PREVALENCE, AWARENESS AND MANAGEMENT OF TYPE 2 DIABETES MELLITUS IN MWANZA CITY, TANZANIA

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EXTENDED ABSTRACT

Type 2 diabetes mellitus (T2DM) is a metabolic disease caused by either inadequate insulin produced by beta cells of the pancreas or inability of body cells to respond to insulin produced. Prevalence of this disease is increasing rapidly around the world. This study was conducted to assess the prevalence, awareness and management of T2DM among adults in Mwanza City, Tanzania. A multistage random sampling technique was employed to obtain representative subjects. A total of 288 males and 352 females' respondents were included in this study. For each subject, anthropometric measurements of height, weight, waist and hip circumference were performed, total body fat mass, and blood pressure were measured using standard procedures. In addition, random blood glucose testing was employed to identify subjects at risk. Subjects with random glucose level of or above 200 mg/dl were subjected to fasting blood glucose testing on the succeeding day. Subjects were confirmed to have T2DM if they had fasting blood glucose level of or above 126 mg/dl. Information about causes, lifestyle behaviors, risk factors and management of T2DM were collected using pre-tested structured questionnaire. Overall, prevalence of T2DM was 11.9% and the prevalence was higher among females (7.2%) than among males (4.7%). T2DM and Impaired Fasting Glucose (IFG) were found to be higher in females than in males and tended to increase with age. Prevalence of T2DM was shown to be higher in 41-60 years and less in 60 and above years. Awareness of the causes of diabetes was very low with only 17% of the respondents having correct knowledge about the causes of T2DM. Over half (54.2%) of the respondents were not aware of the age most affected by the disease. Moreover, 45.5% of the respondents did not know how to manage the disease through diet, physical exercises and medication. Independent associations were found between T2DM and risk factors such as age (OR 3.88, 95% CI 2.16-6.95) heredity (positive first degree relative) (OR 1.34; 95% CI; 1.10-1.64) alcohol intake (OR 1.23; 95% CI: 1.02-1.48) smoking,

(OR 3.86; CI: 2.57-5.78) and hypertension (OR 0.096; 95% CI: 1.954-18.251). Prevalence of overweight in the studied population was 10.5% in males and 18.1% in females. Most females (60.8%) had waist-hip ratio of ≥ 0.85. Results revealed further that, the biggest amount of serving of fruits and vegetables was 250g whereby only 19% of the respondents consumed that amount per day. Prevalence of hypertension was high in 41-50 year age group (10.2%), while the overall prevalence of hypertension was 34.1%. The prevalence of hypertension was 16.7 and 17.3% in females and males, respectively. The relative risk of developing T2DM if one had hypertension was 4.052 (95% CI: 2.55-6.433, p=0.06). The relative risk for developing T2DM by having first class relative with the disease was 2.11 (95% CI: 1.4-3.1). One year follow up after nutrition education intervention showed improvements in metabolic, anthropometric and cardiovascular outcomes. The most notable improvement was the glycemic control. Results revealed that, fasting blood glucose levels decreased gradually from the baseline up to the 12 months endline. There was significant ($p \leq 0.05$) difference in the blood glucose levels during several clinic visits. There was 34% decrease in blood sugar levels during the intervention from the baseline survey up to 12 months. Fasting blood glucose after 3 months of intervention was higher ($p \leq 0.05$) than after 6 months and after 12 months. There was 7.3% decrease in average weight (4.2kg) from baseline to 12 months post intervention. Mean BMI was decreasing gradually with time of intervention. Mean BMI (28.6±5.6) in the first visit was significantly higher ($p \leq 0.05$) than in the subsequent visits. There was an average decrease of 8.8% in the BMI from baseline to 12 months' endline. No differences ($p > 0.05$) in systolic blood pressure were observed among subjects though there was a decrease in the average levels from baseline to 12 months post- intervention. In diastolic blood pressure there was significant variation ($p \leq 0.05$) among subjects from the baseline to 3 months, 6 months and 12 months post-intervention. Mean diastolic blood pressure decreased by 6.3% for the entire intervention

period. Waist-hip ratios among subjects decreased insignificantly ($p>0.05$) from the baseline up to 12 months after intervention. For dietary management of type 2 diabetes mellitus, glycemic indices (GI) of commonly consumed staple foods namely cassava flour, undehuled maize flour, sorghum flour, millet flour and plantains (Matoke) were determined. Cassava diet had the lowest glycemic value (49.8) followed by maize meal (51), while cooked plantains (Matoke) (57.85) and finger millet meal (60.92) had medium GI values. Sorghum meal had the highest GI (65.71). Based on the GIs values, cassava and whole maize meals were recommended as the most suitable staples for the management of type 2 diabetes mellitus. Moreover, finger millet, sorghum and plantains meals can be consumed but moderately. It was concluded from the studies that Health Ministry and other health practitioners should ensure that public education on T2DM is emphasized and routine measurement of blood glucose levels is recommended among adults. Furthermore, health practitioners and the government have to ensure policies are placed to intervene, and modify lifestyle behaviors at young ages so as to reduce the risks of developing T2DM. For proper management of T2DM, policy makers have to ensure that services and proper medicine for patients with T2DM are accessible throughout the primary health care delivery facilities in the country. Moreover, policy makers should identify patients with low income who would receive treatment and medication at subsidized rates to ensure that no patient would skip the management regime for the treatment of T2DM.

DECLARATION

I, CAROLYNE CHARLES RUHEMBE, do hereby declare to the Senate of Sokoine University of Agriculture, that this thesis is my own original work done within the period of registration and that it has neither been submitted nor concurrently being submitted in any other institution.

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LIST OF PUBLICATIONS

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LIST OF ABBREAVIATIONS AND SYMBOLS

ADA	American Diabetes Association
AIDS	Acquired Immune Deficiency Syndrome
ANOVA	Analysis of Variance
AUC	Area Under Glucose Response Curve
BMI	Body Mass Index
CI	Confidence Interval
CSIS	Centre for Strategic and International Studies
CVD	Cardiovascular Disease
FAO	Food and Agriculture Organization
GDM	Gestational Diabetes Mellitus
GI	Glycemic Index
HIV	Human Immunodeficiency Virus
IAUCG	Incremental Area Under the Glucose Curve
IDDM	Insulin Dependent Diabetic Mellitus
IDF	International Diabetic Federation
IFG	Impared Fasting Glucose
MRDM	Malnutrition Related Diabetes Mellitus
NIDDM	Non Insulin Dependent Diabetic Mellitus
NIMR	National Institute for Medical Research
OR	Odd Ratio
SPSS	Statistical Product and Service Solution
SUA	Sokoine University of Agriculture
TDA	Tanzania Diabetic Association
WC	Waist Circumference
WHO	World Health Organization

WHR	Waist Hip Ratio

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

1.1.1 Etiology of the disease

Diabetes mellitus is a metabolic disease of multiple etiologies characterized by chronic hyperglycemia with disturbances of fat, carbohydrate and protein metabolism in the body (Aring *et al*., 2005). Type 2 diabetes mellitus (T2DM) is caused by deficiencies in insulin secretion and insulin action on targeted cells (ADA, 2014). The effects of T2DM include long term damage, dysfunction and failure of various body organs (ADA, 2009). Diabetes mellitus may cause characteristic signs of frequent urination (polyuria), increased thirst (polydipsia) increased hunger (polyphagia), blurring of vision and weight loss (Warren *et al*., 2003). The disease in its most critical conditions may develop to ketoacidosis or non-ketotic hyperosmolar state which may lead to stupor, unconsciousness and without treatment, death (Stonner, 2005).

The symptoms of this disease are often not severe; hence, level of blood glucose sufficient to cause pathological and functional changes may be present for a long time before the diagnosis is made (Amod *et al.*, 2012). The causes of T2DM includes family predisposition, previous gestational diabetes mellitus, overweight and obesity that are found to be closely related to incorrect eating habits such as foods rich in sugars, fats, and processed foods in addition with lack of physical exercises (Swinburn, 2004**)**. Diabetes is a silent disease in which many sufferers become aware that they are sick only when they develop one or several of its life-threatening complications (Ruhembe *et al.*, 2014). Long term effects of diabetes mellitus include development of specific complications of retinopathy and nephropathy that may lead to renal failure or a risk of foot ulcers, sexual

dysfunction, amputation and risk of cardiovascular diseases (Mane *et al*., 2012; Dart *et al.,* 2013). There are several types of diabetes mellitus. These include type 1 insulin dependent diabetes mellitus (IDDM) which is associated with destruction of insulin-producing beta-cells, usually leading to absolute insulin deficiency (ADA, 2014). This type of diabetes is commonly found among children and young people with about 25-50% of cases occurring before the age of 15 years (Celabert, 2009). Classic signs of IDDM include hyperglycemia characterized by thirst (polydispsia), frequent urination (polyuria), increased hunger (polyphagia), general fatigue and weight loss (Cooke and Plotnick, 2008). The disease is always acute and needs regular doses of insulin to sustain life at the same time avoiding acute and more long-term complications (Stang and Story, 2005). The major complications of type 1 diabetes are long-term complications which affect eyes, kidneys, and nerves (Rother, 2007).

The second type of Diabetes Mellitus is NIDDM, also called Type 2 Diabetes Mellitus. Type 2 diabetes mellitus (T2DM) ranges from predominantly insulin resistance with relative insulin deficiency to a predominantly secretory defect with or without insulin resistance (ADA, 2009). T2DM is most common in older age groups (over 40 years) (Chao, 2009), although lately it has been observed among obese adolescents and in young adults of 30-40 years of age (Song, 2012). Risk factors for T2DM include old age, increased body mass index (BMI), high body fat mass, weight gain in adulthood, ethnicity, family history of diabetes, low birth weight, sedentary lifestyle, higher systolic blood pressure, impaired glucose tolerance, impaired fasting glucose, and history of gestational diabetes (Steyn *et al*., 2006).

About 85-95% of all diagnosed diabetes cases are suffering from type 2 diabetes (Routley, 2011). Other specific types of diabetes include gestational diabetes mellitus (GDM), which

develops only during pregnancy when there is a high degree of glucose intolerance, and malnutrition-related diabetes mellitus (MRDM) (Bakhru, 2009**)**. This occurs in pregnant women with no previous history of diabetes.

1.1.2 Prevalence of T2DM

T2DM prevalence is increasing around the world at an alarming rate and is now emerging as a global health problem that threatens to reach pandemic levels by the year 2030 (Wild *et al.*, 2004). At global level, different governments are stressed to meet the cost of diabetes care. Costs to employers and national economies are escalating and every day low-income families are being driven into poverty by loss of earnings due to diabetes and the life-long costs of healthcare (Nguma, 2010). Prevalence of Type 2 Diabetes worldwide was projected to increase from 171 million in 2000 to 366 million by 2030 (Wild *et al.,* 2004). Unfortunately, the prevalence of T2DM worldwide had already reached 366 million by the year 2011 according to the International Diabetes Federation. The global projections showed prevalence of diabetes could reach 552 million by 2030 with an additional 398 million people at high risk. Additionally, three out of four people with diabetes currently live in low-and middle-income countries. Over the next 20 years, it is expected that Africa, Middle East and South-East Asia regions will carry the greatest increase in diabetes prevalence (IDF, 2011).

Globally, the prevalence of diabetes is similar in men and women but slightly higher in men less than 60 years of age than women (Wild *et al*., 2004). But there are more women with diabetes than men at older ages (Aspray *et al*., 2000). The greater number of elderly women than men in most populations and the increasing prevalence of diabetes with age is the most likely explanation for this observation. In Sub-Saharan Africa, type 2 diabetes mellitus appears to be increasing with rapid cultural changes, aging populations, dietary

changes, decreased physical activity levels and smoking behavior and excessive alcohol intake, all of which are associated with urbanization and lifestyle behaviors (Mennen and Mbanya, 2000, Steyn *et al*., 2006).

Type 2 diabetes is now regarded as a major public health problem and an illness of high impact in the developing world including African countries (WHO, 2009). Most of the Sub-Saharan African countries, including Tanzania, have paid little attention over the years to establish public health preventive measures against diabetes (Mbanya *et al*., 2010). This problem originates from under-reporting together with limited epidemiological data on the prevalence of diabetes (IDF, 2009). Assessing the percentage of the population with diabetes and incidence in sub-Saharan Africa is extremely difficult because of the limited information in many countries (IDF, 2009, Mbanya *et al*., 2010). The T2DM prevalence in sub- Saharan Africa varies from 3-14.5%, with an overall prevalence of 3.2%, predicted to rise to 3.7% in 2030 (Mbanya *et al*., 2010).

Studies show that, as soon as new lifestyles are established in urban African areas, the number of people with diabetes tends to increase (Swinburn, 2004). The International Diabetes Federation (IDF) estimated that, impaired glucose tolerance in sub-Saharan Africa would rise by 75.8%, from 26.9 million in 2010 to 47.3 million in 2030. This proportion is more than double the predicted global increase of 37%. It was estimated that, mortality caused by diabetes disease in sub-Saharan Africa was 6%. The report shows that the absolute and relative mortality rates are highest in the 20-39 years age group, affecting the most economically productive population (IDF, 2009).

In Tanzania, there is a rapid increase in the burden of diabetes and about 80% of diabetic patients in the country have Type 2 Diabetes Mellitus (Heri, 2007). Moreover, about 10% of urban Tanzania adults over 35 years of age are estimated to be diabetic (CSIS, 2009).
In 2005, Tanzania was estimated to have, 350 000 people with Type 2 Diabetes Mellitus (Ramaiya, 2005). The cause of such increase is urbanization which leads to changes in lifestyles from traditional to western life style (Steyn *et al*., 2006). Increasing levels of income especially in urban areas is also associated with changes in dietary patterns and lifestyles (Aikins *et al.,* 2010). These changes coupled with reduced physical activities lead to overweight and obesity. Currently, most diets in urban areas are similar to the western diets, which are high in fat and sugar and low in dietary fiber.

All these changes may bring positive energy balance which may lead to obesity and impaired glucose tolerance and hence diabetes (Kapur, 2001). Type 2 diabetes mellitus is bringing a double burden to developing countries which are already facing numerous diseases such as malaria, HIV/AIDS and under-nutrition related disorders (Abegunde and Stanciole, 2006). While problems of under-nutrition and other communicable diseases have not yet been fully eliminated in rural areas, over-nutrition and obesity associated with chronic diseases are emerging as major public health problems in the urban population. As life expectancy increases and the elderly population continue to grow, chronic diseases will place greater burden on society and affects the economic growth (Gillepsie and Haddad, 2003; WHO, 2011).

1.1.3 Awareness of T2DM

In Tanzania limited efforts have been devoted to educate the public about diabetes through the public media, and the impact of such efforts has yet to be evaluated (TDA, 2005). General knowledge on diabetes mellitus to the community can assist in early detection of

the disease and reduce the incidence of complications. Overweight, obesity, unhealthy diet, tobacco use, alcohol consumption, high blood pressure, high cholesterol levels, and lack of physical activity have been described as the major risk factors for non-communicable diseases including diabetes (WHO, 2009).

Knowledge on the level of public awareness is crucial to health educators to plan for future programs related to T2DM (Cullen and Buzek, 2009). Furthermore, there are limited reports available on the level of knowledge on diabetes in the general population in Tanzania (Nguma, 2010). It is important for the public to be aware of T2DM because knowledge is a critical component of behavioral change (Mahrooqui *et al*., 2013). Once awareness is created, people are more likely to participate in prevention and control measures (Ericksson *et al*., 2001).

1.1.4 Cost related in the management of T2DM

Diabetes Mellitus is associated with considerable costs in terms of life and demand on health budgets globally (Arnoldi, 2004). Because of its chronic nature, diabetes affects the most active adult groups of working age. Diabetes is a costly disease due to its severity of its complication. T2DM requires resources to manage the condition both by the health sector and the affected individuals and their families. Additionally, IDF reported that, government's mechanisms for financing T2DM in the health care systems in most of developing countries are non- existing (IDF, 2006).

Another report by WHO (2009), specified that, 80% of people in developing countries pay from their pockets for their own medication for the management of the disease. Such financial constraints may result into spending a high proportion of income on health care. A survey carried out in Tanzania showed that, as the number of patients with diabetes

continues to increase there is a very real threat that excessive demand will be placed on already over strained healthcare systems (Bloom, 2011).

It is costly to treat T2DM because of the expenses associated with repeated clinic visits, laboratory testing, routine medications, glucose monitoring devices, and treatment of complications. In Dar es Salaam, only one in five people with diabetes receive government-funded treatment for the disease (Ramaiya, 2005). This ratio stipulates that, some patients might not be able to access treatment, which may increase their complication rates and deaths.

A study done in Kilimanjaro region has shown that, the total direct costs to patients related to the treatment of diabetes accounts for a quarter of the individual's minimum monthly wage (Mosha and Rashidi, 2010). This has resulted in about 46% of people with diabetes having permanent financial difficulties in managing this disease (Nguma, 2010). A study by Simpson (2003) has showed that, a patient who can afford to self-monitor their blood glucose levels has to pay 65 000 to 150 000 Tanzanian shillings (about US $55 to $130) per year which is more than 20% of an annual low income salary of a wage earner just for glucose monitoring. Other costs which most of diabetic patients may incur include transport to and from the clinic which for many patients could be a major challenge in the management of T2DM.

1.1.5 Management of T2DM

Management of patients with diabetes aims to eliminate symptoms, save lives and in the long term reduce complications and associated risk factors which may cause death (Bastaki, 2005). Effective care and management of diabetes starts with early diagnosis. The latent onset of Type 2 Diabetes and its slow progression may delay the diagnosis and lead to numerous complications (Mbanya and Ramaiya, 2006).

Care and management of diabetes includes carefully managing diet, exercising, blood glucose monitoring, taking oral diabetes medication, using some form of insulin, and foot care and maintaining proper blood circulation in the extremities. The main task of managing diabetes is to keep the blood glucose level within a specified range in order to avoid short-term problems due to hypoglycemia (blood sugar too low) or hyperglycemia (blood sugar too high). Additionally, to reduce possible long-term complications triggered by chronic hyperglycemia (Walker, 2007).

Reduction in energy expenditure and change of dietary intake of fats, sugar and refined carbohydrates, and reductions in the energy intake from complex carbohydrates and in dietary fibres, results into overweight and obesity which are associated with higher risk of chronic diseases including diabetes (WHO/FAO, 2003, Waxman, 2004; Shills *et al.*, 2006). A study by Ramachandran (2004) showed that, increasing BMI brings an increased risk of diabetes in both men and women, and the risk is higher when BMI rises beyond 24. In addition, Wasuja and Siddhu, (2003) showed that, there is an increase in prevalence of diabetes with increasing waist-to-hip ratio (WHR) in both men and women.

For normal people, glucose levels in the blood would rise following the intake of glucose drink, but it would fall quickly to normal ($\leq$ 110 mg/dl). In a diabetic patient, glucose levels would rise higher than the normal levels (i.e greater than 200 mg/dl) after the intake of glucose solution and would come down to normal levels much slowly (Judson, 2007). Insulin treatment helps glucose levels to remain near the normal levels of about 70 to 120 mg/dl. In order to manage Type 2 Diabetes, nutritional intake and modification of lifestyles are the most prominent things to do. Physical exercises, weight control, nutritional therapy and medication (oral glucose lowering drugs and insulin injections) are the most important therapy (Dey *et al.*, 2002).

The American Diabetic Association recommends diet and regular physical activity as the first line treatment for type 2 diabetes mellitus. If normal glycemic levels are not achieved within three (3) months, drug treatment is recommended (ADA, 2008). Diabetics need more nourishing and better balanced diet as other individuals do (Bakhru, 2009**)**. For the successful dietary management it is essential to understand the body's daily food and nutrition requirements and how to select foods which can help in controlling and preventing diabetes (Salvado *et al*., 2011**)**.

Most diets provide nutrients such as vitamins, minerals and fat, carbohydrates and proteins the three sources of energy for the body. The best way to control diabetes is to give higher profile to some foods than the others. The basic principles of a diabetic diet are the same as those that are recommended for any person who wants to follow healthy eating. These basics include assuring a nutritional balance to favor normal growth for children and adolescents. It is recommended to modify wrong eating habits such as excess fats, lack of fiber foods intake, fast foods, and monotonous diets with a consumption of only a certain type of foods (Bakhru, 2009**)**. The European Association for the Study of Diabetes (ADA, 2002**)** recommended high-fiber, low-GI foods for individuals with diabetes as a means of improving postprandial glycemic and weight control.

