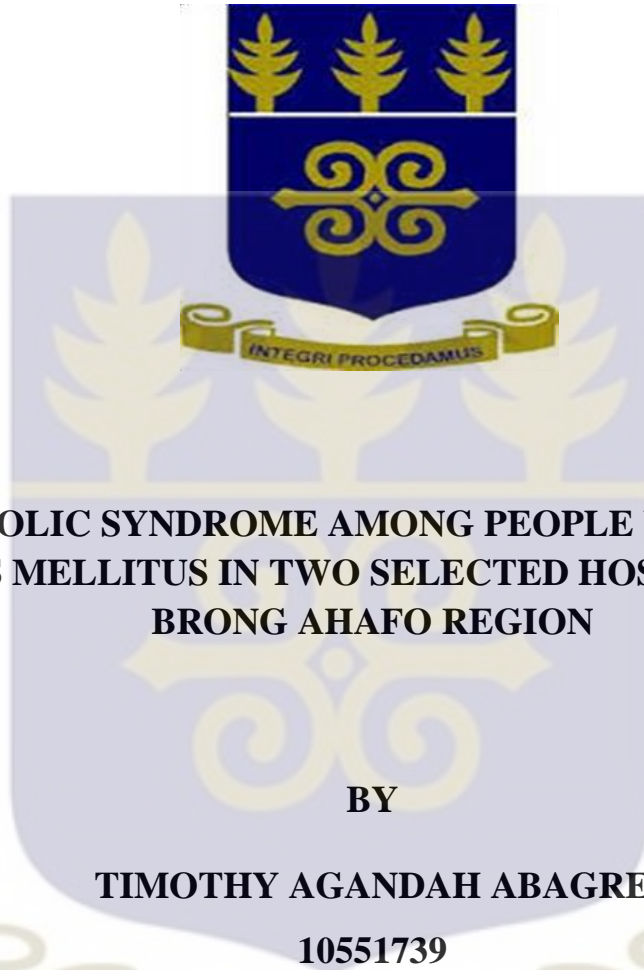


**SCHOOL OF PUBLIC HEALTH  
COLLEGE OF HEALTH SCIENCES  
UNIVERSITY OF GHANA**



**METABOLIC SYNDROME AMONG PEOPLE WITH TYPE 2  
DIABETES MELLITUS IN TWO SELECTED HOSPITALS IN THE  
BRONG AHAFO REGION**

**BY**

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**THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF  
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## Declaration

I, Timothy Agandah Abagre, declare that except for the other people's investigations which have been duly acknowledged, this dissertation is the result of my own work, and that this dissertation, either in whole or in part has not been presented elsewhere for another degree.

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.....  
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.....  
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.....  
DATE



## Dedication

I dedicate this work to Asiel, Melatiah and Ronel. I love you all.

*“I’m coming to get you”*



## Acknowledgment

Firstly, I wish to thank the almighty God for the good health and strength He granted me during the course. God has been my comforter and spiritual guide during the most difficult times in the programme and I am most thankful to Him.

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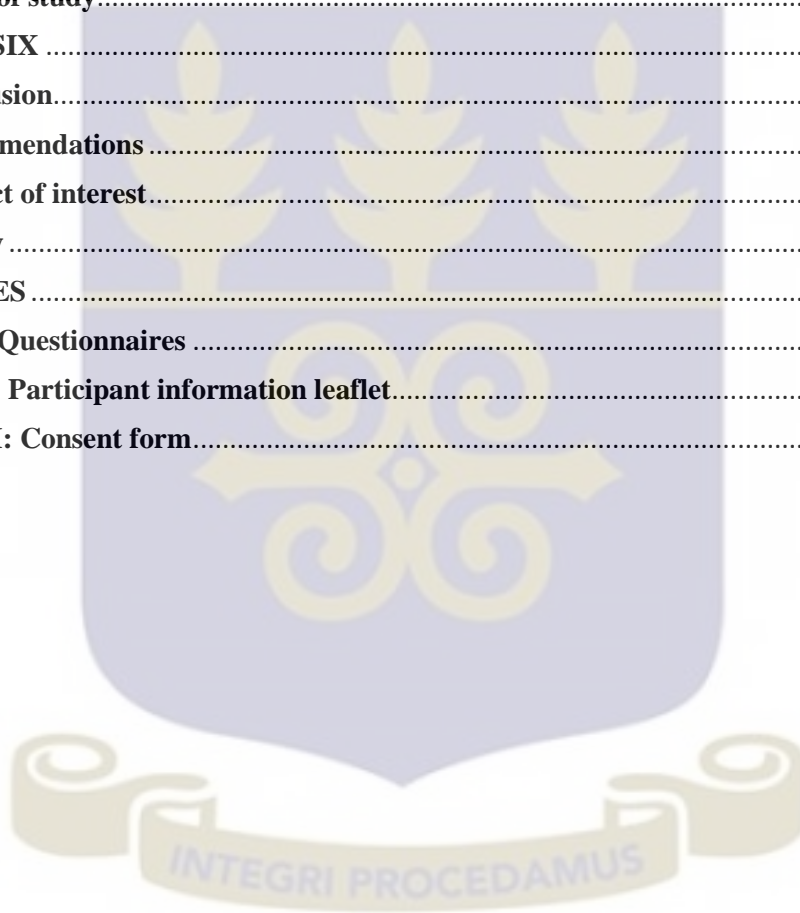
Finally, to my parents and siblings, I am most indebted to you. You have been the supportive companion of my life and in all the challenges, I have faced. May the peace and favours of God be with you all, now and forever!

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## Abstract

**Background:** Metabolic syndrome is a condition characterised by the clustering of cardiovascular disease risk factors such as obesity, hyperglycaemia, dyslipidaemia and high blood pressure. The condition frequently occurs among people with T2DM. The metabolic syndrome is associated with adverse health effects such as heart attack, stroke and other diseases involving the blood vessel. It is linked to more than two-fold increase risk of mortality compared with those without the syndrome. Despite knowledge about the health effects, there is limited data on the prevalence, clustering and associated risk factors of the syndrome in Sub-Saharan Africa. More information is needed to guide health systems in the region to respond adequately to the increasing burden of these metabolic abnormalities. This was one of the rare studies that investigated the prevalence and associated risk factors of METs among people with T2DM using the harmonised definition and the continuous MSR score approach. The study also sought to identify the common components driving the METs burden in the study area.

**Methods:** A cross-sectional study was conducted and METs was assessed using the harmonised definition and the continuous MSR score approaches. Data was collected between 1<sup>st</sup> and 27<sup>th</sup> June, 2016 at two hospitals in Dormaa and Berekum Municipalities respectively. Adults (aged 30-79 years) with type 2 diabetes mellitus who attended routine diabetes clinics were interviewed using semi-structured questionnaires. Medical records were used to confirm the type 2 diabetes mellitus status of participants. Weight, height, waist circumference, and BP were measured using standard procedures. Blood samples were also analysed for blood glucose, triglycerides, and HDL-cholesterol. Multiple logistic analyses model was used to explore the associated risk factors of METs measured as a binary outcome, while multiple linear regression was used to measure the risk factors of METs measured as a continuous risk score.

**Results:** Data was collected from 430 participants. The mean age of participants was 58.8 years. The prevalence of the METs measured as a binary outcome was 68.6% (95% CI: 64.0 -72.8). The prevalence of the syndrome was higher in women (76.3%) than in men (58.0%). The odds of METs in women was 2.2 times (95% CI: 1.29 - 3.58,  $p=0.003$ ) that of men. Duration of T2DM was predictive of the binary METs (OR 5.2, 95% CI: 2.90 - 9.31,  $p<0.001$ ). Overweight was also observed to be a risk factor of the binary METs (OR 6.1, 95% CI: 3.70 - 10.07  $p<0.001$ ). The most pre-dominant components in this study were reduced HDL-cholesterol (70.2%), elevated waist circumference (60.9%) and raised SPB (49.8%). As a continuous outcome, the median MSR score was 0.89, 25<sup>th</sup> percentile (0.28) and 75<sup>th</sup> percentile (1.85). Compared with those aged 30-39 years, participants aged 60-69 years had surprisingly reduced MSR score ( $\beta= -0.65$ , 95% CI: -1.24- -0.07,  $p=0.029$ ). Those aged 70-79 years also had reduced MSR score ( $\beta= -0.65$ , 95% CI: -1.24- -0.05,  $p=0.034$ ). Duration of T2DM, overweight and education were the other independent risk factors of the MSR score in this study.

**Conclusion:** This study demonstrated that METs is common among type 2 diabetes clinic attendees in the Dormaa and Berekum Municipalities. The analyses also support findings from previous studies in Ghana and abroad that observed sex differences in the prevalence of METs and its components. This study revealed that the risk factors of the MSR score might differ from those of the traditional binary METs outcome. Although epidemiologist might find the interpretation of the MSR scores useful, its application in clinical and public health decision making process might prove challenging when classifying who has METs. Nonetheless, the MSR score could be used to monitor the disease progression of an individual. Interventions aimed at promoting early identification of METs and adoption of healthy lifestyle practices should be strengthened among people with T2DM. Routine screening of METs among people with T2DM and at risk individual should be encouraged in health facilities across Ghana.

**Keywords:** Type 2 diabetes, metabolic syndrome, risk factors, insulin resistance, and continuous metabolic syndrome risk score.



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## List of acronyms

AHA	- American Heart Association
ATP III	- Adult Treatment Panel III
BMI	- Body Mass Index
BP	- Blood Pressure
CVD	- Cardiovascular disease
DASH	- Dietary Action to Stop Hypertension
DM	- Diabetes Mellitus
DPB	- Diastolic BP
EGIR	- European Group for the study of Insulin Resistance
FPG	- Fasting plasma glucose
HDL	- High-density lipoprotein
IDF	- International Diabetic Federation
IGT	- Impaired Glucose Tolerance
IFG	- Impaired Fasting Glucose
METs	- Metabolic Syndrome
MOH	- Ministry of Health
NHANES	- National Health and Nutrition Examination Survey
NCEP	- National Cholesterol Education Program
SBP	- Systolic BP
SSA	- Sub-Saharan Africa
T2DM	- Type 2 diabetes mellitus
TG	- Triglyceride
UNICEF	- United Nations Children's Emergency Fund
UK	- United Kingdom
USA	- United States of America
WC	- Waist circumference
WHO	- World Health Organisation

## Definitions of operational terms

**BMI:** A measure of the person's weight relative to the height.

**Diastolic blood pressure:** The minimum blood pressure during relaxation of the heart.

**Fasting blood sugar/glucose:** It is the concentration of sugar in the blood following an 8 hour fast.

**High-density lipoprotein cholesterol:** Complex protein particles that remove and transport fat molecules from body cells. It is normally referred to as good cholesterol.

**Hyperglycaemia:** Elevated level of blood sugar in excess of 6.1 mmol/L after 8 hours of fast or greater than 7.8 mmol/L post prandial.

**Overweight/obesity:** Excessive accumulation of fat that is considered unhealthy weight for the given height.

**Systolic blood pressure:** The maximum blood pressure during contraction of the heart muscles.

**Triglycerides:** They are compounds of fats and oils and they are the major form of fat store by the body.



## CHAPTER ONE

### 1.0 INTRODUCTION

#### 1.1 Background

The metabolic syndrome is a pathologic state characterized by the clustering of metabolic abnormalities described as the most dangerous risk factors linked to CVD (Alberti, Zimmet, Shaw, & Grundy, 2006). The syndrome has many names. It is also referred to as syndrome X, the insulin resistance syndrome, the deadly quartet, the metabolic cardiovascular syndrome, or the atherothrombogenic syndrome (Potenza & Mechanick, 2009; Batey et al., 1997). It occurs when a person has a combination of any three or more of the following metabolic factors: raised blood sugar or diabetes, elevated blood pressure, obesity, elevated triglycerides and low levels of HDL-cholesterol. These metabolic factors are also the components or constituents of the syndrome. In addition, the METs carries prothrombic and proinflammatory states. These multiple biochemical and physiological abnormalities manifest as intertwined disease states that affect the entire body. The syndrome has an International Classification of Diseases code E88.81 and the WHO has recognised its diagnoses among people with T2DM (Alberti & Zimmet, 1998).

Although it has been several decades and thousands of publications since the METs was first described, little is known about the prevalence, clustering, associated risk factors and clinical outcomes of the METs in most developing countries. Much of the work currently available on METs are limited in scope and are inconsistent in how the condition is measured. Due to the lack of uniform approach to measure the METs, information on the burden and associated risk factors depends on the methods used. This lack of standard approach has made it problematic when comparing prevalence data between populations.

In order to ensure consistency in the way the METs is measured in epidemiological studies, a team of world experts in the field of METs have proposed the use of the new harmonized definition (Alberti et al., 2009). Despite this recommendation, studies across the world continue to use varied methods for assessing METs. In one study conducted among 500 Africans and 254 white subjects with T2DM in South Africa, the prevalence of METs was reported to be 46.5% among the Africans and 74.1% among the whites using the IDF criterion (Kalk & Joffe, 2008). In Libya, the prevalence of METs was reported to be 92% among 99 participants with diabetes using the ATP III criterion (Alshkri & Elmehdawi, 2008). One study conducted among 340 subjects at a University College Hospital in Ibadan (Nigeria) using the IDF criterion, found METs prevalence in 66% of participants with T2DM (Ipadeola & Adeleye, 2015).

There is also an inconsistent use of METs definitions in studies in Ghana. Titty (2010) conducted a prospective study among subjects with T2DM at the Tamale Teaching Hospital using the ATP-III criterion and found that at baseline, 43% of participants had METs. Using the IDF definition, Mogre, Salifu, & Abedandi (2014) conducted a cross-sectional study at the Tamale Teaching and estimated the METs prevalence at 24% among 240 subjects with T2DM. Considering that, there is no one method for measuring the METs, there is the need for studies to adopt a uniform approach based on expert recommendations (Alberti et al., 2009). Such an approach would ensure that prevalence data on the METs could be matched in the population.

It is in this light that this present study was conducted using the recent harmonized definition. The harmonized definition it seeks to unify the various criteria used to classify the METs. Secondly, the definition was proposed by a renowned team convened by the International Diabetes Federation; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Association for the Study of Obesity and supported by

the WHO. Unlike in most of the previous definitions, the harmonized definition does not use obligatory components thus eliminating the risk of under classifying METs prevalence.

The adverse long-term consequences of the METs make it a critical public health goal. METs is linked to heart diseases, stroke and other conditions affecting the blood vessels. The risk of CVD in people with the METs is 3 times higher than in those without the syndrome (Alberti et al., 2006; Bhatti, Bhadada, Vijayvergiya, Mastana, & Bhatti, 2015; Mottillo et al., 2010). Data from systematic reviews have established strong correlates between METs and CVD (Mangat et al., 2010) with the incidence of coronary artery disease found to be strongly linked to METs among diabetes patients (Bhatti, Bhadada, Vijayvergiya, Mastana, & Bhatti, 2015). Knowledge of the associated risk factors of METs in a given population are required to guide in the development of interventions for prevention, control and management of the condition.

METs can present in different forms according to the components that make up the syndrome. However, there is lack of data from systematic inquiries on the predominant components making up the syndrome in both developing and developed countries. The available data shows spatial variations in the clustering of the METs components. For instance, one study among Japanese T2DM subjects found that waist circumference followed by BMI and high blood pressure were the most predominant METs components (Shimajiri et al., 2008). In the Seychelles, high blood pressure and adiposity were the commonest components among people with T2DM (Kelliny et al., 2008) while one study in Nigeria identified dyslipidemia followed hypertension and obesity as the commonest components (Isezuo & Ezunu, 2005).

In Ghana, a study conducted at the Komfo Anokye Teaching Hospital in Kumasi found that hypertension was the commonest risk factor, followed by central obesity and dyslipidemia among the participants with T2DM (Nsiah, Shang, Boateng, & Mensah, 2015). In order to

develop effective interventions to control the METs epidemic, there is the need for more studies such as this present one to contribute to the understanding of the clustering of the METs components.

Evidence suggests that METs is a common occurrence among people with T2DM (Eckel et al., 2005). Given that T2DM in itself is already a significant debilitating health condition, were we to ignore the economic cost involved in its treatment; the co-prevalence of METs and T2DM whether or not the risk to CVD or mortality is increased undisputedly imposes unquantifiable amount of suffering to those affected. Despite there being international recommended guidelines on the clinical diagnoses and management of the MET (Grundy, Hansen, Smith, Cleeman, & Kahn, 2004; Alberti et al., 2005), primary care facilities in Ghana are not known to routinely diagnose the syndrome among at risk subjects. Perhaps this is the case because of the lack of data to support the need for its diagnoses and management.

The striking increase in the global prevalence of the METs in the last few decades (Eckel, Grundy, & Zimmet, 2005) also makes this work significant. There are projections of a further increase in the global burden of METs brought about by the global epidemic of obesity and diabetes with developing countries expected to be most affected (Alberti et al., 2006). In Europe, METs prevalence of up to 32% have been reported in a cross-section of the UK population (Scuteri et al., 2015). One review in Sub-Saharan Africa suggests that between 12 and 86% of the population may have METs (Okafor, 2012).

In Ghana, METs has been reported in 58% of subjects with T2DM in Kumasi (Nsiah et al., 2015). A Ghana Ministry of Health (2011) report has also stated that the country is facing an increasing burden of NCDs because of increasing aging, rapid urbanisation and unhealthy lifestyles. The reports posited that hypertension (a component of METs) has ranked in the top

five outpatient diseases over fifteen years. Obesity another component of the METs is said to have more than doubled among women 15-49 years from 13% in 1993 to 30% in 2008. Despite these reports, no systematic studies have been conducted to establish the prevalence, clustering and risk factors of NCDs in the country. This gap in research is indicative of the lack of protocols for managing co-morbid NCDs in Ghana. It is also suggestive that strategies for controlling NCDs in Ghana are premised on the single disease approach. There is therefore the need for studies on the METs to be extended to include other population groups so that a clearer picture of the METs burden can be established.

This study was therefore undertaken to investigate the associated risk factors, prevalence and common METs components among people with T2DM. Data from the study would be used to highlight the burden of the syndrome and advocate for appropriate health interventions to prevent, control and manage it in the country.

### **1.2 Statement of problem**

The projections for an increase in METs prevalence appears inevitable, anticipated because of the global rise in obesity and type 2 diabetes mellitus with developing countries predicted to be hardest hit (Alberti et al., 2006). The METs is a frequent occurrence among the aged and people with T2DM. About a third of the population in every country in the world is estimated to be affected by the condition. An estimated 75% and up to 58% of people with T2DM in sub-Saharan Africa and metropolitan arrears in Ghana respectively may have METs. METs is associated with a two to three fold greater risk of CVD and mortality.

Despite evidence of the health implications of METs, the associated risk factors and prevalence of the METs components are limited in scope in the population and less so among people with T2DM. Furthermore, although a group of world experts have proposed the harmonized

definition as a new approach for classifying METs, data on the syndrome in Africa and Ghana lack uniformity in the criteria used in diagnosing it. This situation has made it challenging when generalizing data across populations. In addition, the majority of studies worldwide have measured METs as binary outcome. The drawback with this procedure is that the risk of CVD in people might be under classified. Growing evidence suggests the sensitivity of continuous MRS in estimating METs as compared with the dichotomous classification of METs.

This study was therefore undertaken to determine the associated risk factors, prevalence and predominant components of METs among people with T2DM in two selected municipal hospitals using the harmonised definition. It also sought to determine the associated risk factors of METs measured as a continuous risk score.

### **1.3 Significance of the study**

The METs is a condition that has serious consequences for both patient and global health agenda. The condition appears to be on the increase although there is paucity of data on the available evidence of the nature of the burden of disease. The limited data on the METs in Ghana is indicative of the lack of guidelines for controlling and managing concurrent METs components.

The dearth of data and the long-term health consequences of the METs makes it a critical public health goal that needs further exploration. Without adequate data on the health problem in Ghana, government institutions and international agencies have no basis for taking action to control the problem. Left unchecked, the combined cost of treating both the METs and T2DM may have far-reaching health and economic implications to individuals, families and communities.

