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DIET QUALITY AND CARDIOVASCULAR DISEASE RISK FACTORS AMONG PEOPLE LIVING WITH HIV

BY:

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DECLARATION

I verify that this thesis is the product of my original independent research work and it has not been submitted in whole or in part for any degree. The thesis has been produced through the supervision of Prof. Amos Laar, Prof. Kwasi Torpey, and Dr. Agnes Kotoh. I also certify that the thesis has been written by me and any help received in writing this thesis, and all resources used in this thesis have been acknowledged.

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ABSTRACT

Introduction: With improved life expectancy, people living with HIV (PLHIV) are burdened with cardiovascular diseases (CVD) as a result of prolonged exposure to the traditional risk factors for CVD (smoking, obesity, alcohol, and sedentary lifestyle), and complications associated with HIV infection such as inflammation, endothelial dysfunction, hyper-coagulation, and immune activation. The role of diet and prolonged use of antiretroviral medications (ARVs) in CVD is also well established. Interactions between dietary habits, HIV infection itself, and ART may escalate the risk of developing CVDs among PLHIV. These complex relationships between HIV, diet, and CVD risk factors among PLHIV is yet to be comprehensively studied in Ghana.

Aim: To assess diet quality and cardiovascular disease risk factors among ARV-exposed PLHIV.

Methodology: A multi-methods study was conducted; a systematic review and meta-analysis, and a facility-based analytical cross-sectional design study. The systematic review and meta-analysis preceded the facility-based analytical cross-sectional study. Cochrane Central, Scopus, PubMed, and Google Scholar databases were systemically searched for papers that compared prevalence of CVD risk factors (diabetes, hypertension, dyslipidemia, and obesity) between PLHIV on ART and PLHIV who are ART-naive in low and middle-income countries (LMIC). Papers that satisfied the inclusion criteria were included in the meta-analysis. Pooled estimates for prevalence were generated using random fixed effects models.

The cross-sectional study was conducted among 440 adults living with HIV randomly selected from two hospitals - St. Martins De Porres Hospital and Atua Government Hospital - providing specialized HIV care in the Lower Manya Krobo Municipality of the Eastern Region, Ghana.

Medline, Cochrane, A structured questionnaire was administered to collect data on socio-demographic information, and lifestyle factors. Dietary intake of participants was measured with a two-day 24-hour recall of their usual food intake (one weekday and one weekend). Individual Dietary Diversity Score (IDDS) was used to measure diet quality of the participants. Height was measured with a stadiometer calibrated to 1.0 cm. Omron Body Composition Monitor and Scale (Model HBF-516) was used to determine weight, Body Mass Index (BMI), percentage muscle mass, percentage body fat, and visceral fat of the participants. Three measurements of participants' blood pressure were taken at a minute's interval in the right arm with participants sitting upright using the Omron HEM 907 oscillometric monitor (Matsusaka, Japan).

Lipid Profile and blood glucose were checked using *LipidPlus* Lipid Profile and Glucose Monitoring System and Blood glucose with *OneTouch Select* glucometer respectively. Mean and standard deviations of continuous variables were determined. Frequencies and percentages were used to describe categorical variables. Univariate, bivariate, and multivariate analyses were conducted using Chi-square test, independent Student's t-test, binary logistic regression, and ordinal logistic regression. Statistical significance was set at $p < 0.05$. Data analyses were conducted using SPSS for windows version 20, and Microsoft Excel 2016.

Results: Results from the systematic review and meta-analysis showed an association between ART intake and prevalence of hypertension, dyslipidemia, and obesity among PLHIV ($p<0.01$ for all). Results from the cross-sectional study showed that proportion of PLHIV with high IDDS (diet quality) was about 14 percent, proportion of those having diet needing improvement was 56 percent, whiles about 30 percent actually had low IDDS (poor diet). Prevalence of cardiovascular risk factors including diabetes, hypertension, and dyslipidemia were found to 20.1%, 33.3%, and 63.5% respectively. The average IDDS (diet quality) was significantly higher among PLHIV who

were hypertensive as compared to PLHIV who were not hypertensive. About 1.4 percent of the participants had high risk of developing CVDs over the next 10 years, 13 percent had intermediate risk, whilst about 86 percent of participants were in the low-risk category of developing CVD over the next 10 years.

Conclusion: In conclusion, HIV/AIDS patients should benefit from systematic CVD screening for CVD risk factors alongside their regular counselling and care services. The findings of this study suggest that PLHIV largely have poor diet quality and a very high risk for cardiovascular diseases. Thus, routine screening of PLHIV for both nutritional issues and cardiovascular disease risk at the ART centers/clinics, and effective ART medications may reduce these adverse outcomes and improve the overall quality of life of PLHIV.

Key words: HIV, ART, diet, CVD risk factors, Agormanya, Atua.

DEDICATION

This research is dedicated to my late father Abdulai Alhassan and my mother Barkisu Yakubu, for their encouragement and prayers, and to my generous sister, Asana Abdulai for her unwavering support. This thesis is also dedicated to my beloved wife Hassana Musah and my adorable daughter Aarifah Mandeiya Kasim. Finally, I dedicate this work to all people living with HIV.

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LIST OF ABBREVIATIONS

ACC	American College of Cardiology
ACSM	American College of Sports Medicine
AHA	American Hearts Association
AHEI	Alternative Healthy Eating Index
AIDS	Acquired Immunodeficiency Syndrome
AMD	Alternative Mediterranean Diet
AND	Academy of Nutrition and Dietetics
APO A	Apolipoprotein A
APO B	Apolipoprotein B
ART	Antiretroviral Therapy
ARVs	Antiretroviral medications
BMI	Body Mass Index
BP	Blood Pressure
CDC	Center for Disease Control and Prevention
CHD	Coronary Heart Disease
CVD	Cardiovascular Diseases
D. A.D	Data Collection on Adverse events of Anti- HIV Drugs

DASH	Dietary Approach to Stop Hypertension
DDS	Dietary Diversity Scores
DHA	Docosahexaenoic acid
EPA	Eicosapentaenoic acid
FA	Fatty Acids
FAO	Food and Agricultural Organization
FBG	Fasting blood glucose
FFQ	Food Frequency Questionnaires
FRS	Framingham Risk Score
G D P	Gross Domestic Product
GHS	Ghana Health Service
HALS	HIV Associated Lipodystrophy Syndrome
HDL	High-Density Lipoprotein
HDL-C	High Density Lipoprotein Cholesterol
HEI	Healthy Eating Index
HIV	Human Immunodeficiency Virus
HR	Hazard Ratio
HSS	HIV Sentinel Survey

HTN	Hypertension
IDDS	Individual Dietary Diversity Score
IPAQ	International Physical Activity Questionnaire
LDL	Low-Density Lipoprotein
LMIC	Low and Middle-Income Countries
MDS	Mediterranean Diet Score
MMDAs	Metropolitan, Municipal, and District Assemblies
MS	Metabolic Syndrome
NCD	Non-Communicable Diseases
NCEP	National Cholesterol Education Program
NIH-AARP	National Institutes of Health and American Association of Retired Persons
NNRTI	Non-nucleoside reverse transcriptase inhibitors
NRTIs	Nucleoside/Nucleotide Reverse Transcriptase Inhibitors
PI	Principal Investigator
PLHIV	People living with HIV
PUFAs	Polyunsaturated fatty acids
SAT	Subcutaneous Abdominal Adipose Tissue
SHS	Senior High School

SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
TC	Total Cholesterol
TG	Triglyceride
UNAIDS	United Nations Programme on HIV and AIDS
VAT	Visceral Abdominal Adipose Tissue
VCT	Voluntary Counselling and Testing
WHF	World Heart Federation
WHO	World Health Organization

OPERATIONAL DEFINITION OF TERMS

Diabetes

Diabetes is a chronic, metabolic disease characterized by elevated levels of blood glucose (or blood sugar), which leads over time to serious damage to the heart, blood vessels, eyes, kidneys and nerves. Fasting blood glucose (FPG) ≥126 mg/dl (7.0 mmol/l). Fasting is defined as no caloric intake for at least 8 hours, or a random plasma glucose ≥200 mg/dl (11.1 mmol/l) among those who have eaten within the last 8 hours.

Hypertension

Hypertension, also known as high or raised blood pressure, is a condition in which the blood vessels have a persistently raised pressure. Blood is carried from the heart to all parts of the body in the vessels. Each time the heart beats, it pumps blood into the vessels. Blood pressure is created by the force of blood pushing against the walls of blood vessels (arteries) as it is pumped by the heart. The higher the pressure, the harder the heart has to pump. Hypertension is a systolic pressure of 140 mm Hg or higher or a diastolic pressure of 90 mm Hg or higher.

Dyslipidemia

Dyslipidemia is defined as the total cholesterol, LDL, triglycerides, apo B or Lp (a) levels above the 90th percentile or HDL and apo A levels below the 10th percentile of the general population. will be defined as TC ≥5.2 mmol/l, HDL-C ≤ 1.03 mmol/l, TG ≥ 1.7 mmol/l or LDL-C ≥ 3.4 mmol/l according to National Cholesterol Education Program (NCEP) guidelines

Diet Quality

Individual dietary diversity score (IDDS) was be used as an indicator of Diet Quality. It is calculated by summing the number of unique food groups consumed during last 24 hour

Cardiovascular disease

Cardiovascular disease (CVD) is the name for the group of disorders of heart and blood vessels, and include: coronary heart disease (heart attack), cerebrovascular disease (stroke), peripheral vascular disease, heart failure, rheumatic heart disease, congenital heart disease, cardiomyopathies.

Risk factors

A risk factor is a variable associated with an increased chance of developing a disease or an infection. Common, preventable risk factors underlie most non-communicable diseases. Most non-communicable diseases are the result of four particular behaviours (tobacco use, physical inactivity, unhealthy diet, and the harmful use of alcohol) that lead to four key metabolic/physiological changes (raised blood pressure, overweight/obesity, raised blood glucose and raised cholesterol).

HIV (*human immunodeficiency virus*)

HIV (*human immunodeficiency virus*) is a virus that attacks cells that help the body fight infection, making a person more vulnerable to other infections and diseases. It is spread by contact with certain bodily fluids of a person with HIV, most commonly during unprotected sex (sex without a condom or HIV medicine to prevent or treat HIV), or through sharing injection drug equipment.

ART

Standard antiretroviral therapy (ART) consists of the combination of at least three antiretroviral (ARV) drugs to maximally suppress the HIV virus and stop the progression of HIV disease. Huge reductions have been seen in rates of death and suffering when use

is made of a potent ARV regimen, particularly in early stages of the disease.

APPENDICES

CHAPTER ONE

INTRODUCTION

This chapter presents background context to the study, the problem statement, and objectives of the study. Further, questions that this research work aimed to address, the public health importance of the study as well as the conceptual framework, and organization of the entire thesis.

1.0 Background

The effective rollout of antiretroviral therapy (ART) has given rise to an increased life expectancy of people living with HIV (PLHIV) (Ingrid T Katz & Maughan-Brown, 2017; McManus et al., 2012; Teeraananchai, Kerr, Amin, Ruxrungtham, & Law, 2017) . By 2019, there were about 38 million individuals living and aging with HIV and 1.7 million becoming infected every year (UNAIDS, 2019). Treatment with effective antiretroviral therapy (ART) has changed the course of disease and is key in the treatment of people infected with human immunodeficiency syndrome (HIV) (Ali et al., 2014; de Coninck et al., 2018; Günthard et al., 2016). The effectiveness of ART has led to a substantial decrease in death among people living with HIV (Deeks, 2009; Justice, 2010; C. A. Sabin, Mallon, & Winston, 2018; Stevens, 2017), leading to an increase in their life expectancy (de Coninck et al., 2018), which nevertheless remains lower than that of the general population (Collaboration, 2009; Lohse et al., 2007; May et al., 2011; Modrich et al., 2010).

Public health and clinical issues related with aging have become more common in HIV-positive individuals (Smit et al., 2015), including increased risks for hypertension, diabetes, and dyslipidemia (Bouatou et al., 2018; Divala et al., 2016; Gueye et al., 2017; Hasse et al., 2011).

Therefore, as patients infected with HIV are now living longer on ART, chronic health complications represent an increasingly important health issue, which is attributed to both HIV-related and traditional risk factors (Collaboration, 2008; Matthew S Freiberg et al., 2013; Ingrid T Katz & Maughan-Brown, 2017; Rotger et al., 2013; Teeraananchai et al., 2017).

The rate of non-communicable illnesses proceeds to rise universally (Gowshall & Taylor-Robinson, 2018; Hunter & Reddy, 2013; Mensah G. A. & Mayosi, 2013; Nyirenda, 2016; Oni et al., 2014), where over 85% of NCD-related deaths are happening in low or middle-income countries (LMIC) (World Health Organization, 2014). Cardio-metabolic and pulmonary diseases, cancers, and mental health disorders are included in the most common NCDs in LMICs (Mayosi et al., 2009). Infections that are opportunistic in nature and acquired immune deficiency syndrome (AIDS) related cancers which characterized the pre-ART era have given way to challenges of non-communicable diseases (NCD) in persons living and aging with HIV (Hirschhorn, Kaaya, Garrity, Chopyak, & Fawzi, 2012; Magodoro, Esterhuizen, & Chivese, 2016).

Non-communicable diseases are chronic diseases that constitute the largest cause of deaths in the world (Gowshall & Taylor-Robinson, 2018), with cardiovascular diseases (CVDs) in the lead (Al-Mawali, 2015). Cardiovascular diseases (CVDs) are the topmost cause of deaths worldwide resulting in 17.3 million deaths per year, projected to reach 23.6 million by 2030 (American Heart Association, 2015). The World Heart Federation mentioned that the number of deaths taking place in a year due to CVDs is 17.3 million (Hao et al., 2017). Diagnosis and treatment costs of CVDs were increasing at a higher rate and expected to escalate more in the next ten years (Pala, Anju, Dyavaiah, Busi, & Nauli, 2020). The financial burden related to CVDs is due to the increment within the chance variables of CVDs such as diabetics, obesity, and development of the geriatric populace (Iafisco, Alogna, Miragoli, & Catalucci, 2019). Current statistics indicate

that cardiovascular diseases have been the single foremost cause of deaths globally (Pala et al., 2020). A study among 525 HIV patients found that, 9.7% (n=51) had hypertension and 15.6% (n=82) were reportedly patients with diabetes. With respect to the serum lipid profile, 24.8% and (n=130) had hypertriglyceridemia (Sanuade, Baatiema, Christian, & Puplampu, 2021).

A survey on 'psychosocial components and cardiovascular diseases' examines the impact of psychosocial components on morbidity and mortality rate of CVDs. Negative enthusiastic states (depression, anger, anxiety, and hostility), social ties, social back, social strife, and unremitting and intense psychosocial stressors have associated with the expanded hazard of cardiovascular dismalness and mortality (Pala et al., 2020).

Lifestyle choices, some health conditions, and ART are considered risk factors for CVD (Fryar, Herrick, Afful, & Ogden, 2016; Muyanja, Muzoora, Muyingo, Muyindike, & Siedner, 2016). Ideal cardiovascular health is defined by being a non-smoker, having a body mass index <25 kg/m^2, meeting physical activity requirements, consuming a diet that adheres to the Dietary Guidelines, having a total cholesterol <200 mg/dL achieved without medication, a blood pressure <120/80 mmHg achieved without medication, and a fasting blood glucose <100 mg/dL (Lloyd-Jones et al., 2010). The odds for CVD increases in the presence of these risk factors along with HIV viral infection (Drozd et al., 2017) and ART (Marcus et al., 2016; Yoshimura, 2017).

Cardiovascular disease has become an important cause of morbidity and mortality in HIV infected persons in industrialized countries (De Socio, Pucci, Baldelli, & Schillaci, 2017; Magodoro et al., 2016). The situation may even be more serious among developing countries. A systematic review conducted by Bloomfield et al. (2014) submits that in low and middle income countries, cardiovascular conditions such as coronary artery diseases, heart failure, and stroke, hypertension amongst others are common in the HIV-infected populace. Another study conducted in Zimbabwe

also found that hypertension and type 2 diabetes which are major risk factors of cardiovascular diseases were common comorbidities among people living with HIV (PLHIV) (Magodoro et al., 2016). A systematic review found that over a third of PLHIV appearing at health facilities and/or receiving antiretroviral treatment (ART) had some kinds of cardiovascular disorders (Haregu, Oldenburg, Sestwe, Elliott, & Nanayakkara, 2012). This evidence points to some relationship that exists between ART and cardiovascular risk factors.

Inevitable age-related changes, increasing exposure to ART toxicities, effects of continuing inflammation, continuous immune dysfunction, and long-term HIV viral infection are postulated to drive these cardiovascular risks among people living with HIV (Longenecker et al., 2013; Martínez, Larrousse, & Gatell, 2009; Pathai, Bajillan, Landay, & High, 2013). It has been long recognized that ART may lead to metabolic syndrome including atherogenic dyslipidaemia, abdominal obesity, endothelial dysfunction, insulin resistance, and inflammation (Loonam & Mullen, 2012). The increase in life expectancy among PLHIV has happened alongside the epidemiological transition that is associated with an increase in non-communicable diseases (Dimala, Atashili, Mbuagbaw, Wilfred, & Monekosso, 2016), which may have confounded the real effect of antiretroviral therapy on the development of cardiovascular risk factors.

Nutrition transition in the last few decades especially among the developing countries has played a major role in the upward trend in non-communicable diseases especially CVDs. Nutrition transition is characterized by a major shift in dietary pattern toward sweetened and fatty foods that have high energy density. This is coupled with a reduced level of physical activity leading to changes in body composition and high risk of obesity (Bishwajit, 2015) and preventable non-communicable diseases (Oyewole & Atinmo, 2015).

Nutrition transition is also explained as a change from lack of food, to a rising problem of accumulation and obesity (Adogu, Ubajaka, Emelumadu, & Alutu, 2015). This has coincided with a change in disease patterns connected with changes in behaviours, lifestyles, diets, physical inactivity, smoking and alcohol consumption (Adogu et al., 2015).

Diet and nutrition are crucial in the management of PLHIV, especially in the case of metabolic alterations related to antiretroviral therapy (ART), which could be associated with cardiovascular diseases (CVD) (Silva et al., 2010). Nutrition is a foundation for good health and development and an important component of this is maintaining a strong immune function (Academy of Science of South Africa, 2007). Achieving fundamental nutritional recommendations is a paramount concern when treating HIV patients at every stage of the disease (World Health Organization 2003). Albeit under-nutrition is still an issue among infected persons, the use of antiretroviral therapy (ART) in the light of nutrition transition has not only prolonged their survival, but also elevated the prevalence of overweight and obesity (Amorosa et al., 2005; Audain, Carr, Dikmen, Zotor, & Ellahi, 2017; Hendricks, Willis, Houser, & Jones, 2006; Silva et al., 2010).

Therefore, long-term complications, such as cardiovascular diseases (CVD) connecting to diet and obesity have become more important (Hendricks et al., 2006). Samaras et al. (2009) in their study among men with HIV-associated lipodystrophy Syndrome (HALS) presented that saturated fat consumption was positively related with percentage body fat. And a study in Brazil that assessed diet quality among PLHIV by A. Duran, L. Almeida, A. Segurado, and P. Jaime (2008) found that people who are overweight had lower Healthy Eating Index (poorer diet quality) and are also not likely to realize dietary goals for dairy products and grains.

Omega 3 fatty acids are dietary components mainly found in fish, nuts, and vegetable oils that are known to lower the risk of CVD by reducing serum triglycerides and decreasing inflammation

(Krauss et al., 2000; Mahan, Raymond, & Escott-Stump, 2013). Omega-3 fatty acids have antiarrhythmic effects, haemodynamics regulation through better endothelial function by helping the release of nitric oxide from endothelial cells (Massaro, Scoditti, Carluccio, & De Caterina, 2008), and arterial endothelial function which help explain potential mechanisms of their action (Kris-Etherton, Harris, Appel, & Nutrition, 2003). Omega 3 fatty acids also act partly to reduce hepatic production of very low-density lipoprotein and by boosting the degradation of fatty acids and quickening triglyceride removal from the plasma (Innes & Calder, 2018). Several population-based studies have revealed that eating boiled or baked fish, is strongly related to reduced heart rate and systemic vascular resistance and lower occurrence of ischemic heart disease and heart failure (Dariush Mozaffarian, Prineas, Stein, & Siscovick, 2006; von Bibra, Paulus, & St John Sutton, 2016).

In order to determine the best mode to provide an all-inclusive care, a complete understanding of the multifaceted health needs of the population living with HIV is required (Kendall et al., 2014), and that should include their overall cardiovascular risk and dietary pattern.

1.1 Problem Statement

The gains made against HIV such as, improved quality of life, reduction in HIV-related mortality and morbidity, and increased viral suppression are under threat, not from the HIV itself, but from non-communicable diseases (NCDs), especially cardiovascular diseases (CVDs) that develop due to exposure to antiretroviral therapy (ART) (World Health Organization, 2016). Long exposure to ART is found to be a major risk factor for CVDs (Islam, Wu, Jansson, & Wilson, 2012; Marcus et

al., 2016; Zanetti, Mendes, et al., 2018). Hypertension, diabetes, and dyslipidemia are commonly associated with ART (Islam et al., 2012; World Health Organization, 2016).

Treatment coverage has almost quadrupled within the span of ten years, from 6.4 million in 2009 to 25.4 million (UNAIDS, 2019), and by December of 2018, approximately 64% of PLHIV in Africa were accessing ART (WHO, 2018). The greatest increase in ART coverage has been in low and middle income countries (Joint United Natiions on HIV/AIDS, 2016) thereby bearing the brunt of the burden of these disease (Bloomfield et al., 2014; Mensah et al., 2015).

In Ghana, the estimated number of people living with HIV by 2019 was 342,307 with an adult prevalence of 1.7% (Ghana AIDS COmmission, 2020). The picture regarding ART coverage in Ghana is not any different form other African countries. About 47 percent of PLHIV are on ART coverage by the end of 2019, projected to reach 100% by 2025 (Ghana AIDS COmmission, 2020; "UNAIDS Ghana Data," 2018), culminating in an increase in longevity among PLHIV in Ghana. Indeed, it is estimated that about 8,000 deaths were averted by ART (Ghana AIDS COmmission, 2020).

However, the implementation and rollout of the ARTs has been accompanied with rising levels of non-communicable diseases among PLHIV, for which cardiovascular diseases stand out. HIV infection and ART are independently associated with a high risk of cardiovascular diseases (David G Dillon et al., 2013). Metabolic and body-fat irregularities are common among HIV-infected adults receiving ART, and there is indication that suggests that such people have an increased risk of cardiovascular conditions (Savvoulidis, Butler, & Kalogeropoulos, 2019). In the D.A.D. study, it was found that CVD is one of the most common causes of deaths (accounting for about 12 percent of total mortality) among people living with HIV (Smith et al., 2011). Several other studies

also report those antiretroviral medications increase the risk of cardiovascular disease, and the plausible explanation for the relationship was pointed at an increase in plasma lipids.

In addition to the role of ARTs in CVDs among PLHIV, Ghana as a country and for that matter the Eastern Region is not spared from the nutrition transition African countries are going through. There is a major shift in diet, characterized by high calories, high sodium, low fruits and vegetables, sedentary lifestyle, high alcohol consumption, and obesity. Luke, Cooper, Prewitt, Adeyemo, and Forrester (2001) found a major change in the Ghanaian dietary pattern, from whole grains, vegetables, and fiber-rich diet to diet characterized by high levels of fats, highly processed carbohydrates, and table sugar. The picture regarding the weight of PLHIV has also changed, from HIV-related weight loss especially during the pre-ART era to an increase in weight gain following the rollout of ART resulting in high levels of overweight and obesity among HIV patients, thereby increasing their CVD risk. In a study carried out among HIV population, about 30 percent were either overweight or obese (Klassen & Goff, 2013).

Today, greater emphasis is placed on reducing diet-related comorbidities in PLHIV because healthy diets remain critical for healthy aging (Katunge, 2017; Maertens, 2011). In fact, PLHIV may be impacted disproportionately by poor diet quality compared to uninfected individuals (Crush, Drimie, Frayne, & Caesar, 2011; Dellar & Karim, 2015). The role of diet is key in the management of conditions such as dyslipidemia among people with higher risk. For instance, consumption of low cholesterol diet and fish increases plasma levels of omega-3 and omega-6 fatty acids (Capili & Anastasi, 2013). Attaining the basic nutritional needs is therefore an important requirement in successful management of PLHIV (Organization, 2003; Tang, Quick, Chung, & Wanke, 2015).

There is however little information regarding the cardiovascular risk burden of HIV population receiving treatment in Ghana. Christian Obirikorang et al., (2016) investigated the prevalence of metabolic syndrome among HIV-infected patients receiving antiretroviral therapy at the St. Dominic Hospital, Akwatia. They found that participants on antiretroviral therapy (ART) were significantly associated with higher prevalence of metabolic syndrome compared to those without ART ($P < 0.05$). Their study however failed to investigate the prevalence of the various cardiovascular disease risk factors. The relationship between ART type and cardiovascular risk factors in Ghanaian setting was not determined. In addition, there is a lack of structured nutritional guide for PLHIV in Ghana, and little is known about their dietary behaviour and nutritional status. Also, no research to date has examined the degree to which the association between ART intake, dietary pattern, and CVD risk factors among PLHIV may interact (Raiten, D. J. et al., 2005).

1.2 Research Questions

Given the research gap in relation to the risk of CVD among PLHIV, the study sought to provide answers to questions below:

1. What is the effect of ART on CVD risk factor (diabetes, hypertension, dyslipidemia, and obesity)?
2. What is the diet quality of the PLHIV?
3. What is the prevalence of diabetes, hypertension, and dyslipidemia among the PLHIV?
4. Are there any relationships between diet quality and CVD risk factors, (diabetes, hypertension, and dyslipidemia)?
5. What is the 10-year cardiovascular disease risk among the PLHIV?

1.3 Objectives

1.3.1 General Objective

The main objective of this study was to assess the Diet Quality and Cardiovascular Disease Risk Factors among PLHIV on Treatment

1.3.2 Specific Objectives

The specific objectives were:

1. To conduct a systematic review on the effects of ART on cardiovascular disease risk factors among PLHIV in Low and Middle-Income Countries (LMIC)
2. To evaluate diet quality of the people living with HIV (PLHIV)
3. To determine the prevalence of cardiometabolic risk factors (diabetes, hypertension, dyslipidemia) among PLHIV
4. To examined the relationship between diet quality and CVD risk factors, including plasma glucose, blood pressure, lipid levels, and metabolic syndrome
5. To model and predict a 10-year cardiovascular heart disease risk among the PLHIV

1.4 Conceptual Framework

This section discusses the possible causality pathways of the metabolic CVD risk factors and how they may lead to the CVDs. Figure 1 describes how socio-cultural factors may affect the traditional risk factors which eventually contribute to cardio-metabolic risk factors of CVD. It illustrates how HIV infection itself and ART modulate the cardio-metabolic risk factors of CVD. It further

describes how socio-cultural and the traditional risk factors may result in individual dietary diversity score which also may eventually lead to the cardio-metabolic risk factors of CVD.

This conceptual framework was adapted because it provides the possible pathophysiological pathways that could lead to cardiovascular diseases and diet quality. This advantage of this framework is that, it provides a clear link between exposure variables and the outcome variables. The disadvantage may be the fact that not all possible explanatory variables may be captured in the conceptual framework.

1.4.1 Description of Framework Components

Treatment with ART either with PI-based or not, and diet quality (dietary pattern) may lead to an increase in the development of cardiovascular risk including diabetes, hypertension, and dyslipidaemia among PLHIV. However, various factors such as exercise, age, smoking, and gender may confound this association. Adjustment of these confounders is necessary to define clearly the associations of HIV related CVD risk (Diabetes, Hypertention, Dyslipidaemia) and treatment of HIV infection with ART and Diet Quality. Good nutrition is deemed one of the few bulwarks against AIDS-related diseases and early death (Lemke, 2005).

Traditional risk factors such as smoking, alcohol, physical inactivity, and obesity have long been found to be associated with cardiovascular risk factors. Ahwal, Andrews, Roy, and Lakshmy (2019); (Gbadamosi & Tlou, 2020; Janakiraman et al., 2020; Nyberg et al., 2018) in their recent study, found that the occurrence of hypertension and dyslipidemia were higher among smokers compared to non-smokers. A new meta-analysis published in the British Medical Journal reveals that, in the context of cardiovascular disease (CVD), no safe level of smoking exists (Le Bras, 2018). Smoking increases oxidative stress leading to systemic inflammation that may ultimately

result in the development of hypertension or dyslipidemia (Bissinger, Bhuyan, Qadri, & Lang, 2019; Cecile C. et al., 2017). Cessation of smoking is therefore suggested to reduce oxidative stress related inflammation (Cecile C. et al., 2017).

High alcohol consumption was also found to be associated increased risk for hypertension and diabetes (Sechi, Colussi, Novello, Pezzutto, & Catena, 2016; Walther et al., 2017). Roerecke et al. (2018) in a systematic review concluded that any alcohol intake was related to elevation in the risk for hypertension among men, and in women, there was no risk increase for intake of 1 to 2 drinks per day but there is an increased risk for higher consumption levels. Consumption of alcohol 3 to 4 times per week was found to be associated with significant risk of developing diabetes (Holst, Becker, Jorgensen, Gronbaek, & Tolstrup, 2017). Physical inactivity was also a traditional risk factor of diabetes, hypertension, and dyslipidemia established by several research studies (Bohn et al., 2015; Jagannathan, Patel, Ali, & Narayan, 2019; Ward, White, & Druss, 2015). Exercise regimens are therefore crucial in a successful management of hypertension, diabetes, dyslipidemia, and for that matter, CVD.

There is a significant reduction in HIV-related morbidities and mortalities, and people living with HIV now have an increased life expectancy (Teeraananchai et al., 2017), making HIV virtually a chronic disease. However, ART is associated with increased risk of non-communicable diseases (NCD) such as hypertension (CU Nduka, Saverio Stranges, AM Sarki, PK Kimani, & OA Uthman, 2016), diabetes (Nazik Elmalaika et al., 2017),dyslipidemia (Amberbir et al., 2018; Nazik Elmalaika et al., 2017), and CVDs (Lundgren, Mocroft, & Ryom, 2018; Muyanja et al., 2016). ART also may alter the appetite of PLHIV resulting in poor dietary choices that can increase their risk to diabetes, hypertension, and dyslipidemia. For instance, in one study, ART was associated

with increased appetite among PLHIV (I. T. Katz et al., 2013) which may lead to overweight and obesity.

HIV infection itself is found to be associated with hypertension, diabetes, and dyslipidemia through endothelial dysfunction, hyper-coagulation, and immune activation (Dau & Holodniy, 2008; Mogadam et al., 2020). HIV itself may also reduce appetite for food, making the infected indulge in unhealthy dietary practices.

Finally, poor diet is one of the main risk factors for diabetes, hypertension, and dyslipidemia (Rodríguez-Monforte, Flores-Mateo, & Sánchez, 2015). Atkins et al. (2016) found in their research that adherence to a high-sugar (high in biscuits, puddings, chocolates, sweets, sweet spreads, breakfast cereals) diet was linked with CVD events, and therefore concluded that avoiding 'high-sugar' food components may decrease the risk of cardiovascular diseases.

A study has revealed that although the energy intake may be the same, the diet of people living with HIV had an increased amount of fat, saturated fat, and cholesterol (Klassen & Goff, 2013). The increased fat intake may be as a result of the need for high-calorie diet resulting from high basal metabolic rate and the effects of the virus and medications on hunger or satiety control, in addition to alterations in taste perception and the poor nutritional support given to PLHIV.

All of the risk factors discussed above therefore increase the cardiovascular risk of PLHIV through diabetes, hypertension, and dyslipidemia, which are the key risk factors.

