DISSERTATION

UNIVERSITY OF NAIROBI-COLLEGE OF HEALTH SCIENCES

THE PREVALENCE OF PREOPERATIVE HYPERGLYCEMIA AMONG ADULT SURGICAL PATIENTS AT THE KENYATTA NATIONAL HOSPITAL

A DISSERTATION SUBMITTED IN PART FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF MEDICINE IN ANESTHESIOLOGY OF UNIVERSITY OF NAIROBI.

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2014

DECLARATION

This dissertation is my original work and has not been presented for a degree or any other

purposes in any institution.

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DEDICATION

'The great and glorious masterpiece of man is to know how to live to purpose',

Michel de Montaigne.

I dedicate this research work to my long time friend Felix, his journey with mature onset diabetes of the young that began eight years ago as a rather unusual surprise inspired this work.

ACKNOWLEDGEMENTS

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LIST OF ABBREVIATIONS

2hPG   Two hour plasma glucose

ADA   American Diabetes Association

ASA   American Society of Anesthesiologists

BMI   Basal Metabolic Rate

CDC   Centers for Disease Control and prevention

CI   Confidence Interval

DCCT   Diabetes Control and Complications Trial

DM   Diabetes Mellitus

ENT   Ear Nose and Throat

FPG   Fasting Plasma Glucose

FBS   Fasting Blood Sugar

GDM   Gestational Diabetes Mellitus

HbA1c   Glycated Hemoglobin

HDL   High Density Lipoprotein

IDF   International Diabetes Foundation

IFCC   International Federation of Clinical Chemistry

IFG   Impaired Fasting Glucose

IGT   Impaired Glucose Tolerance

KNH   Kenyatta National Hospital

MI   Myocardial Infarction

MODY   Mature onset diabetes of the young

NGSP   National Glycohemoglobin Standardization Program

OGTT   Oral glucose tolerance test

SD   Standard Deviation

SPSS   Statistical Package for Social Sciences

UON   University Of Nairobi

USPSTF United States Preventive Services Task Force

WHO   World Health Organization

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OPERATIONAL DEFINITIONS

Hyperglycemia- subjects with fasting blood sugar above 6.1mmol/l will be considered to have hyperglycemia

Impaired fasting glucose –a fasting blood sugar of 6.1- 6.9mmol/l and but with HbA1c < 6.5%.

Diabetes mellitus- A fasting blood sugar $\geq$ 6.1mmol/l and an HbA1c $\geq$ 6.5%.

Hypoglycemia- Any blood sugar reading below 3.9mmol/l

Elective surgery- Non Emergency surgery which is planned, allowing the doctor and patient to determine the best time and place for it

Emergency surgery- Surgery that cannot be delayed, for which there is no alternative therapy and a delay, could result in death or permanent impairment of health.

Hypertension- Blood pressure $\geq$ 140/90mmHg on more than two occasions at least six hours apart.

ABSTRACT

Introduction; Hyperglycemia is a condition manifested by an elevated glucose level in circulation and may be caused by several factors including diabetes mellitus or pre-diabetic states, drugs, acute illness and inflammation. Worldwide changes in lifestyle have led to increased rates of diabetes mellitus. While guidelines on glucose testing are lacking, several studies suggest the need for more widespread glucose testing among hospital patients.

Objective and methodology ; A hospital based cross-sectional survey was carried out over a period of six weeks to evaluate the prevalence of hyperglycemia , impaired fasting glucose and undiagnosed diabetes among adult patients scheduled for elective surgery. Possible predictors of hyperglycemia in this population were also assessed. An Interviewer administered questionnaire was used in addition to weight, height, and fasting blood sugar measurements. Glycated hemoglobin measurement was also done in selected patients.

Results; 163 non-diabetic adult patients who were scheduled to undergo anesthesia and surgical procedures were studied. Subjects were 55.8% female with a mean age of 44.9 ± 14.0 years. 3.7% of the patients were hyperglycemic (FBS > 6.1mmol/l). The prevalence of impaired fasting glucose (FBS 6.1- 6.9mmol/l) was 2.5% while that of undiagnosed diabetes (FBS > 6.1mmol/l and HbA1c $\geq$ 6.5%) was 1.2% This study revealed a lower prevalence of both preoperative impaired fasting glucose and undiagnosed diabetes relative to estimates from the general population and from similar studies. None of the patient characteristics studied was statistically significant as a predictor of hyperglycemia.

CHAPTER ONE
INTRODUCTION

1.1 Background

Hyperglycemia is a condition manifested by an elevated glucose level in circulation. It is not a disease entity in itself and may be caused by several factors including diabetes mellitus or pre-diabetic states, drugs, acute illness and inflammation. Diabetes mellitus refers to a group of common metabolic disorders that share the phenotype of hyperglycemia.[1] It is a syndrome of impaired carbohydrate, fat, and protein metabolism caused by either lack of insulin secretion or decreased sensitivity of the tissues to insulin.[2] Diabetes is a major cause of mortality, but several studies indicate that diabetes is likely underreported as a cause of death.[1] This may partly be attributed to under diagnosis. Diabetes is the fifth leading cause of mortality worldwide.[1]

Worldwide, in the year 2013 International Diabetes Foundation (IDF) estimates that 5.1million people died due to diabetes mellitus. In the same year, 8.3% of adults- 382million people- had diabetes, half of which were undiagnosed[3]. If current demographic patterns continue, IDF projects that in less than 25years, the prevalence will rise to over 592million.[3]

The prevalence of diabetes mellitus in the Africa region was 4.9% in the year 2013 according to IDF atlas.[3] An estimated 62% of diabetics in the Africa region do not know they have the disease.[3].

It is estimated that 749,250 (i.e. 3.58%) persons aged 20 to 79 years in Kenya suffer from diabetes mellitus.[3] 75% of these, that is 562,570 persons in this age group have undiagnosed diabetes.[3] Statistics for the developed world also indicate fairly high number of cases of undiagnosed diabetes. In the United States of America for example more than 60million adults

are estimated to have diabetes, or pre-diabetes. Of these, the proportion of undiagnosed diabetes is approximately 30%.[4] Given that diabetics are more likely to undergo surgical procedures than non-diabetics, [5] the prevalence of diabetes among pre-surgical patients is likely to be much higher than that in the general population.

Diabetes is associated with reduced life expectancy, significant morbidity due to specific diabetes related micro vascular complications, increased risk of macro vascular complications (ischemic heart disease, stroke and peripheral vascular disease), and diminished quality of life.[6]

"Diabetes thus potentially increases the possibility of surgery in affected individuals and also is a major risk factor for postoperative surgical and anesthetic complications, but meticulous control substantially reduces the risk. The stress response to surgery further worsens hyperglycemia. Lack of monitoring and glycemic control during surgery can result in hyperglycemia which causes delayed emergence from anesthesia especially if the patient develops "ketotic coma" [7]

The stress of surgery itself results in metabolic disturbances that alter glucose homeostasis[8] and hence interferes with glycemic control in the otherwise well controlled patient undergoing surgery.[9]

For the anesthetist, the concerns while attending to the diabetic patient include; risk of diabetes ketoacidosis, electrolyte disturbances, [10] hemodynamic instability during intubation, [11, 12] higher risk of difficult airway management and higher risk of aspiration.[12]

Diabetics are also at higher risk of postoperative infections[13] resulting in prolonged hospital stay. Evidence shows intensive lifestyle interventions delay or prevent diabetes onset in persons with prediabetes.[14]

1.2 Justification.

A majority of cases of diabetes mellitus in Africa region (62% as per the IDF Atlas[3]) are undiagnosed. With such a high prevalence of undiagnosed diabetes, case findings should be a public health priority. It would be quite prudent to consider every patient visit to health facility as an opportunity for screening.

Statistics from actual studies on diabetes mellitus in Kenya are lacking. The estimated prevalence of diabetes in Kenya is 3.58%[3] with a majority of those with the disease being undiagnosed. While numerous studies on the disease have been carried out in the country and in particular in the Kenyatta National Hospital, none has looked into the proportion of undiagnosed cases either in the general population or in the hospital setting. This study therefore, sought to address this knowledge gap by investigating both hyperglycemia and undiagnosed diabetes in the pre-surgical patients.

As highlighted above there are numerous peri-operative risks among patients with both acute hyperglycemia and those with diabetes mellitus. There is thus a need for glucose testing prior to surgery to identify all patients with hyperglycemia and thus manage them accordingly to mitigate the peri-operative risks.

The current practice at the Kenyatta National Hospital is that, unless specifically indicated, a complete blood count and renal function tests are the only mandatory investigations done preoperatively for patients scheduled for elective surgical procedures. The investigator thus projected that many patients undergo elective surgery with an unknown diabetes status. Some of these patients may have several evident risk factors for the disease.

For known diabetics however additional tests are usually ordered. In addition, measures are taken to ensure adequate glycemic control peri-operatively. Gwaro J.K.[7] in her study, titled peri-operative glycemic control among diabetics at the Kenyatta National Hospital, demonstrated that glycemic control in the peri-operative period is satisfactory. Undiagnosed diabetics, however would not benefit from this management and hence are predisposed to the risks of poor peri-operative glycemic control.

There is therefore need for research in this area to assess the need for screening patients for diabetes prior to surgery.