It was therefore justified to undertake this study in order to describe the burden, risk factors and common components of the condition using current recommended methods of measuring the METs. The evidence could then be used to justify the need for guidelines on the hospital-based management of the condition. The data from this study could set the basis for routine testing and treatment of METs among people with T2DM. The results of this study could also be used in conjunction with other studies to raise awareness on the METs. The recommendations from this study may be used to initiate public health interventions on the METs.



### 1.4 Conceptual framework

Figure 1: Relationship between exposure risk factors and metabolic syndrome

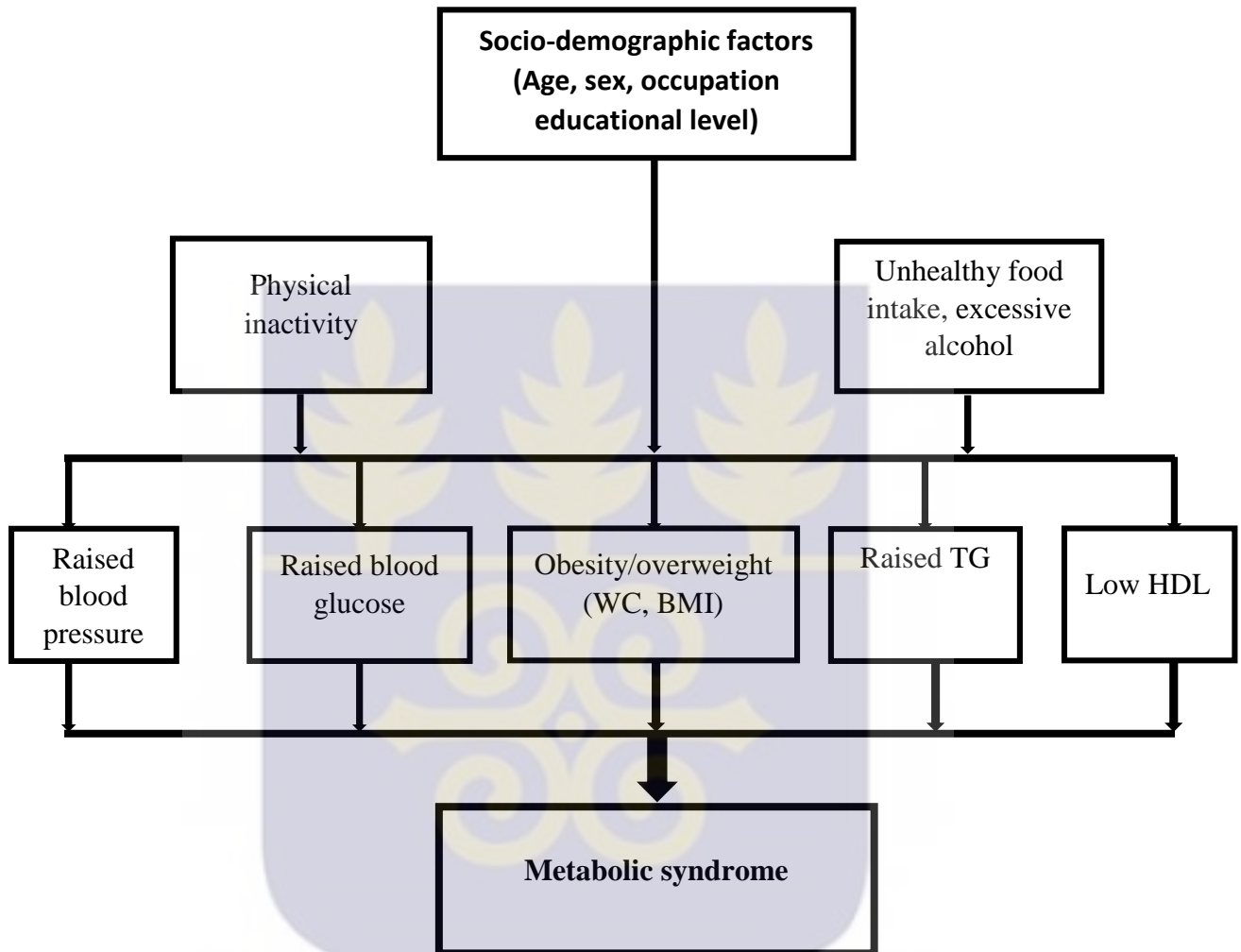


Figure 1 above represents the conceptual model that was used to link the risk factors to the clustering of METs and its components. The model illustrates the interplay between predictive variables such as socio-demographic characteristics (age, sex, level of education) and the clustering of one or more of the METs components. It also shows how physical inactivity, and unhealthy diets and alcohol consumption habits impacts on the METs components.

The conceptual framework also illustrates the influence of age on the abnormal levels of the METs components in both sexes. This observation is in line with that of Ervin (2009) who in analysing data from the USA NHANES using NCEP criteria reported the prevalence of abdominal obesity, hypertriglyceridemia, hypertension, and hyperglycemia to increase with age among females; and hypertension and hyperglycemia to increase with increasing age among males. In another study, those aged  $\leq 65$  years had high triglycerides, low HDL cholesterol, and elevated blood pressure in men (4.8%) (Kuk & Ardern, 2010). The study also observed elevated triglycerides, reduced HDL-cholesterol, and elevated waist circumference in women (4.2%), whereas all five METs components were present in both older men (8.0%) and women (9.2%) (Kuk & Ardern, 2010).

When examining the link between educational level and the METs components, analysis of data from the NHANES III using the NCEP criterion suggests that formal education of less than 12 years is associated with all five METs components in women and only three components (abdominal obesity, hypertension, and hyperglycemia) in men (Loucks, Rehkopf, Thurston, & Kawachi, 2007).

On the effects of physical inactivity on METs, Healy et al. (2008) observed that physical inactivity time, light-intensity time, and mean activity intensity were significantly associated with waist circumference. It also showed significantly beneficial association of moderate-to-

vigorous–intensity activity with triglycerides. Bertrais et al. (2005), using NCEP criterion, demonstrated that except for blood pressure levels, the frequency of most components of the METs were observed to decrease among participants who engaged in physical activity.

The relation between dietary habits such as the consumption of unhealthy diets and the clustering of the METs components has also been illustrated using the conceptual framework. In one experimental study, the intervention group was fed on healthy diet plan during the study period. When the results was compared with a free-living control group, the intervention group had higher HDL cholesterol (7 and 10 mg/dl), lower triglycerides (-18 and -14 mg/dl), and reduced systolic blood pressure (SBP) (-12 and -11 mmHg) among men and women respectively. The groups also had reduced diastolic blood pressure (-6 and -7 mmHg), reduce fasting blood glucose (-15 and -8 mg/dl), and decreased weight (-16 and -15 kg), among men and women respectively (Azadbakht, Mirmiran, Esmailzadeh, Azizi, & Azizi, 2005). Measures of dietary sodium intake in free-living subjects has also been associated with obesity and higher BP (Hoffmann & Cubeddu, 2009). In another study, consumption of red meat was associated with higher prevalence of blood pressure (Alvarez León, Henríquez, & Serra-Majem, 2006).

The conceptual framework also shows that drinking alcohol in excess of the dietary recommendations can result in raised fasting glucose or diabetes, hypertriglyceridemia, abdominal obesity, and hypertension (Fan et al., 2008).

## **1.5 Research Question**

What is the influence of socio-demographic and lifestyle factors on the prevalence of metabolic syndrome among people with type 2 diabetes mellitus in two selected hospitals in Dormaa and Berekum Municipalities respectively?

## **1.6 Research objectives**

### **1.6.1 General objective**

To determine the associated risk factors for metabolic syndrome among people with type 2 diabetes mellitus in two selected hospitals in Dormaa and Berekum Municipalities.

### **1.6.2 Specific Objectives**

1. To determine the socio-demographic and lifestyle characteristics of people with metabolic syndrome among people with type 2 diabetes mellitus.
2. To determine the prevalence of metabolic syndrome among people with type 2 diabetes mellitus.
3. To determine the most predominant components of metabolic syndrome among people with type 2 diabetes mellitus.
4. To determine the viability of the continuous metabolic syndrome risk score as an alternative measure to the binary classification of METs prevalence among people with type 2 diabetes mellitus.

## CHAPTER TWO

### 2.0 Literature Review

#### 2.1 Definition of Metabolic Syndrome

The concept of the metabolic syndrome denotes a health condition characterised by the constellation of risk factors of CVD and diabetes (Eckel, Grundy, & Zimmet, 2005). As a “syndrome”, it signifies a condition in which the overall cardiovascular risk is greater than that posed by its individual components. Designated as such, it implies that the causes and physiological mechanism underlying its pathogenesis are diversified (Redon et al., 2008).

The name and the lack of clarity on its diagnosis and definition has attracted disagreements among scientist for many decades. At present, there is no universal definition of the METs. There are at least six definitions of the METs (WHO, IDF, NCEP: ATP III, EGIR, and Harmonized definitions). The first attempt of an international definition was proposed by the WHO in 1998 (Alberti & Zimmet, 1998). The WHO definition required the presence of any three of five components with insulin resistance or impaired glucose tolerance or diabetes as the core component. With this definition, a person with METs has to have the core component, plus at least any two of the following: elevated blood pressure, dyslipidaemia and/or low HDL-cholesterol, obesity (as measured by waist-hip-ratio or BMI), and micro albuminuria. The WHO has not reviewed its definition since it was first proposed.

As an adjustment of the WHO definition, the European Group for the Study of Insulin Resistance (EGIR) in 1999, produced a variation of the WHO definition excluding people with diabetes, but agreed on the inclusion of glucose intolerance or insulin resistance as the core component (Balkau & Charles, 1999). The EGIR definition also measured obesity using waist-hip-ratio. One limitation of the WHO and EGIR definitions is that people without diabetes or

glucose intolerance or insulin resistance even though they may have the other components (raised BP, elevated WC, reduced HDL cholesterol and elevated triglycerides) would not be classified as having METs. Using core components as a condition pursuant to diagnosing a person with METs would likely obscure the magnitude of the problem especially if all the components have equal weights.

Recent definitions have included those formulated by the International Diabetes Association (IDF) and the National Cholesterol Education Program's Adult Treatment Panel III (NCEP: ATP III). The NCEP: ATP III and IDF definitions also suggested the classification of METs based on the presence of any three of the five risk factors but no core component was required in the NCEP: ATP III whereas obesity as measure by waist circumference was to be the core component in the IDF definition (NCEP: ATP III, 2002; IDF, 2006). The major concern with the IDF definition was that among Asian and other populations the criteria used for classifying obesity could be different from those of Europeans and Americans.

The American Association of Endocrinology also came up with another criterion limiting their definition to only four factors: elevated triglycerides, reduced HDL-cholesterol, elevated blood pressure, and elevated fasting and post load (75 g) glucose (Eckel et al., 2005). However, their definition excluded obesity as a risk factor of METs and this was criticized given that obesity is major risk factor associated with METs (Alberti et al., 2009). Except for the American Association of Endocrinology, all the current definitions of the METs agree on five essential components but differ in the detail and criteria of diagnoses.

In this study, the new harmonized definition was used to classify study participants with METs. It is the most recent definition proposed by a team of renowned experts in the field of METs. The definition aims at providing a uniform approach for diagnosing the METs. The harmonized

definition does not have core component(s), but it is suggested that waist measurement should be used as a preliminary screening tool for METs (Alberti et al., 2009). The new definition maintains that any three abnormal findings out of the five should confirm diagnosis of METs. Unlike in the previous definitions, the new harmonized definition now has a single set of cut-off points for all components irrespective of racial background except waist circumference, for which they say further work is still required. The harmonized definition is very similar to the NCEP: ATP III, but only differs in terms of the cut-off points for triglycerides, fasting blood glucose and HDL cholesterol (Table 1).

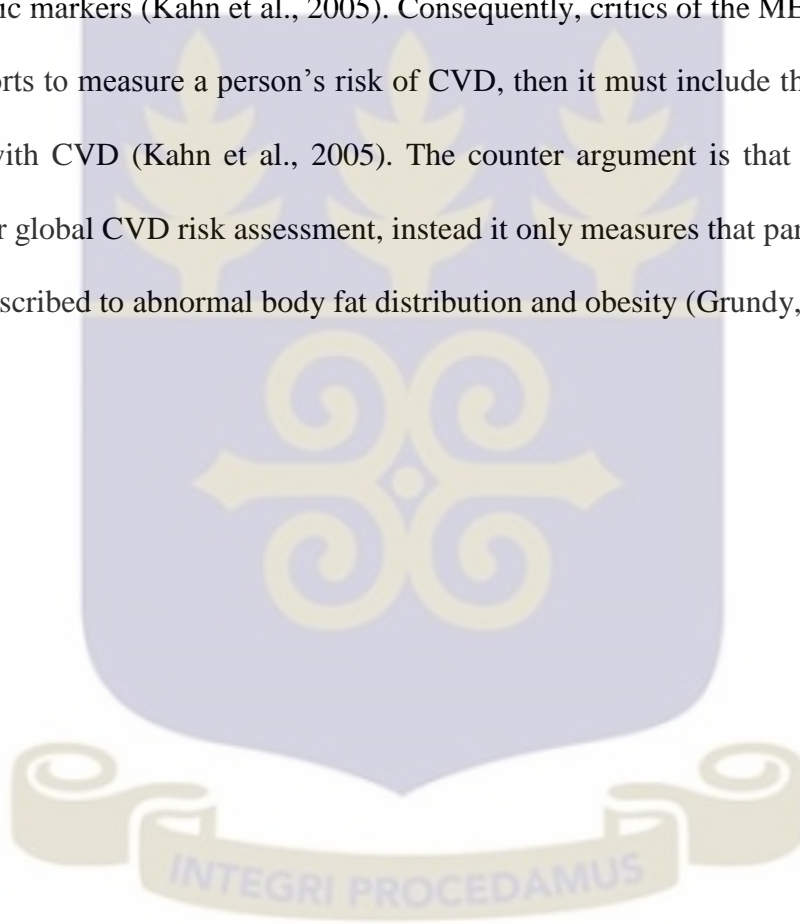
The harmonized definition is probably the best attempt yet at ensuring that researchers have a universal standard for measuring METs. Its use is practical and can easily be applied in both clinical and research settings. Another advantage of this definition is that it includes people with T2DM or hypertension. Therefore, people with T2DM or hypertension or receiving treatment for any of these conditions regardless of their respective blood glucose or blood pressure readings at the time of assessment would be included when assessing the presence METs. However, like in the previous definitions and in the formulators' own admission, the harmonized definition has also failed to suggest cut-off measures for waist circumference for the African population (Alberti et al., 2009). Nonetheless, it remains the best definition yet for the diagnosis of METs.

## **2.2 Components of metabolic syndrome**

There are five main components of the METs. The METs components are also the risk factors associated with CVD. They include raised blood glucose (or type 2 diabetes), central obesity, high triglycerides, low HDL-cholesterol, and raised blood pressure (or hypertension) (Alberti, Zimmet, & Shaw, 2005; Eckel et al., 2005). These risk factors are interrelated and generally

coexist in individuals more often than might be expected by chance (Eckel, Grundy, & Zimmet, 2005; Steele, Brage, Corder, Wareham, & Ekelund, 2008). The WHO definition includes micro albuminuria as a constituent of METs (Alberti & Zimmet, 1998).

The components of the METs are not the only known risk factors of CVD. Other CVD risk factors include age, sex and family history as well as certain proinflammatory and prothrombotic markers (Kahn et al., 2005). Consequently, critics of the METs argue that if the METs purports to measure a person's risk of CVD, then it must include the other risk factors associated with CVD (Kahn et al., 2005). The counter argument is that the METs is not a substitute for global CVD risk assessment, instead it only measures that part of the overall risk that can be ascribed to abnormal body fat distribution and obesity (Grundy, 2008).



**Table 1: Comparison of definitions of metabolic syndrome**

Harmonized definition (Alberti et al., 2009)	IDF (IDF, 2006)	NCEP: ATP III (NCEP: ATP, 2002)	EGIR (Balkau & Charles, 1999)	WHO (Alberti & Zimmet, 1998)
	WC $\geq$ 94cm for Europid men and $\geq$ 80cm for Europid women, with ethnicity specific values for other groups		Insulin resistance—hyperinsulinemia	Diabetes or impaired fasting glycaemia or impaired glucose tolerance or insulin resistance
3 or more of the following Elevated WC: Population- and country-specific definitions	Plus 2 or more of the following	3 or more of the following Central obesity: WC $>$ 102 cm (male), $>$ 88 cm (female)	Plus 2 or more of the following Central obesity: WC $\geq$ 94 cm (male) or $\geq$ 80 cm (female)	Plus 2 or more of the following Obesity: BMI $>$ 30 or WHR $>$ 0.9 (male) or $>$ 0.85 (female)
Elevated triglycerides (or treatment for elevated triglycerides) $\geq$ 150 mg/dL (1.7 mmol/L)	Raised TG level: $\geq$ 150 mg/dL (1.7 mmol/L), or specific treatment for this lipid abnormality	Hypertriglyceridemia: $\geq$ 1.7 mmol/L	Dyslipidaemia: triglycerides $>$ 2.0 mmol/L or HDL cholesterol $<$ 1.0	Dyslipidaemia: triglycerides $\geq$ 1.7 mmol/L or HDL cholesterol
Reduced HDL (or treatment for reduced HDL) $<$ 40 mg/dL (1.0 mmol/L) in males; $<$ 50 mg/dL (1.3 mmol/L) in females	Reduced HDL cholesterol: $<$ 40 mg/dL (1.03 mmol/L) in males and $<$ 50 mg/dL (1.29 mmol/L) in females, or treatment HDL	Low HDL cholesterol: $<$ 1.0 mmol/L (male), $<$ 1.3 mmol/L (female)	Hypertension: blood pressure $\geq$ 40/90 mm Hg and/or medication for hypertension	Hypertension: blood pressure $>$ 140/90 mm Hg
Elevated blood pressure (or history of hypertension) Systolic $\geq$ 130 and/or diastolic $\geq$ 85 mm Hg	Raised blood pressure: systolic BP $\geq$ 130 or diastolic BP $\geq$ 85 mm Hg, or medication for hypertension	Hypertension: blood pressure $\geq$ 135/85 mm Hg or medication	Fasting plasma glucose $\geq$ 6.1 mmol/L	Obesity: BMI $>$ 30 or waist-to-hip ratio $>$ 0.9 (male) or $>$ 0.85 (female)
Elevated fasting glucose (or treatment of elevated glucose) $\geq$ 100 mg/dL	Raised fasting plasma glucose (FPG) $\geq$ 100 mg/dL (5.6 mmol/L), or diagnosed T2DM	Fasting plasma glucose $\geq$ 6.1 mmol/L		Microalbuminuria: albumin excretion $>$ 20 $\mu$ g/min

## 2.4 Prevalence of metabolic syndrome

In the absence of a universal approach for assessing METs, it was always going to be difficult to make accurate comparison of prevalence data between populations using different definitions. Nonetheless, the available data points to a worrying burden of metabolic syndrome across different regions. Current estimates suggest that between 20 and 30% of the adult population in most countries have METs (Grundy, 2008). Using the NHANES data defined by the NCEP:ATP III criterion the overall prevalence of METs in the USA is estimated to be 33% (Deepa, Farooq, Datta, Deepa, & Mohan, 2007). In Europe, using the NCEP:ATP III criterion, 15% of the Swedish population were found to have METs (Hollman & Kristenson, 2008), whereas 31% of the Spanish population had the syndrome using the harmonized definition (Fernández-Bergés et al., 2012). A recent study in 10 European countries using the NCEP:ATP III definition puts the disease prevalence at 24%, but far more common in the UK (32%) (Scuteri et al., 2015). In a review of 25 published surveys measuring the METs prevalence in Asian populations using either the WHO or the NCEP: ATP III definitions; between 10 to 30% of the East and South Asian populations appeared to have the condition (Nestel et al., 2007). In the said review, the prevalence of METs was higher using the WHO definition than the NCEP: ATP III definition.