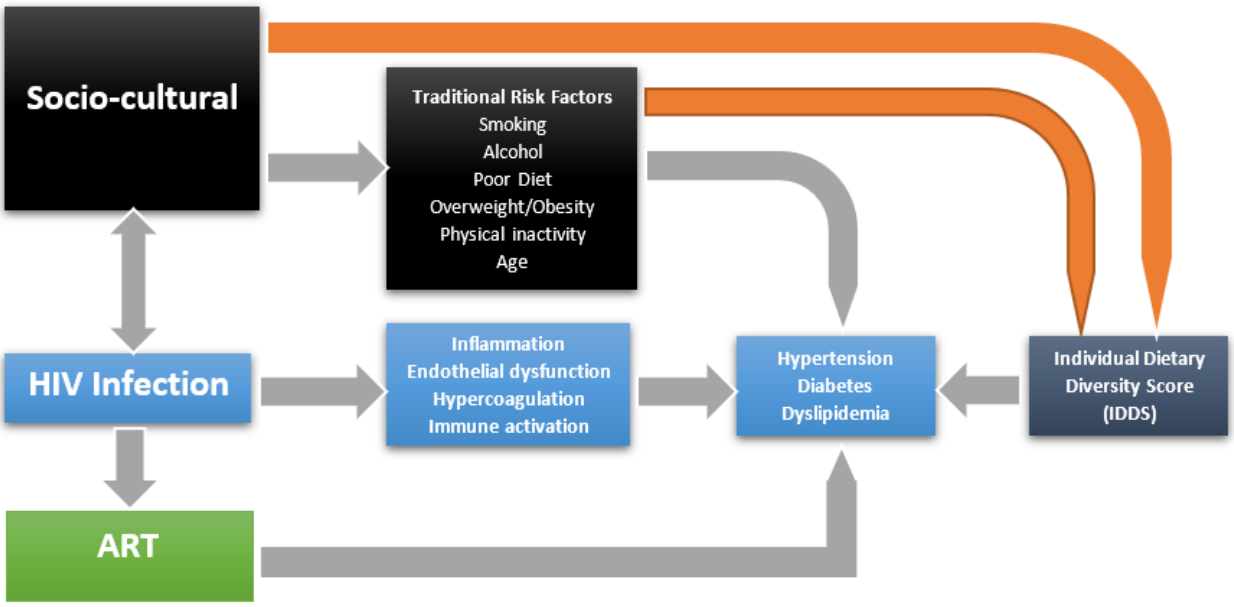


Figure 1. Conceptual framework suggesting plausible mechanisms by which ART, socio-cultural factors, HIV infection, and traditional risk factors may influence cardiovascular disease risk and quality of diet.
Adapted from Stoner, Stoner, Young, and Fryer (2012)

1.5 Justification/Public health implication of the study

The risk of cardiovascular diseases (CVD) among people living with HIV is predicted to increase, given that the increased access to antiretroviral therapy (ART) is linked with increased longevity. HIV-infected individuals are at high risk of CVD associated with aging like all others. In addition, most of the antiretroviral drugs frequently used in SSA are linked with hypertension, diabetes, and dyslipidemia (Cardoso et al., 2013; Chiluba, Nkandu, Daka, Chola, & Chongwe, 2017). This study seeks to estimate the prevalence of CVD risk factors (diabetes, hypertension, dyslipidemia), determine diet quality, and investigate any associations between diet quality, ART type, and CVD risk factors.

Having data on the prevalence of these abnormalities (cardiovascular risk factors) among the HIV infected persons will help in planning public health interventions that are targeted at the PLHIV.

The data on the relationship between ART type and CVD risk factors will specifically facilitate selection of effective ART primary treatment regimen with less cardiovascular risk and develop strategies in managing the CVD risk factors when they occur.

This study will provide evidence to support and improve dietary recommendations and nutritional management of HIV-infected adults that are on ART, including dietary and lifestyle modifications. Knowledge about dietary intake patterns will help to identify areas for improvement regarding unhealthy dietary behavior (Ministry of Health, 2009). Findings of the research may be used to influence other national policies and programs made by government and or other stakeholders that will directly or indirectly restore, promote, and maintain health.

1.6 Organization of the Thesis

Chapter One provides a background to CVD risk factors among PLHIV. It further describes the magnitude of the research problem and provides the objectives of the study, conceptual framework and research questions.

Chapter Two provides literature review on CVD risk factors among PLHIV (HIV, ART, and the traditional risk factors) and a systematic review of studies on the effects of ART on the cardio-metabolic risk factors of CVDs.

Chapter Three gives a brief explanation and characteristics of the study area, target population, the methods used and the study design.

Chapter Four provides the analysis, results and their interpretations in line with the study objectives and the conceptual framework.

Chapter Five discusses the study findings, whiles Chapter Six gives a conclusion to the study based on the study findings and recommendations. Implication for future research interventions as well as contribution to knowledge were also provided by the research (figure 2)

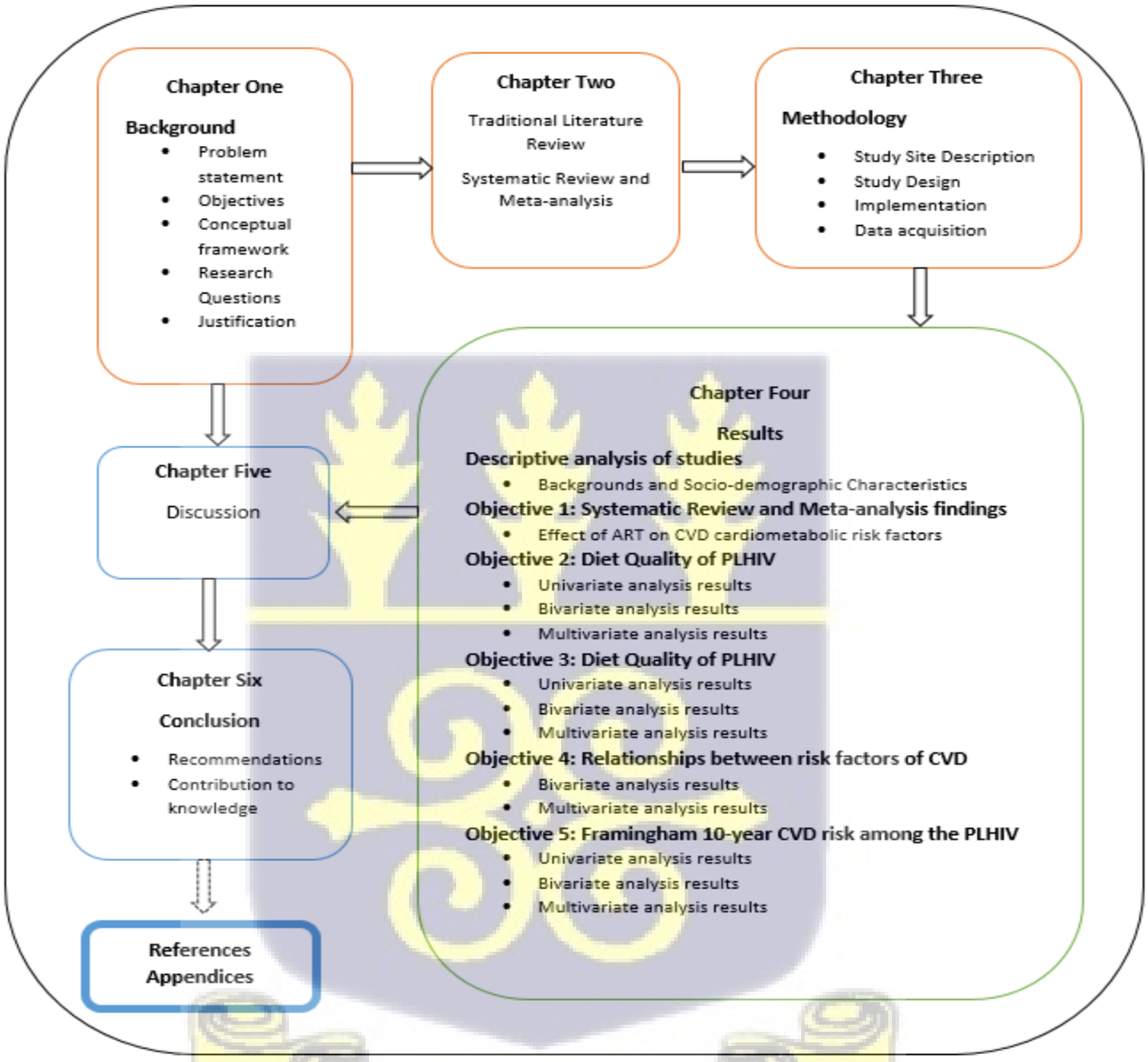


Figure 2: Schematic presentation of the thesis organization

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This study has two main outcome variables; cardiovascular risk factors and individual dietary diversity score (IDDS) [a proxy for diet quality measurement] among the PLHIV. The first part reviews the epidemiology of HIV and the burden of CVDs. The second part examines cardiovascular disease risk factors among PLHIV. The third part discusses dietary patterns and diet quality among the PLHIV. A systematic literature review and meta-analysis was done at the first section to determine the effects of ART on the cardio-metabolic risk factors of CVD among PLHIV.

2.1 HIV and CVDs

2.1.1 Epidemiology of HIV

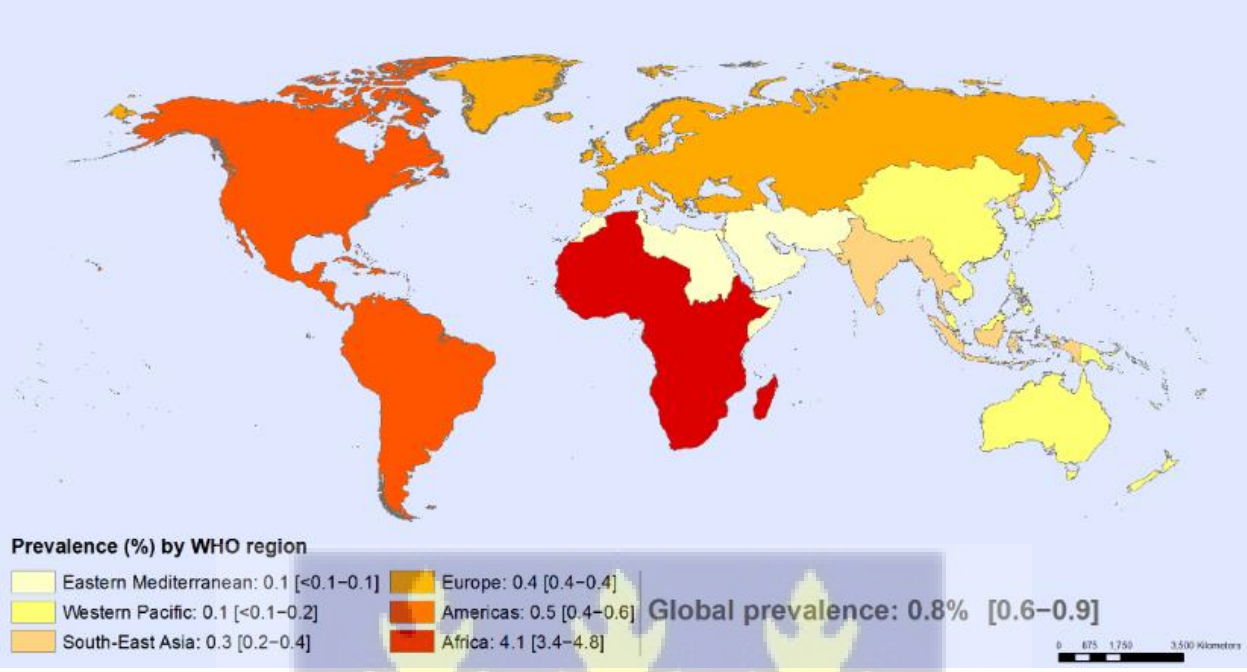
In 2019, there were 38 million people living with HIV (UNAIDS, 2020) out of which 36.2 million are adults. By the end of 2019, 25.4 million (67%) people were accessing antiretroviral therapy, up from 6.4 million in 2009 (UNAIDS, 2020).

New HIV cases have been reduced by 40% from 1998. In 2019, around 1.7 million people were newly infected with HIV, compared to 2.8 million people in 1998 (UNAIDS, 2020). Since 2010, new HIV infections have declined by 23%, from 2.1 million to 1.7 million in 2019 (UNAIDS, 2020).

AIDS-related deaths have been decreased by 60% since the peak in 2004. In 2019, around 690 000 individuals passed on from AIDS-related sicknesses around the world, compared to 1.7 million individuals in 2004 and 1.1 million individuals in 2010 (UNAIDS, 2020).

In 2019, there were 38.0 million people living with HIV (UNAIDS, 2020). Out of which 36.2 million are adults. By the end of 2019, 25.4 million (67%) people were accessing antiretroviral therapy, up from 6.4 million in 2009 (UNAIDS, 2020).

The rate of NCDs is high in sub-Saharan Africa (SSA). In 2016, NCDs accounted for 54.7% of all deaths in South Africa (Maluleke, 2018). Cerebrovascular disease and ischaemic heart disease were graded fourth and fifth for years of life lost in 2015 and diabetes was the second biggest killer after TB in 2016. Only 12% of the global population live in Sub-Saharan Africa (A. G. Vos et al., 2019), yet accounts for 71% of the global burden of HIV infection (Kharsany & Karim, 2016). Ten countries, mostly in southern and eastern Africa, *viz*. South Africa (25%), Nigeria (13%), Mozambique (6%), Uganda (6%), Tanzania (6%), Zambia (4%), Zimbabwe (6%), Kenya (6%), Malawi (4%) and Ethiopia (3%), account for almost 80% of all people living with HIV (Kharsany & Karim, 2016).



Source: World Health Organization, 2018

Fig. 3: Prevalence of HIV among adults aged 15 to 49, 2017, by WHO Regions

An estimated 0.8% [0.6-0.9%] of adults aged 15-49 years worldwide are living with HIV, though the problem of the epidemic continues to vary appreciably between regions. The WHO African region stays most severely affected, with almost 1 in every 25 adults (4.1%) living with HIV and accounting for nearly two-thirds of PLHIV worldwide (World Health Organization, 2019).

2.1.2 The burden of CVDs

Cardiovascular disease (CVD) is the term that embraces diseases of the heart and blood vessels (Pranata et al., 2020). Cardiovascular diseases (which incorporate coronary heart infection and stroke) are the foremost non-communicable diseases universally, responsible for about 17.8 million deaths in 2017, particularly in low and middle-income nations (LMICs) where close to 80% of the total CVD burden occurs (Kaptoge et al., 2019).

The general rate of CVD deaths in low and middle-income countries together is 28%, including more than 3 million deaths before the age of 60, of which the majority can be prevented (Arroyo-Quiroz et al., 2020; Nguyen, 2012). This leads to 7% reduction of gross domestic product (GDP) in these countries (Ruan et al., 2018)

2.2 HIV infection, ART, traditional risk factors, and cardio-metabolic risk factors

2.2.1 HIV infection and cardio-metabolic risk factors

Chronic immune system activation and inflammation related to HIV infection also plays key roles in causing vascular damage and increasing one's risk of CVD (Hileman & McComsey, 2019; Hunt, 2012; Soysal, Arik, Smith, Jackson, & Isik, 2020). Although HIV causes the depletion of CD4 lymphocytes among HIV-infected persons who are antiretroviral therapy-naïve, HIV also paradoxically results in chronic immune activation (Zanni, Schouten, Grinspoon, & Reiss, 2014). Patients with uncontrolled viremia have been found to have elevated levels of circulating immune and inflammatory markers including monocyte activation markers (Kaplan et al., 2012), pro-inflammatory cytokines (Baker et al., 2010), markers of arterial inflammation (Mangili et al., 2014), soluble cytokine receptors (Kaplan et al., 2012; Ross et al., 2008), chemokines (Kaplan et al., 2012), acute-phase proteins (Beltrán et al., 2014), soluble leukocyte adhesion markers (Baker et al., 2010; Ross et al., 2008), and fibrin degradation products (Baker et al., 2010; Kaplan et al., 2012).

Immune alterations are known to contribute to atherosclerosis (Hansson & Hermansson, 2011); more specifically through immune cell subsets (e.g., intermediate monocytes, CD4+ T-helper 1 cells), inflammation, and T-cell activation (Ammirati et al., 2012; Rogacev et al., 2012; Tracy et al., 2013). Indeed, studies have found that HIV-infected patients who were ART-naïve had more

advanced subclinical atherosclerosis (Oliviero et al., 2009), increased arterial inflammation (Subramanian et al., 2012), and greater monocyte and lymphocyte activation when compared with HIV-uninfected controls (Oliviero et al., 2009; Pereyra et al., 2012; Subramanian et al., 2012).

2.2.2 ART and cardio-metabolic risk factors

Medications introduced in the mid-1990s transformed HIV treatment (Boccara, 2008; Hoffmann & Jaeger, 2001; Kramer, Lazzarotto, Sprinz, & Manfroi, 2009; Nehal & Muredach, 2005). These medications enhanced longevity and quality of life in persons with HIV by significantly dropping morbidity and mortality rates (Areri, Marshall, & Harvey, 2020).

Progresses within the treatment of HIV/AIDS given colossal benefits to communities and governments through decrease of budgetary and society burdens, but these focal points appear to have come at a cost (Watson, 2015). Despite all the exceptional properties of antiretroviral solutions, some chronic conditions such as hyper-insulinemia, dyslipidemia, and disturbances in glucose homeostasis have been recorded as the direct antagonistic impacts of ART or as a result of combination with other risk factors such as HIV itself, an unhealthy way of life, and environmental variables (Bowman & Funderburg, 2019; Carr, Samaras, Burton, et al., 1998; Walli et al., 1998). The metabolic side effects of Art showing as chronic complications generally have multiple pathogenic mechani sms. However, ART is considered the foremost noteworthy contributing factor compared with other causal components such as maturing or an undesirable way of life (Bowman & Funderburg, 2019).

It is not clear whether the units that have been clustered under the term “lipodystrophy syndrome” are different or interrelated components (Hejazi & Rajikan, 2015). Each single peculiarity within

the serum lipid or glucose level can happen freely and exclusive of others, and the seriousness of the anomaly may vary from case to case (Hejazi & Rajikan, 2015). Of the six antiretroviral drug classes, the metabolic side effects of ART are most frequently detected with protease inhibitors (PIs), followed by Nucleoside/Nucleotide Reverse Transcriptase Inhibitors (NRTIs), and Non-nucleoside reverse transcriptase inhibitors (NNRTIs) that have different and specific effects (Ahmed, Woodward, & Mital, 2017; Husain & Ahmed, 2015).

Generally, ARTs (including NNRTIs, NRTIs, Fusion inhibitors (FIs), CCR5 antagonists and integrase inhibitors) are less involved in metabolic disorders with the exception of efavirenz (NNRTI agents), which may have a role in the occurrence of dyslipidemia (Hejazi & Rajikan, 2015).

2.2.3 Traditional and cardio-metabolic risk factors

2.2.3.1 Smoking

Cigarette smoking increases the occurrence of CVD in a dose-dependent way (Conen et al., 2011; Y. H. Lee et al., 2011; Tomiyama et al., 2010), with even occasional smoking increasing the risk of CVD (Witter et al., 2015). The association between CVD and smoking results from several mechanisms that interact to contribute to vascular injury, atherosclerosis, thrombosis and vascular dysfunction, although the exact mechanisms are mainly unknown (DiGiacomo, Jazayeri, Barua, Ambrose, & health, 2019; Witter et al., 2015). Long-term prospective studies have demonstrated the considerable mortality risk reduction related to smoking cessation (Sitas, Bradshaw, Egger, Jiang, & Peto, 2018).

2.2.3.2 Alcohol

Gathering scientific evidence shows that light to moderate alcohol intake may significantly lessen the risk of CVD and all-cause mortality (Ronksley, Brien, Turner, Mukamal, & Ghali, 2011).

In contrast, excessive alcohol intake is poisonous to both the heart and general health of an individual (Corrao, Rubbiati, Bagnardi, Zambon, & Poikolainen, 2000; Ronksley et al., 2011). In particular, binge drinking, even among otherwise low drinkers, raises cardiovascular events and deaths (Corrao et al., 2000; Ronksley et al., 2011).

The American Heart Association guidelines caution individuals not to begin drinking in the event that they don't as of now drink alcohol because it isn't conceivable to anticipate in which individuals liquor abuse will get to be an issue (Lucas, Brown, Wassef, & Giles, 2005).

2.2.3.3 Obesity

Obesity has been linked with CVD as well as its risk factors (Starrett, 2016). A study conducted over a 22-year period examined the trajectories of change in BMI and other CVD risk factors before a CVD diagnosis. It was found that high BMI and waist circumference are risk factors for developing CVD (Dhana et al., 2016; Renzaho, Halliday, & Nowson, 2011). In another study, data were collected from CVD free participants from the Framingham Heart Study between 2002 and 2005 (n=3,001). Subcutaneous abdominal adipose tissue (SAT) and visceral abdominal adipose tissue (VAT) can be a more precise measurement of waist circumference; they were used to identify if there was a correlation with metabolic risk factors such as fasting plasma glucose, high-density lipoprotein cholesterol, total cholesterol, and triglycerides (Fox et al., 2007). After controlling age, waist circumference and BMI were associated with SAT and VAT levels (Fox et al., 2007).

Overweight as well as obese individuals have a noticeably higher prevalence of hypertension (HTN) compared with lean subjects (Alpert, Lavie, Agrawal, Kumar, & Kumar, 2016; Bastien, Poirier, Lemieux, & Despres, 2014; Ng et al., 2014), and obesity increases coronary heart disease (CHD) risk factors for example hypertension (Alpert et al., 2016). Certainly, overweight and obese

individuals have noticeably abnormal CHD risk factors, including higher blood pressure (BP), glucose abnormalities, dyslipidemia, and increased inflammation, all of which increase the risk of CHD (Alpert et al., 2016; Lavie, De Schutter, & Milani, 2015). Indeed the prevalence of CVD is increased in the setting of obesity (Lavie et al., 2016).

HIV infection used to be a wasting disease, especially during the pre-ART era. But since the rollout of ART, the dynamics have shifted, from weight loss and wasting among PLHIV to accumulation of body fat and weight gain. In a study of 1683 HIV patients, only 2% were underweight, 37% were overweight, and 9% were obese (Crum-Cianflone et al., 2010). Multivariate predictors of a higher body mass index (BMI) at diagnosis embraced more current year of HIV diagnosis, older age, African American race, and earlier HIV stage (all $p<0.05$) (Crum-Cianflone et al., 2010). Most of patients (62%) gained weight during HIV infection (Crum-Cianflone et al., 2010).

Therefore, the high prevalence of obesity and overweight among PLHIV also increases their risks for developing cardiovascular diseases just as found in non-HIV populations (Alpert et al., 2016; Lavie et al., 2016).

2.2.3.4 Physical inactivity

The American College of Cardiology (ACC) and the American Hearts Association (AHA) Lifestyle Management Guideline suggest that adults require at least 150 minutes every week of moderate-intensity aerobic activity or 75 minutes per week of vigorous aerobic activity, or a combination of the two, if possible, spread during the week (American Heart Association, 2019). In a prospective cohort analysis, female registered nurses 30-55 years old were followed for 8 years to inquire about physical activity and CVD events using questionnaires (n=72,488) (Manson et al., 2000). Physically active women were more likely to be non-smokers, leaner, had a lower

prevalence of reported diabetes, hypertension, hypercholesterolemia, and alcohol (Manson et al., 2000).

Even after controlling for age, smoking status, BMI, and other related factors, the total physical-activity score was inversely related to risk of CVD events when comparing quintile groups with increasing relative risks for physical activity, and the lowest quintile group ($p=0.002$) (Manson et al., 2000). Using multivariate analyses, CVD risk was decreased by 31 % when averaging 4.0 to 6.9 hours every week spent in moderate or vigorous activity as well as 37 % when averaging 7 hours per week compared to those who averaged less than 1 hour per week ($p<0.001$) (Manson et al., 2000).

Walking was also shown to reduce coronary events. Those in the top two quintiles had significantly lower risk for a CVD event compared to those in the lowest quartile (Manson et al., 2000). In women, vigorous activity in addition to walking can reduce CVD events; however, this study did not investigate these risks for men.

The Harvard Alumni Health Study investigated physical activity effect of CHD risk in men (n=12,516) (Sesso, Paffenbarger, & Lee, 2000). Quality and intensity of the physical activity were extracted from questionnaires provided from men with a mean age of 57.7 years old. Sesso et al. (2000) found that total activities and vigorous activities showed a relationship with the risk of CHD. Men who expended >8400 kJ per week participating in vigorous activities had a 10% to 20% decreased risk of CHD. Men who walked ≥5 km per week had a reduced risk of CHD by 13 % compared to those who did not (Sesso et al., 2000). Similar to women, an increase in physical activity proved a reduced rick for coronary related illnesses.

Table 1: Lifestyle and cardio-metabolic risk factor analysis

Risk factor	Metric	Optimum	Low risk	High risk	Disease outcome	Reference
Alcohol use	Standard drinks/day	M: ≤1 F: ≤1	M: ≥3 F: ≥2	M: ≥5 F: ≥4	CVD; respiratory disease; cancers; diabetes; digestive disorders	(O'Keefe, Bybee, & Lavie, 2007)
Tobacco smoking	Cigarettes/day	0	≥1	≥1	CVD; respiratory disease; cancers; diabetes; hypertension	(Erhardt, 2009; Stoner et al., 2012)
Poor diet	Fruit and vegetable (servings/day)	≥5	< 5	< 1	CVD; cancers	(Grimm et al., 2010; Saha et al., 2011)
Overweight/ Obesity	Waist: hip ratio1	M: ≤0.90 F: ≤0.80	M:≥0.92 F: ≥0.82e	M: ≥0.98 F: ≥0.88	CVD; hypertension; diabetes; cancers	(Huxley, Mendis, Zheleznyakov, Reddy, & Chan, 2010; Qiao & Nyamdorj, 2010)
Physical inactivity	Moderate physical activity (minutes/day)	≥30 days (5 days/ week)	<30 days	Sedentary	CVD; cancers; diabetes; hypertension	(Garber et al., 2011)

CVD: Cardiovascular diseases; F: Female; M: Male

2.2.4 Cardio-metabolic Risk Factors Among PLHIV

The demographics of a population, physical activity level, smoking, obesity, and alcohol consumption have all been related to CVD (Starrett, 2016). Healthy lifestyle choices of individuals can dictate health status later in life. Healthy lifestyles including, five or more servings of fruits and vegetables daily, consistent exercise, BMI 18.5-29.9 kg/m^2, and smoking status led to a

reduction in the risk of developing CVD and mortality (King, Mainous, & Geesey, 2007; Pallazola et al., 2019).

2.2.4.1 Cholesterol

The two main blood lipids are triglycerides and cholesterol. These two blood lipid are borne on lipoproteins, the most vital of which are high-density lipoprotein (HDL) and low-density lipoprotein (LDL). Both blood lipids carry cholesterol, but it is high LDL-cholesterol levels that have been shown to be pro-atherogenic (Defesche et al., 2017; Karalis, 2009; Teramoto et al., 2010), whereas low levels of HDL-cholesterol are related to increased CVD morbidity and mortality (A. A. Lucero et al., 2014; D. Lucero, Neufeld, & Remaley, 2018; Mohtavinejad, Nakhaee, Harati, Poodineh, & Afzali, 2015).

Conversely, high HDL-cholesterol levels are related to reduced risk of CVDs (A. A. Lucero et al., 2014; D. Lucero et al., 2018; Mohtavinejad et al., 2015). In population studies, serum total cholesterol is regularly utilized as a surrogate for LDL-cholesterol levels; be that as it may, estimation of LDL-cholesterol concentrations confers more prominent predictive value for cardiovascular events (Teramoto et al., 2010).

High cholesterol levels usually have no symptoms, and people may not know that they have the condition unless they did a blood test (Witter et al., 2015). Therefore, the best way to ascertain the true prevalence of high cholesterol in the community is through fasting blood samples (Marzetti et al., 2018). An LDL-cholesterol level <100 mg/dL is considered optimal (N. J. Stone, Bilek, & Rosenbaum, 2005).

A survey done by the World Health Organization (WHO) found higher total cholesterol levels in urban (38%) than rural (35%), and an increased prevalence with age (30% among 18 to 35-year-olds vs. 44% for 50 to 65-year-olds) (World Health Organization, 2010).

2.2.4.2 Hypertension

Hypertension is a major risk factor for CVD (Witter et al., 2015). For every 20-mmHg increase in systolic or 10 mmHg increase in diastolic blood pressure, there is twice increase in deaths from both coronary heart disease (CHD) and stroke (Chobanian et al., 2003). Hypertension is linked with more years lived with CVD, shorter life expectancy free of CVD, and shorter overall life expectancy, (Franco, Peeters, Bonneux, & de Laet, 2005).

2.2.4.3 Diabetes

Triant et al. (2007) found a higher prevalence of Type 2 diabetes mellitus among PLHIV, compared to those who were HIV-negative (11.5% versus 6.6%; $P < 0.001$). Brown et al. (2005) also found PLHIV to be about four times more likely to develop Type 2 diabetes, compared with persons without HIV.

Antiretroviral therapy has been known as a key predictor of diabetes mellitus in PLHIV (Llabre et al., 2006); Larsson et al., 2006): about 10 percent of PLHIV on ART may present with diabetes mellitus (Calza et al., 2011; Kalra & Agrawal, 2013). HIV-infected persons also stand a chance of developing diabetes mellitus (Dagogo-Jack, 2008; Kalra et al., 2011). The clinical presentation of antiretroviral-associated diabetes mellitus is usually consistent with Type 2 diabetes (Dagogo-Jack, 2008; Kalra et al., 2011). However, some PLHIV may present with a form of Type 1 diabetes that is autoimmune-related resulting from an exaggerated immune response to ART treatment (Kalra et al., 2011; Takarabe et al., 2010).

2.2.5 Pathogenesis of CVDs among PLHIV

Enhanced inflammatory response underlying the mechanism of early development of atherosclerosis in HIV disease could be attributed to direct viral effects, host immune response to infection, or be secondary to metabolic dysfunction by HAART use (Grinspoon & Carr, 2005;

Marin-Palma, Castro, Cardona-Arias, Urcuqui-Inchima, & Hernandez, 2018; Saylor et al., 2016; Triant, Lee, Hadigan, & Grinspoon, 2007).

Many studies have indicated that HIV-infected macrophages and reservoir could adversely affect vascular and myocardial function through systemic release of inflammatory cytokines that control the immune response, including tumor necrosis factors, interleukins, and interferon (Brothers et al., 2009). Higher level of these cytokines in ART naive patients indicates the role of HIV infection per se rather than that of ART induced metabolic dysfunction. Lipid abnormalities in HIV infection are usually characterized by reduction in HDL and LDL cholesterol, and a substantial increase in triglycerides and very low-density lipoprotein (VLDL) (Haser & Sumpio, 2017; Safrin & Grunfeld, 1999).

Dyslipidemia linked with administration of protease inhibitors (PIs) is dependent specifically on the type of protease inhibitor. Generally, among protease inhibitors, ritonavir is the main ART agent that brings about dyslipidemia (Ballocca et al., 2016; Group, 2008; Maagaard & Kvale, 2009). Several theories exist for the mechanism of protease inhibitors in the display of dyslipidemia. The main effect of protease inhibitors is to prevent lipogenesis (the process that changes glucose to fatty acids) and adipocyte differentiation and to bring about lipolysis (the breakdown of fat) of subcutaneous fat in different mechanisms (Souza, Luzia, Santos, & Rondo, 2013).

Carr, Samaras, Chisholm, and Cooper (1998) postulated one discovered mechanism, which is based on the similarities among the chemical constructions of PIs and the catalytic area of HIV-1 protease, protein binding of retinoic acid cytoplasmic type I (CRABP-1-cellular retinoic acid binding protein 1), and LDL receptor-related protein (LRP). Two human body proteins-CRABP-1 and plasmatic lipoprotein lipase, which is an enzyme protein linked to the receptor for low-

density lipoprotein (LDL-R) - are involved in this mechanism (Carr, Samaras, Burton, et al., 1998). In general, these two proteins play a part in lipid metabolism via their linkage to these receptors (LDL-R), which catalyze lipids. In a competition, protease inhibitors attach to CRABP-1, which limits the activation of LDL-R, and thus the lipids cannot be broken down. As a result of the defect in lipid breakdown, a stream of lipids enters the blood circulation, resulting in hyperlipidemia. LDL-R suppressions result and worsen the hyperlipidemia grade and may lead to fat deposition in the neck and breasts, central obesity, IR, and DM type 2 (Carr, Samaras, Chisholm, et al., 1998).

The relative viro-immunological control in HIV has also been shown to be an independent predictor of cardiovascular lesions (Ho & Hsue, 2009; Milanini et al., 2017). Moreover, traditional risk factors for cardio-metabolic disorders such as smoking may be higher in prevalence among PLHIV as compared to that of general population (Katoto, Thienemann, Bulabula, Esterhuizen, Murhula, Lunjwire, Bihehe, & Nachega, 2018; C. Sabin, Friis-Moller, & Lundgren, 2007; Savès et al., 2003).

Therefore, one or several of these mechanisms may lead to a non-communicable disease or a cardiovascular disease.

2.2.6 Diet and CVD Risk

Nutrition plays a vital role in preventing and treating chronic conditions, such as CVD (Starrett, 2016). Increasing the consumption of saturated fats and sodium and decreasing the consumption of vegetables and fruits is associated with higher incidences of cardiovascular disease (Starrett, 2016). The American College of Cardiology/American Heart Association (ACC/AHA) Lifestyle Management Guideline suggests a diet that is higher in whole grains, fruits, and vegetables; moderate intake of low-fat dairy products, fish, poultry, non-tropical vegetables oils, nuts, and

legumes; and lower in intake of red meats, sugar-sweetened beverages and sweets(Eckel et al., 2014)

The Mediterranean Diet Score (MedDietScore) was used to assess diet quality and was then used to correlate with a calculated 10-year risk for developing a CVD event (Georgousopoulou, Panagiotakos, Pitsavos, Stefanadis, & Group, 2015). A high intake of Mediterranean foods correlated with lower CVD risk ($p<0.001$) (Georgousopoulou et al., 2015). These findings demonstrate the importance of diet quality when predicting CVD risk (Georgousopoulou et al., 2015). Other studies try to determine if certain components of the diet may be particularly important in predicting future health status.