Noting the well documented association between hyperglycemia in hospitalized patients (with or without diabetes) and increased risk for complications and mortality, the Endocrine Society, in its clinical practice guidelines published in the year 2012, recommended blood glucose testing for all patients on admission to a hospital.[15]

Undiagnosed diabetes is typically not anticipated, which can result in a delay in recognition and treatment. This is likely to result in adverse outcomes especially in the peri-operative period.

Many patients presenting for elective surgery are fasting, providing an excellent opportunity for preoperative blood glucose testing and risk stratification. Adding a simple, inexpensive fasting glucose to other surgery-specific laboratory tests, or HbA1c where doing a fasting blood sugar is inappropriate, is not only essential to proper peri-operative care, but also capitalizes on a screening opportunity for a patient that may not otherwise present for regular routine health care.[16]

Detecting hyperglycemia preoperatively would not only allow initiation of measures to ensure adequate peri-operative glycemic control and thus minimize peri-operative morbidity and mortality, but it would also benefit the patient in the long term should diabetes be confirmed. Detection and proper management of preoperative hyperglycemia is therefore likely to reduce length of hospital stay, readmissions due to avoidable complications and overall cost of care.

By evaluating the prevalence of preoperative hyperglycemia among surgical patients, this study provides information to stakeholders on the proportion of patients scheduled for elective general surgery at the Kenyatta National Hospital who might benefit from screening for diabetes.

1.3. General Objective

To assess the prevalence of hyperglycemia among non-diabetic adults scheduled for elective surgery.

1.4. Specific Objectives

To:

a) Assess the prevalence of hyperglycemia among adults scheduled for elective surgery at the Kenyatta National Hospital.

b) Assess the prevalence of impaired fasting glucose among patients scheduled for elective surgery.

c) Identify the proportion of surgical patients with possible undiagnosed diabetes.

d) Identify possible predictors of hyperglycemia in the pre-surgical population.

CHAPTER TWO
LITERATURE REVIEW

Hyperglycemia is a condition in which an excessive amount of glucose circulates in the blood plasma. Hyperglycemia has several causes most common among them being diabetes mellitus. Intermittent hyperglycemia may be present in pre-diabetic states.[6]

Certain medications may increase the risk of hyperglycemia including phenytoin, niacin, thiazide diuretics, corticosteroids, niacin and pentamidine.[17] Patients suffering from an acute stress such as stroke or myocardial infarction, physical trauma, surgery may develop hyperglycemia in the absence of a diagnosis of diabetes.[6]

Hyperglycemia and glucose intolerance are common manifestations of peri-operative stress in many hospitalized patients[18]

Hyperglycemia also occurs naturally during times of infection and inflammation due to among other factors release of endogenous catecholamines. A plasma glucose of > 7.7mmol/l in the absence of diabetes is a clinical sign of sepsis.[19]

2.1 Definition and classification of Diabetes

Diabetes mellitus (DM) is a metabolic disorder resulting from a defect in insulin secretion, insulin action, or both. Insulin deficiency in turn leads to chronic hyperglycemia with disturbances of carbohydrate, fat and protein metabolism.[20]

Diabetes Mellitus is classified on the basis of the pathogenic process that leads to hyperglycemia.[1] It may be categorized into several types but the two major types are type 1 and

type 2.[20]   Type 1 diabetes mellitus is the result of complete or near-total insulin deficiency. Type 2 DM is a heterogeneous group of disorders characterized by variable degrees of insulin resistance, impaired insulin secretion, and increased glucose production.[1]

Diabetes Mellitus can be classified as follows:[21]

1. Type 1 diabetes mellitus

- Autoimmune induced

- Idiopathic

2. Type 2 diabetes mellitus

- Obese person with diabetes

- Non-obese persons with diabetes

3. Gestational diabetes mellitus (GDM)

4. Other types of diabetes associated with certain conditions and syndromes.

2.2 Type 2 diabetes [1,20,21,22]

This form of diabetes accounts for 90-95% of the total diabetes burden. Type 2 diabetes frequently goes undiagnosed for many years (up to four to seven years) because of the gradual onset of either pancreatic dysfunction or insulin resistance and the subsequent hyperglycemia.

The causes of this form of diabetes are many and varied. The specific etiologies are however unknown. Its frequency varies in different racial/ethnic subgroups. Type 2 diabetes is associated with a strong complex and generally poorly defined genetic predisposition. The risk of developing this form of diabetes increases with age, obesity, and lack of physical activity.

2.3 Risk Factors for Diabetes Mellitus

Table 3 Risk Factors for Type 2 Diabetes Mellitus[1]
Family history of diabetes (i.e., parent or sibling with type 2 diabetes)
Obesity (BMI $\geq$ 25 kg/m^2)
Habitual physical inactivity
Race/ethnicity (e.g., African American, Latino, Native American, Asian American, Pacific Islander)
Previously identified IFG or IGT
History of GDM or delivery of baby >4 kg (>9 lb)
Hypertension (blood pressure $\geq$ 140/90 mmHg)
HDL cholesterol level < 35 mg/dl (0.90mmol/l) and/or a triglyceride level > 250 mg/dl (2.82mmol/l)
Polycystic ovary syndrome or acanthosis nigricans
History of vascular disease

Karekethi and colleaques[23] did random blood sugars in 6,028 persons in central Kenya in the year 2013. In their study yet to be published they concluded that age between 50-59 years, hypertension, presence of symptoms (e.g. blurred vision, osmotic symptoms),positive family history of DM, and a BMI $\geq$30 kg/m2 were the main predictors of dysglycemia (RBS $\geq$7.8mmol/l).

2.3.1 Hypertension and Obesity as risk factors for diabetes.
Hypertension

Hypertension is present at diagnosis in many patients with type 2 diabetes, but generally does not occur until after the onset of renal disease in patients with type 1 diabetes .[24]

In England, surveys have found the prevalence of hypertension to be as high as 70% of adults with type 2 diabetes –with about 50% having blood pressure of 160/95mmHg or higher.[25]

Obesity

Central obesity is the most common cause of insulin resistance, which can lead to impaired glucose tolerance and eventually to diabetes mellitus.

Insulin becomes elevated with obesity because higher insulin levels are necessary to send glucose into the cells. The beta cells in the pancreas become exhausted, increasing the risk of diabetes. Elevated serum fat content leads to dyslipidemia. The triad of hypertension, elevated lipids, and elevated risk for diabetes contributes to inflammation and accelerated risk of developing atherosclerosis. [26]

In a cross-sectional study carried out among Luo, Kamba and Maasai in rural and urban Kenya among 1430 individuals aged 17-68years, abdominal visceral and subcutaneous fat, BMI, and waist circumference increased with age, and were highest in the Maasai and in the urban population. The prevalence of overweight (BMI $\geq$ 25) (39.8% vs. 15.8%) and obesity (BMI $\geq$ 30) (15.5% vs. 5.1%) was higher in the urban than in rural population.[27]

The other factors associated with a higher risk of diabetes mellitus are as listed in Table 3 above.

2.4 Screening and Diagnosis of Diabetes

The necessary requirements for screening for a disease include[28]:

1. That the condition is an important health problem

2. An accepted treatment is available

3. The disease has an early asymptomatic stage

4. A suitable screening test exists.

Undiagnosed type 2 diabetes mellitus meets all four requirements.

Harris MI *et. al.*[22] demonstrated that on average type 2 Diabetes Mellitus occurs 4-7 years prior to diagnosis. They further noted that undiagnosed type 2 Diabetes Mellitus is not a benign condition and that clinically significant morbidity is present at diagnosis and for years before diagnosis. It is therefore appears prudent to make the diagnosis at the earliest opportunity.

The American Diabetes Association (ADA) recommends that fasting glucose concentration should be used in routine screening for diabetes as well as epidemiological studies.[29]

At the present time the World Health Organization[6] emphasizes that the fasting plasma glucose is the most reliable and convenient test for identifying DM in asymptomatic individuals.

Table 1 Summary of 2006 WHO Recommendations for the diagnostic criteria for diabetes and intermediate Hyperglycemia [6]

Diabetes

Fasting plasma glucose	$\geq$ 7.0mmol/l
	Or
2-h plasma glucose *	$\geq$ 11.1mmol/l

Impaired Glucose Tolerance

Fasting plasma glucose	< 7.0mmol/l
	and
2-h plasma glucose *	$\geq$ 7.8 and < 11.1mmol/l

Impaired Fasting Glucose

Fasting plasma glucose	6.1 to 6.9mmol/l
	And if measured
2-h plasma glucose *	< 7.8mmol/l

* Venous plasma glucose 2–h after ingestion of 75g oral glucose load (OGTT)

* If 2–h plasma glucose is not measured, status is uncertain as diabetes or IGT cannot be excluded.

A random plasma glucose concentration of 11.1mmol/l accompanied by classic symptoms of DM (polyuria, polydipsia, weight loss) is sufficient for the diagnosis of DM. Oral glucose tolerance testing, although still a valid means for diagnosing DM is not recommended as part of routine care.

While earlier guidelines by the WHO do not advocate for use of HbA1c in making a diagnosis of diabetes mellitus, in an addendum to the 2006 guidelines published in the year 2011,[30] the organization allows the use of HbA1c in making a diagnosis of diabetes mellitus provided that stringent quality assurance tests are in place and assays are standardized to criteria aligned to the international reference values, and there are no conditions present which preclude its accurate measurement. An HbA1c of ≥ 6.5% is the cut off for diagnosis of Diabetes mellitus, however no guidelines are given for pre-diabetic conditions.

