisted of closed and open-ended questions that solicited information on duration of NIDDM, diseases suffered other than NIDDM, complications suffered due to NIDDM and management of identified complications.

PART 3: Meal patterns.

Information on meal patterns were sought using the 24-hour recall method on meals taken prior to the study, where information was given on number of meals, foodstuffs taken for breakfast, lunch, supper and snacks. Time lapse between consecutive meals, two weeks recall method on frequency of consumption of selected foodstuffs, influence on choice of foodstuff as well as cooking and preparation methods questions were also asked.

PART 4: Physical activity.

This section solicited information on involvement in physical activity, type of physical activity, frequency and duration on the activity. There were also questions on meal timing during physical activity.

PART 5: Glycemic index.

A table was provided to be filled appropriately with the medics on blood glucose level of a subject before and two hours after consumption of a selected foodstuff.

3.8 Ethical Consideration.

Consent was sought from the respondents before administration of the questionnaire. Participants were given clear and accurate statements about the significance of the study and direct relevance to them. Confidentiality during data collection was assured and names were substituted with numbers to secure privacy. The researcher ensured that all information obtained was kept in strict confidence and used only for the purpose of the study.

3.9 Pre-Testing.

The instrument was pre-tested to check on its validity and reliability. A sample size of 10% was drawn from the study area (subjects did not participate in the main research) to be part of the pre-test. After pre-testing, the instrument was revised by the researcher based on the response obtained.

3.10 Study Procedure.

The researcher-assisted questionnaire was read to each subject and the answers ticked appropriately in the spaces provided; especially questions concerning demographic information, medical history, meal patterns and physical activity. GI of selected local foods was determined by the following procedure;

A test food, which was white bread (100gms), was first fed to the patients and their blood glucose determined before and two hours after consumption. The difference in the two readings was calculated per subject and the mean determined for the entire population of 116 subjects (3.1). This served as reference food as the tolerance level of white bread has been found to be better than that of glucose (Wolever et al, 1985). The selected local foods were then prepared by the hospital nutritionists on clinic days and fed to various NIDDM patients in portions of 100 grams. The blood glucose levels were then taken before and two hours after consuming the food.

The patients were served with food to eat. Before consumption the patients' blood sample was determined using a glucometre to establish the sugar level, two hours after consumption another blood sample was drawn from the patient and its glucose level measured. The difference in blood sugar levels before and after consumption was then calculated. The difference between the test food and the reference food were then expressed as a percent of the value for the reference food for the same subject. The percentages from each subject were then averaged together to obtain the GI for that food (Wolever et al, 1985). The test foods were given various textures such as mashing, chopping and grinding to make sources.

3.11 Data Analysis and Presentation.

Questionnaires completed by respondents were edited, cleaned, coded and analyzed using computer packages. A statistical package for social sciences (SPSS) was used to analyze quantitative data. The results have been presented in both descriptive and inferential modes. Quantitative data has been presented in tables, graphs and pie charts.

Frequencies were done on SPSS statistical computer software to determine percentages and glycemic indexes of various foodstuffs. Qualitative data was analyzed by coding and organizing it into themes and concepts drawn. The data was presented in text form that described and accounted for the relationship between independent and dependent variables.

CHAPTER FOUR

RESULTS AND DISCUSSIONS.

4.1 Introduction

This chapter presents the analysis and discussion of the results of the study. The chapter specifically presents the socio-economic characteristics of NIDDM patients, severity and management of NIDDM complications, glycemic index of selected local foodstuffs as well as suitability of local foods in management of NIDDM.

4.2 Socio-economic characteristics of NIDDM patients in Kisii and Homa-bay Districts.

NIDDM patients were drawn from various socio-economic divide and behavior patterns such as gender, marital status, education level and occupation.

4.2.1 Gender

The results in table 1 revealed that there were more males with NIDDM disorder (58.6%) compared to the females (41.4%). In the two communities studied (luo and kisii), the woman carries out 80% of the daily activities that include fetching water from distant water sources, fetching fire-wood from the forests, herding cattle, laundry, tilling land and the daily household chores. These activities burn a lot of calories and keep the females active for eighteen hours a day. This keeps the female muscle toned up and they are able to burn down most of the calories consumed in the day as they go about their activities. This phenomenon could have contributed to reduced incidences of obesity and the lower occurrence of NIDDM among the females. This agrees with the study carried

out by Zawadski et al (1992), which revealed that endurance in exercise increases fat oxidation and reduces reliance on carbohydrate fuel.

Males on the other hand tend to carry out heavy activities that come occasionally like construction work. Many of the males are businessmen and formally employed and spend most of their time at the work places. This allows for sedentary lifestyle with little activity thus more fat deposits in their tissues that lead to over weight and obesity successively that are risk factors for the onset of NIDDM as was found out in the study carried out by American Diabetes Association (1994).

Table 1. Distribution of NIDDM patients by gender in Kisii and Homa-Bay district hospitals.

Gender	Frequency	Percent
Female	48	41.4
Male	68	58.6
Total	116	100.0

4.2.2 Marital Status

Table 2 results indicate that most NIDDM patients (91.4%) were married while only (8.6%) were single. This is because NIDDM exhibits itself at a later stage in life and very rare in the earlier stage below 40 years of age (ADA, 1996). By the time one is diagnosed with NIDDM, he/she would be at a mature age and would be married. In the Luo and Kisii communities, marriage is highly regarded in the social status and many individuals are expected to be married between 15 and 30 years.

Table 2: Distribution of NIDDM Patients by Marital Status in Kisii and Homa-Bay District Hospitals.

Marital Status	Frequency	Percent
Single	10	8.6
Married	106	91.4
Total	116	100.0

4.2.3 Education Level

The results in table 3 indicate that most NIDDM patients (36.2%) did not have any formal education with a small portion (3.5%) of the patients having post secondary education. The observed trend may be attributed to the fact that the selected hospitals were the only public hospitals in the districts with diabetes clinics that could easily be accessed by the rural poor, majority of whom have no formal education. Those with higher education qualification are likely to have better income levels which may enable them access private clinics in the districts that were not selected for the study. Lack of formal education may make it a challenge in training NIDDM patients on the nutrition principles they need to observe with their meals and snacks. The importance of a balanced diet and portioning of various carbohydrate sources may not be regarded highly and given priorities during meal planning since they may not understand the mechanisms under which the body utilizes the sugar from various diet sources. This would pause prevalence in high levels of fluctuations in the blood sugar.

Table 3: Distribution of NIDDM patients by education level in Kisii and Homa-Bay district Hospitals

Education Level	Frequency	Percent
Non-formal education	42.0	36.2
Primary	34.0	29.3
Secondary	36.0	31.0
Post secondary	4.0	3.5
Total	116.0	100.0

4.2.4 Occupation

The results in table 4 indicated that majority of NIDDM patients (34.5%) were self employed, followed by 25.9% unemployed, while only 24.1% had formal employment. The largest proportion of the sample population 60.4% were not formally employed due to low education level since a large number in the sample did not have any formal education. This shows that NIDDM does not necessarily affect the rich that feed on refined food with little exercise, but also affects the poor depending on food choices and eating habits together with their genetic constitution. Low earnings make an individual live below poverty line and a variety of foodstuffs may not be available at household level due to lack of purchasing power. The poor may be forced to survive on the foodstuffs they can afford regardless of their nutritive value. It has been established by ADA (2000) that nutrition is the primary tool for management of NIDDM. Low income therefore becomes a hindrance to management of NIDDM since the patients may not afford nutritionally balanced meals.

Table 4: Distribution of NIDDM patients by occupation in Kisii and Homa-Bay district Hospitals.

Occupation	Frequency	Percent
Formally employed	28	24.1
Self-employed	40	34.5
Unemployed	30	25.9
Retiree	18	15.5
Total	116	100.0

4.3 Nutrition patterns and management of NIDDM.

4.3.1 Introduction.

Medical history of NIDDM patients has been discussed in relation to duration and long-range complications suffered by NIDDM patients. Management patterns have been sought in regard to meal patterns and physical activity.

4.3.2 Duration of NIDDM

The results presented in table 5 indicate that a large proportion of NIDDM patients were below 3 years category, followed by 3-6 years and 7-10 years category with the least proportion in over 10 years category. This data collected indicated the period when the individuals were diagnosed for the time with NIDDM disorder. The disorder could have been treated earlier for other ailments within the small clinics in the rural areas that did not run sugar tests on blood samples. After fruitless trials then one would decide to consult a doctor in the District Hospital. By the time the NIDDM would be diagnosed, it would have taken some time with the individual. Due to unmanaged conditions, one would be experiencing complication even though diagnostic duration may be short.