Hung et al. (2004) investigated if fruit and vegetable intake affected incidences of cancer and cardiovascular disease. Two prospective cohorts that were free of 10 chronic diseases were given questionnaire that included questions about food frequency, lifestyle choices, and medical history at baseline. Follow-ups were completed to assess any changes in status of chronic diseases and other baseline variables. The results showed that increased fruit and vegetable consumption was inversely correlated to CVD (RR=0.70; P = 0.0003), with the strongest inverse relationship happening between leafy green vegetables and CVD (Hung et al., 2004). This study showed an association between the consumption of fruit and vegetables with lower incidences of CVD.

Another study examined the influence of changing diet scores on the short-term and long term risk for CVD in two cohorts: men from the Health Professionals Follow-up Study (n=29,343) and women from the Nurses' Health Study (n=51,195). Questionnaires on topics concerning medical history, lifestyle behaviours, and health information were given. Responses were analyzed using the Alternative Healthy Eating Index (AHEI-2010), the Alternative Mediterranean Diet score (aMED), and the Dietary Approach to Stop Hypertension (DASH). After a 4-year period,

improvements in diet quality of 11% to 22% were shown to lower CVD risk by 7%-8% compared to individuals who make no change to their diet quality (Sotos-Prieto et al., 2015). From baseline to year 4, those who started with the poorest diet quality scores and made the largest improvements had a 15% lower CVD risk compared to those who had the lowest adherence to diet scores (Sotos-Prieto et al., 2015). This showed that diet quality significantly influences CVD risk (Starrett, 2016). In a similar study, Reedy et al. (2014) researched the relationship between diets, using the following diet assessment methods: Healthy Eating Index–2010 (HEI-2010), AHEI-2010, aMED, and DASH, and all-cause, cardiovascular disease, and cancer mortality. This study used data collected from the National Institutes of Health and American Association of Retired Persons (NIH-AARP) Diet and Health Study, a prospective cohort (n=492,823). Participants were between the ages of 50 and 71 residing in 6 different states. The scores were 11 formulated from a 124-item food frequency questionnaire. There were comparable results across all five diet assessment methods. Men and women had a 12% to 28% decreased risk of all-cause, CVD, and cancer mortality when comparing those receiving top scores to those receiving low scores (Reedy et al., 2014). These findings, similar to the previous study, support that diet quality influences CVD risk. Multiple lifestyle factors influence CVD, along with diet (Starrett, 2016). Hulsegge et al. (2016) conducted a prospective cohort over 5 years, with an 8 to15 years of follow-up, that investigated the changes in lifestyle factors on CVD and all-cause mortality risk (n=5,263). Lifestyle factors, such as physical activity, diet, alcohol consumption, and cigarette smoking, were self-reported. Diet quality was evaluated from a validated 178 item semi-quantitative food frequency questionnaire. A 57% to 60% lower risk of CVD with a hazard ratio (HR) of 0.43 was observed in participants who maintained a healthy lifestyle profile over the 5-year period compared to those who maintained an unhealthy lifestyle. Each healthy lifestyle factor lost from baseline to follow-

up increased the risk of CVD to 35%, however it was not significant (Hulsegge et al., 2016). A 48% lower risk of CVD accompanied the transition from the classification of obesity to the classification of overweight or normal weight compared to remaining obese for an extended period of time. The study results concluded that the factors collected can increase an individual's susceptibility to CVD.

Thomson et al. (2011) evaluated the diet quality in the Lower Mississippi Delta region, a high-risk population. The diets intakes were collected using a 24-hour diet recall. The results showed differences between demographic groups (sex, race, age, income level, and education level) in the area. The top five dietary sources in each pre-determined food category were ranked 12 differently between these different groups. Among the groups, race and income seem to have less of an effect on dietary choices compared to age. The age of 60 years and above had a statistically significant higher score than the younger age groups (Thomson et al., 2011). The cross-sectional telephone survey targets the problematic eating habits among the population. The data collected allowed for the identification of the greatest contribution of energy across all demographics from the category of solid fats, alcoholic beverages and added sugars, as well as soft drinks. Salty snacks were also seen as a top selection in total and whole grains category which could be the culprit of the high sodium intake (Thomson et al., 2011).

2.2.7 Dietary Intake of PLHIV on ART

The diet quality of patients with HIV appears to be bad as compared with individuals without HIV (Joy et al., 2007), and a study has found that although the energy intake may be similar, the diet of PLHIV had a higher amount of saturated fat, and cholesterol (Klassen & Goff, 2013). The high fat consumption appears to be justified by the need for high energy food culminating from the increased basal metabolic rate and the influence of the virus and medications on hunger or satiety

control, in addition to alterations in taste perception and the poor nutritional guidance and counselling given to that population.

The effect of the intake of cholesterol and saturated fat on serum lipid levels and CVD development has been well documented in persons without HIV (Lichtenstein, 2006; Paul & Watson, 2015). A positive association between TG levels and saturated fat intake appears to be there in patients with HIV (Joy et al., 2007; P. Mirmiran, Hadavi, Mottaghi, & Azizi, 2018). Saturated fat is predominantly found in animal source food such as poultry, meat, pork, milk, sausage, and cheese (Talbot, 2016).

An investigation in persons with HIV has documented a positive association between dyslipidemia and high trans-fat intake (Shah et al., 2005). In that study population, the mean trans-fat ingestion got to 2% (Shah et al., 2005), whereas a diet with lower than 1% trans-fat consumption is endorsed (Fields-Gardner, Campa, & American Dietetics, 2010; Jacobson et al., 2014; National, 2002). The major contributors of trans-fat are bakery products such as cookies and breads, fried foods, and margarine. Also, the food industry often combines that type of fat to products to enhance their texture.

Dietary protective factors for persons with HIV comprise proteins (Fields-Gardner et al., 2010) and monounsaturated and omega-3 polyunsaturated fatty acids (PUFAs). But, some investigations have indicated that the consumption of those nutrients in persons with HIV is lower than current references (Shah et al., 2005). The major sources of unsaturated fat are olive oil, tuna, avocado, and salmon.

A meta-analysis of studies in persons who do not have HIV has clearly indicated opposite association between soluble fiber consumption and serum cholesterol levels (Truswell, 1999),

particularly as a result of increase in the elimination of biliary acids (Chandalia et al., 2000). A study conducted in Brazil has shown that individuals with HIV on antiretroviral therapy have high fat intake and reduced fiber intake (K. V. Giudici, A. C. Duran, & P. C. Jaime, 2013). The recommended daily fiber consumption is 10-25 g (Fihn et al., 2012).

With regard to micronutrients, a study done in Brazil has found low calcium intake (K. V. Giudici, A. C. F. L. Duran, & P. C. Jaime, 2013) in individuals with HIV on ART, whereas other studies have shown reduced intake of vitamins A, B6, C, and E (Woods et al., 2002). The reduced consumption of minerals and vitamins, worsened by a poor nutritional status, due to either overweight or malnutrition, can badly influence the immune system. Another Brazilian study on persons with HIV on ART has shown poor quality of their diet (A. C. Duran, L. B. Almeida, A. A. Segurado, & P. C. Jaime, 2008; Fields-Gardner et al., 2010).

Docosahexaenoic acid (n-3) polyunsaturated fatty acids (PUFAs) have proven to be beneficial. The beneficial effects of n-3 polyunsaturated fatty acids (PUFAs), primarily docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), were first known in the late 1960s when epidemiological evidence from the Inuit population, who took an n-3 PUFA-rich diet found that they have a reduced occurrence of myocardial infarction (D. Mozaffarian & Wu, 2011). Subsequently, a large number of randomized clinical trials have studied the effectiveness of supplementation with omega-3 PUFAs or fish oil (Albert, Cameron-Smith, Hofman, & Cutfield, 2013; Bowen, Harris, & Kris-Etherton, 2016; Kwak, Myung, Lee, Seo, & Korean Meta-analysis Study, 2012).

GISSI Prevenzione trial (GISSI-Prevenzione Investigators, 1999) was the first large-scale, randomized trial to show prove that dietary supplementation with omega-3 PUFAs had promising effects on hard clinical end-points in post myocardial infarction patients. The GISSI-HF trial (Romagna, 2008) also documented that omega-3 PUFAs could reduce morbidity and deaths in

persons with symptoms of chronic heart failure who were on standard treatments, such as aspirin, angiotensin-converting enzyme inhibitor/angiotensin receptor blockers, beta-blockers, and aldosterone receptor blockers.

Again, the JELIS study, a randomized large trial done in Japan, revealed that treatment with a pharmaceutical preparation of highly purified EPA in addition to statin significantly prevented cardiovascular events in patients with recent myocardial infarction through an apparently cholesterol-independent mechanism (Yokoyama et al., 2007). The results of the above-mentioned studies showed that omega-3 PUFA treatment is safe and well tolerated, and the clinical improvements observed were additive to those of other well established therapies (Endo & Arita, 2016).

Hence, in a scientific statement from the American Heart Association, the consumption of >1 g/day of omega-3 PUFAs (EPA+DHA; this was largely determined from the results of the GISSI-Prevenzione study) was advised for persons with coronary artery disease to lower triglyceride (TG) levels, keep cardiac function, and lower the risk of coronary heart disease (Kris-Etherton, Harris, Appel, & American Heart Association. Nutrition, 2002). And this can even be applied in the case of HIV.

2.3 cardiovascular disease risk estimation

Cardiovascular risk estimates are used to quantify risk of cardiovascular events and enable primary care providers to have a "risk discussion" with their patients to discuss preventative measures (Lloyd-Jones et al., 2019; Neil J Stone et al., 2014). There are over 10,000 publications on CVD risk prediction models, with about 360 different CVD risk prevention models identified (Damen et al., 2016). These risk models covered a variety of predicted outcomes, with a majority covering

coronary heart disease or cardiovascular disease, but some including other factors such as stroke and atrial fibrillation (Cho et al., 2020). Most of the measures have a shared core of common risk factors; smoking, blood pressure, cholesterol, age, and gender. One of the commonly utilized models is the Framingham risk score, which is used by medical providers to guide treatment approaches and for policymakers to prioritize where to invest with low risk (Damen et al., 2016).

The most commonly used measure of CVD risk was the Framingham CVD risk score, a cardiovascular risk estimate to help physicians advise their patients on CVD risk (D'agostino et al., 2008). This score was developed using data from a predominantly Caucasian American cohort in Framingham. The 2008 version builds on the Framingham Risk score developed by Wilson et al. (1998), and incorporates the most common traits Damen et al. (2016) identified: smoking, age, blood pressure, and blood cholesterol measurements. Diabetes was the next most frequent factor included, present in 52% of the models (Damen et al., 2016).

The 2008 score is different in several meaningful ways than the 1998 Framingham score. The 2008 score covers the 10-year likelihood of a cardiovascular disease event, defined as a "composite of coronary heart disease (coronary death, myocardial infarction, coronary insufficiency, and angina), cerebrovascular events (including ischemic stroke, hemorrhagic stroke, and transient ischemic attack), peripheral artery disease (intermittent claudication), and heart failure" (D'agostino et al., 2008). The 1998 model was focused on coronary heart disease only (Wilson et al., 1998). In addition, the 2008 model also incorporates whether participants are taking blood pressure medicine, while the 1998 model does not, which has been identified as a major shortcoming of other CVD risk prediction models (Liew, Doust, & Glasziou, 2011).

These risk scores may over or underestimate the risks of populations who have associations of risk factors with CVD that are not consistent with the sample population used to define the measure or the broader population (Jin, Gullick, Neubeck, Koo, & Ding, 2017).

2.4 A systematic review that determines the effect of ART on Cardiovascular Risk Factors among People Living with HIV (PLHIV) in Low and Middle-Income Countries (LMIC)

A systematic review is a type of literature review that uses systematic methods to gather secondary information, critically appraise research studies, and synthesize studies (Liberati et al., 2009). "Systematic reviews formulate research questions that are broad or narrow in scope, and identify and synthesize studies that directly relate to the systematic review question" (Pallazola et al., 2019). They are intended to provide a whole, thorough summary of current facts relevant to a research objective (Liberati et al., 2009). This provides a thorough knowledge on the topic and enable the researcher to perform searches of all relevant databases on the selected topic. This review was therefore done systematically to identify, synthesize and assess all available evidence, quantitative and or qualitative, in order to generate a robust, empirically derived answer to the said research topic.

2.4.1 Introduction to Systematic Review

As individuals with Human immunodeficiency syndrome (HIV) on combination antiretroviral treatment (Craftsmanship) are presently living longer, they are likely to obtain extra inveterate conditions related to ordinary maturing as well as from the impacts of HIV and its treatment (Kendall et al., 2014). The past decade has seen the rapid increase in

Antiretroviral Therapy (ART) coverage worldwide (Dimala et al., 2016). Globally, there are about 36.7 million people living and aging with HIV and 2.1 million becoming infected every year (World Health Organization, 2016).

Treatment coverage however, has more than doubled within the span of seven years, from 7.5 million (23.0%) in 2010 to 19.5 million (53.3%), and from 21% to 54% in Africa as of 2017 (World Health Organization, 2017). As life anticipation among HIV-infected individuals moves forward, it is pivotal to get it the long-term affect of HIV and its treatment (David G Dillon et al., 2013). HIV infection and ART are independently associated with an increased risk of cardiovascular diseases (David G Dillon et al., 2013).

In sub- Saharan Africa (SSA), this affiliation between ART and CVD has been bewildered by the epidemiological move characterized by the expanded predominance and frequency of non-communicable maladies due to changes in way of life designs (Dimala et al., 2016). Understanding the overall impact of Art on VD risk is hence of open wellbeing significance since the nonstop Art scale-up has got to go with by appropriate rules and measures to guarantee the long-term decreased morbidity and mortality of these patients isn't contrarily influenced, particularly in low-income and middle-income nations with wellbeing frameworks insufficiently prepared to oversee these constant con ditions in Sub-Saharan Africa (Dimala et al., 2016; Negin, Mills, & Bärnighausen, 2012), and for that matter the Low and Middle Income Countries. And there is some evidence that suggests that there may be differences in cardio-metabolic risk profiles in people of African descent compared with people of European descent (Schutte et al., 2010; Triant et al., 2007) . This systematic review and meta-analysis of published data was conducted to re-assess the associations between ART and CVD risk factors among PLHIV in Low and Middle-Income Countries.

2.4.2 Objectives of the review

2.4.2.1 Primary Objectives

The main objective of the review was to investigate the effect of ART on CVD risk factors (diabetes, dyslipidemia, hypertension) among PLHIV in LMIC aged 18 years and above.

2.4.2.2 Secondary Objectives

Specific objectives of the systematic review and meta-analysis were:

1. To estimate overall measures of effect for the association between ART and hypertension in PLHIV
2. To estimate overall measures of effect for the association between ART and diabetes in PLHIV
3. To estimate overall measures of effect for the association between ART and dyslipidaemia in PLHIV
4. To estimate overall measures of effect for the association between ART and obesity in PLHIV

2.4.3 Systematic Review Methods

2.4.3.1 Settings

The study setting was Low and Middle-Income Countries

2.4.3.2 Design

The review used a quantitative approach to review evidence on the relationship between antiretroviral treatment and cardiovascular risk factors. The focus was to understand whether PLHIV who receive ART medication for at least 6 months have increased risk of cardiovascular diseases (hypertension, diabetes, and dyslipidemia) compared with PLHIV who are not on ART medication.

The protocol for the systematic review and meta-analysis was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (ID: CRD42018084661).

2.4.3.5 Search Strategy

The criteria for including studies in the review followed the PICOs format.

2.4.3.6 Peer review literature

Using appropriate search terms/key words, a comprehensive search for peer review literature was conducted in various electronic databases listed below: Google Scholar, PubMed, Scopus, and Cochrane Central. These databases were purposively selected, as they are known to "house" the majority of journals on HIV and cardiovascular diseases.

Table 2: Keywords used in literature search

PICO	Search Terms
Population	HIV OR HIV+ OR HIV positive OR HIV patients OR PLHIV OR PLWHA OR AIDS patients OR HIV$
Intervention	Antiretroviral therapy OR Antiretroviral Therapy OR ART OR Nucleotide reverse transcriptase inhibitor OR NRTI OR Non-nucleoside reverse transcriptase inhibitor OR NNRTI OR Protease inhibitor OR PI OR PIs OR lopinavir OR ritonavir OR lamivudine OR

	zidovudine OR stavudine OR nevirapine OR efavirenz OR tenofovir OR emtricitabine OR atazanavir OR darunavir
Comparator	People living with HIV who are ART naïve
Outcome	Cardiovascular risk factors OR cardiovascular diseases OR hypertension OR high blood pressure OR systolic blood pressure OR diastolic blood pressure OR SBP OR DBP OR diabetes mellitus OR diabetes OR type 2 diabetes mellitus OR diabetic OR type 2 diabetic OR dysglycemia OR dysglycaemia OR hyperglycemia OR hyperglycaemia OR glucose OR insulin resistance OR insulin OR hyperinsulinemia OR dyslipidemias OR dyslipidemia OR hyperlipidemia OR hypercholesterolemia OR hypertriglyceridemia OR cholesterol OR triglyceride OR triglycerides OR HDL OR LDL OR VLDL OR hyperlipoproteinemia OR lipoprotein OR hyperlipidaemia OR hypercholesterolaemia OR hypertriglyceridaemia.

PICO = Population, Intervention, Comparator, and Outcome

2.4.3.7 Selection of papers

Papers were screened for their relevance before they were included in the review. Screening took place at three stages:

1. One reviewer first screened the titles of all papers to determine their relevance. A second reviewer did a cross check of the tittle screening to ensure that only papers with titles that qualify are included in stage two of the screening

2. In the second stage, abstracts of all the papers selected after the title screening stage were screened by two reviewers, paying attention to the review question, inclusion criteria and the outcome of interest.
3. Full texts of potentially qualifying papers were then printed out and read by two reviewers to ascertain the relevance and usefulness to the review. A spread sheet was used to enter the appropriate relevant information for each paper during the screening process.

   To minimize inter-observer variability in the screening and coding process, several measures including discussions to clarify any points of contention or disagreement in the selection of the papers were put in place.

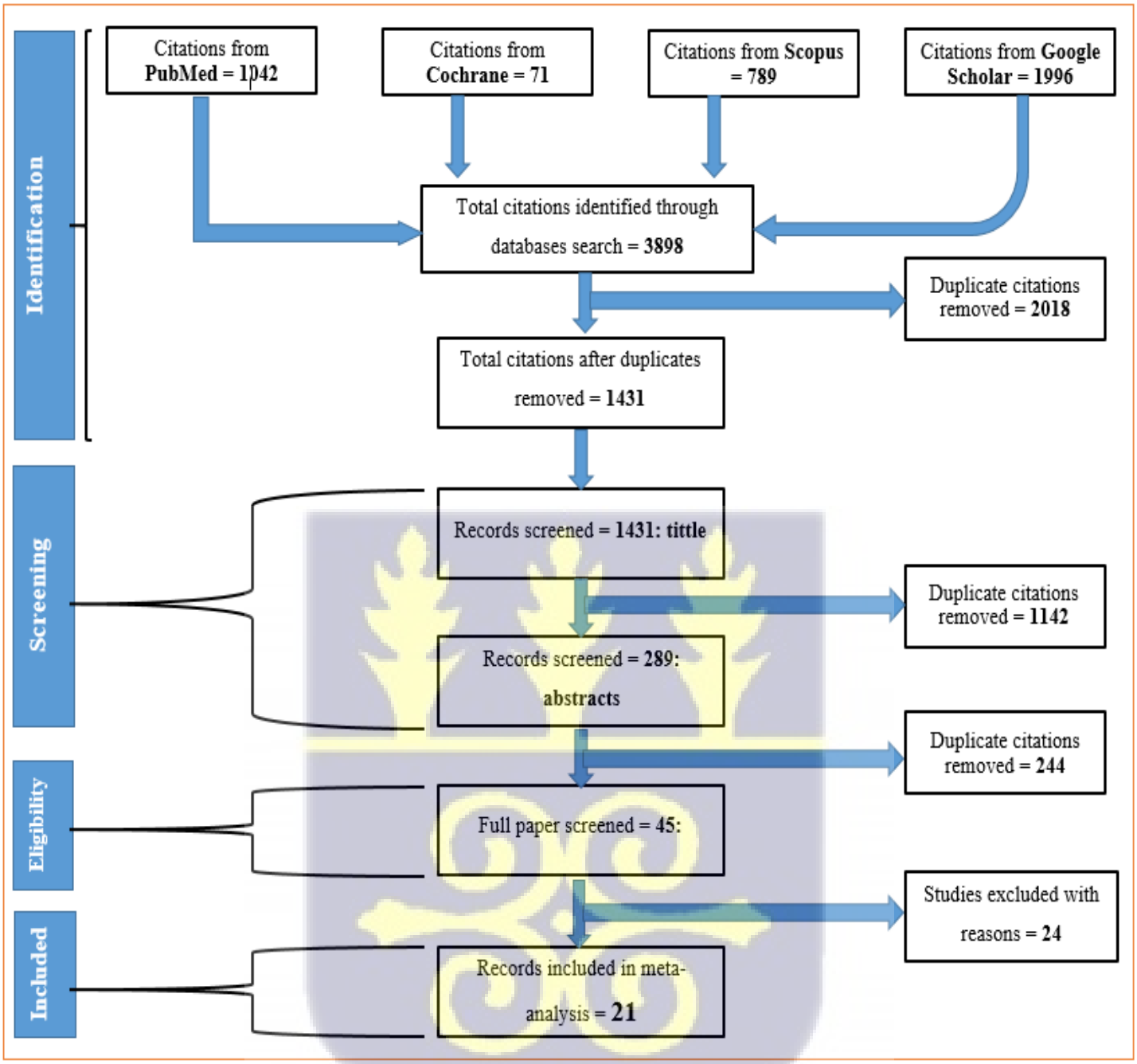


Figure 4: Flow diagram of study selection procedure

2.4.3.8 Data Extraction and management

Data extraction form was developed and piloted among participating authors to ensure that authors are achieving comparable results. The form was used by two independent reviewers to extract the relevant information from the selected studies. The data collected on the extraction form included;

Author, year of publication, study title, Design type, geographic area and setting, patient sampling & locations, age, sex, sample size, ART use, hypertension, diabetes, dyslipidemia, overweight, and obesity

Duplicate records were identified using Endnote x9 reference manager. In instances where multiple articles were reported on the same study, data were extracted from the one with the latest publication.

2.4.3.9 Measurement of effect

Outcomes were reported as risk factors that were summarized as percentages at 95% confidence interval. Prevalence of CVD risk factors (dyslipidemia, hypertension, and diabetes) were determined to ascertain the prevalence ratios or relative risk of developing these co-morbidities among ART+ and ART-.

2.4.3.10 Dealing with missing data

As possible, original researchers were contacted to ask for any detected missing data. Missing data were handled with replacement values based on predicted values from regression analysis.

2.4.3.11 Data Synthesis

Data was analyzed using Review Manager 5.3 statistical software. Owing to the likelihood of heterogeneity among the studies, random effects meta-analysis models was rather reported instead of fixed-effects models. Odds Ratios comparing the ART+ and ART− groups were calculated and summarized. The exposure variable was ART use and the outcome variable was the respective

cardiovascular risk factors: diabetes, hypertension, dyslipidemia. These outcomes were defined according to the standard international criteria.

Eligible studies were evaluated for the quality of their prove and chance of bias by two autonomous reviewers with regard to: imperfections in think about plan, comparability of the ART+ and ART− groups, inadequately measured or managed confounders, determination of associations at bivariate or multivariate levels of analysis, inaccuracies in the measurements of the key indicators such as diabetes, hypertension, obesity, and dyslipidemia or inappropriate diagnostic cut-off values.

2.4.3.12 Sensitivity Analysis

Sensitivity analyses was performed to explore the influence of non-eligible studies on effect sizes. This was done by doing the meta-analysis of the data twice. First analysis included all studies, and second analysis included only those that were known to be eligible.

2.4.3.13 Findings of the systematic review and meta-analysis

2.4.3.13.1 Study Characteristics

The characteristics of studies included are outlined in **Table 2** and were published from 2007 to 2018. Participants (n = 12,229) consisted of HIV positive persons who were on ART and HIV positive persons who were not on ART, males and females aged between 18-75. All the studies were conducted in eight (8) Low and Middle-Income Countries (LMIC). Sixteen (16) studies used a cross-sectional study design, three (3) used cohort study design, and one (1) case-control study design, in which the intervention was use of ART.

Table 3: Study Characteristics in the study

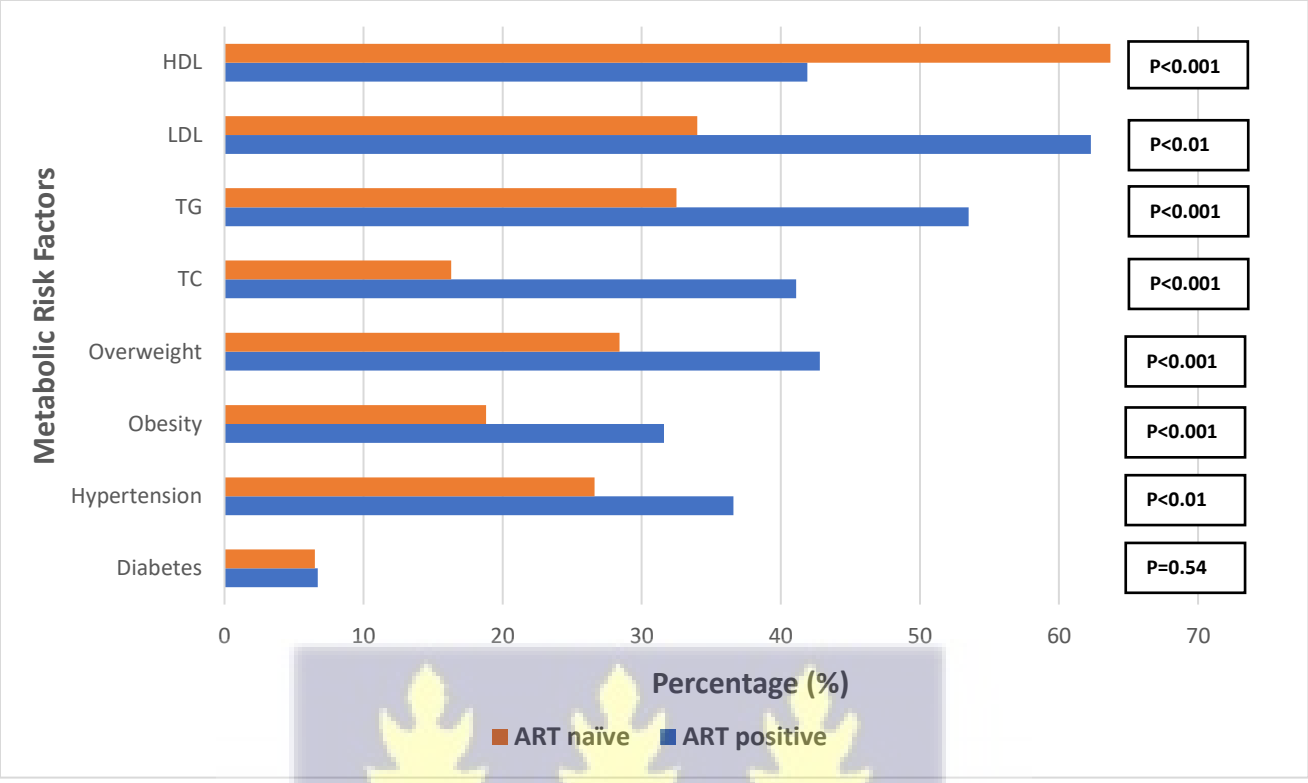
Author	Year	Age Range	Male	Female	Country	Location	Study Design	Sample Size
Fred Stephen Sarfo et al.	2018	30 - 75	132	569	Ghana	Facility	Cross Sectional	701
IndumatI V et al.	2013	≥20	127	73	India	Facility	Case-Control	200

Nirdesh Jain et al.	2013	>18	66	19	India	Facility	Cross Sectional	80
carey RAB et al.	2013	≥20	100	96	India	Facility	Cross Sectional	196
Gibson B. Kagaruki et al.	2011	>18	317	354	Tanzania	Facility	Cross Sectional	671
Annie Phoebe Kalyanasundaram et al.	2007	>18	167	195	India	Facility	Cross Sectional	363
Jureeporn Jantarapakde et al.	2014	>18	268	312	Thailand	Community	Cross Sectional	580
E. M Manuthu et al.	2006	≥20	124	171	Kenya	Facility	Cross Sectional	295
Abdurehman eshete Mohammed et al.	2014	21 -75	133	270	Ethiopia	Facility	Cross Sectional	403
Joel A. Dav et al.	2012	20 - 50	196	653	South Africa	Facility	Cross Sectional	849
Piconi, Stefania et al.	2012				Uganda	Facility	Cross Sectional	79
Solomon Mekonnen Abebe et al.	2013	<20	147	320	Ethiopia	Facility	Cross Sectional	467
Emmanuel Maganga et al.	2013	>18	156	298	Tanzania	Facility	Cohort	454
Jennifer Manne-Goehler et al	2014	>40 years			South Africa	Community	Cohort	4547
Robert N Peck	2012	>18	156	298	Tanzania	Facility	Cross Sectional	454
Naomi S Levitt et al.	2013	>18	331	549	South Africa	Community	Cross Sectional	880
Alfred Osoti et al.	2014	>18	108	192	Kenya	Facility	Cross Sectional	300
Justin R Kingery et al.	2012	>18	156	298	Tanzania	Facility	Cross Sectional	454
Eduardo Rodrı´guez-Arbolı et al.	2013	>18	34	46	Tanzania	Community	Cohort	80
Piconi, Stefania et al.	2012				Uganda	Facility	Cross Sectional	79
JoelA.Dave et al.	2015	>18	97	0	South Africa	Facility	Cross Sectional	97

2.4.3.13.2 Prevalence of the Cardio-metabolic Risk Factors among ART positive and ART-naïve

Figure 3 shows the prevalence of CVD risk factors among ART positive and ART-naïve patients.

The prevalence of all the CVD risk factors except diabetes are higher among ART positives.



ART: Antiretroviral therapy; HDL: High density lipoprotein; LDL: Low density lipoprotein; TG: Triglycerides; TC: Total cholesterol

Figure 5: Pooled prevalence of metabolic risk factors among ART naïve and ART patients

2.4.3.13.3 Effect of ART on the prevalence of Obesity

Nine studies assessed the impact of ART on obesity (Abebe et al., 2016; Carey, Rupali, Abraham, & Kattula, 2013; Kingery et al., 2016; Maganga et al., 2015; Manne-Goehler et al., 2019; Piconi et al., 2013; Sarfo, Nichols, Agyei, et al., 2019). Being on ART was found to significantly increase the risk of obesity (RR=1.45, 95% CI: 1.29-1.63; Z = 6.35, p<0.001; I^2 = 88%).

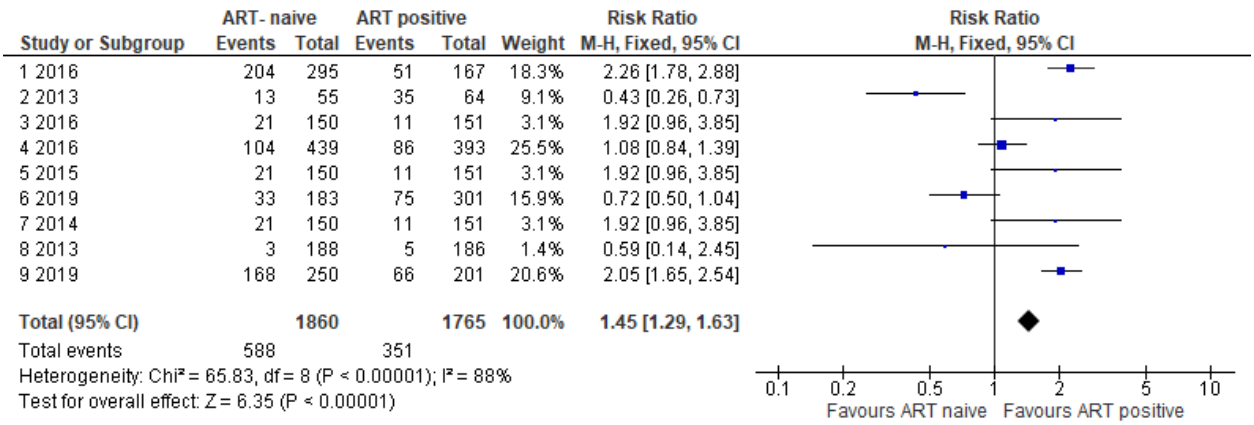


Figure 6: Obesity prevalence forest plot for PLHIV on ART versus PLHIV but ART-naïve

2.4.3.13.4 Effect of ART on the prevalence of Diabetes

Fifteen studies assessed the impact of ART on diabetes (Abebe et al., 2016; Dave et al., 2011; Dave et al., 2016; Jain et al., 2013; Jantarapakde et al., 2014; Kingery et al., 2016; Levitt et al., 2016; Maganga et al., 2015; Manne-Goehler et al., 2019; Mohammed, Shenkute, Gebisa, targets, & therapy, 2015; Osoti et al., 2018; Peck et al., 2014; Piconi et al., 2013; Sarfo, Nichols, Agyei, et al., 2019). There was no significant association between being on ART and risk of diabetes (RR=0.88, 95% CI: 0.58-1.33; Z = 0.61, p=0.54, I^2 = 72%).