On the other hand, the American Diabetes Association in both its 2010[29] and 2012[31] guidelines allows the use of HbA1c in making a diagnosis of Diabetes Mellitus and increased risk of diabetes. These 2012 ADA guidelines are as detailed in the table below.

TABLE 2 -TESTS TO DIAGNOSE DIABETES AS PER THE AMERICAN DIABETES ASSOCIATION [31]

For all the below tests, in the absence of unequivocal hyperglycemia, results should be confirmed by repeat testing.

STAGE	HbA1C NGSP certified & standardized assay	Fasting Plasma Glucose (FPG) No intake 8 hrs	Random Plasma Glucose	Oral Glucose Tolerance Test (OGTT) 75-g
Diabetes	HbA1C ≥ 6.5%	FPG ≥ 7.0mmol/l	Random plasma glucose ≥ 11.1 mmol/l plus symptoms.	Two-hour plasma glucose (2hPG) ≥ 11.1mmol/l
Increased risk of diabetes	HbA1C 5.7 – 6-4%	Impaired Fasting blood glucose (IFG) = FPG 5.6-6.9mmol/l	Random = any time of day w/out regard to time since last meal; symptoms include usual polyuria, polydipsia, and unexplained wt loss.	Impaired Glucose Tolerance (IGT) = 2hPG 7.8-11.0mmol/l
Normal	HbA1C < 5.7%	FPG < 5.6mmol/l		2hPG < 7.8mmol/l

To avoid misdiagnosis when the client is asymptomatic or in the absence of unequivocal hyperglycemia both WHO and ADA recommend repeat testing on a different day. When both a glucose test and HbA1c level measurements are in the abnormal range these confirm a diagnosis.[30]

Tekumit H *et. al.*[32] further demonstrated that when used in combination HbA1c and fasting blood glucose have a higher specificity and sensitivity than either used alone.

Wide spread use of the FPG as a screening test for type 2 DM is recommended because:

1. A large number of individuals who meet the current criteria for DM are asymptomatic and unaware that they have the disorder,

2. Epidemiologic studies suggest that type 2 DM may be present for up to a decade before diagnosis, [1]

3. As many as 50% of individuals with type 2 DM have one or more diabetes-specific complications at the time of their diagnosis, [1] and

4. Treatment of type 2 DM may favorably alter the natural history of DM.

The ADA recommends screening all individuals >45 years every 3 years and screening individuals at an earlier age if they are overweight [body mass index (BMI) > 25 kg/m^2] and have one additional risk factor for diabetes.[1]

Studies have a shown that persons with more risk factors are at a higher risk with a prevalence of type 2 diabetes mellitus of up to 25% in those with all the four major risk factors (a positive family history, Age above 45years, hypertension and a BMI $\geq$ 25 Kg/M^2).[33]

On the other hand the United States Preventive Services Task Force (USPSTF) advocates

diabetes screening for adults with hypertension only, citing insufficient evidence ("I statement") to recommend screening for other groups.[16]

However, Sheehy A.M. *et. al.*[16], 2009 in a review point out that both the USPSTF and ADA admit to the difficulties of carrying out proper randomized trial to support screening.

As can be seen opinions differ on who should be screened for diabetes. Lack of guidelines not withstanding it appears that there is need to have more widespread glucose testing in the hospital setting for both surgical and medical patients. Noting the well documented association between hyperglycemia in hospitalized patients (with or without diabetes) and increased risk for complications and mortality, the Endocrine Society, in its clinical practice guidelines published in the January 2012 issue of the Journal of Clinical Endocrinology & Metabolism, recommends blood glucose testing for all patients on admission to a hospital.[15]

2.5 Preoperative Evaluation

Patients are reviewed preoperatively to reduce the surgical and anesthetic peri-operative morbidity or mortality and to ensure they return to desirable functioning as quickly as possible.[13] In his review of preoperative evaluation and preparation for surgery and anesthesia, Zambouri A[13] notes the following as the primary goals of preoperative evaluation and preparation:

1. Documentation of the condition(s) for which surgery is needed.
2. Assessment of the patient's overall health status.
3. Uncovering of hidden conditions that could cause problems both during and after surgery.
4. Peri-operative risk determination.

5. Optimization of the patient's medical condition in order to reduce the patient's surgical and anesthetic peri-operative morbidity or mortality.

6. Development of an appropriate peri-operative care plan.

7. Education of the patient about surgery, anesthesia, intra-operative care and postoperative pain treatments in the hope of reducing anxiety and facilitating recovery.

8. Reduction of costs, shortening of hospital stay, reduction of cancellations and increase of patient satisfaction.

Zambouri A [13] further notes that, while persons without concomitant medical problems need little more than a quick medical review, those with co-morbidities should be optimized for the procedure.

It is well recognized that safe and efficient surgical and anesthesia practice requires an optimized patient. Several of the large-scale epidemiological studies have indicated that inadequate preoperative preparation of the patient may be a major contributory factor to the primary causes of peri-operative mortality.[13]

2.6 Preoperative hyperglycemia

Roberts *et. al.*[34] did fasting blood sugars on 1,000 patients scheduled for elective surgery. They found 3.6% of them to have hyperglycemia ($\geq$ 7.0mmol/l) and an additional 26.9% (5.6-6.9mmol/l) had impaired fasting blood glucose. They also found out that age, male gender, family history, and body mass index were the independent predictors of elevated fasting blood sugar among pre-surgical patients. Hatzakorzian *et. al.*[35] did a similar study among patients scheduled for non cardiac surgery and found 25% of patients not previously diagnosed to have diabetes had an elevated fasting blood sugar. Of these 6.5% had a provisional

diagnosis of diabetes. Koumpan and colleagues[36] did HbA1c, fasting blood sugar and random blood sugar among all 406 patients scheduled for elective surgery (both diabetic and non diabetics). A sub-analysis of their data revealed that, 23% of the non diabetics at time of enrolling into the study actually had pre-diabetes and a further 3.9% had a HbA1c of > 6.5% (i.e. diabetes).

2.7 Hyperglycemia and Peri-operative complications

When blood glucose is poorly controlled over long periods in diabetes mellitus, blood vessels in multiple tissues throughout the body begin to function abnormally and undergo structural changes that result in inadequate blood supply to the tissues. This in turn leads to increased risk for heart attack, stroke, end-stage kidney disease, retinopathy and blindness, and ischemia and gangrene of the limbs. Chronic high glucose concentration also causes damage to many other tissues. For example, peripheral neuropathy, which is abnormal function of peripheral nerves, and autonomic nervous system dysfunction are frequent complications of chronic, uncontrolled diabetes mellitus. These abnormalities can result in impaired cardiovascular reflexes, impaired bladder control, decreased sensation in the extremities, and other symptoms of peripheral nerve damage. In addition, hypertension, secondary to renal injury, and atherosclerosis, secondary to abnormal lipid metabolism, often develop in patients with diabetes and amplify the tissue damage caused by the elevated glucose.[2]

Peri-operatively cardiovascular complications are of most concern. Peri-operative MI is the most common major peri-operative vascular complications, and it is associated with poor prognosis. Most patients who have a peri-operative MI will not experience ischemic symptoms; however,

asymptomatic peri-operative MI is as strongly associated as symptomatic MI with 30-day mortality. Therefore it is essential to do cardiac biomarkers in the peri-operative period.[37]

Frisch A *et al*.[38] did an observational study on 3,184 non cardiac surgery patients and demonstrated that both pre and postoperative hyperglycemia are associated with increased length of stay, hospital complications, and mortality after non-cardiac general surgery. In particular they noted higher rates of postoperative pneumonia, urinary tract infections, acute renal failure and acute myocardial infarction amongst patients with significantly higher peri-operative glucose levels.

In non-cardiac surgery patients, pre-operative blood glucose levels above 11.1mmol/l (200 mg/dl) have been shown to be associated with a 2.1-fold higher risk in overall 30 day mortality and a f our-fold higher risk of 30 day cardiovascular mortality.[39]

The presence of autonomic neuropathy predisposes the patient to peri-operative hypotension, gastroparesis with possible aspiration, and hypoglycemia unawareness.[40]
Limited joint mobility of the neck from non-enzymatic glycosylation and abnormal cross-linking of collagen may render endotracheal intubation difficult.[40]

While transient hyperglycemia is usually benign, persistent hyperglycemia is a risk factor for endothelial dysfunction, postoperative sepsis, cerebral ischemia and inhibits host defenses against infection, including many leukocyte functions as well as impairing wound healing because of detrimental effects on collagen formation and the resulting diminished wound tensile strength.[13] Hyperglycemia also increases the risk of renal allograft rejection.[6]

2.8 Diabetes: the Kenyan scenario

Although there is paucity of published data as regards the actual prevalence of undiagnosed diabetes in Kenya or in any subpopulation in Kenya, several studies on diabetes mellitus have been done most of them at the Kenyatta National Hospital. Among them are studies by Mwendwa FM [41], Vaghela VP [42], Nguchu HK [43], Nalwa WZ [44], Kiunga SK [45], Mwale C [46], Ngalyuka PK [47] and Gwaro JK [7]. Vaghela VP[42] examined the adequacy of glycemic control among patients attending the KNH Diabetic outpatient clinic while Gwaro JK[7] evaluated peri-operative glycemic control among patients scheduled for surgery at the KNH. On the other hand, Nalwa WZ[44] investigated glycemic control, cardiovascular risk profile and therapeutic interventions in type 2 diabetes mellitus patients at the new Nyanza Provincial General Hospital, Kisumu.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Study Design.