The big percentage below three years after diagnosis showed the rampancy in the disorder. In the sample of 110 NIDDM patients 69% had the disorder for more than 3 years signifying the chronic nature of the disorder which with good management an individual my live comfortably in the years to come. Since nutrition plays a big role in management of NIDDM (ADA, 1995), wise eating habits would contribute quite a lot on good management.

Table 5: NIDDM duration of patients in Kisii and Homa-Bay district Hospitals.

Duration	Frequency	Percent
Over 10 years	24	21.8
7-10 years	26	23.6
3-6 years	26	23.6
Below 3 years	34	31.0
Total	116	100

4.3.3 Complications of NIDDM

The results presented in table 6 indicate that a large number (81.0%) had experienced complications due to NIDDM with only 19% indicating not having experienced long-range complication. This could have been brought about by a large population having experienced NIDDM disorder for over three years. Even though from the time NIDDM was diagnosed in the individual, it could be below three years but presence of complications was evidence that the disorder had been in the individual for more than three years. Hyperglycemia that remained in the blood unaltered for long periods of time

led to NIDDM related complications as also reported by Herald et al, (1997). On the other hand, if the disorder was poorly managed both nutritionally and medically, then long-range complications would arise earlier with duration of the disorder.

Table 6: Distribution of NIDDM patients by complication in Kisii and Homa-Bay district Hospitals.

Complication	Frequency	Percent
Yes	94.0	81.0
No	22.0	19.0
Total	116	100.0

Further analysis of the complications are presented in table 7 and indicate that most NIDDM patients experienced poor vision, followed by swollen legs while a few experienced diabetic coma and kidney related complications. The poor vision would have arisen from constant hyperglycemia, which results into deposits of sobitol in the eye lenses that draw in fluid and bulge; as a result, interfering with focus of light rays on the retina. Swollen legs condition would arise due to high sugar levels in the blood and that of tissue fluid that increases the osmotic pressure and making it difficult for the tissue fluid to be reabsorbed back to bloodstream. High blood sugar also makes the environment conducive to pathogenic microbes that may infect the lymphatic system leading to oedema in the legs (Herald et al, 1997). Lack of enough exercise would enhance retention of lymph in the hind limb region causing the legs to swell. Diabetic coma was encountered by 6.9% due to hypoglycemia that lead to low glucose supply to the brain that can only oxidize glucose to produce energy for its functions.

Low blood sugar would result from selectiveness of types of food to eat coupled with their small quantities due to lack of purchasing power. Long strenuous exercises like

digging and herding of cattle that would keep one away from home for long hours before taking a meal. This agrees with the findings of Wolever et al, (2004) that established that if meals are not taken frequently yet energy is used to perform exercises, then the individuals level of glucose falls bellow normal leading to hypoglycemia and diabetic coma in type two diabetes.

These results show that a greater percentage of the complications were hyperglycemia related signifying poor blood glucose control among NIDDM individuals.

Table 7: Frequency of type of complication suffered by NIDDM patients in Kisii and Homa-Bay district Hospitals.

Long-range Complication	Frequency	Percent
Poor vision	74	63.8
Swollen legs	42	36.2
Diabetic coma	8	6.9
Kidney-related complications	2	1.7
No complication	22	18.97

4.3.4 Management of NIDDM complications.

The results presented in figure 5 indicated that the predominant method of management of NIDDM complication was medication (87%) followed by taking foods such as sugar and carrots that were 2.1% each. Eight point six percent of the NIDDM patients did not take any action in management of the complications. Diet was not a popular method of management in NIDDM complications as most patients resulted to medication. Low use

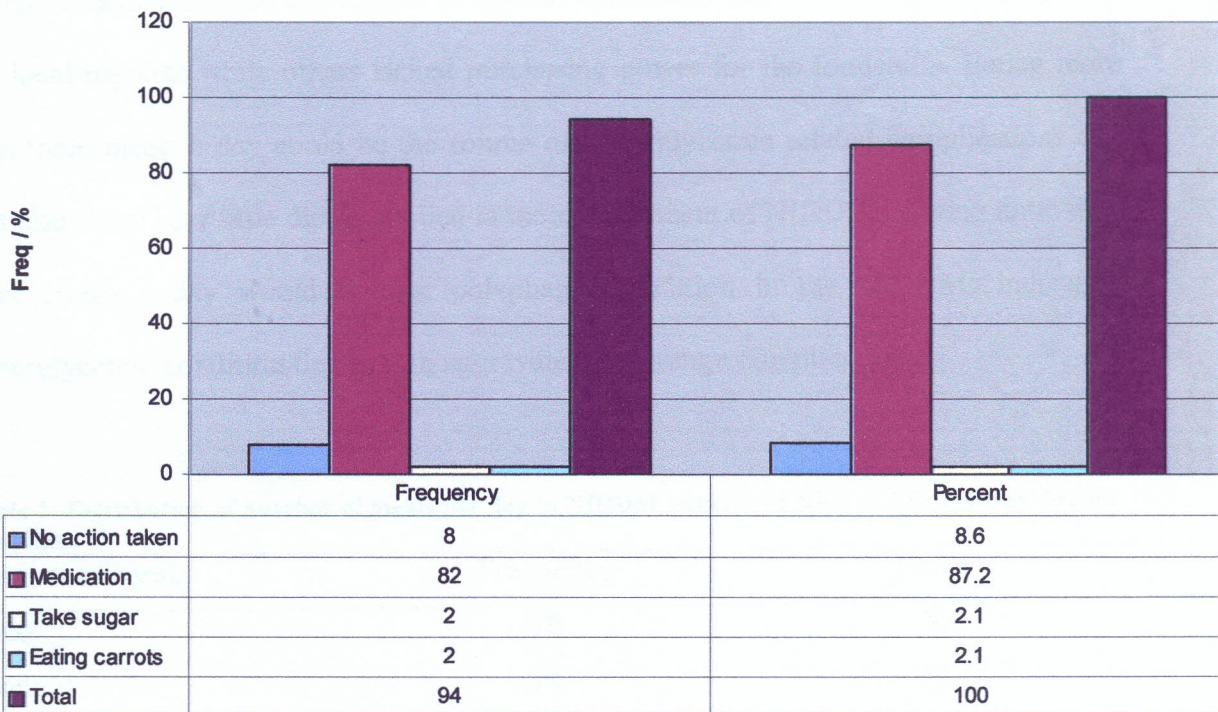
of dietary method could be attributed to belief that NIDDM as a disease that would require medication like any other disease. Medication would apply to cases of hyperglycemia where one would take the oral hypoglycemia tablets which were readily available to the patients as they were collected from district diabetes clinics free of charge. This medication could irregularly reduce the level of glucose in the blood since some of them like diabenese is a long acting drug that may later on cause hypoglycemia in the same patient if not properly balanced with food intake (Franz et al 1994).

Management of some other complications may not be accomplished by taking drugs since the conditions arise as a result of low blood sugar in NIDDM's that deprives the brain of sufficient glucose. Taking hypoglycemic drugs could only worsen the situation since the immediate corrective measure should be administration of glucose. While at home a patient would readily administer the oral drugs in case of any complication believed to be related to NIDDM disorder even in inappropriate cases. The patients therefore need to be educated on the type of drugs they are using and mechanisms under which they operate in the human system to prevent drug abuse. Due to low income, it was quite difficult to NIDDM individuals to purchase blood sugar monitors to be more accurate in the administration of the drugs.

Nutrition remains the ultimate method of maintenance of stable blood glucose levels and correction of fluctuating blood glucose levels among NIDDM's (WHO, 1997). Eating carrots to provide vitamin A will not correct the situation of sorbitol deposits in the retina due to hyperglycemia and therefore may not improve the diabetic eye complication.

Such patients need to consult a diabetes specialist in eye clinics for proper advice instead of eating carrots. The level of sugar should always be within the control range in the blood to reduce the deposits of sobitol in the retina. Sugar intake may only be applicable in correcting hypoglycemia and not any other complication that is not hypoglycemia related.

Figure 4: Complication management by NIDDM patients in Kisii and Homa-Bay district Hospitals



4.3.5 Meal Patterns

The meal patterns will present the number of meals taken in a day, types of food taken at each mealtime and meal intervals.