Although, there is limited data on METs in Africa, the available data shows wide variations in the prevalence of METs across the continent. A recent review of 11 surveys in SSA found METs prevalence to range between 12.5% (NCEP: ATP III) in Ethiopia to 86% (IDF) in Nigeria (Okafor, 2012). The Sumner et al., (2010) cross-sectional study comparing the prevalence of METs among subjects in West Africa and African Americans in the USA observed that 32% and 24% of West Africans and African Americans respectively had METs. In a Cameroonian population, the WHO definition identified METs in 4.4% of the population while the IDF and

NCEP: ATP III definitions identified it in 0.75 and 0.18% respectively (Fezeu, Balkau, Kengne, Sobngwi, & Mbanya, 2007). In Benin, the IDF definition identified METs in 11% of the population (Ntandou, Delisle, Agueh, & Fayomi, 2009). High prevalence of METs have been reported in other developing countries; South Africa (30.7%) Brazil (32%) and India (47.4%) (Peer, Lombard, Steyn, & Levitt, 2015; Dutra, de Carvalho, Miyazaki, Hamann, & Ito, 2012; and Mangat et al., 2010).

In Ghana, one study in a rural setting revealed that 35.9% (IDF) and 15% (NCEP:ATP) of the population had METs (Gyakobo, Amoah, Martey-Marbell, & Snow, 2012). In another study among women, the overall prevalence of METs were reported as follows: IDF (29.2%), NCEP-ATP III (25.6%), WHO (14.4%), and harmonized criteria (30.4%) (Arthur, Adu-Frimpong, Osei-Yeboah, Mensah, & Owusu, 2013).

In summary, depending on the criteria used the prevalence of METs in Africa is estimated to average 50% (Okafor, 2012). The prevalence of METs in the continent is likely to be higher using the IDF followed by the WHO and NCEP: ATP III definitions. In Ghana, between 14.4 and 35.9% of the population may have METs.

#### **2.4 Prevalence of metabolic syndrome among people type 2 diabetes**

Most people who have T2DM also tend to have METs (Eckel, Grundy, & Zimmet, 2005). This suggests that METs prevalence is generally higher among people with T2DM than in the population. However, there is limited data on the prevalence of METs among T2DM patients. One study in an urban setting in India observed METs, as defined by the harmonized criteria, in 71% of T2DM patients (Bhatti et al., 2015). In the study of Kalk & Joffe (2008), using the IDF definition, METs was present in 46.5% and 74.1% of African and white T2DM patients

respectively in South Africa. In Nigeria, the IDF definition identified over 66% of T2DM patients with METs (Ipadeola & Adeleye, 2015).

The few studies conducted in Ghana have shown wide variations in prevalence data. In one study in Kumasi using the NCEP: ATP III definition, 58% of T2DM patients were found to have METs (Nsiah et al., 2015). In a cross-sectional study in Tamale, using the IDF criteria, 24% of T2DM had METs (Mogre et al., 2014). In an earlier prospective study in Tamale, Titty (2010) using the NCEP: ATP III criteria found METs in 43% of T2DM patients. Although both Tamale studies used different study designs the dissimilar results obtained from the two studies highlights the challenges researchers face when comparing data from studies that have used different METs definitions.

## **2.5 Diagnoses**

The name, much as the medical importance of diagnosing the METs has been a subject of controversy for many years. Kahn, Buse, Ferrannini, & Stern (2005), have questioned the basis of the METs in predicting an increased risk of CVD above the risk posed by each individual component. They contend that the METs has negligible association with the risk of CVD; therefore, its diagnoses is unnecessary in clinical practice. However, the overwhelming evidence suggests that the overall cardiovascular risk associated with the METs maybe greater than the sum of its parts (Alberti et al., 2009; Mancia et al., 2007). Evidence from systematic reviews suggests that, however defined, the METs has a much higher CVD risk in people with the syndrome compared with those without it (Eckel, Grundy, & Zimmet, 2005; Grundy, 2008; Gami et al., 2007). Furthermore, it is prudent to suggest that persons with two or more risk factors are more likely to suffer increased risks of morbidity and mortality than in persons with one risk factor.

Some authors have also questioned the clinical significance of making a METs diagnosis among people with T2DM. Song & Hardisty (2008) contended that T2DM is an established risk factor of CVD and therefore it is needless diagnosing METs among subjects with T2DM. They however concede that T2DM presents with multiple CVD risk factors, among which are the METs components, which should be actively searched for and treated. It is been known where studies of METs have been done on subjects with known CVD risk factors such as obesity and hypertension (Scholze et al., 2010; Goodpaster et al., 2005; Yousefzadeh & Sheikvatan, 2013). However, the criticisms on such studies are muted compared to the criticism on studies of METs among people with T2DM. It seems that there is a biased criticism of the relevance of diagnosing METs among people T2DM as against diagnosing it among people with obesity or hypertension. This is perhaps the case because of the high prevalence of the syndrome among people with T2DM.

Diagnosing the METs depends on the type of definition used. A combination of three components must certify the criteria for diagnosing METs. However, depending on the type of definition a core component may be used as a prerequisite for diagnosing the syndrome. The WHO definition uses diabetes or hyperglycaemia whiles the IDF definitions uses waist circumference as the conditions president to diagnosing METs. The other definitions do not require core components. When diagnosing METs, cut-off points are used to decide whether the measurement(s) of a particular component is within the limit(s) for inclusion or otherwise in the identification of METs (Table 1).

The diagnostic criteria and cut-offs used for classifying people with METs based on the harmonized definition is also shown in Table 1. There are 10 possible ways by which a person may be diagnosed with the syndrome based on harmonized definition (Table 2).

**Table 2: The 10 ways a person may be diagnosed with METs using the harmonized definition**

Elevated WC	Raised BP	Elevated FBG
Elevated WC	Raised BP	Reduced HDL cholesterol
Elevated WC	Raised BP	Elevated TG
Elevated WC	Raised FBG	Reduced HDL cholesterol
Elevated WC	Raised FBG	Elevated TG
Elevated WC	Reduced HDL cholesterol	Elevated TG
Raised BP	Elevated FBG	Reduced HDL cholesterol
Raised BP	Elevated FBG	Elevated TG
Raised BP	Reduce HDL cholesterol	Elevated TG
Elevated FBG	Reduce HDL cholesterol	Elevated TG

## 2.6 Metabolic syndrome risk score

Besides assessing METs as a dichotomous outcome, another approach is to assess METs as a continuous MSR score. The majority of studies have classified the occurrence of METs as a binary outcome when determining the risk factors associated with it. It is argued that in populations where the prevalence of METs is low the ability to determine the strength of association between exposure variable and the binary METs outcome using logistics regression analysis limits the power of the association (Okosun, Lyn, Davis-Smith, Eriksen, & Seale, 2010). Another limitation of the traditional binary METs criteria has been that individuals may be classified as low risk even though the levels of the components in them may just be short of the cut-off levels required to be classified as having METs (Gurka, Lilly, Oliver, & DeBoer, 2014). In order to address this problem and assess the link between the exposure variables and a continuous outcome variable, the American Diabetes Association and the European Association for the Study of Diabetes have recommended that the continuous MRS score should be used (Kahn et al., 2005). Measuring METs as a continuous variable takes into account the measured contribution of each METs component into the overall risk assessment.

Eisenmann (2008) demonstrated the use of the continuous MRS as an alternative measure to the categorical classification of METs. Kahn and colleagues (2005) argue that CVD risk is a continuous function of numerous METs risk factors, thus eliminating the need to classify them as binary variables. Further, the continuous MSR score is more vigorous, sensitive and less error prone compared with the dichotomous measure of METs (Okosun et al., 2010).

Wijndaele et al. (2006) reported that using the continuous MRS increases the statistical power of association. Okosun et al., (2010) used the Z-score analysis method and demonstrated that the continuous MSR score was greater in subjects with METs, and that the score increased with increasing numbers of METs components. There is, however, limited data on the use of the continuous MSR score among subjects with T2DM.

One method of constructing the continuous MRS involves assigning weights to WC, blood pressure and plasma levels of glucose, triglycerides and total cholesterol. However, Wu et al. (2014), have opposed this suggestion. The authors argue that the present definition of METs does not have a single pathophysiological article therefore giving equal weights to each component would not produce consistent results between populations. They further argue that the METs components vary with age and between sexes hence using the same cut-off values for subjects of all age groups and both sexes would produce unreliable results between populations. Nonetheless, there is growing evidence on the use of the MSR score as an alternative measure to the dichotomous classification often used in epidemiological studies (Eisenmann, 2008; Okosun et al., 2010; Eisenmann, 2007). Different approaches such as principal components, Z-scores and percentile rankings have also been used to derive MRS score (Batey et al., 1997; Katzmarzyk et al., 2001; Bjørge et al., 2010; Stocks et al., 2011; Eisenmann, 2007; Stocks et al., 2010; Andersen et al., 2006; Häggström et al., 2013). However,

these approaches failed to take into account sex and racial differences in the loading and levels of METs components. Thus more recently, Gurka et al. (2014) have proposed an equation (Table 3) that accounts for the age, racial and sex difference in the levels and clustering of METs components.

### **2.7.0 Factors underlying the manifestation of the metabolic syndrome**

The concept of the METs has existed for many decades albeit controversies regarding its pathogenesis. While some have associated it to obesity as a result of central adipose tissue (Cheung & Li, 2012; Cameron et al., 2008); others have linked it to insulin resistance (Eckel et al., 2005; Gallagher, Leroith, & Karnieli, 2010). In one review, it was concluded that elevated plasma free fatty acids in obese subjects induced insulin resistance (Boden, 2011). Insulin resistance in turn is known to elicit the development of the METs factors (Eckel et al., 2005). Excess dietary energy has also been implicated in the METs pathogenesis. In the Alemany (2013) review, it was reported that excess dietary energy (largely fat), elicits insulin resistance thus creating the problem of excess accumulation of fat in body cells. There appears, however, to be a general leaning towards central obesity as the cause of the syndrome brought in part by the global rise of obesity, consumption of high energy diets and sedentary behaviour (Reaven, 2006; Alberti et al., 2009).

#### **2.7.1 Insulin resistance and hyperglycaemia**

Insulin resistance is probably the most posited factor said to underlie the mechanism for the aetiology of METs (Eckel et al., 2005). Insulin resistance is a pathophysiological state in which anomalies in fatty acid metabolism results in excess build-up of lipids in musculoskeletal and liver cells causing impairment in the action of insulin (Sesti, 2006). Overabundance of fatty acids in the blood stream, from dietary sources, may also result in its accumulation of the body

cells. The deposition of lipids on musculoskeletal cells prevents insulin from transporting glucose into the cells thereby causing hyperinsulinemia and the accompanying hyperglycaemia (excess accumulation of glucose). Insulin resistance is what causes hyperglycaemia in both T2DM and METs patients.

Mendelson (2008) has posited that in METs the body suffers from both insulin resistance and compensatory hyperinsulinemia and this interferes with normal synthesis, uptake and storage of fat. Uncontrolled hyperinsulinemia may also stimulate overgrowth of arterial walls causing hypertension (a component of METs). Insulin resistance plays an important part in the risk factor constellation in METs, and probably contributes in some ways to the many health hazards attributed to the syndrome (Sesti, 2006; Lann & LeRoith, 2007 and Gallagher, Leroith, & Karnieli). It has also been suggested that insulin resistance in native Americans may account for the high prevalence of obesity and METs in the USA (Grundy, 2008).

### **2.7.2 Obesity**

Crucial to the METs burden is central obesity - a metabolic state characterized by excess adipose tissue. Obesity is the most visible and most important driver of METs. It occurs when there is an imbalance between energy intake (food consumption) and energy expenditure in which the amount of energy expended is less than what is taken in through food consumption (Singla, Bardoloi, & Parkash, 2010). The resulting effect is the deposition of unexpended energy in the form of fat in adipose tissues. The link between obesity and metabolic has long been established with METs found to increase with waist circumference (Singla et al., 2010; Després & Lemieux, 2006; Goodpaster et al., 2005). In Europe, van Vliet-Ostaptchouk et al. (2014), found that METs was prevalent in 52% of obese subjects as compared to 24.4% of METs in the population (Scuteri et al., 2015). The prevalence of METs among obese subjects

in Cameroon and Benin is also suggestive of the role of abdominal obesity in the pathophysiology of METs (Fezeu et al., 2007; Ntandou et al., 2009).

The process by which obesity affects METs is related to fat metabolism. The process releases fatty acids that accumulates in the musculoskeletal cells and interacts with insulin causing insulin resistance, which in turn interferes with glucose metabolism (Boden, 2011). It has been purported that obesity measured by central adipose tissue, rather than insulin resistance, is the precursor of METs (Cameron et al., 2008). However, since not all obese subjects have insulin resistance; abnormal insulin action in the skeletal muscle and the liver, but not entirely lipid accumulation in adipose tissue may be responsible for the cause of the METs (Redon et al., 2008). Nonetheless, abdominal obesity is probably the most prevalent risk factor associated with the syndrome (Després & Lemieux, 2006).

The critical role of central obesity in the aetiology of METs was recognised by the IDF who made it the core component in the classification of the syndrome (IDF, 2006). This notion has also been recognised in the harmonized definition where abdominal obesity is to be used as a screening tool prior to METs diagnoses (Alberti et al., 2009).

### **2.7.3 Age**

There is substantial evidence to suggest that the prevalence of METs increases with age (Yousefzadeh & Sheikvatan, 2013; Guarner-Lans, Rubio-Ruiz, Pérez-Torres, & Baños de MacCarthy, 2011). The mechanism by which age affects METs has however not been fully understood, but it has been suggested that as a person ages, body fatness, adoption to unhealthy lifestyle behaviours and physical inactivity increases (Ferreira, Twisk, van Mechelen, Kemper, & Stehouwer, 2005). The influence of these factors in the aging may be responsible for the clustering of the METs components. Further, since high blood glucose, which results from

insulin resistance have both been shown to increase with age (Longo-Mbenza, On'kin, Okwe, Kabangu, & Fuele, 2010), age must be implicated in the risk factor scoring of METs.

Further evidence has established the association between age and the prevalence of several components of the METs: high FBG, high BP and abdominal obesity. For instance, one study in Taiwan found the prevalence of METs and almost all the components of the syndrome to increase with age (Wu et al., 2014). A recent report also suggests that irrespective of baseline METs status, the severity of the syndrome increases with time (Vishnu, Gurka, & DeBoer, 2015). However, it remains unclear the pathophysiological changes in ageing that influence the occurrence of METs. In addition, ageing could only be an influencing risk factor but not a cause of it since there are adolescents and even children who have METs. Furthermore, if age were to be a causal factor, at what specific age does METs start to occur?

#### **2.7.4 Sex**

The effect on METs of the different biological and physiological characteristics of the male and female phenotype has attracted divergent opinions. While some studies have found marginal to no difference in the prevalence of METs between the sexes (Adegoke et al., 2010; Ogbera, 2010) some sweeping statements have been made regarding sex differences in the prevalence of METs. However, such statements may be misleading due to the variable genetic backgrounds, foods consumed, physical activity levels, and nutritional status influencing the prevalence of the syndrome and its components (Vishnu et al., 2015).

Despite these observations, there is overarching evidence to suggest that METs may be more prevalent in females than in males. Guarner-Lans et al (2011) have argued that the prevalence, time of onset and severity of many pathological conditions including METs differ between males and females. The difference in METs components between male and female is because

of the different rates of decrease in sex hormones (and the protective roles they play during adulthood).

Significantly higher prevalence of METs have been reported in females than males in Iran (Yousefzadeh & Sheikvatan, 2013). In the USA after adjusting for age and race the prevalence of METs was reported to be twice higher in female Hispanics than in their male counterparts (Ervin, 2009). Similar observations have been made in the Caribbean and in Africa (Cherry, Serieux, Didier, Nuttal, & Schuster, 2014; Okafor, 2012).

In subjects with diabetes, the prevalence of METs has also been reported to be marginally higher in women than in men (Mak et al., 2007; Mogre et al., 2014). There is one suggestion that gender differences such as parity, which may lead to increased abdominal adiposity may be associated to the high prevalence of METs in females than in males (Loucks et al., 2007).

### **2.7.5 Dyslipidaemia**

Abnormal amounts of lipids consisting of raised triglyceride (TG) levels, increased small dense low-density lipoprotein (LDL) particles and low high-density lipoprotein (HDL) cholesterol levels tend to be associated with METs and diabetes (Adeli, Taher, Farr, Xiao, & Lewis, 2016). Although these disorders of lipid and lipoprotein metabolism tend to occur together, the levels of low HDL-cholesterol and triglycerides in the blood are normally measured as separate entities. The mechanism by which dyslipidaemia increases in the body appears to be related to increased accumulation of free fatty acids in the liver cells (Eckel et al., 2005). This results in increased production of very LDL. On the other hand, raised triglyceride levels are a reflection of hyperglycaemia due to insulin resistance. Reduced HDL-cholesterol levels in the blood is normally a consequence of raised triglycerides (Eckel et al., 2005).

Although non-HDL cholesterol such as LDL cholesterol has been found to be associated with METs, only low HDL-cholesterol and triglyceride levels are used for detecting METs (Liu & Reaven, 2013). Consequently, it has been suggested that non-HDL-cholesterol/HDL-cholesterol ratio should be used in place of reduced HDL-cholesterol for diagnosing METs (Kim et al., 2013). However, this might not be practical in the clinical setting since doctors require an easy-to-use tool to enhance diagnoses. Nevertheless, elevated TG levels and low HDL rather than raised LDL cholesterol remain important contributors to the burden and diagnoses of METs.

In studies among people with hypertriglyceridemia in Spain it was found that the prevalence of both METs and diabetes was higher in the sample (Ascaso et al., 2011) than in the population (Fernández-Bergés et al., 2012). In another study, low HDL-cholesterol and elevated triglyceride levels were found to be the most prevalent predictors of METs in West Africans and African Americans (Sumner et al., 2010). Diabetes patient with METs were also observed to have high prevalence of low HDL-cholesterol and high levels of triglycerides as the predominant components of the syndrome, with low HDL-cholesterol occurring more frequently than high triglyceride levels (Orchard, 2005; Bhatti et al., 2015).

### **2.7.6 High blood pressure**

High blood pressure is a major component of the constellation of risk factors associated with the METs. As with hyperglycaemia, the relation between raised BP and METs has been well established (Ferrannini & Natali, 1991). However, the association has largely been associated with factors such as insulin resistance, abnormal renal sodium functioning and over-activity of the sympathetic nervous system (Redon et al., 2008). The overlap between hypertension and diabetes has been noted with the two conditions reported to frequently coexist because of a

common pathophysiologic pathway they share (Cheung & Li, 2012). However, the frequency of occurrence of the component varies between populations.

In the review of Okafor (2012), obesity and dyslipidaemia rather than hypertension were observed to be the most frequently occurring components in Africa. Sumner et al. (2010) found that in addition to dyslipidaemia, hypertension was frequent in West African Subjects. In the study among premenopausal women in Ghana Arthur et al. (2013), found high blood pressure to be the second commonest component after abdominal obesity. In a similar study conducted in a rural setting in Ghana, hypertension was the third most predominant component (Gyakobo et al., 2012).

Among T2DM patients, a notable increase in hypertension (49%) was observed as the second most predominant risk factor after dyslipidaemia in India (Yadav et al., 2014). In one study in Botswana hypertension was the most predominant component among people with T2DM (Mengesha, 2007). In Tamale, hypertension was the third commonest component after obesity and triglyceride levels (Mogre et al., 2014) whereas in Kumasi it was the commonest among diabetes patients (Nsiah et al., 2015). Despite the variability of high BP prevalence in the studies, it remains amongst the top three most predominant components of METs in people with diabetes.

## **2.8.0 Lifestyle factors influencing the occurrence of METs**

### **2.8.1 Diet and the development of METs**

The role of diet on the development of the METs is probably the most plausible explanation as both a cause and a risk factor of the syndrome. As a cause, the mechanism by which diet elicits METs can be put into two pathways. Firstly, the overabundance of plasma lipids provided by hypercaloric diets inhibits insulin receptors in skeletal muscle and liver tissues eliciting insulin

resistance (Sesti, 2006). In the second pathway Alemany (2013) hypothesises that the constant consumption of foods rich in fats, sugar, salt and high-quality animal protein derived from modern diets induces cell enlargements and stress in white adipose tissue. In the past, accumulation of excessive energy from dietary sources was scarce and hence not perceived by the body as stress or aggression. With the consumption of modern high-energy diets, the body cells are attacked by the constant build-up of excess energy, nutrients and insulin resistance induced by the insulin-inhibiting action of lipids. This aggression triggers adipose tissue enlargement and the release of alarm proinflammatory cytokines, which in turn induce the filtration of immune system cells to fight the threat. Immune system cells increases proinflammatory biomarkers and induce insulin resistance. Insulin resistance is a key pathologic trait of METs and is responsible for inducing the clustering of the metabolic factors seen in METs (Eckel et al., 2005).