A study from Harvard University indicated that, long-term consumption of a diet with a high glycemic load and glycemic index was an independent predictor of risk for developing T2DM (Godley, 2009). Glycemic index acts as a scale which ranks the carbohydrate in foods depending on how they affect blood glucose levels in a span of 1 to 2 hours after a meal. Its response to food which affects insulin response depends on the rate of gastric emptying, as well as on the rate of digestion and absorption of carbohydrate from the small intestines (Wolever, 2008). This implies that, while foods with elevated GI break down

quickly during digestion and release glucose rapidly into the bloodstream the foods with lower GI usually take a long time to get digested and absorbed, resulting into slower and gradual changes in blood sugar levels (Ostman, 2001).

The lower glycemic response usually relates to a lower insulin demand and may improve glucose level over time (Mendosa 2009). A low-GI food will release glucose more slowly and steadily, which leads to more suitable postprandial (after meal) blood glucose readings (Atkinson, 2008). Starches are not completely digested, some are quite poorly digested. It has been learned that the indigestible carbohydrates are not just neutral bulking agents, but have important physiological effects, and even contribute energy to the diet. Starches are not all equal in their effects on blood glucose and lipids. Furthermore, carbohydrate foods often contain vitamins and minerals plus other compounds, such as phytochemicals and antioxidants, which may have health implications. Many factors together, including carbohydrate type, fiber, protein, fat, food form and method of preparation, determine the GI of a particular food.

The Glycemic Index scale measures starch digestibility through comparison. Observation shows that, for similar portions of carbohydrates from one foodstuff to another, the postprandial Glycemic response can vary immensely since there are fractions of starches which cannot be digested and this is what determines their absorption rate. Several factors can cause these variations and the purpose of GIs is precisely to classify starches according to this variation in their digestibility (Sadler and Michele, 2011).

Macro-nutrients absorption does not occur throughout the whole length (about 20 feet) of the small intestine. The fact is that 80% of the carbohydrates and lipids and 50% of the proteins consumed are absorbed in the first 28 inches of the small intestine. Carbohydrates

are digested using salivary and pancreatic alpha-amylase digestive enzymes. Sugar hydrolyzation transformation into absorbable glucose depends directly on a carbohydrate Glycemic Index. GI also measure the corresponding carbohydrate hydrolyzing potential as well its chances of being transformed into absorbable glucose. In other words, Glycemic Indexes measure the portion of the carbohydrate transformed into glucose which will be absorbed and will thus pass into the bloodstream. If the GI for glucose is ranked at 100, this means that it will be totally (100%) absorbed in the small intestine. Comparatively, white bread has a 70 GI which means that 70% of its pure carbohydrate content (starch) will be hydrolyzed and pass the intestinal wall as glucose (Wilson, 2010).

Equal amounts of calories in different carbohydrates will not necessarily pass the intestinal wall in the same proportion, the proportions that pass the intestinal wall as glucose might be half or twice as much, it depends on the carbohydrate GI. This is the reason why carbohydrate GI measures the bioavailability of its glucose content.

Different tests have shown that eating sugar at the end of a meal will have little, or practically no, incidence on the meal's glycemic outcome. Considering the complexity of a meal, particularly the degree of fibers and proteins consumed, sugar (70 GI) absorption will be considerably reduced. Not all of the calories in food are available immediately after consumption. The GI knowledge helps in understanding how the same amount of food eaten will help someone to lose weight simply by eating it differently (Meinhold, 2010).

Starch is a carbohydrate which consists of two types of molecules: amylopectin and amylose. Amylose accounts for about 20-30% of the starch molecules and amylopectin about 70-80%. Amylose absorbs less water; the molecules form tight

clumps which slows the rate of ingestion. Kidney beans are an example of a low GI food with higher levels of amylose (GI 28) (Queiroz *et al*., 2012).

Amylopectin the other type of molecule in starch absorbs more water. Amylopectin molecules are more open and lead to a higher rate of digestion. Gluttonous rice is an example of a high GI ranking food (GI 98) (Wilson, 2010). Physical entrapment of the food item can affect its GI ranking. Physical entrapment refers to the way food is encased and the ability of the food to be absorbed by the body. For example, bran has a physical barrier which slows down the enzymatic activity of the internal starch layer during digestion. Bran has a low GI of 38. Differently corn flakes a high GI food (GI 92), do not have a pronounced physical barrier like bran and are more quickly absorbed (Jonnalagadde, 2011).

Viscosity is the measurement of the thickness of a liquid. A high viscosity item has a thick sticky consistency somewhere between a liquid and a solid. The viscosity of fiber can have a large influence on a foods GI ranking as viscous soluble fibers can transform the contents of the intestine into a gel-like /gooey matter. The gooey consistency of this matter slows down the enzymatic activity on starch and so slows down the rate of digestion. A slower rate of digestion reduces the rate of rise in blood glucose levels. Apples (GI 40) and rolled oats (GI 51) are examples of low GI foods which have a high viscosity of fiber. By contrast, whole wheat bread (GI 73) and the breakfast cereal, Cheerios (GI 74) are higher GI foods which have a low viscosity of fiber (Wanjeck, 2012).

The sugar content of the food item also affects its ranking. Foods with higher sugar content are more likely to be ranked higher as sugar is a food item very similar to glucose. For

example, the breakfast cereal, Golden Grahams has a GI of 71, whilst Frosted Flakes has a lower GI of 55 (Mahgoub *et al*., 2013). Fats and proteins can slow gastric emptying. Gastric emptying is the process by which food exits the stomach and enters the duodenum. The duodenum, the first section of the small intestine, aids digestion by secreting enzymes into the material passing down from the stomach. By slowing down gastric emptying the food matter is absorbed more slowly by the body which reduces blood glucose levels. Examples of foods with high fat and protein content include peanut (GI 33), and potato chips (GI 54) (Queiroz *et al*., 2012). Like fats and proteins, acid also slows down gastric emptying. Kidney beans are a low acid vegetable with a GI of 28 (Aziz *et al*., 2013).

Highly processed foods have a higher GI compared to their unprocessed equivalents. Processed foods require less digestive processing and give rise to higher levels of blood glucose levels once absorbed by the body. For example, traditional rolled oats have a low GI of 51 whilst processed quick 1-minute oats have a higher GI of 66. The cooking process swells the starch molecules in food and softens it. This speeds up the rate of digestion giving rise to higher levels of blood glucose. The spaghetti which is cooked but firm to touch boiled for 10 -15 minutes has a GI of 44 whilst the same over cooked spaghetti boiled for 20 minutes has a higher GI of 64 (Itam *et al.*, 2012).

1.1.6 Diagnosis of T2DM

Diabetes mellitus is characterized by recurrent or persistent hyperglycemia. The WHO (2006) diagnostic criteria for diabetes include the following: Fasting plasma glucose level at or above (126 mg/dl); Plasma glucose at or above (200 mg/dl) two hours after a 75 g oral glucose load as in a glucose tolerance test; Symptoms of hyperglycemia and non-fasting plasma glucose at or above 200 mg/d; and Glycosylated hemoglobin (hemoglobin A1C) at or above 6.5. It is also recommended that oral glucose tolerance test (OGTT) should be

used in individuals with fasting plasma glucose of (110–125 mg/dl) to determine their glucose tolerance status (WHO, 2006).

Impaired Fasting Glycaemia (IFG) is an elevated non diabetic fasting blood glucose level. It is defined by fasting plasma glycaemia (FPG) ≥110 mg/dl − <126 mg/dl (and if measured) 2-hour plasma glucose <140 mg/dl. Impaired Glucose Tolerance (IGT) is defined by 2-hour plasma glucose ≥140 to 200 mg/dl (and if measured) fasting plasma glucose (FPG) 140 mg/dl and diabetes is diagnosed by FPG ≥140mg/ dl or 2-hour plasma glucose ≥200 mg/dl (WHO, 2006). Both IFG and IGT are transitional stages in the development of type 2 diabetes. Table 1 summarizes the WHO (2006) recommendations for the diabetes mellitus diagnostic criteria and intermediate hyperglycemia.

Table 1: Diabetes mellitus diagnostic criteria and intermediate hyperglycemia.

Condition	**2 hrs Post prandial glucose**	**Fasting glucose**
	Mg/dl	Mg/dl
Normal	<140	<110
Impaired fasting glucose	<140	≥110-<126
Impaired glucose tolerance	≥140	<126
Diabetes mellitus	≥200	≥126

Source: WHO (2006)

1.2 Problem Statement and Justification

Type 2 diabetes mellitus is a non- communicable chronic disease that affects many people in the population especially after the age of 40 years. The trend of the disease in Tanzania has doubled as compared to the situation in the last ten years (TDA, 2005). People living in

urban areas have been mostly at risk of the disease as opposed to those living in rural areas (FAO, 2006). The prevalence rate of the disease has increased to more than 5.8% on adult population living in towns (Kolling *et al*., 2010). The disease is increasing an economic burden on the families and on the national budget for health care over and above the burden caused by HIV/AIDS, malaria, and under-nutrition related disorders. The cost of treatment for a diabetic patient accounts for a quarter of the annual wage earned by a medium wage earner (Mosha and Rashid, 2010).

A study which was conducted in Dar es Salaam indicated that, only 1 out 5 diabetic patients was receiving public financial support for treatment of the disease (Ramaiya, 2005). Moreover, awareness of the disease among the people is still a major challenge as education about diabetes has reached only those who are already affected. Also, diagnosis and treatment of diabetes particularly for people in the rural areas is still limited (Ramaiya, 2005). Furthermore, there is very little data on the level of awareness and prevalence of type 2 diabetes mellitus in developing countries (Ramachandran *et al.*, 2004). There is also a problem with dietary management of type 2 diabetes mellitus due to the fact that the glycemic index and glycemic load of our local foods are not known. This study is designed to fill these gaps by assessing the prevalence, awareness, and management of type 2 diabetes mellitus in communities in Mwanza City and assess the GI and GL of the local staples so as to come up with best solution on the management of type 2 diabetes mellitus using available local foods.

1.3 Objectives

1.3.1 Main objective

To assess the current prevalence, awareness and management of type 2 diabetes mellitus in Mwanza City so as to reduce the prevalence rates and improve management of T2DM.

1.3.2 Specific objectives

i. To determine the prevalence of type 2 diabetes mellitus among people aged 30 and above years in Mwanza City.
ii. To assess nutritional status (Body Mass Index (BMI), Waist Hip Ratio (WHR), and body fat mass) of the respondents.
iii. To assess awareness of people on the causes, management, complications for type 2 diabetes mellitus in the study area.
iv. To assess the lifestyles behaviors and associated risk factors among respondents.
v. To determine the glycemic index and glycemic load of commonly eaten staple foods.
vi. To assess the management of type 2 diabetes mellitus patients.

1.4 Organization of the Thesis

This thesis is organized in three chapters. The first chapter consists of the extended abstract and introduction of the overall theme studied. It offers a description of the commonality of the concepts being presented in separate papers. This section also includes the methodology used to collect the information's in this study. Chapter two contains a series of originally published papers consisting of one or two objectives of the study in different journals and the last chapter presents conclusion and overall implication of the study findings.

1.5 Methodology

1.5.1 Description of the study area

The study was conducted in Mwanza City, which is located in the Northern part of Tanzania between latitude 20^0 15' and 20^0 45' South of Equator and longitudes 320^0 45' and 33^0 00' East of Greenwich. The City covers 1 324 km^2 out of this 424km^2 is dry land and 900 km^2 covered by water. The estimated population of Mwanza City was 924 221 (445

535 males and 478 686 females) with growth rate of 3.2% and the average per capita income of Mwanza is US $ 21 per month. Major ethnic groups are Sukuma, covering 90% of the total population, and the rest are Zinza, Haya, Sumbwa, Nyamwezi, Luo, Kurya, Jita, and Kerewe (URT, 2012). The City represents urban living conditions with heterogeneous characteristics. Mwanza City is one of the areas reported to have high prevalence rate of non-communicable diseases in Tanzania (Njelekela *et al.*, 2003). The economy of Mwanza region is dominated by small holder farmers producing rice, cotton and maize. The fishing industry, mining and livestock keeping sectors are also major sources of livelihood in the region. Mwanza City has six hospitals led by Bugando Medical Centre a referral hospital, 12 Health Centers, and 52 Dispensaries (Mwanza Socio Economic Profile, 2010).

1.5.2 Research design

Cross-sectional community random blood glucose testing was conducted to identify those at risk of T2DM. Thereafter, fasting blood glucose testing followed to confirm the cases. The cases were then allocated to intervention study for 12 months.

1.5.3 Study population

The study population comprised adults (males and females) aged 30 years and above who were residing in Mwanza City for at least 3 months. Mentally ill people and pregnant women were excluded from the study.

1.5.4 Sampling techniques

A multistage random sampling technique was used to obtain representative districts and wards as described by Kothari (2006). Six wards from Ilemela and Nyamagana districts were randomly selected. From each ward, four streets were randomly selected and from each street 27 households were randomly selected by using random table numbers. At the

household, subjects were stratified by sex. From the age group of 30 years and above a representative sample was randomly selected. A cross-sectional study design was employed to determine the prevalence and identify those at risk of T2DM. A fasting blood glucose testing was done twice for those with elevated blood glucose to confirm the cases.

1.5.5 Sample Size

Sample size was calculated using the formula by Daniel (1999) for prevalence studies.

$$n = \frac{Z^2 P(1-P)}{d^2} \quad \ldots\ldots(1)$$

Where

n = sample size,

Z = Z statistic for a level of confidence,

P = expected prevalence or proportion (in proportion of one; if 20%, $P = 0.2$), and

d = precision (in proportion of one; if 5%, $d = 0.05$).

Z statistic (Z): For the level of confidence of 95%, which is conventional, Z value is 1.96 with 95% confidence intervals (CI). The prevalence for diabetes mellitus used was 2.6% in Tanzania (Sobngwi, 2001) and the prevalence was smaller than 10% thus, half of P was used (Naing, 2006). Therefore, the sample size was $1.96^2(0.026)\ (1\text{-}0.026)/\ (0.026)^2{}_{/2}$ with 24% attrition rate to cover the dropouts, then the sample size was 640 respondents.

1.5.6 Data collection

1.5.6.1 Construction of the questionnaires

Two questionnaires were constructed to solicit information from the subjects. The first questionnaire was for baseline survey, which included four sections. Section A established rapport; section B solicited information about awareness of diabetes, causes, risk factors,

age most affected by a disease**.** Section C gathered information about lifestyle behaviors of the respondents. Section D solicited information about anthropometric measurements, body composition, blood pressure and blood glucose levels.

Another questionnaire was constructed to assess the management of T2DM among respondents who were confirmed to be diabetic and were subjected to the intervention study for 12 months. The questionnaire consisted of four sections whereby section A consisted of demographic information, Section B solicited information about lifestyle characteristics of respondents which included food frequency and 24 hour dietary recall. Section C solicited information concerning anthropometric measurements, blood pressure, and blood glucose levels to see the effects of the intervention. Moreover, physical activity questionnaire to assess the physical activities levels was attached. Section D collected information regarding accessibility to treatment and general care and management practices of diabetes at individual and at clinical level.

1.5.6.2 Pre - testing of the questionnaires

The questionnaire for the baseline survey was pre-tested in Morogoro urban on 20 subjects (males and females) aged 30 years and above. The second questionnaire on the follow-up study was pre tested on ten diabetic patients in the study area who were not participating in the study. The necessary adjustments were incorporated into the questionnaires.

1.5.6.3 Training of enumerators

Before administration of the questionnaires five enumerators were trained for one day on ethical issues and on how to interview the respondents, proper recording of the answers and taking measurements. The target of the study were males and females, 30 and above years. The pre-tested questionnaires were administered to the subjects by face- to- face interview

through home visits during the morning, evening or midday hours. In case none of the parents were found at home the enumerators were supposed to return back on the following day.

1.5.6.4 Nutritional status, body composition and biochemical measurements

Nutritional status was measured using anthropometric measurements:

i. Anthropometric measurements

Weight was measured using standard weighing scale (digital electronic SECA scale; Model 8811021659, Germany) that was kept on a firm horizontal surface. The subject was weighed without shoes and with light clothing and the weight was recorded to the nearest 0.1g. Height was measured using stadiometer (model No PE-AIM-101-USA) and recorded to the nearest 0.1cm. Subjects were requested to stand upright without shoes on with their back kept against the wall and heels put together in a V-shape and looking forward. Body mass index (BMI) was calculated using the formula, weight (kg)/height^2 (m^2). Waist circumference was measured by a non – stretchable measuring tape (SR-18, USA) to the nearest 0.1cm. Waist circumference was taken at the mid –point between the costal margin and iliac crest, with the subject standing erect in a relaxed position and feet placed 25-30 cm apart. Hip circumference was measured at the level of the greater trochanters (widest portion of the hip) using non-stretchable measuring tape and the circumference recorded to the nearest 0.1cm while the subject was standing with arms on side and feet together. The waist and hip circumferences were used to determine waist hip ratio, which was a marker for cardiovascular disease risks.

ii. Body composition measurement

Total body composition was determined by using Bioelectric Impedance (BIA) Body Composition Analyzer (BF 350, TANITA Corporation. Japan). A subject was requested to stand on the electrodes without shoes and minimum clothing and gender and age should be recorded first before the weight and fat percentage to be displayed. Lean body fat mass was determined by difference.

iii. Biochemical measurements

Random blood glucose (RBG) for the subjects was measured by trained enumerators at the baseline screening by standardized Gluco Plus machine (Glucometer Type 25 KB JPG) using capillary finger prick method. Respondents with RBG ≥ 200 mg/dl on succeeding day fasting plasma glucose (FPG) was done on them. A person was confirmed to have diabetes when fasting plasma glucose was ≥126mg/dl.

1.5.6.5 Case identification and intervention study

Possible cases of diabetes mellitus were identified through screening. The cases were placed in the nutrition and lifestyle education intervention program for one year. The intervention study comprised only diabetic patients who attended Bugando clinic for the management of diabetes. These adults were males and females aged 30 years old and above residing in Mwanza City for one year during the clinical management of T2DM. Seventy six participants were included in the study where by at the end only 61participants remained. The drop out was because of various reasons such as including schedule conflict (n=3), lost the follow-up track (n=5) and unforeseeable circumstances (n=4).

The intervention continued for a period of 12 months and were followed at intervals of three months to check body mass index (BMI), blood glucose level, waist hip ratio (WHR)

and blood pressure to assess the effects of nutritional education and lifestyle modification intervention.

1.5.6.6 Dietary assessment

(i) Food frequency

Food frequency questionnaire with foods list and frequency response was used to assess how frequently the food items in question were consumed by diabetic subjects. During the interview respondents were required to explain how frequent the food items in question were consumed within three months of living in that particular area. Frequency of consumption was grouped into five categories as follows: Foods never consumed means the food was not consumed in a specific period, foods less consumed means the food was consumed 1-2 days per week, foods moderately consumed means the food was consumed 3-5 times per week, foods highly consumed means the food was consumed 6-7 days per week, occasionally consumed means the food was consumed once per month.

(ii) A 24 hour dietary recall method

The follow up diabetic subjects were asked about foods consumed in the past 24 hour. This was done for three days, (one weekend and two weekdays). The detailed descriptions of all foods and beverages consumed, including the quantities, cooking methods and the types of cooking oil used were recorded. The quantities of foods consumed were estimated using household measures such as cups, bowls and spoons and quantified in milliliters and grams.

1.5.6.7 Measurement of glycemic index of common staples

Glycemic index (GI) of the most commonly consumed staple foods used for the management of type 2 diabetes mellitus were determined by a method by Wolever *et al*., (2008). Ten volunteers were given a serving of the test-food containing 50 grams of

digestible (available) carbohydrate and rising and falling level of glucose was measured from the blood sample and recorded after every 15 minutes in first hour. Thereafter, glucose was measured after every 30 minutes in the second hour and recorded. The values of glucose concentrations were recorded on a graph paper and the shape of the curve plotted. The area under the curve was the GI of that particular food. The average glycemic index for 10 respondents was the glycemic index of that particular food.