4.3.5.1 Number of meals

The results in table 8 indicate that a large number (46.6%) of NIDDM patients had more than three meals in the last 24 hours preceding the study. This was followed by those who had three meals and two meals respectively, while only 8.6% had one meal. A total of 20.7% of the respondents had less than three meals in 24 hours preceding the study. Some of them attributed this to lack of specific foodstuffs they were advised to take from the local markets while others lacked purchasing power for the foodstuffs. Eating more than three meals a day could be the source of hyperglycemia related complications and this also show how little diet is applied in the management of NIDDM. Having more than three meals a day would suggest polyphagia condition in the NIDDMs indicating hyperglycemia condition that in turn aggravates long-range complications.

Table 7: Distribution of number of meals per day in NIDDM patients in Kisii and Homa-Bay district Hospitals.

Number of meals	Frequency	Percent
Once	10	8.6
Twice	14	12.1
Three times	38	32.7
More than three times	54	46.6
Total	116	100.0

4.3.5.2 Types of food in the meals

In the study, the types of food taken at each mealtime were assessed for breakfast, lunch, supper and snacks.

Breakfast

The results in table 9 indicate that the most common breakfast meal comprised of brown porridge and sweet potato (42.3%), followed by brown bread, peanut butter and white tea (17.3%) and a combination of milk and mandazi at 17.3%. The least percentage of 1.9% consisted of the combinations of ugali and sukumawiki; white tea; white tea and sweet potatoes and white tea and groundnuts. The highest consumed foodstuff was sweet potatoes followed by porridge and tea respectively. A meal of sweet potatoes and porridge is basically starch and will not cater for other food sources like proteins vitamins and minerals that are equally important to the individual. The high carbohydrate meal will also make blood sugar level shoot up leading to spikes that would result to production of more insulin followed by high conversion of sugar to glycogen and fats leading to polyphagia and weight gain respectively.

The main aim of meal management in Diabetes is to maintain blood glucose as near normal as possible at all times as well as catering for a balanced diet for general good health. A meal of sweet potatoes and porridge has high carbohydrate levels and if one enjoys it, then their glycemic index may be used to include them in their right quantities in the breakfast meal while leaving room for proteins, vitamins, minerals and lipids to make a balanced diet. This way an NIDDM patient may continue enjoying previously

enjoyed foodstuffs while maintaining the blood sugar level within the normal range. All breakfast meals did not portray a balanced diet, which is quite vital in NIDDM management.

Table 9: Frequency distribution of foodstuffs consumed for breakfast in the last 24 hours by NIDDM patients in Kisii and Homa-Bay district Hospitals.

Foodstuff	Frequency	Percent
Brown porridge and sweet potato	44	42.3
Brown bread, peanut butter and tea	18	17.3
Milk and mandazi	18	17.3
White tea and chapati	16	15.5
Ugali and sukumawiki	2	1.9
White tea	2	1.9
White tea and sweet potatoes	2	1.9
White tea and groundnuts	2	1.9
Total	104	100

Lunch

The results presented in table 10 indicated that in the meals consumed for lunch, Brown Ugali and Vegetables was the most frequent food combination (55.8%) followed by Brown Ugali and Fish (26.9%) and Brown Ugali and Beans (9.6%). The other foodstuffs consumed included green bananas and beans; ugali and eggs; green bananas and Irish potato and white ugali, vegetables and eggs. Brown ugali took the center stage in the meals consumed for lunch. This shows that brown ugali was quite famous with the NIDDMs. The meals taken for lunch were not generally balanced especially the meal of green bananas and Irish potato that is made up entirely of starch. To a diabetic individual, protein in their diet is just as important as it is to any other non-diabetic individual

(Wolever et al, 1981). The quantities could only be reduced in cases of NIDDM's that had encountered nephropathy as a complication (ADA, 1994).

The meal containing brown ugali and fish lacked vegetables that would be a rich source of dietary fiber. The fiber would be very beneficial to the NIDDM's as it maintains normal gastrointestinal functions like reducing speed of digestion and absorption resulting into steady entry of glucose into the blood stream (ADA, 1995). Varieties of vegetables such as kales, saggets, cow pea leaves and amaranth leaves were readily available in the local markets and could also be easily grown within kitchen gardens among the subsistence farmers that constituted a big percentage of the respondents.

Other types of food like green bananas, milk and eggs were very unpopular with 1.9% each in the meals consumed during lunch. These are foodstuffs that were readily available to the subsistence farmer who could supplement them with milk from the cows and eggs from the poultry that they kept. Green bananas were also available in the gardens. Milk and eggs readily provide rich sources of protein and should not be spared for sale to purchase other types of food not available in the home farms. Enlightenment to the NIDDM's on the importance and contribution of both milk and eggs in their diet may help in the campaign to improve good meal management at minimum costs among NIDDM's. Homa-bay district lies along the shores of Lake Victoria making fish quite readily available and easily accessed by the members in the district.

Table 10: Distribution of foodstuffs consumed for lunch in the last 24 hours by NIDDMs in Kisii and Homa-Bay district Hospitals.

Food stuff	Frequency	Percent
Brown ugali and vegetables	58	55.8
Brown ugali and fish	28	26.9
Brown ugali and beans	10	9.6
Green banana and beans	2	1.9
Brown ugali and boiled eggs	2	1.9
Green banana and Irish potato	2	1.9
White, Ugali, vegetables and eggs	2	1.9
Total	104	100.0

Supper

The results from table 11 indicated that the highest frequent food combination consumed for supper in the last 24 hours prior to the study was brown ugali and vegetables at 43.3% followed by brown ugali and meat at 32.1%, brown ugali and beans at 13.2%, rice and white tea at 3.8%, white ugali and chicken at 3.8% while green bananas and beans was least with 1.9%. The meals for supper were not balanced and left out other classes of food required to make a balanced diet.

White ugali and rice were not famous with the respondents interviewed and were rarely consumed since the nutrition advice the respondents had did not include them as they were expected to raise blood sugar very fast. White ugali is a staple food and every

individual interviewed confessed presence of maize grain in their homes. Using glycemic Index and glycemic load of ugali, white ugali can safely be consumed by NIDDMs and so is rice so that they do not have to move away from their stocks to purchase food from the markets. This will make meal management among NIDDM's to be cheap and affordable.

Table 11: Distribution of foodstuffs consumed for supper in the last 24 hours by NIDDM patients in Kisii and Homa-Bay district Hospitals.

Food stuff	Frequency	Percent
Brown Ugali and vegetables	46	43.3
Brown Ugali and meat	34	32.1
Brown Ugali and beans	14	13.2
White tea and rice	4	3.8
Green bananas	4	3.8
White Ugali and chicken	2	1.9
Green bananas and beans	2	1.9
Total	106	100.0

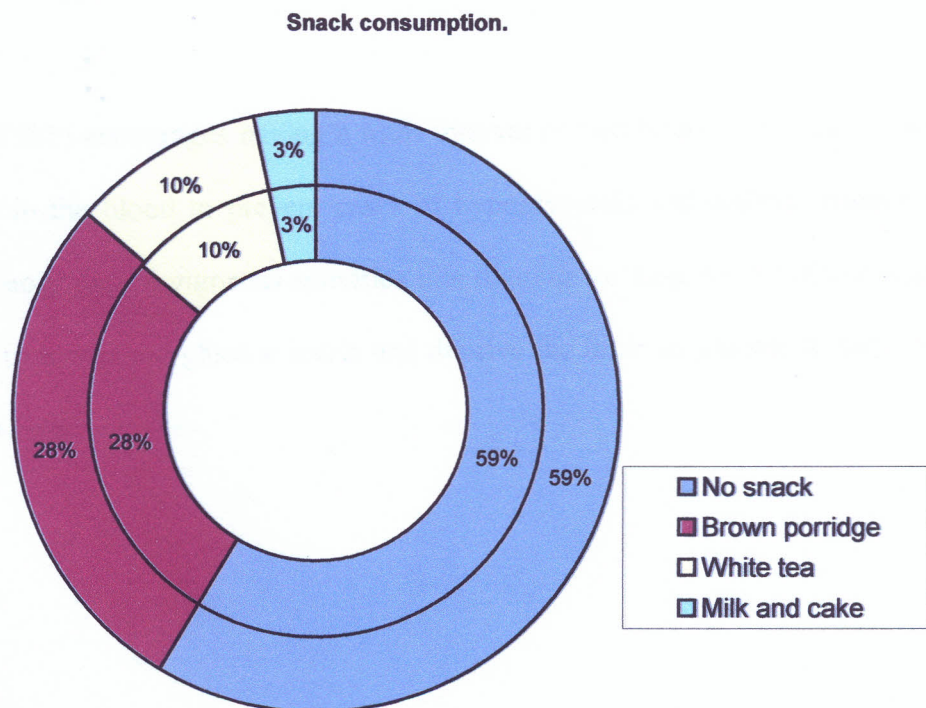
Snacks.