The research was a cross sectional survey involving non-diabetic patients scheduled for elective surgery at the Kenyatta National Hospital. Only clients above the age of 18 years were considered.

3.2 Study Site.

The study was carried out at Kenyatta National Hospital surgical wards. KNH is the largest referral and teaching hospital in Kenya. The clientele of the Kenyatta national Hospital is national in outlook with both rural and urban catchments.

It has a bed capacity of more than 1,800. Currently the hospital has 50 wards, 20 outpatient clinics, 24 operating theatres and accident and emergency department.

The study was carried out in all surgical wards accommodating adult patients scheduled for elective surgery. These include gynecological surgeries, ENT surgery, plastic surgery, maxillofacial surgery, neurosurgery, general surgery, orthopedic surgery, eye surgery, cardiothoracic surgery and urological surgeries.

3.3 Study Population

The target population of the study was all clients scheduled for elective surgery at the Kenyatta national Hospital. After giving informed consent, clients were interviewed and subsequently measurements including weight, height and fasting blood sugar taken as detailed above.

3.4 Sample size estimation

This study used a cross-sectional design to determine the prevalence of hyperglycaemia among patients scheduled for elective general surgery. Therefore, Fisher's formula [48] was used to estimate a minimum sample size required for this study. The calculation was done as follows:

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

n – Sample size

Z – 1.96 (95% confidence interval)

P – Estimated prevalence of hyperglycemia in pre-surgery patients – 3.6% (Roberts *et al*, 2007[34])

d – Margin of error (precision error) = ±3%

Substituting into the formula,

 n = 148

Adding 10% to this number gives a total 163 patients.

3.5 Inclusion/exclusion criteria

3.5.1 Inclusion criteria

Patients scheduled for elective surgery

Patients not known to be diabetic

Patients who were willing and able to give consent

Patients above 18years of age

American Society of Anesthesiologists (ASA) class I and II patients.

3.5.2 Exclusion criteria

Patients already known to have diabetes Mellitus

Patients below the age of 18years

Patients who were unwilling or were unable to give consent

Patients whose weight and height could not be measured (see height and weight measurement below)

3.6 Sampling and recruitment

Systematic sampling method was used. Potential study subjects were all patients scheduled for elective surgery and who had already been selected and their names included in the theatre list. A list of all the patients scheduled for elective surgery was compiled from theatre lists submitted to the operating theatres by the different surgical specialties a day prior to the scheduled surgical procedure. From this list every third patient was picked to be included in the study. The subjects were then approached in view of recruiting them to the study. The intention to include them in the study, the aims and benefits of the study, the data collection procedures and the potential ill effects related to the study were then explained. A preliminary assessment to evaluate whether the patient met the inclusion criteria was also made. Those meeting the inclusion criteria and who consented to participating in the study were recruited. This procedure was repeated on each day of data collection till the required sample size was attained.

3.7 Study protocol and Data collection

Data collection was done by the chief investigator and a study assistant. This was done on the evening prior to surgery and at 6 to 8a.m. on the morning of surgery. Collection of data took place in the surgical wards. An interviewer administered questionnaire (Appendix i), was used to

collect data. The clients had their weight and height taken and from these their body mass index (BMI) calculated the evening before the scheduled surgery. The format in Appendix i was followed in the examination and recording of these measurements

Fasting blood sugar measurement was done on the morning prior to surgery. Based on WHO criteria on the diagnosis of Diabetes[24], clients were classified either as having normal glucose levels (normoglycemia), or hyperglycemia. For those with a fasting blood sugar equal or higher than 6.1mmol/l a venous blood sample was taken and from this glycated hemoglobin measured. Those with a fasting blood sugar between 6.1 and 6.9mmol/l were classified as having impaired fasting glucose, while those with an HbA1c of > 6.5% with or without hyperglycemia were deemed to be diabetic as per the 2011 WHO criteria.[24]

The patients found to have either diabetes or pre-diabetes were referred to a physician for further confirmatory diagnostic testing and further management.

3.7.1 Research Questionnaire (Appendix i)

This was written in English, but translated to Swahili as need arose during the interview. The chief investigator and a research assistant administered the questionnaires to the research subjects. The research assistant was trained on how to administer the questionnaires, take height, weight and safely do FBS measurements and draw venous blood samples.

3.7.2 Height and weight measurements

All recruited subjects had their weight and height measurements taken and these were used to calculate their body mass index. Both height and weight measurements were taken with the patient in an upright position. For this reason, patients who were unable to stand in the upright

position for example, bedridden patients and orthopedic patients on traction were excluded from the study. A digital medical weighing scale was used. With only light clothing on, the patient were requested to stand bare foot at the center of the platform of the weighing scale. The weight measured was recorded in the questionnaire. For height measurement a height rule mounted on a vertical wall was used. The clients stood barefoot on a flat surface with the back of the head, back, buttocks and calves to the wall on which the height rule was mounted on. The height measurement was then taken from the foot to the vertex with patient looking straight ahead. Both the weighing scale and the height rule were standardized to ensure accuracy.

3.7.3 Blood pressure measurement

Blood pressure measurements were taken on all research subjects on two occasions, on the evening before surgery and on the morning of surgery. A digital blood pressure machine was used. Blood pressure was measured with the client seated with his/her arm resting on a flat surface. Subjects who were considered as hypertensive were those with either a history of treatment for hypertension or on measurement had blood pressure above 140/90mmHg on both measurements taken.

3.7.4 Fasting Blood Sugar measurement

The fasting blood sugar was taken on the morning of the operation. A Hemocue 201 glucose analyzer which is based on a glucose dehydrogenase method will be used. The Glucose analyzer was calibrated according to the manufacturer's guidelines. An additional sample from every 25th measurement was taken for laboratory glucose measurement for quality control. On the morning of the scheduled surgical operation, a capillary blood sample was collected by finger prick method after ascertaining from the patient that he or she had not taken any meal or drink in the

preceding 8-hour period. The investigator or his trained assistant washed their hands dried them and put on a pair of clean gloves. The middle finger tip was massaged and then cleaned with an alcohol swab and after allowing it to dry pricked lightly with a lancet. A drop of blood (about 50µl) was collected onto the glucose strip attached to the Hemocue 201 glucose analyzer to obtain blood sugar measurement.

3.7.5 Glycated hemoglobin.

For patients found to have a fasting blood sugar equal or higher than 6.1mmols/l a venous blood sample for HbA1c measurement was collected. The procedure was explained to the patient. The chief investigator or his assistant put on a pair of clean gloves after cleaning and drying his hands. An alcohol swab was then used to clean the antecubital fossa after which 2mls of blood was drawn using a sterile gauge 23 needle attached to a 2mls syringe from the antecubital vein. The sample was then submitted in a preservative free vacutainer to the appointed laboratory for analysis. A COBAS INTEGRA 400/800 Tina-quant Hemoglobin A1c Gen.2 analyzer, that is standardized according to the International Federation of Clinical Chemistry (IFCC), was used to analyze samples for HbA1c. IFCC standards are transferable to the National Glycohemoglobin Standardization Program (NGSP) as recommended by WHO.

3.8 Data management and analysis.

At the end of each day data cleaning was done to ensure correctness and enable retrieval of any missing information. Data from the questionnaires was coded and entered into SPSS (Statistical Package for the Social Sciences) version 17.0 software for analysis.

Descriptive analysis was done and the population described by summarizing socio-demographic data into means or medians for numeric variables such as age and percentages for categorical

variables such as sex. Prevalence of hyperglycemia and impaired fasting glucose was calculated as proportions of patients with high blood sugar (refer to operational definitions) with 95% confidence interval. In addition, proportion of patients with undiagnosed diabetes was calculated and presented as a percentage with 95% confidence interval.

Hyperglycemia was associated with other factors such as age, sex, BMI, family history of diabetes mellitus and presence and/or history of hypertension. Chi-square test was used to analyze association for categorical variables while Student's t test was used to compare means for both age and BMI. Odds ratio were also calculated to identify possible predictors of hyperglycemia. All the statistical tests were performed at 5% level of significance.

3.9 Ethical considerations.

For purposes of obtaining an informed consent of the respondents, every client, on an individual basis, was furnished with brief information concerning the research i.e. the research objectives, benefits and the importance of examining them. It was clarified that:

- The choice to participate in the research was completely voluntary,

- Every client, even after giving consent to participate, would retain the right to opt out of the research any time they wished like without repercussion against them ,

- Blood sample to check blood sugar would be via a finger prick which was liable to cause some inconvenience or discomfort to the client. Only those clients who would require further testing with glycated hemoglobin would have venous blood drawn,

- No surgical intervention, or other invasive procedure apart from the finger prick, and where necessary phlebotomy would be performed on the subject,

- No monetary or other forms of tangible benefits would be realized in appreciation for participation in the research as a respondent,

- Every respondent would be entitled to full information pertaining to the progress and findings of the research,

- All information obtained would strictly be kept confidential and would only be used for purposes of the said research,

- A respondent who consented to participate would confirm such consent by appending her signature or thumb print on the availed Consent Form. (Appendix iii)

Subjects were also informed of the availability of professionals and other resources to assist manage hyperglycemia or diabetes detected during the study. Subsequently, clients who gave written consent to the research were recruited into the study.