As a risk factor, epidemiological studies have implicated unhealthy diets in the METs burden (Lottenberg, Afonso, Lavrador, Machado, & Nakandakare, 2012). As with most of the METs risk factors, the role of food in the risk factor modelling of METs is mixed. When food is consumed, the quantity and types of nutrients released depends on the amount and type of food consumed. In the work of Barbaresko et al. (2014), they found that in addition to beef, processed meat and bouillon, diets high in legumes were positively associated with the prevalence of the METs. However, in an earlier study, Panagiotakos, Pitsavos, Skoumas, & Stefanadis (2007) did not associate eating legumes to METs. In fact, consumption of nuts was observed to have favorable effects on several lipid factors in Korean women with METs (Lee et al., 2014).

Inconsistencies in the literature also relates to the effective role of carbohydrate and fatty diets in the prevalence of METs. Fatty foods such as dairy was suggested to have a lower risk of

METs (Kim, 2013). Higher content of fat was also not associated to METs among Iranian women (Shirani, Esmailzadeh, Keshteli, Adibi, & Azadbakht, 2015). Interestingly low fat diets, less than 15% of total energy intake, was implicated in the higher incidence of METs among adults whose diet consisted of low levels of carbohydrate (Park, Ahn, & Lee, 2015). On the contrary, Steckhan et al. (2015) reported that low fat and low carbohydrate diets had favourable effects on insulin and body weight. In one cross-sectional study, diets with lower amounts of carbohydrates (not fat) was not significantly associated with the risk of METs in Iranian women (Shirani et al., 2015).

While there are mixed reports on the specific impact of diet on METs, the general consensus is that energy-dense diets that contain large amounts of fats and high-quality animal proteins are not protective against (Lottenberg et al., 2012; Pereira, 2006; Panagiotakos, Pitsavos, Skoumas, & Stefanadis, 2007; Hoffmann & Cubeddu, 2009; Wang & Beydoun, 2009). Sugars salts and diets low in fruits and vegetables are also not protective against METs.

### **2.8.2 Physical activity**

Physical inactivity is a modifiable risk factors associated with METs. The process by which physical activity affects METs involves changes in body weight and improvements in glucose tolerance (Hawley & Lessard, 2008). There is strong evidence supporting the inverse relation between physical activity and METs (He et al., 2014).

### **2.8.3 Smoking**

The mechanism underlying smoking and METs is said to be related to a hormonal imbalance that results in the accumulation of central adipose fat causing insulin resistance (Cena, Fonte, & Turconi, 2011). It has also been reported that as compared to people who do not smoke, smoking tobacco regularly was associated to a 1.07–1.66-fold greater risk of developing METs

(Nakanishi, Takatorige, & Suzuki, 2005). Weitzman et al. (2005) demonstrated a dose-response, cotinine-confirmed relationship between tobacco smoking and METs. The researchers found that exposure to tobacco smoke, whether by active smoking or exposure through environmental tobacco smoke is associated with a fourfold increased risk of METs among adolescents who are overweight or at risk of overweight. Kawada et al. (2010) also found that current smoking and insulin resistance were associated to a high prevalence of METs.

Despite the overarching evidence on the harmful effects of smoking on health, Onat et al. (2007), reported a protective effect of smoking on METs. Other studies have observed that cigarette smokers usually have a lower BMI compared to non-smokers (Filozof, Fernández Pinilla, & Fernández-Cruz, 2004). One study reported that smoking cessation leads to body fat accumulation, and elevated levels of BMI, systolic blood pressure, and fasting glycaemia (Y.-M. Song, Chang, Hsu, & Chen, 2015). But these suggestions have attracted criticism referring to misclassification biases resulting in the categorization of variables (Durusoy, 2010). The temporal weight gain associated to smoking cessation (if at all such association exist) may be as a result of a modified behaviour on the part of previous smokers to continuously snack on unhealthy foods to satisfy their craving for cigarettes.

#### **2.8.4 Alcohol consumption**

Alcohol consumption is one of the most prevalent life style factors linked to the METs. However, while some evidence has suggested the protective effects of moderate alcohol consumption and the incidence of T2DM (Baliunas et al., 2009), others have linked alcohol consumption to both beneficial and hazardous health effects (Alkerwi et al., 2009). A U-shaped trend relationship between alcohol use and the development of diabetes has been observed, with

modest and high consumptions being protective and harmful respectively (Baliunas et al., 2009; Koloverou et al., 2015). In the study of Koloverou et al. (2015), it was reported that individuals who drank up to one (1) glass per day of alcohol had a 53% lower risk of developing diabetes within ten years when compared with abstainers. Improvement in insulin sensitivity following light to moderate consumption of alcohol has been linked to the beneficial effects associated with alcohol consumption (Bonnet et al., 2012).

Although, studies have confirmed the benefits of consuming moderate amounts of alcohol in the USA (Kerr & Ye, 2010) and Sweden (Rasouli et al., 2013), similar observations were not made among Japanese (Teratani et al., 2012). In one study, waist circumference was observed to be bigger in people who drank more than 200g of alcohol per week than abstainers. The study also found that the level of HDL-cholesterol was significantly higher in all alcohol consuming groups compared with abstainers (W.-Y. Lee, Jung, Park, Rhee, & Kim, 2005).

There is no consensus on which direction consumption of alcohol impacts on METs. Perhaps drinking moderate amounts of alcohol improves insulin sensitivity thus controlling blood glucose levels, but when consumed in excessive quantities alcohol could increase the risk of METs and its components. What is considered moderate consumption of alcohol remains unclear.

### **2.10 Management of metabolic syndrome**

Whiles there are pharmacological approaches for the treatment of METs components (Martin, Mani, & Mani, 2015; Dunkley et al., 2012), lifestyle change is a more sustainable and the preferred first-line choice (Eckel et al., 2005). Lifestyle change involves managing all the components in one approach through lifestyle modifications without using drugs. The lifestyle

approach is probably more suited for public health professionals because groups of people can be assisted to make healthy changes.

The type of approach used depends on the immediate risk of the individual to CVD (Eckel et al., 2005). If a 10-year risk assessment reveals that the individual is at a 10-year risk of developing CVD, then the pharmacological approach should be recommended. If however, the risk of CVD were greater than 10 years, then the lifestyle change approach would be more appropriate. In some circumstances surgical procedures may be recommended to treat some components of the syndrome such high blood pressure, hyperglycaemia and obesity (Batsis, Nieto-Martinez, & Lopez-Jimenez, 2007; Bogun & Inzucchi, 2013).

The lifestyle approach for the management of METs generally involves dietary and physical activity modifications, weight management, limiting alcohol and avoiding smoking (Wannamethee, Shaper, & Whincup, 2006). Dietary choices that include cereals, fish, legumes, vegetables, and fruits have been found to be independently associated favourable outcomes of METs components. However, meat, sweets, fats and alcohol intake have been shown to have unfavourable effects on health (Panagiotakos, Pitsavos, Skoumas, & Stefanadis, 2007; Farhangi, Jahangiry, Asghari-Jafarabadi, & Najafi, 2015).

Mediterranean diet have been shown to have protective value on METs. Mediterranean diet uses olive oil as the main source of fat, and emphasizes on judicious use of dairy products, low to moderate consumption of fish and poultry, and generous consumption of fresh fruits and vegetables on a daily basis. It also promotes daily consumption of whole grain cereals, low intake of red meat, and moderate consumption of alcohol (mainly red wine) as some of the also beneficial effects on METs and its components (Alvarez León, Henríquez, & Serra-Majem, 2006; Kiortsis & Simos, 2014; Bach-Faig et al., 2011; Tortosa et al., 2007). DASH diets, which

emphases on portion sizes in addition to fruits and vegetables, limiting alcohol and avoiding smoking can reduce most of the metabolic risks in both men and women (Azadbakht et al., 2005).

Despite the evidence in support of healthier food choices, some researchers have raised concern about the protective role of whole grains in the fight against METs. In a review on Cochrane, it was reported that the evidence from prospective cohort trials was too weak to draw conclusions on the role of whole grain foods in the prevention of raised blood glucose/T2DM (Priebe, van Binsbergen, de Vos, & Vonk, 2008). Giacco et al. (2014) also found that postprandial insulin and triglyceride response was reduced in subjects treated with whole grain cereals as compared to those treated with refined cereals (Giacco et al., 2014). These findings implicate the role of whole grains as a healthy food choice for the dietary management of METs.

These findings notwithstanding, dietary approaches that reduce macronutrients and are rich in functional food constituents such as vitamins, flavonoids and unsaturated fats when combined with weight loss and anti-inflammatory nutrients has beneficial effects to people with METs (Steckhan et al., 2015). Western dietary patterns are associated with obesity while wise dietary habits are linked to healthful weight (Giugliano, Ceriello, & Esposito, 2006). Making minor changes toward a healthy lifestyle may be all that we need to prevent and treat METs (Kiortsis & Simos, 2014).

## CHAPTER THREE

### 3.0 Methodology

#### 3.1 Study Design

A cross-sectional study was conducted to assess the burden of METs among people with T2DM in two selected hospitals in the Brong Ahafo Region of Ghana. The study also examined the association between risk factors and the clustering of the METs components. Data on individual characteristics and exposure to risk factors was collected alongside information about the outcome of interest (METs).

The relatively short period available for this research made it difficult to consider other study designs such as longitudinal or cohort studies that require extensively longer periods to conduct. Secondly, since the study was not intended to examine exposure factors in cases and controls, a cross-sectional study design was considered more appropriate for this type of survey.

#### 3.2 Study setting

The survey was carried out among people with T2DM who attend routine clinic sessions at Berekum Holy Family Hospital and Dormaa Presbyterian Hospital in the Brong Ahafo Region. Dormaa-Ahenkro is the capital town of Dormaa Central Municipal and it is located about 65 km from Sunyani (capital town of the Brong Ahafo Region). The Presbyterian Hospital is the only hospital in Dormaa Central Municipal. The population of Dormaa Central Municipal is estimated at 125, 621 people. The Dormaa Presbyterian Hospital also serves as the Municipal Hospital and it is the main referral centre for most cases from Dormaa East and West Districts. The hospital also provides health care services to people from communities in neighbouring La Cote D'Ivoire where it shares boundaries with the French speaking country. The average weekly diabetes clinic attendance in 100.

Berekum Municipal on the other hand has an estimated population of over 145,746 people and the Holy Family Hospital is main referral centre for patients from health facilities within the municipality and neighbouring Dormaa East district. It is the only hospital in the municipality. The hospital has a daily outpatient attendance of 280 and a bed capacity of 162. The average weekly diabetes clinic attendance is 80.

### **3.3 Criteria for selection of hospitals**

The choice of the Brong Ahafo Region for the study was based on the fact that previous studies had been in the northern and southern parts of Ghana, but not in the middle belt of the country. Secondly, the previous studies were done in the regional capitals but not in the districts. Therefore, a decision was taken to carry out the study in two district or municipal hospitals depending on whether the monthly diabetes clinic attendance would meet the required sample size for the study.

There are 27 districts and 18 district hospitals in the Brong Ahafo Region. Selection of hospitals for the study was based on the following criteria:

1. That the hospital(s) was a district or municipal hospital not located in the regional capital, Sunyani.
2. That the hospital(s) had a diabetes clinic with monthly attendance greater than the estimated sample size of 444.
3. That the hospital(s) had a functioning biochemical laboratory.
4. That permission would be granted for the study at the hospital(s).

When data from the regional health information office was examined, 16 of the 18 district hospitals were observed to be located outside Sunyani. Only 10 of the hospitals had diabetes clinics and none had monthly diabetes clinic attendance of at least 444 patients. When

availability of biochemical laboratory was assessed, only six of the remaining 10 hospitals had functioning biochemical laboratories.

In order to meet the sample size requirement, the Presbyterian and Holy Family hospitals at Dormaa and Berekum Municipalities were selected because both hospitals and the districts have similar characteristics. Until the recent creation of the Dormaa East District, Dormaa and Berekum Municipals shared boundaries. The monthly attendance at the diabetes clinics in both hospitals summed up to 720 and they are proximate. They are also both mission hospitals.

### **3.4 Study Population**

The survey respondents were adults who had previously been diagnosed with T2DM according to WHO criteria (WHO, 1999) and were 30 years or above and not pregnant. All T2DM patients attending the hospitals' diabetes clinic for care during the study period were considered eligible for participation in the survey. The consent of participants was sought before participating in the survey. Medical records of participants were used to confirm T2DM status, the medication profile, and information on any previous diagnoses related to the five METs components.

### **3.5 Inclusion criteria**

Study participants were aged 30 to 79 years with clinical diagnoses of T2DM regardless of the duration of illness. All study participants were apparently healthy adults; including those on treatment for hypertension and diabetes. Only those who had consented and willing to participate were included in the research. Only information from participants whose diabetes status had been confirmed by a physician and there was information on the patient's hospital records to prove it were used for data analysis.

### **3.6 Exclusion criteria**

Participants aged less than 30 or above 79 years of age as well as pregnant or lactating mothers were excluded from the study. In addition, participants with type 1 DM, history of heart failure, myocardial infarction, hypogonadism, hypothyroidism, acromegaly and any other chronic diseases were not selected in the study. Patients on prolonged steroid use and those who were on active drug treatment for obesity at the time of study were also excluded. Critically ill participants, including those on self-reported cardiac problems were also excluded from the study.

### **3.7.0 Variables**

#### **3.7.1 Independent/Exposure Variables**

The independent variables that were measured included socio-demographic, and lifestyle factors. The socio-demographic characteristics that were measured and analysed as categorical variables included sex, occupation, educational status, marital status, duration of diabetes, family history of diabetes, and residence of participant (district). Lifestyle factors such as engagement in physical activity, consumption of fruits, vegetables and oil-cooked foods were also analysed as categorical variables. Age and duration of diabetes were both analysed as categorical and as a continuous variable.

#### **3.7.2 Intermediary variables**

Noting that METs results from the clustering of three or more METs components, this study determined that the five METs components (waist circumference, raised blood glucose, raised BP, raised TG, and low HDL-cholesterol) including BMI and diastolic blood pressure constituted intermediary variables. All the intermediate variables were analysed as continuous variables.

### 3.7.3 Outcome variables

The main outcome variable of interest, METs, was measured as a binary categorical variable using the harmonized definition (Alberti et al., 2009). The presence of METs was determined if a person had three or more abnormal results of waist circumference, blood glucose, BP, TG, and HDL cholesterol. The METs components and their cut-offs is indicated in Table 1. Waist circumference and raised blood pressure were determined by direct physical measurements (described in detail below). The biochemical indices of raised blood glucose, raised TG, and low HDL cholesterol were determined by the analysis of blood samples of participants.

A second outcome variable, continuous MSR score was also measured using the Gurka et al. (2014) equation for non-Hispanic black adult men and women (Table 3). The METs components that were used to compute the continuous MRS were waist circumference, TG, HDL cholesterol, systolic BP and FBP.

### 3.8 Sample size estimation

The investigator set out to calculate the sample size needed to estimate the proportion of T2DM patients with METs identified by the harmonised definition. The sample size for the study was calculated using the Cochrane's formula. The formula is as follows:

$$SS = \frac{Z^2 * p(1 - p)}{d^2}$$

Where:

SS – Sample size

Z – Standard normal variant at 5% type 1 error (p<0.05) and 95% confidence interval

p – Point prevalence (estimated proportion of METs among T2DM subjects in a similar area)

d – Distance on either side of the expected prevalence of condition of interest

The researcher used this equation to compute the sample size needed to determine the associated risk factors and prevalence of METs among people with T2DM in the study area. An assumed 50% prevalence of METs among people with T2DM in a similar area or in the population was applied in the sample size calculation. This assumption was made in the light that the researcher was unable to obtain estimated prevalence data from previous studies. Further, due to time limitations, the researcher could not conduct a mini survey in a similar area to prevalence data to be used in the sample size calculation. Consequently, the researcher calculated the sample size using  $p = 50\% = 0.05$ ,  $Z=1.96$  (obtained from standard tables), and  $d=0.05$ . The resulting calculation produced a sample size of 384.16. An assumed nonresponse rate of 15% = 57.6  $\approx$  60 was added to give an estimated sample size of 444 that was used for the study.

The average weekly attendance of people with T2DM at Dormaa and Berekum municipalities are 100 and 80 respectively. Therefore, participants in Dormaa and Berekum municipalities were recruited on a ratio of 5:4 respectively. Consequently, 56% (249) and 44% (195) participants were recruited from Dormaa and Berekum municipalities respectively.

### **3.9 Sampling technique**

Simple random sampling technique was used to give each unit (T2DM participant) in the population of T2DM clinic attendants an equal chance of participating in the research. People with T2DM attend the hospitals' clinics on a cycle of ones every four weeks. To ensure equal chance of selection, sample selection and data collection was done over a four week period in each hospital. In Dormaa, the 249 participants were recruited in the following order: 62 participants per week for the first 3 weeks and 63 participants on the fourth week. In Berekum, the 191 participants were recruited in the following order: 49 participants per week were recruited in the first 3 weeks and in the fourth week, 48 participants were recruited.

The following steps were followed (at each clinic, in each of the four weeks of data collection) to select the sample size of 444 participants for the study:

**Step one:** A list of all T2DM clinic attendants was made.

**Step two:** A consecutive number from 1 to  $n$  (number of clinic attendants for the specific day) was assigned to each attendant on the list.

**Step three:** Using a random number generator on Microsoft Office excel 2013, a set of random numbers equal to  $n_1$  (sub-sample size for the particular clinic, on the specific day) was generated.

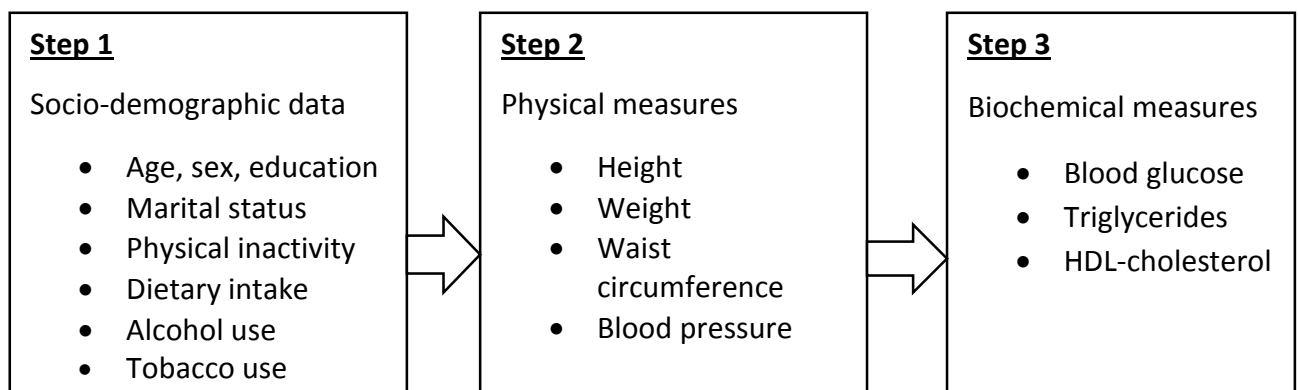
**Step four:** The generated random numbers in step three were then used to select the participants from the list of attendants.

The steps narrated above were repeated at each hospital for four weeks to select  $n_1, n_2 \dots$  to  $n_8$  sub-samples. The sum of  $n_1 + n_2 \dots + n_8 = SS$

### 3.10 Data collection

Data collection was carried out from May to June 2016. A three-step approach (Figure 2) similar to the WHO stepwise approach for chronic disease risk factor surveillance was used to collect data on socio-demographic, physical and biochemical measures (WHO, 2008).