The results from figure 6 indicated that the greatest percentage (58.7%) in the sample population did not take snacks in the last 24 hours preceding the study. This showed that snacks had not been taken seriously by the NIDDMs in both Homa-bay and Kisii districts. This could be attributed to low income levels whereby an individual could not afford bites between meals. Regular meals with snacks in between meals enhances regular flow of blood glucose and prevent cases of hypoglycemia and an NIDDM

Individual may operate as any other normal person with the daily chores that have to be accomplished.

Other members of the household living with the NIDDM individual need to be educated on the importance of snacks to the individual such that members of the households understanding may register no cases of selfishness or gluttony when NIDDMs take snacks between meals without involving others due to scarcity of resources. The most frequent consumed snack was brown porridge (27.6%) followed by white tea (10.3%) and lastly milk and cake with (3.4%). Brown porridge ranked highest among snacks taken and this could be due to availability of millet flour in both Kisii and Homa-Bay districts.

Figure 5: Frequency of snack consumption by NIDDM patients in Kisii and Homa-Bay district Hospitals.



4.3.6 Meal Intervals

The results from table 12 indicated that most NIDDM patients (72.4%) in the sample population took their meals within the interval of above 3 hours; followed by 2-3 hours interval with (20.8%) while a lower percentage of (3.4%) took meals after one hour and less than one hour respectively.

Most patients took longer than recommended meal intervals of two hours with very few taking very short intervals between meals of less than one hour. The long hours could be attributed to the daily activities carried away from home for long hours like digging and herding where one spent several hours. Economic instability within the households could lead to one or two meals a day giving a wide interval between successive meals. Absence of snacks in between meals could also make an individual take more than three hours between successive meals.

Wolever et al, (1981) encourages having a meal interval of two hours to enhance steady flow of glucose in the blood to prevent cases of hypoglycemia and diabetic coma that may come after engaging in vigorous activities like digging for long hours without food. This could lead to low blood glucose levels and deprive the brain of glucose to carry out respiration in its cells.

Table 12: Distribution of meal intervals in successive meals by NIDDMs in Kisij and Homa-Bay district Hospitals.

Meal Interval	Frequency	Percent
Above 3 hours	84	72.4
2-3 hours	24	20.8
1 hour	4	3.4
Less than 1 hour	4	3.4
Total	116	100.0

4.3.7 Food Frequency

In the study, the rate of consumption on selected local foodstuffs was assessed using two-week recall method where various locally available foods were listed and the subject ticked appropriately the number of times the food had been consumed in the last two weeks. The selected foodstuffs included sweet potatoes, maize, rice, arrowroots, sorghum, millet, fish, milk, beans and green bananas. The results have been presented in table 13.

Sweet Potatoes

As presented in table 13, a large number of NIDDM patients (43.1%) had not consumed sweet potatoes in the last two weeks; followed by those who consumed it once (20.7%); twice (15.5%); four times and above (13.8%) and three times (6.9%) in the last two weeks.

Although sweet potatoes are a common subsistence food crop in Kisii and Homa-Bay districts, it happens to have low consumption frequency among the NIDDM patients in the sample. An in depth interview was conducted and the patients revealed that they did not take sweet potatoes as a result of doctor's advice. There could be fear of consuming sweet potatoes by NIDDM patients since it constitutes majorly of starch and would elevate their sugar levels very fast.

With knowledge of glycemic index of sweet potatoes its consumption quantities may be controlled such that an NIDDM individual can safely feed on it without causing spikes in blood glucose level. This would reduce cost since sweet potatoes are locally cultivated in the household farms as well as enabling the individual to continue enjoying the foodstuff since quantity will be regulated instead of doing away with it in the diet.

Maize

A big proportion of NIDDMs (44.8%) had not consumed maize in the previous two weeks either as ugali, porridge or a mix of maize and beans. A significant proportion (19.0%) had taken the foodstuff once with another (13.8%) indicating having consumed maize twice and four times and above in both categories. The least number of frequencies was reported in the three times category (6.9%). This trend could be attributed to strictness of NIDDMs to the prescribed diets. Maize is a staple food crop both in Kisii and Homa-Bay districts and quite available in almost every household. Consideration of glycemic index of maize would enable NIDDMs to consume it within safe quantities.

This would reduce cost of purchasing prescribed diets as well as maximizing the use of available foodstuffs in the management of NIDDM.

Rice

Table 13 indicates that large number of NIDDM patients (39.7%) had not consumed rice in the last two weeks. This was followed by (24.1%) who had consumed the foodstuff once within the same period of time while (13.8%) had consumed rice either twice or four times and above with only (6.9%) having consumed the foodstuff twice in the period of time under review.

The trend could be attributed to past beliefs about rice and NIDDM management where it is believed to sharply raise blood sugar levels after consumption. This belief was eluded to by one of the NIDDM patients from Homa-bay who revealed that he was a farmer and grew among other crops rice which he could not consume since it was not included in the list of foods in NIDDM diet prescribed. This showed that rice was not recommended to NIDDM patients for fear of elevating blood sugar. If the portion of rice in a meal could be measured within safe quantities it could be safely included in the meals and promote consumption of available foodstuffs to the NIDDM individual.

Arrow roots

The results presented in table 13 revealed that a large proportion of NIDDM patients (53.4%) did not consume arrowroots in the last two weeks. This was followed by (10.3%) who had consumed arrowroots once, (6.9%) which had consumed arrowroots twice,

(5.2%) who had consumed arrowroots four times and above and (1.7%) who had consumed arrow roots three times within a period of two weeks.

Arrowroots are largely cultivated along the shores of Lake Victoria in Homa-Bay district and are available in Kisii district; yet it was not popular in the diets of the NIDDMs. This could be attributed to its starchy nature even though they are also very rich in fiber. The fiber aspect may be advantageous in gastric emptying as well as rumen fill that would discourage consumptions of large quantities while preventing constipation.

Sorghum

The highest proportion (72.4%) of NIDDM patients indicated to have consumed sorghum four times and above within a period of two weeks. This was followed by (10.3%) who indicated that they had not consumed sorghum, (5.2%) which indicated they had consumed sorghum twice, (3.4%) who had consumed sorghum one and (1.7%) who had consumed sorghum thrice in a period of two weeks.

Sorghum was rating highly among foodstuffs consumed and this could be attributed to its frequency in recommended NIDDM diet by nutritionists. This choice could have been influenced by diabetic food labels in the market that is mostly brown bread, atta chapatti flour that is brown in colour among other brown items that give the impression that brown foods do not raise blood sugar very fast. The brown aspect of the foodstuff may not include other factors like degree of processing , particle size, quantities of fats and proteins as well as fibre content that would determine how fast the blood sugar has been

elevated. Brown colour alone does not guarantee the safety of consumption of a foodstuff by NIDDMs.

Millet

The results in table 13 indicated that a large proportion of NIDDM (70.7%) patients had consumed millet four times and above followed by those who did not consume it at all (12.2%). A small proportion of NIDDM patients (6.9%) consumed millet once while (3.4%) consumed millet twice in two weeks. Millet was a frequent consumed food among the NIDDM patients. Millet is brown in colour and could have been recommended with the group of brown foods.

Fish

The results presented in table 13 showed that a large proportion of NIDDM patients (44.8%) consumed fish more than four times in a period of two weeks followed by (29.3%) did not consume fish at all within the two weeks. Twelve point one percent indicated having consumed once while 5.2% twice and 1.7% consumed three times.

The large frequencies recorded for consumption of four times and above and non-consumption could be attributed to presence of two ethnic communities, Luos and Kisii. Among Luo, fish is considered a staple foodstuff and is readily available to them from Lake Victoria and surrounding rivers. The Kisii community is majorly agriculturalists in the highlands and fish is not their traditional staple foodstuff. Fish is a rich source of proteins and omega 3 fatty acids that are required for control of neuropathy. Its

consumption should be encouraged even among the communities that may not readily source it from the lake and rivers but can access it from the local markets either as fresh, smoked, sun dried or fried.