The glycemic load (GL) of a food is calculated by multiplying the glycemic index by the amount of carbohydrate in grams provided by a food and dividing the total by 100 (Barclay *et al*., 2005). Dietary glycemic load is the sum of the glycemic loads for all foods consumed in the diet. The concept of glycemic load was developed by scientists to simultaneously describe the quality (glycemic index) and quantity of carbohydrate in a meal or diet. The glycemic load of a food tells how much eating that food raises blood glucose. It is a similar concept as the glycemic index, except it takes serving sizes into account. Therefore, the GL provides a summary measure of the relative glycemic impact of a typical serving of the food. Foods with a GL ≤10 have been classified as low GL, and those with a value ≥20 as high GL (Powell, 2002). The GL is the product of a food's GI and its total available carbohydrate content: glycemic load = [GI × carbohydrate (g)]/100.

1.6 Data Analysis

Data were analyzed using Statistical Package for Social Science (SPSS) version 16. Descriptive statistics of body mass index, age, and glucose level, glycemic index of foods sex, waist hip ratio and fat mass were computed and expressed as frequency distribution, percentage and mean ± standard error of the mean. Chi square test was computed to test the dependency/relationship between the categorical variables which were awareness of causes, lifestyles and risk factors for developing a disorder and management of the disease.

Multiple regression analysis was done to predict the relationship between independent variables (risk factors) and response variable (glucose levels). Student t test and analysis of variance (ANOVA) were performed to evaluate differences among the means of different samples. A difference was considered to be significant at $p \leq 0.05$.

Glycemic index data were analyzed according to the method recommended by Arvidssonne *et al*., (2004). The incremental area under the glucose response curve (AUC) above the fasting glucose concentration was calculated. The AUC of each subject after taking each test food was expressed as a percentage of the mean and AUC elicited by the reference food in the same subject. The mean of these values for all the subjects gave the food GI. IAUCG and GI were calculated using trapezoidal rule. Statistical differences between the GI values of the different foods were investigated by comparing the means in SPSS. P values of ≤ 0.05 were considered significant.

1.7 Ethical Consideration

Ethical clearance to conduct this study was obtained from Medical Research Coordinating Committee (MRCC) with reference number NIMR/HQ/R.8a/Vol. IX/1322. After the objectives and benefits of the study were explained to the subjects, they were requested to sign an informed consent form to affirm their willingness to participate in the study. Confidentiality of the collected data was assured. Permission to conduct the study was also obtained from Mwanza region and from Ilemela and Nyamagana district health authorities and also from Bugando referral hospital.

CHAPTER TWO

PAPER ONE

Prevalence and Awareness of Type 2 Diabetes Mellitus among Adult Population in Mwanza City, Tanzania

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Prevalence and awareness of type 2 diabetes mellitus among adult population in Mwanza city, Tanzania

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Abstract: Type 2 diabetes mellitus (T2DM) prevalence is increasing rapidly around the world. This cross-sectional study was conducted to assess the prevalence and awareness of type 2 diabetes mellitus in Mwanza city, Tanzania. A multistage random sampling technique was used to obtain representative subjects. Information about causes and risk factors were collected using structured questionnaire. In addition, community random blood glucose testing was employed to identify those at risk. Subjects with ≥200mg/dl on the following day were subjected to fasting blood glucose testing and they were confirmed to have T2DM if they had blood glucose level of ≥126mg/dl. In each subject, height, weight, waist and hip circumferences and total fat and fat free mass were measured using standard procedures. A total of 640 participants were included in this study, 55% were females and 45% were males. Mean age of the respondent was 43.84 ± 10.80 years. Most (46.4%) respondents were in the age group 30-40 years. Mean age for females was 44.0 ± 10.31 years while for males was 43.6 ± 11.3 years (Table 1). Overall prevalence of T2DM was 11.9%, (n=76). Prevalence was high in females (7.2%; n=46) than in males (4.7%; n=30). The age between 41-50 years had the highest prevalence of T2DM 28.6% followed by 51-60 years age group (17.2%). Significant independent associations were found for age (OR 3.88, 95% CI: 2.16-6.95) positive first degree relative with T2DM (OR 1.34; 95%C: 1.10-1.64) alcohol intake (OR 1.23; 95%CI: 1.02-1.48,) smoking (OR 3.86; 95%CI: 2.57-5.78) and hypertension (OR 0.096; 95%CI: 1.954-18.251). Only 49.2 (n=315) of the respondents knew about the causes and symptoms of T2DM. Public education on T2DM should be emphasized and routine measurement of blood glucose levels is recommended among adults.

Keywords: diabetes, type 2, prevalence, awareness, urban, Tanzania

Introduction

Diabetes is a chronic, non-communicable disease, characterised by high levels of glucose in the blood. It occurs either because the pancreas stops producing the hormone insulin (Type 1 diabetes), or through a combination of the pancreas having reduced ability to produce insulin alongside the body being resistant to its action (Type 2 diabetes) (OECD (2011). Prevalence of type 2 diabetes mellitus (T2DM) is now increasing rapidly around the world and emerging as a global health problem that is expected to reach pandemic levels by 2030 (Wild *et al*., 2004; Shaw *et al.,* 2010). It is estimated that 439 million people globally, will have T2DM by 2030 (Chamnan *et al.*, 2011). This increase will be noticeable in developing countries where the number of people with T2DM is expected to increase from 84 million to 228 million people (IDF, 2009), and this would be more than 75% of the world population (Egede & Elis, 2010).

Chronic diseases, including T2DM, have been rising in sub Saharan Africa currently due to urbanization and changing lifestyle characteristics. With the increase of life expectancy which causes elderly population to continue growing and eventually, the burden of chronic diseases has been increasing in recent years (Gillepsie & Haddad, 2003).

In Tanzania, between 18 and 24 % of deaths are attributable to non-communicable diseases (NCD) and injuries (AMMP, 1997). The non-communicable diseases contributing most to overall mortality are cardiovascular diseases, cancer, central nervous system diseases, diabetes and chronic respiratory disease (AMMP, 1997). In Tanzania, there is a marked variation

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in the prevalence of diabetes among rural (<2%) and urban (>5%) populations (Aspray *et al*., 2000) and higher in people of Asian origin (>7%) (Ramaiya *et al*., 1991).

Diabetes is a silent disease in which many sufferers become aware that they are sick only when they develop one or more of its life-threatening complications (Wee *et al*., 2002). Complications from T2DM include blindness, renal disease and amputation among others (Dart *et al*., 2013). In Tanzania limited efforts have been devoted to educate the public about diabetes through the public media, but the impact of such efforts has yet to be evaluated (TDA, 2005). General knowledge on diabetes mellitus to the community can assist in early detection of the disease and reduce the incidence of complications. Overweight, obesity, unhealthy diet, tobacco use, alcohol consumption, high blood pressure, high cholesterol levels, and lack of physical activity have been described as the major risk factors for non-communicable diseases including diabetes (WHO, 2009).

It is not known how much the public actually knows about diabetes through the current programmes. Knowledge on the level of public is crucial to health educators to plan for future programmes related to T2DM (Cullen & Buzek, 2009). Furthermore there are limited reports available on the level of knowledge on diabetes in the general population in Tanzania (Nguma, 2010). It is important for the public to be aware of T2DM because knowledge is a critical component of behavioural change (Mahrooqui *et al*., 2013). Once awareness is created, people are more likely to participate in prevention and control measures (Ericksson *et al*., 2001). The objective of this study was therefore, to determine the prevalence and awareness of T2DM among residents of Mwanza city, Tanzania. The information from this study will be useful in educating the communities on risks factors and possible interventions and control measures against T2DM.

Material and Methods

Study area

The study was conducted in Mwanza city, Tanzania which is located in the north-western part of Tanzania between latitude $1^{o}30'$- $3^{o}0'S$ and longitudes $31^{o}45'$-$34^{o}10'E$. The estimated population is 706,453 with 3.2% growth rate. Majority of Mwanza people a self employed involved in petty business, peasantry and micro fishing activities. The average per capita income of Mwanza city is US$ 21 per month (URT, 2012).

Sampling and sample size

A multistage random sampling technique was used to obtain representative districts and wards as described by Kothari (2006). Six wards from Ilemela and Nyamagana districts were randomly selected. From each ward, four streets were randomly selected and from each street 27 households were randomly selected by using random table numbers. At the household, subjects were stratified by sex. From the age group of 30 years and above a representative sample was randomly selected. Sample size was calculated using the formula by Daniel (1999) for prevalence studies. Using a prevalence rate of T2DM in Tanzania as 2.6% (Sobngwi *et al*., 2001), the sample size was estimated at 640 subjects (320 per district) was obtained. The study population comprised of adults (males and females) aged ≥ 30 years residing in Mwanza city for at least 3 months prior to the study. Mentally ill people and pregnant women were excluded from the study. A cross-sectional study design was employed to determine the prevalence and identify those at risk of T2DM. A fasting blood glucose testing was done twice for those with elevated blood sugar to confirm the cases.

Data collection

A structured questionnaire was constructed to solicit information from the subjects. Seven aspects of awareness concerning Type 2 Diabetes mellitus were examined from the study namely. These were knowledge of diabetes, symptoms, causes, group most affected, management of the disease, risks factors and complications of diabetes. Section three

solicited information about lifestyle characteristics and other associated risks for type 2 diabetes mellitus. The questionnaire was pretested for its validity and was amended accordingly prior to administration. Questionnaires were administered using face to face interview in the morning, at noon and afternoon and also measurements were taken during the same time. For those subjects with increased blood glucose level of ≥200mg/dl fasting blood glucose was done on them on the following day.

Anthropometric measurements

Weight, height, and waist circumference (WC) were measured according to standard procedures (WHO, 2004). Weight was measured using a standard weighing scale (digital electronic SECA scale; Model 8811021659, Germany) that was kept on a firm horizontal surface. The subject's weight was recorded to the nearest 0.1g. Height was measured by using a stadiometer whereby subjects were requested to stand upright without shoes with their back against the wall and heels put together, in a V-shape and looking forward. Body mass index was calculated using the formula, weight (kg)/height (m^2) and categorized as proposed described by WHO (2004). Waist circumference was measured by a non–stretchable measuring tape to the nearest 0.1cm taken at the mid –point between the costal margin and iliac crest, with the subject standing erect in a relaxed position and feet placed 25-30 cm apart. The waist circumference was recorded to the nearest 0.1cm. Hip circumference was measured at the level of the greater trochanters (widest portion of the hip) using a non-stretchable tape while the subject was standing with arms on side and feet together. The hip circumference was recorded to the nearest 0.1cm.Waist and hip circumferences were used to determine waist hip ratio. Information on demographic characteristics, lifestyle behaviour, risk behaviours and awareness were collected.

Blood pressure (BP) was measured by using standard protocol. Three serial measurements of BP were taken one minute apart, using a digital blood pressure monitor sphygmomanometer (CH-432B, Citizen Systems Japan Co Ltd) with subjects in the sitting position. The BP was measured after the subject had rested for at least 5 minutes. Total body fat composition was determined by using Bi-electric impedance (BF 905, Maltron, UK) (BIA) method. A subject was requested to stand on the electrodes without shoes and minimum clothing.

Biochemical measurement

Random blood glucose (RBG) of the subjects was measured at the time of the interview by using a standardized Gluco Plus machine (Glucometer Type 25 KB JPG) using capillary finger prick method. Subjects with RBG ≥ 200 mg/dl were requested to do a follow up fasting plasma glucose (FPG) whereby they were requested to fast for at least 8 hrs to confirm if they were normal or diabetic. A person was confirmed to be diabetic when Fasting Plasma glucose was ≥126mg/dl.

Ethical consideration

Ethical clearance certificate to conduct this study was obtained from the Medical Research Coordinating Committee of the National Institute for Medical Research (NIMR/HQ/R.8a/Vol. IX/1322) after the objectives and benefits of the study were explained to the subjects. A written informed consent was sought before any of the individual was enrolled in the study. Confidentiality of the collected data was assured. Permission to conduct the study was obtained from Mwanza Region and from Ilemela and Nyamagana district health authorities.

Data analysis

Comparison was done by student t-test for continuous variables and $\chi 2$ –test for categorical variables. Multiple regression analyses were conducted to control the effects of potential confounding factors. All diabetic risk factors and other potential risk factors, were entered into regression model, with diabetes (0 =no, 1 =yes) as the dependent variables. Categorical data were expressed as frequency and percentages and compared by Chi-square test and non-parametric test in different subgroups or proportion in case of the violation of normal distribution. Normal waist hip ratio for women was <0.80, overweight 0.80-0.84 and ≥ 0.85 was obesity while in men < 0.90 was normal weight, 0.90-0.99 was overweight and ≥ 1 was obese (WHO, 2008b). Body-fat-percent categories for this analysis were as follows: 10%, under-body-fat, 10% to 20% normal-fat, 20% to 25% over-fat and >25% higher-body-fat (Yamashita *et al.*, 2012).

Results

Demographic, biochemical and anthropometric characteristics

A total of 640 participants were included in this study of whom 352 (55%) were females and 288 (45%) were males. More respondents had 30-40 years (46.4%) while age group >60 years were few (11%). The mean age and standard deviation for the study participants (SD) was 43.84 ± 10.80 years. Mean age for females was 44.0 ± 10.31 years while for males was 43.6 ± 11.3 years (Table 1). There were 64.5% respondents having primary level of education while only 9.8% were having college level of education where males showed significantly ($p<0.05$) higher education level than females. There were 34.37% respondents dealing with petty businesses while 28.4% were waged employees. In the study population 68.7% were married 17.8% singles, 5.4% divorced, and 7.9% widowed. Most of the respondents 47.65% earned less or equal to US$43.75 per month while only 1.1% earned higher or equal to US$625 per month. Males earned significantly higher incomes than females counterparts ($p<0.05$).

The mean percentage fat mass for the study population was 24.42±10.31. The mean body fat mass percentage for females (27.86±10.52%) was significantly higher than that of the males (20.07 ± 8.20%) ($p<0.05$). The mean systolic blood pressure was significantly higher in males (139.11±68.04 mmHg) than in females (128.82±20.11 mmHg). The overall mean BMI was 25±5.1 kg/m^2. The mean BMI for females was significantly higher (26.26 ± 5.50kg/m^2) than of males (23.42±4.14kg/m^2) ($p<0.05$). The overall mean blood glucose level was 103.82 ± 47.52 mm/dl and it was similar between male and female respondents (Table 1).

Prevalence of Type 2 diabetes mellitus by age and sex

During this study 76 (11.9%) respondents were diagnosed with type 2 diabetes mellitus with mean value of 103.8 ± 47.5 Table 1. The crude prevalence of diabetes was 4.7% for males and 7.2% for females figure 1. impaired fasting glucose (IFG) (110-125 mg/dl) was 3% to 3.9% for males and females respectively Figure 1. Diabetes and IFG was found to be higher in females than in males. Age has an overall effect on diabetes. It was found to be the most important factor. Diabetes tends to increase with increasing age as it is shown to be high in 41-60 years and tend to decrease in >60 years for both men and women ($p<0.05$) Table 2.

Table 1: Socio-demographic, biochemical and anthropometric characteristics

Characteristic	Value/response	Total No. (%) (n=640)	No. females (%) (n=352)	No. males (%) (n=288)
Education level	Informal	64(10.00)	46(13.120	18 (6.22) *
	Primary	413(57.22)	248(70.510	165 (57.39)
	Secondary	100(62.53)	31(8.82)	69 (24.00)
	College	63(9.81)	27(7.71)	36 (12.51)
Marital status	Single	114(17.82)	46(13.11)	68 (23.63) *
	Married	440(68.70)	236(67.00)	204 (70.83)

	Divorced	35(5.43)	25(7.13)	10 (3.52)
	Widow/widower	51(7.92)	45(12.84)	6 (2.12)
Age group (years)	30-40	297(46.40)	154(43.84)	143 (49.72)
	41-50	174(27.13)	100(28.46)	74 (25.71)
	51-60	98(15.34)	62(17.67)	36 (12.51)
	>60	71(11.09)	36(12.51)	35 (12.22)
Income per month	<43.74$	305(47.60)	190(54.00)	115 (39.91*
	43.74-62.5$	183(28.52)	102(29.2)	81 (28.12)
	62.5-311.875	131(20.44)	54(15.32)	77 (26.71)
	312.5-624.375	14(2.13)	2(0.65)	12 (4.22)
	>625$	7(1.12)	4(1.17)	3 (1.00)
Occupation	Formal sector	54(18.81)	35(9.92)	89 (13.91)
	Private sector	20(6.90)	17(4.83)	37 (5.82)
	Self employed	31(10.91)	25(7.15)	56 (8.84)
	Farmer	80(27.84)	61(17.32)	141 (22.00
	Housewife	5(1.72)	72(20.58)	77 (12.00)
	Not working	1(0.33)	0(0.00)	1 (0.23)
	Entrepreneurship	83(28.85)	137(38.93)	220 (34.44)*
	Students	14(4.91)	5(1.44)	19 (3.00)
Biomedical/Anthropometric	Age in (years)	43.82 ± 10.81	44.03 ± 10.31	43.63 ± 11.42
	Fat mass (%)	24.42 ± 10.31	27.86 ± 10.52	20.07 ± 8.20*
	Blood glucose levels(mm/dl)	103.82 ± 47.52	105.72 ± 54.91	101.52± 36.51
	Systolic pressure ((mmHg)	133.41 ± 48.21	128.82 ± 20.11	139.11± 68.04*
	Diastolic pressure (mmHg)	83.51 ± 14.02	82.22 ± 13.41	83.52 ± 15.13
	BMI kg/m2	25.03 ± 5.11	26.26± 5.50	23.42 ± 4.14*
	Waist/hip ratio	0.90 ± 0.22	0.89 ± 0.23	0.90 ± 0.13*

Mean with SD for clinical and frequency and percentages for socio-demographic data. Significant at *p= <0.05 by student t test and $\chi 2$

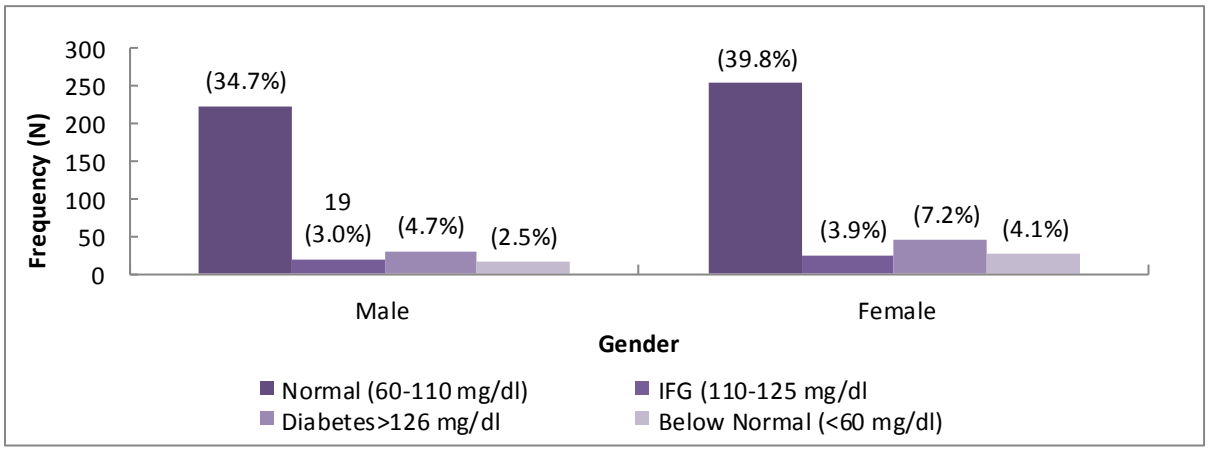

Figure 1: Prevalence of type 2 diabetes and impaired fasting glucose (n=640)

Diabetes prevalence increased with increasing age, and it was highest in the 41-60 years old group (Table 2).