**Figure 2: Three-step data collection process**



### **Step 1**

Structured pre-coded questionnaires were used to collect respondents' demographic and socio-economic data such as age, sex, educational level, occupation, and ethnicity. Information on duration of diabetes since first diagnosed, family history of diabetes and hypertension were also collected using the questionnaires. Any known health conditions and medication profile were also collected in this step. Hospital records were used to retrieve/confirm information about the clinical history of patients. In addition, information on respondents' behavioural factors such as physical inactivity, use of tobacco, alcohol consumption, and dietary habits was obtained using an adapted semi quantitative Fenland Food Frequency questionnaire (University of Cambridge, 2014).

### **Step 2**

Physical measurements of weight, height and waist circumference were used to collect anthropometric data. Blood pressure was also measured in this step.

### **Step 3**

Blood samples of respondents were collected and analysed for the levels of blood glucose, triglycerides and HDL-cholesterol.

#### **3.11.0 Measurements**

##### **3.11.1 Anthropometry**

Anthropometric measurements of heights and weights were measured with participants wearing light clothing and without shoes. Weight and height was measured using Seca weighing scale and stadiometer respectively. A simple tape measure calibrated in meters to the nearest centimetre was used for measuring waist circumference. Waist circumference measurements were done to the nearest centimetre on the bare skin at the end of a gentle respiration. The

measurement was taken at the narrowest indentation midway between the lowest rib and the iliac- crest.

### **3.11.2 Blood pressure**

The mean of two blood pressure measurements taken after five minutes apart was determined for each participant using Omron electronic blood pressure apparatus. Each participant was measured in the sitting position after they had had at least 15 minutes of rest and the readings recorded in the questionnaire.

### **3.11.3 Biochemical data**

Once the interviews and anthropometric measurements were over, participants were given laboratory forms to go to the laboratory to have their blood samples taken and analysed for glucose, TG and HDL cholesterol after which the results were entered in their respective questionnaire. In order that no substantial delay was caused to participants, the laboratory tests were carried out as part of the routine blood glucose tests patients undergo monthly. Unused blood samples were discarded in line with the hospitals' protocols.

### **3.11.4 Dietary assessment**

Using the Fenland Food Frequency Questionnaire, participants were asked questions on their average use of food last year. The focus was on the consumption of fruits, vegetables, and oily or fried foods. Portions sizes were not specified. Participants reported the usually number of times they consumed each type of food per month, week or day categorised from 'never ate' to once per day'.

### **3.11.5 Consumption of alcoholic and non-alcoholic beverages**

Data on the use of alcoholic drinks last year was assessed using the Fenland food frequency questionnaire. For each beverage type (beer, red and white wine, pito, palm wine, hard liquor,

tea, coffee, chocolate), participants reported the ones they usually drank. As in the case of the dietary assessments participants reported their frequency of consumption of each type of drink per month, week or day categorised from ‘never drunk’ to ‘daily’. Portion sizes were not specified.

### **3.11.6 Smoking pattern**

Smoking status was categorized into current smokers, former smokers and never smoked.

### **3.12 Data Analysis**

Information recorded on the questionnaire was inputted into Microsoft excel 2013. A spread sheet was designed on excel with rows indicating information of each participant while the columns showed the variables. The resulting dataset was cleaned for correctness and completeness before it was exported to Stata 13 for analysis. Descriptive statistics like frequencies, percentages and mean  $\pm$  standard deviation were used to describe the independent and outcome variables. Frequencies and percentages were used to describe the socio-demographic characteristics as well as the dietary pattern and physical activity status of participants.

The mean and standard deviation was used to describe the measurements of continuous variables such as age, MSR score and METs components (waist circumference, blood glucose, blood pressure, HDL cholesterol, and triglycerides).

Frequencies and percentages were used to describe the prevalence of METs in the sample of T2DM subjects. For categorical variables, *chi square* test was used to test the temporal association between potential risk factors and METs. For continuous variables such as age, BMI, WC, SBP, TG, HDL and FBS, *student t-test or ranksum* was used to test the difference in mean measurements between men and women and by the presence of METs. Two logistic

regression models on Stata 13 were used to test the strength of association between risk factors and the traditional binary METs outcome. First, the simple logistic model was ran to test the crude relationship between potential risk factors and METs. Secondly, the multiple logistic model was used to establish the independent relationship between the risk factors and the traditional binary METs.

Odds ratios (OR) and 95% confidence intervals were constructed as part of the logistics regression procedure. *P*-values were also generated to determine whether the observed difference in prevalence of METs between subgroups were real or simply by chance. Statistical significance was assumed if *p*-values were  $<0.05$ . Thus a given risk factor whose association with METs or any of its components generated a *p*-value  $<0.05$  was described as significant; stating the probability of such a result happening by chance was very small.

The Gurka et al. (2014) equation for the non-Hispanic black people (Table 3) was used to compute the MSR scores. In the equation, age, sex and race factors are applied to the Z-scores of the numerical values of SBP, triglycerides, WC, FBS and HDL-cholesterol to generate continuous MSR scores. The equation was promulgated at University of Virginia School of Public Health in the USA.

The linear regression models were used to test the strength and association between the independent/exposure variables and the MSR score. First, a simple linear regression model was constructed to determine the crude relationship between the exposure variables and MSR score. Secondly, a multiple linear regression model was constructed to determine the adjusted relationship between the exposure variables and the MSR score.

**Table 3: Equations for sex-specific Metabolic Syndrome Risk Z-Score for adults****Men**

$$= -6.3767 + 0.0232 * WC - 0.0175 * HDL + 0.0040 * SBP + 0.5400 * \ln(TG) + 0.0203 * FBS$$

**Women**

$$= -7.1913 + 0.0304 * WC - 0.0095 * HDL + 0.0054 * SBP + 0.4455 * \ln(TG) + 0.0225 * FBS$$

**3.13.0 Ethical considerations****3.13.1 Ethical clearance**

Before the study was carried out, a proposal was written to the Ghana Health Service Ethical Review Committee on Research Involving Human Subjects (ERCRIHS) through the School of Public Health of the University of Ghana for ethical clearance. A letter was also written to the hospital authorities through the respective Municipal Health Directorates to seek permission to carry out the study.

At the field, the consent of prospective respondents was sought before they participated in the research. The purpose and risks/benefits of the study, as well as the rights of participants was read to them before they participated. Except for the needle prick and somewhat intrusive questions, no risks were posed to participants from this study. There were also no direct benefits of the study to participants. Participants were required to demonstrate their agreement of participation by endorsing the consent form.

On anonymity and confidentiality, participants were assured the strictest confidentiality and privacy of information. Participants were assured that information collected was to be used solely for the purpose of this study. Hard copies of data were locked in filing a cabinet and only accessed by agreed members of the research team. Questionnaires were anonymised and serialised so that respondents could not be identified by the questionnaires. Soft data were

password protected and could only be accessed by approved members of the research team. The names of respondents were not recorded.

Participation in the research was voluntary and at no cost to participants. The cost of laboratory tests was borne by the principal investigator. Participants with abnormal test results who wanted to seek further medical attention were issued referral forms to seek appropriated care.

### **3.14 Quality Control**

The process of data collection was standardized to ensure uniformity and of high quality of work. Credible and reliable research assistants who are health personnel working in the area were trained on ethical issues, consenting process, anthropometry and data collection. The research assistants were also coached on questionnaire administration and data extraction. The activities of research assistants and data entry clerks were monitored and supervised by the principal investigator throughout the study.

Questionnaires were checked for completeness before they were accepted. Errors detected during the data collection were discussed with the research assistants and the necessary corrections made before entry. Questionnaires were numbered during data entry to ensure that they were not entered twice. Computer entered data were double-checked for completeness and correctness before saving.

### **3.15 Pre-test study**

Pre-testing the questionnaires for the study was carried out at the Dormaa East District. This is not the area of study but the T2DM patients there have similar characteristics as those in the study areas.

The purpose of the pre-test was to enable the researcher to clarify the adequacy of the questions, estimate the approximate time for each questionnaire and help make the necessary corrections

on the questionnaire for the actual study. After the pre-test, no major changes were done to the structure and content of the questionnaires.

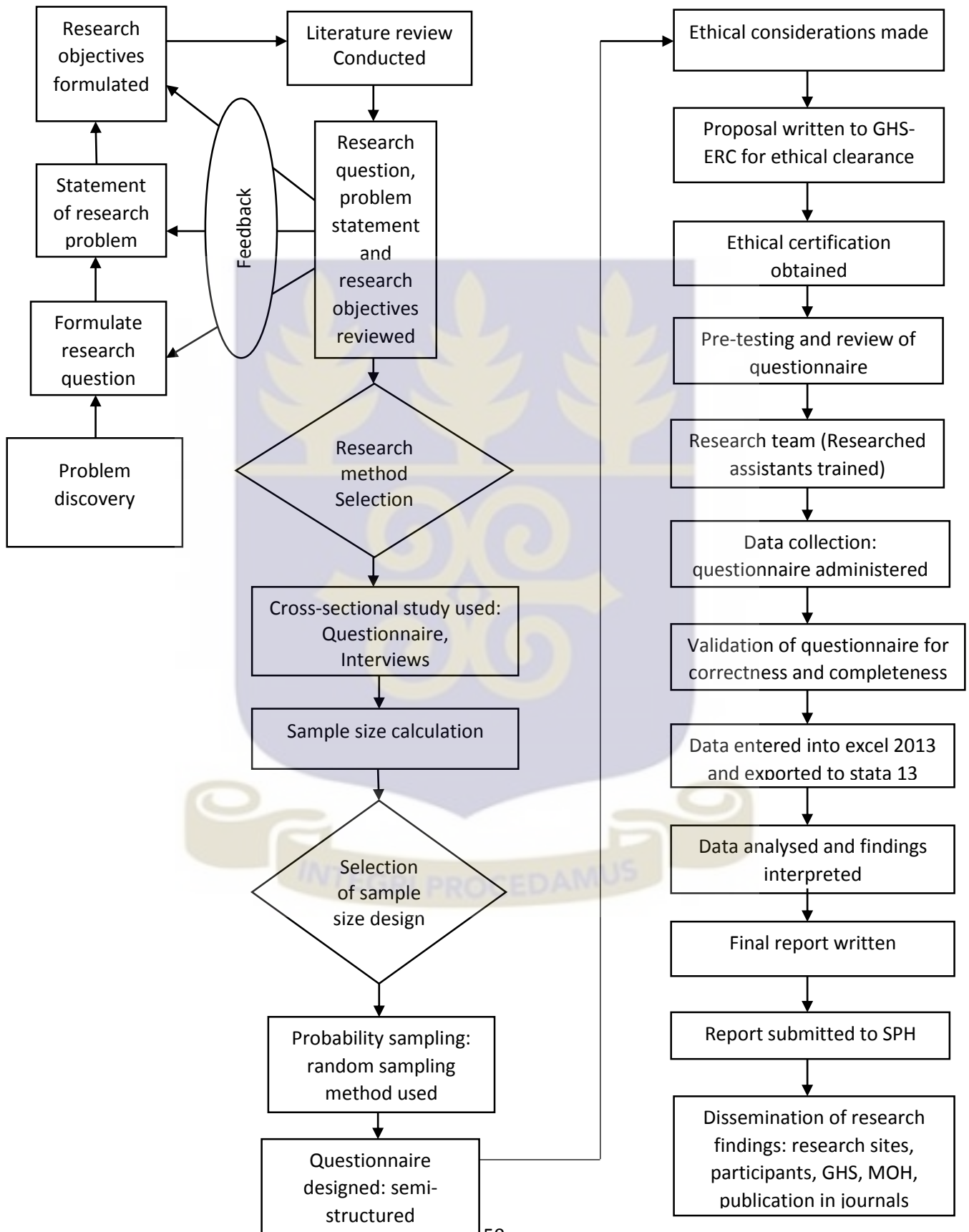
### **3.16 Research process**

Figure 3 below is a flowchart of the research process. It shows how the research process first began with the identification of a problem resulting in the formulation of a research question and objectives. It also shows the steps followed through to deciding on the research methodology, calculating the sample size and designing the questionnaires. It show the ethical considerations that were made before the proposal was written to the GHS-ERC for their consideration and clearance.

The flowchart shows that questionnaires were pre-tested and a research team assembled and trained. Data collection was followed by coalition, data entry, analysis of results and compilation of the final report. The flowchart also illustrates that dissemination of research findings is an important final step in the research process. Dissemination is particularly important for communicating research findings to research participants, the public, researchers, policy makers, and interested parties so that action may be taken to address the issues identified in the research.



**Figure 3: Algorithm of research process**



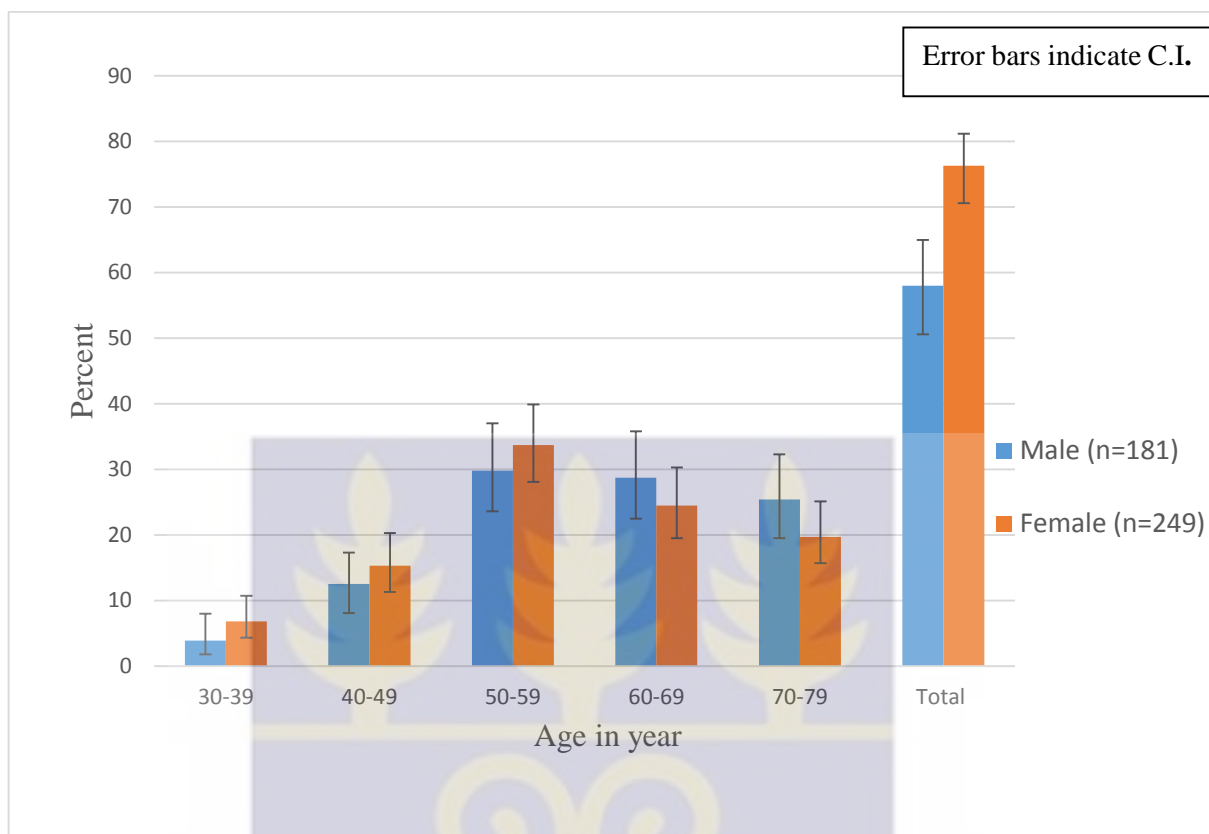
## CHAPTER FOUR

### 4.0 Results

#### 4.1.0 Baseline characteristics of study participants

The baseline socio-demographic characteristics of respondents are presented in Table 4. Initially, 444 respondents (aged 30-79 years) were interviewed and laboratory, physical and matching medical information obtained for 430 participants. The final sample size of 430 participants was recruited from both Dormaa and Berekum Municipals, of which 56.1% were from Dormaa Municipal. There were 57.9% women in the sample. The mean age of participants was  $58.84 \pm 11.49$  years. Men had a higher mean age than women,  $60.39 \pm 11.46$  and  $57.71 \pm 11.40$  years respectively ( $p=0.015$ ). The age of respondents ranged from 30-79 years with the majority (32.1%) of participants in the 50-59 years age category. The minority (5.6%) of participants were in the 30-29 years' age group. This study did not find subjects who were less than 30 years of age. All participants had previous diagnoses of T2DM with mean disease duration of  $5.30 \pm 3.84$  years (Table 6). Majority of participants (66.0%) were married whiles the rest were divorced, separated or never married.

Farming was the main occupation for (60.0%) of participants. Those who were engaged in administrative or office related work were 6.3% and 15.35% were unemployed or retired. The rest were traders, carpenters or construction workers. The proportion of participants with educational status equal to or higher than secondary education was 10.9%. On the lifestyle characteristics (Table 4), tobacco and alcohol use was 2.1% and 4.4% among participants respectively. The proportion of participants who said they engaged in moderate to vigorous physical activity at least 3 times per week was 22.8%. Participants who said they consumed fruits daily were 5.1% whiles 19.1% said they ate vegetables (other than tomatoes) daily. Oil-cooked foods such as fried foods and stews were eaten by 14.7% of participants.



**Figure 4: Prevalence of METs among people with T2DM by age and sex in Dormaa and Berekum Municipals, June 2016**

The physical and biochemical characteristics of respondents are presented in Table 6. The mean BMI was  $25.76 \pm 4.74$  kg/m<sup>2</sup> in the sample. The difference in mean BMI between men ( $25.60 \pm 4.17$  kg/m<sup>2</sup>) and women ( $25.87 \pm 5.11$  kg/m<sup>2</sup>) was not significant ( $p= 0.775$ ). On the METs factors or components used for classifying or measuring METs (triglycerides, HDL-cholesterol, waist circumference, SBP, DBP and fasting blood glucose or T2DM), the difference in mean measurements between men and women was significant for only triglycerides. Men had a mean triglyceride measurement of  $127.12 \pm 50.28$  mg/dl while women had  $143.08 \pm 57.24$  mg/dl,  $p= 0.004$ . For all the components except FBS, the difference in mean measurements between participants with METs and those without METs was significant with  $p < 0.001$ . The implication is that mean FBS was not initially associated with the binary METs outcome.