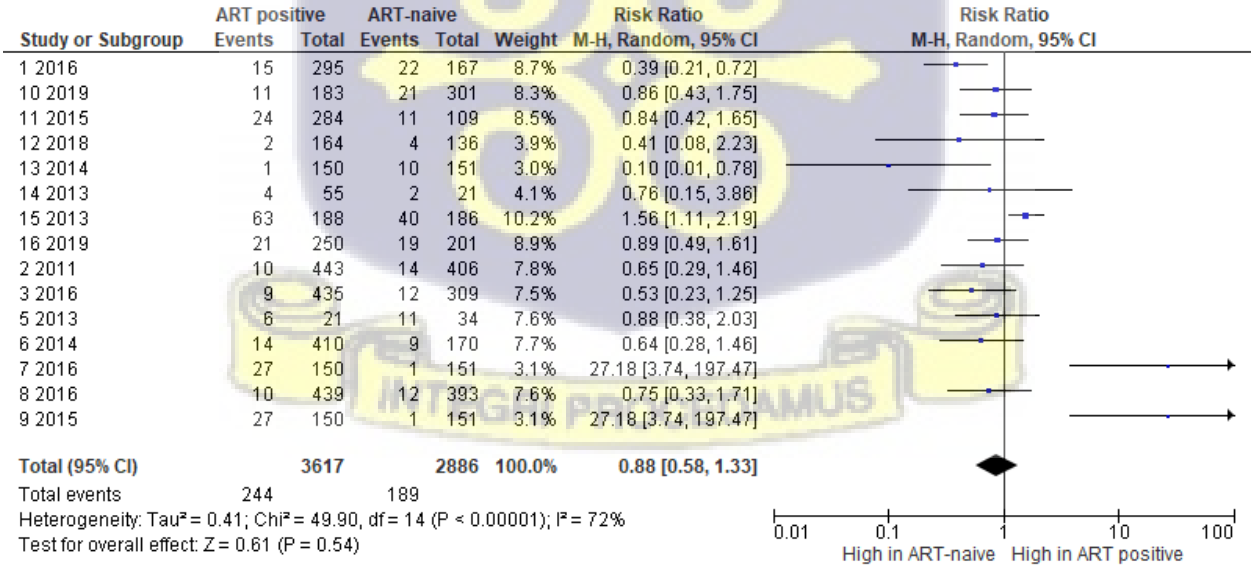


Figure 7: Diabetes prevalence forest plot for PLHIV on ART versus PLHIV but ART-naive

2.4.3.13.5 Effect of ART on the prevalence of Hypertension

Ten studies assessed the impact of ART on Hypertension (Carey et al., 2013; Jantarapakde et al., 2014; Kingery et al., 2016; Manne-Goehler et al., 2019; Peck et al., 2014; Piconi et al., 2013; Rodríguez-Arbolí, Mwamelo, Kalinjuma, Furrer, Hatz, Tanner, Battegay, Letang, & one, 2017; Sarfo, Nichols, Agyei, et al., 2019). Being on ART was found to significantly increase the risk of hypertension (RR=1.74, 95% CI: 1.21-2.50; Z = 2.99, p<0.01, I^2 = 92%).

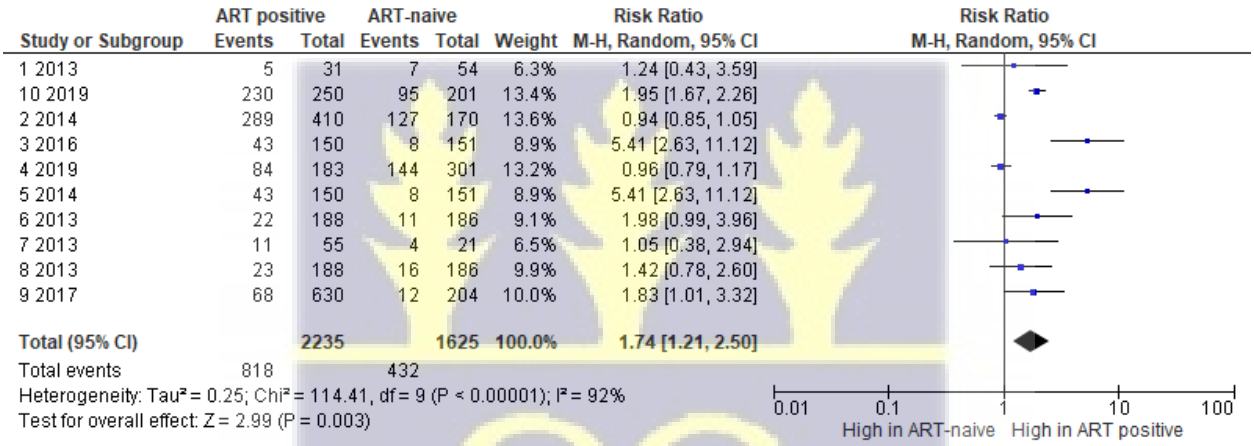


Figure 8: Blood Pressure prevalence forest plot for PLHIV on ART versus PLHIV but ART-naïve

2.4.3.13.6 Effect of ART on the prevalence of High Triglycerides

Eight studies assessed the impact of ART on triglyceride (Carey et al., 2013; Indumati et al., 2014; Jain et al., 2013; Jantarapakde et al., 2014; Gibson B Kagaruki et al., 2014; Kalyanasundaram, Jacob, Hemalatha, & Sivakumar, 2012; Piconi et al., 2013; Sarfo, Nichols, Agyei, et al., 2019). Intake of ART was found to significantly increase the risk of high triglycerides (RR=1.64, 95% CI: 1.50-1.80; Z = 10.4, p<0.01, I^2 = 77%).

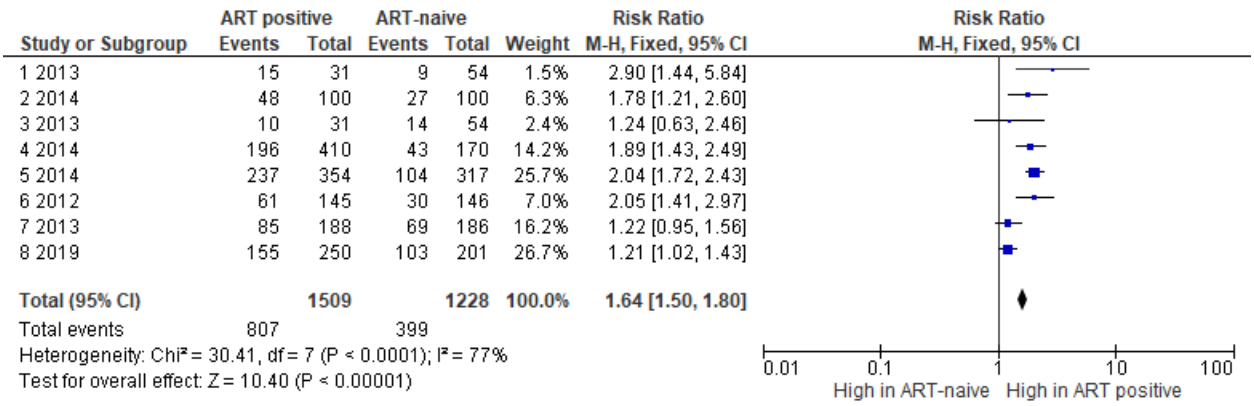


Figure 9: High Triglyceride prevalence forest plot for PLHIV on ART versus PLHIV but ART-naive

2.4.3.13.7 Effect of ART on the prevalence of Total Cholesterol (TC)

Eight studies assessed the impact of ART on Total Cholesterol (Carey et al., 2013; Indumati et al., 2014; Jain et al., 2013; Jantarapakde et al., 2014; Gibson B Kagaruki et al., 2014; Kalyanasundaram et al., 2012; Piconi et al., 2013; Sarfo, Nichols, Agyei, et al., 2019). Intake of ART was found to significantly increase the risk of High Cholesterol (RR=2.72, 95% CI: 1.75-4.23; Z = 4.46, p<0.01, I^2 = 85%).

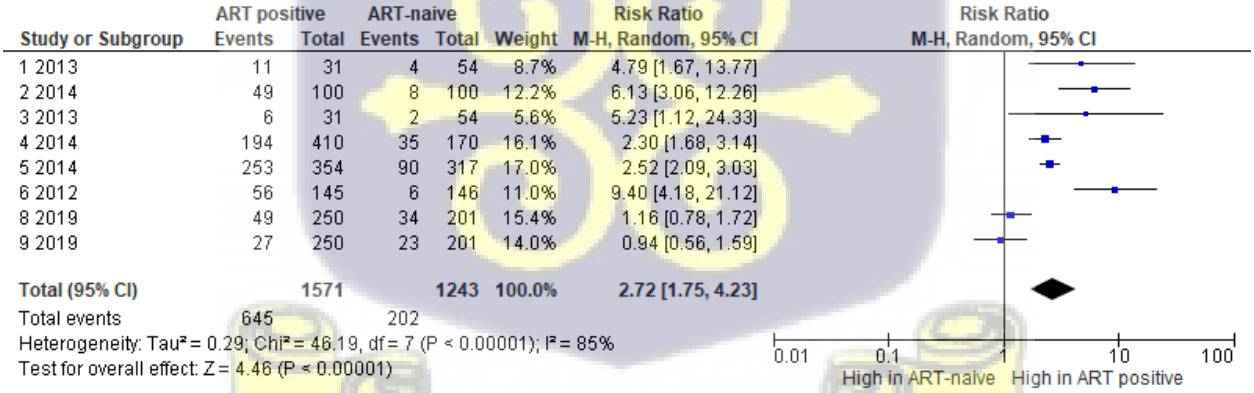


Figure 10: Total Cholesterol prevalence forest plot for PLHIV on ART versus PLHIV but ART-naive

2.4.3.13.8 Effect of ART on the prevalence of High LDL Cholesterol

Eight studies assessed the impact of ART on LDL Cholesterol (Carey et al., 2013; Indumati et al., 2014; Jain et al., 2013; Jantarapakde et al., 2014; Gibson B Kagaruki et al., 2014; Kalyanasundaram et al., 2012; Manuthu, 2007; Sarfo, Nichols, Agyei, et al., 2019). Intake of ART was found to significantly increase the risk of High LDL Cholesterol (RR=2.72, 95% CI: 1.75-4.23; Z = 4.46, p<0.01, I^2 = 85%).

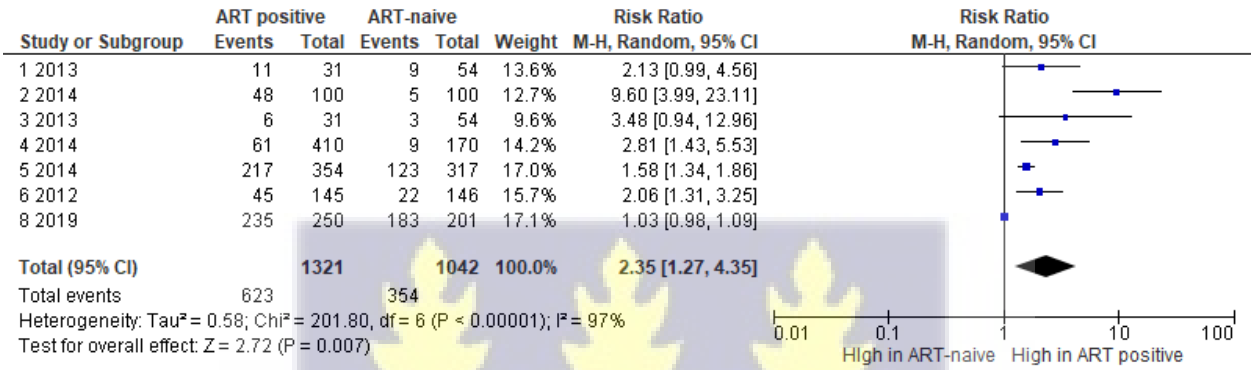


Figure 11: High LDL prevalence forest plot for PLHIV on ART versus PLHIV but ART-naive

2.4.3.13.9 Effect of ART on the prevalence of High HDL Cholesterol

Eight studies assessed the impact of ART on LDL Cholesterol (Carey et al., 2013; Indumati et al., 2014; Jain et al., 2013; Jantarapakde et al., 2014; Gibson B Kagaruki et al., 2014; Kalyanasundaram et al., 2012; Manuthu, 2007; Sarfo, Nichols, Agyei, et al., 2019). Intake of ART was found to significantly increase the risk of High LDL Cholesterol (RR=0.65, 95% CI: 0.58-0.77; Z = 5.48, p<0.01, I^2 = 71%).

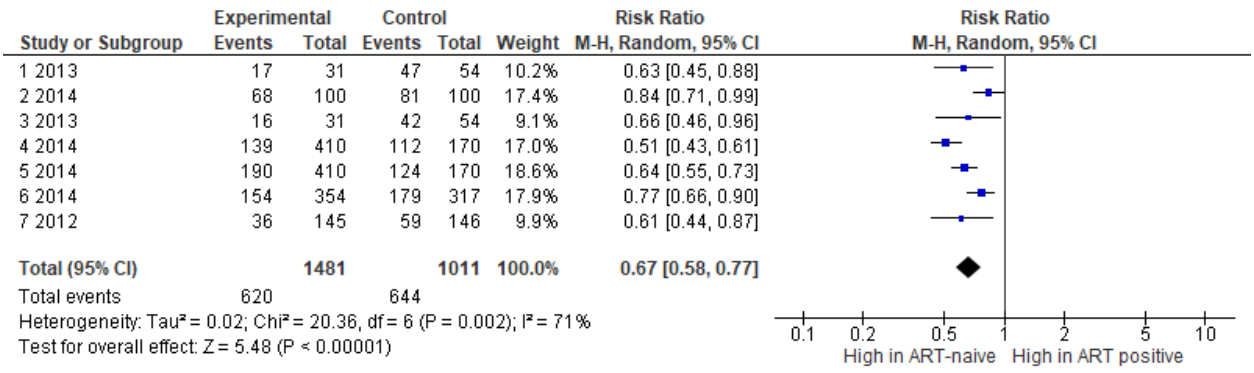


Figure 12: High HDL prevalence forest plot for PLHIV on ART versus PLHIV but ART-naïve

2.4.3.14 Discussion of key findings

This study aimed to evaluate the effect of ART exposure on CVD risk factors in low and middle-income countries by reviewing published studies with measures of effect on the association between ART and CVD risk factors (diabetes, hypertension, dyslipidemia, and obesity) and deriving corresponding pooled estimates of these measures via meta-analysis. Except diabetes, the review found significant association between ART and the CVD risk factors (obesity, diabetes, hypertension, dyslipidemia).

The average risk of CVD for PLHIV receiving ART was found to be 1.80 times greater than the risk for PLHIV who were treatment-naïve. There is controversy regarding the type of ART in terms of the degree of risk of CVD. Quite recently, systematic review, ART did not seem to increase the risk of hypertension among PLHIV (Dimala, Blencowe, & Choukem, 2018). But, other studies have shown noticeably increased risk of CVD connected with PI-based ART.

There was no significant association between ART use and diabetes. This finding is similar to that earlier reported by Dimala et al. (2018) and D. G. Dillon et al. (2013) who did not observe any association between ART use and fasting blood glucose levels in SSA. Some large prospective studies have reported an association between ART and diabetes (Brown et al., 2005; De Wit et al.,

2008; P. C. Tien et al., 2007). and the studies by Brown et al. (2005) and Phyllis C Tien et al. (2007) had HIV-uninfected patients as control subjects making it difficult to attribute the detected association solely to ART utilization given the fact that HIV infection itself has been associated to some extent with diabetes (Bastard et al., 2019; Mondal et al., 2020). Also, the large cohort study consisted of participants from North and South America, Europe and Australia but not LMIC (Zanetti, Roever, Gonçalves, & Resende, 2018), raising up the question of whether the effect of ART on glucose metabolism varies with ethnicity. Even though the studies with evidence of no association between ART use and diabetes were of higher quality than those that found an association, the meta-regression analysis did not identify the studies' quality as a possible explanation for the heterogeneity in the studies.

There was a significant statistical association between ART and hypertension. Patients on ART were found to have about 75% higher odd of having hypertension compared to their ART naïve counterparts, this is comparable with a study by Dimala et al. (2018) which found a 90% odds of having hypertension among ART patients than ART-naïve patients. One study that found no association between ART and hypertension also reported that the prevalence of hypertension increased significantly as treatment duration increased (Ekali et al., 2013). As such, the inclusion of patients on ART for very short durations in that study and the inclusion of such studies with low median ART durations in our analyses could have contributed to diminishing the observed effect of ART on blood pressure (Dimala et al., 2018). This was earlier mentioned by studies which suggested that the effects of ART on blood pressure are best appreciated after prolonged exposure to ART (Palacios et al., 2006; Seaberg et al., 2005). Another systematic review study that was conducted in 2016 also found a significantly higher risk of hypertension associated with ART use worldwide (CU Nduka, Saverio Stranges, AM Sarki, PK Kimani, & OA Uthman, 2016). The

effect of ART on blood pressure should be considered and addressed with other factors such as genetic, environmental factors and lifestyle predispositions to hypertension.

There was a strong association between ART use and abnormal lipid parameters implying that patients on treatment are at a greater risk of having these CVD risk factors. ART-exposed patients had significantly higher concentrations of low density lipoprotein-cholesterol, total cholesterol, and triglycerides compared with ART-naïve patients. These findings are largely consistent with those of a recent review associating ART to dyslipidemia (Dimala et al., 2018; E. R. Feeney & P. W. Mallon, 2011; Nduka, Sarki, Uthman, & Stranges, 2015). D. G. Dillon et al. (2013) in the review in SSA found no association between ART and high TG, and explained this was probably due to the relatively greater use of NNRTI-based regimes compared to PI based regimens, known to induce more dyslipidemia (D. G. Dillon et al., 2013).

Most studies did not report the precise extents of patients on particular Art regimens to enable us to survey affiliations between specific Art agents andthe individual CVD risk factors but numero us studies detailed the use of NNRTIs over PIs as is right now the case with first-line regimens in SSA (Dimala et al., 2018). Associations of greater magnitude could therefore be observed in settings with predominantly PI-based regimens which have been identified as inducing more extreme dyslipidemic profiles compared to NNRTIs (E. R. Feeney & P. W. J. T. o. c. m. j. Mallon, 2011; Hill, Sawyer, & Gazzard, 2009; Sension & Deckx, 2015).

“Several mechanisms have been proposed as possible pathways through which ART could lead to this multitude of metabolic abnormalities including chronic inflammation due to the HIV infection itself, increased circulating inflammatory markers and cytokines involved in insulin and lipid regulation” (Grunfeld et al., 1992; Hadigan & Kattakuzhy, 2014). The association of ART to particular CVD risk factors instead of others always suggests that the overall effect of ART in

HIV/AIDS patients depends on the complex interplay and combination of several factors such as environmental predispositions and genetic (Dimala et al., 2018).

Nine studies assessed the impact of ART on obesity; six of the studies reported higher prevalence of obesity PLHIV on ART (Abebe et al., 2016; Kingery et al., 2016; Levitt et al., 2016; Maganga et al., 2015; Peck et al., 2014; Sarfo, Nichols, Agyei, et al., 2019), and three reported higher obesity prevalence among ART-naïve (Carey et al., 2013; Manne-Goehler et al., 2019; Piconi et al., 2013). Overall, being on ART was found to increase significantly the risk of obesity compared to ART-naïve with an increased odd of 45%.

In conclusion, HIV/AIDS patients should benefit from systematic CVD screening for CVD risk factors in addition to their regular care and counseling services.

CHAPTER THREE

3.0 METHODS

3.0 Introduction

In this chapter, different study approaches were carried out to answer the research questions. The chapter, therefore, presents the detailed description of the topics and sub-topics such as study area profile, study design and participants' allocation, study participants and their eligibility criteria. It includes sample size determination and sampling procedures, data collection tool, procedures and related activities, study variables, quality assurance measures, intervention description and implementation. The data processing and analysis methods descriptions, ethical considerations and study findings dissemination plan are also presented

3.1 Study design

A multi-method study was conducted; a systematic review and meta-analysis was conducted to ascertain the effect ART on CVD risk factors (which is reported in details under Chapter 2), and a facility-based analytical cross-sectional design study.

The facility-based analytical cross-sectional design was adopted because of the nature of the research objectives. In a cross-sectional study, the investigator measures the outcome and the exposures in the study participants at the same time (Setia, 2016). Participants in a cross-sectional study are selected based on the inclusion and exclusion criteria set for the study (Setia, 2016). Once the participants have been selected for the study, the investigator follows the participants to assess the exposure and the outcomes (Setia, 2016). Cross-sectional designs are appropriate to assess the prevalence of diseases in clinic-based samples (Setia, 2016). Cross-sectional design is

therefore apt for this research. Moreover, there is a repletion of studies that have used cross-sectional design to assess these parameters (Carey et al., 2013; Choi et al., 2019; Indumati et al., 2014; Gibson B Kagaruki et al., 2014; Kuwabara et al., 2018; Sarfo, Nichols, Agyei, et al., 2019)

3.2 Philosophical Foundations of the Study

An important consideration in any research process is the philosophical underpinnings of the study as this provides the foundation upon which the study is conducted. The two important philosophical issues to consider in designing a study are ontology and epistemology (Teddlie, Tashakkori, & research, 2010). Ontology refers to the form and nature of the reality that the researcher investigates and how this reality can be measured. Epistemology on the other hand, examines the relationship between the researcher and what is being researched (Creswell, Fetters, Plano Clark, Morales, & sciences, 2009). These philosophical paradigms therefore often influence the design of the study and the methodology that is often employed to acquire the knowledge that the research sets to investigate.

The concept of ontology often leads to dichotomy in study designs (quantitative and qualitative) with a most recent design that combines these two strategies. Quantitative study design operates on the positivist philosophy that holds the view that reality is one, fixed and can therefore be measured by following a set of laid down objective procedures. Qualitative study designs on the other hand operates on the interpretivist philosophy that views reality as subjective and multiple, as seen by participants in the study (Bernard, 2017).

The concept of epistemology on the other hand looks at how the knowledge is acquired by examining the relationship between the researcher and the researched. In adopting the positivist

approach to research, which is the quantitative, the researcher embarks on the study of the reality by maintaining a distance between him/herself and the researched. Contrarily to this approach, researchers who hold the view of interpretivists (qualitative) adopt strategies which will lessen the distance between him/herself and what is being studied (Creswell et al., 2009).

Guided by these philosophical stands, my ontological view regarding diet quality and cardiovascular disease risk factors among PLHIV is that, the reality could vary between individuals as experiences may vary and be shaped by the society one lives in. However, it is still possible to measure this reality with some level of objectivity. In measuring this reality (socio-cultural and health system) factors affecting diet quality and cardiovascular disease risk factors, one needed to get closer to the situation to be able to gain a deeper understanding of the situation. This has therefore led to the adoption of the mixed quantitative approach for this research as it also allows for objective measurement of the situation.

3.3 Study Location

The study was conducted in the Lower Manya Krobo Municipality, one of the twenty-one districts and municipalities in the Eastern Region of Ghana. The first case of confirmed HIV/AIDS in Ghana in 1986, was from Lower Manya Krobo Municipality (Owusu & Laar, 2018). According to the 2016 HIV Sentinel survey report, Eastern Region has the second highest HIV prevalence rate of 2.6%, only second to Volta Region and Brong Ahafo Region with a prevalence of 2.7% each ("Ghana AIDS Commission," 2018). In 1999, the prevalence rate for Agomenya was 13%, which was about four times the then national prevalence of 3% (Ghanaweb, 2013; NACP, 2003)

The Lower Manya Krobo Municipality has a total population of 89,246 and about 58 percent of the population are adults (Ghana Statistical Service, 2012). Dwellers of this municipality largely engage in farming and fishing. Two hospitals in the Municipality were used; St. Martins De Porres Hospital at Agormanya and Atua Government Hospital at Atua. These two hospitals provide a specialized HIV care in the Municipality.

3.3.1 Research setting

Ghana is located on the West Coast of Africa and has a total land area of 238,538 square kilometers. It is bordered by three Francophone Countries; Togo to the east, Burkina Faso to the north and northwest and Cote d'Ivoire to the west. To the south is the Gulf of Guinea which has a coastline of 560 kilometers. The country is divided into 16 administrative Regions; North East, Oti, Bono East, Savannah,Western, Central, Greater Accra, Volta, Upper East, Upper West, Eastern, Ashanti, Brong Ahafo, Northern, Ahafo, and Western North. The regions are subdivided into districts (Ghana Statistical Service, 2019). Ghana achieved the World Bank Group (WBG) per capita threshold classification as a Low-Middle Income Country (LMIC) on July 2011 (World Bank, 2015).

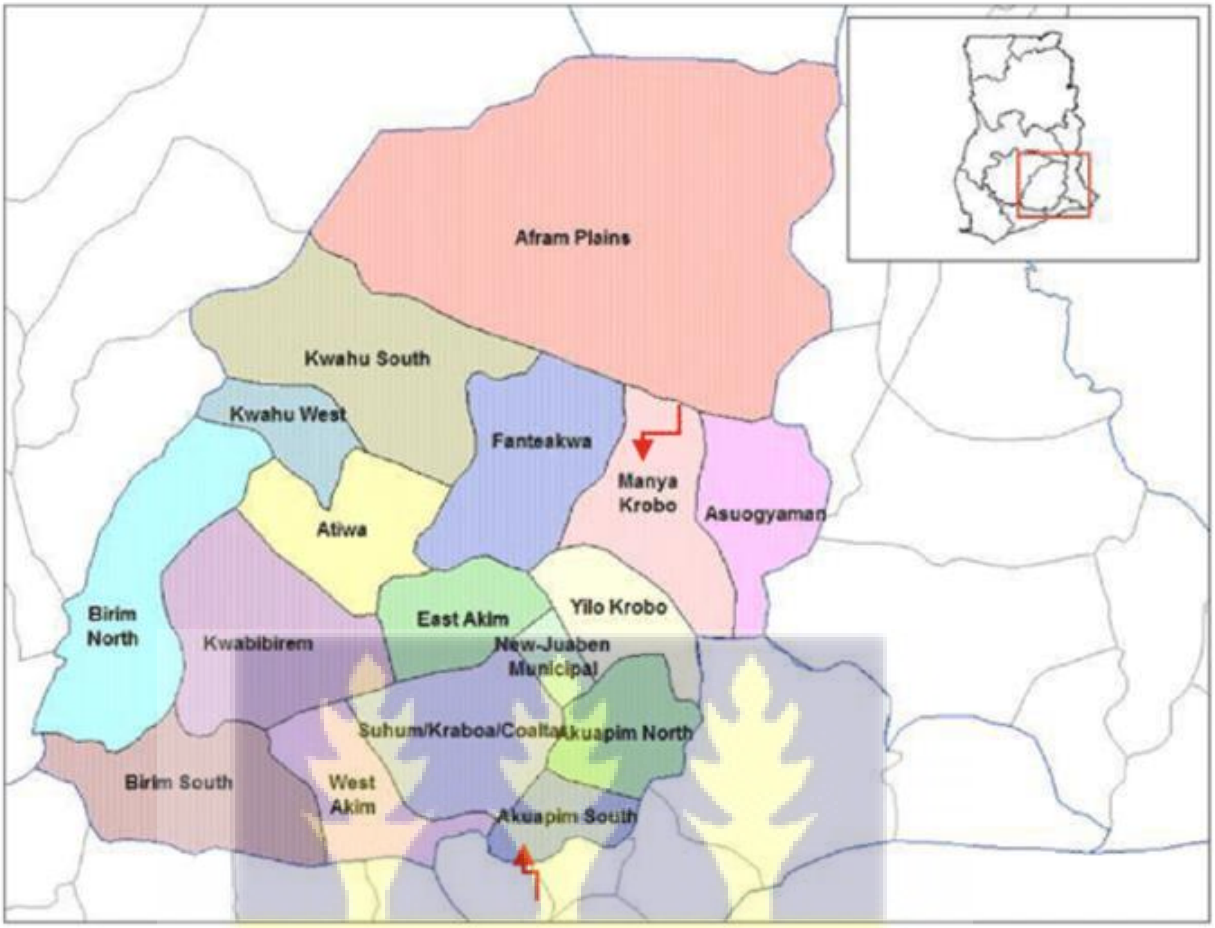


Figure 13: Study setting

The total population of Ghana is estimated at 30 million with annual growth rate of 2.2% (World Bank, 2019). Currently, the Gross Domestic Product (GDP) stands at 65.56 billion USD with a growth of 6.5% (World Bank, 2019). Eastern region is one of the administrative regions in Ghana that shares boundaries with Brong Ahafo, Central, Ashanti, Greater Accra, and Volta Regions. The 2017 projected population for the Eastern Region was 2,952,399 based on the 2010 population census figure of 2,633,154 and an annual growth rate of 2.5%. The population is 49% male and 51% female with an urban - rural split of 43.3% to 56.6% respectively. About 41.3% of the population is below age 15 (Eastern Regional Co-rd. Council, 2016).

The Eastern Region lies between latitudes 6º and 7º North and between longitudes 1º3ºWest and 0º3º East. The Region has a land area of 19,323 square kilometers (which constitutes 8.1 % of the total land area of Ghana). The administrative capital is Koforidua (Eastern Regional Co-rd. Council, 2016).

3.3.2 Occupation

Agriculture is the main economic activity in the Region and employs about 53% of the population, 10.7% of the population are in industry and about 22% in the services sub-sector (Eastern Regional Co-rd. Council, 2016).

3.3.3 Agriculture

The extensive ranges of forest highlands such as the Akwapim, Atiwa-Atwaredu, and the Krobo and Shai Hills have plains and heights that offer various potentials for agricultural production and industry (Eastern Regional Co-rd. Council, 2016). The Kwahu Mountain for example has offered the opportunity to institute the annual Easter Paragliding Festival which attracts tourists to the Region (Eastern Regional Co-rd. Council, 2016). While plains around the Osudoku hills and Yogaga are renowned for banana, mango and vegetable cultivation, the Akwapim range is a prominent horticultural crop growing zone in Ghana (Eastern Regional Co-rd. Council, 2016). The soils and climate of the region support a variety of food and cash crops including kola, cocoa, paddy rice, cassava, and oil palm (Eastern Regional Co-rd. Council, 2016).

3.3.4 District health service

The District Health Administration provides technical and administrative support to health service providers. These include resource mobilization and distribution, training and research programs. The District Health Administration ensures that services provided are in line with national policies.

There are six (6) sub-districts (Sekesua, Odumase, Anyaboni, Asesewa, Kpong/Akuse Otrokper,) which provides mainly preventive services, and four hospitals which serve as first referral points: Atua Government Hospital (one of the study sites), Akuse Hospital, St. Martin's De Porres (the second study site), and Asesewa Hospital.

3.3.5 Description of selected hospitals

i. Atua Government Hospital

HIV treatment in Atua Government hospital started in June 2003 (Hospital Profile, 2015). The hospital was the second health facility that started treatment for HIV in Ghana as well as in the Eastern Region. The health of the inhabitants is sub-served by limited skilled health professionals. The 2014 HIV Sentinel Survey (HSS) report (cross sectional survey targeting pregnant women in selected antenatal clinics in Ghana) rated Atua as the highest district with HIV prevalence of 8.7% which is far higher than the national prevalence rate of 1.6%.

ii. St. Martin De Porres Hospital

St. Martin De Porres Hospital is located in the Eastern Region part of Ghana under the Lower Manya Krobo and Upper Manya districts. It is one of the populous hospital in the region, inhabited mainly by peasant farmers and traders of various merchandise whose turnover could hardly cater

for their needs due to lack of funds to expand the farms and trading activities (St. Martin De Porres Hospital, 2009).

The area, with big towns such as Odumase-Krobo, the traditional capital, Agormaya and Asesewa, all big marketing centers, Kpong and Sekesua, like other parts of the region, had no health facility in the colonial period to cater for the people. In view of that, most of the inhabitants had to rely on herbal medicine which although helped a lot, could not be used in the treatment of certain diseases (St. Martin De Porres Hospital, 2009).

While the poor and the disadvantaged had no other choice than to rely on herbs, the rich who could afford the cost of orthodox medicine, had to go for treatment at either the Ridge hospital, which was for some time preserved for the whites (colonialists) and the Korle bu teaching hospital, all in Accra, a distance of about 65 kilometers (St. Martin De Porres Hospital, 2009). The long distance covered led to the death of a number of patients whose lives could have been saved if facilities for treatment were available in the community.

To make it possible for all to access healthcare without necessarily covering long distances, the Roman Catholic Church which had gained a foothold in the area, decided to put up a health facility at Agomanya in 1946 (St. Martin De Porres Hospital, 2009). This facility which was established by Rt. Revered Joseph Oliver Bowers, one of the priests stationed in the area, started as a maternity home to take care of pregnant women. It was later expanded to a clinic when realized that a number of patients other than those pregnant related cases also reported there for treatment (St. Martin De Porres Hospital, 2009).

The situation led to a high patronage of the facility by the sick, not only from the district, but also from neighbouring Asuogyaman, Yilo krobo, Fanteakwa districts, all in the Eastern region as well

as Dangbe west in Greater Accra. To make it possible to adequately cater for the medical needs of the people, in April 1997, it was upgraded to a hospital status by the Ministry of Health in recognition of the sterling health care delivery services offered at the facility (St. Martin De Porres Hospital, 2009).