Table 2: Prevalence of type 2 diabetes mellitus by sex and age (%)

Age group	Male (n=288)	Female (n=352)	Total (n=640)
30-40	3(10.0)	7(15.2)	10(13.2)
41-50	14(46.7)	16(34.8)	30(39.5)
51-60	9(30.0)	19(41.3)	28(36.8)
>60	4(13.3)	4(8.7)	8(10.5)
Total	30(4.7)	46(7.2)	76(11.9)

Significant at p<0.05

Relationship between diabetes and some selected risk factors

Univariate logistic regression analysis of percentage fat mass, BMI, hypertension systolic blood pressure, diastolic blood pressure, waist hip ratio, smoking behaviour, alcohol intake, age, sex, hypertension and first class relative with T2DM was conducted. The model revealed that other variables were not significantly related to T2DM, therefore were removed from the model. Significant variables remained in the model for further analysis by binary logistic regression adjusting for confounding factors by backward conditional. Significant independent association were found for Age (OR 7.36, 95% CI 3.08-17.56) positive first degree relative (OR 1.16; 95%, 95%C1: 0.56-2.42) sex (OR 0.22; 95% CI: 0.09-52) smoking, (OR 66.9; CI: 28.97-154.49) and hypertension (OR 0.096; 95%CI: 1.954-18.251). BMI, systolic blood pressure, and diastolic blood pressure were not significantly related with T2DM.

Table 3: Multivariate regression models for the relationship between T2DM and some selected risk factors

Variable	Response/Value	Frequency	OR	P-value	95%CI
Sex	Male	288			
	Female	352	0.22	0.001*	0.09-0.52
Age	≥40	342			
	≤40	298	7.36	0.000*	3.08-17.56
Smoking	Smokers	106			
	Non smokers	534	66.90	0.000*	28.97-154.49
1st Degree relative to T2DM	Yes	156			
	No	484	1.168	0.031*	0.56-2.42
SBP	≥140	477			
	≤140	163	0.57	0.212	0.24-1.36
DBP	≥90	169			
	<90	471	0.618	0.298	0.25-1.52
BMI	High	286			
	Low	354	0.69	0.342	0.33-1.46
Hypertension	Yes	232			
	No	408	0.096	0.002*	1.954-18.25

*Significant at p<0.05

Relationship between T2DM and some selected awareness variables

Only 49.2% of the respondents reported that they knew about a condition called diabetes. Only 32.2% of the respondents were aware of the symptoms of diabetes. Knowledge of the causes of diabetes was very low with 83% of the respondents didn't know the causes of T2DM. Slightly over half (54.2%) of the respondents were not aware which age is affected by the disease. Moreover 45.5% of the respondents did not know how to manage the disease through diet, exercises and medication. Regarding knowledge of the risk factors for diabetes it was revealed that, only 29.1% of the respondents had knowledge of the risk factors for T2DM ($\chi 2=57.16$ $p<0.05$). Moreover, only 26.3 % of the respondents were aware of the complications associated with diabetes ($\chi^2=60.57$ $p<0.05$).

Table 4: Relationship between T2DM mellitus and selected awareness variables

Awareness/Knowledge	Response	Number	%	df	P-Value	$\chi 2$
Diabetes disease	Yes	315	49.2	3	0.870	0.07
	No	325	50.8			
Symptoms	Know	206	32.2	9	0.036*	17.97
	Don't know	434	67.8			
Causes	Too much eating and sedentary lifestyle	73	11.4	12	0.136	17.37
	Inherited	31	4.8			
	Not aware	536	83.8			
Age affected	Adults aged >40	215	33.6	12	0.188	16.07
	All age groups	78	12.2			
	Don't know	347	54.2			
Management	Diet and exercise	349	54.5	18	0.000*	111.77
	Don't know	291	45.5			
Risk factors	Know	186	29.1	3	0.000*	57.16
	Don't know	454	70.9			
Complications	Aware of	168	26.3	3	0.000*	60.57
	Not aware	472	73.8			

*Significant at p < 0.05

Discussion

The crude prevalence estimates rates of type 2 diabetes and IFG in the study were 11.9% and 6.9% respectively. Previous studies in urban Tanzania have reported lower prevalence of diabetes (Ramaiya *et al.*, 1991; Aspray *et al.*, 2000). In a recent national survey, 9% of 5,860 adults (25-64years) were found to have raised fasting blood glucose (WHO, 2012). It should be noted that the study by Aspray *et al.* (2000) used the world population, rather than national or district level population, and the findings were adjusted for the age standardization. In the current study the crude prevalence for T2DM and IFG were not adjusted for age. In our study, women had a significant higher prevalence of diabetes than men. Similar findings were reported in the recent national survey (WHO, 2012). In Nigeria, Ekpenyong *et al*. (2012) also found diabetes to be higher among females than males. However, in previous surveys in Tanzania, the prevalence of diabetes in males was similar to that in females (Ramaiya *et al*., 1991; Aspray *et al*., 2000).

Generally, worsening glycaemic status was associated with increasing age, sex, smoking behaviour and first class relative with T2DM. Globally, age and sex have been identified as risk factors for diabetes mellitus. Generally, worldwide diabetes prevalence is similar in men and women, but it is shown to be slightly higher in men greater than 60 years of age (Wild *et al.*, 2004). In this study, diabetes was more prevalent in the women of 51-60 years group. The combined effect of a greater age has an overall effect on diabetes. Age was found to be the most important factor because diabetes tends to increase with increasing age (Cowie *et al.*, 2006). Advanced age showed triple risks of developing T2DM as compared to younger ages. Globally, the largest proportion of people with T2DM is between 40-59 years (Whiting *et al.*, 2011) which was also reflected in this study. The high diabetes prevalence in Mwanza and elsewhere in Tanzania is likely to be associated with several reasons. For instance, life expectancy has slightly increased (MoHSW/IHI/NIMR/WHO, 2013) leading to increased risks to age related metabolic disorders and secondly there is an increased risk of overweight, obesity and sedentary type of activities which have continued to overshadow genetic causes (Nardo *et al.*, 2009; Frank, 2010; Travers & McCarthy, 2011; WHO, 2012).

In this study the mean percent fat mass and mean BMI were found to be significantly higher in females than males. However, the mean systolic blood pressure was significantly higher in males than females. On the other hand, fat mass, BMI level, waist-hip ratio was higher among females than males indicating increasing risk for developing chronic diseases. A study by Wang *et al. (*2005) suggested that, waist circumference and waist-hip ratio (measures of central obesity) were more positively and more significantly associated with T2DM than BMI in males.

Subjects having first class relative with T2DM were more likely to develop T2DM than subjects without positive first class relatives. The present study showed a significant association between family history and incident T2DM, with no remarkable sex difference in the association. These findings are in agreement with previous study elsewhere (Wada *et al.,* 2006; Papazafiropoulou *et al*. 2009). The differences could be due to genetic, environmental or other confounders. Also this study reveals that smokers had higher chances of developing T2DM than non smokers. Cigarette smoking is an independent risk factor for type 2 diabetes and it has been found that current smokers have an increased risk of developing diabetes compared with non-smokers (Bodemann *et al.*, 2007; Ekpenyong *et al.,* 2012). However, in a study in Nigeria smoking status was found to be a significant factor in males only (Ekpenyong *et al.*, 2012).

A significant number of the respondents had little or no knowledge of T2DM. Majority of the subjects did not know the risk factors as well as symptoms for developing T2DM. Lack of exposure to diabetic patients and lack of interest in issues unrelated to them may be the possible explanation for the low scores. For those who were aware knew the disease only by the Kiswahili name "*Kisukari*", and failed to understand the word diabetes mellitus. The study revealed that, awareness about the disease was more related to the affected family member rather than the national education system. Most respondents had no knowledge about the pathophysiology of the disease, preventive measures, and the possible outcomes of the

disease. The respondent's poor knowledge of the pathophysiology of diabetes showed up again in the other questions. Only few knew the complications of T2DM. This poor knowledge may render the general public to be less prudent in taking measures to prevent diabetes. There is a need to highlight the social and economic impact of diabetes in future educational programmes so that the general public would have a better understanding of the severity of the disease. Findings of this study were similar to those by Saleem *et al*. (2009) who reported that knowledge of diabetes mellitus is confined to those with T2DM disease and their relatives.

In conclusion, findings of this study showed very high prevalence of T2DM in Mwanza city as affecting mostly individuals 40-60 years old. Significant independent associations were found for age, sex, first relative with T2DM, and smoking with T2DM. The findings also indicate that knowledge and awareness about T2DM is minimal among Mwanza City residents. It is therefore recommended that awareness about T2DM should be raised starting from young age. Routine checks of blood glucose levels should be done frequently for all adults above 35 years. Health education on causes, risk factors and management of T2DM should be promoted and people should be encouraged to report to health facilities whenever they observe symptoms of T2DM. This would help to control the disease before secondary stage complications develop.

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PAPER TWO

Risk factors associated with elevated blood glucose among adults in Mwanza City, Tanzania

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Risk factors associated with elevated blood glucose among adults in Mwanza City, Tanzania

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ABSTRACT

Type 2 diabetes mellitus prevalence is increasing at alarming rates posing significant health problems in Tanzania. Urbanization with economic advancement has led to lifestyle behaviors such as high intake of dense caloric foods, sedentary lifestyle, smoking, and limited intake of fruits and vegetables. All these have been associated with the higher prevalence of cardiovascular diseases, hypertension and T2DM. This cross-sectional study design was conducted to assess the risk factors and lifestyles characteristics associated with type 2 diabetes mellitus among adults in Mwanza City, Tanzania. A multistage random sampling technique was used to obtain 640 male and females respondents aged 30 and above years. Data were collected through face to face interview by using a structured questionnaire which was constructed to solicit information about risk factors and lifestyle characteristics of the respondents. Anthropometric measurements such as height, weight, waist and hip circumferences and total fat and fat free mass were also taken. Random blood glucose and blood pressure levels were measured. The prevalence of overweight in the studied population was 10.5% in males and 18.1% in females. Most females 60.8% (n=79) had waist hip ratio of ≥ 0.85. BMI and body fat were significantly ($p>0.05$) related to elevated blood glucose. It was further noted that, relationship between diabetic respondents with their first degree relative with diabetes was significant ($p>0.05$). The relative risk for developing type 2 diabetes mellitus by having first class relative with the disease was 2.11, 95% CI: 1.4-3.1. There was a significant ($p>0.05$) association between smoking and elevated blood glucose. Results revealed that, the biggest amount of serving of fruits and vegetables was 250g whereby only 19% of the respondents consumed that amount per day. It can be concluded that it is of utmost importance to intervene, and modify lifestyle of adults so as to reduce the risks of developing T2DM.

Key words: Lifestyles, Risk factors, T2DM, adults, Mwanza City, Tanzania

1. INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a type of diabetes which affects about 90% of the diabetic population globally (WHO, 2013). Globally the prevalence of diabetes is estimated to increase from 4% in 1995 to 5.4% by 2025 (Nather, 2004). The burden of the disease is expected to occur in the developing countries where-by there will be an increase from 84 to 228 million in 2025 (Ramachandran, 2002). T2DM is among the major causes of mortality worldwide. In Tanzania, T2DM is the 14th cause of death which accounts for 1.9% of all causes of death (WHO, 2013). About 5% of the health budget was estimated to be spent in the management of the disease in Tanzania in the year 2010 (Zhang, 2010).

Tanzania and other countries in Sub Saharan Africa are experiencing the most rapid epidemiological transitions. Urbanization with economic advancement has led to lifestyle behaviors such as high intake of dense caloric foods, sedentary lifestyle, smoking, and limited intake of fruits and vegetables. All these have been associated with the higher prevalence of cardiovascular diseases, hypertension and T2DM (Hamada, 2010), (Brown, 2012). Sedentary lifestyle, poor diet and excessive alcohol intake may lead to overweight, obesity, excessive body fat and large waist hip ratios. These are important risk factors for the development of T2DM.

Studies have shown that lifestyle modification, by maintaining a healthy diet with wholegrain starchy foods, fruits and vegetables, participating in regular physical activities, achieving and maintaining a healthy body weight, limiting alcohol intake, and quitting smoking can be effective in controlling many of the adverse risk factors for the development of T2DM (Schulze, 2004; Manumbu, 2011). This study was therefore conducted to assess major risk factors and lifestyles characteristics among adults in relation to the development of T2DM disease in Mwanza City, Tanzania. The results will therefore help health professionals to plan for interventions to modify lifestyles and reduce risk factors for the development of T2DM.

MATERIAL AND METHODS

Description of the Study Area

The study was conducted in Ilemela and Nyamagana district of Mwanza City, Tanzania. Mwanza is located in the northern part of Tanzania, between latitude 1^{o} 30' and 3^{0} 0' and longitudes 31^{0} 45' and 34^{0} 10' 1(URT, 2012). The estimated population of Mwanza City was 924,221 with growth rate of 3.2%. The average per capita income of Mwanza was US$ 21 per month (URT, 2012). Mwanza City had six hospitals, 12 health centers, and 52 dispensaries (Mwanza socio- economic profile, 2010). The majority of Mwanza people are self-employed involved in petty trading, agriculture, and micro fishing activities and those employed are working in the public sector (Mwanza Socio- Economic Profile, 2010).

Study design

Cross-sectional study design was employed to identify those at risk of T2DM. Thereafter, a fasting blood glucose test was conducted for those with elevated blood sugar (200 mg/dl) to confirm the cases. The study population comprised of adults (males and female) of 30 years

old and above who had been residing in Mwanza City for at least 3 months prior to the study. Mentally ill people and pregnant women were excluded from the study.

Sampling techniques and sample size

A multistage random sampling technique was used to obtain representative wards as described by Kothari (2006). Six wards from Ilemela and Nyamagana districts were randomly selected. From each ward, four streets were randomly selected and from each street, 27 households were randomly selected. At the household, respondents were stratified by sex. From the age group of 30 years and above, a representative sample was randomly selected. Sample size was calculated using the formula by Daniel (1999) for prevalence studies,

$$n = \frac{Z^2 P (1 - P)}{d^2}$$

where n = sample size,

Z = Z statistic for a level of confidence,

P = expected prevalence or proportion

(in proportion of one; if 20%, $P = 0.2$), and

d = precision

(in proportion of one; if 5%, $d = 0.05$).

Z statistic (Z): For the level of confidence of 95%, which is conventional, Z value is 1.96.

with 95% confidence intervals (CI).

Because the prevalence for diabetes mellitus used was 2.6% in Tanzania (Sobngwi, 2001) and the prevalence was smaller than 10% thus, half of P was used (Naing, 2006). Therefore, the sample size was $1.96^2(0.026)\ (1\text{-}0.026)/\ (0.026)^2/_2$ with 24% attrition rate to cover the dropouts, approximately 640 respondents.

Data collection

A questionnaire was designed to solicit information about risk factors for T2DM and lifestyle behaviors from the respondents and was pretested prior to the study. Anthropometrics such as height, weight, waist and hip circumferences and total fat and fat free mass were also measured. Current smoking was self-reported and classified as yes/no. Alcohol consumption was determined by inquiring about the number of alcoholic drinks consumed per day and categorized as abstainers 0 units/day, moderate drinkers 1-4 drinks /day, or heavy drinkers ≥ 4 drinks/per day (IDG, 2010). First's degree relative with the diseases was self-reported and classified as yes/no.

Overall fruit intake was assessed by asking how much fruits were eaten per day so as to determine if people were adhering to fruits intake according to recommendations. Dietary guidelines require that people should take five servings of fruits of about 400 g per day in order to have good health (WHO, 2005). Therefore, information about fruits and vegetable intake was assessed by using Nhanes food frequency questionnaire was adopted and changed to suit the study environment and 24 hour dietary recall. Bowls which showed amounts were used to establish the grams which were eaten per days. Also preparation methods of all the foods items were recorded. Physical activities were assessed by adopting international physical activity questionnaire. The questionnaire included frequency and duration of participation in different physical activities and exercises that were used to calculate hours per week at each intensity level. Participants were classified according to guidelines for data processing and analysis of the international physical activities questionnaire (IPAQ). Classification levels were as follows; People are classified as doing heavy activities if they were doing heavy activities for ≥2.5 hours/week of moderate or ≥1 hour/week of vigorous physical activity; sedentary if they were doing sedentary type of activities for ≤1 hour/week of moderate and ≤1 hour/week of vigorous physical activities, or not active if they did less than the active and sedentary do or they were inactive.

Anthropometric measurements

Height and weight were measured using standard procedures (WHO, 2005). Body mass index was calculated and categorized in four groups (underweight, BMI >18.5; normal BMI 18.5-24.9; overweight BMI, 25-29.9; obese BMI, ≥30) on the basis of (WHO, 2004) classification these values were used because no other values to represents African population. Waist and hip circumferences were measured using standard procedures according to (WHO, 2008). Waist circumference was measured by using a non–stretchable tape and the readings were taken at the mid–point between the costal margin and iliac crest, with the subject standing erect in a relaxed position and feet placed 25-30 cm apart. Hip circumference was measured at the level of the greater trochanters (widest portion of the hip) using a non-stretchable tape while the subject was standing with arms on side and feet together. The hip circumferences were thereafter recorded to the nearest 0.1cm. Waist and hip circumferences were used to determine waist hip ratio. Where normal waist hip ratio for women was <0.8, overweight was 0.80-0.84 and obesity ≥ 0.85. While in men < 0.9 was normal weight, 0.9-0.99 was overweight and ≥ 1 was obese. Information on demographic characteristics and lifestyle behaviors were collected by trained interviewers.

Total body fat composition was determined by using Bi-electric impedance (BIA) method (BF 905, Maltron, UK). A subject was requested to stand on the electrodes without shoes on and with minimum clothing. Body-fat-percent categories for this analysis were as follows: 10% for under-body-fat, 10% to 20% for normal-fat, 20% to 25% for over-fat and >25% is higher-body-fat (Yamasita *et al.,* 2012).

Biochemical measurement

Random blood glucose (RBG) of the respondents was measured at the time of the interview by using a standardized Gluco Plus machine (Glucometer Type 25 KB JPG). Respondents with RBG ≥ 200 mg/dl were requested to do a follow up fasting plasma glucose (FPG) on the following day. A subject was confirmed to be diabetic when fasting plasma glucose was ≥126mg/dl.

Blood pressure measurements

Blood pressure was measured by using standard procedures. Respondents were made comfortable in the sitting position. The subject's arm was resting on the desk so that the antecubital fosa were at the level of the heart and a palm was facing up. Three serial measurements of blood pressure were taken one minute apart, using a digital blood pressure monitor sphygmomanometer (make-CH-432B, Citizen Systems Japan Co Ltd) The blood pressure was measured after the subject has rested for at least 5 minutes.

Ethical consideration

Ethical clearance to conduct this study was obtained from Medical Research Coordinating Committee (MRCC) with reference number NIMR/HQ/R.8a/Vol. IX/1322. After the objectives and benefits of the study were explained to the respondents, they were requested to sign an informed consent form to affirm their willingness to participate. Confidentiality of the collected data was assured. Permission to conduct the study was obtained from Mwanza region and from Ilemela and Nyamagana district health authorities. If respondents were identified to have the disease they were given a referral forms to report to Bugando hospital for further check up and clinic registration.

Statistical analysis

Data were analyzed by using SPSS (Statistical Packages for Social Sciences) commander software version 16. Descriptive statistics such as frequency, percentage and cross tabulations were computed for socio-demographic information's. Inferential statistics such as the chi square statistic analysis were computed with 95% confidence interval to find the relationship among lifestyles and risk factors with T2DM. A difference was considered to be significant at $p<0.05$.

RESULTS

Socio-economic and demographic characteristics of the respondents

A total of 640 participants were involved in this study of whom 352 (55%) were females and 288 (45%) were males. Most of respondents had 30-40 years (46.4%) while few (11%) had more than 60 years. About 57.2% of the respondents had primary level of education while only 9.8% had college level of education. Males had a significantly higher education level than females ($p<0.05$). Findings showed that 28.8% of the respondents were dealing with petty businesses while 18.8% were employed in formal sectors. It was further depicted that 68.7% of the respondents were married, while 17.8% were singles, 5.4% divorced and 7.9% widowed. Most of the respondents (47.7%) earned less or equal to 70000Tsh per month while only 1.1% earned higher or equal to 1000000 Tsh per month. Males earned significantly higher incomes than female counterparts ($p<0.05$).