**Table 4: Characteristics of study participants and prevalence of METs among people with T2DM in Dormaa and Berekum Municipals, June 2016**

Parameter	Participants (N = 430)		Metabolic syndrome (N=295)		95% C.I.	p-value
	N	%	Prevalence	%		
<b>Sex</b>						<0.000
Men	181	42.1	105	42.0	35.0-49.4	
Women	249	57.9	190	76.3	70.6-81.2	
<b>District</b>						0.443
Dormaa Municipal	241	56.0	169	70.1	64.0-75.6	
Berekum Municipal	189	44.0	126	66.7	59.6-73.1	
<b>Marital status</b>						0.009
Married	284	66.0	183	64.4	58.7-69.8	
Divorce/Not married	146	34.0	112	76.7	69.1-82.9	
<b>Age categories</b>						0.697
30-39	24	5.6	16	66.7	44.5-83.3	
40-49	60	14.0	46	76.7	64.0-85.9	
50-59	138	32.1	93	67.4	59.0-74.8	
60-69	113	26.3	75	66.3	57.0-74.6	
70-79	95	22.1	65	68.4	58.2-77.1	
<b>Occupation</b>						0.212
Farmers	258	60	173	67.1	61.0-72.6	
Traders	64	14.9	52	81.3	69.5-89.2	
Office related	27	6.3	17	63.0	42.5-79.7	
Unemployed	66	15.3	43	65.1	52.6-75.9	
Other	15	3.5	10	66.7	37.2-87.1	
<b>Educational status</b>						0.679
Less than secondary	383	89.1	264	68.9	64.1-73.4	
Secondary or higher	47	10.9	31	66.0	50.9-78.4	
<b>Family history of T2DM</b>						0.351
Yes	306	71.2	214	69.9	64.5-74.8	
No	124	28.8	81	65.3	56.2-73.3	
<b>Duration of T2DM</b>						<0.001
Less than 5 year	267	62.1	156	58.4	52.4-64.2	
5 year and above	163	37.9	139	85.3	78.9-90.0	
<b>Physical activity</b>						0.153
Less than three times/week	332	77.2	222	66.9	61.6-71.7	
Three or more times/week	98	22.8	73	74.5	64.8-82.3	
<b>Fruits</b>						0.368
Daily	22	5.1	17	77.3	53.5-90.1	
Not daily	408	94.9	278	68.1	63.4-72.5	
<b>Vegetables (excludes tomatoes)</b>						0.946
Daily	82	19.1	56	68.3	57.3-77.6	
Not daily	348	80.93	239	68.7	63.6-73.4	
<b>Oil-cooked foods</b>						0.523
4-6 time/week	64	14.8	42	65.6	52.2-76.0	
Once/week or occasionally	366	85.31	253	69.1	64.2-73.7	

## 4.2.0 Prevalence of metabolic syndrome

### 4.2.1 Metabolic syndrome as a binary variable

Measured as a dichotomous categorical variable, METs prevalence was present in 68.6% of participants (95% CI: 64.0 -72.8). The prevalence of the syndrome among women (76.3%) was higher than in men (58.0%), Figure 4. Table 4 summarises the prevalence of METs among participants according to socio-demographic characteristics. *Chi-square* test of association was used to test the association between potential risk factors and METs. The METs prevalence in women compared with men was significant with  $p < 0.001$ . In Dormaa Municipal, 70.1% of participants had METs while in Berekum Municipal 66.7% of them had the syndrome ( $p = 0.443$ ). When the prevalence of METs in married participants (76.7%) was compared with that in unmarried (divorced, separated or never married) participants (64.4%), the result showed a significant relationship between marital status and METs ( $p = 0.009$ ).

When the syndrome was observed among subjects according to age distribution, METs prevalence increased from 5.6% in the 30-39 year age group to 32.1% in the 40-49 year age group, before reducing to 22.1% in the 70-79 year age group. The relation between age and METs was not significant with the *chi-square* test,  $p = 0.697$ . This study did not also observe a significant association between the METs and occupation, and between METs and educational attainment.

### 4.3.0 Metabolic syndrome components

The prevalence of the METs components is presented in Table 5. The proportion of participants who had only one (1) component was 3.7% while 11.6% participants had all five (5) components. The majority of participants had either two (2) components (28.8%) or four (4) components (28.8%). Should we ignore FBS because of its direct association with T2DM in

this study, the top three predominant METs components were reduced HDL-cholesterol, 302(70.2%), followed by elevated waist circumference of 60.9% and SBP of 49.8% participants. The least occurring component was TG (32.3%). Reduced HDL-cholesterol, (46.3%), followed by SBP (22.1%) and WC (17.4%) were the most frequent occurring components among men. In women WC, (43.5%), followed by reduced HDL-cholesterol (42.6%) and SBP (27.7%) were the three most predominant components.

When a multiple logistic model was constructed for only the METs components (Table 11) the association between diastolic blood pressure and METs ( $p=0.052$ ), and fasting blood sugar and MSR score ( $p=0.819$ ) were not significant. However, the association between WC, SBP, TG and HDL-cholesterol were all independently associated with the binary METs with significant  $p$ -values  $<0.001$ .

#### **4.4.0 Risk factors for the metabolic syndrome measured as a binary outcome**

In the univariate logistic regression models, sex, marital status, duration of T2DM, overweight and being a trader were shown to be associated with METs to varying extents (Table 9). The crude analysis showed that as compared to men, being a woman was associated with a 2.3 times increased odds of METs (95% CI: 1.53- 3.53),  $p<0.001$ . The odds of having METs among unmarried participants was 1.8 times that in married participants (95% CI: 1.15-2.86),  $p<0.001$ . Overweight participants were more likely to have METs than normal or underweight participants, crude OR 5.5 (95% CI: 1.15-2.86,  $p<0.001$ ). Duration of T2DM was associated with METs [crude OR of 4.1, (95% CI 2.51-6.77,  $p<0.001$ )]. Compared with farmers, participants who described themselves as traders had 2.1 times the odds of developing METs (95% CI: 1.08 - 4.20,  $p=0.029$ ).

Following the results of the univariate analyses, a multiple logistic regression model was constructed to adjust for the effects of those risk factors, which were observed to be significantly associated with METs. All the variables described in the univariate logistic model in Table 9 were regressed onto the binary METs outcome in the multiple logistic regression model. The results showed that sex, duration of T2DM and overweight were independently associated with the odds of developing METs. Table 10 summarises the results from the multiple logistic regression analysis.

Compared with normal participants, overweight participants were more likely to have METs with an estimated OR of 6.1 (95% CI: 3.70 - 10.07,  $p < 0.001$ ). The odds of METs in participants with T2DM duration of more than 5 year was 5.2 times the odds of those with a disease duration of less than 5 years (95% CI: 2.90 - 9.31,  $p < 0.001$ ). There was also a strong association between sex of respondents and the odds of METs in this study (OR 2.15 95% CI: 1.29 - 3.58,  $p < 0.003$ ).

**Table 5: Metabolic syndrome components by sex among participants with T2DM in Dormaa and Berekum Municipals, June 2016**

Number of components	Male	% (95% CI)	Female	% (95% CI)	Total	% (95% CI)
1	5	2.8(1.1-6.5)	11	4.4(2.4-7.8)	16	3.7(2.2-6.0)
2	74	40.9(33.9-48.3)	50	20.1(15.5-25.6)	124	28.8(24.7-33.3)
3	53	29.3(23.1-36.4)	63	25.3(20.3-31.1)	116	26.9(23.0-31.4)
4	38	21.0(15.6-27.6)	86	34.5(28.9-40.7)	124	28.8(24.7-33.3)
5	11	6.1(3.4-10.7)	39	15.7(11.6-20.8)	50	11.6(8.9-15.0)
<b>Obesity/overweigh METs component</b>	92	50.8(43.5-58.1)	137	55.0(48.8-61.1)	229	53.3(48.5-57.9)
TG	44	24.3(18.6-31.2)	95	38.2(32.3-44.4)	139	32.3(28.1-36.9)
DBP	65	35.9(29.2-43.2)	91	36.5(30.8-42.8)	156	36.3(31.9-41.0)
SBP	95	52.5(45.1-59.7)	119	47.8(41.6-54.0)	214	49.8(45.0-54.5)
WC	75	41.1(34.4-48.8)	187	75.1(69.3-80.1)	262	60.9(56.2-65.4)
FBS	138	76.2(69.4-81.9)	199	79.9(74.4-84.5)	337	78.4(74.2-82.0)
HDL	119	65.4(58.5-72.4)	183	73.5(67.6-78.6)	302	70.2(65.7-74.4)

#### 4.5.0 Metabolic syndrome risk score

The mean metabolic syndrome risk scores by socio-demography characteristics of participants is presented in Table 7. The mean MSR score in the sample was  $16 \pm 1.32$  with a range of -1.34-7.42. Women ( $1.26 \pm 1.41$ ) had a slightly higher mean MSR score than men ( $1.02 \pm 1.19$ ). However, using the *student t-test* it was revealed that MSR score was not significantly related to sex,  $p=0.06$ . Participants in Dormaa Municipal had a slightly lower MSR ( $1.14 \pm 1.27$ ) score than those in Berekum Municipal ( $1.19 \pm 1.40$ ), but this difference was not significant ( $p=0.672$ ). The difference in mean MSR scores between married ( $1.19 \pm 1.40$ ) and unmarried ( $1.12 \pm 1.18$ ) participants was also not significant,  $p=0.617$ . However, participants who had attained at least secondary education had mean MSR score of  $1.53 \pm 1.43$  compared with  $1.12 \pm 1.30$  for those with less than secondary education or no formal education. The comparison of mean MSR score of participants with secondary or higher educational versus those with less than secondary or no formal education was marginally significant in this study,  $p=0.046$ . When the MSR score was compared by the number of metabolic factors or METs components, participants with 3 or more component (i.e. METs present) had a score of  $1.40 \pm 1.28$  while participants with 1 or 2 components (i.e. METs absent) had a score of  $0.64 \pm 1.27$ . As expected, the MSR score was found to be significantly related to the number of components a person has,  $p<0.001$ . Overweight participants also had higher MSR score ( $1.50 \pm 1.28$ ) than normal or underweight participants ( $0.78 \pm 1.27$ ),  $p<0.001$ .

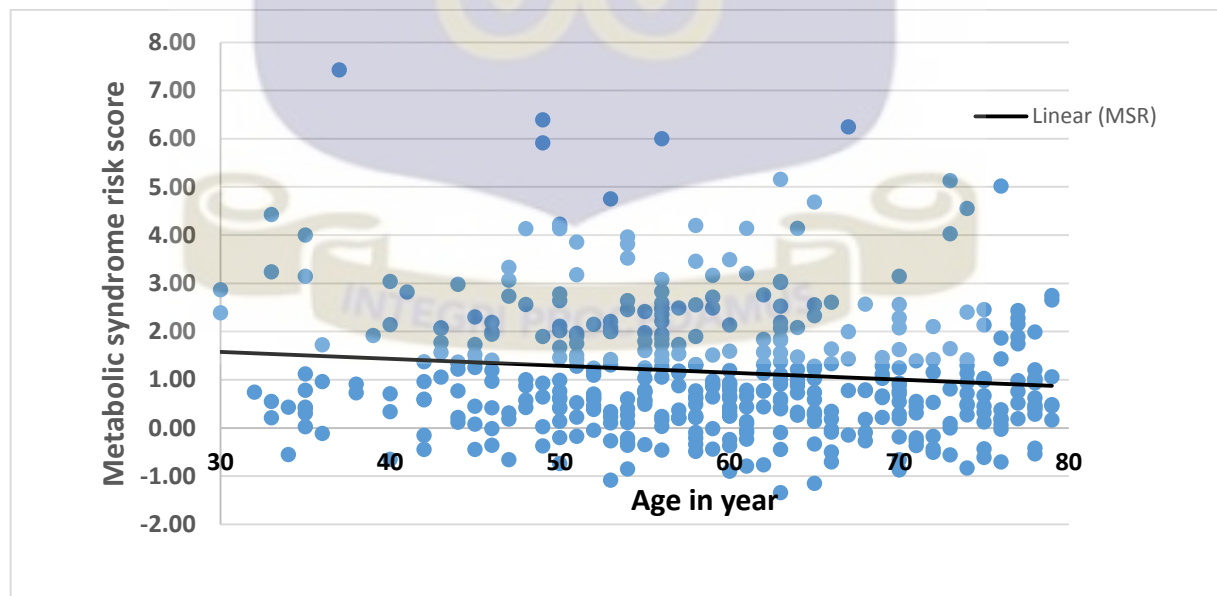
The percentile ranks of the MSR scores are indicated in Table 8. The table shows that 25% of participants had MSR scores below -0.24 while 75% of participants had scores below 1.85.

**Table 6: Mean physical and biochemical measurement of subjects with and without METs among people with T2DM in Dormaa and Berekum Municipals, June 2016**

Parameter	Total		Men		Women		<i>p</i> (men versus women)
	Mean±SD	<i>p</i>	Mean±SD	<i>p</i>	Mean±SD	<i>P</i>	
<b>Age (years)</b>		0.626		0.635		0.703	
No mets	59.14±11.50		59.96±10.96		58.08±12.17		0.395
Mets	58.71±11.50		60.70±11.89		57.6±11.18		0.024
Combined	58.84±11.49		60.39±11.46		57.71±11.40		0.015
<b>Duration of T2DM (years)</b>		<0.001		0.002		<0.001	
No mets	3.87 ± 2.89		4.09±2.12		3.63±3.65		0.011
Mets	5.94 ± 4.04		5.89±3.95		5.97±4.10		0.917
Combined	5.30 ± 3.84		5.12±3.42		5.41±4.11		0.973
<b>BMI (kg/m<sup>2</sup>)</b>		<0.001		<0.001		<0.001	
No mets	23.06 ± 3.60		23.92 ± 3.46		21.95 ± 3.51		0.001
Mets	26.99 ± 4.69		26.83 ± 4.24		27.08 ± 4.93		0.653
Combined	25.76 ± 4.74		25.60 ± 4.17		25.87 ± 5.11		0.573
<b>WC (cm)</b>		<0.001		<0.001		<0.001	
No mets	83.82±9.31		86.85±8.40		79.92±9.02		<0.001
Mets	94.83±10.50		95.49±9.92		94.46±10.82		0.423
Combined	91.37±11.34		91.86±10.23		91.02±12.11		0.447
<b>SBP (mm/Hg)</b>		<0.001		<0.001		<0.001	
No mets	123.40±15.61		124.30±18.47		122.24±10.95		0.883
Mets	138.94±20.42		141.94±19.68		137.28±20.68		0.046
Combined	134.06±20.35		134.54±21.02		133.72±19.87		0.674
<b>DBP(mm/Hg)</b>		<0.001		<0.001		<0.001	
No mets	77.30 ± 8.68		77.76 ± 9.36		76.71 ± 7.75		0.509
Mets	84.85 ± 10.75		85.53 ± 10.13		84.47 ± 11.08		0.396
Combined	82.48 ± 10.72		82.27 ± 10.51		82.63 ± 10.89		0.729
<b>TG(mg/dL)</b>		<0.001		0.001		<0.001	
No mets	107.60±31.17		109.32±33.41		105.38±28.15		0.67
Mets	149.52±58.36		139.99 ±56.32		154.79±58.94		0.041
Combined	136.36±54.92		127.12 ± 50.28		143.08±57.24		0.004
<b>HDL(mg/dL)</b>		<0.001		0.015		<0.001	
No mets	41.71 ± 16.00		37.05 ± 14.46		47.72 ± 16.00		0.001
Mets	33.20 ± 14.38		32.33 ± 15.36		33.68 ± 13.83		0.229
Combined	35.87 ± 15.41		34.31 ± 15.13		37.01 ± 15.54		0.061
<b>FBS(mg/dL)</b>		0.056		0.897		0.015	
No mets	134.71±58.22		139.81±64.89		128.14±48.06		0.31
Mets	139.46±52.31		132.72±45.49		143.19±55.49		0.135
Combined	137.97±54.22		135.69±54.43		139.62±54.11		0.385

**Table 7: Mean metabolic syndrome risk score by socio-demography characteristics of participants with T2DM in Dormaa and Berekum Municipal, June 2016**

Parameter	Mean	p-value
<b>MSR score (All)</b>	<b>1.16±1.32</b>	
<b>Sex</b>		0.060
Male	1.02 ±1.19	
Female	1.26 ±1.41	
<b>Distict</b>		0.672
Dormaa Municipal	1.14 ±1.27	
Berekum Municipal	1.19 ±1.40	
<b>Age group</b>		0.065
30-49	1.40 ±1.54	
50-79	1.10 ±1.26	
<b>Marital status</b>		0.617
Married	1.19 ±1.40	
Unmarried	1.12 ±1.18	
<b>Education</b>		0.046
Less than secondary education	1.12 ±1.30	
Secondary education or higher	1.53 ±1.43	
<b>Number of METs components</b>		<0.001
1-2 MetS components (METs absent)	0.64 ±1.27	
3-5 MetS component (METs present)	1.40 ±1.28	
<b>Overweight</b>		<0.001
Absent	0.78 ±1.27	
Present	1.50 ±1.28	



**Figure 5: Metabolic syndrome risk score by age of people with T2DM in Dormaa and Berekum Municipals, June 2016**

**Table 8: Percentile scores of metabolic syndrome risk score**

Percentile (%)	10	25	50	75	90
MSR	-0.24	0.28	0.89	1.85	2.80

#### 4.6.0 Risk factors for metabolic syndrome risk score

In Table 12, the potential effects of socio-demographic and lifestyle factors are individually modelled against MSR score to form a simple linear regression model. In this crude analysis, age, obesity status, duration of T2DM, family history of T2DM, being a trader and education produced  $\beta$ -coefficients values that were significantly associated with MSR score. In the multiple linear regression analysis, age, obesity, duration of T2DM and education attainment were observed to be independently associated with MSR score. Overweight remained the most significant risk factors of metabolic syndrome. As compared with non-overweight participants, MSR score was increased by 0.64 in overweight participants (95% CI: 0.06 - 0.89,  $p=0.026$ ). The multiple linear regression model explained only a modest proportion of the variability in MSR score due to the risk factors ( $R^2=13.4$ ).

Figure 5 the relationship between MSR scores and age in years is demonstrated in the scatter plot. The graph shows that this study found MSR score to decrease with increasing age. When age was regressed onto the MRS score, participants aged 60-69 and 70-79 years were found to be at reduced risk of METs compared with those aged 30-39 years. Estimated  $\beta$ -coefficient values were -0.65 for participants 60-69 years of age (95% CI: -1.24 to -0.07,  $p=0.029$ ) and -0.65 for those age 70-79 years (95% CI: -1.24- -0.05,  $p=0.034$ ).

Among participants who had attained at least secondary education, MSR score was 0.47 higher in them than in participants who had less than secondary education attainment or no formal education combined (95% CI: 0.06 - 0.89,  $p=0.026$ ). Having had T2DM for 5 years or more

years was linked to a higher MSR score of 0.41 than in those whose disease duration was less than 5 years. Table 13 summarises the output of the multiple linear regression model showing the independent association between potential risk factors and the continuous MSR score.

When the METs components were regressed on the MSR score (Table 14), diastolic blood pressure was not significantly associated with MSR ( $p=0.726$ ), however, WC, SBP, FBS, TG and HDL-cholesterol were all independently associated with the MSR score with  $p<0.001$ .