In order to ensure patients found to have hyperglycemia after FBS measurement go through surgery and anesthesia safely, the surgeon and anesthetist scheduled to handle the case were informed. The physician on call was also called in to review the patient and advise on management.

Approval was sought from the KNH/UON-Ethics and Research Committee prior to carrying out the study.

CHAPTER 4

RESULTS

Between 29th January and March 10th 2014 a total of 163 patients from the surgical wards at the Kenyatta National Hospital were systematically sampled.

Demographic Data

Demographic characteristics of the clients studied are as detailed below.

Gender Distribution

Out of the 163 clients sampled 91 were female while 72 were male patients,

Figure 1: Pie Chart showing Gender distribution
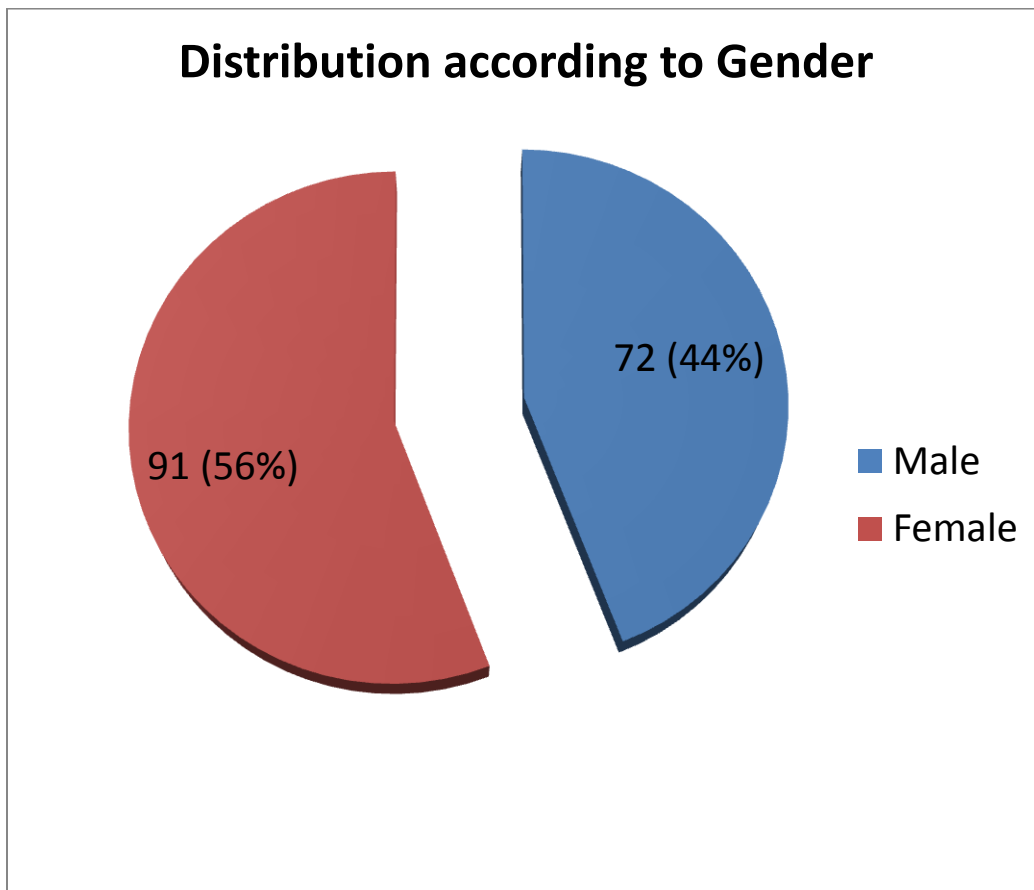
Figure 2: Figure showing age distribution of patients included in the study
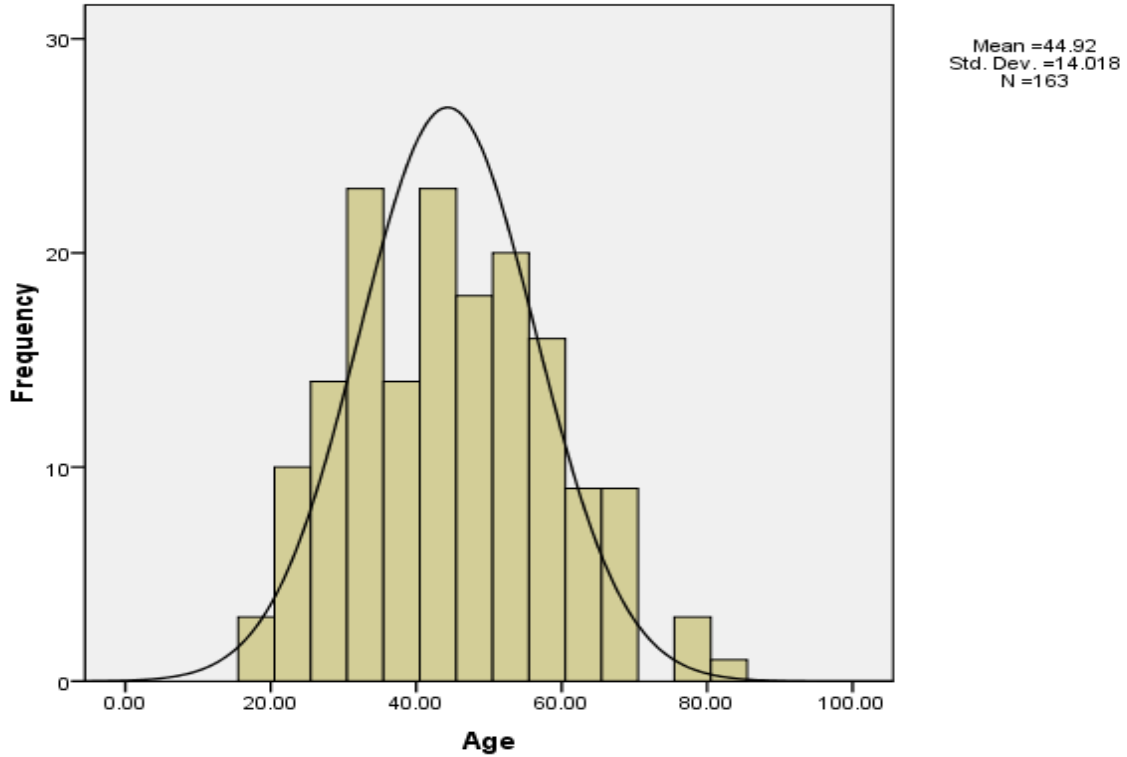
Only patients above the age of eighteen years were included in the study. The youngest of those studied was eighteen years while the oldest was 82years old. As shown in the figure the vast majority of the patients were aged between 30 and 60 years.

The mean age was 44.9 years with a standard deviation of 14.0.

Surgical diagnosis

Patients studied had the following surgical diagnoses:

1. Gynecological- Infertility, Cervical High grade squamous intraepithelial lesion , obstetric fistulae, Endometrial carcinoma, Ovarian cancer, cervical cancer, Vulvovaginal warts,

uterine fibroids, vulval cancer, ovarian mass, chronic pelvic pain, Adenomyosis, third degree perineal tear,

2. Orthopedic – Fracture Humerus, fracture radioulnar, L3/L4 spondylolisthesis, spinal stenosis, disc prolapse

3. Obstetric- previous cesarean section,

4. Cardiovascular/Thoracic- Varicose veins, esophageal stenosis, aspergilloma lung, extracardiac mass, ESRD for AV fistula , valvular heart disease, mediastinal mass, constrictive pericarditis, arrow head in thoracic cavity, bronchopleural fistula, empyema thoracis, carotid body tumour, dermatofibromyosarcoma of the chestwall,

5. Otolaryngological- chronic suppurative otitis media, Cancer of the hypopharynx, subglottic stenosis, carcinoma of adenoids, nasal polyposis, sinonasal fibroma, cancer of the larynx,

6. Neurosurgical/Head and Neck- Fronto-orbital mass, meningioma, Chiari malformation, parotid cyst, intraventricular tumour, parotid mass, supraclinoid aneurysm, anterior communicating artery aneurysm, posterior cranial fossa tumour

7. Urological- urethral stricture, bladder outlet obstruction, renal malignancy, urethral meatal warts, bladder cancer, retroperitoneal mass, benign prostatic enlargement, pelvi-ureteric junction obstruction, testicular tumour

8. General Surgical- Stomach cancer, colostomy for closure, lipoma, breast cancer, cholelithiasis, chronic wound, rectal cancer , fistula in ano, pancreatic mass, postfasciotomy wound, multinodular goiter, thigh sarcoma, epigastric hernia, inguinal hernia, squamous cell carcinoma of the foot, thigh mass,hemorrhoids,

9. Dental/maxillofacial- Ameloblastoma, infected mandibular bone graft,

10. Opthalmological- retinal detachment, macular edema, vitreomacular traction syndrome

11. Plastic Surgery- Burns

Risk Factors for Hyperglycemia and Diabetes

The table below shows the prevalence of major risk factors of hyperglycemia and diabetes mellitus in the study group:

Table 4: Prevalence of major risk factors for Diabetes Mellitus

Variable		Frequency (%)
Family History of Diabetes Mellitus	Yes	23 (14.1)
	No	140 (85.9)
Relatives suffering from diabetes	Parent	6 (26.1)
	Sibling	6 (26.1)
	Both parent & sibling	2 (8.7)
	Other	9 (39.1)
Previous or current diagnosis of hypertension	Yes	82 (50.3)
	No	81 (49.7)
Age		
	45 and above	81 (49.7)
	Below 45	82 (50.3)
Body mass index	Above 25	62(38.1)
	Below 25	101(61.9)
Clustered Risk factors		
0		36 (22.1)
1		53 (32.5)
2		38 (23.3)
3		28 (17.2)
4		8 (4.9)

Hypertension

Table 5: Table showing diagnosis of Hypertension in the study subjects

Variable	Frequency (%)
Patients with history of hypertension	
Yes	27 (16.6)
No	136 (83.4)
Hypertensive patients on medication	
Yes	23 (85.2)
No	4 (14.8)
Newly diagnosed hypertension[a]	
Blood pressure equal or above 140/90 mmHg	55 (39.3)
Blood pressure below 140/90 mmHg	85 60.7)

[a] This analysis excludes patients on anti-hypertensives but includes those with history of hypertension but were not on treatment at the time of the study.