3.4 Study population

The study population was people living with HIV who were age 18 years and above, on Antiretroviral Therapy (ART) for at least 6 months. Subjects received ART from either St. Martins De Porres Hospital in Agormanya and Atua Government Hospital at Atua. From this population, those who met the study's inclusion criteria and consented to enroll in the study were recruited. Their records were reviewed from the time of ART initiation till when data was collected.

3.5 Inclusion and Exclusion criteria

3.5.1 Inclusion Criteria

The inclusion criteria of the PLHIV who were included are as follows:

- Age of at least 18 years who are diagnosed sero-positive for HIV
- Receiving ART for at least 6 months from either St. Martins De Porres Hospital in and Atua Government Hospital
- Ability to give informed written consent

3.5.2 Exclusion Criteria

The exclusion criteria of the PLHIV who were included are as follows:

- Pregnant and lactating women
- People on special diet
- PLHIV who visit either of the two hospitals, but not for ART

3.6 Study variables

3.6.1 Outcome Variables

The study's main outcome variables included metabolic risk factors of CVDs (diabetes, hypertension, and dyslipidemia), diet quality (individual dietary diversity score), and Framingham Risk Score (FRS).

3.6.2 Explanatory Variables

The independent variables of the study included: dietary pattern, alcohol consumption, ART drug type, duration of exposure to ART, smoking, age, sex, gender, level of education, and exercise.

3.7 Sampling

A multistage sampling procedure was followed in this study to select respondents. The process and procedure are described below in details.

3.7.1 Sample size calculation

Objective based sampling was done. Cochrane formula for sample size determination (Dell, Holleran, & Ramakrishnan, 2002) was used to calculate the minimum sample size for objectives 2, 3, and 5, whose outcome variables were proportions. It is the ideal formula for determining the minimum sample size where the outcome variables are proportions (Singh & Masuku, 2014). Statcalc statistical module in the Epi Info software (Version 7.2.3.1) was used to calculate the

sample size for objective 4, where two groups are compared against the outcome variables. Epi Info is public domain statistical software for Epidemiology developed by Center for Disease Control and Prevention (CDC).

3.7.1.1 Sample size calculation using Cochrane formula

For objective 2, a similar research done in Ghana found a proportion of dietary inadequacy (poor diet) among PLHIV to be 50% (Nti, Hayford, & Opare-Obisaw, 2012) which was used as a basis for calculating the sample size.

The following formula (Daniel, 1999) was employed to compute the minimum sample size. A 95% confidence interval (CI) was chosen with precision level of 0.05.

$$n = \frac{Z^2 * P(1-P)}{d^2} = \frac{1.96^2 * 0.5(1-0.5)}{0.05^2} = \mathbf{384}$$

n = minimum sample size

z=1.96 at 95% CL

p=estimated proportion of the outcome variable

p=absolute amount of error tolerated (5% chance of error)

The same procedure was used to calculate for objectives 3 and 5 as illustrated in the table below.

Table 4: Sample size calculation for objectives 2, 3, and 5.

Objective	Outcome of Interest	Estimated Proportion (P)	Calculated minimum sample size (n)	Reference for estimated (P)
Objective 2	Dietary Inadequacy	P = 0.5	384	(Nti et al., 2012)
Objective 3a	Diabetes	P = 0.068	78	(Sarfo, Nichols, Agyei, et al., 2019)

Objective 3b	Hypertension	P = 0.402	368	(Sarfo, Nichols, Agyei, et al., 2019)
Objective 3c	Dyslipidemia	P = 0.795	250	(Sarfo, Nichols, Agyei, et al., 2019)
Objective 5	Framingham Risk Score	P = 0.05	384	Maximum variability

P: Estimated proportion

3.7.1.2 Sample size calculation using Statcalc module in Epi Info

In the absence of any empirically documented local data on the outcome variables (diabetes, hypertension, dyslipidemia) of objective 2 among PLHIV with good diet quality and PLHIV with poor diet quality, the findings from a study conducted in China (Y. Wang et al., 2018) is used.

The study provided data on the three outcomes - diabetes, hypertension, and dyslipidemia, which formed the basis for the sample size calculation. The prevalence of diabetes, hypertension, and dyslipidemia among PLHIV with good diet quality (herein referred to as the unexposed) are 21%, 18%, and 22% respectively; the prevalence of diabetes, hypertension, and dyslipidemia in the exposed group (PLHIV with poor diet quality) are 33%, 46.6%, and 33.7%. At a 95% confidence level, with a statistical power of 80%, a sample size of 438 which is the largest minimum sample size determined, was deemed adequate to answer all the research questions (Flies, 1981).

Table 5: sample size calculation for objectives 4.

Objective	Outcome of interest	Poor Diet	Good Diet	Statistical Power	Minimum sample size (n)
Objective 4a	Diabetes	33%	21%	80%	428
Objective 4b	Hypertension	46.60%	18%	80%	82
Objective 4c	Dyslipidemia	33.70%	22%	80%	438

As shown in table 3.2, the largest of all the eight (8) samples is 438, and was rounded up to 440. A decision of 1:2 ratio of exposed (PLHIV with poor diet quality) to unexposed (PLHIV with good

diet quality) was made to satisfy the apriori. The number of PLHIV with poor diet quality and number of PLHIV with good diet quality needed to be enrolled were 147 and 293 respectively.

3.7.1.3 Selection of participants

The two ART referral centers (Atua Government Hospital and St. Martins De Porres Hospital) have active HIV patients of 2,274 and 2,662 respectively. The two facilities are the biggest ART centers in the district. Probability proportionate to size sample allocation was used to obtain the number of PLHIV from each of the facilities.

3.7.1.3.1 Probability proportional to size allocation

Probability proportional to size allocation of the sample size was carried out for each of the two hospitals, by taking the total number of active patients in each hospital divided by the total number of active patients for both hospitals combined to obtain a sample fraction for each of the hospitals. Then the computed sample fraction was multiplied by the calculated sample size to get the number of the calculated sample to be obtained from each of the hospitals (table 6).

Table 6: Selection of study participants

Description	Atua Government Hospital	St. Martin De Porres Hosp.	Total
Active Patients	2,274	2,662	**4,936**
Sample size	212	228	**440**
Estimated data collection period	February 2020	to	Jun 2020

A simple random sampling was applied to get the study subjects from each of the two hospitals (St. Martins De Porres Hospital and Atua Government Hospital). A preliminary investigation had revealed that an average of 50 people visit Atua Government Hospital on ART clinic days, whiles 60 people visit St. Martin De Porres Hospital on the hospital's ART clinic days. 20 participants were randomly selected through balloting on each of the ART clinic days at Atua Government

Hospital until the required number of 228 was attained. Similarly, 25 people were selected from St. Martins De Porres Hospital until the required number of 212 was attained. For each of the clinic days, potential study participants who met the inclusion criteria were made to randomly pick from a box containing folded pieces of paper in which was written either "YES' or 'NO', the number of YESs were either 20 (for Atua Government Hospital) or 25 (for St. Martin De Porres Hospital). The rest of the papers contained NO. Anyone who picked YES, and consented to take part in the research was recruited.

3.8 Data Source and Instrument

Questions used for this study were developed from similar studies in both developed and developing countries (Jahangiry, Farhangi, Rezaei, & Nutrition, 2017; Sarfo, Nichols, Singh, et al., 2019; Sarfo et al., 2018; Starrett, 2017; Z. Wang et al., 2018). Questions that were strange to the Ghanaian setting were modified to suit the country's cultural circumstances. The systematic review also helped the researcher to generate a few questions as well.

3.9 Data Collection Techniques

The following data collection techniques were employed to gather data that were needed for the study.

3.9.1 Structured Questionnaire

A structured questionnaire with closed and open-ended questions was used to obtain information on various aspects. Questionnaires are normally used to collect an extensive range of facts from

participants such as their opinions, attitudes, knowledge or intentions on the issue of interest. Yet questionnaire respondents often have limited choices of answers, especially with close-ended types. They may also not disclose or express their factual opinions or attitudes if they do not match the 'false choice' (Walsh & Wigens, 2003). The questionnaire was organized into eight sections, which defined the risk categories and outcomes. These included: Section A: socio-demographic characteristics; section B: lifestyle factors; section C: medical history; section D: body composition and anthropometry; section E: biochemical data; section F: dietary intake assessment.

Section A: This section had questions on the demographic characteristics of the participants, including age, sex, educational level, occupation, religion, marital status, and ethnicity. The demographic questions were developed by the researcher based on reviewed literature of the possible demographic determinants of CVD risk factors.

Section B: This section focused on lifestyle related questions such as whether they smoke, consume alcohol, smoke cigarette, level of physical activity, and whether they eat outside of the home. This section was also developed based on reviewed literature of the possible lifestyle determinants of CVD risk factors.

Section C: This section contained questions on their medical history. Questions on their history of some CVD risk factors such as diabetes, hypertension, and dyslipidemia were asked. ART regimen taken and duration on ART were also obtained.

Section D: Section D recorded values of body composition and anthropometric measurements including; height, weight, percentage muscle mass, body mass index, visceral fat, basal metabolic rate, percentage body fat, and metabolic age.

Section E: Section E also recorded values of biochemical measurements and analyses including; fasting/random blood sugar, triglycerides, total cholesterol, low density lipoprotein, and high density lipoprotein,

Section F: This section asked questions on the dietary intakes and behavior of participants. A 2-day 24-hour recall was administered where questions on food quantities, type, mode of preparation, and eating timings were asked. It also contained the food groupings and index based on which the diet quality (individual dietary diversity score) was determined.

3.9.2 24- Hour Recall

Dietary intake of participants was measured with a two- day 24- hour recall of usual food intake (one weekday and one weekend). Detailed information on all meals, snacks, and beverages consumed in the past 24 hours was obtained. It required subjects to remember the specific foods as well as quantities consumed in the past 24 hours. Techniques such as strategic prompting to help the subject recall any drinks, snacks, condiments, etc. that may otherwise be forgotten were applied.

Respondents were asked to report portion size based on standard sizes (e.g. one soup ladle of porridge) and/or using food models to improve accuracy of portion size estimation. The 24-hour recall was then coded and matched to foods in the corresponding nutrient analysis database, and analyzed for nutrient content. The main limitation generally cited for the 24-hour recall is that they are dependent on the ability of the subject to adequately remember what they consumed and accurately report portion sizes (Carter, Sharbaugh, & Stapell, 1981; Kahn et al., 1995; Karvetti & Knuts, 1985; Sempos et al., 1993).

3.9.3 Diet Quality/Individual Dietary Diversity Score

The diet quality of the PLHIV was assessed based on individual dietary diversity scores (FAO, 2010) of the participants. The diet quality of the study participants was ascertained by obtaining data on their usual food intakes using a 24-Hour Recall. The Individual Dietary Diversity Score was used as a proxy to determine the quality of their diet (Azadbakht, Mirmiran, Esmaillzadeh, & Azizi, 2006; Drewnowski et al., 1996; Habte & Krawinkel, 2016; Horsey, Swanepoel, Underhill, Aliakbari, & Burkhart, 2019; Kojima, Murayama, & Suga, 2020; Parvin Mirmiran, Azadbakht, Esmaillzadeh, & Azizi, 2004; Savy, Martin-Prével, Sawadogo, Kameli, & Delpeuch, 2005; Shamim et al., 2016; Tavakoli et al., 2016; Zhao et al., 2017).

The Individual Dietary Diversity Score is a modified version of the FAO dietary diversity questionnaire (FAO, 2010). The FAO dietary diversity questionnaires is a 12-item scale designed to assess the variety of the diet by summing the number of food groups eaten by household members but uses 9-item scale for individuals in the last 24 hours (FAO, 2010; Saaka, 2013).

It is very applicable in developing countries (Saaka, 2013). The 12 major food groups inquired about are vegetables, fruits, cereals, meat, fish, tubers, legumes, eggs, milk and milk products, fats and oils, sugar and sweets, beverages. The reference period can either be the previous day or week (Brinkman, de Pee, Sanogo, Subran, & Bloem, 2009; FAO, 2010). At the household level, dietary diversity score is a measure of access to food, (e.g. of households' capacity to access costly food groups). At the individual level, dietary diversity scores (DDS) provide simple, validated measures of dietary quality or nutrient adequacy (Kennedy, Ballard, & Dop, 2011).

In this study, the individual dietary diversity score (IDDS) of PLHIV was derived on the basis of the number of food groups consumed from a 24-hour recall. Any food group consumed in the past

24 hours was given a score of one (1) which was aggregated to give the IDDS, with a maximum possible score of nine (9). A score of zero (0) was assigned to a food category if not consumed in the past 24 hours. A score 3 or less indicates lower IDDS (poor diet), a score of 4 and 5 indicates medium IDDS (diet needing improvement), and a score of 6 or more indicates high IDDS (good diet) (FAO, 2010).

Table 7: Individual dietary diversity score guide

Question number (s)	**Food group**	**1 = Yes 0 = No**
1,2	Starchy staples	
4	Dark green leafy vegetables	
3, 6	Other vitamin A rich fruits and vegetables and red palm oil	
5,7	Other fruits and vegetables	
8	Organ meats	
9,11	Meat and fish	
10	Eggs	
12	Legumes, nuts and seeds	
13	Milk and milk products	

IDDS=……

3.9.4 Body Composition and Anthropometry

Height was measured with a stadiometer calibrated to 1.0 cm and comprising of a vertical rod, which has a fixed measuring tape and a flat platform on which the subjects stood. Each subject was made to stand erect and upright on the platform with both feet together and the arms by the sides. The height was then read off the scale and recorded in centimeters to one (1) decimal place.

Omron Body Composition Monitor and Scale (Model HBF-516) was used to determine weight, Body Mass Index (BMI), percentage muscle mass, percentage body fat, basal metabolic rate, metabolic age, and visceral fat of the participants using their heights and ages. The portable device was placed on a hard and flat surface. Participants were made to stand on the device looking straight ahead with their knees and backs straight. They were then made to raise their hands horizontally such that their elbows were straight enough to form a 90 degrees' angle to their body whiles holding the display unit in front of them. All the parameters were calculated and displayed after about 10 seconds.

3.9.5 Blood Pressure Measurement

The blood pressure was measured in a quiet area after the subject had rested for at least 10 minutes. Three measurements were taken at one minute's intervals in the right arm with participants sitting upright using the Omron HEM 907 oscillometric monitor (Matsusaka, Japan). The arm of a participant was relaxed on a hold-up at a height approximately around the heart level and subjects were asked to sit quietly. These precautions were observed to minimize measurement errors and to reduce bias of a single measurement. The average of the 3 readings was used for the analysis. This method of measuring blood pressure is widely used in several studies (Chen et al., 1995; Dosoo et al., 2019; Gao et al., 2013; McNiece et al., 2007; Rose, Blackburn, Gillum, & Prineas, 1982; Tripathy, Thakur, Jeet, Chawla, & Jain, 2017).

3.9.6 Biochemical Assessment

3.8.6.1 Fasting Blood Sugar

Blood glucose levels of the participants were checked with *OneTouch Select* glucometer. The middle fingers of participants were punctured with a lancet and a drop of blood taken for glucose levels.

3.9.6.2 Lipid Profile

Lipid Profile was checked using LipidPlus Lipid Profile and Glucose Monitoring System (Dosoo et al., 2019). The LipidPlus® Professional Lipid Profile and Glucose Measuring System is intended for multiple patient use in professional health care settings and for testing outside the body (in vitro diagnostic use only). The LipidPlus® Professional Lipid Profile and Glucose Measuring System, which consists of meter and test strips: measures Total Cholesterol (TC), high density lipoprotein cholesterol (HDL-C), and triglyceride (TG). The LipidPlus® Professional Lipid Profile and Glucose Measuring System was only used with auto-disabling, single-use lancing device. A blood drop was taken from the already punctured middle finger for the lipid profile.

3.9.7 Assessment of 10-year cardiovascular risk

Framingham Risk Score (FRS) was used to investigate the risk of cardiovascular disease (Jahangiry et al., 2017; Sohn, Kim, Bae, & Practice, 2012). FRS scores were calculated based on the six coronary risk factors including age, gender, Total Cholesterol, HDL-cholesterol, systolic blood pressure, and smoking habits. The cutoffs for calculating FRS were as follows: TC < 4.1, 4.1-5.19, 5.2-6.19, 6.2-7.2, and > 7.2 mmol/L; for systolic blood pressure: < 120, 120–129, 130–139, 140–159, and ≥ 160 mmHg; and for HDL-C: > 1.6, 1.3-1.6, 1.2-1.29, 0.9-1.19, < 0.9 mmol/L (Sohn et al., 2012). Ten-year risk in percentage was calculated by total points (1 point 6%, 2 points 8%, and 3 points 10%, 4 points 12%, 5 points 16%, 6 points 20%, 7 points 25%, 10 points or more

> 30%). Absolute CVD risk percentage over 10 years was classified as low risk (< 10%), intermediate risk (10–20%), and high risk (> 20%) (Sohn et al., 2012).

3.10 Quality Control/Assurance

Generally, the quality assurance activities were carried out to minimize the threats of internal and external validities of the study findings from the multi-method research. To assure the quality of data, training, tool validation, pretest, supportive supervision and other series of activities were carried out at pre-data collection and during data collection.

3.10.1 Pre-data collection quality assurance measures

3.10.1.1 Protocol registration

The study protocol was registered with *Prospero* (Registration ID: CRD42018084661). This helped us to utilize standardized study protocol and implemented during fieldwork.

3.10.1.2 Recruitment and Training of field staff

Before the commencement of the study, research assistants were trained on the use of study instruments, functions etc. and their competence tested. The research tools and equipment were validated, i.e. tools and equipment were well calibrated and used to take known measures for validity and reliability.

Seven field assistants were recruited to assist in data collection. Three of the field assistants were nurses, two were medical laboratory scientists (qualified phlebotomists), and two were public health professionals. To ensure and maintain confidentiality of the study participants, the research assistants were not local residents of the communities (Atua and Agormanya). The field staff were invited to a two-day workshop where the principal investigator trained them. Firstly, they were made to understand the objectives of the study. They were then given definition of key concepts

like diabetes, hypertension, and dyslipidemia outcomes. Secondly, they were trained on sampling of participants at the health facility level. The assistants were further taught questionnaire administration and data collection from hospital records.

They were particularly taught how to operate and use devices/tools: blood pressure machine; bioelectrical impedance analysis machine; and tablet (ODK collect) to administer the questionnaire. They also received training on ethical issues pertaining to the research, how to approach a respondent, obtain consent and how to administer the questionnaire. Confidentiality and other ethical issues of the research were also highlighted. The sensitive nature of HIV was explained to research assistants to keep confidentiality and the quality of data. A brief explanation was provided to field research assistants on how to approach participants and priority for safety to the research teams as well as the PLHIV. In addition, refresher training or orientation/debriefing was provided to research assistants regularly. The training was done before the study commenced.

3.10.1.3 Pre-testing of questionnaire

The questionnaire was pre-tested at the Cape Coast Teaching Hospital in the Central Region which was not one of the study sites. Twenty questionnaires (5% of the sample size) were used for pretesting and the feedback from the testing showed a need to adjust aspects of the questionnaire to aid understanding and have a logical flow. This was done before final data collection.

To determine the quality of data, some data extraction forms were randomly selected by the principal investigator and cross-checked with original hospital records to be sure of the data. The questionnaires were verified for completeness before processing.

3.10.2 Quality assurance measures during study period

3.9.2.1 Appropriate allocation and selection of the study participants

Quantitative data were gathered using adapted standardized questionnaires, and interview or guides. A representative sample was taken using scientifically sound procedures.

3.10.2.2 Provide supportive supervision

In order to keep the quality of the fieldwork data collection, the Principal Investigator (PI) supervised the field data collection process. Strict follow-ups and regular checking of filled questionnaires from the field and at the office were carried out. Any incomplete or inconsistently filled questionnaires were returned to data collectors for re-interviewing. The questionnaires that missed the core components of the tool were omitted and considered as non-responses.

3.11 Data Processing/Data entry

Filled questionnaire were checked for completeness and consistency regularly on a daily basis. Independent and dependent variables were pre-defined (coded, labeled and assigned values) in the data entry template. The collected data were then entered into MS excel 2016 and saved in a file on a laptop only accessible to the researcher. As back up, the data were also saved in Google cloud, so it could be retrieved in case of any losses. The questionnaires after entry were filed and kept in a safe cupboard.

3.12 Data Analysis/Statistical Methods

Frequencies and means were used for descriptive data. The Kolmogorov-Smirnov (K-S) test was performed to test for normality of all continuous variables. Data that were skewed were log (log10) transformed in order to allow parametric tests to be used.

The data were analyzed using univariate, bivariate and multivariate statistical analysis methods. Univariate analysis was used to derive prevalence of outcome variables. It was also used to characterize the socio-demographic and other characteristics of the respondents. Bivariate analysis (using chi square tests) was used to assess association between independent variables and dependent variables. For multivariate analysis, all the variables that predicted the outcome variables ($p \leq 0.20$) at the bivariate analysis were used.

This was to obtain a parsimonious model controlling for confounding and effect measure modification. Adjusted odd ratios were reported and a p-value less than 0.05 was considered statistically significant at a 95% confidence level. The analyses were done using IBM SPSS Statistics for Windows, Version 20.0, similarly used in other studies (Amos K Laar, Taylor, & Akasoe, 2015; Semahegn, Torpey, Manu, Assefa, & Ankomah, 2019), and Microsoft Office excel 2016.

3.13 Ethical considerations

This study followed ethical requirements of the Ghana Health Service Ethics Review Committee (GHS-ERC). Ethical clearance was therefore sought from GHS-ERC (GHS-ERC 007/07/19). The procedures to ensure ethical considerations are described in the following sub-sections of the chapter.

3.13.1 Ethical and Administrative approval

Ethical approval was sought and obtained from the Ghana Health Service Ethics Committee (Appendix 3) before commencement of the study. Study subjects were adequately informed of the purpose, nature, procedures, risks and hazards of the study. Points emphasized included anonymity, confidentiality and freedom to decline participation at any time without penalty and that refusal to participate will not affect clinical management of the subject's condition. Permission was also taken from health facility authorities of the two hospitals before commencing the study.

3.13.2 Informed consent

Before each potential study participant was interviewed, a written informed consent was obtained. The informed consent contained names and telephone numbers of the Principal Investigator and the contact email of the secretary of the Ghana Health Service Ethics Committee. Prior to the interviews, the interviewers reviewed the informed consent form with the participants. Participants were to sign/thumbprint the informed consent form before answering the questionnaire. Participants were informed of the rationale of the study, the procedures and length of the quantitative interviews. The benefits and risks of the study and how they were selected to take part in the study were communicated to them. A copy of the signed consent form was given to the participants and the other one kept by the lead investigator for future reference. Participation was strictly voluntary and any participant was free at any time to withdraw from the study.

3.13.3 Confidentiality

The confidentiality of the participants was protected. The questionnaires were identified using numbers and codes. All collected questionnaires were kept locked up in a cabinet. For all data

entries in the software used, only codes were used to differentiate the entries. Participants have not been reported by names in the results of the study.

3.13.4 Privacy

The privacy of participants was ensured. The questionnaires were administered to them while they were waiting to refill their drugs. Respondents were interviewed away from the patients waiting space (sitting area), in a place where the respondent feels comfortable speaking openly. Whenever an interview was interrupted by a guest, the interviewer immediately stopped the interview and locked the device to protect the data collected from being accessed by anyone else outside the research team.

3.13.5 Benefits

Participants were given a result copy of their blood pressure, weight and height, and their lipid profile. The study provided data on the diet quality of PLHIV. Prevalence of CVD risk factors including diabetes, hypertension, and dyslipidemia, as well as their associated factors were known. And data from this study provides a better insight that will assist in formulating a more holistic CVD risk screening criteria and nutrition intervention policies for PLHIV in Ghana. Participants who had abnormal test results were referred to see a Doctor within the facility.

3.13.6 Safety procedures

Samples were collected by single use, disposable equipment by trained qualified Phlebotomist. Participants' were positioned with hand palm-side up. The ring, middle, or index fingers, were

chosen based on the one that was least calloused. Intermittent pressure was applied to the finger to help the blood flow to the fingertip and the fingertip cleaned with alcohol. The finger was allowed to air dry and a new sterile lancet used for each person. The lancets were shown to the participants so they are reassured that it is new and unused. Participants' fingers were held firmly and a quick firm prick made. Used lancets were disposed in a biohazard sharps container.

The first blood drop was wiped away with a sterile gauze pad. To help the blood flow, the finger was held lower than the elbow. Blood specimen was collected, and participants were given a gauze to place on their finger until the bleeding stops. The gauze pads were properly disposed off, before the participant left the testing area.

3.13.7 Right to withdraw

Respondents' participation in the study was purely voluntary and they could choose not to participate in the study, withdraw consent at any time, and refuse to answer any question in the process of the interview if they decided to do so and it was not compulsory to explain if they chose to withdraw from the study. Participants were informed that their decision not to participate in the study will not affect them negatively in any way.

3.13.8 Data Management and Protection

Data from this research was entered into excel and there was a password on the computer accessible only to the Principal Investigator (PI). There were no names or identifying information on the data entries.

3.13.9 Compensation

The participants were given GHC 8.00 each as a form of compensation for participating in this research.

3.14 Dissemination plan

The findings of this study are planned to be disseminated to different stakeholders accordingly, using the following mechanisms. The finding will be presented at international research conferences. In addition, efforts will be made to publish the findings in different open access peer review journals. Furthermore, policy briefs will be prepared, to communicate with policy makers at regional, national, and international levels accordingly. In addition, the findings of this study will be disseminated to the local or general community using compatible forms in collaboration with concerned stakeholders.

3.15 Chapter Summary

Chapter three has discussed the methods used in the study. It has explained the study design, study area, sample size calculations, sampling, data collection, processing and analysis. The chapter has also explained the study variables and how each was measured. Issues of ethics at administrative and individual levels have also been indicated in this chapter. The following chapter therefore presents the results of the collected and analyzed data in relation to the study objectives.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter presents the findings of the study. The socio-demographic characteristics of the study participants are described in detail. In addition, this chapter presents the magnitude of cardiovascular disease risk factors among people living with HIV (PLHIV), the diet quality of the PLHIV, prevalence of diabetes, hypertension, and dyslipidemia, relationship between diet quality and CVD risk factors, and then provide an assessment of a 10-year cardiovascular risk of the PLHIV using Framingham Risk Score (FRS).

4.1 Demographic Characteristics of Participants

Table 8 presents the socio-demographic characteristics of the study participants. A total of four hundred and forty (n=440) PLHIV were selected. There were more females (85%) than males (15%). The mean age of the participants was 49.28 years (SD = ±11.96). A greater proportion of the participants (32%) belonged to the age group 45 – 54 years. About a quarter (25%) had never been to school and only about 3% had attained educational level higher than secondary.

One hundred and thirty-seven (31%) of the PLHIV who participated in the research were married, followed by the bachelors and the spinsters (29%). One hundred and twenty-seven (29%) were widowed and 11% were either divorced or separated.

The participants were also categorized based on their occupational status. In this respect, majority (58%) of them are into trading. Participants were predominantly Ga/Dangmes (81%), followed by

Ewes (10%), Akans (6%), and about 3% belonged to other ethnic groups. Again, participants were predominantly Christians (98.2%). There were six (1.4%) Muslims and two (0.5%) Traditionalists (Table 8).

Table 8: Socio-Demographic Characteristics of Participants

Characteristics	Female, n (%) *374 (85)	Male, n (%) **67 (15)	Total, n (%) 441 (100)
Facility			
Atua	197 (52.7)	32 (47.8)	229 (51.9)
St. Martins	177 (47.3)	35 (52.2)	212 (48.1)
Age Group			
15 – 24 years	4 (1.5)	0 (0)	4 (1.4)
25 – 34 years	24 (9.8)	5 (10.2)	29 (9.9)
35 - 44 years	71 (29.0)	7 (14.3)	78 (26.5)
45 – 54 years	80 (32.7)	13 (26.5)	93 (31.5)
55 – 64 years	41 (16.7)	17 (34.7	58 (19.7)
65+ years	25 (10.2)	7 (14.3)	32 (10.9)
Level of Education			
None	108 (28.9)	3 (4.5)	111 (25.2)
Primary	73 (19.5)	12 (17.9)	85 (19.3)
Middle/Secondary	159 (42.5)	40 (59.7)	199 (45.1)
Higher	9 (2.4)	4 (6.0%)	13 (2.9)
Marital Status			
Single	114 (30.6)	14 (20.9)	128 (29.1)
Married/Cohabiting	100 (26.9)	37 (58.3)	137 (31.1)
Divorced/Separated	43 (11.6)	5 (7.5)	48 (10.9)
Widowed	116 (31.1)	11 (16.4)	127 (28.9)
Employment status			
Unemployed	44 (11.8)	5 (7.5)	49 (11.1)

Farmer	14 (3.7)	25 (37.3)	39 (8.8)
Artisan	41 (11.0)	24 (35.8)	65 (14.7)
Formal Public Sector	19 (5.1)	2 (3.0)	21 (4.8)
Formal Private Sector	5 (1.3)	4 (6.0)	9 (2.0)
Trading	250 (66.8)	5 (7.5)	255 (57.8)
Others	1 (0.3)	2 (3.0)	3 (0.7)
Ethnicity			
Akan	22 (5.9)	4 (6.0%)	26 (5.9)
Ga/Dangme	302 (80.7)	57 (85.1%)	359 (81.4)
Ewe	40 (10.7)	4 (6.0%)	44 (10.0)
Others	10 (2.7)	2 (3.0%)	12 (2.7)
Religion			
Christianity	367 (98.1)	66 (98.5%)	433 (98.2)
Islam	5 (1.3)	1 (1.5%)	6 (1.4)
Traditional	2 (0.5)	0 (0.0%)	2 (0.5)

***Total number of females (n=374)**
****Total number of males (n=67)**
The mean age of the participants was 49.28 years (SD = ±11.96)

4.2 Normality test of predictor variables

Normality test was conducted for continuous predictor variables in order to identify which variables are not normally distributed. The normality test was conducted on Age, BMI, % Body Fat, % Muscle Mass, Visceral Fat, Basal Metabolic Rate, Metabolic Age, Systolic BP, Diastolic BP, Fasting Blood Sugar, Random Blood Sugar, IDDS, Total Cholesterol, HDL Cholesterol, Triglyceride, LDL Cholesterol, and VLDL Cholesterol. Out of all the variables, only BMI and Diastolic BP were found not to be normally distributed as indicated in **appendix 1**.

4.3 Diet Quality of the study participants

Determining the diet quality of the study participants was the second specific objective of the study. The diet quality of the study participants was measured using individual dietary diversity scores obtained from participants. The results in this regard are presented below.

4.3.1 Consumption of different food groups by the PLHIV

Figure 14 shows the consumption of food from different food groups among the study population in the previous day of the survey. When considering the dietary diversity and consumption pattern of the sample, most of the PLHIV (73%) consumed from 'Starchy staples" food group. Furthermore, about 28 percent of the participants had used 'Meat and fish' in the previous 24 hours, whiles about 25 percent of the study population consumed 'Milk and milk products'. Overall, fruits and vegetables consumption were not at the satisfactory level. Less than 18 percent of the study sample had consumed 'Fruits', 'Vegetables', and 'Organ meat'; 17 percent, 14 percent, and 1 percent respectively.

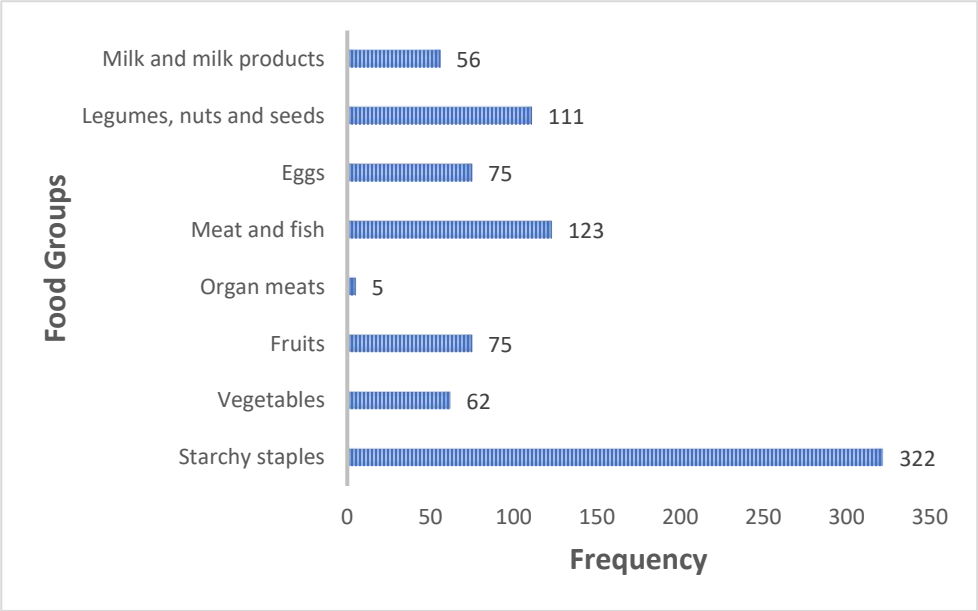


Figure 14: Consumption of different food groups in the previous 24 hours of the study

4.3.2 (Individual Dietary Diversity Score-IDDS) of study participants

Individual dietary diversity score was used as a proxy for determining diet quality of the study participants. The mean IDDS was 4.11 (SD = 1.29). Overall, most of the people living with HIV (56%) had medium IDDS which is equivalent to "diet needing improvement'. About 31% of the participants actually had poor diet (lower IDDS), with only about 14% having higher IDDS (good diet). The prevalence of poor diet is higher among males than females; 40% and 29% respectively.