**Table 9: Simple logistic regression analysis of potential risk factors for METs among participants with T2DM in Dormaa and Bererekum Municipal, June 2016**

<b>Parameter</b>	<b>Crude OR</b>	<b>95% C.I.</b>	<b>p-value</b>
<b>Age (years)</b>			
30-39	1		
40-49	1.64	0.58 - 4.64	0.349
50-59	1.03	0.41 - 2.59	0.944
60-69	0.99	0.39 - 2.51	0.978
70-79	1.08	0.42 - 2.81	0.869
<b>Sex</b>			
Men	1		
Women	2.33	1.53 - 3.53	<0.001
<b>District</b>			
Berekum Municipal	1		
Dormaa Municipal	1.17	0.78 - 1.77	0.443
<b>Marital status</b>			
Married	1		
Unmarried	1.82	1.15 - 2.86	0.010
<b>Education</b>			
Less than secondary	1		
Secondary and higher	0.87	0.46 - 1.66	0.679
<b>Occupation</b>			
Farmers	1		
Traders	2.13	1.08 - 4.20	0.029
Office related	0.84	0.37 - 1.90	0.668
Unemployed/pensioner	0.92	0.51 - 1.62	0.770
Other	0.98	0.33 - 2.97	0.975
<b>Family history of T2DM</b>			
No	1		
Yes	1.24	0.793 - 1.924	0.351
<b>Duration of T2DM</b>			
Less than 5 years	1		
More than 5 Year	4.12	2.51 - 6.77	<0.001
<b>Obesity</b>			
Not overweight/obese	1		
Overweigh/obese	5.49	3.49 - 8.64	<0.001
<b>Physical activity</b>			
3 or more time/week	1		
Less than 3 times per week	1.45	0.87 - 2.41	0.154
<b>Vegetables</b>			
Daily	1		
Not daily	1.02	0.61 - 1.71	0.946
<b>Fruits</b>			
Not daily	1		
Daily	0.63	0.23 - 1.74	0.372
<b>Oil-cooked food</b>			
4-6 time/week	1		
Once/week or occasionally	1.201	1.11 - 3.13	0.523

**Table 10: Risk factors for the binary metabolic syndrome among study participants with T2DM in Dormaa and Berekum Municipal, June 2016****Pseudo  
R<sup>2</sup>=22.33**

Risk factor	Adjusted		
	OR	95% C.I.	<i>p</i> -value
<b>Sex</b>			
Men	1		
Women	2.15	1.29 - 3.58	0.003
<b>Duration of T2DM</b>			
Less than 5 years	1		
More than 5 years	5.20	2.90 - 9.31	<0.001
<b>Obesity</b>			
Normal/underweight	1		
Overweight	6.10	3.70 - 10.07	<0.001

**Table 11: Association between metabolic syndrome components and the binary metabolic syndrome**

Component	OR	95% CI	<i>P</i>	Pseudo R2
WC	1.12	1.09 - 1.16	<0.001	43.20%
SBP	1.06	1.03 - 1.08	<0.001	
DBP	1.04	1.00 - 1.08	0.052	
FBS	1.01	0.92 - 1.11	0.819	
TG	1.02	1.01 - 1.03	<0.001	
HDL	0.95	0.94 - 0.97	<0.001	

**Table 12: Simple linear regression analysis of potential risk factors for metabolic syndrome risk score among participants with T2DM in Dormaa and Bererekum Municipals, June 2016**

<b>Parameter</b>	<b><math>\beta</math>-coefficient</b>	<b>95% C.I.</b>	<b><i>p</i>-value</b>
<b>Age (years)</b>			
30-39	0.00		
40-49	-0.26	-0.88 - 0.37	0.420
50-59	-0.30	-0.87 - 0.27	0.307
60-69	-0.57	-1.15 - 0.11	0.055
70-79	-0.64	-1.23 - -0.05	0.034
<b>Sex</b>			
Men	0.00		
Women	0.24	-.001-0.49	0.060
<b>District</b>			
Berekum Municipal	0.00		0.672
Dormaa Municipal	-0.05	-0.31 - 0.20	0.617
<b>Marital status</b>			
Married	0.00		
Unmarried	-.07	-0.33 - 0.20	0.046
<b>Education</b>			
Less than secondary	0.00		
Secondary and higher	0.41	0.01 - 0.82	
<b>Occupation</b>			
Farmers	0.00		
Traders	0.45	0.09 - 0.81	0.015
Office related	0.50	-0.01 - 1.02	0.059
Unemployed/pensioner	-0.20	-0.56 - 0.15	0.262
Other	0.30	-0.65 - 0.71	0.930
<b>Family history of T2DM</b>			
No	0.00		
Yes	0.28	0.01 - 0.56	0.044
<b>Duration of T2DM</b>			
Less than 5 years	0.00		
5 year and above	0.34	0.08 - 0.59	0.010
<b>Obesity</b>			
Normal/underweight	0.00		
Overweight	0.71	0.47 - 0.95	<0.001
<b>Physical activity</b>			
Less than 3 times/week	0.00		
3 of more time/week	0.10	-0.20 - 0.40	0.525
<b>Vegetables</b>			
Not daily	0.00		
Daily	0.21	-0.10 - 0.53	0.185
<b>Fruits</b>			
Not daily	0.00		
Daily	-0.18	-0.75 - 0.39	0.545
<b>Oil-cooked food</b>			
4-6 time/week	0.00		
Once/week or occasionally	0.24	-0.11 - 0.60	0.182

**Table 13: Risk factors of MSR score for participants with T2DM in Dormaa and Bererekum Municipal, June 2016**

Parameter	$\beta$ -coefficient	95% C.I.	<i>p</i> -value	R <sup>2</sup> =13.4
<b>Age (year)</b>				
30-39	0.00			
40-49	-0.36	-0.96-0.25	0.245	
50-59	-0.40	-0.96-0.16	0.159	
60-69	-0.65	-1.24- -0.07	0.029	
70-79	-0.65	-1.24- -0.05	0.034	
<b>Education attainment</b>				
Less than secondary	0.00			
Secondary and higher	0.47	0.06 - 0.89	0.026	
<b>Obesity</b>				
Normal/underweight	0.00			
Overweight	0.64	0.39 - 0.89	<0.001	
<b>Duration of T2DM</b>				
Less than 5 years	0.00			
More than 5 years	0.41	0.15 - 0.68	0.003	

**Table 14: Association between metabolic syndrome components and the metabolic syndrome risk score**

Component	$\beta$ -coefficient	95% CI	<i>P</i>	R <sup>2</sup> = 99%
WC	0.027	0.025 - 0.028	<0.001	
SBP	0.047	0.004 - 0.006	<0.001	
DBP	0.0003	-.0001 - 0.002	0.726	
FBS	0.387	0.380 - 0.390	<0.001	
TG	0.004	0.003 - 0.004	<0.001	
HDL	-0.013	-.0013 - -0.012	<0.001	

## CHAPTER FIVE

### 5.0 Discussion

Despite controversies regarding the utility of diagnosing the METs (Richard Kahn, 2008), the global epidemic of the METs makes it a critical public health problem (Grundy, 2008). There are projections of a worldwide increase in the prevalence of the condition with developing countries likely to be most affected (Alberti et al., 2006). Furthermore, the METs is a significant risk for many cardiovascular diseases including myocardial infarction, angina and stroke (Mottillo et al., 2010; Gami et al., 2007). This study was therefore necessary to contribute to existing knowledge about the condition in Ghana.

This study was probably one of the few attempts yet at assessing the risk factors of the METs measured as a dichotomous outcome and as a continuous MSR score in the same sample of T2DM participants. Most studies in Ghana used the WHO, IDF or NCEP:ATP III definitions. In this study the harmonised criteria was used and METs was defined as the presence of at least any three abnormal METs components. In this regard, participants were categorised into METs present and METs absent. In another procedure, continuous MSR scores were computed using the Gurka et al. (2014) equation. The 430 participants studied here is probably the largest sample of people with T2DM ever assessed for METs in Ghana.

The findings of this present study indicate that METs is a common occurrence among people with T2DM in the municipal hospitals at Dormaa Ahenkro and Berekum respectively. Unlike in the other studies conducted in Ghana, the prevalence of METs in this study was higher than in most of the studies conducted in Ghana. The Nsiah et al., (2015) study, conducted at the Komfo Anokye Teaching Hospital in Kumasi using the NCEP:ATP III definition reported METs prevalence of 58.0% among 150 participants with T2DM. The study design was also

cross-sectional. In a similar study at the Tamale Teaching Hospital, Mogre et al., (2014) recruited 200 participants, used IDF definition and observed METs prevalence in 24.0% of participants, while Titty (2010) conducted a prospective study, recruited 240 participants and used the NCEP: APT III definition and found the syndrome in 43.3% of T2DM subjects. The variability in METs prevalence rates in these studies compared with the current study could be due to the different METs definitions, sample sizes and study designs used. Further, the Mogre et al., (2014) study did not include triglycerides and HDL-cholesterol in the assessment, consequently they recorded the lowest prevalence estimates.

The results of the present study were also inconsistent with some studies outside Ghana. In one study in northern Nigeria for instance, Isezuo & Ezunu (2005) reported 59.0% METs prevalence among 254 participants with T2DM at a University teaching hospital. In South Africa, using the IDF definition, METs prevalence rates of 46.5% and 74.1% were reported among African and white patients with T2DM respectively (Kalk & Joffe, 2008). Besides the variable definitions, ethnic difference could have accounted for the different findings obtained from these studies.

However, the findings of this study could be related to one study among people with T2DM in Cameroon where the prevalence of the METs was 71.7% defined by the IDF criterion, but dissimilar when compared with the NCEP-ATP III definition (60.4%) in the same study (Kengne, Limen, Sobngwi, Djouogo, & Nouedoui, 2012). Similar results were also found in a study at a University Hospital in Ibadan, Nigeria where the prevalence of METs classified by the IDF definition was 66.0% among 340 participants with T2DM (Ipadeola & Adeleye, 2015).

Studies of METs among people with T2DM using the harmonized definition are limited. Probably the results that best mirror the findings of the present study relates to an Indian study

that used the harmonized definition and found METs prevalence to be 71.9% among 1522 participants with T2DM (Bhatti, Bhadada, Vijayvergiya, Mastana, & Bhatti, 2015).

On the associated risk factors of METs, age was not observed to be directly associated with the binary METs and the continuous MRS score in this study. Although increasing age has been linked to many metabolic abnormalities, the influence of age was not directly related to the METs. Many studies have overwhelmingly linked METs to the aging process (Yousefzadeh & Sheikvatan, 2013; Guarner-Lans, Rubio-Ruiz, Pérez-Torres, & Baños de MacCarthy, 2011). Using data from the USA NHANES, Gurka et al. (2014) observed increasing age to be associated with increasing MSR score. However, this current study along with the Mogre et al. (2014) study did not associated age to METs. The North Indian Diabetes and Cardiovascular Disease Research (NIDCR) study that mirrors the findings of this study in many respects did not also observe a direct relation between increasing age and METs (Bhatti et al., 2016). It is unclear the obvious lack of positive association between age and METs. However, it is important to note that, like in the NIDCR study, the prevalence of METs in this present study rose sharply from the 30-49 age group, peaking among those aged 50-59 before declining.

On the influence of sex on the METs, this present study found that women were more likely to be diagnosed with METs than men using the traditional harmonised definition, which categorises METs as a binary outcome. These findings were consistent with several studies conducted in Ghana (Mogre et al., 2014; Titty, 2010; Nsiah et al., 2015) and other parts of Africa (Ipadeola & Adeleye, 2015; Kalk & Joffe, 2008). Similar results have been reported in Iran (Janghorbani & Amini, 2012) and in the NIDCR (Bhatti et al., 2015). However, one study conducted in India observed that the prevalence of METs was higher in men than in women (Hathur, Basavegowda, Kulkarni, & Ashok, 2015). The higher prevalence of METs among

women than in men, in this present study, could be because more women than men were overweight. Several studies have linked obesity and waist circumference to METs (Singla et al., 2010; Després & Lemieux, 2006; Goodpaster et al., 2005). It has also been suggested that hormonal changes in adulthood may influence differential clustering of metabolic factors in men and women (Kuk & Ardern, 2010). Another suggestion is that because of the influence of genetic backgrounds, diet, level of physical activity, and levels of under or over-nutrition, METs is bound to differ between sexes (Pradhan, 2014). However, sex was not a risk factor of METs when regressed on the continuous MRS score.

Another important finding of this study is that duration of T2DM had a positive independent and significant association with the binary METs ( $p < 0.001$ ) and the continuous MSR score ( $P = 0.003$ ). Mogre et al. (2014) made a similar observation (though crude association) and attributed it to the lack of awareness and inadequate health care for people with T2DM. However, some studies in more developed countries than Ghana, made observations contrary to this current finding (Shimajiri et al., 2008; Novel et al., 2002). The authors attributed the decreased METs prevalence following increased diabetes duration to decreased BMI brought about by improved medical care and improved metabolic control. In this present study, the positive association between duration of T2DM and METs could be due to poor metabolic control due to increased WC and poor glycaemic control.

This study also observed overweight to have a significant positive association with both the binary METs and the continuous MSR score. This observation was also not surprising since obesity is a known predictor of the METs (Singla et al., 2010; Després & Lemieux, 2006).

Educational attainment was also observed to be significantly associated with the continuous METs score but not with the binary METs. However, contrary to expectations, those who had

secondary or higher education were more likely to have higher MSR scores than those with less than secondary or no formal education. It is unclear the reasons for this finding, but it could be attributed to unhealthy behaviours of the more educated once. In the Bhatti et al. (2016) study education was not also associated with METs among people with T2DM.

Analyses of the METs components showed different rates. Were we to consider the effect of raised FBS, then FBS would have emerged as the most predominant component in this study. However, this study ignored the effect of raised FBS considering that all participants had T2DM and elevated FBS levels are not unexpected among people with T2DM especially in situations of uncontrolled diabetes. Therefore, in this study the prevalence of reduced HDL-cholesterol levels was considered the commonest component. Although the Mogre et al. (2014) and Ogbera (2010) studies reported WC, while the Nsiah et al. (2015) study reported hypertension as the most predominant components, reduced HDL-cholesterol was reported among the three most predominant components in people with T2DM in the three studies in Ghana. Other studies among people with T2DM have reported reduced HDL-cholesterol as among the top three most prevalent components (Alshkri & Elmehdawi, 2008; Isezuo & Ezunu, 2005). It is unclear the reasons for the high prevalence of participants with reduced HDL-cholesterol in this study; however, it could be a consequence of the high levels of participants with raised FBS. In one review, Eckel et al. (2005) suggested that people with elevated FBS levels may also present with reduced HDL-cholesterol.

Another predictive component for the high prevalence of METs in this study was WC. This observation was not unexpected considering that obesity has strong links with METs (Singla et al., 2010; Després & Lemieux, 2006; Goodpaster et al., 2005). Other studies have also reported WC as among the three most predominant components (Ogbera, 2010; Mogre et al., 2014; Kelliny

et al., 2008). However, it seems that in non-obese subjects, WC may not be observed among the three most predominant components. Reference is made to one study among non-obese individuals with T2DM where elevated serum triglyceride for men and low serum HDL-cholesterol in women were the strongest predictors of METs (Dhanaraj et al., 2008).

This study also observed raised SBP as among the three commonest METs components. This finding mirrors those of many other studies (Nsiah et al., 2015; Alebiosu & Odusan, 2004; Bhatti, Bhadada, Vijayvergiya, Mastana, & Bhatti, 2016). The occurrence of SBP as one of the most frequent components in this study was not unexpected. Insulin resistance, hyperglycaemia, abnormal renal sodium functioning and raised blood pressure are known risk factor that coexist in people with T2DM (Redon et al., 2008; Cheung & Li, 2012).

### **Limitations**

Being a cross-sectional study, this study was unable to establish temporal associations between the explanatory factors and the occurrence of METs. However, it is safe to note that although sex and family history of diabetes do not change over time, it not possible to establish the exclusive effect of sex and family history on METs using the methodology.

Secondly, considering that participants were selected from clinic-based attendants, the findings of the present study might be unrepresentative of all people with T2DM. Thus this study may fail to reflect the burden of METs in the wider community where the true prevalence estimates lie. Nonetheless, the burden of METs in this present study reflects the problem faced by the health care system in the area.

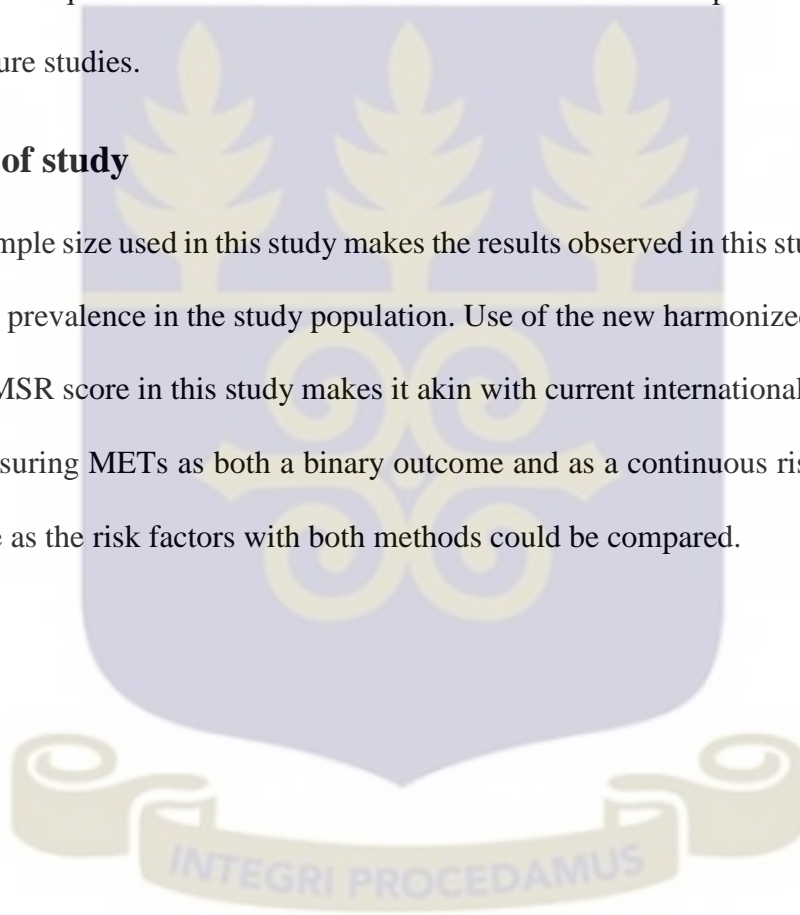
Given that various methods have been used in different studies to assess METs prevalence in different populations, making comparison from this study to other studies should be done with reference to the setting and definition used. Although, the T2DM status of participants was

confirmed with the hospital records before inclusion in the current study, such information may only reflect the local diagnosing pattern.

Finally, this study was unable to collect information on exact quantities of various foods consumed per day. Information on the amount of time spent on physical activity per day was also not collected. These lifestyle factors are important predictors of METs and detailed information is required to draw accurate conclusions on their independent associations with METs in future studies.

### **Strengths of study**

The large sample size used in this study makes the results observed in this study a good estimate of the METs prevalence in the study population. Use of the new harmonized definition and the continuous MSR score in this study makes it akin with current international recommendations. Finally, measuring METs as both a binary outcome and as a continuous risk score makes this study unique as the risk factors with both methods could be compared.



## CHAPTER SIX

### 6.0 Conclusion

The findings of this study show that, using the harmonized definition, METs is highly prevalent among people with T2DM who attend diabetes clinics at Dormaa and Berekum municipalities. The results of the current study have important implications for public health work. This results of this study supports the finding of many studies conducted in Ghana, which found that the clustering of METs components was more prevalent in women than in men. This study also confirms the known effect of obesity on the METs prevalence. Furthermore, the effect of duration of diabetes on METs was evaluated and found to be significantly related to METs. Like in the majority of studies conduct in Ghana, this present study also found that, excluding FBS, the three most frequent metabolic syndrome components among people with T2DM were HDL-cholesterol, followed by waist circumference and elevated SBP. This result suggests the need for targeted interventions to control these three most predominant components of the METs.

Compared with the binary metabolic syndrome, four risk factors were found to be independently associated with the continuous MSR score, whereas three risk factors were independently associated with binary METs. Age (70-80 years old compared with those aged 30-39 years old), educational attainment, obesity and duration of T2DM independently associated with MSR score. Sex, duration T2DM and obesity were independently associated with the binary METs. Two of the risk factors (obesity and duration of T2DM) were common between the two outcome variables. Age and education were independently associated with the MSR score, but not the binary METs. It is surprising that this study found age to be negatively associated with the MSR score, but duration of diabetes was positively associated with the MSR

score. Further research is needed to determine whether increasing duration of diabetes rather than increasing age is positively linked to the MSR score. Despite the fact that increasing age is known to be directly linked to METs and low educational attainment is known to increase the risk of METs, the contrary findings in this study should be treated with caution. It is also noteworthy that the clustering of the METs components may be influenced by the population dynamics such as physical activity levels and types of foods consumed (Pradhan, 2014).

Use of the MRS score may produce different results compared with the traditional binary METs outcome. This finding has implications for public health research when deciding which method produces the most reliable estimates of risk factors of METs. The MSR score is a good measure for tracking the disease progression of an individual (Gurka et al., 2014) and its interpreting might be suitable for epidemiological studies. However, the lack of cut-off point for deciding who has METs makes its clinical application and use in public health decision making challenging.

## **6.1 Recommendations**

Considering the high prevalence of METs in this study, hospital authorities must develop a protocol that includes the routine identification of the METs in people with T2DM. Priority should be placed on testing for the most predominant components identified in this study. There is also the need for hospitals to set-up diabetes management teams to ensure close monitoring and treatment of emerging metabolic factors among people with T2DM.