Milk

The results in table 13 showed that milk was one of the most frequently consumed foodstuffs among NIDDM patients either as pure milk or in tea, with (72.4%) having consumed it four times and above in the two weeks recall, (8.6%) had not consumed milk within the period under review while an equal proportion (6.9%) had consumed milk two and three times in two weeks. A small number (3.4%) had consumed milk once in two weeks.

The high consumption rate of milk could be attributed to the fact that most NIDDM patients were farmers, therefore likely to keep livestock making milk readily available. Milk is a source of protein and may be used frequently to provide first class proteins in the diet due to its availability.

Beans

The results in table 13 indicated that (58.6%) of NIDDM patients consumed beans four times and above in a period of two weeks, followed by (12.1%) who consumed beans once, (10.3%) who consumed beans twice, (8.6%) consumed beans three times while (6.9%) indicated non consumption in two weeks.

A very small percentage (6.9%) recorded having not consumed beans while (93.1%) recorded consumption and least once in two weeks under review. This could be attributed to the fact that beans is readily available from household farms and exists in various varieties that gives the patients a range of choices to select from depending on ones preferences.

Green bananas

The results presented in table 13 indicated that 34.5% of NIDDM patients had not consumed green bananas in the past two weeks, 27.6% had consumed green bananas twice, 24.1% had consumed once, 8.6% had consumed green bananas four times and above while only 5.2% had consumed green bananas three times in a period of two weeks.

The high frequencies of non-consumption of green bananas could have been due to commercialization of the crop in both green and ripe status. The white colour of green bananas could also reduce its popularity among the NIDDMs leading to high levels of commercialization of the crop. The knowledge of glycemic index and glycemic load of green bananas can assist in quantifying the safe measures in the diet such that it can be readily and safely consumed by the NIDDMs.

Table 13: Distribution and rates of consumption of selected local foodstuffs in the last two weeks by NIDDM patients in Kisii and Homa-Bay district Hospitals.

Food type	Frequency									
	None		Once		Twice		Thrice		Four times and above	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Sweet potatoes	50	43.1	24	20.7	18	15.5	8	6.9	16	13.8
Maize	52	44.8	22	19.0	16	13.8	8	6.9	16	13.8
Rice	46	39.7	28	24.1	8	6.9	8	6.9	22	19.0
Arrow roots	62	53.4	12	10.3	8	6.9	2	1.7	6	5.2
Sorghum	12	10.3	4	3.4	6	5.2	2	1.7	84	72.4
Green bananas	40	34.5	28	24.1	32	27.6	6	5.2	10	8.6
Millet	20	17.2	8	6.9	4	3.4	0	0	82	70.7
Fish	34	29.3	14	12.1	6	5.2	2	1.7	52	44.8
Milk	10	8.6	4	3.4	8	6.9	8	6.9	84	72.4
Beans	8	6.9	14	12.1	12	10.3	10	8.6	68	58.6

Summary on food frequencies.

Foodstuffs like sorghum, millet and beans were rated highly among the foodstuffs consumed in the previous two weeks. All the three types of cereals have a dull brown colour that seemingly was a favorite of the NIDDM's in the study. The brown colored foodstuffs were believed not to raise blood sugar levels and many NIDDM's in the study confessed of having them recommended for consumption in their diet prescriptions, hence their high frequencies.

On the other hand, arrowroots, green bananas, maize, rice and sweet potatoes were rated among selected foodstuffs that were majorly consumed once within the two weeks preceding the study. These foodstuffs shared a common characteristic of white colour. This could show the controversy of white against brown in food choices by type II diabetics. The foodstuffs white in colour were believed to raise blood sugar faster than foodstuffs that were brown in colour. This belief restricted the diets of NIDDM's and confined them to a strict diet that did not provide varieties. This could lead to monotony in meals and low appetite among NIDDM's. Incase of scarcity of sorghum or millet in the area, then, the meal became very expensive regardless of presence of other foodstuffs within the homestead.

With knowledge on glycemic index and glycemic load of various foodstuffs, any available foodstuff may be consumed regardless of the colour to provide varieties in meals among NIDDM's. Foodstuffs like green bananas, maize, sweet potatoes and rice are readily available in the local markets and in the farms hence their consumption by

NIDDM's will reduce the complexity of NIDDM meal management in terms of cost and food choices (Josline, 2004).

4.3.8 Physicals activity

Involvement in physical activity is essential in the management of NIDDM. The current study assessed the frequency of involvement in physical activity, type of Physical activity, duration of physical activity and meals and physical activity.

4.3.8.1 Frequency of Involvement

The results in table 14 indicated that most NIDDM patients (70.7%) were involved in physical activity on a daily basis while 20.7% were involved occasionally and 8.6% were involved once a week.

The high levels of involvement in physical activity could be attributed to livelihood pattern in Kenyan rural that entail activities that provide some form of exercise like fetching water, collecting firewood, walking to the market, herding and cultivation of farms. There are no self-contained houses in the rural areas hence some activities like walking may be inevitable. Physical activities should be encouraged among NIDDMs since exercise Increases Insulin Sensitivity by the receptor cells thus conversion of blood glucose to the storage form of glycogen as well as the take up of glucose by muscle cells would be increased (Foster et al, 1979). This would reduce cases of hyperglycemia.

Table 14: Frequency distribution of level of involvement in physical activity by NIDDMs in Kisii and Homa-Bay district Hospitals.

Level of Involvement	Frequency	Percent
Occasionally	24	20.7
Once in a week	10	8.6
Daily	82	70.7
Total	116	100.0

4.3.8.2 Types of Physical activity

Table 15 showed that the highly performed physical activity was walking (89.7%), followed by digging (55.2%), herding (29.3%) and finally swimming and jogging that had (3.4%) each.

Walking being the least strenuous type of exercise that would not require elaborate preparation was easily performed by most NIDDM patients. The daily chores ran by the NIDDMs also entailed walking. Digging ranked second after walking as most people in Homa-Bay and Kisii districts depended on subsistence farming for their livelihoods. Swimming was ranked among the least performed exercises since it would only be performed by the people who lived around Lake Victoria and not from the highlands.

Table 15: Distribution of NIDDM patients in Kisii and Homa-Bay district Hospitals by type of physical activity

Activity Type	Frequency	Percent
Digging	64	55.2
Herding	34	29.3
Walking	102	89.7
Swimming	4	3.4
Jogging	4	3.4

4.3.8.3 Duration of Physical activity

The results in table 16 indicated that most NIDDM patients (43.1%) were involved in physical activities two hours, followed by 31.0% involved for over 2 hours while 13.8% and 12.1% were involved for one hour and 30 minutes respectively per day.

The high frequencies observed for two hours and two hours and above could be attributed to the type of physical activities the NIDDM patients engage in. Activities such as digging and herding which were mentioned by a large number of farmers could require more than two hours of participation.

Table 16: Frequency distribution of NIDDM patients in Kisii and Homa-Bay district Hospitals by duration of physical activity

Duration of physical activity	Frequency	Percent
30 minutes	14	12.1
1 hour	16	13.8
2 hours	50	43.1
Above 2 hours	36	31.0
Total	116	100.0

4.3.8.4 Meals and physical activity

The results of the study figure 7 indicated that most NIDDM patients (48.4%) preferred to take meals before commencement of physical activity while 17.2% took their meals in between exercise, after the exercise or simply did not have regular meal timing. High

frequency of NIDDM patients feeding before commencement of physical activity could be attributed to large number of NIDDM patients involved in physical activity for long hours as in the case of digging and herding.

Meal timings are an essential element in the management of NIDDM. A study carried out by Kiens, (1990) established that exercise depleted muscle glycogen stores thus allowed more prolonged glucose disposal. As glycogen stores are depleted, more glucose is drawn from blood stream to replenish them. Hence, food must be taken adequately with exercise to prevent hypoglycemia.

Physical activities that were intensive and lasted long hours like digging would require that one ate at the onset, in between and after the exercise to enhance endurance of performance. Studies carried out by Guezennec, (1995) established that taking of foodstuffs with low Glycemic Index would encourage endurance of substrate levels to supply energy. The low GI foods minimizes hypoglycemia that may occur at the start of exercise, increases concentration of fatty acids in the blood as well as increasing oxidation of fat while reducing reliance on carbohydrate fuel.