Body Mass Index

As assessed from calculation of BMI after weight and height measurements, 25.2% of the subjects were overweight (BMI 25.0 – 29.9) while 12.9% were obese (BMI above 30.0). The figure below shows the BMI of the study subjects.

Figure 3: Figure showing BMI of the subjects

18(11%)

6(4%)

15(9%)

41(25%)

83(51%)

- underweight -11%
- Normal BMI -50.9%
- Overweight 25.2%
- obese class I -9.2%
- obese class II -3.7%
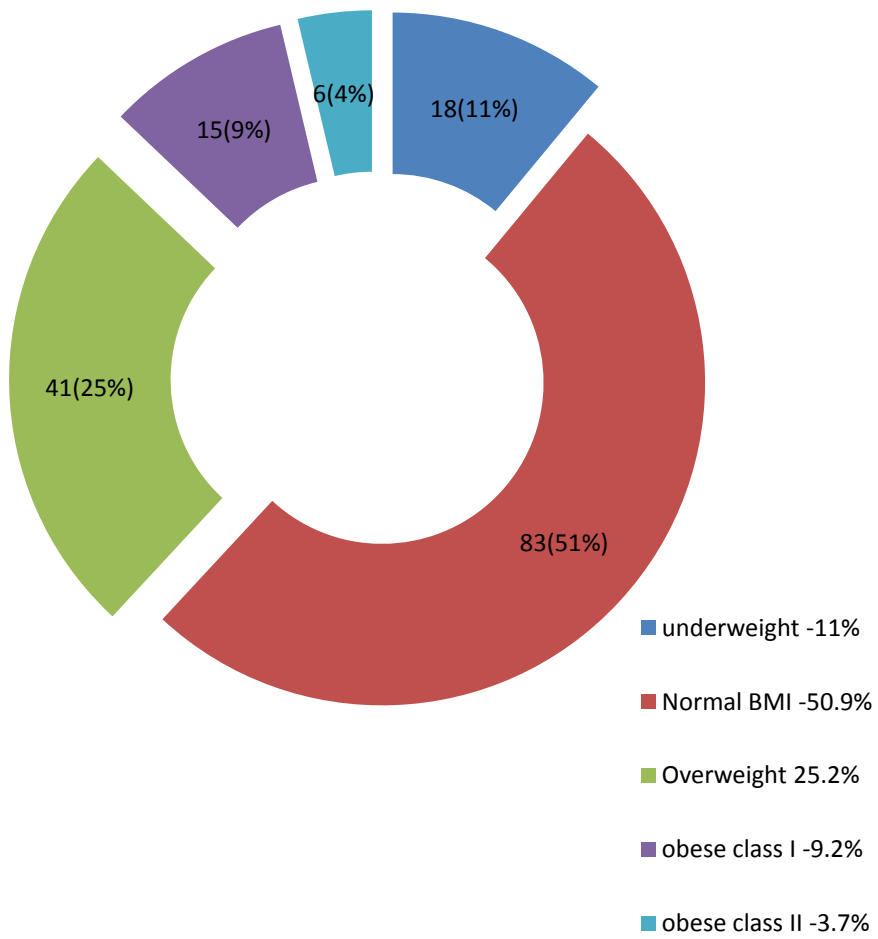
Fasting Blood Sugar

The mean fasting blood sugar was 4.7mmol/l while the median was also 4.7mmol/l. The range was 2.5 to 19.6mmol/l.

The figure below outlines the fasting blood sugar distribution among the study subjects.

Figure 4: Bar Chart showing distribution of fasting blood sugar
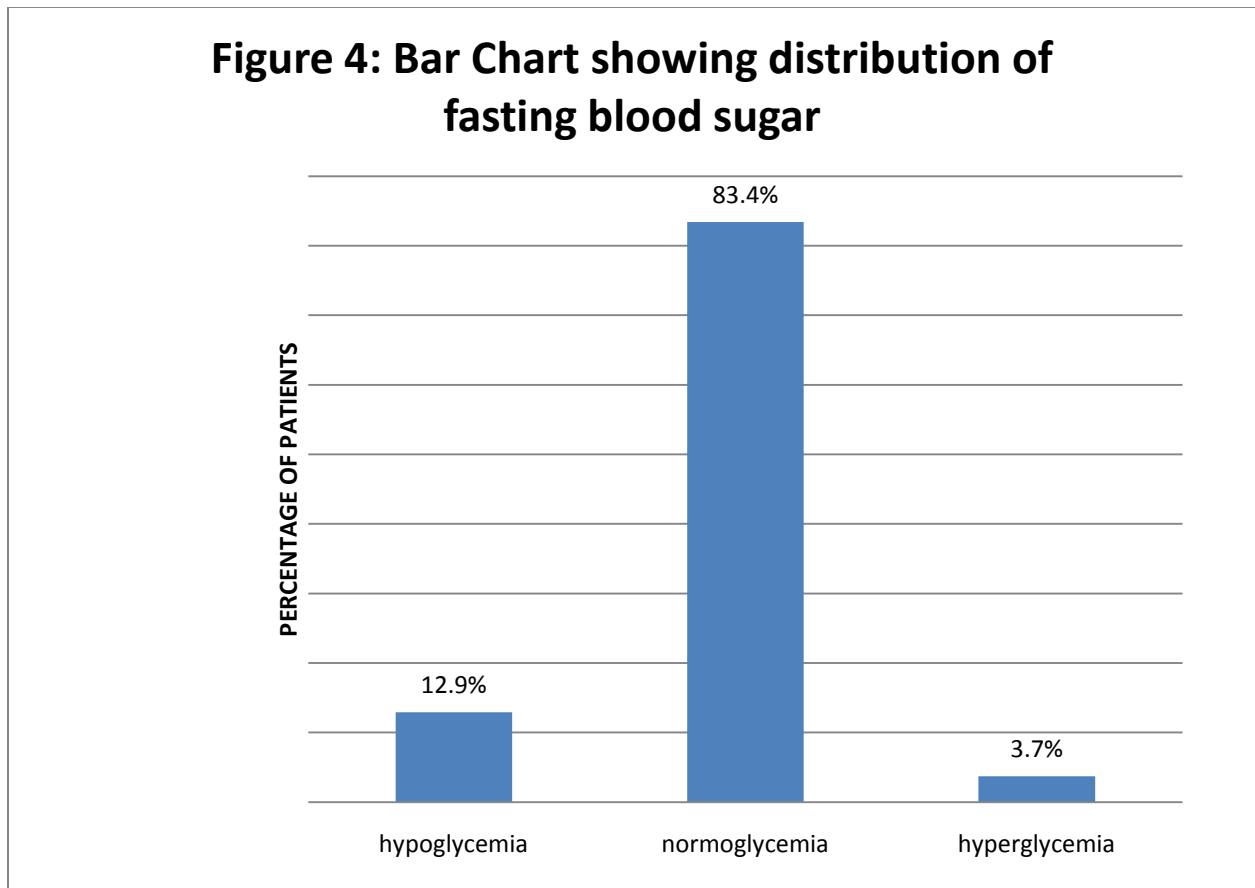
<u>Prevalence of impaired fasting glucose and diabetes mellitus</u>

Glycated hemoglobin levels were done for 6 clients who had a fasting blood sugar above 6.1mmol/l. Of these the mean HbA1c was 6.6%. Two clients had a glycated hemoglobin above 6.5%.