Table1. **Socio-economic and demographic characteristics of the respondents**

Characteristic	**Value/response**	**Total N (%)**	**No. females N (%)**	**No. males N (%)**
Education level	Informal	64(10.00)	46(13.12)	18 (6.22) *
	Primary	413(57.22)	248(70.51)	165 (57.39)
	Secondary	100(62.53)	31(8.82)	69 (24.00)
	College	63(9.81)	27(7.71)	36 (12.51)
Marital status	Single	114(17.82)	46(13.11)	68 (23.63) *
	Married	440(68.70)	236(67.00)	204 (70.83)
	Divorced	35(5.43)	25(7.13)	10 (3.52)
	Widow/widower	51(7.92)	45(12.84	6 (2.12)
Age group (years)	30-40	297(46.40)	154(43.84)	143 (49.72)
	41-50	174(27.13)	100(28.46)	74 (25.71)
	51-60	98(15.34)	62(17.67)	36 (12.51)
	>60	71(11.09)	36(12.51)	35 (12.22)
Income per month Tsh	< 70000	305(47.60)	190(54.00)	115 (39.91*
	70000- 100000	183(28.52)	102(29.2)	81 (28.12)
	100000-499000	131(20.44)	54(15.32)	77 (26.71)
	500000-999000	14(2.13)	2(0.65)	12 (4.22)

	>1000000	7(1.12)	4(1.17)	3 (1.00)
Occupation	Formal sector	54(18.81)	35(9.92)	89 (13.91)
	Private sector	20(6.90)	17(4.83)	37 (5.82)
	Self employed	31(10.91)	25(7.15)	56 (8.84)
	Farmer	80(27.84)	61(17.32)	141 (22.00
	Housewife	5(1.72)	72(20.58)	77 (12.00)
	Not working	1(0.33)	0(0.00)	1 (0.23)
	Petty businesses	83(28.85)	137(38.93)	220 (34.44)*
	Students	14(4.91)	5(1.44)	19 (3.00)

* Significant at p= <0.05

Distribution of different risk components with random blood glucose levels

Findings showed that about 38.8% (n=248) of the screened normal respondents had normal blood glucose levels while 5.3% (n=34) of overweight and 2.3% (n=15) of the obese respondents had higher blood glucose levels. Respondents with elevated BMI had strong association with elevated blood glucose ($\chi2$=22.45, p=0.008) (Table 2). It was observed in the study that about 20.1% (n=43) of females with elevated blood glucose had w:h ratio ≥ 0.85 while 23.5% (n=4) of males with elevated blood glucose had w:h ratio ≥ 1.0. Result revealed further that about 21.4% of respondents with elevated blood glucose had body fat above 25% while 17.2% of the respondents with elevated blood sugar were in over fat category with fat mass of 20-25%. There was a significant relationship between fat mass of respondents and the blood glucose levels ($\chi2$=20.52, p=0.05) (Table 2).

Table 2. Distribution of different risk components with random blood glucose levels (mg/dl)

	Under normal (≤70) N (%)	**Normal (71-139) N (%)**	**Impaired Glucose (140-199) N (%)**	**Diabetic (≥200) N (%)**	**$\chi2$**	**P value**

BMI Kg/m^2						
<18.5	4(0.6)	32(5)	1(0.2)	0(0)	22.45	0.01*
18.5-24.9	25(3.9)	248(38.8)	22(3.4)	27(4.2)		
25-29.9	10(1.6)	126(19.7)	13(2)	34(5.3)		
>30	3(0.5)	72(11.3)	8(1.3)	15(2.3)		
W:H						
< 0.9 men	8(5.3%)	126(83.4%)	5(3.3%)	12(7.9%)	0.081	11.23
0.9-0.99 men	7(5.8%)	86 (71.7%)	13(10.8%)	14(11.7%)		
>1,0 men	1(5.9%)	11(64.7%)	1(5.9%)	4(23.5%)		
< 0.8 in women	5(11.6%)	27(62.8%)	7(16.3%)	4(9.3%)	0.609	4.50
0.8-0.84 women	11(11.6%)	60(63.2%)	8(8.4%)	16(16.8%)		
0.85>0.85women	22(10.3%	125(58.4%)	24(11.2%)	43(20.1%)		
% Body fat						
< 10%	24 (9.9)	182(76)	15(6.2)	19(7.9)		
10-20%	10(4.8)	162(77.9)	14(6.7	22(10.6)	20.52	0.02*
20-25%	6(4.5)	96(71.6)	9(6.7)	23(17.2)		
>25%	2(3.6)	36(64.3)	6(10.7)	12(21.4)		

Figures in parenthesis indicates percentage

*Shows significance at ($p \leq 0.05$)

Distribution of risk factors and selected lifestyle characteristics in males and females with random blood glucose levels

The prevalence of overweight in the studied sample was 10.5% (males) and 18.1% (females) (Table 3). The relative risk of developing type 2 diabetes mellitus for obese or overweight respondents was 0.621, 95% CI: 0.080-1.881. The majority of female respondents had higher fat mass compared to their male counterparts. More than 7.1% (n=46) of respondents who had high percentage body fat mass were females, while only 1.2% (n=8) of the respondents with high percentage body fat mass were males. Most of respondents classified as under fat mass percent were males 64.2% (n=158). There was a significant relationship between body fat mass and sex of the respondents ($\chi 2=85.5$, $p=0.00$) with females having more fat mass percent than their male counterparts (Table 3).

Findings showed that 10.1% (n= 65) of males were smoking and only 0.46% (n=3) of the females had the habit of smoking. There was a significant (P=0.00) association between smoking and elevated blood glucose. The relative risk of developing T2DM if one smokes observed to be 16.23, 95% CI: 9.98-26.39. Prevalence of hypertension was high in 41-50 age group (10.2%, n=65) while the overall prevalence of hypertension was 34.1%. The prevalence of hypertension was 16.7% and 17.3% in females and males, respectively (Table 3). The relative risk of developing elevated blood glucose if one has hypertension was 4.052, 95% CI: 2.553-6.433 (p=0.06). Findings from this study show that 24.37% of respondents had their first degree relatives with type 2 diabetes mellitus. The relationship between diabetic respondents with their first degree relative with diabetes was significant (P=0.00). The relative risk for developing type 2 diabetes mellitus by having first class relative with the disease was RR 2.11, 95% CI: 1.4-3.1.

Table 3. Distribution of risk factors and selected lifestyle characteristics in males and females with random blood glucose levels (N=640)

Category	Sex n (%)		$\chi 2$	P- value
	Male	Female		
BMI				
Underweight	24 (3.8)	13 (2.0)		
Normal	178 (27.8)	144 (22.5)	50.03	<0.001*
Overweight	67(10.5)	116 (18.1)		
Obese	19(3)	79(12.3)		
Fat mass				
Underbody fat <10%	158 (24. 6)	88(13. 7)	85.54	<0.001*
Healthy 10- 20%	94 (14. 6)	116(18. 1)		
Over fat 20-25%	28 (4. 3)	102(15. 9)		
High body fat >25%	8(1. 2)	46(7. 1)		
Smokers				
Smokers	65(10. 1)	3 (0. 46)	45. 06	<0.001*
Non Smokers	223(34)	349 (54. 5)		
Blood pressure				
Hypertension	114 (17.3)	118 (16.7)	12.426	0. 060
Normal	174 (27.7)	234 (38.3)		
First relative with T2DM				

Relative T2DM	60 (9.3)	86(13. 4)	13.245	0.003*
Relative without T2DM	12.426	266(41.5)		

*Shows significant at p ≤0.001 and\ p≤0.05

Fruits and vegetables intake

Findings showed that 31.2% (n=200) of the respondents ate fruits and vegetables once per day while only 27.5% (n=98) ate fruits and vegetables twice per day (Figure 1). More than 10% (n=64) of the respondents did not consume vegetables and fruits in a week. The average serving size for the fruits and vegetables was 250g and only 19% (Figure 2) of the respondents were able to consume that amount per day. The relative risk of developing diabetes mellitus if one doesn't consume fruits and vegetable was 0.90, 95% CI: 0.575-1.446 (p=0.68).

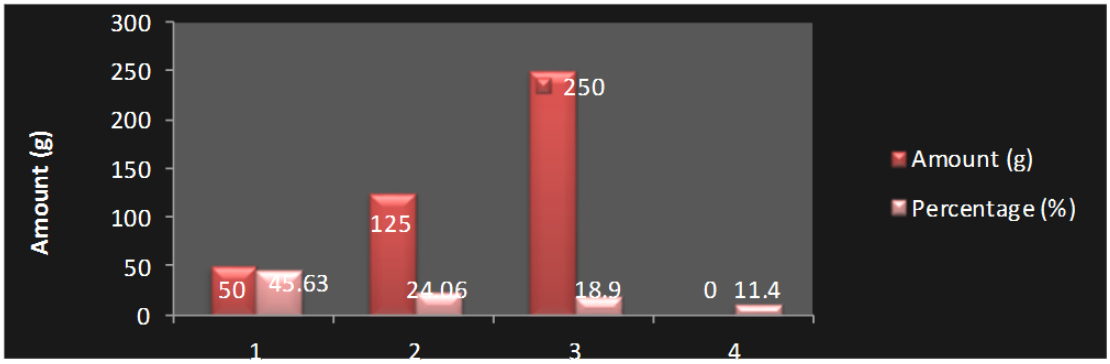

Figure 1. Amount of fruits consumed

Physical activities and exercises

This study revealed that 65.7% (n=421) of the respondents usually walk to, and from their usual activities, 3.6% (n=23) use bicycles as their mode of transport, 25.31% (n=162) used public buses while 5.3% (n=34) use personal cars for transportation. It was also observed that 76.7% (n=491) of the respondents were engaged in sedentary activities. Furthermore, the results indicated that only 4.5% (n=29) of the respondents actively participated in exercises for ≥ 2.5 hours/week of moderate or ≥1 hour/week of vigorous physical exercise. The relative risk of developing T2DM if one does not exercise was RR 1.65, 95% CI: 0.696-1.630, P=0.80.

Alcohol use

Results from this study showed that, 27% (174) of the respondents were used to take alcohol. There was a significant association (P=0.01) between alcohol intake and development of T2DM in the study population. The amount of intake showed that 7.5% (n=48) of the respondents were drinking more than 5 units of alcohol per day while 16.40% (n=105) drank moderate amount per day. The relative risk for developing T2DM due to alcohol intake was RR 1.562, 95% CI: 1.148 - 2.125).

DISCUSSION

These findings indicated that, most of the respondents studied had low education level and hence limited knowledge of the disease. Moreover, most of the respondents earned their livelihoods through small businesses which reflected to their low income of about 70000 Tsh per month. Generally this study revealed that most of respondents with high body fat category and those with over fat were diabetic though the relationship was not significant. It was observed further that females were having higher fat contents compared to their male's counterparts. Studies have shown that fat mass exceeding 32% increased the risk of developing chronic diseases for women (Eyre, 2004). These findings also were consistent with other research done elsewhere which indicated that those who suffer excessive body weight and body fat had increased prevalence of diabetes (Despres, 2006, Perry, 2013).

Increased BMI had shown to be a risk factor for elevated fasting blood glucose level in this study though there was no significant difference. Findings also revealed that women were more overweight and obese as compared to males, and therefore, they had increased risk for developing T2DM. A study by Mokdad, (2003) observed that the prevalence of diabetes increased with increasing BMI. Moreover overweight and obesity were among the most factors that have shown to increase the global diabetes epidemic (Kelly, 2005, Narayan, 2007). They have shown to affect most of adults in developed and developing countries.

Generally, the findings in this study indicated that visceral obesity which is determined by waist circumference (WC) or waist-hip ratio (WHR) is typically seen in overweight and obese males and females. Respondents with elevated blood glucose also tended to have elevated waist-hip ratios. Females had large waist hip ratios therefore more likely to develop increased blood glucose levels eventually T2DM as compared to males though the relationship was not significant. A study by Shah (2009) reported waist –hip ratio to be the best predictor of the risk for developing T2DM among population. Also Wang (2005) suggested that WC and WHR (measures of central obesity) were more positively and significantly associated with T2DM than BMI. Moreover, epidemiologic studies have demonstrated that, waist circumference, waist-hip ratio and obesity were strong and consistent predictors for T2DM (Bray, 2008, Miljkovic, 2008).

The prevalence of hypertension was significantly related with increasing blood glucose levels in this study. The findings revealed that the prevalence of blood pressure was in line to previous findings in the country (Mayige, 2012). Therefore, there is increased risk for the rising prevalence of T2DM as it is attributed by hypertension. According to the study by Feldstein (2002), an estimated 35% to 75% of diabetic complications can be triggered by hypertension. Hypertension and T2DM occur together so frequently that they are considered to be comorbidities diseases likely to be present in the same patient (Weber, 2009). Studies have shown that obesity is the major precipitating factor for both hypertension and T2DM because of the obesity-induced insulin resistance (Landsber, 2013). Furthermore, insulin resistance may contribute to hypertension in diabetic individuals through effects on sodium retention, activation of sympathetic nervous system and direct effects on blood vessels (Paton, 2013).

This study found that the prevalence rate of alcohol users was 27%. These findings were aligned with the prevalence's reported by Mayige, (2012) which were suggested to be 23% to 37% in males and 13% to 23% in females. Moreover, relative risk of developing type two diabetes mellitus was doubled for alcohol users compared to non-alcohol users as stipulated in this study. This study also revealed a significant relationship between alcohol intake and elevated blood glucose. It was suggested that heavy alcohol intake has multiple deleterious metabolic effects, including excess caloric intake and obesity, increased triglyceride levels, pancreatitis, disturbance of carbohydrate glucose metabolism, and impairment of liver function (Manumbu, 2011)

Prevalence of smoking in males was significantly related to elevated blood glucose levels. These findings revealed that respondents who were diabetic were smoking or were formerly smokers. According to available statistics the prevalence of smoking was 11.0% for males and 0.4% for females in Tanzania (Frank, 2011) which was also reflected in this study. It was observed that smokers had 16 times chances of developing diabetes mellitus compared to non-smokers in this study. Results from other studies indicated that active smokers have a 44% increased risk of developing type 2 diabetes compared with non-smokers (Culliton, 2008).

The frequency and amount of intake of fruits and vegetable was minimum among the respondents compared to the recommended intakes. Recommended intake of fruits and vegetables per day is 400g or 5 servings or more (WHO, 2005). Most of the respondents reported that the cost of fruits was high and therefore they could not afford to buy them often. According to a study by Schulze (2004) people who eat fewer fruits and vegetables had increased risk of developing chronic diseases. A study by Culliton (2008) also revealed that higher blood levels of vitamin C were associated with a substantially lower risk of developing diabetes. Eating even a small quantity of fruits and vegetables may be beneficial and the protection against diabetes increases progressively with the quantity of fruit and vegetables consumed (Schulze, 2004). In this study, most of the respondents were engaged in sedentary type of activities while very few were engaged in vigorous physical

exercises. Numerous epidemiologic studies have shown that increased physical activities reduced the risk of diabetes, while sedentary lifestyles increased the risk for chronic diseases including T2DM.

Conclusion

This study highlights the risks and lifestyles characteristics that were associated with the development of T2DM among adults in Mwanza City. Lifestyles characteristics were observed to increase the risk for T2DM. The prevalence of blood pressure was significantly related with increasing blood glucose levels in this study. Prevalence of smoking in males was significantly related to elevated blood glucose levels. In this study, most of the respondents were engaged in sedentary type of activities while very few were engaged in vigorous physical exercises. The frequency and amount of fruits and vegetable intake were very low as revealed by this study. Therefore, it is important to intervene, and modify lifestyle of adults so as to reduce the risks of developing T2DM. A good approach for professions is to create awareness about the risks factors for the development of the disease and frequent screening of the population so as to identify those at risk at the very early stages of the disease.

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PAPER THREE

Glycemic Index of Selected Staple Foods used in the Management of Type 2 Diabetes Mellitus in Tanzania

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PAPER FOUR

Effect of Nutrition Education Intervention and Lifestyle Behaviors on Management of T2DM in Mwanza City, Tanzania

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Effect of nutrition education intervention and lifestyle behaviors on management of Type 2 Diabetes Mellitus in Mwanza City, Tanzania

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Type 2 diabetes mellitus (T2DM) is a chronic disease associated with impaired glucose metabolism. This study aimed at assessing the effect of nutrition education intervention on the lifestyle behaviors and management of T2DM among adult diabetic patients who attended clinic at Bugando hospital, Mwanza City for a period of one year. A cross-sectional study design was used to identify the population at risk of T2DM. Random blood glucose testing was conducted. Thereafter a fasting blood glucose test was performed for the study sample with elevated blood sugar (≥200 mg/dl) to confirm the cases. The cases were subjected to nutrition and lifestyle education intervention program for one year. Findings showed that baseline mean fasting blood glucose was 285.15±86.08mg/dl. Mean age was 55.8525 ± 9.36 years while mean BMI was 28.18 kg/m^2 falling within the overweight category (24.9-29.9 kg/m^2) and there was significant ($p \leq 0.05$) difference in fasting blood glucose between males and females. Results of the intervention revealed that fasting blood glucose levels were decreasing gradually from the baseline up to 12 month and there was a significant ($p \leq 0.05$) difference in blood glucose levels among several clinical visits. There was 34% average decrease in blood glucose levels from the baseline survey to the post-intervention. Fasting blood glucose during baseline was significantly ($p \leq 0.05$) higher than at the 3 month. There was 7.3% mean decrease in average body weight from the baseline to the post intervention. Mean BMI also was decreasing gradually with time. This study revealed that nutrition and modification of lifestyle behaviors such as participation in exercises and reducing of the amount of starch had delayed the effects of type 2 diabetes by one year. It is therefore, possible to delay or prevent the development of complications of diabetes by adherence to clinical recommendation on nutrition and lifestyle modification.

Key words: Nutrition, education, lifestyle, management of T2DM.

Introduction

Type 2 diabetes mellitus (T2DM) is a chronic disease associated with impaired glucose metabolism (ADA, 2009). It may be caused by inadequate insulin produced by beta cells of the pancreas or inability of body cells to respond to insulin produced. This condition can lead to accumulation of glucose in blood due to defects in insulin secretion and insulin action on targeted cells (Erickson, 2007). The effects of this condition include long term damage, dysfunction and failure of various body organs (ADA, 2012).

Long term accumulation of blood glucose can lead to different body disabilities such as nephropathy that may lead to renal failure or a risk of foot ulcers, amputation, sexual dysfunction, risk of cardiovascular diseases and specific complications of retinopathy (Cade, 2008). The short-term management of T2DM aims at lowering and stabilizing mean

blood sugar levels, while long-term management aims at avoiding hyperglycemia and ketoacidosis as well as later complications (Teuscher, 2007). Lifestyle modification and nutrition education, in particular recommendations to follow an appropriate dietary pattern and exercises, have generally been accepted as a cornerstone of treatment for people with type 2 diabetes, with the expectation that an appropriate intake of energy and nutrients will improve glycemic control and reduce the risk of complications (Mann *et al*., 2004). However, adherence to healthy lifestyle changes is difficult for many people, and taking tablets is often an easier option (Coppell *et al*., 2010).

Management of glucose levels calls for strict adherence to a medical regimen which may include simple lifestyle measures that have been shown to be effective in preventing or delaying the onset of type 2 diabetes (Joy**,** 2011). These measures include maintaining a healthy body weight through physical activities/exercises at least 30 minutes of regular, moderate-intensity activity/exercise on most days; eating a healthy diet of between three and five servings of fruit and vegetables a day and reduce sugar and saturated fats intake (Department of Health and Human Services, 2010). Additionally, diabetic patients are advised to avoid tobacco use, because tobacco increases the risk of cardiovascular diseases (Ford, 2006). In many cases, such initial efforts can substantially restore insulin sensitivity. In some cases strict diet and physical activity can adequately control the glycemic levels. In many cases, oral anti-diabetic drugs are required, and in about 30% of cases insulin injection may be necessary (Rodbard, 2008).

Interventions that are cost effective and feasible in developing countries include, moderate blood glucose control, screening for retinopathy, blood lipid control and screening for early signs of diabetes-related kidney disease. These screenings have to be conducted to reduce complications of the disease. This study aimed at assessing the effect of nutrition education intervention on the lifestyle behaviors and management of T2DM among adult's diabetic patients who attended clinic at Bugando hospital, Mwanza region for a period of one year.

Methodology

This intervention study was conducted for one year at Bugando referral hospital in Mwanza City which is located in the northern part of Tanzania. The City lies between latitude 20^0 15' and 20^0 45' South of Equator and longitudes 320^0 45' and 33^0 00' East of Greenwich (URT, 2012). This nutritional and lifestyle behavior modification education intervention took place at the diabetic unit of the Bugando referral hospital between December 2012 and December 2013.