Consumption of high GI foods soon after intensive exercise optimally promotes restoration of muscle glycogen. Ingestion of high GI foods at the onset of intensive exercise would result in over stimulation of islets of langerhans in pancreas producing lots of insulin in the blood that results in glucose uptake leading to hypoglycemia and

suppression of fatty acid concentration in the blood as found out in the studies carried out by Sherman, (1991).

In another study carried out by Goodpaster et al, (1996) found out that ingestion of food at the onset of exercise only results in quick depletion of body carbohydrate or blood glucose. Provision of carbohydrate –rich—foods during exercise will slow down depletion rate of body carbohydrate stores and delay the onset of fatigue. This encourages feeds in between exercises that last hours. The NIDDMs are also encouraged to feed after the exercise, as this will elevate glucose levels in the blood as soon as possible and to provide substrate for glycogen synthesis.

Another study carried out by Jozsi et al, (1996) supported this phenomenon when their results revealed that glycogen synthesis could occur more rapidly if carbohydrate is consumed quickly in adequate amounts after exercise. A high GI meal after exercise causes less of a rise in blood glucose when glycogen stores are depleted than when they are at least partly replenished. A high GI diet may be safer for NIDDM's after exercise for quick recovery of oxidized glucose to supply energy during the exercise, at the same time high GI food increases blood glucose especially insulin that is critical for re-synthesizing muscle glycogen, as found out by Burke et al, (1993).

Proper meal balancing with physical activity is inevitable for proper management of NIDDM. The patients therefore must take their meals according to the degree of strain and the duration of the physical activity. Long strenuous exercises like digging require

food before onset, in between and at the end to prevent severe cases of hypoglycemia and diabetic coma among NIDDMs.

Physical activity & meal balancing.

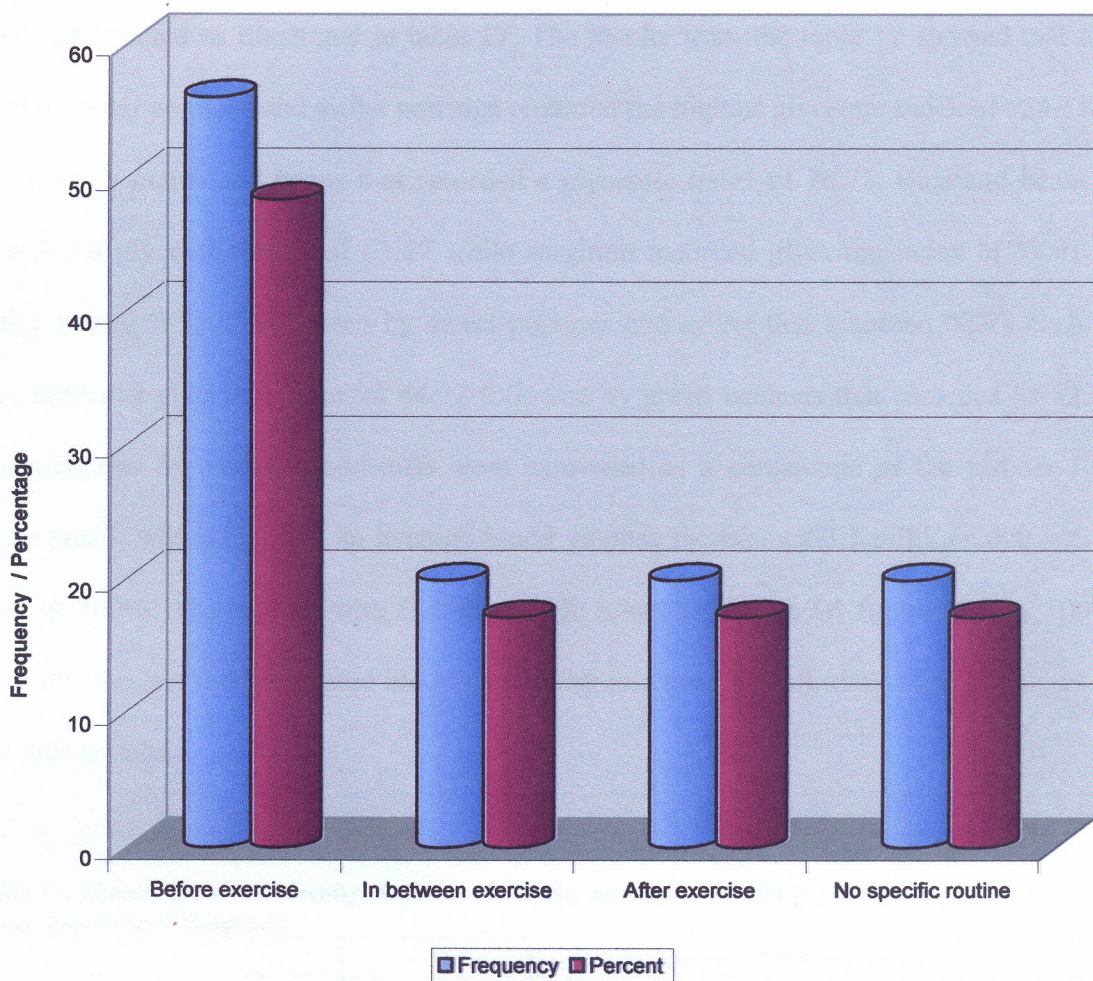


Figure 6: Physical activity and meal balancing by NIDDM patients in Kisii and Homa-Bay district hospitals

4.4 Glycemic Index of Locally Available Foods in Kisii and Homa-Bay Districts.

4.4.1 Introduction:

Various locally available foodstuffs were fed to NIDDM patients and their glycemic index determined as illustrated in table 17. The results from the table 17 showed that a meal of sweet potatoes and millet porridge recorded the highest glycemic index of 124.11 followed by maize and beans that recorded a glycemic index of 76.75. Rice and beans recorded a glycemic index of 63.87 while sorghum recorded glycemic index of 54.41. Maize recorded 53.95 followed by sweet potatoes and millet that recorded 52.73 each. Rice recorded glycemic index of 44.72 followed by green bananas that recorded 34.82. These figures for various foodstuffs were expressed as a percentage of the test food- white bread, which had had an average blood glucose increase of 3.1 millions that was rated at 100%. The figures with G.I above 100 hours while the GI figures below 100 show that the test foods elevated blood glucose by less than 3.1 millimols after two hours of administration.

Table 17: Glycemic Index of locally available foodstuffs tested on NIDDM patients in Kisii and Homa-Bay district Hospitals.

Food type	Descriptive statistics on Glycemic index.					
	N	Range	Mean	std. Deviation	Variance	Glycemic index
Sweet potatoes	58	6.2	1.634	1.455	2.117	52.725
Millet	58	6.2	1.634	1.455	2.117	52.725
Sorghum	36	4.1	1.689	1.406	1.976	54.407
Maize	58	7.7	1.672	2.011	4.043	53.95
Rice	58	8.5	1.386	1.729	2.988	44.716
Green bananas	58	6.1	1.079	1.455	2.117	34.816
Maize \$ Beans	34	17.25	2.379	4.052	16.423	76.754
Rice \$ Beans	30	4.7	1.98	1.549	2.4	63.87
Sweet potatoes \$ Millet porridge	36	7.9	3.847	2.378	5.656	124.109

4.4.2 Suitability of the tested local foods in management of NIDDM.

Suitability of nine locally available foodstuffs in Kisii and Homa-Bay Districts has been discussed based on their glycemic index.

The foodstuffs with very high glycemic index were sweet potatoes, maize and beans followed by rice and beans. Maize, millet, sorghum, and sweet potatoes recorded average glycemic index while rice and green bananas recorded low glycemic index.

It was significantly noted that mixed meals yielded higher GI than foods consume singly. A combination of sweet potatoes and finger millet porridge recorded the highest GI followed by a combination of rice and beans. According to Hermansen et al (1992), carbohydrates have got varied chemicals composition. Some break down quickly during digestion and can raise blood glucose to dangerous levels. Other carbohydrates break down more slowly, releasing glucose gradually into the blood stream. The carbohydrates that break down fast during digestion have low GI.

Biochemical structure of the carbohydrate, the absorption process, size of the food particle, degree of thermal processing and co-ingestion of fat, fibre or protein influence the GI of a food (Guezennec, 1995). Sweet potatoes have got less fibre, fat and proteins hence was broken down fast during digestion. A study carried out by Horowitz and coyle (1993) proved that addition of fat to the diet reduced glycemic responses of carbohydrates sources tested. Sweet potatoes also have less fibre that could have promoted faster movement of food along the gut that would result in large absorption of glucose in the intestinal mucosal cells after a short period.