Table 6: Prevalence of impaired fasting glucose and diabetes mellitus

Variable	Frequency (%)	95% CI
Diabetes mellitus	2 (1.2)	0.2-4.4%
Impaired Fasting Glucose	4 (2.5)	0.7 – 6.2%

Predictors of Hyperglycemia

Table 7: Table showing Statistical Relationship of Hyperglycemia with Patient Characteristics

Patient Characteristic	Hyperglycemia		OR (95% CI)	P value
	Yes (%)	No (%)		
Age, mean (SD) **Categories** Age >45 years Age ≥45 years	53.0 (16.4) 5 (6.2) 1 (1.20	44.6 (13.9) 76 (93.8) 81 (98.8)	- 5.3 (0.6-46.7) 1.0	0.151 0.117
Gender Female Male	 5 (5.5) 1 (1.4)	 86 (94.5) 71 (98.6)	 4.1 (0.5-36.2) 1.0	 0.167
Family diabetes history Yes No	 5 (3.6) 1 (4.3)	 135 (96.4) 22 (95.7)	 0.8 (0.1-7.3) 1.0	 0.855
Hypertension Yes No	 2 (7.1) 4 (3.0)	 26 (92.9) 131 (97.0)	 2.5 (0.4-14.5) 1.0	 0.285
BMI, mean (SD)	26.4 (5.7)	24.2 (4.9)	-	0.299

The table below shows the frequency of risk factors among the patients who had hyperglycemia

Table 8: Table showing frequency of risk factors among patients with hyperglycemia

Risk factor	Frequency(%)
Age above 45years	5(83)
Previous or current diagnosis of hypertension	4(67)
Body Mass index $\geq$ 25	3(50)
Family History of Diabetes mellitus	1(17)

CHAPTER 5

DISCUSSION

Hyperglycemia and glucose intolerance are common manifestations of peri-operative stress in many hospitalized patients[18]. Hyperglycemia is associated with numerous peri-operative complications thus adversely affects patient outcomes. In itself diabetes mellitus especially when poorly controlled contributes to poor surgical outcomes related to both attendant surgical and anesthetic complications.

During the six week study period, a total of 163 patients were evaluated. The patients were aged between eighteen and eighty two years with a fairly normal distribution curve. The mean age of the participants was 44.9 years. There were a slightly higher number of females 91 (55.8%) than males 72 (44.2%). This probably reflects a higher number of females admitted to the surgical wards than males. In this study the higher number of females may also be explained by the fact that despite the study being carried out across all surgical wards most patients in the orthopedic wards (which has more males than females) did not meet the inclusion criteria. Patients who could not stand upright (e.g. due to pelvic or lower limb fractures or traction for any other reason) were exempted as weight measurements could not be done. In addition inclusion of patients with gynecologic and obstetric diagnoses contributed to the female preponderance, since there was a VVF repair program that was being carried out during study period.

The study was carried out amongst patients with a wide range of surgical diagnoses including cardiovascular/ thoracic, neurosurgical, orthopedic, gynecological, dental/maxillofacial, obstetric, otolaryngology, ophthalmological, urological, plastic and general surgical.

Risk factors for diabetes Mellitus

This study evaluated the following risk factors for hyperglycemia and diabetes mellitus:

- Family history of diabetes Mellitus

- Hypertension

- Being overweight/obese

- Age above 45years

In this study, participants were asked questions concerning their family history of diabetes mellitus. 14.1% of those studied had at least one blood relative with diabetes and of these, 26.1% the relative is a parent. Out of the total 163 participants 14 (i.e. 8.6%) had a parent, a sibling or both with diabetes.

Clients were asked whether they had ever been informed they had elevated blood pressure any time in the past. Of the 27 clients who admitted to having had a history of hypertension in the past 85.2% of them were on anti-hypertensives at the time of the study while 14.8% were not on any medication for hypertension.

Blood pressure measurements were done on all patients sampled. The average systolic blood pressure was 139 mmHg while the average diastolic blood pressure was 85.3 mmHg.

A further analysis of blood pressure measurements was made including only those clients who were not on medications that lower blood pressure. This revealed that 39.3% of these had blood pressure higher than 140/90 mmHg on two separate occasions. The mean systolic blood pressure for this group was 161 mmHg while the mean diastolic blood pressure was 94.5mmHg. Overall, therefore 47.9% of persons studied had this risk factor.

Analysis of data from height and weight revealed that 62 participants had a body mass index of more than 25. This translates to 38% of patients who were either overweight or obese and therefore at risk of hyperglycemia and diabetes. Incidentally, however 11% of patients were underweight. This relatively large proportion of underweight persons might be due to the fact that some of the patients had lower than normal weight due to the current surgical diagnosis or due to the presence of co-morbidities.

The study focused on the adult population only and of those studied, 49.7%% were over the age of 45 years. The ADA recommends screening of persons above the age of 45years for diabetes mellitus even in absence of any other risk factor.[1]

When all the major risk factors stated above were considered together (see Table 4), only 36% did not have a single risk factor for diabetes mellitus while 8% of those studied were aged above 45years, had hypertension, had a relative with diabetes and had a $BMI \geq 25Kg/M^2$. Studies have a shown that persons with more risk factors are at a higher risk with a prevalence of type 2 diabetes mellitus of up to 25% in those with all the four risk factors listed above.[33]

Prevalence of hyperglycemia, impaired fasting glucose and undiagnosed diabetes mellitus

A total of six patients had fasting blood sugar measurement of 6.1mmol/l and above giving a prevalence of hyperglycemia of 3.7% (95% CI 1.2- 6.7%). Two of the six patients had an HbA1c above 6.5% and the rest had a HbA1c of less than 6.5%. The prevalence of undiagnosed diabetes was thus 1.2% (95% CI 0.2-4.4%). This is lower than the 2.69% estimated prevalence of undiagnosed diabetes in the general Kenyan adult population.[3] This may indicate near adequate glucose setting in the Kenyan hospitals given that the subjects studied had electively been

booked for surgery having visited the hospital as outpatients. The prevalence of hyperglycemia in this study is also lower than the 3.6% found by Roberts *et.al*[34] in a similar study in the United States of America. This might be explained by the difference in characteristics of population studied but may also be attributed to the smaller sample size given that Roberts et al studied 1,000 pre-surgical patients in an outpatient setting. Roberts *et.al.*[34] however used 7.0mmols and above as the cut off for hypoglycemia. Hatzakorzian *et.al.*[35] also did a similar study among patients scheduled for non cardiac surgery and found 25% of patients not previously diagnosed to have diabetes had an elevated fasting blood sugar. Of these, 6.5% had a provisional diagnosis of diabetes. One of the clients found to have hyperglycemia in this study was a male aged 67yrs, whose fasting blood sugar was 19.6mmol/l. In this particular instance, incidentally, the patient had fistula in ano. Perianal abscess and fistula in ano are seen more often in immuno-compromised patients, including those with poorly controlled diabetes mellitus. Diagnosis of diabetes mellitus and the eventual institution of treatment to ensure adequate glycemic control formed a key part in the treatment of the current surgical condition.

A further 2.5 %(95% CI 0.7 – 6.2%) of participants in this study had impaired fasting glucose (FBS 6.1- 6.9mmol/l). This is also lower than the 26.9% (FBS 5.6 -6.9mmol/l) found by Roberts *et.al.*[34] in a similar study. Koumpan and colleagues[36] ,did HbA1c, fasting blood sugar and random blood sugar among all 406 patients scheduled for elective surgery (both diabetic and non diabetics). A sub-analysis of their data revealed that, 23% of the non diabetics at time of enrolling into the study actually had pre-diabetes and a further 3.9% had an HbA1c of > 6.5% (i.e. diabetes). It is important to note however, that the WHO definition[6,30] of impaired fasting glucose (FBS 6.1 – 6.9mmol/l) was used in this study rather than the ADA criteria[31] (FBS5.6 -6.9mmol/l) used by both Roberts *et. al.*[34] and Hatzakorzian *et.al.*[35] This may explain the lower

prevalence of impaired fasting plasma glucose. In addition glucose intolerance, which requires an oral glucose tolerance test for diagnosis was not investigated.

The International Diabetes Federation[3] estimates that 562,570 Kenyan adults (forming 2.69%) have undiagnosed diabetes. The lower prevalence rates in the pre-surgical population at the Kenyatta National Hospital might suggest that some clients are diagnosed as diabetes during prior hospital visits necessitated by their surgical condition.

Of note, 12.9% of the patients had a FBG below 3.9mmol/l, with an average value of 3.5mmol/l (range 2.5- 3.8mmol/l), although none of the hypoglycemic patients were symptomatic. Older (age above 60years) patients with low BMI (< 19) were more likely to have very low fasting blood sugars (< 2.7mmol/l). In a similar study Roberts *et.al.*[34] found a 4.6% prevalence of hypoglycemia (FBS < 3.9mmol/l).

Predictors of hyperglycemia

In this study patients who were older, of female gender, hypertensive and with higher body mass index were more likely to have hyperglycemia. However, none of these patient characteristics was statistically significant as predictors of hyperglycemia. The explanation for this is likely the relatively small size of the sample survey. Patients >45 years of age had a higher risk of hyperglycemia than those less than 45 years of age (OR 5.3 (95% CI 0.6 – 46.7), P= 0.117) while females were more likely to have hyperglycemia more than their male counterparts (OR 4.1(95% CI(0.5-36.2) P= 0.167). Though still not statistically significant, (P= 0.855) clients with a family history of diabetes were less likely to have FBS ≥ 6.1mmol/l than those without a positive family history of diabetes (OR 0.8 (95% CI 0.1-7.3))

In the study done by Roberts *et.al*[34], multiple logistic regression analysis indicated that age, male gender, family history, and body mass index were the independent predictors of elevated FBG.   Karekethi and colleaques[23] on the other hand in a community based study in central Kenya identified the following predictors of dysglycemia: age bracket 50-59 years, hypertension, blurred vision and osmotic symptoms, family history of diabetes mellitus and a BMI $\geq$30 kg/m^2.

In the study by Roberts et al[34] a family history of DM was not associated with hyperglycemia when patients' other characteristics were included in the analysis.