Subjects

A cross-sectional study design was used to identify the population at risk of T2DM. Random blood glucose testing was conducted. Thereafter a fasting blood glucose test was performed for the study sample with elevated blood sugar (≥200 mg/dl) to confirm the cases. The cases were subjected in nutrition and lifestyle behavior education intervention program for one year. The follow-up study sample comprised of only diabetic patients who attended Bugando clinic for the management of diabetes. These comprised adults (males and females) aged 30 years old and above residing in Mwanza City for at least a year by the time the clinical study on management of T2DM was done. Seventy six participants were recruited into the study. At the end of the study only 61participants remained. The drop out from the study was caused by various reasons including schedule conflict (n=3), lost the follow-up track (n=5) and unforeseeable circumstances (n=4).

Interventions

The recognized cases of diabetes were trained on how to manage the disease through lifestyle behavior modification such as physical exercises, medical, dietary methods, minimize alcohol intake and abstain smoking. Adherence to the treatment regimen was assessed quarterly on the basis of structured interviews and measurements. Measurements of Body Mass Index (BMI), blood glucose level, systolic pressure, blood diastolic pressure and Waist Hip Ratio (WHR) were performed to monitor if the participants were improving. The standard lifestyle behavior recommendations were provided in the form of written information and in an annual 20-to-30-minutes individual session that emphasized the importance of a healthy lifestyle. The participants/respondents were required to attend clinic once after three months for nutrition, lifestyle behavior modification and foot care education at the clinic level. While attending those education session participants were encouraged to follow the Food Guide Pyramid (Cellabert, 2009) and to increase their physical activities in order to reduce body weight. The goals for the participants assigned to the intensive lifestyle intervention were to achieve and maintain a weight reduction through a healthy low calorie, low-fat diet and to engage in physical activities of moderate intensity, such as brisk walking, for at least 150 minutes per week.

A lesson program covering diet, exercise, and behavior modification was designed to help the participants achieve these goals. The program, taught by diabetic clinic nurses on a one-to-one basis during the first 24 weeks after enrollment, was flexible, culturally sensitive, and individualized. Subsequent individual sessions (usually 3 months) and group sessions with diabetic nurses were designed to reinforce the behavioral changes. Generally, the sessions were designed to increase participants' knowledge of healthy eating and physical activity, provide practical suggestions for safe weight loss and positive lifestyle changes. The primary diet-related goal was to reduce the amount of carbohydrate and fats intake. In addition, participants had weekly education on physical activity with their health diabetic clinical nurses during the weight loss phase. A physical activity session usually followed an educational session. The exercises was developed and each given to participants. Each participant had a weekly physical activity goal, depending on their physical abilities and fitness level. Also, they were asked to record the number of minutes spent in all physical activities performed per day. The goal here was to engage participants in regular physical activity of moderate intensity for at least 150 minutes per week.

Data Collection

Fasting plasma glucose of the subjects was measured to see if they were attaining normal levels of this indicator after the intervention. Using a standardized Glucometer (Glucometer Type 25 KB JPG) fasting blood glucose was determined once after three months for a period of 12 months. Anthropometric measurements such as height, weight, waist and hip circumferences were measured during the baseline and at every clinical visit. Smoking behavior was self reported and classified as yes/no at baseline. Alcohol consumption was determined by inquiring about the number of alcoholic drinks consumed per day and categorized as abstainers (0 units/day), moderate drinkers (1-4 drinks /day), or heavy drinkers (>4 drinks/per day) (International Drinking Guidelines, 2010). First class relative with diabetes was self-reported and classified as yes and no during baseline survey. Information about fruits, vegetable, fats, proteins and carbohydrate intake were assessed by using food frequency questionnaire and 24hr dietary recall. Bowls which showed amounts

consumed were used to establish the grams that were eaten per day. Physical activities were assessed by using questions on the frequency and duration of participation in moderate or vigorous physical exercises. The questionnaire included questions on the frequency and duration of participation in different physical activities that were used to calculate hours per week at each intensity level.

Anthropometric and blood pressure measurements

Height and weight were measured by following standard procedures (WHO, 2005). Body mass index was then calculated and categorized in four groups (underweight BMI ≤18.5; normal BMI 18.5-24.9; overweight BMI, 25-29.9; obese BMI, ≥30) according WHO (2004) classification. Waist circumference was measured by using a non –stretchable tape and the readings were taken at the mid –point between the costal margin and iliac crest, with the subject standing erect in a relaxed position and feet placed 25-30 cm apart and all measurements were recorded to the nearest 0.1 cm. Hip circumference was measured at the level of the greater trochanters (widest portion of the hip) using a non-stretchable tape while the subject was standing with arms on side and feet together. The hip circumference was thereafter recorded to the nearest 0.1cm. Waist and hip circumferences were used to determine waist hip ratio where normal hip ratio for women was <0.8, overweight was 0.80-0.84 and obesity ≥ 0.85. For men < 0.9 was normal weight, 0.9-0.99 was overweight and ≥ 1 was obese. Blood pressure was measured by using standard protocol (Pickering *et al*., 2005). Three serial measurements of blood pressure were taken one minute apart, using a digital blood pressure monitor sphygmomanometer (CH-432B, Citizen Systems Japan Co Ltd) with subjects in the sitting position. The blood pressure was measured after the subject had rested for at least 5 minutes.

Ethical consideration

Ethical clearance to conduct this study was obtained from the Medical Research Coordinating Committee (MRCC) hosted by National Medical Research (NIMR). Permission to conduct the study was obtained from Mwanza region and from Ilemela and Nyamagana district health authorities and also from Bugando referral hospital**.** After the objectives and benefits of the study were explained to the subjects, they were requested to sign an informed consent form to affirm their willingness to participate in the study. Confidentiality of the collected data was assured.

Data analysis

Data were analyzed by using Statistical Package for Social Sciences (SPSS) commander software version 16 where descriptive statistics such as frequency, percentage, means and standard deviations were computed for demographic, biomedical and anthropometric variables. Inferential statistics such as chi-square statistics and student t test analysis were computed with 95% confidence interval to find the relationship between stated variables. A difference of analyzed variables was considered to be significant at $p \leq 0.05$.

Results

Table 1 indicates demographic, biomedical and anthropometric characteristics of diabetic respondents. About 36.1% (n=22) of respondents had primary school education while 31.1% (n=19) had college level education. Majority of the respondents 62.3% (n=38) were married and 39.3% (n=24) had an age ranging between 50- 60 with mean age of 55.85 ±

9.36 years. The income level of the respondents was 400 000-700 000 Tsh (26.2%). Biomedical results showed, that diabetic respondents had waist hip ratio of 0.90 ± 0.13 indicating high waist-hip ratio above normal for both males and females. Mean fasting blood glucose was 285.15±86.08 and there was significant ($p \leq 0.05$) difference in fasting blood glucose between males and females. Mean BMI was 28.18 kg/m^2 falling under the overweight category (24.9-29.9).

Table1. Baseline demographic, biomedical and anthropometric characteristics of diabetic respondents (N=61)

Characteristics	Value/response	Males N (%)	Females N (%)	Total No N (%)
Education level	Informal	2 (3.3)	3(4.9)	5(8.2)
	Primary	11(18.0)	11(18.0)	22(36.1)
	Secondary	5(8.2)	10(16.4)	15(24.6)
	College	10(16.4)	9(14.8)	19(31.1)
Marital status	Unmarried	1(1.6)	3(4.9)	4(6.6)*
	Married	23(37.7)	15(24.6)	38(62.3)
	Divorced	3(4.9)	7(11.5)	10(16.4)
	Widowed	1(1.6)	8(13.1)	9(14.8)
Income	0-70000	9(14.8)	9(14.8)	18(29.5)
	70000-100000	4(6.6)	8(13.1)	12(19.7)
	100000-300000	6(9.8)	5(8.2)	11(18.0)
	400000-700000	8(13.1)	8(13.1)	16(26.2)
	>700000Tsh	1(1.6)	3(4.9)	4 (6.6)
Age group(years)	30-40 Years	2(3.3)	0(0)	2(3.3)
	40-50 Years	7(11.5)	10(16.4)	17(27.9)
	50-60 years	8(13.1)	16(26.2)	24(39.3)
	>60 years	11(18)	7(11.5)	18(29.5)
Biomedical/Anthropometrical	Waist hip ratio	0.8802±0.13449	0.9099±.13534	0.8963±0.13465
	BMI (Kg/m^2)	26.6207±3.08168	29.4993±6.85909	28.1780*
	Fasting glucose(mg/dl)	296.31±96.58	275.68±76.30	285.15±86.08
	Pulse (mmhg)	81.2857±12.12	79.6515±9.66	80.4016±10.79
	Diastolic(mmg)	131.43±15.95	139±30.81	135.89±25.26*
	Sytolic(mmhg)	80.9286±10.06	86.0909±12.10	83.7213±11.42
Energy intake	Kilocalories	2376±441.14	2359±483.40	2367±462. 27
	Age in years	56.1429±10.60	55.6061±8.33	55.8525±9.36

Effects of the intervention on Biomedical and Anthropometric for study participants

Table 2 shows biomedical and anthropometric differences after intervention. Results revealed that, fasting blood glucose levels were decreasing gradually from the baseline up to 12 months and there was significant ($p \leq 0.05$) difference in blood glucose levels among several clinical visits. There was 34% decrease in blood sugar levels from the baseline survey up to12 months. Fasting blood glucose after 3 months was significantly ($p \leq 0.05$) higher than after 6 months and after 12 months. There was 7.3% (4.2kg) mean decrease in weight from baseline to 12 months post intervention. The mean BMI also decreased gradually with time of intervention. Mean BMI in the first visit was significantly higher ($p \leq 0.05$) than in the subsequent visits where there was an average 8.8% decrease in the BMI from the baseline to post intervention results.

No differences ($p > 0.05$) in systolic blood pressure was observed among subjects though there was a decrease in the mean levels from the baseline to 12 months post intervention. In the case of diastolic blood pressure there was significant variation ($p \leq 0.05$) among subjects in the baseline and 3 months, 6 months and 12 months post intervention results. Mean diastolic blood pressure decreased by 6.3% for the entire intervention period. The waist-hip ratios among subjects decreased from the baseline up to 12 months after intervention but not significantly ($p > 0.05$).

Table 2. Changes on anthropometric and biomedical characteristics over time

Characteristics	Baseline Mean ± SD	3 Months Mean ± SD	6 Months Mean ± SD	12 Months Mean ± SD
Weight (Kg)	78.7±14.3[a*]	78.7±14.7[a]	77.1±13.3[b]	72. 9±13.1[b]
BMI (Kg/m^2)	28.4±5.1[a]	28. 6±5.6[a]	27.5±5. 1[b]	25.9±4. 6[b]
Waist circumference (cm)	92. 1±13.6[a]	91.3±9.7[a]	90.4±9.9[a]	89.6±9.3[a]
Hip circumference (cm)	1.0±12. 6[a]	1.0±9.9[a]	1.0±10.5[a]	1.0±10.2[a]
WHR (cm)	0. 91±0.10[a]	0.91±0.1[a]	0.89±0.1[a]	0.89±0.13[a]
Fasting glucose (mg/dl)	285.5±86.1[a]	247.2±95.4[b]	217.9±95.9[c]	188.4±100. 4[c]
Systolic BP(mmHg)	86. 1±15.7[a]	87.0±11.6[a]	86.5±10. 2[a]	83.7±11.4[a]
Diastolic BP (mmHg)	135.5±20.9[a]	135.9±25.3[a]	134.5±20.1[a]	126.9±15.3[b]
Pulse rate (beats per minute)	83. 5±31.4[a]	80.4±10.8[a]	80. 2±11.5[a]	80.1±13. 3[a]

***Different superscript along the row means significant difference at p≤0.05**

Self-care practices of diabetic respondents for the management of T2DM

Self-care practices of respondents in the management of T2DM were indicated in Table 3 below. About 39% (n=24) of the male respondents and 47% (n=29) females claimed to follow a healthy diet. The mean calorie intake was 2376 ± 441.14 Kcal and 2359 ± 483.40 Kcal for males and females, respectively. About 32.8% (n=20) of females respondents used only 20 minutes for vigorous exercises per day while 26.2% (n=16) of males used an average of half an hour for vigorous exercises per day. Moreover, majority of respondents were monitoring blood glucose once every 3 months. Generally, most of the respondents were used to inspect their feet to prevent injuries which could cause amputation. About 32.8% (n=20) males and 39.3% (n=24) females reported that oral medication was the common method used in the treatment of T2DM disease. About 21.3% (n=13) of the respondents reported to be taking pills to reduce blood pressure. Furthermore 26.2% (n=16) of males and 36.1% (n=22) of females used to take fruits twice per day while very few took fruits more than 3 times per day. Only 14.8% (n=9) of males used to smoke before they were diagnosed to be diabetic and only very few 3.3% (n=2) were still smoking at the time of the study. Findings showed that, about 24.6% (n=15) of males and 45.9% (n=28) females ($p<0.05$) had abstained from alcohol intake.

Table 3. Care practices of diabetic respondents for the management of T2DM

Self-care practices	Response	Males (%)	Females (%)	χ^2	p-value
Following a healthy diet	Yes	24(39. 3)	29(47. 5)	0. 06	0. 80
	No	4(6.6)	4(6.6)		
Physical exercises	Half an hour	16(26. 2)	11(18)	7. 15	0. 06
	Only 20 minutes	8(13. 1)	20(32. 8)		
	Not exercising	4(6.6)	2(3. 3)		
Monitoring blood glucose	Every 3 months	17(27. 9)	19(31. 1)	0. 13	0. 80
	Not often	11(18)	14(23)		
Inspecting feet	Yes	24(39. 3)	29(47. 5	0. 46	0. 80
	No	4(6.6)	4(6.6		
Management style	Oral medication and diet	20(32. 8)	24(39. 3)	1. 20	0. 03*
	Insulin	8(13. 1)	8(13. 1)		
	Exercise and diet	0(0)	1(1.6)		
Using blood pressure pills	Yes	13(21. 3)	24(39. 3)	4. 02	0. 02*
	No	15(24. 5)	9(14. 75)		
Diseases apart from DM	Hypertension	10(16. 4)	8(13. 1)		
	Diabetic Foot ulcer	2(3. 3)	4(6. 6)		

	Hypertension, Numbness, foot aching	3 (4. 9)	9 (14.17)		
	No	9(14. 8)	5(8. 2)	3.42	0. 03*
	Pulmonary tuberculosis, hypertension	0(0)	5(8. 2)		
	Diabetic foot and hypertension	1(1. 6)	3(4. 9		
	HIV/AIDS	3(4. 9)	0(0)		
Frequency of intake of fruits	Once per day	3(4.9	2(3.3)	0.74	0.92
	Twice per day	16(26.2	22(36.1		
	Tree times per day	6(9.8	6(9.8		
	More than 3 times a day	3(4.9	3(4.9		
Smoking behavior	Previous smoked	9(14.8	1(1.6		
	Current smoked	2(3.3	0(0	12.6	0.00*
	Never smoked	17(27.9	32(52.5		
Alcohol intake	Abstainers	15(24.6	28(45.9		
	Moderate drinkers	12(19.7	5(8.2	7.45	0.01*
	Heavy drinkers	1(1.6	0(0		

Means significant different at p≤0. 05

Discussion

One year follow up of the intervention study of nutrition education and lifestyle modification showed improvements in metabolic, anthropometric and cardiovascular outcomes. The most notable improvement among the findings was the glycemic control. Other studies have similarly found significant improvements in glycemic control to emerge at a longer follow-up term (18 months and beyond) (Dunning, 2005, Ruchirawanitchathep, 2008). For example, in a study of a diabetes involving education group visit intervention, blood glucose level was significantly lowered at 2-year follow -up but not at 1-year post-intervention (Ruchirawanitchathep, 2008).

Mean BMI of the respondents fell in the overweight category throughout the study but tended to decrease gradually with significant decrease in the mean BMI from the baseline, 3 months, up to 12 months. Also weight was shown to decrease by 4.2kg (7%) from baseline to 12 months of the intervention. The participants showed weight fluctuations during the entire study whereby most of them continued to lose weight after the 6 months assessment. However, as a group, participants achieved an average 1.6-kg weight reduction at 6 months and they continued to lose weight up to 4.2 kg at the end of the study. These results were similar to another study by Matvienko *et al*., (2009) who suggested that at 6 months, similar participants achieved 7% weight loss goal compared with 50% in the DPP program, this was very intensive controlled study compared to this study. Moreover during the final assessment, same participants (at 12 months) maintained a weight loss of 7%.

No significant difference was observed in systolic and diastolic blood pressures though there was a decrease in the levels from the baseline up to12 months. The waist hip ratio was decreasing from 3 months to 6 months and there was no significant reduction in the w:h ratio from 6 months to 12 months. Generally findings of this study revealed that, improvements in lifestyles and behavior changes achieved during the one-year intervention (e.g. making good dietary choices, spacing out carbohydrates, using insulin as prescribed, exercising and fruits intake) showed positive results. Respondents could attain more improvements if the intervention time would have been extended. In another similar study by Aas *et al.,* (2005) using a similar group of patients confirmed that an intensive educational program, including dietary instruction, had the potential to improve blood glycemic levels within a six month duration of the intervention.

Self-care practices of the respondents in the management of T2DM suggested that, majority of the respondents claimed to adhere to intake of healthy diets. The mean intake of Kcal was acceptable as recommended by Cellabert (2008). This was because the respondents

were advised to minimize the dietary intake of carbohydrates, fats and proteins because of their rising effects in blood sugar levels. Furthermore, respondents were advised to reduce dietary intake of red meats and increase intake of fish, chicken and other white meats as sources of proteins. Usually, high iron content of red meat diminishes insulin's effectiveness or damages the cells that produce insulin (Haimoto, 2009).

Dietary education on the management of T2DM given by nurses at diabetic unit focused on intake of generous amount of fruits and vegetables while high consumption of starch was discouraged. The nutrition education provided based on the fact that vegetables and fruits are rich in antioxidants such as vitamin C and E and beta carotene. These are very important in counteracting the artery clog process which is very common in diabetes. The Low Density Lipoproteins (LDL) in the diabetics are more susceptible to oxidation which is caused by high blood sugar levels and thus more likely to become toxic in diabetics. In turn such oxidized LDL is more likely to clog arteries. As sugar is metabolized, it releases the oxygen free radicals that tend to make cholesterol toxic. This can be counteracted by steady supply of antioxidants which are free radical scavenger which wipe up the destructive reaction caused by free radicals (Cade, 2008). Some of the respondents followed the dietary advices given for the management of T2DM. Other respondents suggested that sometimes they cannot afford to buy advised foods such as fruits because they are expensive basing on their low income. John and Zielbland (2003) proposed that among the many influences on diet is availability, cost and time for preparation.

Majority of females used to work and perform other household chores rather than performing physical exercises. This was because they had limited time for exercises and they preferred to work at home as one way of reducing weight. Most men preferred to exercise vigorously for thirty and above minutes every day which was acceptable in the management of the disease (ODPHP, 2008).

Patients on insulin medication were supposed to check their blood glucose levels more often than those on normal oral medication in order to prevent hypoglycemia effect of induced insulin. Oral medication was the most commonly used method in the management of the T2DM disease. Individual patients with serious conditions were treated with insulin but after recovery they returned to normal oral medication. Moreover, most of diabetic respondents in this study used to inspect their feet frequently in order to prevent injuries which could lead to amputation. It was revealed that, blood pressure was the most common condition which affected a number of diabetic patients. It was also found that, most of the respondents were taking blood pressure pills. This was in line with what was reported by Long and Dagogo (2011) who reported that, up to 75% of adults with diabetes also have hypertension, and patients with hypertension alone often show evidence of insulin resistance.

Conclusion

This study revealed that, education on nutrition and lifestyle modification intervention had positive behavioral changes that produced clinical benefits. In this intervention study, improvement in both glycemic control and anthropometric measures in patients with type 2 diabetes were revealed. Nutrition and modification of lifestyle education were effective means of delaying and reducing complications associated withT2DM. It is recommended based on this study that, patients should adhere to clinical recommendation on nutrition and lifestyle modification so as to prevent secondary complications of T2DM.