Table 4.7: Individual Dietary Diversity Score (IDDS) of study participants

IDDS Category	*Female*	*Male*	*Total*
Lower IDDS (≤ 3)	107 (28.8%)	26 (40.0%)	133 (30.5%)
Medium IDDS (4 $ 5)	213 (57.4%)	30 (46.2%)	243 (55.7%)
Higher IDDS (≥ 6)	51 (13.7%)	9 (13.8%)	60 (13.8%)

IDDS = Individual Dietary Diversity Score
IDDS categorization by FAO

4.3.3 Determinants of Individual Dietary Diversity Score (diet quality)

The determinants of adherence were classified into socio-demographic factors and other factors.

4.2.3.1 Socio-demographic factors and Individual Dietary Diversity Score (diet quality)

The socio-demographic determinants of adherence considered in the study were age, sex, educational level, marital status, and occupation. Only variables with complete entries for both individual dietary diversity score (IDDS) and the particular variable were considered. All missing variables were excluded. Table 9 shows the results from bivariate chi-square test of the relationship between socio-demographic factors and IDDS. Males reported greater proportion of low IDDS (poor diet) level (40%). Both males and females reported the same higher IDDS (good diet) levels of 14%. The relationship between sex and IDDS was however statistically not significant (p= 0.172). There was also no association between IDDS and level of education, age of participants, and marital status. An association with a borderline significance was observed between marital status and IDDS (p=0.051).

The only socio-demographic factor that showed a statistically significant association with IDDS was occupation. The categories considered included: Unemployed; Farmer; Artisan; Public Sector; Private Sector' Trading; Others. Low IDDS (poor diet quality) was highest among farmers (50%), followed by PLHIV who were unemployed (44%), and then Artisans (35%). Formal sector workers (both public and private) reported the highest proportion of IDDS (good diet quality). The difference in IDDS (diet quality) between the different occupations was statistically significant (p < 0.01) (Table 9).

Table 9: Association between Socio-Demographic Variables and Individual Dietary Diversity Score (IDDS)

Factor	IDDS Category			Total, n (%)	Chi Square	p-value
	Low, n (%)	Medium, n (%)	Higher, n (%)			
Sex						
Female	107 (28.8)	213 (57.4)	51 (13.7)	371 (100.0)	3.516	.172
Male	26 (40.0)	30 (46.2)	9 (13.8)	65 (100.0)		
Level of Education						
None	32 (29.4)	67 (61.5)	10 (9.2)	109 (100.0)	7.302***	.395
Primary	27 (32.1)	48 (57.1)	9 (10.7)	84 (100.0)		
Middle/JHS	61 (30.8)	102 (51.5)	35 (17.7)	198 (100.0)		
Secondary/SHS	9 (27.3)	18 (54.5)	6 (18.2)	33 (100.0)		
Higher	4 (33.3)	8 (66.7)	0 (0.0)	12 (100.0)		
Age Category						
18 – 34 years	16 (32.0)	28 (56.0)	6 (12.0)	50 (100.0)	7.640	.106
35 – 54 years	63 (25.5)	147 (59.5)	37 (15.0)	247 (100.0)		
55 + years	54 (38.8)	68 (48.9)	17 (12.2)	139 (100.0)		
Marital Status		()				
Single	33 (25.8)	72 (56.2)	23 (18.0)	128 (100.0)	18.273	**.051****
Married	29 (32.6)	55 (61.8)	5 (5.6)	89 (100.0)		
Divorced	13 (38.2)	17 (50.0)	4 (11.8)	34 (100.0)		
Widowed	40 (31.7)	72 (57.1)	14 (11.1)	126 (100.0)		
Separated	6 (46.2)	3 (23.1)	4 (30.8)	13 (100.0)		
Cohabiting	12 (26.7)	23 (51.1)	10 (22.2)	45 (100.0)		
Occupation						
Unemployed	21 (43.8)	21 (43.8)	6 (12.5)	48 (100.0)	15.846***	**.004***
Farmer	19 (50.0)	16 (42.1)	3 (7.9)	38 (100.0)		
Artisan	23 (35.4)	33 (50.8)	9 (13.8)	65 (100.0)		

Public Sector	2 (9.5)	12 (57.1)	7 (33.3)	21 (100.0)
Private Sector	2 (22.2)	4 (44.4)	3 (33.3)	9 (100.0)
Trading	66 (26.2)	155 (61.5)	31 (12.3)	252 (100.0)
Others	0 (0.0)	2 (66.7)	1 (33.3)	3 (100.0)

n= number of participants (frequency)
***Significant at p<0.01**
****Borderline Significance**
Fisher's Exact test
IDDS = Individual Dietary Diversity Score

4.3.3.2 Individual Dietary Diversity Score (diet quality) and other factors

Other factors which were compared with Individual Dietary Diversity Score (IDDS) included smoking, alcohol intake, exercise, eating outside of home, antiretroviral (ARV) type, duration on ARV, muscle mass category, and visceral fat category.

Only variables with complete entries for both IDDS and the particular variable were considered. Table 10 shows the results from bivariate or chi-square test of independence analysis of the relationship between these other factors and IDDS. According to the results (Table 10) PLHIV who never smoked reported greater proportion of low IDDS (poor diet) level of 34 percent than those who have ever smoked (30.2%). PLHIV who ever smoked reported a greater higher IDD (good diet) levels of 14 percent. The relationship between smoking and IDDS was however statistically not significant (p= 0.193).

Similarly, there was no association between IDDS and alcohol consumption (p= 0.863), exercise (p= 0.053), eating outside of home (p= 0.251), ARV type (p= 0.437), and duration of exposure to ART (p= 0.277).

In addition, IDDS was compared with visceral fat. A higher proportion of PLHIV who belong to higher visceral fat category also had the highest level of low IDDS (38%), followed by high

visceral fat category (44%). PLHIV who belonged to Normal visceral fat category had the lowest level of poor diet quality (29%). The difference was statistically significant (p< 0.01),

Table 10: Association between A Group of Explanatory Variables and Individual Dietary Diversity Score (IDDS)

Factor	IDDS Category			Total, n (%)	Chi Square	p-value
	Low, n (%)	Medium, n (%)	Higher, n (%)			
Ever Smoked						
YES	122 (30.2)	223 (55.2)	59 (14.6)	404 (100.0)	3.292	.193
NO	11 (34.4)	20 (62.5)	1 (3.1)	32 (100.0)		
Ever consumed Alcohol						
YES	31 (31.3)	56 (56.6)	12 (12.1)	99 (100.0)	.294	.863
NO	102 (30.3)	187 (55.5)	48 (14.2)	337 (100.0)		
Exercise						
YES	78 (26.9)	172 (59.3)	40 (13.8)	290 (100.0)	5.684	.058
NO	55 (37.7)	71 (48.6)	20 (13.7)	146 (100.0)		
Eating Outside of Home						
YES	20 (39.2)	23 (45.1)	8 (15.7)	51 (100.0)	2.764	.251
NO	113 (29.4)	220 (57.1)	52 (13.5)	385 (100.0)		
ARV type						
First line	121 (31.4)	213 (55.3)	51 (13.2)	385 (100.0)	1.654	.437
Second line	12 (23.5)	30 (58.8)	9 (17.6)	51 (100.0)		
Duration of medication						
< 6 months	10 (31.2)	20 (62.5)	2 (6.2)	32 (100.0)	7.499	.277
6 months - <12 months	13 (48.1)	13 (48.1)	1 (3.7)	27 (100.0)		

1 – < 4 year	28 (29.8)	53 (56.4)	13 (13.8)	94(100.0)		
4 years and above	82 (29.0)	157 (55.5)	44 (15.5)	283 (100.0)		
Visceral fat category						
Normal	110 (28.5)	224 (58.0)	52 (13.5)	386 (100.0)	14.544	**.006***
High	19 (44.2)	19 (44.2)	5 (11.6)	43 (100.0)		
Very High	4 (57.1)	0 (0.0)	3 (42.9)	7 (100.0)		

n= number of participants (frequency)
***Significant at p<0.01**
IDDS= Individual Dietary Diversity Score

4.3.3.3 Regression of Individual Dietary Diversity Score (IDDS) on predictor factors

An ordinal logistic regression was done to identify the influence of independent (predictor) variables on IDDS (diet quality). The predictor variables were tested priori to verify that there was no violation of multi-collinearity.

The predictor variable, meal frequency per day (eating twice), in the ordinal logistic regression was found to contribute to the model (table 11). For every one unit increase in meal frequency per day (eating twice), there is a predicted increase of 17.06 in the log odds of a participant being in a higher IDDS (diet quality). This indicates that a participant eating twice a day is more likely to indicate higher IDDS (diet quality) ($p< 0.01$).

Again, for every one-unit increase in meal frequency per day (eating thrice), there is a predicted increase of 16.955 in the log-odds of a participant being in a higher IDDS (diet quality). This indicates that a participant eating three times a day is more likely to indicate higher IDDS (diet quality) ($p< 0.01$).

ART type also showed a significant contribution to the model. Every one unit increase in probability of taking the first line ART resulted in a predicted decrease of 0.707 in the log odds of

a participant being in a higher IDDS (diet quality) category. This indicates that taking first line ART is associated with lower IDDS (diet quality) (p = 0.028).

Another predictor that showed significant contribution to the model was duration on ART. Every one unit increase on falling under ARV duration (one year) resulted in a predicted decrease of 1.203 in the log odds of a participant being in a higher IDDS (diet quality). This indicates that a participant taking ARV for a year was associated with lower IDDS (diet quality) (p< 0.01).

There was a significant improvement in fit of the Final model over the null model [χ^2 (32) = 64.983, p<.001] indicating a good model. Overall, the model accounts for 16.4% of the variation in IDDS (diet quality) Negelkerke pseudo R square = 0.164).

Table 11: Ordinal logistic regression of IDDS on predictor factors

Variables	Estimates	Std. Error	Walid	Sig.	95% Interval	
					Lower Bound	Upper Bound
IDD Category						
[Low IDDS]	12.45	2.66	21.912	.000	7.237	17.663
[Medium IDDS]	15.423	2.651	33.843	.000	10.227	20.619
Exercise						
YES	0.372	0.235	2.508	0.113	-0.088	0.833
NO	0[a]	.	.	.	.	*Ref.*
Meal frequency per day						
Once	-0.792	2506.233	0	1	-4912.919	4911.335
Twice	**17.06**	**0.578**	**872.1**	**0.000***	**15.928**	**18.192**
Thrice	**16.955**	**0.543**	**976.243**	**0.000***	**15.892**	**18.019**
4 times	16.581	0	.	.	16.581	16.581
5 times	0[a]	.	.	.	.	*Ref*
Type of ART						
First line ART	**-0.707**	**0.322**	**4.823**	**0.028****	**-1.339**	**-0.076**
Second line ART	0[a]	.	.	.	.	*Ref*
Duration on ART						
< 6 months	-0.102	0.407	0.063	0.802	-0.899	0.696
6 months - <12 months	**-1.203**	**0.444**	**7.333**	**0.007***	**-2.074**	**-0.332**

1 – < 4 years	-0.219	0.249	0.77	0.38	-0.707	0.27
4 years and above	0[a]	.	.	.	.	*Ref*

n= number of participants (frequency)
***Ref*. =: Reference group**
***Significant at p<0.01**
****Significant at p<0.05**

4.4 Prevalence of diabetes, hypertension, and dyslipidemia among PLHIV

Assessing the prevalence of diabetes, hypertension, and dyslipidemia among the study participants was the third specific objective of the study. Prevalence was determined by the proportion of cases (diabetes, hypertension, and dyslipidemia) among the sampled study participants over the total sample (N). The results are presented below.

4.4.1 Prevalence of diabetes

The prevalence of diabetes among the PLHIV was examined. Results show diabetes prevalence was higher among males (22.4%) in the study, as against prevalence of 19.7% among females (Figure 15). The overall prevalence of diabetes was about 20%.

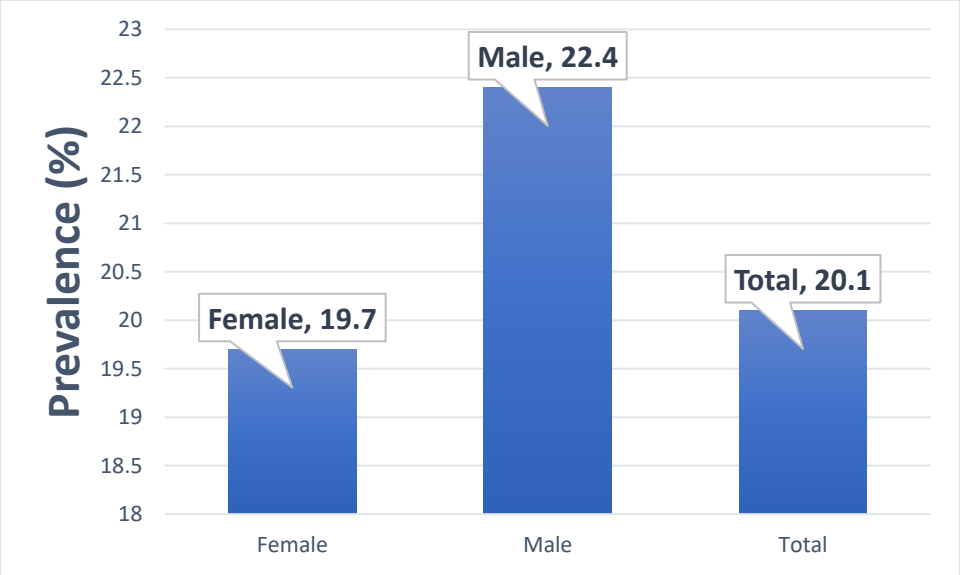


Figure 15: Prevalence of diabetes

4.4.2 Prevalence of hypertension

The prevalence of hypertension among the PLHIV was also examined. Unlike diabetes, the results show hypertension prevalence was higher among females (33.7%) in the study, as against prevalence of 31.3% among males (Figure 16). The overall prevalence of hypertension among the PLHIV was about 33%.

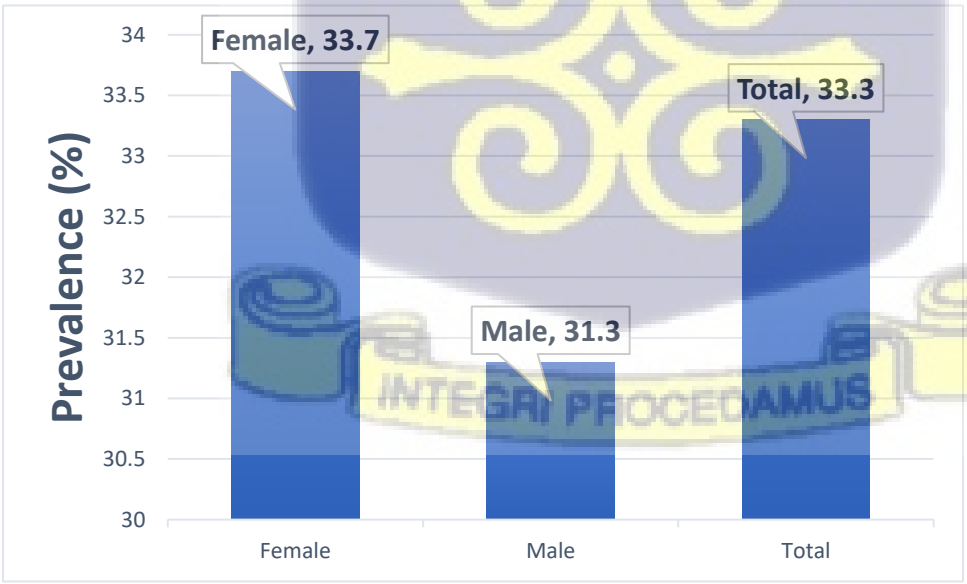


Figure 16: Prevalence of hypertension

4.4.3 Prevalence of dyslipidemia

The prevalence of dyslipidemia among the PLHIV was also examined. Dyslipidaemia prevalence was also higher among females (64.4%). The prevalence among males is 58.2% (Figure 17). The overall prevalence of dyslipidemia among the PLHIV was found to be about 64%.

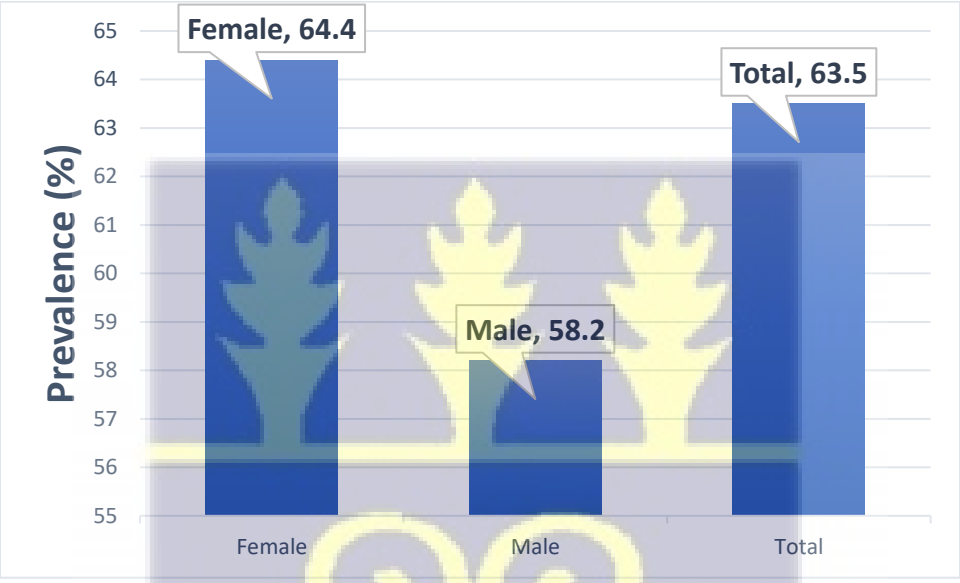


Figure 17: Prevalence of dyslipidemia

4.4.4 Diabetes prevalence and other factors

Prevalence of diabetes was compared among the different levels of education. Prevalence of diabetes was highest among those who attained educational level higher than senior high (30.8), and lowest among those who had senior high education (9%). The difference was not statistically significant (p = 0.175).

In addition, diabetes prevalence was compared between first line ARV and second line ARV. Prevalence of diabetes was higher (25.5%) among those on second line ARV compared with 19.4% for those on first line ARV. However, the difference was not statistically significant (p= 0.305),

In terms of participants' duration on ARV, prevalence of diabetes was quite comparable across the different categories considered: < 6 months (21.2%), 6 months -< 12 months (20%), 1-<4 years (21.3%), and 4 years and above (19.6%). There was therefore no statistical difference (p = 0.894).

Furthermore, diabetes prevalence was also compared among IDDS categories. Prevalence of diabetes was highest (25.2%) among PLHIV who had higher IDDS and lowest (15.6%) among PLHIV who had low IDDS. However, the observed difference in diabetes prevalence was not statistically significant (p= 0.177).

Finally, diabetes prevalence was also compared among visceral fat category. Prevalence of diabetes was highest (62.5%) among PLHIV who had higher visceral fat and lowest (18.5%) among PLHIV who had low visceral fat. Prevalence of diabetes among PLHIV who had normal visceral fat was 26.8%. The observed difference in diabetes prevalence was statistically significant (p< 0.01).

Table 12: Association between a Group of Explanatory Variables and Diabetes

Factor	Diabetes Status		Total, n (%)	Chi Square	p-value
	Normal, n (%)	Diabetic, n (%)			
Level of Education					
None	82 (75.9)	26 (24.1)	108 (100.0)	6.343	.175
Primary	71 (85.5)	12 (14.)	83 (100.0)		

Middle/JHS	150 (78.5)	41 (21.5)	191 (100.0)		
Secondary/SHS	30 (90.9)	3 (9.1)	33 (100.0)		
Higher	9 (69.2)	4 (30.8)	13 (100.0)		
Line of medication					
First line ART	304 (80.6)	73 (19.4)	377 (100.0)	1.050	.305
Second line ART	38 (74.5)	13 (25.5)	51 (100.0)		
Duration of medication					
< 6 months	26 (78.8)	7 (21.2)	33 (100.0)	.156	.984
6 months -< 12 months	20 (80.0)	5 (20.0)	25 (100.0)		
1-<4 years	74 (78.7)	20 (21.3)	94 (100.0)		
4 years and above	222 (80.4)	54 (19.6)	276 (100.0)		
IDDS category					
Low	38 (84.4)	7 (15.6)	45 (100.0)	3.462	.177
Medium	200 (82.0)	44 (18.0)	244 (100.0)		
Higher	104 (74.8)	35 (25.2)	139 (100.0)		
Visceral fat category					
Normal	309 (81.5)	70 (18.5)	379 (100.0)	10.741	**.005***
High	30 (73.2)	11 (26.8)	41 (100.0)		
Very High	3 (37.5)	5 (62.5)	8 (100.0)		

n= number of participants (frequency)
***Significant at p<0.01**

4.4.5 Determinants of Diabetes

A binary logistic regression analysis to investigate factors contributing to the risk of developing diabetes among the PLHIV was conducted (Table 13). The predictor variables were tested a priori to verify there was no violation of the assumption of multi-collinearity.

The predictor variable, level of education (secondary/SHS) in the binary logistic regression analysis was found to contribute to the model. Participants who attained Secondary education had 80% lower odds of developing diabetes (OR= 0.196; 95%:0.047-0.809; p = 0.024) compared to those who did not have education. Exercise in the binary logistic regression analysis was found to contribute to the model. PLHIV who reported not to be exercising had 23% odds of developing diabetes than PLHIV who exercised (OR = 2.228; 95% CI: 1.249-3.975; p = 0.007).

Overall, the model accounts for 13% of the variation in the prevalence of diabetes (*Negelkerke* pseudo R square = 0.130).

Table 13: Binary logistic regression of diabetes and other factors

Variable	B	S.E.	Wald	Df	Sig.	Exp(B)	95% CI for EXP(B)	
							Lower	Upper
Level of Education								
None			7.372	4	.117			***Ref***
Primary	-.814	.417	3.807	1	.051	.443	.196	1.004
Middle/JHS	-.540	.334	2.617	1	.106	.583	.303	1.121
Secondary/SHS	-1.631	.724	5.078	1	**.024****	.196	.047	.809
Higher)	-.593	.821	.522	1	.470	.553	.111	2.763
Smoking								
YES								***Ref***
NO	-.284	.611	.216	1	.642	.753	.227	2.495
Alcohol Intake								
YES								***Ref***
NO	-.351	.333	1.110	1	.292	.704	.367	1.352
Exercise								
YES								***Ref***
NO	.801	.295	7.359	1	**.007***	2.228	1.249	3.975

Eats Outside Home								
YES								***Ref***
NO	-.514	.402	1.635	1	.201	.598	.272	1.315
Duration on ART								
< 6 months								***Ref***
6 months - <12 months	-.654	.801	.667	1	.414	.520	.108	2.497
1 – < 4 years	-.473	.552	.735	1	.391	.623	.211	1.838
< 6 months	-.390	.501	.608	1	.436	.677	.254	1.805
BMI	-.061	.085	.514	1	.474	.941	.796	1.112
% Body Fat	-.006	.041	.020	1	.887	.994	.918	1.077
% Muscle Mass	-.063	.047	1.821	1	.177	.939	.857	1.029
Visceral Fat	.106	.141	.561	1	.454	1.111	.843	1.466
IDDS	.169	.116	2.122	1	.145	1.184	.943	1.485
Age	.004	.015	.059	1	.809	1.004	.974	1.034
Constant	-17.805	20013.458	.000	1	.999	.000		

***Ref.* =: Reference group**
***Significant at p<0.01**
****Significant at p<0.05**

4.4.6 Hypertension prevalence and other factors

Prevalence of hypertension was compared among the different levels of education. Prevalence of hypertension was highest among those who attained educational level higher than senior high (46.2%), followed by PLHIV who had no education at all (36.9%), and lowest among those who had senior high education (30.3%). The difference was not statistically significant (p = 0.660).

In addition, hypertension prevalence was compared based on marital status. Prevalence of diabetes was higher (43.5%) among those are married, followed by PLHIV who are widowed (37.8%). PLHIV who are cohabiting had the lowest prevalence of hypertension (20%). The difference was statistically significant (p= 0.038), implying that the observed difference in prevalence of hypertension was not due to chance.

In terms of participants' occupation, prevalence of hypertension was highest (55.6%) among formal private sector, followed by PLHIV who are into trading (39.6%), and then the unemployed (32.7%). Farmers and artisans had the lowest prevalence of hypertension, 17.9% and 18.5% respectively. The difference in prevalence of hypertension was statistically significant (p = 0.004).

Furthermore, hypertension prevalence was compared among smokers and non-smokers, the prevalence of hypertension were 21.2% and 34.3% respectively. However, the observed difference in hypertension prevalence was not statistically significant (p= 0.125).

Prevalence of hypertension was also compared between ARV first line and ARV second line, prevalence of hypertension was higher (35.1%) among those who took first line ARV, as compared to 19.6% for those who took second line ARV. The difference in prevalence of hypertension was statistically significant (p = 0.027). The difference in prevalence was therefore not due to chance.

With regards to alcohol intake, prevalence of hypertension was higher (33.6%) among those who ever took alcohol, as compared to 32.3% for those who never took alcohol. The difference in prevalence of hypertension was not statistically significant (p = 0.809).

Prevalence of hypertension was compared among the different Individual Dietary Diversity Score (IDDS) categories. Prevalence of hypertension was highest among those who attained higher IDDS (39.7%), followed by PLHIV who had medium IDDS (32.8%), and lowest among those who had the lowest IDDS (18%). The difference was statistically significant (p = 0.019).

Hypertension prevalence was also different for the different age groups. PLHIV who were age 55 years and above had the highest prevalence of hypertension (36.7%), followed by those who were ages between 35 and 54 years (36.2%). PLHIV who were between the ages of 18 to 34 years had

the lowest prevalence of hypertension (24.8%). The difference was statistically significant (p = 0.0.063).

Based on body mass index classification, prevalence of hypertension was highest among PLHIV who were obese (50%), followed by PLHIV who were overweight (40.4%), PLHIV with normal (29.8%), and lowest among those who were underweight (23.4%). The difference was statistically significant (p = 0.008).

Different hypertension prevalence were also reported among PLHIV with different percentage body fat. Prevalence of hypertension was highest among PLHIV who had very high percentage body fat had (42.9%), followed by PLHIV who had high percentage body fat (40.7%), PLHIV with normal (31.3%), and lowest among those who had low percentage body fat (21.7%). The difference was statistically significant (p = 0.006).

Finally, prevalence of hypertension was highest among PLHIV who had low percentage muscle mass (42.9%), followed by PLHIV who had normal percentage muscle mass (36.3%), PLHIV with high muscle mass (20.8%), and lowest among those who had very high percentage muscle mass (17.4%). The observed difference in hypertension prevalence was statistically significant (p< 0.01).

Table 14: Association between a Group of Explanatory Variables and Hypertension

Factor	BP Status		Total, n (%)	Chi Square	p-value
	Normal, n (%)	Hypertensive, n (%)			
Level of Education					
None	70 (63.1)	41 (36.9)	111 (100.0)	2.413	.660

Primary	56 (65.9)	29 (34.1)	85 (100.0)		
Middle/JHS	138 (69.3)	61 (30.7)	199 (100.0)		
Secondary/SHS	23 (69.7)	10 (30.3)	33 (100.0)		
Higher	7 (53.8)	6 (46.2)	13 (100.0)		
Age category					
18 – 34 years	100 (75.2)	33 (24.8)	133 (100.0)	5.542	.063
35 – 54 years	155 (63.8)	88 (36.2)	243 (100.0)		
55 + years	38 (63.3)	22 (36.7)	60 (100.0)		
Marital Status					
Single	91 (71.1)	37 (28.9)	128 (100.0)	11.763	**.038****
Married	52 (56.5)	40 (43.5)	92 (100.0)		
Divorced	26 (76.5)	8 (23.5)	34 (100.0)		
Widowed	79 (62.2)	48 (37.8)	127 (100.0)		
Separated	10 (71.4)	4 (28.6)	14 (100.0)		
Cohabiting	36 (80.0)	9 (20.0)	45 (100.0)		
Occupation					
Unemployed	33 (67.3)	16 (32.7)	49 (100.0)	18.865	**.004***
Farmer	32 (82.1)	7 (17.9)	39 (100.0)		
Artisan	53 (81.5)	12 (18.5)	65 (100.0)		
Public Sector	15 (71.4)	6 (28.6)	21 (100.0)		
Private Sector	4 (44.4)	5 (55.6)	9 (100.0)		
Trading	154 (60.4)	101 (39.6)	255 (100.0)		
Ever Smoked					
No	268 (65.7)	140 (34.3)	408 (100.0)	2.358	.125
Yes	26 (78.8)	7 (21.2)	33 (100.0)		
Ever consumed Alcohol					

No	67 (67.7)	32 (32.3)	99 (100.0)	.059	.809
Yes	227 (66.4)	115 (33.6)	342 (100.0)		
Type of ART					
First line ART	253 (64.9)	137 (35.1)	390 (100.0)	4.889	**.027****
Second line ART	41 (80.4)	10 (19.6)	51 (100.0)		
Duration of medication					
< 6 months	20 (60.6)	13 (39.4)	33 (100.0)	.734	.865
6 months -< 12 months	18 (66.7)	9 (33.3)	27 (100.0)		
1-<4 years	63 (65.6)	33 (34.4)	96 (100.0)		
4 years and above	193 (67.7)	92 (32.3)	285 (100.0)		
IDDS category					
Low	41 (82.0)	9 (18.0)	50 (100.0)	7.907	**.019***
Medium	168 (67.2)	82 (32.8)	250 (100.0)		
Higher	85 (60.3)	56 (39.7)	141 (100.0)		
BMI Category					
Underweight	49 (76.6)	15 (23.4)	64 (100.0)	11.762	**.008***
Normal	158 (70.2)	67 (29.8)	225 (100.0)		
Overweight	65 (59.6)	44 (40.4)	109 (100.0)		
Obese	21 (50.0)	21 (50.0)	42 (100.0)		
Body fat category					
Low	83 (78.3)	23 (21.7)	106 (100.0)	12.537	**.006***
Normal	103 (68.7)	47 (31.3)	150 (100.0)		
High	64 (59.3)	44 (40.7)	108 (100.0)		
Very High	44 (57.1)	33 (42.9)	77 (100.0)		
Muscle mass category					
Low	26 (49.1)	27 (50.9)	53 (100.0)	18.595	**.000***

Normal	165 (63.7)	94 (36.3)	259 (100.0)		
High	84 (79.2)	22 (20.8)	106 (100.0)		
Very High	19 (82.6)	4 (17.4)	23 (100.0)		
Visceral fat category					
Normal	266 (68.2)	124 (31.8)	390 (100.0)	3.838	.147
High	23 (53.5)	20 (46.5)	43 (100.0)		
Very High	5 (62.5)	3 (37.5)	8 (100.0)		

n= number of participants (frequency)
***Ref.* =: Reference group**
***Significant at p<0.01**
****Significant at p<0.05**
BP = Blood Pressure

4.4.7 Determinants of Hypertension

A binary logistic regression analysis to investigate factors contributing to the risk of developing hypertension among the PLHIV was conducted. The predictor variables were tested a priori to verify there was no violation of the assumption of multi-collinearity (Table 15).

The predictor variable, ARV type, in the binary logistic regression analysis was found to contribute to the model. Participants who were on second line ARV had 62% less odds of developing hypertension (OR = 0.379; 95% CI: 0.169-0.846; p = 0.018) compared with participants who were on first line ARV.

Percentage muscle mass was also found to contribute to the model. PLHV with high percentage muscle mass had 82% less odds of developing hypertension (OR = 0.177; 95% CI: 0.064-0.487, p < 0.01) than PLHIV with low percentage muscle mass. Similarly, very high percentage muscle mass also had 78% less odds of developing hypertension (OR = 0.22; 95% CI: 0.051-0.943; p = 0.041) than PLHIV with low percentage muscle mass.

Obesity in the binary logistic regression analysis had 4 times likelihood of developing hypertension (OR = 4.046, 95% CI: 1.018-16.083; p = 0.047) as compared with underweight**.** Furthermore, both medium (OR = 1.968; 95% CI: 1.15-3.369; p=0.014) and higher (OR = 2.348; 95% CI: 1.078-5.115; p=0.032) IDDS were associated with about 2 times likelihood of developing hypertension than PLHIV who had low IDDS.

Overall, the model is a good one, Chi-square = 68.756, p<0.01, which accounts for over 20% of the variation in the prevalence of hypertension (*Negelkerke* pseudo R square = 0.204).