STUDY LIMITATIONS

The study sample (n= 163) was small relative to the study outcomes. From the study only six patients had hyperglycemia. This may have contributed to the difficulty in identifying the possible predictors of hyperglycemia and diabetes in our set up.

The fasting periods of the clients were not controlled. Long fasting periods may have contributed to lower rates of impaired fasting glucose and hyperglycemia.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

The prevalence of hyperglycemia (FBS > 6.1mmol/l) among non-diabetic patients scheduled for elective surgery at the Kenyatta National Hospital is 3.7%. The prevalence of impaired fasting glucose (FBS 6.1- 6.9mmol/l and HbA1c < 6.5%) is 2.5% while that of undiagnosed diabetes (FBS > 6.1mmol/l and HbA1c ≥ 6.5%) is 1.2% This study revealed a lower prevalence of both preoperative impaired fasting glucose and undiagnosed diabetes relative to estimates from the general population and from similar studies. None of the patient characteristics studied was statistically significant as a predictor of hyperglycemia.

Recommendations

From the results of this study, 2.5% of patients scheduled for elective surgery had impaired fasting glucose while 1.2% had presumed diabetes mellitus. While this is a small number, its significance cannot be denied. Diabetes Mellitus is a chronic illness with serious complications that are worse when diagnosis is delayed. Given the availability of cheap and readily available glucose testing, screening of patients prior to surgery for hyperglycemia would be worthwhile. Though as an incidental finding, the study also revealed a 12.9% prevalence of preoperative hypoglycemia. The peri-operative risks of hypoglycemia are probably more acute and more severe than those of hyperglycemia. An example is the risk of much more severe brain damage in patients with hypoglycemia than those with normal or high blood sugar levels in case of a cardiac arrest. This further emphasizes the need for preoperative glucose testing.

The results of this study showed lower rates of hyperglycemia, impaired fasting glucose and undiagnosed diabetes than most other studies carried out elsewhere. It is necessary to note, however that all the other studies had much higher sample sizes. We therefore recommend a bigger study to ascertain the true picture.

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APPENDICES

Appendix i: RESEARCH QUESTIONAIRRE

 Serial NO……..

Section One-Demographic Data

1. Date of Birth   ……………….

2. Gender ;   Female

Male

Section Two- Family and personal history

3. Did or do any of your relatives suffer from diabetes?

Yes

No

4. Please Specify:

Parent

Sibling

Both parent and Sibling

Other

5. Has a health worker ever told you that you have hypertension?

Yes

No

6. If Yes in 5 above: Are you or have you ever been on medications for hypertension

   Yes

   No

7. Current surgical diagnosis ………………………………………………….

8. Are you currently on any medications?

   Yes

   No

9. If yes please specify:

   a) ………………………
   b) …………………………
   c) …………………………
   d) …………………………
   e) ………………………
   f) ………………………..

Section Three- Measurements

10. Height ;………………..Centimeters (recorded to the nearest 0.1cm)

11. Weight;………………..Kilograms (recorded to the nearest 0.1kg)

12. Calculated Body Mass Index……….(rounded to the nearest one decimal)

13. Blood Pressure

    a. First reading…………

    b. Second reading……….

Section Four- Laboratory Data

    14. Fasting blood sugar   …………mmol/l

    15. HbA1c………………….%

Appendix ii: CONSENT FOR PARTICIPATION IN THE HYPERGLYCEMIA PREVALENCE STUDY (English version)

Consent explanation.

My name is Dr Samwel Njihia, a postgraduate student in Anesthesia at the University of Nairobi. As part of my course work I am required to perform clinical research. I am conducting a study at the Kenyatta National Hospital on the number of adult patients scheduled for elective surgery have elevated blood sugar levels and the different factors that may help predict this.

The aim of this study is to help doctors improve the care given to patients. To do this, I will ask you a few questions, after which I will measure your height and weight.

The study will also involve collecting a blood sample by pricking your second or third finger tip which will used to test your fasting blood sugar level. Should your blood sugar level be higher than 6.1mmol/l I will proceed to take a further 2mls of blood from your antecubital vein. This additional sample will be used to test your glycated hemoglobin level that ascertains whether you may have diabetes mellitus or not. Removal of blood may be associated with mild discomfort and very occasional bleeding or infection. However, some of these are very rare complications and extreme care will be taken when doing the procedure to minimize the risks.

A sterile technique will be performed with thorough cleaning and sterilization of the skin using an alcohol/spirit swab prior to removing the blood. After removal, gentle pressure will be applied to prevent/stop any bleeding.

Thereafter, I will do statistical calculations on this information and publish it in a book that will be in the custody of the University of Nairobi. All information gathered will be treated with utmost confidentiality. Results from blood tests done will be available on request. No names or other identifiers will be used in the study.

Your participation in this study is voluntary and you may withdraw from the study at any point without affecting the treatment being given to you in any way.

You are now free to ask questions relating to this study to get clarification on any issues that may be unclear to you.

If you accept to be part of this study please append your signature on the space provided

Any questions about the study may be forwarded to the KNH-ERC, Kenyatta National Hospital, P.O. BOX 20723, Nairobi, Tel: 2726300-9.

Consent Form

Serial No: ……………………………..

I have been adequately explained about the study by Dr Samwel Njihia. I understand that my rights will be respected and confidentiality maintained.

I also understand that participation is voluntary and I can withdraw at anytime and this will not compromise the quality of care I am receiving. I therefore consent to be recruited into the study.

Client's Signature …………………………….Or

Thumb print ………………………...

Date …………………………………….

Witness ……………………………………...

Signature………………………………

Date……………………………….

For further information, issues or clarification you may contact:

Dr Samwel Njihia. Telephone number – 0724867445

Or

KNH/UON – Ethics & Research Committee. Telephone number – 2726300-9

Idhini ya kushiriki katika utafiti

Maelezo.

Jina langu ni Daktari Samwel Njihia mwanafunzi wa shahada ya pili katika chuo kikuu cha Nairobi. Kama sehemu ya masomo yangu ninastahili kufanya utafiti wa kitabibu. Lengo langu ni kufanya utafiti katika Hospitali ya Taifa ya Kenyatta juu ya idadi ya watu wazima wanaoweza kuwa na wingi wa sukari kupita kiasi kabla ya kufanyiwa upasuaji na sababu mbalimbali zinazochangia hali hii. Lengo la utafiti huu ni kusaidia madaktari kuboresha huduma zinazotolewa kwa wagonjwa.

Kwa kufanya hivyo, nitakuuliza maswali kadhaa na baada ya hapo nitakupima uzito, urefu na kiwango cha sukari kwenye damu.

Damu itatolewa kwa kudunga kwenye kidole na ikiwa kiwango cha sukari kitakuwa juu kupita kiasi damu kipimo cha mililita mbili itatolewa kutoka kwenye mshipa na kupelekwa kwenye maabara ambapo itatumiwa kupimia kipimo kiitwacho "HbA1c" kitakacho tueleza kwa uhakika kama kuna uwezekano uwe na ugonjwa wa kisukari.

Wakati wa utoaji damu waweza kuhisi uchungu kiasi. Madhara mengine kama kutokwa na damu kupita kiasi na uwezekano wa kupata ya maambukizi hufanyika kwa nadra sana. Kila hatua na tahadhari itachukuliwa ilikuepusha madhara haya kwa vyovyote vile.

Baada ya hapo nitafanya hesabu za takwimu na taarifa hii na kutangaza habari hiyo katika kitabu ambacho kitakuwa chini ya ulinzi wa Chuo Kikuu cha Nairobi. Taarifa zote zitakazokusanywa zitashughulikiwa kwa usiri. Hakuna majina au vitambulisho vingine vitakavyotumika katika utafiti.

Kushiriki kwako katika utafiti huu ni kwa hiari yako na unaweza kujiondoa wakati wowote bila kuathiri matibabu utakayopewa.

Waweza uliza maswali kwa ufafanuzi zaidi.

Pia waweza kuuliza swali wakati wowote kwa kuwasiliana nami Daktari Njihia kupitia nambari ya simu: 0724867445 au KNH/UON – Ethics & Research Committee. Nambari ya simu – 2726300-9

Idhini

Serial No:…………………..

Nimeelewa matakwa ya kushiriki kwenye utafiti huu wa Daktari Samwel Njihia.

Naelewa pia kuwa kushiriki kwangu ni kwa hiari yangu na ya kwamba naweza kujiondoa wakati wowote bila kuathiri matibabu ninayopewa.

Nakubali kushiriki kwenya utafiti huu.

Sahihi: …………………………………………au

Kidole cha gumba: ………………………………

Tarehe: …………………………………………..

Shahidi…………………………………………

Sahihi…………………………………………..

Tarehe…………………………………………..

Kwa maelezo zaidi na ufafanuzi, unaweza kuwasiliana na:

Daktari Samwel Njihia. Nambari ya simu – 0724867445

KNH/UON – Ethics & Research Committee. Nambari ya simu – 2726300

Appendix iv: BODY MASS INDEX

BODY MASS INDEX (BMI) = WEIGHT (KG)$/$HEIGHT (m)^2

Classification of BMI

Underweight	< 18.5
Normal	18.5 – 24.9
Overweight	25.0 – 29.9
Obesity (class I)	30.0 – 34.9
Obesity (class II)	35.0 – 39.9
Extreme Obesity (class III)	≥ 40.0