Millet porridge has very small carbohydrates particles in flour improving their surface area to volume ratio that is quite favorable for digestion by enzymes. The porridge also has water content that makes the mixture which reduces high dependency on saliva to provide water medium for enzyme action. The semi- solid state of the porridge also allows for faster peristalsis down the gut hence moves faster through the various digestion stations like mouth, stomach, and duodenum and into ileum where the glucose is absorbed into the blood stream. Porridge preparation involves mixing flour and water. Gelatinization occurs which involves bonding of water molecules to the starch structure, which increases its viscosity and bioavailability (Kirwan et al, 1996).

Both sweet potatoes and millet porridge are sources of starch that break down into maltose and glucose respectively after complete digestion. Glucose is actively transported with a carrier protein to help them cross the ileum epithelial membrane into the blood capillaries underlying the membrane (Foster et al, 1995). This rules out dependency of concentration gradient for absorption to take place. Presence of glucose within the ileum will be followed by active transportation that elevates blood sugar level respectively.

Sorghum has a glycemic index of 54.407, millet GI of 52.725 while maize GI was 53.95. According to the meal frequencies, sorghum and millet were ranging high in the respondents diets. Sorghum and millet are brown in color and were often recommended to the NIDDM's yet maize was almost omitted in the diets. When all the cereals of sorghum, maize and millet are taken as whole meals where they are wholly ground

without shifting, the fiber content in maize makes it quite competent in GI and can comfortably be fed on by NIDDM's. Whole grain flour has high fiber content and would hence lower the gastrointestinal emptying together with digestion and absorption rates.

GI of rice was 44.716 that ranged among the lowest in the foodstuffs tested.

Rice is white in colour and its frequency in the diet consumed by the respondents was very low. According to international glycemic index table, some brands of rice have high GI while others have low GI. This attributed to presence of two forms of starch in rice cereal that is amylose and amylopectin. Amylose is made up of a straight chain of repeating glucose molecules while amylopectin is made up of a branched chain of glucose molecules (Guezennec, 1993 and Brand miller, 1994). Starch source containing amylopectin is digested faster than starch sources containing amylose. High amylose content in the rice tested (Ahero rice) could have led to low GI.

Green bananas registered the lowest GI of 34.816 among the foodstuffs tested. A recent study reported that GI for under-ripe bananas was lower than GI for overripe bananas by almost half. Hermansen et al (1992) study on ripe and under-ripe bananas revealed that under-ripe bananas constituted of 80-90% starch of the carbohydrate content which as banana ripens to changes to free sugars. High levels of starch in the green bananas coupled with fiber content would lead to the low GI hence can comfortably fit in the diet of NIDDM's.

Individual GI of selected locally available foodstuffs, which included sweet potatoes, finger millet, maize, rice and green bananas compared favorably to revised International table of GI (Rick, 2002). There are slight differences due to food variety, cooking method, processing and sample population. The high GI registered in mixed meals could have been due to the combinations that influence their bioavailability as reported by (Ludwig, 2002). The findings support the hypothesis of the study that locally available foodstuffs are appropriate in the management of NIDDM.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS.

5.1 Conclusion.

Majority of the NIDDMs interviewed were married and this confirmed the onset of the disorder at a later age when individuals are mature adults with families. Many of the individuals did not have formal education or occupation posing a challenge on their understanding of nutritional management of NIDDM and their purchasing power respectively. High poverty levels made it difficult to afford prescribed balanced meals.

The NIDDM patients have irregular meal patterns. Majority of the patients interviewed had encountered long range complications specifically poor vision that is caused by recurring unmanaged hyperglycemia. This shows that nutrition has not been applied exhaustively in the management of NIDDM and the results also reveal that medication was sought well above nutrition in case of any complication observed.

Most frequent meals in the diet consisted of millet and sorghum ugali yet unpopular foodstuffs in the diet like maize, rice and green bananas yielded favorable GI which points to the potentiality of their usefulness in management of NIDDM. Other mixed meals like sweet potatoes and millet porridge registered high GI but considering their GI in the diets, their measures can be regulated in a meal to ensure normal blood glucose level as well as continuous consumption by the individual that previously enjoyed it before the onset of NIDDM.

Application of GI policy in meal planning for management of NIDDM makes locally available foodstuffs appropriate in the management of NIDDM. The GI of food stuffs will guide the meal planner on types and amounts of food to be ingested at different meal times as well as when involved in various physical activities.

Low GI food is advisable before onset of strenuous physical activity that would last long hours while high GI foods are advised to be consumed immediately after strenuous exercise. Thus both low and high GI foods have a place in the diet of NIDDMs. When properly balanced, both low and high GI foods could enhance steady blood glucose levels in NIDDM individuals.

The study therefore accepts the hypothesis that locally available foodstuffs are appropriate in the management of NIDDM.

5.2 Recommendations.

From the results, the study makes two sets of recommendation for practice and for further studies.

5.2.1 Recommendations for Practice.

The following recommendations could be useful in the management of NIDDM.

1. The NIDDM patients should practice mixed farming so that they can get most of the foodstuffs such as milk, eggs, legumes, cereals and vegetables from their household farms to reduce costs on NIDDM management.

2. Nutritionists dealing with NIDDM patients should be empowered with the knowledge of GI so as to apply it in choice of foods to maximize consumption of locally available foodstuffs to reduce costs and inconveniences.
3. Nutrition counseling to NIDDM by nutritionists to empower them regarding portions of meals depending on bioavailability of nutrients in food sources and measures translated to household cups and spoons.
4. Creation of public awareness on NIDDM disorder and management practices based on GI of local foods.
5. Commercial GI testing of food by the food industry should be conducted in Kenya for each food item to have a GI label.
6. GI trademark certification program to be put in place so that GI values are indicated on food labels as a means of guiding consumer selection.

5.2.2 Recommendations for further studies.

- 1) Studies on glycemic load of various local foods to enhance precise dietary prescriptions.

- 2) Studies to establish the nutritional status and micro- nutrient intake among NIDDM individuals.

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APPENDICES

Appendix 1: Interview Schedule

An Investigation of the Use of Local Foods in the Management of Diabetes Mellitus

QUESTIONNAIRE

Introduction

This questionnaire is intended to provide the researcher with information to help verify the suitable locally available foodstuffs that can be used in the management of non-insulin dependent diabetes mellitus. Your cooperation in this study by providing information required in the questionnaire will be highly appreciated by both the researcher and the patients who will be beneficiaries of this research.

DEMOGRAPHIC INFORMATION NIDDM

RESPONDENT'S NUMBER:-----

DIVISION-----LOCATION-----

Marital status----- Gender----- Age----- Body weight-----

Section I: Background Information

1.1 What is your education level? (Check your answer with a tick in brackets provided)

1. College level
2. K.C.S.E holder
3. K.C.P.E holder
4. Below std 8

1.2 What is your occupation?

1. Civil servant
2. Non governmental organization
3. Self-employment
4. None
5. Other(state)-----

Section II MEDICAL HISTORY

2.1 Are you suffering from Non-insulin Dependent Diabetes Mellitus (NIDDM)?

1. Yes
2. No

2.2 If yes, for how long have you suffered from Non-insulin Dependent Diabetes mellitus?

1. Over 10 years
2. 5 – 10 years
3. 3 – 5 years
4. Below 3 years

2.3 Have you suffered any other disease other than NIDDM in the recent past?

1. Yes
2. No

2.4 If yes, which one

1. Malaria
2. Hypertension
3. Kidney failure
4. Typhoid
5. Other (state)-----

2.5. Are there any complications you experience due to NIDDM?

1. Yes
2. No

2.6 If yes, what are these complications of NIDDM?

1. Poor vision
2. Diabetic coma
3. Swollen legs
4. Kidney failure
5. Other (state)-----

2.7 How do you manage these complications mentioned in 2.6 above?

.....

.....

.....

.....