Table 15: Binary logistic regression of hypertension on other factors

Variable	B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for EXP(B)	
							Lower	Upper
Type of ART								
First line ART								Ref.
Second line ART	-0.971	0.41	5.603	1	**0.018****	0.379	0.169	0.846
Does the Medication Affect your Appetite?								
YES								Ref
NO	-0.56	0.386	2.105	1	0.147	0.571	0.268	1.217
%Body Fat Category								
Low			2.723	3	0.436			Ref
Normal	0.002	0.419	0	1	0.997	1.002	0.44	2.278
High	-0.408	0.523	0.607	1	0.436	0.665	0.238	1.855
Very High	-0.874	0.661	1.748	1	0.186	0.417	0.114	1.524
%Muscle Mass								
Low			11.789	3	0.008			Ref
Normal	-0.741	0.397	3.488	1	0.062	0.476	0.219	1.037
High	-1.734	0.517	11.245	1	**0.001***	0.177	0.064	0.487
Very High	-1.516	0.744	4.157	1	**0.041****	0.22	0.051	0.943
BMI Category								
Underweight			3.953	3	0.267			Ref
Normal	0.546	0.453	1.451	1	0.228	1.725	0.71	4.192
Overweight	0.843	0.547	2.372	1	0.124	2.324	0.795	6.795
Obese	1.398	0.704	3.942	1	**0.047****	4.046	1.018	16.083
IDDS Category								
Low IDDS			7.13	2	0.028			Ref
Medium IDDS	0.677	0.274	6.098	1	**0.014****	1.968	1.15	3.369
Higher IDDS	0.853	0.397	4.614	1	**0.032****	2.348	1.078	5.115
Constant	0.705	1.003	0.495	1	0.482	2.025		

***Ref.* =: Reference group**

***Significant at p<0.01**
****Significant at p<0.05**

4.4.8 Association between a Group of Explanatory Variables and Dyslipidemia

Prevalence of dyslipidemia was compared among the different levels of education. Prevalence of dyslipidemia was highest among those who attained educational level higher than senior high (69.2%), followed by PLHIV who had no education at all (66.7%), and lowest among those who had primary education (61.2%). The difference was not statistically significant (p = 0.660).

In addition, dyslipidemia prevalence was compared against occupation. Prevalence of dyslipidemia was higher among farmers (59%), followed by PLHIV who are artisans (40%). PLHIV who are public sector workers had the lowest prevalence of hypertension (14.3%). The difference was statistically significant (p= 0.013), implying that the observed difference in prevalence of dyslipidemia was not due to chance.

In terms of whether participant ever smoked, prevalence of dyslipidemia was higher (66.4%) among those who never smoked as compared to 27.3% for those who ever smoked. The difference in prevalence of dyslipidemia was statistically significant (p < 0.01).

Regarding whether participant ever consumed alcohol, prevalence of dyslipidemia was higher (65.5%) among those who have ever consumed alcohol as compared with 56.6% for those who never took alcohol. The difference in prevalence of dyslipidemia was not statistically significant (p= 0.104).

Furthermore, dyslipidemia prevalence was compared among different meal frequencies per day, the prevalence of dyslipidemia was highest among those who ate three times a day (66%), followed by those who ate twice a day (59.6%) the observed difference in dyslipidemia prevalence was statistically significant (p < 0.01).

Prevalence of dyslipidemia was also compared between ARV first line and ARV second line, prevalence of dyslipidemia was higher (63.6%) among those who took ARV first line, as compared to 62.7% for those who took ARV second line. The difference in prevalence of dyslipidemia was not statistically significant (p = 0.906). The difference in prevalence was therefore most likely due to chance.

With regards to duration of ARV intake, prevalence of dyslipidemia was highest (67%) among those who took ARV for at least four years. Those who had taken ARV less than a year had the lowest prevalence of dyslipidemia (51.5%). The difference in prevalence of hypertension was not statistically significant (p = 0.136).

Prevalence of dyslipidemia was compared among the different Individual Dietary Diversity Score (IDDS) categories. Prevalence of dyslipidemia was highest among those who attained medium IDDS (69.6%), followed by PLHIV who had higher IDDS (59.6%), and lowest among those who had the lowest IDDS (44%). The difference was statistically significant (p < 0.01).

Dyslipidemia prevalence was also different for the different age groups. PLHIV who were aged 55 years and above had the highest prevalence of hypertension (71.7%), followed by those who were aged between 35 and 54 years (62.1%). PLHIV who were between the ages of 18 to 34 years had the lowest prevalence of hypertension (60.9%). The difference was not statistically significant (p = 0.323).

Based on body mass index classification, prevalence of dyslipidemia was highest among PLHIV who were overweight (73.4%), followed by PLHIV who were underweight (62.5%), PLHIV who were obese (61.9%), and lowest among those who were normal (59.1%). The difference was not statistically significant (p = 0.088).

Different dyslipidemia prevalence were also reported among PLHIV with different percentage body fat. Prevalence of dyslipidemia was highest among PLHIV who had very high percentage body fat (72.7%), followed by PLHIV who had high percentage body fat (67.6%), PLHIV with normal (61.3%), and lowest among those who had low percentage body fat (55.7%). The difference was not statistically significant (p = 0.081).

Also, prevalence of dyslipidemia was highest among PLHIV who had low percentage muscle mass (71.7%), followed by PLHIV who had normal percentage muscle mass (65.6%), PLHIV with high muscle mass (60.4%), and lowest among those who had very high percentage muscle mass (34.8%). The observed difference in dyslipidemia prevalence was statistically significant (p = 0.014).

Finally, prevalence of dyslipidemia was highest among PLHIV with very high visceral fat (75%), followed by PLHIV who had normal visceral fat (63.6%), and lowest among those who had low visceral fat (60.5%). The observed difference in dyslipidemia prevalence was not statistically significant (p = 0.730).

Table 16: Bivariate analysis of Dyslipidemia and other factors

Factor	Dyslipidemia Status		Total, n (%)	Chi Square	p-value
	Normal, n (%)	Dyslipidemia, n (%)			
Level of Education					
None	37 (33.3)	74 (66.7)	111 (100.0)	.984	.912
Primary	33 (38.8)	52 (61.2)	85 (100.0)		
Middle/JHS	75 (37.7)	124 (62.3)	199 (100.0)		
Secondary/SHS	12 (36.4)	21 (63.6)	33 (100.0)		

Higher	4 (30.8)	9 (69.2)	13 (100.0)		
Occupation					
Unemployed	17 (34.7)	32 (65.3)	49 (100.0)	16.057	**.013****
Farmer	23 (59.0)	16 (41.0)	39 (100.0)		
Artisan	26 (40.0)	39 (60.0)	65 (100.0)		
Public Sector	3 (14.3)	18 (85.7)	21 (100.0)		
Private Sector	2 (22.2)	7 (77.8)	9 (100.0)		
Trading	90 (35.3)	165 (64.7)	255 (100.0)		
Others	0 (0.0)	3 (100.0)	3 (100.0)		
Ever Smoked					
No	137 (33.6)	271 (66.4)	408 (100.0)	20.187	**.000***
Yes	24 (72.7)	9 (27.3)	33 (100.0)		
Ever consumed Alcohol					
No	43 (43.4)	56 (56.6)	99 (100.0)	2.642	.104
Yes	118 (34.5)	224 (65.5)	342 (100.0)		
Meal frequency per day					
Once	0 (0.0)	4 (100.0)	4 (100.0)	14.638	**.006***
Twice	42 (40.4)	62 (59.6)	104 (100.0)		
Thrice	107 (34.0)	208 (66.0)	315 (100.0)		
4 times	12 (75.0)	4 (25.0)	16 (100.0)		
5 times	0 (0.0)	1 (100.0)	1 (100.0)		
Line of medication					
First line ART	142 (36.4)	248 (63.6)	390 (100.0)	.014	.906
Second line ART	19 (37.3)	32 (62.7)	51 (100.0)		
Duration of medication					
< 6 months	16 (48.5)	17 (51.5)	33 (100.0)	5.540	.136

6 months -< 12 months	13 (48.1)	14 (51.9)	27 (100.0)		
1-<4 years	38 (39.6)	58 (60.4)	96 (100.0)		
4 years and above	94 (33.0)	191 (67.0)	285 (100.0)		
IDDS category					
Low	28 (56.0)	22 (44.0)	50 (100.0)	13.153	**.001***
Medium	76 (30.4)	174 (69.6)	250 (100.0)		
Higher	57 (40.4)	84 (59.6)	141 (100.0)		
Age category					
18 – 34 years	52 (39.1)	81 (60.9)	133 (100.0)	2.262	.323
35 – 54 years	92 (37.9)	151 (62.1)	243 (100.0)		
55 + years	17 (28.3)	43 (71.7)	60 (100.0)		
BMI category					
Underweight	24 (37.5)	40 (62.5)	64 (100.0)	6.539	.088
Normal	92 (40.9)	133 (59.1)	225 (100.0)		
Overweight	29 (26.6)	80 (73.4)	109 (100.0)		
Obese	16 (38.1)	26 (61.9)	42 (100.0)		
Body fat category					
Low	47 (44.3)	59 (55.7)	106 (100.0)	6.723	.081
Normal	58 (38.7)	92 (61.3)	150 (100.0)		
High	35 (32.4)	73 (67.6)	108 (100.0)		
Very High	21 (27.3)	56 (72.7)	77 (100.0)		
Muscle mass category					
Low	15 (28.3)	38 (71.7)	53 (100.0)	10.676	**.014****
Normal	89 (34.4)	170 (65.6)	259 (100.0)		
High	42 (39.6)	64 (60.4)	106 (100.0)		
Very High	15 (65.2)	8 (34.8)	23 (100.0)		

Visceral fat category					
Normal	142 (36.4)	248 (63.6)	390 (100.0)	.629	.730
High	17 (39.5)	26 (60.5)	43 (100.0)		
Very High	2 (25.0)	6 (75.0)	8 (100.0)		

n= number of participants (frequency)
***Significant at p<0.01**
****Significant at p<0.05**

4.4.9 Determinants of dyslipidemia

A binary logistic regression analysis to investigate factors contributing to the risk of developing dyslipidemia among the PLHIV was conducted. The predictor variables in this analysis were also tested a priori to verify there was no violation of the assumption of multi-collinearity.

The predictor variable, smoking, in this regression analysis was found to contribute to the model. PLHIV who never smoked had 84% less odds of developing dyslipidemia than those who said they ever smoked (OR = 0.157, 95% CI: 0.06-0.414; p < 0.01). PLHIV who reported to have ever taken alcohol had 67% probability of developing dyslipidemia as compared with those who have never taken alcohol (OR = 2.053; 95% CI: 1.198-3.517; p < 0.01). Similarly, the odds of developing dyslipidemia is 1.9 times among PLHIV who never exercised compared with those who ever exercised (OR = 1.879; 95% CI: 1.122-3.146; p = 0.016).

Furthermore, a unit increase in body mass index (BMI) resulted in 1.24 times odds of developing dyslipidemia (OR = 1.241; 95% CI: 1.024-1.503; p = 0.027). There is about 55% probability of developing dyslipidemia for every unit increase in BMI. Percentage muscle mass, in the binary logistic regression analysis was found to also contribute to the model. Finally, a unit increase in percentage muscle mass lead to 15% less odds of developing dyslipidemia among the PLHIV (OR = 0.85; 95% CI: 0.747-0.968; p = 0.014).

Overall, the model is a very good one, Chi-square = 82.356, p<0.001, which accounts for over 24% of the variation in the prevalence of dyslipidemia (*Negelkerke* pseudo R square = 0.204).

Table 17: Binary logistic regression of dyslipidemia on other factors

Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Level of Education								
None			1.983	4	0.739			***Ref***
Primary	-0.216	0.34	0.401	1	0.526	0.806	0.414	1.571
Middle/JHS	-0.298	0.289	1.064	1	0.302	0.742	0.421	1.308
Secondary/SHS	-0.06	0.481	0.015	1	0.901	0.942	0.367	2.416
Higher	-0.836	0.758	1.218	1	0.27	0.433	0.098	1.914
Ever smoke?								
YES								***Ref***
NO	-1.849	0.493	14.056	1	**0.000***	0.157	0.06	0.414
Ever taken alcohol?								
YES								***Ref***
NO	0.719	0.275	6.85	1	**0.009***	2.053	1.198	3.517
Exercise								
YES								***Ref***
NO	0.631	0.263	5.755	1	**0.016****	1.879	1.122	3.146
Eats Outside of Home?								
YES								***Ref***
NO	-0.394	0.381	1.071	1	0.301	0.674	0.32	1.422
Type of ART								
First line ART								***Ref***
Second line ART	0.203	0.375	0.292	1	0.589	1.225	0.587	2.556
Duration on ART								
< 6 months			7.93	3	0.047			***Ref***
6 months - <12 months	-0.807	0.634	1.621	1	0.203	0.446	0.129	1.545
1 – < 4 years	-0.055	0.481	0.013	1	0.908	0.946	0.369	2.427
4 years and above	0.413	0.446	0.857	1	0.355	1.511	0.631	3.619
BMI	0.216	0.098	4.864	1	**0.027****	1.241	1.024	1.503
%Body fat	-0.092	0.056	2.719	1	0.099	0.912	0.817	1.018
%Muscle mass	-0.162	0.066	6.036	1	**0.014****	0.85	0.747	0.968
Visceral fat	-0.225	0.122	3.378	1	0.066	0.799	0.629	1.015
IDDS	-0.031	0.097	0.104	1	0.747	0.969	0.802	1.172
Age	0.01	0.013	0.636	1	0.425	1.01	0.986	1.035
Constant	23.882	19718.805	0	1	0.999	23548806658		

***Ref*. =: Reference group**
***Significant at p<0.01**
****Significant at p<0.05**

4.5 Relationship between Diet Quality and CVD Risk Factors (Dyslipidemia, Hypertension, and Diabetes)

The fourth objective of this study was to test the relationship between diet quality and CVD risk factors, including dyslipidemia, diabetes, and hypertension.

4.5.1 Association between Dyslipidemia Status and IDDS

The dyslipidemia group (N=275) was associated with IDDS, M = 4.1477 (SD=1.146) by comparison, the normal group (N=161) was associated with numerically smaller IDDS, M = 4.081 (SD=1.146) (Table 21a). To answer the question whether there is a difference between IDDS of dyslipidemia group and IDDS of normal group (non-dyslipidemia group), an independent sample t-test was performed. As can be seen in (Table 21a), the normal group and the dyslipidemia group distribution were sufficiently normal for purpose of conducting a t test (skew < |2.0| and kurtosis < |9.0|) (Schminder et al., 2010). The mean difference = -.06636; 95% CI (-.30474 - .17202); p = .585 (Table 21b). Therefore, the difference between the two means is not statistically significantly different from zero at the 5% level of significance.

4.5.2 Association between Diabetes Status and IDDS

As was done with dyslipidemia, the diabetes category (N=82) was compared with IDDS, M = 4.273 (SD=1.213), the normal group (N=341) was associated with numerically smaller IDDS, M = 4.088 (SD=1.213) (Table 21a). The normal group and the diabetes group distribution were

sufficiently normal for purpose of conducting a t test (Table 21a). The mean difference = -.18483; 95% CI (-.48298-.11333); p = .224 (Table 21b). Here too, the difference between the two means is not statistically significantly different from zero at the 5% level of significance. Thus, the risk of diabetes was not found to be associated with IDDS.

4.5.3 Association between Hypertension Status and IDDS

Finally, hypertension group (N=143) was also compared with IDDS, M = 4.292 (SD=1.181). In the comparison, the normal group was associated with numerically smaller IDDS, M = 4.041 (SD=1.234) (Table 18a). The normal group and the hypertension group distribution were sufficiently normal for purpose of conducting a t test Additionally (Table 18a), the assumption of homogeneity of variance was tested and satisfied via Levene's F test, F (434) = 0.008, p = 0.929 (Table 18b). The mean difference = -.25110; 95% CI (-.49509 - -.00712); p = 0.044. Unlike dyslipidemia and diabetes, the difference between the two means is statistically significantly different from zero at the 5% level of significance. Thus, the risk of hypertension was found to be associated with IDDS.

Table 18a: Independent t-test descriptive statistics

		N	*Mean*	*Std. Deviation*	*Std. Error Mean*
	Dyslipidemia Status				
IDDS	Normal	161	4.0813	1.14649	.09036
	Dyslipidemia	275	4.1477	1.26434	.07624
	Diabetes Status				
IDDS	Normal	341	4.0877	1.21301	.06569

	Diabetic	82	4.2725	1.31487	.14520
	Hypertension Status				
IDDS	Normal	341	4.0877	1.21301	.06569
	Hypertensive	82	4.2725	1.31487	.14520

N= number of participants (frequency)
IDDS = Individual Dietary Diversity Score

Table 18b: Independent t-test inferential statistics

CVD Risk Factor	*t*	*df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*	*95% Confidence Interval of the Difference*	
Dyslipidemia	-.547	434	.585	-.06636	.12129	-.30474	.17202
	Levene's F test, F (434) = 1.664, p = 0.198						
Diabetes	-1.218	421	.224	-.18483	.15168	-.48298	.11333
	Levene's F test, F (421) = 1.664, p = 0.142						
Hypertension	-2.023	434	**.044***	-.25110	.12414	-.49509	-.00712
	Levene's F test, F (434) = 0.008, p = 0.929						

*** Significant at p<0.05**
t = t statistic
df = degree of freedom
Sig. = Significance

4.6 10-Year Cardiovascular Heart Disease Risk of the PLHIV

To model and predict a 10-year cardiovascular heart disease risk among the PLHIV was the fifth and last specific objective of the study. This was determined using the Framingham Risk Score (FRS). The results are presented below.

4.6.1 Proportions of the PLHIV that belong to the various FRS levels

From Table 19 below, the overall proportion of PLHIV who have high risk of cardiovascular diseases (CVDs) was 1.4%. The proportion for high risk of CVDs based on FRS was found to be higher among males (6.8%) compared with females (0.5%).

Also, the proportion of PLHIV who have medium risk of cardiovascular diseases (CVDs) was 12.5%. The proportion for the medium risk of CVDs was found to be higher among males (37.3%) compared with females (8.6%).

About 86.1% of the PLHIV belonged to the low risk category; 90.5% for females, and 55.9% for males (Table 19)

Table 19: Framingham Risk Score category

FRS Level	Female, n=374		Male, n=59		Total, n=433	
	f	Proportion (%)	f	Proportion (%)	f	Proportion (%)
Low Risk	340	90.5	33	55.9	373	86.1
Intermediate Risk	32	8.6	22	37.3	54	12.5
High Risk	2	0.5	4	6.8	6	1.4

f = frequency
n= number of participants
FRS = Framingham Risk Score

4.6.2 Association between a Group of Explanatory Variables and Framingham Risk Score (FRS)

Framingham Risk Score was compared among males and females. High 10-year CVD risk was observed among males (6.8%) compared with females (0.5%). The difference was statistically significant ($p < 0.001$).

In addition, Framingham Risk Score was compared on the level of education. High 10-year CVD risk was higher among PLHIV who attained education level higher than secondary/SHS (15.4%), followed by PLHIV who attained middle/SHS education (1.5%), and PLHIV who had primary education, 1.2% was reported. The difference was statistically significant ($p< 0.01$).

In terms of whether participant ever smoked, the proportion of high risk for CVDs was 1.5% for those who said they never smoked and 0% for those who reported to have ever smoked. The difference in proportions of CVD risk was statistically significant ($p = 0.023$).

In terms of whether participant exercised, the proportion of high risk for CVDs was 3.5% for those who said they exercise and 0.3% for those who reported no exercise. The difference in proportions of CVD risk was statistically significant ($p = 0.010$).

Regarding ARV type, the proportion of high risk for CVDs was 1.6% for those who were on ARV fist line and 0% for those on ARV second line. The difference in proportions of CVD risk was not statistically significant ($p = 0.646$).

Furthermore, Framingham Risk Score was compared among the different age groups. Proportion of high risk for CVD was highest among PLHIV age 55 years and above (3.7%), 0.4% for 35 – 54 years, and 0% for ages 18 – 34 years. The observed difference in high risk proportions was statistically significant ($p < 0.001$).

Prevalence of dyslipidemia was also compared between ARV first line and ARV second line, prevalence of dyslipidemia was higher (63.6%) among those who took ARV first line, as compared with 62.7% for those who took ARV second line. The difference in prevalence of dyslipidemia was not statistically significant ($p = 0.906$). The difference in prevalence was therefore most likely due to chance.

Diabetes status, hypertension status, and dyslipidemia status, all showed significant association with FRS p<0.05 for all) (Table 20).

Table 20: Bivariate analysis of Framingham Risk Score (FRS) and other factors

Factor	FRS Levels			Total, n (%)	Chi Square	p-value
	Low, n (%)	Medium, n (%)	Higher, n (%)			
Sex						
Female	340 (90.9)	32 (8.6)	2 (0.5)	374 (100.0)	55.313	**.000***
Male	33 (55.9)	22 (37.3)	4 (6.8)	59 (100.0)		
Level of Education						
None	99 (89.2)	12 (10.3)	0 (0)	111(100)	23.371	**.003***
Primary	72 (86.7)	10 (12.0)	1 (1.2)	83 (100)		
Middle/JHS	165 (85.1)	26 (13.4)	3 (1.5)	194(100)		
Secondary/SHS	29 (90.6)	3 (9.4)	0 (0)	32 (100)		
Higher	8 (61.5)	3 (23.1)	2 (15.4)	13 (100)		
Ever Smoked						
No	349 (87.2)	45 (11.2)	6 (1.5)	400(100)	7.517[a]	**.023****
Yes	24 (72.7)	9 (27.3)	0 (0)	33 (100)		
Line of medication						
First line ART	329 (86.1)	47 (12.3)	6 (1.6)	382 (100)	.874	.646
Second line ART	44 (86.3)	7 (13.7)	0 (0)	51 (100)		
Duration on ART						
< 6 months	29 (96.7)	1 (3.3)	0 (0.0)	30 (100.0)	8.435[a]	.208
6 months - <12 months	25 (96.2)	1 (3.8)	0 (0.0)	26 (100.0)		
1 – < 4 years	86 (89.6)	9 (9.4)	1 (1.0)	96 (100.0)		
4 years and above	233 (82.9)	43 (15.3)	5 (1.8)	281 (100.0)		

BMI **Category**						
Underweight	61 (95.3)	3 (4.7)	0 (0)	64 (100)	6.217[a]	.399
Normal	184 (84.0)	31 (14.2)	4 (1.8)	219 (100)		
Overweight	91 (85.0)	15 (14.0)	1 (0.9)	107 (100)		
Obese	36 (85.7)	5 (11.9)	1 (2.4)	42 (100)		
Age Category						
18 – 34 years	50 (100)	0 (0)	0 (0)	50 (100)	87.739	**.000***
35 – 54 years	237 (96.0)	9 (3.6)	1 (0.4)	247 (100)		
55 + years	86 (63.2)	45 (33.1)	5 (3.7)	136 (100)		
DM status						
Normal	296 (88.1)	35 (10.4)	5 (1.5)	336 (100)	8.935	**.011****
Diabetic	64 (76.2)	19 (22.6)	1 (1.2)	84 (100)		
Hypertension status						
Normal	270 (93.8)	18 (6.2)	0 (0)	288 (100)	44.384	**.000***
Hypertensive	103 (71.0)	36 (24.8)	6 (4.1)	145 (100)		
Dyslipidemia status						
Normal	104 (89.7)	14 (9.0)	2 (1.3)	158 (100)	2.777	.249
Dyslipidemic	233 (84.1)	40 (14.4)	4 (1.4)	277 (100)		

n= number of participants (frequency)
***Significant at p<0.01**
****Significant at p<0.05**
FRS = Framingham Risk Score

4.6.3 Determinants of Framingham Risk Score (FRS)

An ordinal logistic regression analysis to investigate factors contributing to the Framingham 10-year risk of developing CVDs among the PLHIV was conducted (Table 11).

Sex in the ordinal logistic regression was found to contribute to the model. Being a female was associated with a predicted decrease of 2.765 in the odds of a participant being in CVD high risk

category compared to their male counterparts. This indicates that a female sex indicates lower CVD risk (p< 0.001). ARV duration also contributed to the model. Taking ARV for less than 6 months was associated with a predicted decrease of 3.2 times odds of a participant developing high risk for CVD high risk compared to taking ARV for 4 years or more. This indicates that duration on ARV increases the risk of CVD among PLHIV (p< 0.01).

Having a normal body weight was associated with a predicted decrease of 2.86 times in the odds of a participant being in CVD high risk category as compared to being obese (p= 0.046). Similarly, being underweight was associated with a predicted decrease of 4.58 times in the odds of a participant having high risk for CVD as compared to being obese (p<0.01) This indicates that ARV duration and obesity are linked with high risk of CVD over the next 10 years.

Finally, not having a high blood pressure lead to a predicted decrease of 2.708 in the odds of a participant being in CVD high risk category. This indicates that PHIV who don't high have blood pressure had lower CVD (p< 0.001).

Table 21: Ordinal logistic regression of FRS on predictor factors

Variable	Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[FRS - Category = 1]	-4.566	1.711	7.124	1	0.008	-7.919	-1.213
[FRS - Category = 2]	-1.045	1.719	0.37	1	0.543	-4.415	2.324
Sex							
Female	-2.765	0.561	24.254	1	**0.000***	-3.866	-1.665
Male	0[a]	.	.	0	.	.	Ref
Duration of medication							
< 6 months	-3.209	1.2	7.146	1	**0.008***	-5.561	-0.856
6 months - <12 months	-1.52	1.148	1.752	1	0.186	-3.77	0.73
1 – < 4 years	-1.011	0.507	3.974	1	**0.046****	-2.005	-0.017
4 years and above	0[a]	.	.	0	.	.	Ref
%Body Fat Category							
Low	3.853	1.108	12.083	1	**0.001***	1.681	6.026
Normal	3.354	1.01	11.019	1	**0.001***	1.374	5.335
High	1.493	0.916	2.655	1	0.103	-0.303	3.288

Very High	0[a]	.	.	0	.	.	Ref
Visceral Fat Category							
Normal	-0.805	1.351	0.355	1	0.551	-3.453	1.843
High	-1.239	1.283	0.933	1	0.334	-3.755	1.276
Very High	0[a]	.	.	0	.	.	Ref
BMI Category							
Underweight	-4.586	1.412	10.554	1	**0.001***	-7.353	-1.819
Normal	-2.859	1.177	5.899	1	**0.015****	-5.166	-0.552
Overweight	-1.864	0.997	3.497	1	0.061	-3.817	0.09
Obese	0[a]	.	.	0	.	.	Ref
IDDS Category							
Low IDDS	0.051	0.587	0.008	1	0.931	-1.099	1.201
Medium IDDS	-0.318	0.561	0.322	1	0.570	-1.418	0.781
Higher IDDS	0[a]	.	.	0	.	.	Ref
BP Status							
Normal	-2.708	0.437	38.451	1	**0.000***	-3.563	-1.852
Hypertensive	0[a]	.	.	0	.	.	Ref
Diabetes Status							
Normal	-0.744	0.43	2.99	1	0.084	-1.588	0.099
Diabetic	0[a]	.	.	0	.	.	Ref
Dyslipidemia Status							
Normal	-0.281	0.468	0.362	1	0.547	-1.198	0.635
Dyslipidemia	0[a]	.	.	0	.	.	Ref

***Ref*. =: Reference group**
***Significant at p<0.01**
****Significant at p<0.05**
FRS = Framingham Risk Score

4.7 Chapter Summary

This chapter presented the results of the study. Proportion of the people living with HIV (PLHIV) with high IDDS (diet quality) was about 14 percent, proportion of those having diet needing improvement was 56 percent, whiles about 30 percent actually had low IDD (poor diet). Factors influencing IDDS (diet quality) were explored.

Prevalence of cardiovascular risk factors including diabetes, hypertension, and dyslipidemia were found to 20.1%, 33.3%, and 63.5% respectively. Determinants of diabetes, hypertension, and dyslipidemia were assessed via binary and multivariate analyses.

Specifically, the relationships between individual dietary diversity score - IDDS (diet quality) and diabetes, hypertension, and dyslipidemia were investigated. The average diet quality was

significantly higher for PLHIV who are hypertensive as compared with PLHIV who are non-hypertensive. Finally, Framingham Risk Score (FRS) was used to determine a 10-year risk of developing cardiovascular diseases (CVDs) among the PLHIV. About 1.4 percent of the participants had high risk of developing CVDs over the next 10 years. About 13 percent had intermediate risk, whiles about 86 percent of participants were in the low risk category. The next chapter discusses the results presented in this chapter.

CHAPTER FIVE

DISCUSSION

5.0 Introduction

This chapter is a discussion of the key findings. It, among others, compares the study findings with existing literature and attempts to offer explanations to find and highlight implications of key findings for programming. The following sub-topics are narrated according to the study objective and summary of key findings of the study; discussion of Diet quality of the PLHIV; Food groups consumed by the PLHIV; Factors associated with diet quality among the PLHIV; Prevalence of diabetes; Factors associated with diabetes; Prevalence of hypertension; Factors associated with hypertension; Prevalence of dyslipidemia; Factors associated with dyslipidemia; Individual dietary diversity score-IDDS (diet quality) and CVD risk factors; 10-year CVD risk among the PLHIV; Factors associated with CVD risk among the PLHIV; Generalizability and transferability of the study findings; Strengths and limitations of the study; Lessons learned from fieldwork about feasibility; What is new from this research; and Implication of the study finding.

5.1 Foods consumed by PLHIV

From the results of this study, it was discovered that most of the respondents consumed starchy staples. Few respondents were noted to consume fruits and vegetables. This was necessary to be evaluated because type of food consumed has an association with developing some chronic conditions, and being prevented from developing them in the first place. Accordingly, a study reported that early dietary modifications play a role in reducing the risk of developing Type 2

diabetes mellitus (Ojo, 2019). The most prominent chronic conditions that have been identified include diabetes mellitus, which is reported to be responsible for about 1.6 million deaths annually; cardiovascular diseases, which are reported to cause about 17.9 million mortalities and cancers, which have been documented to result in some 9 million global deaths every year (; World Health Organization, 2018). It is noteworthy that dietary habits are different across multiple cultures. It is known that the dietary patterns of Americans are significantly diverse from that of Asians (H. Wang, Deng, Qu, Yang, & Yang, 2014). Even among Asians, specific diversities have been reported (H. Wang et al., 2014). Several studies conducted among PLHIV have reported dietary diversity among this group. It is noteworthy that optimum nutrition plays a critical role in the care of PLHIV, especially in locations where malnutrition is prone to set in as a result of limited nutritional resources (Weldegebreal, Digaffe, Mesfin, & Mitiku, 2018). In a study, about eight different food varieties were identified among PLHIV (Weldegebreal et al., 2018). A study, however, has reported lower dietary diversity among PLHIV. It has been argued that in a continent like Africa, providing good quality diet is a challenge. Studies have posited that malnutrition is a challenge in many developing countries (Schonfeldt & Hall, 2012). This challenge is further exacerbated with co-morbid conditions like HIV/AIDS. Consequently, nutritional deficits have been noted to be among the notable challenges facing PLHIV (Weldegebreal et al., 2018). In a study, it was reported that improving the nutritional status of PLHIV will improve the prognosis (Anand & Puri, 2014). Thus, dietary diversity is imperative for optimum health of PLHIV.

5.2 Diet quality of PLHIV

This study sought to evaluate the dietary quality of PLHIV using Individual Dietary Diversity Score (IDDS). The scores indicated that most PLHIV need to improve their diet. Further, very few

participants consumed good quality diet. A lot of them had poor diets on which they fed. This can be attributed to the findings from the study that starchy staples were the most consumed diet among respondents, whereas fruits and vegetable consumption was considered to be unsatisfactory. It has been reported that starchy staples are the major sources of energy for most Africans (Cisse, 2014). Traditionally, African meals are predominantly roots and tubers, cereals and grains, and plantains, which are often complemented with soups, stews and sauces (Cisse, 2014). Consuming starchy foods alone is not considered a balanced meal. Starchy foods are loved among the African population because they are reported to be the major cash crops among farmers in the region (Cisse, 2014). It can thus be appreciated why starchy staples were the most consumed food substances. Similar to the findings of this study, a Nigerian study reported that over a period of three weeks, carbohydrate-based foods were consumed almost every day of the week (Mgbekem et al., 2015). The reason for the high interest in starchy foods consumption has been attributed to the fact that they are readily available and cheap (Mgbekem et al., 2015). In addition, the study identified that fruits and vegetables were least consumed. Studies have reported that fruits and vegetables play a crucial role in optimum nutrition. Enough consumption of fruits and vegetables has been reported to result in reduced risk of developing chronic disease conditions (Pem & Jeewon, 2015). The poor consumption of fruits and vegetables among PLHIV in this study can be attributed to unavailability. In a study, it was reported that although PLHIV had knowledge on the importance of nutrition, their knowledge was not translated into practice, as most respondents were noted to consume less good quality diet (Anand & Puri, 2014). This can be attributed to poor counselling services being provided at ART clinics. It has been reported that good nutritional knowledge among PLHIV is as a result of repeated ART clinic visits (Anand & Puri, 2014). It is noteworthy that among male and female PLHIV, males were identified to consume poor diet

compared to their female counterparts. Studies have shown that there are a number of gender-specific peculiarities in several areas of nutrition. A study concluded that women consume more fruits and vegetables than males, who are noted for consuming pork, eggs and foods high in sucrose (Kiefer, Rathmanner, & Kunze, 2005). Further, women have been reported to seek nutritional counselling more often than men do (Kiefer et al., 2005). In another study, it was reported that households that are headed by women enjoy higher dietary diversity than male-headed households (Taruvinga, Muchenje, & Mushunje, 2013).