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CHAPTER THREE

3.0 SUMMARY OF MAJOR FINDINGS, CONCLUSIONS AND RECOMENDATIONS

3.1 Summary of Major Findings and Conclusions

The overall objective of this study was to assess the prevalence, awareness and management of type 2 diabetes mellitus among adults in Mwanza City, Tanzania. This chapter presents the summary of major findings of this study which is the basis for major recommendations made.

3.1.1 Prevalence and awareness of type 2 diabetes mellitus among adults in Mwanza City, Tanzania

In general, the findings presented in the first paper of this study showed that, prevalence rates of T2DM and IFG in the study area were 11.9 and 6.9%, respectively. Women had a significantly higher prevalence of diabetes mellitus than men. The current study suggests that, awareness and knowledge about type 2 diabetes mellitus were low among the respondents. The causes of type 2 diabetes were unclear to many, even among the patients who had already lived with this disease for more than a year. Majority of the subjects did not know the risk factors as well as symptoms of T2DM. Lack of exposure to diabetic patients and lack of interest in issues not related to them could be the possible reasons for the low knowledge. Worsening glycemic status was associated with old age, sex, smoking behavior and heredity (first class relative with T2DM). In this study, the mean percent fat mass and mean BMI were found to be significantly higher in females than males. However, the mean systolic blood pressure was significantly higher in males than females. On the other hand, fat mass, BMI level and waist-hip ratio was higher among females than males; indicating increasing risk of developing chronic diseases among females.

3.1.2 Lifestyle behaviors and associated risk factors for type 2 diabetes mellitus

This specific objective of the study sought to assess the nutritional status of respondents that could have contributed to the high prevalence of T2DM. Increased BMI showed to be a risk factor for elevated fasting blood glucose level, though there was no significant difference. Findings also revealed that, women were more overweight and obese compared to males, and therefore, they had a higher risk for developing T2DM.

Generally, the findings of this study indicated that, visceral obesity which is determined by waist circumference (WC) or waist-hip ratio (WHR) is typically seen in overweight and obese males and females. Subjects with elevated blood glucose (diabetic) also tended to have elevated waist-hip ratios. Females had larger waist hip ratios therefore more likely to develop T2DM than males, though the mean WHR were not significantly different. This study revealed that, most of the respondents with high body fat category were also diabetic. It was observed further that, females had higher fat mass composition compared to their male counterparts.

This study revealed that, prevalence rate of alcohol users was generally low (27%). This study also revealed a strong relationship between alcohol intake and T2DM. Prevalence of smoking among males was significantly related to elevated blood glucose levels.

The frequency and amount of intake of fruits and vegetable was very low among the respondents relative to the recommended intakes. Recommended intake of fruits and vegetables per day is 400 g or 5 serving or more per day. Most of the respondents reported that, the cost of fruits was high and therefore could not afford to buy them often. In this study, most of the respondents were sedentary with very low levels of activities. Very few of the respondents were engaged in vigorous physical activities.

3.1.3 Glycemic index and glycemic load of commonly consumed staple foods

For the management of type 2 diabetes mellitus a study on glycemic index of various staple foods was conducted. The GI value of maize meal was 51 which ranged in the GI values 44-92.3 reported in maize-based products. These values were similar as those observed in this study (60.92) for millet-based foods and (65.71) for sorghum-based foods. The glycemic index of cassava meal which was observed in this study was 49. This was lower than the GI value of 56 reported by the International Table of GI. The findings indicated that, there was variability of GI among subjects consuming the same food product. It is thus important to inform diabetic patients on varied physiological responses to carbohydrate foods among individuals when choosing carbohydrate foods. High GI food for one individual may not necessarily be the same for another individual.

Hardness or softness of the food may influence the availability of its glucose to the blood stream. This may explain the differences in the GI values among the subjects in the present study. For instance, meat was eaten with all of the food products tested as an accompaniment and this influenced the GI values of various foods. Plantains were cooked with water to form a soft meal while the other composite flours were cooked with minimum amount of water to make products that were stiff.

The GI for banana meal observed in this study was lower than the values reported by revised international table of GI. The disparity in the GI values of the studied food products could be attributed to the characteristics of their carbohydrate. Maize and sorghum grains were not dehulled to remove their outer husks. As a result, the dietary fiber present therein may have resisted the digestibility and fast release of glucose into the blood. These dietary fibers are collectively known as non-digestible carbohydrates especially in relation to their physiological effects on digestion.

3.1.4 Management of type 2 diabetes mellitus among adults in Mwanza City

One year follow-up after nutrition and lifestyle education intervention study on self-care and management of diabetes mellitus showed improvement as demonstrated by improvement in metabolic, anthropometric and cardiovascular outcomes. Most notable among the findings was the significant improvement in glycemic control during the one-year follow-up period. After the intervention, findings of this follow up study revealed that, there was improvement in lifestyles and behavioral changes achieved in the one-year intervention.

The mean intake of energy was 2359 kcal and it was acceptable as recommended. Dietary advice for the management of T2DM given by nurses at diabetic clinic as reported by the respondents included generous intake of fruits and vegetables and starch should be taken in minimum amount. Some respondent's adhered to the advice given on food selection and consumptions, while others could not adhere to the advices due to income limitations. The majority of females preferred to work and perform other household chores rather than engaging in physical exercises for at least 30 minutes per day. Oral medication was the commonly used method in the management of the T2DM disease.

It was revealed that, blood pressure was the most common disease which affected a number of diabetic patients as compared to other diseases. It was found that, most of the respondents were taking pills to reduce blood pressure. Physical examinations such as eye check-up, kidney function test, nerve damage and heart disease as well as screening for other medical problems were not commonly performed in the clinics. Furthermore, respondents claimed that, the services were not available at their district levels. They were supposed to travel to Bugando which was the referral hospital where most of diabetic patients reported from different regions of the lake zone. This caused inconveniences for

patients because they spent a lot of time queuing to get the services at the diabetic clinic. Another observation was that, many patients could not attend their regular clinic appointments due to lack of funds to pay for the public transport. Another problem facing diabetic respondents was the cost of diabetic treatment. Majority of patients were supposed to pay from their pockets for the medication and clinical service fees while attending the clinic. Very few patients were covered by National Health Insurance Fund (NHIF) or old people policy assistance on medical services provision.

3.2 Recommendations

On the basis of the findings presented in the four papers the following recommendations were drawn.

3.2.1 Prevalence and awareness of type 2 diabetes mellitus

The prevalence of type 2 diabetes mellitus was high. Generally, awareness of type two diabetes mellitus on causes, risk factors as well as management was very poor in the study population. It is therefore recommended to the policy makers and health practitioners that awareness about T2DM be raised starting from young age. Routine checks of blood glucose levels should be done frequently for all adults above 35 years. Health education on causes, risk factors and management of T2DM should be promoted and people should be encouraged to report to health facilities whenever they observe symptoms of T2DM. This would help to control the disease before secondary stage complications develop.

3.2.2 Lifestyles and associated risk factors for type 2 diabetes mellitus

Lifestyle behaviors were observed to increase the risk for T2DM. Prevalence of smoking in males was significantly related to elevated blood glucose levels. In this study, most of the respondents had sedentary lifestyles with very low level of activities while very few were

engaged in vigorous physical activities. The frequency and amount of fruits and vegetables consumed were very low. Therefore, it is recommended to the ministry of health to advocate, intervene, and modify lifestyle behaviors of adults so as to reduce the risks of developing T2DM. One way is to create awareness about the risk factors associated with the development of the disease and frequent screening of the population so as to identify those at risk at the very early stages of the disease.

3.2.3 Glycemic index of selected staple foods used in the management of type 2 diabetes mellitus in Tanzania

According to GIs data, cassava and whole maize meals had the lowest glycemic index values and therefore are recommended in a diet for the regular management of type 2 diabetes mellitus. Moreover, finger millet, sorghum and banana meals should be consumed moderately. Findings of the present study may serve as a useful guidance for dietitians who are involved in meal planning for diabetic patients. The GI values can be used to achieve healthy eating and to plan chronic disease risk reduction programs in high-risk populations. It is also recommended that, the GI concept be applied in the context of mixed meals so as to formulate dietary guidelines while planning diet for T2DM patients in Tanzania. It is therefore recommended to the ministry of health that, managing T2DM and the associated complications, GI and GL values must be used in planning appropriate meal for diabetic patients. As many GI and GL values of the local foods must be known and documented for proper planning of diabetic diet.

3.2.4 Management of Type 2 Diabetes Mellitus among adults in Mwanza City

One year follow-up intervention study of nutrition education and lifestyle modification showed improvements in metabolic, anthropometric and cardiovascular outcomes. The most notable improvement among the findings was the glycemic control.

Findings of the intervention study in the management of type 2 diabetes mellitus revealed that improvements in lifestyles and behavioral changes achieved in the one-year intervention produced significant clinical benefits. Therefore it is recommended that the ministry of health should put in place policies that will provide the nutrition and modification of lifestyle education as effective means of delaying and reducing complications associated with T2DM. Patients should adhere to clinical recommendations on nutrition and lifestyle modifications so as to prevent secondary complications of T2DM. This study recommends that, the government should ensure that there is adequate integration of accessible and affordable diabetic care and management services throughout the primary health care delivery facilities in the county. These health care facilities will also need to be staffed with competent skilled health workers, adequate equipment and related materials.

3.3 Areas for Further Studies

(i) Further studies on glycemic index values of different foods eaten in the country should be conducted. This will help to establish a basis for planning meals for diabetic people in the society.

(ii) Studies to establish prevalence of T2DM among 30 and above year's group should be conducted on different intervals to ascertain the number of T2DM patients in the country.

(iii) Studies to ascertain the medical causes of diabetes should be conducted.

(iv) There is a need to investigate more on the factors associated with poor health services for diabetic patients in the country.

(v) Further studies are needed to establish relationship between hypertension and T2DM in the country.

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APPENDICES

Appendix 1: Questionnaire on prevalence, awareness, and management of type 2 diabetes mellitus in Mwanza City

Section B: Demographic information

1. No. of respondent ……..
2. District……..
3. Ward……..
4. Village name…….
5. Sex: a) Male [ ] b) Female [ ]
6. Educational level

   a) Informal [ ] b) Primary level [ ] c) Secondary Education [ ]

   d) College [ ]
7. Marital status

   a) Single [ ] b) Married [ ] c) Divorced [ ] d) Widowed [ ]
8. Income (Per months)…….

Section C: Awareness of causes

1. Do you know that excessive weight can results to problems in the body?

   a)Yes [ ] b) No [ ]
2. If Yes, choose below some of the problems (at least three)

   a) Malaria [ ] b) Laziness [ ] c) Diabetes [ ] d) High Blood Pressure [ ]5) Sleeping apnea [ ]
3. Do you know a disease known as diabetes?

   a) Yes [ ] b) No [ ]

4. If yes what are symptoms of the disease

   a) Excessive urination, hunger and thirsty [ ] b) Sleeping all day [ ] c) Vomiting and sweating [ ]

5. What do you think are the causes of diabetes mellitus

   a) It is just a disease [ ] b) Overeating and sedentary life style [ ] c) Genetics [ ] d) I don't know [ ] e) Bacteria [ ]

6. Which age is usually affected by the disease (DM)

   a) Children below 18 [ ] b) Youth [ ] c) Adults more than 40 years [ ]

Section D: Accessibility to treatment and general care for diabetic patients (DM Patients)

1. Are services to diabetic patients available in your district?

   a)Yes [ ] b) No [ ]

2. How many times are you given advice on diabetic management, dietary management, physical management, psychosocial management and foot care?

   a) Always when attending clinic [ ] b) Not always [ ] c) Some of the advice are provided some not [ ] d) We are not advised anything we are just checking blood sugar only [ ]

3. What are the advices provided for diabetic management?

   a) Dietary management [ ] b) Psychosocial advices [ ] c) Physical management [ ] d) Foot care [ ] e) About what type of Medicine to use [ ]

4. While attending clinic are you usually meeting with diabetic specialist (doctor)

   a) Yes [ ] b) No [ ]

5. What type of clinical diagnosis usually measured while attending clinic.

   a) Fasting Blood glucose [ ] b) Foot [ ] c) Only a [ ] d) Blood pressure [ ] d) Eye [ ] f) All of the above [ ] g) Nothing [ ]

6. What kind of advice are you given for the management of the disease especially dietary management?

   a) Advised what types of food to be eaten [ ]

   b) Advised the amount of food to be eaten [ ]

   c) To avoid high fat diets and meat [ ] d) Not given any advice [ ]

7. Are you given any counseling services on how to live with the disease?

   a) Yes [ ] b) No [ ]

8. Are health practitioners in health centers know how to take care for diabetic ulcer (foot?)

   a) Yes [ ] b) No [ ]

9. How do they treat a diabetic foot……..……...

10. What is the most management style your using in controlling your diabetes a) Medication for lowering sugar [ ] b) Exercises and diet [ ] c) Herbal and traditional medication [ ] d) Insulin therapy [ ]

Section E: Lifestyle characteristics of respondents

1. What kind of activities do you normally do?

   a) Sedentary [ ] b) Moderate [ ] c) Very heavy [ ]

2. Do you drink more often?

   a) Yes [ ] b) No [ ]

3. What kind of transport are you using while going to work?

   a) On foot [ ] b) by Bicycle [ ] c) By car [ ]

   d) Both on foot and by car [ ]

4. Do you normally do any kind of exercises?

   a) Yes [ ] b) No [ ]

5. If yes how often

a) Once per day for [ ] Minutes b) More than twice a day [ ] min c) Twice a week [ ] min d) Once a week [ ]

6. Type of exercises if any

a) Strenuous [ ] b) Not any [ ] c) Minor exercises [ ] d) Walking [ ]

7. How do you maintain your normal body weight? ……..

Do you eat outside home mostly frequently?

a) Yes [ ] b) No [ ]

8. What types of foods normally you eat outside

a) Fried foods (fish, chips, chicken and Pork) [ ] b) Boiled foods with vegetables [ ]

c) Soft drinks like soda and cakes [ ]

8. Are you taking alcohol more often

a) More often a week (how many bottles) [ ] b) Once a week [ ] c) Twice a week [ ]

d) Thrice a week [ ]

9. What types of food are you normally eating at home

a) Fried foods [ ] b) Boiled foods with vegetables [ ] c) Mixed [ ]

10. Are you normally eat fruits and vegetables in your daily meals

a) Yes [ ] b) No [ ]

11. If yes what amount of fruits are you taking in every meal of the day…….

12. If yes what amount of vegetables are you taking in every meal of your diet…….

13. How many servings of fruits and vegetables eaten per day……..

Section F. Anthropometrics

a) Height……Metres

b) Weight……Kg

c) Waist…….cm

d) Hip circumference……cm

e) Fat……..%

f) Fat free mass…..%

g) 24 hr dietary recall measures (50 families will be selected randomly to find the 24 hr dietary recalls.

Section G: Risk factors for diabetes

1. Is there a history of diabetes in your family a) Yes [ ] b) No [ ]

2. Are you over 40 a) Yes [ ] b) No [ ]

3. Are you a smoker b) Yes [ ] b) No [ ]

4. Do you tend to eat more than other people a) Yes [ ] b) No [ ]

5. Do you feel thirsty more than other people a) Yes [ ] b) Yes [ ]

6. Do you pass urine frequently a) Yes [ ] b) No [ ]

7. Do you feel run down and tired easily a) Yes [ ] b) No [ ]

8. Do you get boils or sores on your body a) Yes [ ] b) No [ ]

9. Do your wounds and bruises seem to take longer to heal a) Yes [ ] b) No [ ]

10. Do you change glasses frequently a) Yes [ ] b) No [ ]

11. Have you experienced any unexplained loss of weight loss of weight lately a) Yes[ ] b) No [ ]

12. Women, Were your babies over-weight at birth a) Yes [ ] b) No [ ]

13. Women Do you have vaginal itching a) Yes [ ] b) No [ ]

14. Do you have any of these complications a) Albinuria [ ] b) Proteinuria [ ] c) Heart pain or angina [ ] d) High blood pressure [ ] e) Foot ulcer [ ] f) Retinopathy [ ] g) Neuropathy [ ]

Appendix 2: Follow up questionnaire on management of type 2 diabetes mellitus in Mwanza City

FIRST SECTION: Tick where appropriate

1) No of respondents……
2) District……..
3) Ward……
4) Street……..
5) Sex a)Me [ ] b) Ke [ ]
6) Marital status b) Married [ ] b) Single [ ] c) Separated [ ] d) Widowed [ ]
7) Monthly income …… Date of birth…….

Section: Services for diabetic patients

1. Are diabetic services available easily at your district hospital

   a) Yes [ ] b) No [ ]

2. How many times are you advised on how to manage diabetic disease trough diet, exercises, and care of feet to avoid injuries.

   a) Always wen attending to clinic [ ] b) Not always [ ]

   c) Some of advices are given but others not given [ ] d) We are checked blood sugar levels only. [ ]

3. What kind of advise do you get in managing the disease

   a) We are given some advises on diet [ ] b) counseling advises on how to live with the Disease [ ] c) Exercises to manage the disease [ ] d) Protection of feet to avoid injuries [ ] e) Advise on how to use proper medication to manage the disease [ ] e) All the advises above [ ] f) No advise [ ]

4. Whenever you attend clinic do you contact diabetes specialist

   a) Yes [ ] b) No [ ]

5. What type of diagnosis are you given when you visit hospital

   a) Fasting blood sugar [ ] b) feets [ ] d) Blood pressure [ ] d) all of the above [ ] e) Nothing [ ]

6. What advise are given on appropriate foods to eat for the management of diabetes

   …….

7. What type of management are you using to manage your diabetes

   a) Medication to reduce hyperglycemia [ ] b) Exercises to maintain normal body weight [ ] c) Insulin injection [ ] d) Traditional medication [ ] e) Self insulin injection [ ]

8. What were the symptoms experienced before coming to the hospital for medical examination

   a) Abrupt loss of weight [ ] b) Frequent urination [ ] c) Frequent hunger[ ]

   d) Others specify [ ]

9. Every time you attend clinic which type of diagnosis methods your done

   a) Blood glucose measurement [ ] b) Blood pressure [ ]

   c) Cholesterol [ ] d) Weight [ ]

   d) Height [ ] e) Urinary albumin [ ]

10. In your visit to clinic were you advised to do the following

    a) Don't smoke [ ] b) Drink in moderation [ ]

    c) Exercise for thirty minutes everyday [ ] d) No advice

    e) Eat balanced diet wit limited amount of carbohydrate [ ]

11. What do you think were the reasons for you to get Type two diabetes mellitus

    a) I am More than forty years of age [ ] b) History of diabetic in our family [ ]

    c) Large weight [ ] d) I don't want to do heavy activities [ ]

e) High blood pressure history [ ]

f) Giving birth to Large babies [ ] g) History of pre eclampsia [ ]

h) intake of medicines which caused Diabetes [ ]

12. What are personal problems facing you while looking for diabetic services in the clinics ……
13. Are you given about services /advices on how to manage the disease ……
14. Are nurses and doctors available to help while looking for the services……..
15. Are equipment's enough for all of you or you have to wait in order to get diagnosis services……
16. Are services received enough or you would like it to be improved

…… …….

17. Are services free or you have to pay to get it

……..

18. Are service providers/nurses and doctors enough or you have to wait for a long time to get services……
19. If you have to wait your waiting for how long before attended……..
20. Do you have good relationship wit doctors and nurses

……

21. Do you have enough time to learn on how to manage the disease

……

22. Are nurses/doctors enough to listen and advice to your individual problems

…….

23. Are you paying for the services or it is free given by the government

……

24. Are you happy with the services received or not…….

25. If your not happy why……

26. When did you know you have diabetes……

27. When did you start clinic for diabetes……..

28. How much are you using per month for medication and clinical fees for the management of this disease……

29. What type of foods are you advised to eat for the management of diabetes

……

30. Are you following advices given for the management of the diseases

…….

31. According to your economic status are capable of getting all the required foods advised for the management of the disease

……..