Section III MEAL PLAN

3.1 How many times have you taken meals in the last 24 hours?

- 1) Once
- 2) Twice
- 3) Three times
- 4) More than three times

5) None

[]

3.2 What did you eat in the last 24 hours?

1. Breakfast-----
2. Lunch-----
3. Supper-----
4. Snacks-----

3.3 After consuming a foodstuff, how long does it take before you eat again?

1. 30 minutes []
2. 1 hour []
3. 1 ½ hours []
4. 2 hours []
5. Above 2 hours []

3.4 How many times have you fed on the following foodstuffs in the last two weeks?

- | | | | | | |
|-------------------|------|------|------|----------------|----------|
| 1. Green banana | 1() | 2() | 3() | 4and above () | none () |
| 2. Sweet potatoes | 1() | 2() | 3() | 4and above () | none () |
| 3. Maize | 1() | 2() | 3() | 4and above () | none () |
| 4. Rice | 1() | 2() | 3() | 4and above () | none () |
| 5. Arrow roots | 1() | 2() | 3() | 4and above () | none () |
| 6. Sorghum | 1() | 2() | 3() | 4and above () | none () |
| 7. Millet | 1() | 2() | 3() | 4and above () | none () |
| 8. Fish | 1() | 2() | 3() | 4and above () | none () |
| 9. Milk | 1() | 2() | 3() | 4and above () | none () |
| 10. Beans | 1() | 2() | 3() | 4and above () | none () |

3.5 What influences the choice of your foodstuffs?

1. Doctors advice []
2. Personal preference []
3. Availability of food []
4. Other(state)-----

3.6 Which cooking methods do you use for preparing your meals?

1. Boiling []
2. Frying []
3. Stewing []
4. Baking []
5. Roasting []
6. Other (state) -----

3.7 How do you prepare your foodstuffs before cooking?

1. Chopping []
2. Mincing []

3. Mashing
4. Other (state)

3.8 Do you add any spices or flavours to your food?

1. Yes
2. No

3.9 If yes, specify-----

Section IV: PHYSICAL ACTIVITY

4.1 Are you involved in any routine exercise/physical activity?

1. Yes
2. No

4.2 If yes, which one among the following?

1. Digging
2. Herding
3. Walking
4. Swimming
5. Jogging
6. Other (state).....

4.3 How often are you involved in the exercise/ physical activity?

1. Daily
2. Once a week
3. More than twice a week

4.4 For how long do you carry out the exercise/physical activity?

1. 30 minutes
2. 1 hour
3. 2 hours
4. Above 3 hours

4.5 How do you balance your meals with the physical activities you are involved in?

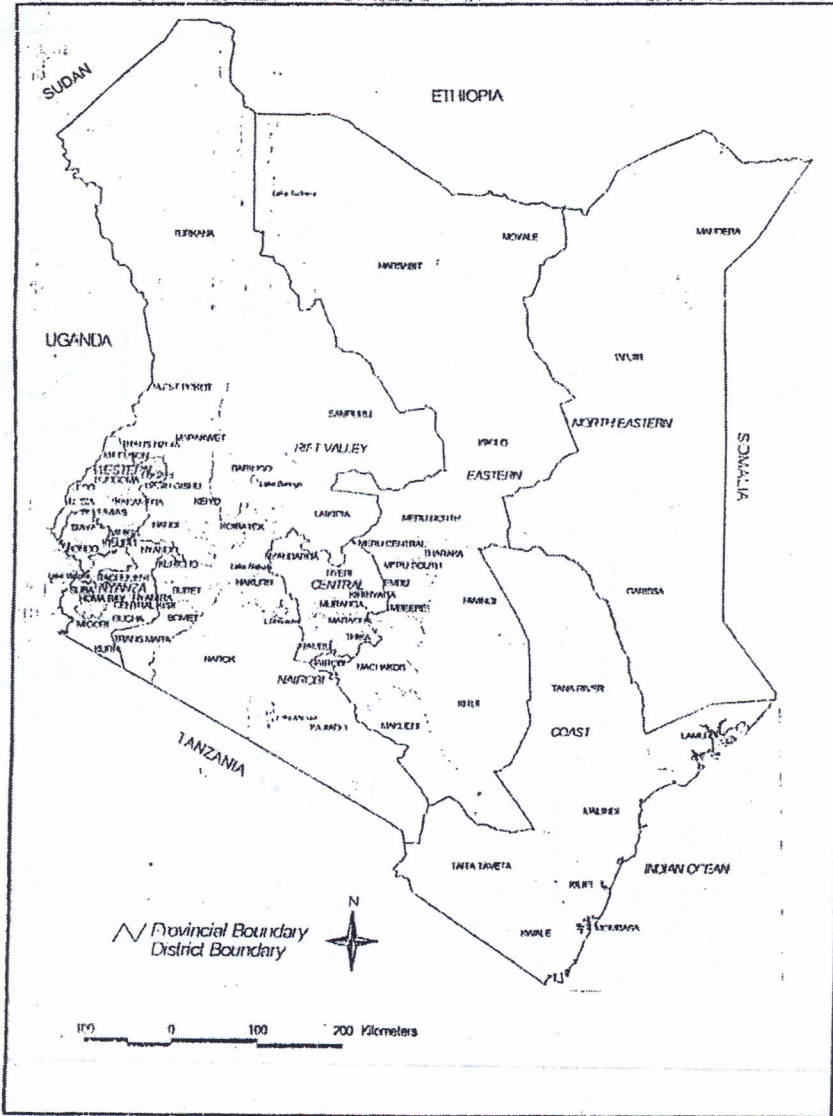
1. Eat before commencement of exercise
2. Eat in between the exercise period
3. Eat after the exercise
4. No specific routine

Section V: LABORATORY TESTING OF GLYCEMIC INDEX OF VARIOUS FOODS

Food type	Texture	Method of preparation	Blood glucose Level before consumption	Blood glucose Level 2 hours after consumption
Sweet potatoes	1. Mashed 2. Unmashed			
Millet	1. Flour			
Sorghum	1. Flour			
Maize	1. Grains 2. Flour			
Rice	1. Grains			
Green bananas	1. Mashed 2. Unmashed			
Maize&Beans	Grains			
Beans	1. Grains			
Rice&Beans	Grains			
Sweet potatoes& Millet porridge	Whole potato & millet flour			

APPENDIX 2

LOCATION OF HOMA BAY IN KENYA



Prepared by CRS, 1989 Pop Census

This map is not to be drawn over administrative boundaries

APPENDIX 3



KENYATTA UNIVERSITY BOARD OF POSTGRADUATE STUDIES

P.O. Box 43844,
NAIROBI
Tel. No. 810901/9 Ext. 57530
E-mail: kubps@yahoo.com

Our Ref: H60/7276/01

Date: 16th Sept, 2003

Your Ref:

The Permanent Secretary,
Ministry of Education, Science & Technology
P.O. Box 30040,
NAIROBI.

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION:

I write to introduce Ms. Judith Munga who is a Postgraduate Student of this University. She is registered for a M.Sc degree programme in the Department of Foods, Nutrition & Dietetics.

Ms. Munga intends to conduct research for a project entitled, "An Investigation in the Use of Local Foods in the Management of Diabetes Mellitus: A Case Study of Kisii, Homabay and Rachuonyo District Hospitals", as a partial fulfillment of the requirement of her degree programme.

Any assistance given to her will be highly appreciated.

Yours faithfully,


J.K. LANGAT

FOR DIRECTOR, BOARD OF POSTGRADUATE STUDIES

C.C. Registrar (Academic)
Director, BPS - to see on file
Dean, School of Pure & Applied Sciences
Chairman, Foods, Nutrition & Dietetics Dept.

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When replying please refer to

MOEST 137001/35C 113/2

JOGOO HOUSE
HARAMBEE AVENUE
P. O. Box 30040
NAIROBI

10th December 2003

JUDITH MUNGA
KENYATTA UNIVERSITY
P.O. BOX 43844
NAIROBI.

Dear Madam,

RE: RESEARCH AUTHORIZATION

Please refer to your application for authority to carry out research on "An Investigation into the use of Locally Available Foodstuffs in the Management of Diabetes Mellitus. A case study of Kisii and Homa-Bay District Hospitals". I am pleased to inform you that you have been authorized to carry out research in Kisii and Homa-Bay Districts ending 10th February 2004.

You are advised to report to the District Commissioner, the District Education Officer and the Medical Officer of Health, Kisii and Homa Bay Districts before embarking on your research project.

On completion of your research, you are advised to submit two copies of your research findings to this office.

Yours faithfully,


B. O. ADEWA

FOR: PERMANENT SECRETARY

Cc

The District Commissioner
Homa Bay District

The District Education Officer
Homa Bay District