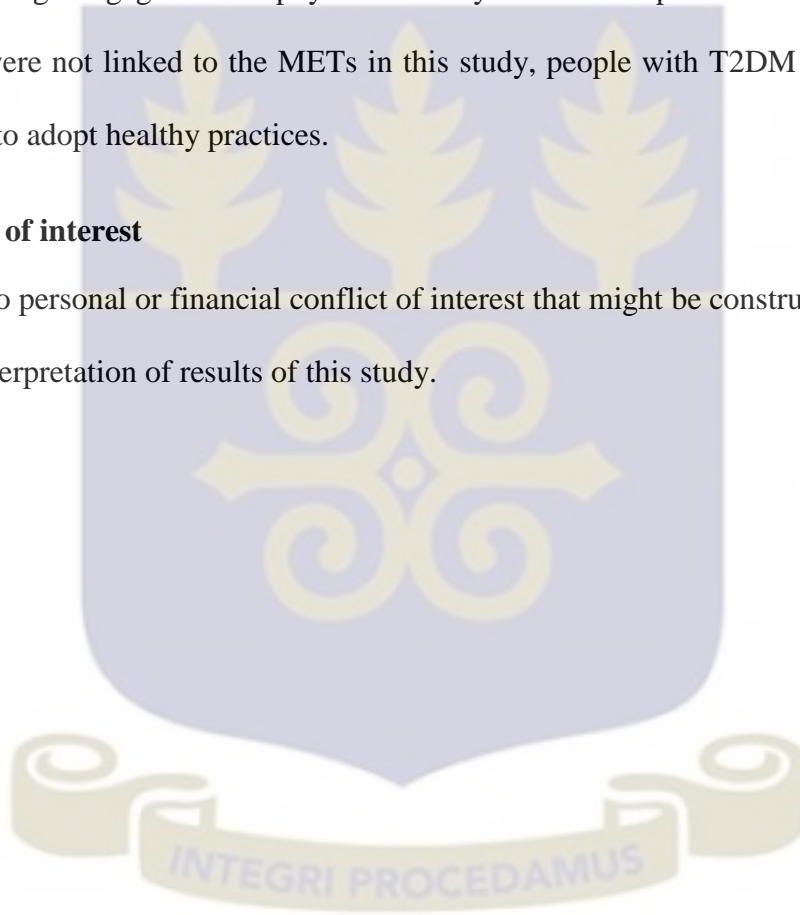
Additionally, the Ministry of Health together with Ghana Health Service ought to adopt a standard definition or approach for assessing METs in epidemiological studies. This will ensure that studies on METs in different studies can be compared. However, in clinical settings where

a person's risk of METs is to be monitored over time, we recommend that the MSR score should be used.

More controlled studies are required to investigate why increasing age relates to a reduced likelihood of having METs among people with T2DM in this population. Further studies are also required to investigate the association between lifestyle patterns and METs among people with T2DM. Although engagement in physical activity and consumption of fruits, vegetables and oily foods were not linked to the METs in this study, people with T2DM should strongly be encouraged to adopt healthy practices.

## **6.2 Conflict of interest**

There was no personal or financial conflict of interest that might be construed to influence the results or interpretation of results of this study.



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## APPENDICES

### Appendix I: Questionnaires

UNIVERSITY OF GHANA  
SCHOOL OF PUBLIC HEALTH  
EPIDEMIOLOGY AND DISEASE CONTROL DEPARTMENT

#### INTERVIEW SCHEDULE FOR PEOPLE WITH TYPE 2 DIABETES

Greetings, my name is..... I am a member of a team from the University of Ghana conducting a research on metabolic syndrome among type 2 diabetes patients in Dormaa and Berekum. I will like to ask you questions regarding your condition and your lifestyle as part of the research. If you agree to take part in this study, I will read and explain the questions to you and your response will be recorded by me.

Your participation is voluntary and any responses you give including your laboratory results will be confidential and will not be shared with anyone other than members of the study team. Any information obtained from you is entirely for the purpose of this study and would not be used for any other reason. The results of this research could be used to improve the services given to people with diabetes.

**Principal investigator: Tim Agandah Abagre (0200185095)**

#### Identification information

Participant number: .....

Questionnaire number: ..... Date: .....

Name of interviewer: .....

#### A. Socio-demographic Characteristics

1. Sex: Female  Male . If female, are you pregnant Yes  No
2. Age: .....
3. Educational background:
  - a. None
  - b. Primary
  - c. JHS
  - d. SHS
  - e. Tertiary
  - f. Other, please specify.....
4. Religious affiliation
  - a. Christianity
  - b. Islamic
  - c. Traditional
  - d. Other .....
5. Marital Status
  - a. Never married
  - b. Married
  - c. Divorced
  - d. Separated
  - e. Widow/er
6. Do you live with other family members in the same household? Yes  No .
7. If **YES**, are they aware of your condition? Yes  No .
8. Place of birth ..... Region .....
9. Current occupation .....
10. Ethnicity .....

**Medical history**

11. Do you have type 2 diabetes or have ever been told you have type 2 diabetes? Yes [ ]  
No [ ]
- Confirmed with medical records: patient has diabetes? Yes [ ] No [ ]
12. How long have you had diabetes for? 0 [ ], 1 - 4 years [ ] more than 5 years [ ]
13. What is the current treatment for your diabetes?
- a. [ ] Metformin
  - b. [ ] Glibenclamide/Daonil
  - c. [ ] Metformin + Glibenclamide/ Daonil
  - d. [ ] Gliclazide
  - e. [ ] Insulin
  - f. [ ] Insulin + OHA
  - g. Confirmed from medical records Yes [ ] No [ ]
14. How long have you been on the current treatment.....years.....months
15. Is there any one in your family who has or has ever suffered from any of the following:
- a. Diabetes [ ] relation to you .....(e.g uncle, sister)
  - b. Hypertension [ ] relation to you .....
  - c. Heat attack [ ] relation to you .....
  - d. Stroke [ ] relation to you .....
  - e. Obesity [ ] relation to you .....

**Blood pressure**

16. Blood pressure reading:
- a. First reading: Systolic.....mmHg. Diastolic.....mmHg
  - b. Second reading: Systolic.....mmHg. Diastolic.....mmHg

**Anthropometric measurements**

17. Weight.....kg Height.....cm
18. Waist circumference.....cm

**PHYSICAL ACTIVITY**

**PLEASE PUT A TICK (✓) ON EVERY LINE**

19. Physical activity	Indicate how frequently you engaged in that activity		
	Never or less than once per month/occasionally	3 or more times/week	Less than 3 times/week
Type physical activity engaged in			
Use of gymnasium			
Cycling			
Running/Jogging			
Walking			
Stretching			
Other: .....			

**YOUR DIET OVER THE LAST ONE YEAR**

Please put a tick in the box to indicate how often, **on average**, you have eaten the specified type of food during the past year. Please **estimate your average food as best as you can, and answer every question - do not leave any lines blank.**

20. Foods and amounts	Average use last year			
	<4 times per month	2-3 times per week	4-6 times per week	Daily
<b>Meat and Fish and Eggs</b>				
Beef: roast, soup, stew, kebab				
Lamb: roast, soup, stew, kebab				
Chicken or other poultry (e.g turkey)				
Sausage				
Khebab (any type <b>except sausage</b> )				
Fried fish: any fried fish				
Smoked fish: in soup, stew				
Fish: roast, grilled				
Fish: fresh, canned (e.g sardines, herrings, tuna, mackerel, salmon)				
Eggs: fried, boiled, scrambled (2 eggs = 2 times per day)				



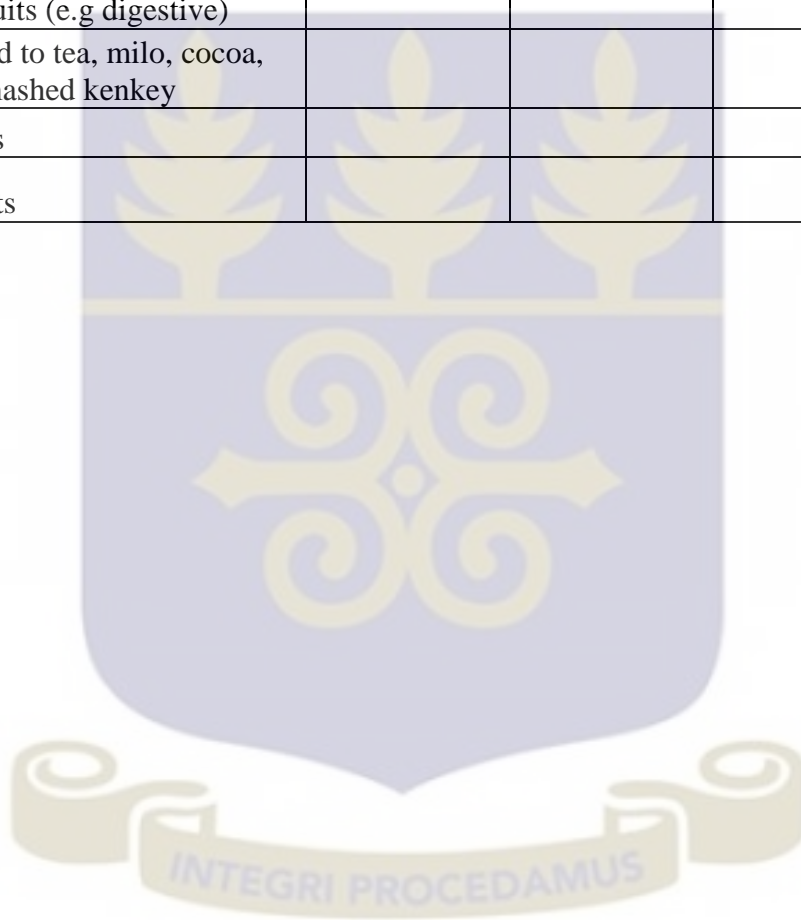
**PLEASE PUT A TICK (✓) ON EVERY LINE**

<b>21. Foods and amounts</b>	Average use last year			
<b>Bread and savoury biscuits</b>	<4 times per month	2-3 times per week	4-6 times per week	Daily
Tea bread				
Wheat bread				
Butter bread				
Sugar bread				
<b>Cereals and porridge</b>				
Cornflakes				
Oats porridge				
Wheat porridge				
Rice water				
Moli/Hausa coco				

<b>PLEASE PUT A TICK (✓) ON EVERY LINE</b>				
<b>22. Foods and amounts</b>	Average use last year			
<b>Grains, Pasta</b>	<4 times per month	2-3 times per week	4-6 times per week	Daily
Polished rice				
Brown (unpolished) rice				
<b>Corn and corn products</b>				
Banku				
Kenkey (Fanti or Ga)				
TZ				
<b>PLEASE PUT A TICK (✓) ON EVERY LINE</b>				
<b>23. Foods and amounts</b>	Average use last year			
<b>The following on bread</b>	<4 times per month	2-3 times per week	4-6 times per week	Daily
Margarine/Butter				
Groundnut paste				

**PLEASE PUT A TICK (✓) ON EVERY LINE**

24. Foods and amounts	Average use last year			
	<4 times per month	2-3 times per week	4-6 times per week	Daily
<b>Sweets, snacks and pastries</b>				
Doughnuts (puff loaf)				
Pie: any type of pie				
Cakes				
Sweet biscuits (e.g digestive)				
Sugar added to tea, milo, cocoa, porridge, mashed kenkey				
Groundnuts				
Cashew nuts				



<b>PLEASE PUT A TICK (✓) ON EVERY LINE</b>				
<b>25. Foods and amounts</b>	<b>Average use last year</b>			
	<4 times per month	2-3 times per week	4-6 times per week	Daily
Drinks				
Tea				
Coffee				
Cocoa, cold/hot chocolate (e.g milo, milo drink)				
Palm wine				
Beer/Guinness				
Spirits (e.g. gin, schnappes, akpetsetsie)				
Soft drinks (e.g. coca cola, fanta, lemonade, alvaro, malt)				
Fruit juice				
Syrups and Sobolo				

<b>PLEASE PUT A TICK (✓) ON EVERY LINE</b>				
<b>26. Foods and amounts</b>	<b>Average use last year</b>			
<b>Seasonal fruits</b>	Never or less than 4 times per month	2-3 times per week	4-6 times per week	Daily
Apple (1 fruit)				
Orange (1 fruit)				
Mango (1 fruit)				
Banana (1 fruit)				
Water melon (1 slice)				
Pineapple (1 slice)				

<b>PLEASE PUT A TICK (✓) ON EVERY LINE</b>				
<b>27. Seasonal vegetables</b>	Never or less than 4 times per month	2-3 times per week	4-6 times per week	Daily
Carrots				
Okro: Fresh/dried in soup/stew				
Nkontomire (in soup or stew)				
Mushrooms				
Cabbage				
Lettuce				
Cucumbers				
Avocado				
Corn: roast, boiled				
Beans in beans stew of waakyei				
Groundnut soup				
Palmnut soup				
Garden eggs in soup or stew				
Tomatoes ( <b>fresh</b> ) in soup, stew or eaten in salad				
Tomatoes: Tinned, Puree, Paste in soup or stew				

<b>28. Roots, tubers and starches in fufu, ampesi, roast and fried</b>	Never or less than once per month	1-3 per month	Once per week	2-4 per week
Yam				
Cocoa yam				
Cassava				
Plantain				
Fufu				
<b>23. Fried or oily foods</b>				
Fried food of any type (e.g. fried yam, plantain, meat, doughnuts, fried egg)				
Oily stew of any type (e.g. vegetable stew, tomato stew, beans stew)				

**University of Ghana**

**School of Public Health**

**Epidemiology and Disease Control Department**

**Investigator: Tim Agandah Abagre (0200185094)**

**Study participant laboratory form**

Participant number: .....

Questionnaire No.: ..... Date .....

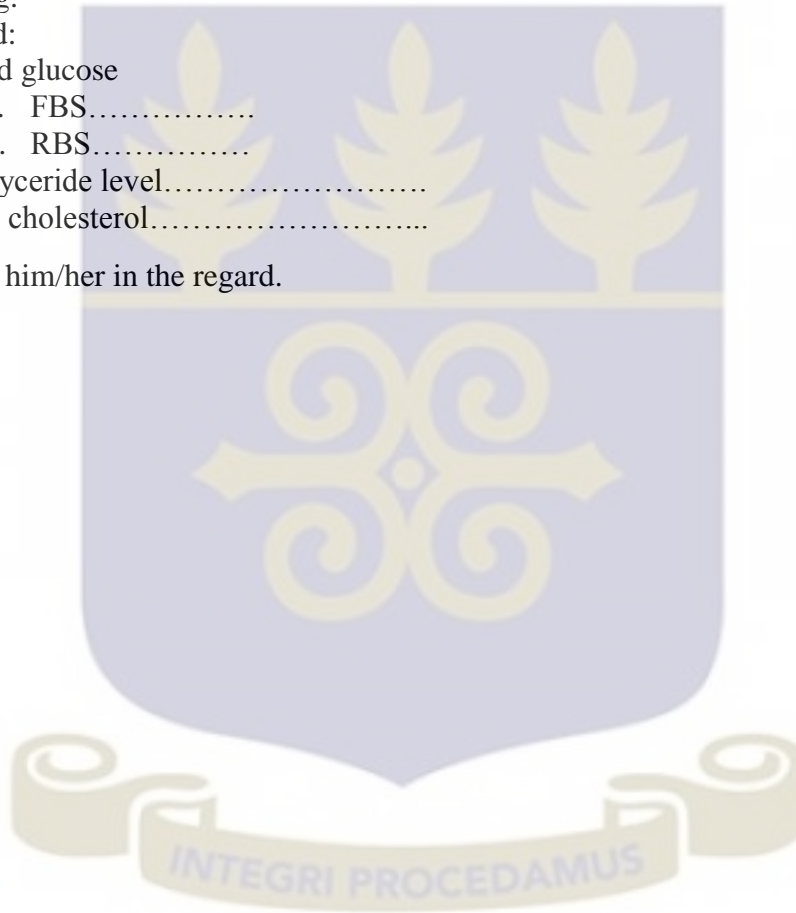
The bearer of this form is participating in a study on metabolic syndrome among people with type 2 diabetes. He/she has consented to having his/her blood sample taken and analysed for the following:

Test required:

1. Blood glucose
  - a. FBS.....
  - b. RBS.....
2. Triglyceride level.....
3. HDL cholesterol.....

Please assist him/her in the regard.

Thank you.



## **Appendix II: Participant information leaflet**

### **Project Title:**

**METABOLIC SYNDROME AMONG PEOPLE WITH TYPE 2 DIABETES IN TWO SELECTED HOSPITALS IN THE BRONG AHAFO REGION**

### **Name and address of Principal Investigator:**

Timothy Agandah Abagre, Department of Epidemiology and Disease Control, School of Public Health, College of Health Sciences, University of Ghana. Legon. Accra.

Or

Dormaa Municipal Health Directorate, Post Office Box 343, Dormaa Ahenkro, Brong Ahafo Region, E-mail address: [timoagandah@yahoo.com](mailto:timoagandah@yahoo.com), Mobile: 0200185094

### **Introduction**

I am a student from the University of Ghana conducting a research on the risk factors associated with metabolic syndrome among type 2 diabetes patients. Kindly spend some time to answer this questionnaire with me. All information will be treated as confidential and no one will be able to trace any information back to you. If you consent to participating in this study, in addition to your routine blood glucose tests, your blood sample would also be analysed for the levels of triglyceride and high density lipoproteins when you go to the laboratory.

### **Purpose of the study**

The purpose of this study is to collect data to assess the burden of metabolic syndrome among people with type 2 diabetes and also to identify the predominant component(s) driving the metabolic syndrome prevalence. The results of this work, when disseminated, could be used to improve the kind of medical care given to type 2 diabetes patients as well as to make decisions on the need for active diagnosing and treatment of the syndrome among type 2 diabetes patients.

### **Selection of participants**

The study is targeted at people with type 2 diabetes. Selection of participants is by random sampling and voluntary participation. Participants would be asked to complete a questionnaire that would be returned to the principal investigator.

### **Risks and benefits**

You may feel uncomfortable with some of the questions however; they are for the purpose of the research and may help give a better understanding of the prevalence and risk factors associated with metabolic syndrome so that improvements can be made on how type 2 diabetes patients are given care at the clinics.

### **Right to refuse**

Your consent to participate in this study is voluntary. You are under no obligation to participate and you may withdraw from the study at any point. However, your participation would be most appreciated.

### **Anonymity and confidentiality**

Any information given will be used purely for the purpose of this research and would be treated with the utmost confidentiality. Your name would not be used in the study however; your ideas and suggestions may help in future research and in the design of interventions for the prevention of metabolic syndrome among type 2 diabetes patients.

### **Your rights as a participant**

This research has been reviewed and approved by the Ethical Review Committee of the Ghana Health Service. If you have any questions about your rights as a research participant you may contact the Ethical Review Committee on 0507041223 and speak to Ms Hannah Frimpong. You may stop me at any point during the interview to ask questions about the research or seek further clarification if you do not understand a question.

### **Laboratory tests**

As part of the study you would also be requested have your blood sample tested for the levels of blood glucose, triglycerides and high density lipoproteins. These tests would be carried out as part of your routine laboratory test so that you would not have to have your blood sample taken twice. The procedure they would use to collect the blood sample would be the same as before and the results would only be used for the purpose of this study. The blood sample would be discarded appropriately once accurate results have been obtained from the tests.

Be reminded that you would not be required to pay for the cost of the laboratory test.

**Compensation issues**

You will not be given any financial compensation however; your participation would be most appreciated.

**Reporting concerns**

If at any time during or after participating in this study you have questions or concerns you may contact the researcher, using the contact information on this consent form.

**Appendix III: Consent form**

**Voluntary agreement form for patients**

I have read the information on this study/research or have had it translated into a language I understand. I have also talked it over with the interviewer to my satisfaction.

I understand that my participation is voluntary (not compulsory).

I know enough about the purpose, methods, risks, laboratory tests involved and benefits of the research study to decide that I want to take part in it.

I understand that I may freely stop being part of this study at any time without having to explain myself.

I have received a copy of the information leaflet and consent form to keep for myself.

NAME: \_\_\_\_\_

DATE: \_\_\_\_\_ SIGNATURE/THUMB PRINT: \_\_\_\_\_

**Statement of person witnessing voluntary agreement form (For non-literate participants):**

I \_\_\_\_\_ (Name of Witness) do hereby certify that the information given to \_\_\_\_\_ (Name of Participant), in the local language, is a true reflection of what I have read from the study Participant Information Leaflet, attached.

WITNESS' SIGNATURE (maintain if participant is non-literate):

\_\_\_\_\_

**Interviewer's statement**

I have fully explained this research to \_\_\_\_\_ and have given sufficient information about the study, including that on procedures, risks and benefits, to enable the prospective participant make an informed decision to or not to participate.

DATE: \_\_\_\_\_ NAME: \_\_\_\_\_