32. Do you have other diseases apart diabetes…….

33. Mention

34. The diseases……

Third Section [**Antropometrics**]

Height …… metres Weight …….Kg

Waist…….cm Hip circumference……..cm

Blood pressure systolic ……..Blood pressure diastolic……

SECTION 4: Food Frequency

Major source: 1=Own production 2=Purchased/bought 3=transfers (gifts, loans, remittance) 4=Relative assistance 5=Butter/exchange 6=Food aid 7=food for work, 99=others (specify

Food item	**Frequency of consumption**			**Rare**	**Never**
	Per day	**Per week**	**Per month**[##]		
Cereals					
Maize					
Sorghum					
Finger millet					
Bulrush millet					
Wheat					
Rice					
Roots, tubers, plantain					
Cassava					
Sweet potatoes					
Round potatoes					
Yams					
Green bananas					
Legumes					
Beans					
Peas					
Cowpeas					
Pigeon peas					
Green grams					
Chickpeas					
Soybeans					
Bambara nuts (Njugumawe)					
Lablab bean (fiwi)					
Nuts and seeds					
Groundnuts					
Bambara nuts!!!!					
Coconut					
Cashew nut					
Other seeds					

Food item	**Frequency of consumption**			**Rare**	**Never**
	Per day	**Per week**	**Per month**		
Meat, poultry, fish, eggs					
Cow-beef					
Liver					
Other organ meats					
Goat					
Sheep-lamb					
Pork					
Wild game meat					
Poultry-chicken/duck					
Eggs					
Fresh-water fish					
Sea fish					
Dried fish					
Sardines					
Seafoods					
Milk and milk products					
Cow's milk (whole)					
Goat's milk (whole)					
Processed & packed milk					
Yoghurt					
Butter/lard					
Ghee					
Cheese					
Oils and fat					
Sunflower oil					
Red palm oil					
Korie oil					
Ground nut oil					
Other oil or fat (mention)					
Vegetables					
Cabbage					
Amaranth leaves					
Sweet potato leaves					
Cassava leaves					
Pumpkin leaves					

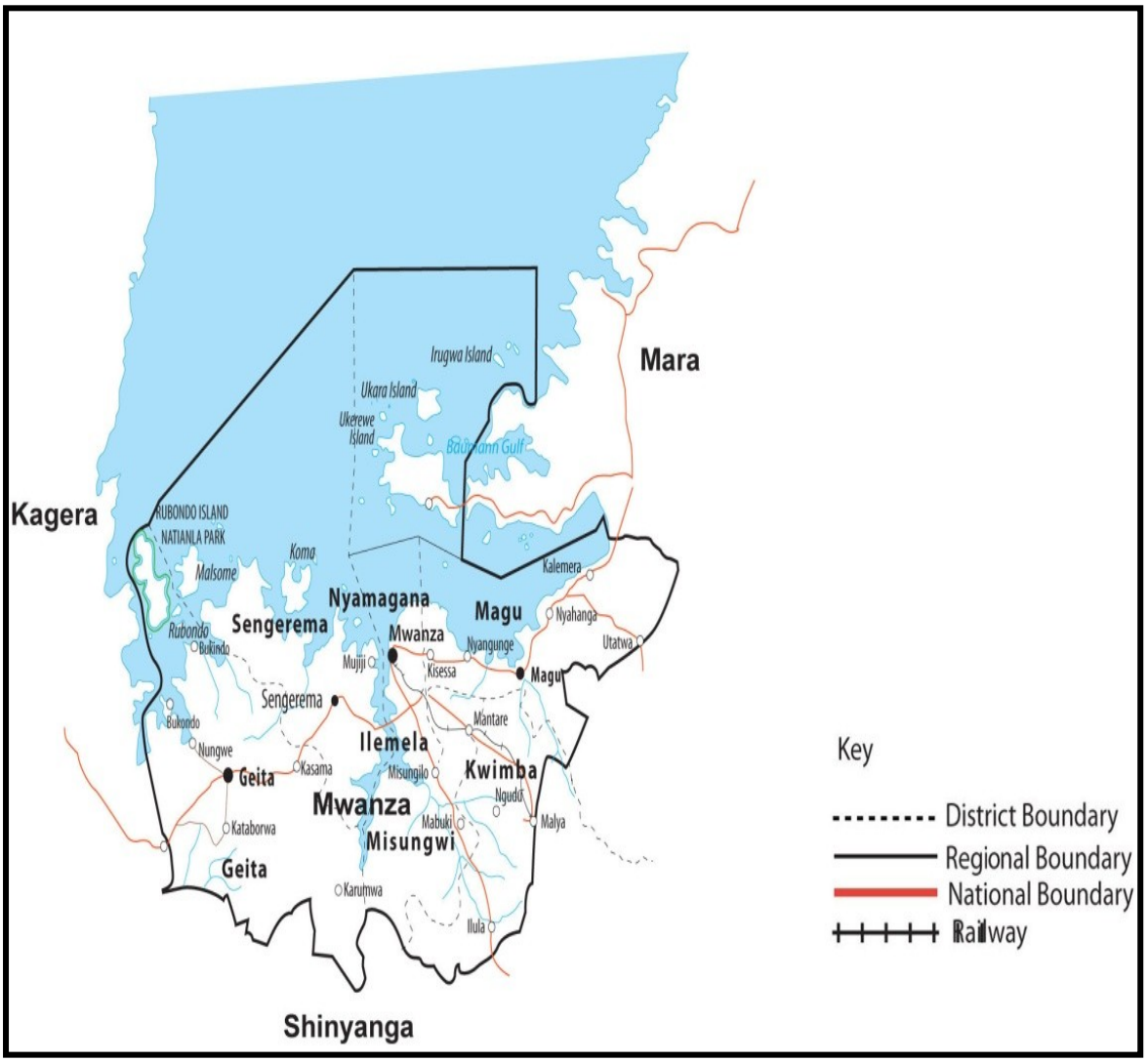
Food item	**Frequency of consumption**			**Rare**	**Never**
	Per day	**Per week**	**Per month**		
Carrots					
Pumpkin fruit					
Tomatoes					
Spinach					
Chinese cabbage					
African eggplant					
Eggplant					
Cowpea leaves					
Kale leaves					
Other indigenous veges!!!					
Fruits					
Citrus e.g oranges					
Mangoes					
Passion fruit					
Water melon					
Bananas					
Pineapple					
Papaya					
Avocado					
baobab					
Ukwaju					
Other indigenous fruits					
Beverages					
Coffee					
Tea					
Juice					
Milk					
Local brew					
Beer					
Spirits					
Other beverages (mention)					

SECTION 3: 24 HOUR DIETARY RECALL- Mother/Woman responsible for food preparation

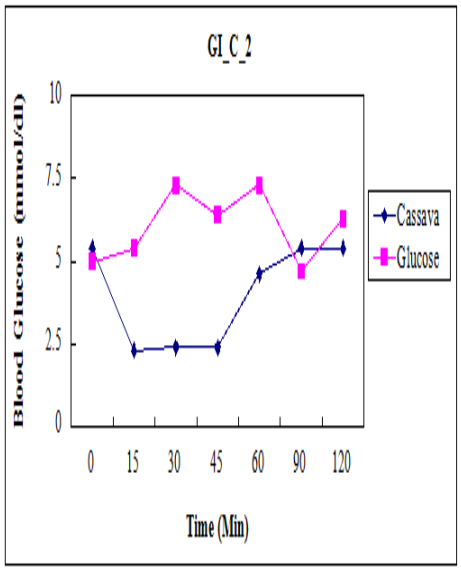
***Note to Enumerator**: **Explanation to interviewer:** Please describe everything that you ate and drank yesterday during the day or night, whether at home or outside the home. Record the amount on the 24 hr recall sheet using household equipments. Be sure to probe until the respondent says nothing else. If the respondent mentions mixed dishes like porridge, sauce or stew, probe what ingredients were in that mixed dish.*

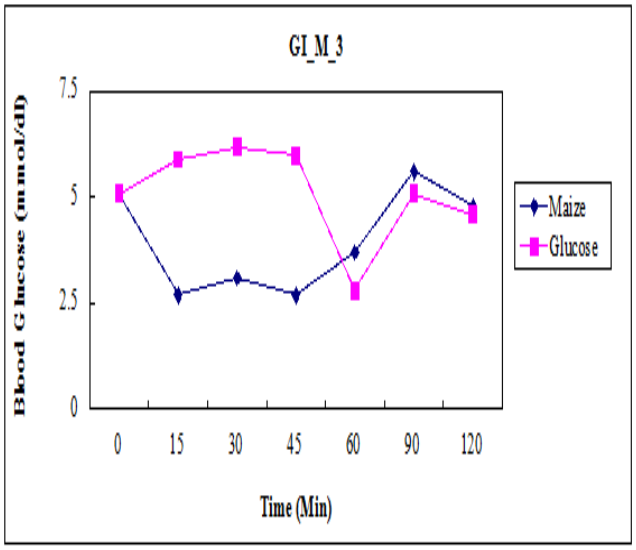
Meal time (as determined by the respondent)	Name of food or dish consumed (list one food per line	Ingredients	Amount served	Amount not consumed	Amount consumed	How consumed (1=cooked 2=raw)
Breakfast						
Late morning/snack						
Lunch						
Late afternoon/ snack						
Dinner						
Snack						
Probe for alcohol					1=Yes 2=No	
Abbreviations: Tablespoon=Tbsp, Tea spoon=tsp, Cup standard=c, glass standard=g						

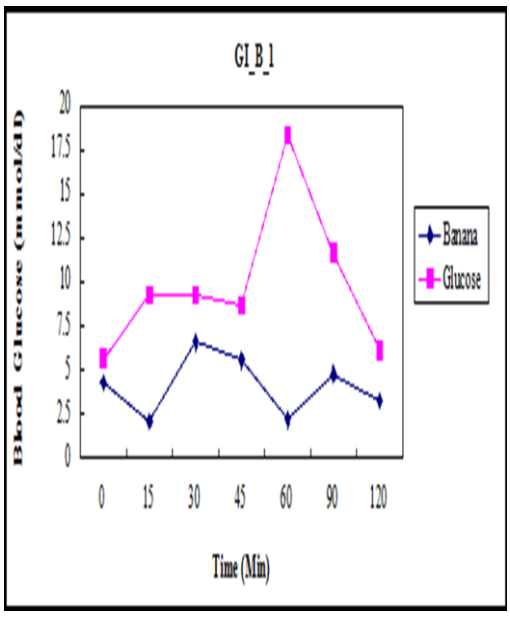
Appendix 3: Map of Mwanza Region

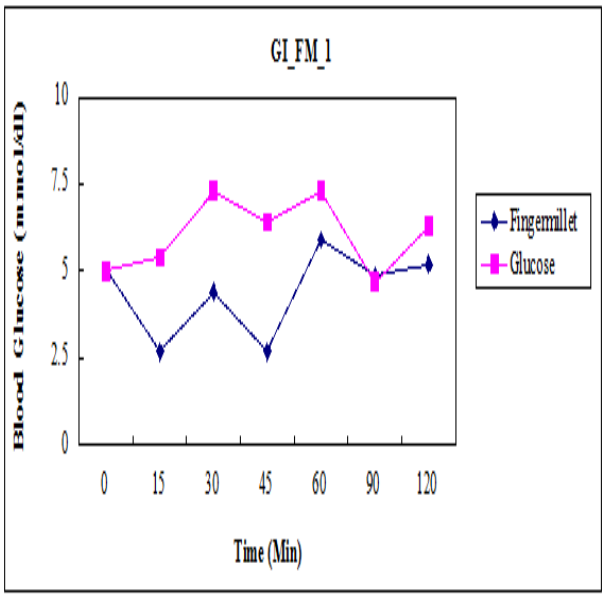


Appendix 4: Graphs showing the rise and fall of glucose in the blood over time after intake of different foods









Appendix 5: Pictures of different stages of glycemic study

Appendix 6: Ethical clearance Form

THE UNITED REPUBLIC OF
TANZANIA

National Institute for Medical Research
P.O. Box 9653
Dar es Salaam
Tel: 255 22 2121400/390
Fax: 255 22 2121380/2121360
E-mail: headquarters@nimr.or.tz

Ministry of Health and Social Welfare
P.O. Box 9083
Dar es Salaam
Tel: 255 22 2120262-7
Fax: 255 22 2110986

NIMR/HQ/R.8a/Vol. IX/1322

04th May 2012

Carolyne C Ruhembe
Sokoine University of Agriculture, Faculty of Agriculture
Department of Food Science and Technology
P O Box 3006, MOROGORO

CLEARANCE CERTIFICATE FOR CONDUCTING MEDICAL RESEARCH IN TANZANIA

This is to certify that the research entitled: Prevalence awareness and management of type 2 diabetes mellitus in Mwanza City, Tanzania (Ruhembe C C *et al),* has been granted ethics clearance to be conducted in Tanzania.
The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health & Social Welfare and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine. NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Approval is for one year: 04th May 2012 to 03rd May 2013.

Name: Dr Mwelecele N Malecela

Signature

CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Dr Donan Mmbando

Signature

ACTING CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, SOCIAL WELFARE

CC: RMO
DMO

Appendix 7: Permission letter to conduct a study with patients at Bugando hospital

BUGANDO MEDICAL CENTRE
Consultant and Teaching Hospital

P.O. Box 1370
Mwanza, Tanzania
Telephones 2540610/5
2500513
Fax: 255 – 028 - 2500799
Bugandohospital@gmail.com

Department of : ***Administration***

Our Ref: AB.317/440/01/Part F/35

Date: 09th June, 2014

Carolyne C. Ruhembe,
Sokoine University of Agriculture,
P.O. Box 3006,
MOROGORO.

RE: PERMISSION TO CONDUCT A MEDICAL RESEARCH

Reference is made to the above mentioned heading.

The permission is granted to conduct a Medical Research study titled: **"Prevalence, Awareness and Management of T2DM in Mwanza City".**

Wish you all the best.

Kagine, L.D
FOR: DIRECTOR GENERAL

FOR DIRECTOR GENERAL
BUGANDO MEDICAL CENTRE
MWANZA

Appendix 8: Research permission

JAMHURI YA MUUNGANO WA TANZANIA

OFISI YA WAZIRI MKUU

TAWALA ZA MIKOA NA SERIKALI ZA MITAA

OFISI YA MKUU WA WILAYA
WILAYA YA ILEMELA
S.L.P 2315
MWANZA

Kumb. Na.E.10/1 Vol.IV/140 21/08/2012

KWA YEYOTE ANAYEHUSIKA
ILEMELA

YAH: KIBALI CHA KUFANYA UTAFITI
NDG. CAROLYNE C. RUHEMBE

Mtajwa hapo juu ni Mwanafunzi wa Chuo Kikuu CHA SOKOINE CHA KILIMO (SUA) kilichoko Morogoro. Ameruhusiwa kufanya utafiti katika wilaya ya Ilemela na mada ya utafiti wake ni "PREVALENCE AWARENESS AND MANAGEMENT OF DIABETES MELLITUS TYPE 2 IN MWANZA REGION.

Tafadhali apewe ushirikiano ili aweze kufanikisha utafiti huo.

Nawasilisha,

W. Kassanga
Kny: KATIBU TAWALA WA WILAYA
ILEMELA

KNY. KATIBU TAWALA
ILEMELA

Appendix 9: Consent Form for Respondents

INFORMED CONSENT FORM

I am a PhD student of Sokoine University of Agriculture. My name is Carolyne Charles Ruhembe. I am currently doing my research titled "Prevalence, awareness and Management of Type 2 Diabetes Mellitus Among adults in Mwanza City Tanzania".

I need to collect information about prevalence awareness and management of type 2 diabetes mellitus in Mwanza City. I am therefore asking if you would agree to participate in my research by answering questions on the questionnaire and do some measurements such as weight, height, waist and hip circumferences, blood pressure, and blood glucose.

You are not forced to participate at all, or, even if you agree now, you can terminate your participation at any time without prejudice. You also do not have to answer individual questions you don't want to answer. Your name will not be attached to the questionnaire and I will ensure that your participation remains confidential. (This consent form will be kept separate from the questionnaire for all participants.)

Your responses may be included in the paper at the end of this research; however, your responses would be anonymous and nobody could connect your responses with you as an individual.

Benefits you may experience by participating in this study are greater knowledge of Type 2 diabetes mellitus and knowing your health status if you have diabetes or blood pressure.

By participating in this study, your risks are being upset or made uncomfortable by the questions asked and the measurements taken.

If you have any questions or concerns, please feel free to contact me:

Carolyne C.Ruhembe Mobile: 0683216074 or my Supervisor

Prof. T.C.E Mosha Mobile: 0767844024

I f you agree to participate please sign below

_____ _____

Participant signature Date

_____ _____

Researcher Signature Date

Appendix 10: Physical Activities Questionnaire For respondents

PHYSICAL ACTIVITIES QUESTIONNAIRE

Think about all the vigorous and moderate activities that you did in the last 7 days. Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3

1. Do you currently have a job or do any unpaid work outside your home?
   Yes…….
   No……. IF no Skip to part 2: transportation

   The next questions are about all the physical activity you did in the last 7 days as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, heavy construction, or climbing up stairs as part of your work? Think about only those physical activities that you did for at least 10 minutes at a time.
   Yes _____ days per week
   No…….. vigorous job-related physical activity
   Skip to question 4
3. How much time did you usually spend on one of those days doing vigorous physical activities as part of your work?
   _____ hours per day
   _____ minutes per day
4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do moderate physical activities like carrying light loads as part of your work? Please do not include walking.
   _____ days per week
   No …… moderate job-related physical activity Skip to question
5. How much time did you usually spend on one of those days doing moderate physical activities as part of your work?
   _____ hours per day
   _____ minutes per day
6. During the last 7 days, on how many days did you walk for at least 10 minutes at a time as part of your work? Please do not count any walking you did to travel to or from work. _____ days per week
   No…… job-related walking skip to part 2: transportation

7. How much time did you usually spend on one of those days walking as part of your work?
   _____ hours per day
   _____ minutes per day

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the last 7 days, on how many days did you travel in a motor vehicle like a train, bus, car, or tractor_____ days per week
   No traveling in a motor vehicle skip to question 10
9. How much time did you usually spend on one of those days traveling in a train, bus, car, tram, or other kind of motor vehicle_____ hours per day_____ minutes per da
   Now think only about the bicycling and walking you might have done to travel to and from work, to do errands, or to go from place to place.
10. During the last 7 days, on how many days did you bicycle for at least 10 minutes at a time to go from place to place? _____ days per week
    No…….bicycling from place to place Skip to question 12
11 How much time did you usually spend on one of those days to bicycle from place to place?_____ hours per day_____ minutes per day
12. During the last 7 days, on how many days did you walk for at least 10 minutes at a time to go from place to place? _____ days per week No……. walking from place to place.
    Skip to part 3: housework, house maintenance, and caring for family
13. How much time did you usually spend on one of those days walking from place to place?_____ hours per day _____ minutes per day

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the last 7 days in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, chopping wood, shoveling snow, or digging in the garden or yard? _____ days per week
    No vigorous activity in garden or yard Skip to question 16
15. How much time did you usually spend on one of those days doing vigorous physical activities in the garden or yard? _____ hours per day _____ minutes per day
16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do moderate activities like

carrying light loads, sweeping, washing windows, and raking in the garden or yard? _____ days per week . No….. moderate activity in garden or yard Skip to question 18

17. How much time did you usually spend on one of those days doing moderate physical activities in the garden or yard?_____ hours per day_____ minutes per day
18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do moderate activities like carrying light loads, washing windows, scrubbing floors and sweeping inside your home?_____ days per week If No moderate activity inside home Skip to part 4: recreation, sport and leisure-time physical activity
19. How much time did you usually spend on one of those days doing moderate physical activities inside your home?_____ hours per day _____ minutes per day

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the last 7 days solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the last 7 days, on how many days did you walk for at least 10 minutes at a time in your leisure time?_____ days per week No…….. walking in leisure time Skip to question 22
21. How much time did you usually spend on one of those days walking in your leisure time? _____ hours per day_____ minutes per day
22. Think about only those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do vigorous physical activities like aerobics, running, fast bicycling, or fast swimming in your leisure time? _____ days per week. No……vigorous activity in leisure time Skip to question 24
    How much time did you usually spend on one of those days doing vigorous physical activities in your leisure time?_____ hours per day_____ minutes per day
24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do moderate physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis in your leisure time?_____ days per week No…….. moderate activity in leisure time Skip to part 5: time spent sitting.
25. How much time did you usually spend on one of those days doing moderate physical activities in your leisure time?_____ hours per day _____ minutes per day.

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the last 7 days, how much time did you usually spend sitting on a weekday? _____ hours per day _____ minutes per day.
27. During the last 7 days, how much time did you usually spend sitting on a weekend day?_____ hours per day____ minutes per day.