5.3 Factors associated with diet quality among PLHIV

The study identified several factors that are associated with the quality of diet consumed among PLHIV. Socio-demographic factors were evaluated, and it was noted that occupation played a significant role in determining diet quality. It is interesting to note that the predominant occupation that was identified to be associated with poor diet quality was farming. PLHIV who were unemployed were noted to feed better than the farmers. According to Cisse (2014), starchy staples are the frequently consumed meals in Africa. A study reported that rural areas, more than urban areas, consume most amounts of starchy staples (Bricas & Tchamda, 2017). In East Africa, subsistence farming is recorded to be practiced by about 90% of the population. The predominant crops produced are maize, millet and wheat (Adhikari, Nejadhashemi, & Woznicki, 2015). Cassava is one of the staple foods produced in this region. It is reported that more of farmers cultivate cassava, and it is cultivated for its caloric value (Adhikari et al., 2015). Further, it has been noted that rural areas in developing countries have reduced dietary diversity. This is because diet is principally starchy staples, with minute quantities of animal products, fruits and vegetables (Taruvinga et al., 2013). This explains why although most respondents in this study are farmers,

there is little dietary diversity observed. In addition, pest infestation is a challenge that plagues many African farmers. In a study on fruit and vegetable farming in Africa, the researchers stated that although fruit and vegetable farming contribute to eradicating poverty on the continent, infestation from the fruit fly pest has contributed to huge losses in yield, as well as reducing the quality of fruits (Badii, Billah, Afreh-Nuamah, Obeng-Ofori, & Nyarko, 2015). Thus, although most PLHIV involved in this study were farmers, it is likely that their crops are usually destroyed by pests, resulting in smaller yield, and consequently contributes to low dietary diversity. PLHIV who worked in the formal sector were identified to have good quality diets. It has been noted that unemployment results in unhealthy eating habits, and results in alcohol and drug abuse (Brand, 2015). Thus, when individuals are employed, they are better situated to consume healthy foods. Good employment status does not only benefit individuals, but their families as well, as they are well-equipped to provide for them. In accordance with the findings of this study, Taruvinga et al. (2013), argue that employment status influences dietary diversity. The study reported that whereas unemployment was associated with low dietary diversity, employment in any field of work was associated with high dietary diversity (Taruvinga et al., 2013).

Another factor that was identified to affect diet quality among PLHIV in this study was type of fat. There are principally three types of fat storage in the body: visceral fat, subcutaneous fat and essential fat. Whereas visceral fat refers to fat that is found primarily on the mesentery and omentum (Liu et al., 2017), subcutaneous fat refers to fat cells that are located directly below the skin (Chau et al., 2014). Each type of fat plays a peculiar role, although excessive visceral fat is associated with dysfunctional metabolism whereas subcutaneous fat is considered protective (Chau et al., 2014). Pertaining to IDDS and visceral fat, it was discovered in the study that PLHIV who had normal visceral fat fed better compared to those who had higher visceral fat. Generally,

excessive amounts of visceral fat in the body is considered dangerous, and has been documented to be a strong predictor of cardiovascular diseases (Ozato et al., 2019). Thus, it is considered that consumption of food that results in high visceral fat accumulation is unhealthy. A study has reported that adequate nutrition among PLHIV was a strong indicator of survival in the long term (Anand & Puri, 2014). Consequently, adequate nutrition with the right amounts of essential minerals tends to improve the immune system of PLHIV and ensures good prognosis. This sheds light on why normal visceral fat levels of respondents in this study were associated with quality dietary intake. It is important to appreciate that dietary diversity has been associated with quality diet (Rathnayake, Madushani, & Silva, 2012). This implies that individuals who eat meals with diverse varieties of nutrients are considered to be eating healthy. A study has reported that visceral fat can be reduced by eating soluble dietary fibre (Ozato et al., 2019). A typical source of soluble dietary fibre is maize. In Ghana, maize is considered the most prominent staple food (Ekpa, Palacios-Rojas, Kruseman, Fogliano, & Linnemann, 2019). In the entire sub-Saharan region, maize is known to contribute to about 30% of the total amount of calories consumed (Ekpa et al., 2019). Normal visceral fat levels could be attributed to adequate intake of soluble dietary fibre foods. Further, PLHIV who were noted to eat twice a day were recorded to have higher quality diet. Meal frequency is an important aspect of nutrition. Although some studies report different results, most studies have reported that eating more frequently during the day is associated with higher risk of obesity and developing chronic diseases (Kahleova, Lloren, Mashchak, Hill, & Fraser, 2017). Noteworthy, however, is the fact that risk of developing chronic diseases and obesity is associated with frequent snack-eating, and not general optimum diet (Kahleova et al., 2017). This goes to say that eating quality diet a number of times in the day is associated with good health

outcome. This could explain why higher diet quality was indicated among PLHIV when meal times were increased from twice a day to thrice a day.

For PLHIV, there are first line medications and second line ARV medications that are prescribed, depending on adherence and positive health outcomes. The World Health Organization has recommended that first line medications, which are usually non-nucleoside reverse-transcriptase inhibitor-based medications, should be switched to second line medications, which usually constitute protease inhibitor-based medications (Ramadhani et al., 2014). It has been reported that most PLHIV respond better to treatment on second line regimen compared to those who are on first line medications. In this study, participants were noted to have poor diet quality when they took first line ARVs. This is consistent with findings from a study which reported that although ARV is efficacious in suppressing HIV replication, it often compromises adequate nutrition because of the numerous associated side effects (Amos K. Laar et al., 2018). Some noted side effects to ARV medications include nausea, diarrhoea, vomiting and abdominal pains. Poor diet quality can also be attributed to the fact that there is reduced food intake among PLHIV, especially because the HIV infection increases the body's metabolic rate, which in turn causes fatigue because the body fails to keep up (Amos K. Laar et al., 2018). Accordingly, from the findings of this study, PLHIV who had taken ARV medications for a year could not consume good quality diet. Oral lesions, altered mental state and depression also contribute to poor dietary intake (A. Laar & Tandoh, 2016).

5.4 Prevalence of Diabetes

Studies that have been conducted among PLHIV have identified several chronic diseases that are common with such individuals. This includes diabetes, hypertension and dyslipidaemia. It is commonly reported that diabetes mellitus among PLHIV is associated with hypertension and dyslipidemia (Putcharoen et al., 2017). In recent years, it has been noted that PLHIV have better health outcomes and longevity as a result of the use of highly effective combination antiretroviral therapy (cART) (Han et al., 2019). The prevalence of diabetes among PLHIV in this study was recorded to be about 20.1%, with higher prevalence amongst males than females. This is similar to findings from a study that was conducted in the Asia-Pacific region, which reported that diabetes was more prevalent among males than females (Putcharoen et al., 2017). In addition, a study that was conducted in the United States reported a prevalence of diabetes which is 3.8% higher among PLHIV compared to the rest of the population who are not infected (Hernandez-Romieu, Garg, Rosenberg, Thompson-Paul, & Skarbinski, 2017). Further, the overall prevalence of diabetes among PLHIV in the US has been documented to be about 10.3% (Hernandez-Romieu et al., 2017), which is rather lower, compared to the findings of this study. Again, contrary to the findings of this study, a study reported higher prevalence of diabetes among females than males (M. S. Freiberg et al., 2013). The lower prevalence rates in other studies can be attributed to improved health interventions for PLHIV who have co-morbidities including diabetes. Although prevalence values were lower in the US, the researchers argued that lower rates were recorded due to undiagnosed diabetes (Hernandez-Romieu et al., 2017). In Asia, prevalence of diabetes and other non-communicable diseases have been documented to be rising steadily over the past years (Han et al., 2019). In addition, results from the European region also reports there is an increased risk of elevated blood glucose among PLHIV (Njuguna et al., 2018).

5.5 Factors associated with Diabetes

To evaluate the factors that were associated with developing diabetes among PLHIV in this study, visceral fat was considered. The findings reported that diabetes was most prevalent among PLHIV who had higher levels of visceral fat compared to those who had lower levels of visceral fat. Visceral fat is more harmful than subcutaneous fat. This is because visceral fat cells undergo mechanisms which release protein cells that result in inflammation and dyslipidemia (Jung, Ha, & Kim, 2016). Thus, visceral fat cells are closely related to development of diabetes. Generally, studies have documented the relationship between visceral fat cells and diabetes. First, being overweight and obese increases an individual's risk of developing diabetes. The measure of body weight and obesity is according to the body's distribution of fat, which could be either visceral fat or subcutaneous fat. Excess amounts of visceral fat is known to be related to insulin resistance, consequently leading to diabetes (Xia et al., 2018). Relating visceral fat deposits to ethnic backgrounds, a study reported that Europeans are less likely to have more visceral fat cells, compared to Asians (Han et al., 2019). This implies that Asians are more likely to suffer insulin resistance compared to their European counterparts. Findings on the relationship between ethnic backgrounds and visceral fat deposits have produced varying results among diverse ethnic groups. Whereas some studies have indicated that African Americans possess much total body fat compared to Whites, other studies have reported no differences between the two groups. Further, younger Americans are noted to have more visceral fat cells compared to African Americans of similar age and gender, yet other studies have reported no association (Staiano, Broyles, Gupta, & Katzmarzyk, 2013). Similar to the findings of this study, it has been reported that excessive visceral fat is found in PLHIV, which increases their risk of developing health conditions as diabetes (Lake,

2017). Another study reported that visceral fat is highly predictive of pre-diabetes and diabetes, compared to other anthropometric measures including body mass index (BMI).

Another factor that was identified to influence developing diabetes among PLHIV was educational status. According to the results reported in this study, it was observed that respondents who had some form of secondary education were less likely to develop diabetes. This is consistent with findings from another study which reported higher level of knowledge on diabetes as a result of higher level of education (Gibson B. Kagaruki et al., 2018). The study reported that participants' educational status determined their knowledge of the disease conditions, its risk factors and complications, and means of preventing it (Gibson B. Kagaruki et al., 2018). This is to say that with increasing level of education, PLHIV are better exposed to likely co-morbid conditions they are prone to, and live appropriately to prevent their development. Commenting on the association between level of education and risk of developing diabetes, a study reported that high educational levels were associated with increased risk of developing latent autoimmune diabetes (Olsson, Ahlbom, Grill, Midthjell, & Carlsson, 2011). Generally, latent autoimmune diabetes is considered predominant amongst adults than younger individuals, and is thought of to be in between Type 1 and Type 2 diabetes mellitus (Pieralice & Pozzilli, 2018). PLHIV who live in rural areas, and who have no form of formal education have been noted to have some weird perception about living with HIV and having diabetes. A study reported that PLHIV tend to perceive that reducing in weight as happens among PLHIV is a mark of being poor, and so they tend to eat foods which in their opinion would make them gain additional weight (Gibson B. Kagaruki et al., 2018). Consequently, the finding that PLHIV who had higher educational status were less likely to develop diabetes can be attributed to the fact that most people with higher levels of education are privy to the information that influences the development of diabetes.

The third factor that was identified to influence the risk of diabetes among PLHIV was exercise. The findings of the study revealed that PLHIV who engaged in exercises were less likely to develop diabetes, compared to those who did not engage in exercises. It is widespread knowledge that glycaemic control is improved with physical activity, and tends to reduce the risk of mortality among people with type 2 diabetes (Hamasaki, 2016). Optimum physical activity is important for managing diabetes. According to the American College of Sports Medicine, and the American Diabetes Association, people with diabetes should engage in at least 150 minutes of moderate to vigorous physical activity (Hamasaki, 2016). A study established a difference in physical activity and exercise, stating that whereas exercise is structured and planned, physical activity generally involves all forms of movement which involve utilization of energy (Colberg et al., 2016). Despite the benefits exercise poses for PLHIV who have diabetes, it is not a frequent practice. It has been observed that the suggested length of time for exercising for people with diabetes tends to become a burden on them because they have a lower threshold for activity compared to healthy individuals (Hamasaki, 2016). Consistent with the findings of this study, a study that was conducted on the metabolic profile of people with diabetes suggested that walking for a total of one hour and standing for same period of time would reduce postprandial glucose and insulin (Henson et al., 2016). Further, sedentary lifestyle has been associated with poor prognosis of diabetes. According to the American Diabetes Association, people with diabetes should be as much as possible not sit for more than an hour and a half (American Diabetes Association, 2015). In another study, the researchers established that engaging in either aerobic exercises, resistance exercises or a combination of both forms of exercises, among PLHIV tends to improve their quality of life (Jaggers & Hand, 2014).

5.6 Prevalence of Hypertension

Another chronic disease condition that is often associated with PLHIV is hypertension. The total prevalence of hypertension among PLHIV in this study was noted to be 33.3%. This value is rather high compared to LMIC prevalence of 25.2% that was observed from a meta-analysis conducted for studies between 2011-2016 (Xu, Chen, & Wang, 2017). A study that was conducted in Senegal reported a prevalence rate of 22% among PLHIV (Noelle A. Benzekri et al., 2019). Comparing these values to the result of this study, it can be argued that most respondents in this study had little knowledge of hypertension. Further, a study attributed high prevalence of hypertension among PLHIV to poor recognition and management of disease (Noelle A. Benzekri et al., 2019). It has been documented that the overall prevalence of hypertension among PLHIV in the West Africa region is estimated to be more than 30% (Non-Communicable Disease Risk Factor Collaboration, 2017). This rate is rather higher than the prevalence rate that was observed in this study. Several other studies have also reported prevalence rates of hypertension among PLHIV to range between 20-35% (Noelle A Benzekri et al., 2018; Katoto, Thienemann, Bulabula, Esterhuizen, Murhula, Lunjwire, Bihehe, Nachega, et al., 2018; Rodríguez-Arbolí, Mwamelo, Kalinjuma, Furrer, Hatz, Tanner, Battegay, Letang, & on behalf of the, 2017). In a Ghanaian study, it was recommended that health insurance coverage be increased to bridge the gap of inequities in the health service (Sanuade, Boatemaa, & Kushitor, 2018). Thus, it can be argued that the high prevalence of hypertension among PLHIV in this study is as a result of lack of accessibility to health care services. Hypertension has been identified to be a predominant risk factor for disability and mortalities globally (Noelle A. Benzekri et al., 2019). This makes it a disease condition that must be curbed. Generally, it has been reported that there is high tendency for cardiovascular conditions, including hypertension among PLHIV (Rodríguez-Arbolí, Mwamelo, Kalinjuma, Furrer, Hatz, Tanner, Battegay, Letang, & on behalf of the, 2017). Adequate interventions must be

implemented to address the awareness, prevalence and treatment of hypertension among PLHIV. It is noteworthy also, that increased prevalence of hypertension in the sub-Saharan region has been attributed to exponential population growth that takes place in urban areas (Sanuade et al., 2018). In urban areas, people have several unhealthy lifestyles which are risk factors for developing hypertension.

5.7 Factors associated with Hypertension

Certain factors were identified to be associated with risk of developing hypertension among PLHIV. One such factor was marital status. The results of the study revealed that the prevalence of hypertension was highest among PLHIV who had married. The least prevalence was identified among those who were cohabiting. Marriage is considered as a fundamental institution that plays a major part of the lives of most people. Contrary to the findings of this study, it has been reported that unmarried men are associated with an increased risk of developing hypertension, compared to men who are married (Ramezankhani, Azizi, & Hadaegh, 2019). The increased prevalence in this group has been attributed to age, BMI, and lifestyle factors such as smoking and excessive alcohol intake (Ramezankhani et al., 2019). Further, in a cross-sectional study, it was reported that individuals who have never married, or were divorced or separated were at an increased risk of developing hypertension, compared to their married counterparts (Tuoyire & Ayetey, 2019). This can be explained to be because of the life most people live when they get married. It has been suggested that, especially among men, they have better sleep and are likely to eat better and feel less stressed, compared to unmarried men (Causland, Sacks, & Forman, 2014). The findings of this study, however, can be attributed to stress and psychological challenges that most PLHIV encounter in their marriage. PLHIV do not only come under the burden of physical challenges, but

social and psychological stress as well. They are often faced with such problems as discrimination, loss of jobs, financial challenges, and changes in their relationships, especially if they are married (Dejman et al., 2015). A study reported that some spouses and relatives considered their relatives who were infected with HIV to be a disgrace to the family, and would want nothing to do with them (Dejman et al., 2015). A study that was conducted in Nigeria reported that PLHIV who were going through psychological stress resorted to alcohol intake and drug abuse, in order to cope with their situation (Egbe et al., 2017). These, undoubtedly, makes them prone to developing chronic conditions such as hypertension.

The second factor that was identified to be associated with risk of developing hypertension is occupation. The risk of developing hypertension was discovered to be highest among respondents who were employed in the formal private sector. Although some PLHIV have reported to have lost their jobs as a result of their illness, some are able to keep their jobs. Usually, workers in the public sector are said to experience more stress compared to those who work in the private sector. However, a study has refuted these claims. It has been documented that the commonly held notion that public sector workers experience higher stress levels is not true, and that private sector workers are highly stressed (Macklin, Smith, & Dollard, 2006). It is noteworthy that private employers are driven by a passion for success, and would not tolerate lazy employees who would reduce productivity. Stress at work does not only cause physical illness, but psychological and mental distress as well (Bhui, Dinos, Galant-Miecznikowska, de Jongh, & Stansfeld, 2016). As has been discussed above, PLHIV face dejection and shame from friends and relatives alike, and tend to suffer psychological and emotional stress. Going through emotional struggles at home and encountering a similar situation in the workplace poses great danger to the health of PLHIV. Private sector employees are driven by a passion for excellence and passion, and so tend to ensure

their employees put in extra work. It has been documented that when employees have very little authority at work, coupled with high demands from their employers, they tend to experience occupational stress which is harmful to their health (Landsbergis et al., 2015). Further, farmers and artisans were noted to have the least risk to developing hypertension in this study. Farming can be considered a form of physical activity. Physical activity tends to reduce cortisol secretions, and reduces the risk of developing obesity. In a study, it was reported that farmers over a 6-month period were observed to have reduced significantly in measures of obesity (Brumby et al., 2013).

Studies have established that first line ARV medications are usually protective against developing hypertension in PLHIV (Kotler, 2008). It has been reported that more advanced disease, which is classified according to the WHO stage III/IV, low haemoglobin level and low CD4 counts, is protective against hypertension (Kotler, 2008). However, the results of this study reported otherwise. It was noted in this study that participants who took first line ARV medications had higher prevalence of hypertension compared to those who took second line ARV. The reason for the protective ability of first line ARV medications over second line medications have been explained to be as a result of the pharmacokinetic interactions between the ARV medications and antihypertensive medications (Peyrière, Eiden, Macia, & Reynes, 2012). Consequently, it has been advised that the pharmacokinetic interactions between antihypertensive medications and antiretroviral medications are considered in PLHIV before antihypertensive medications are prescribed (Peyrière et al., 2012). Consistent with the findings of this study, Brennan et al. (2018) reported a diagnosis of hypertension among previously normotensive PLHIV prior to initiation on ARV medications. It is noteworthy that contrary to the findings of other similar studies, PLHIV who took second line ARV medications had about 60% protection from developing hypertension. Because there is increased risk of developing hypertension upon the initiation of ARV

medications, several studies have been conducted to discover the mechanism behind the rise in prevalence of hypertension among PLHIV. Notably, usage of some antiretroviral medications have been reported to result in renal and venous complications (Hejazi, Huang, Lin, & Choong, 2013). It results in narrowing of the blood vessels, thereby increasing venous pressure, and eventually causes a rise in blood pressure (Hejazi et al., 2013). Use of ARV medications have been noted to result in complications, although their acceptance and use have been reported to improve quality of life of PLHIV, and has reduced morbidity and mortality that is associated with Acquired Immune Deficiency Syndrome (AIDS) (Hejazi et al., 2013). Consequently, some people on ARV medications have been documented to modify their regimen. First line ARV medications, Zidovudine-Lamivudine-Nevaripine regimen have been swapped for second line medications Stavudine-Lamivudine-Nevaripine in some parts of sub-Saharan Africa (Dimala, Bechem, Aroke, & Kadia, 2017). The respondents of the study were reported to have switched medications due to shortage of the first line medications at the facility. Contrary to this, however, a study reported toxicity to be the reason behind which PLHIV on ARV medications changed their medications (Woldemedhin & Wabe, 2012).

Another factor that was evaluated to be associated with hypertension among PLHIV was the Individual Dietary Diversity Score (IDDS). The study identified an association between hypertension and IDDS levels. Higher IDDS levels were noted to be associated with higher prevalence of hypertension among respondents. A risk of more than twice of developing hypertension was reported among respondents with higher IDDS levels. Hypertension and diabetes are co-morbidities that are frequently found to co-exist among PLHIV. In identifying diet quality, IDDS are used. Consistent with the findings of this study, it has been established that the prevalence of hypertension increases proportionally with the prevalence of obesity, which is a

result of poor dietary habits (Livingstone & McNaughton, 2017). In addition, it has been documented that modifiable risk factors for developing hypertension, including dietary modifications, physical activity and smoking must be appropriately managed to prevent increasing prevalence of hypertension (Livingstone & McNaughton, 2017). Evidence from several studies reiterate the import of diet on development of hypertension. In a study, it was reported that risk of developing hypertension among adolescents was reduced significantly with appropriate adherence to recommended dietary modifications (Zafarmand Mohammad et al., 2020). IDDS scores aim to ascertain the nutritional quality of diet. Among PLHIV, it is reported that a complex interaction exists between HIV, dietary intake and malnutrition (Weldegebreal et al., 2018). Whereas higher scores indicate good diet quality, lower IDDS scores imply poor quality of diet consumed. Thus, the results of this study contradict with the expected results. This can be attributed to the fact that respondents of this study were identified to feed poorly, based on the fact that the predominant food consumed was noted to be starchy staples. Further, respondents who were identified to have medium IDDS levels were noted to be twice at risk of developing hypertension, compared to those who had low IDDS levels. This can be attributed to the fact that hypertension results from multiple co-existing factors, and not only dietary quality. Thus, it has been suggested that appropriate health behaviours are taught to PLHIV in order to manage co-morbid conditions that are likely to emerge because of their present state of health (Livingstone & McNaughton, 2017).

Modifiable risk factors associated with developing hypertension include body weight. In this study, it was observed that PLHIV who were obese were four times more at risk of developing hypertension, compared to those who were underweight. This is consistent to findings from other studies which have reported similar results. In the Framingham Study, it is reported that the prevalence of obesity among hypertensive men was twice that of women (Bricas & Tchamda,

2017). Further, it was reported that blood pressure elevation resulted from increasing body weight (Bricas & Tchamda, 2017). In persons who are overweight and obese, hypertension is believed to be prevalent. It has been reported that obesity results in increased reabsorption of sodium in the kidneys, leading to impairment in the renal pressure and alteration of the rennin-angiotensin forces (Bricas & Tchamda, 2017). It is important that PLHIV adhere to adequate dietary advice in order to maintain their weight. As with examining the impact of IDDS scores on hypertension, obesity tends to increase the prevalence of hypertension among PLHIV. The findings of this study can be attributed to the meal patterns and frequency that was reported among respondents. Obesity is known to be associated with frequent binge-eating and consumption of starchy foods (Kahleova et al., 2017). In a study, it was reported that PLHIV who had hypertension were observed to have higher abdominal obesity and increased body fat (Hejazi et al., 2013). In another study that was conducted in South Africa, it was reported that prevalence of hypertension was expected to increase because of predicted rise in obesity among the population (Brennan et al., 2018). Reports from these studies indicate the association between obesity and hypertension is directly proportional. This is to say that an increase in obesity would result in hypertension. Likewise rise in prevalence of hypertension can be explained from increasing obesity among the population. According to one study, the prevalence of hypertension has been predicted to increase by 2025 because of the exponential rise in obesity among people across the globe (Park et al., 2019).

Similarly, body fat was discovered in this study to be associated with hypertension. Previous studies that have been conducted in this area have reported similar associations between body fat and hypertension as observed in this study. It was observed in this study that PLHIV who had high body fat percentage were at risk at developing hypertension, compared to those who had low body fat percentage. In a study, it was reported that increased body fat percentage was significantly

associated with increased risk of developing hypertension, although respondents had normal waist-to-hip ratio and waist circumference (Park et al., 2019). It is noteworthy that, assessing cardiovascular risk from body fat values has been reported to be less inaccurate as compared to body fat percentage values. It is argued that, BMI, which is calculated from body mass may be masked by proportions of muscle mass as well, thereby providing false values of BMI (Park et al., 2019). In a study, it was reported that early detection of hypertension among PLHIV can be predicted by evaluating body fat percentage (S.-B. Lee, Cho, Kwon, & Jung, 2019). Incidence of hypertension is known to be higher among black people as compared to white people. The differences in prevalence rates has been attributed to the fact that black people have less central fat but more peripheral fat, compared to white people (George et al., 2016). Thus, prevalence of hypertension is dependent on distribution of body fat mass across different ethnic groups. It has been reported that waist circumference, which is a measure of central adiposity, is strongly associated with increased risk of developing hypertension, compared to fat mass, which is a measure of total body fat (George et al., 2016). Adults who are found to be overweight or obese are likely to have been overweight or obese during their adolescence. Consequently, body fat percentage is appropriate in measuring risk of hypertension among adolescents before reaching adulthood (Mushengezi & Chillo, 2014). Among adolescents, skinfold thickness is utilized in measuring body fat. It is a more affordable and easy way to determine subcutaneous fat, and with a combination of special formulae, calculate a person's body fat (Mushengezi & Chillo, 2014). Among PLHIV, body fat is reported to be reduced as a result of poor nutrition among this group (Mutimura et al., 2010).

Muscle mass was also identified to be associated with hypertension. Muscle mass is often classified as low percentage muscle mass, normal percentage muscle mass, high percentage muscle

mass and very high percentage muscle mass. According to the results of this study, respondents who were identified with high percentage muscle mass and very high percentage muscle mass were at risk of developing hypertension, whereas those with low percentage muscle mass are associated with minimal risk of developing hypertension. This finding is contrary to a study that was conducted among obese individuals. It was reported that increasing muscle mass among obese people is likely to reduce risk of cardiovascular events, including hypertension (Butcher Joshua et al., 2018). A means by which muscle mass can be increased is by engaging in regular exercises. However, because of increasing age and obesity, many individuals are unable to exercise to beneficial levels. They are unable to exert themselves fully as the exercise therapy may demand. Among PLHIV, exercises tend to wear them out (Hamasaki, 2016). Thus, engaging in exercises to build muscle mass may be a difficult task for PLHIV to undertake. It is noteworthy, however, that exercises have been documented to result in a reduction of elevated blood pressure values among obese persons (Butcher Joshua et al., 2018). The findings in this study can be because of the fact that PLHIV in this study were noted to be engaging a lot of physical activity.

5.8 Prevalence of Dyslipidaemia

Dyslipidaemia has been reported to be one of the prominent chronic conditions that are associated with PLHIV. The overall prevalence of dyslipidaemia that was noted in this study was about 64%. This rate is quite high, compared to other studies that have been conducted in a similar area. Dyslipidaemia is characterized by high triglycerides and low high density lipoproteins, as well as reduced CD4 counts among PLHIV (Shen et al., 2015). Based on this, a study that was conducted in China reported high prevalence of dyslipidaemia among PLHIV who were on ARV medications (Shen et al., 2015). It has been suggested that individuals who are newly diagnosed with HIV should be screened for dyslipidaemia because it is an essential part of the quality of life of PLHIV

(Shen et al., 2015). In a Tanzanian study, a prevalence of 67% was reported, indicating increased triglycerides among PLHIV, although these were not on any ARV medications (Armstrong et al., 2011). A rather lower prevalence of 4.5% was recorded in a study that was conducted in Ethiopia (Tadewos, Addis, Ambachew, & Banerjee, 2012). In commenting on other prevalence rates of dsylipaedmia among PLHIV, Tadewos et al. (2012) reported on 43.5% in Cameroon, 22.5% in Kenya, and 42.1% in India. The reason for the difference in prevalence rates has been attributed to the different ARV medications that are being administered by PLHIV in those locations (Tadewos et al., 2012).

5.9 Factors associated with Dyslipidaemia

In determining factors that were associated with the developing of dyslipidaemia among PLHIV, socio-demographic characteristics including occupation, smoking, alcohol intake, and BMI, among others were studied. These provided diverse results which are discussed in the ensuing paragraphs.

Occupation was noticed to be associated with developing of dyslipidaemia. Similar to this finding, a study indicated that the job stress was highly predictive of developing dyslipidaemia (Romero et al., 2013). In this study, dyslipidaemia was reported to be highest among farmers, with the least prevalence among public sector workers. Rather contrary to this finding, it was reported among a predominantly farming community that dyslipidaemia was low amongst the respondents (Agongo et al., 2018). This can be attributed to the fact that farming is a physical activity that reduces risk of hypercholesterolaemia. In another study, it was observed that public sector workers in urban areas were diagnosed with dyslipidaemia, owing to the fact that there is reduced physical activity, and lack of visits to health facilities (Agongo et al., 2018).

Smoking is known to be a modifiable risk factor associated with dyslipidaemia. This study reported higher prevalence of dyslipidaemia among respondents who ever smoked compared to those who had never smoked. Cigarette smoking has been reported to result in an increased risk of developing dyslipidaemia. In China, high smoking rates have been reported to result in dyslipidaemia, consequently resulting in death (Yan-Ling, Dong-Qing, Chang-Quan, & Bi-Rong, 2012). Again, smoking has been documented to lead to dyslipidaemia which results in endothelial injury and causes atherosclerosis and other cardiovascular accidents (Yan-Ling et al., 2012). This finding therefore confirms what is known already.

Pertaining to frequency of meals consumed per day, respondents who were noted to eat thrice a day were more likely to develop dyslipidaemia compared to those who ate only twice a day. This can be attributed to the fact that most respondents in this study were noted to be predominant consumers of starchy staples. It has been documented that increased consumption of carbohydrates may lead to deposition of low density lipoproteins, which influence the risk of developing dyslipidaemia (Rosa, Dos Santos, Leite, Caldas, & Bressan, 2015). It must be noted that a rise in low density lipoprotein results in the development of atherosclerosis, which is a risk factor for most cardiovascular accidents. Thus, consumption of lots of starchy staples is likely to result in development of dyslipidaemia, as has been seen in this study.

Another factor that was identified in this study to be associated with developing dyslipidaemia is the Individual Dietary Diversity Score (IDDS) levels. PLHIV who were reported to have medium IDDS levels were noted to have higher prevalence of dyslipidaemia. Those with low IDDS were noted to have lower prevalence of dyslipidaemia. Most PLHIV who were involved in this study were noted to have low IDDS scores, which implies poor dietary quality among them. This has been explained to be as a result of the high starchy content of their meals. To affirm this, a Chinese

study reported that excessive intake of carbohydrates results in the development of most metabolic disorders (Feng et al., 2015).

PLHIV in this study who had low percentage muscle mass were identified to have the highest prevalence of dyslipidaemia. Those with very high percentage muscle mass were noted to have the least prevalence of dyslipidaemia in this study. This is similar to findings from a study that was conducted to establish the relationship between muscle mass and the risk of developing cardiovascular events. The study reported that high muscle strength was associated with lower dyslipidaemia (Blakeley, Van Rompay, Schultz, & Sacheck, 2018). Consequently, the findings from this study indicate that PLHIV who have high percentage muscle mass are less likely to develop dyslipidaemia compared to those who have low percentage muscle mass. With regards to muscle mass and dyslipidaemia, when there is high percentage muscle mass, there is reduction in the risk of developing cardiovascular accidents (Blakeley et al., 2018). Skeletal muscle is known to be the largest tissue that is sensitive to insulin, and acts to create glucose homeostasis (Vella, Nelson, Unkart, Miljkovic, & Allison, 2020). Thus, muscle mass percentage is key in regulating cardio-metabolic pathways. High density lipoproteins, very low density lipoproteins, total cholesterol and triglycerides have been noted to be in low amounts in the event of increased abdominal mass percentage (Vella et al., 2020). Effect of muscle mass percentage on risk of developing dyslipidaemia is not an independent factor. That is to say that, there are other confounding factors which may influence the effect of muscle mass percentage on dyslipidaemia. Some of these include anthropometric measures as waist circumference and waist-to-hip ratio (Blakeley et al., 2018).

Alcohol consumption influences the risk of developing dyslipidaemia. Alcohol is noted to have several effects on the metabolism of lipids in the body. A study reported that alcohol disrupts the

usual pathway of lipid metabolism and causes an increase in triglycerides (Capurso & Petrakis, 2016). The findings of this study indicate that respondents who consumed alcohol were twice more likely to develop dyslipidaemia, compared to those who had never taken alcohol. Alcohol is noted as a modifiable risk factor to the developing dyslipidaemia. This means that respondents who refrain from taking alcohol are less likely to develop dyslipidaemia. A study agreed to the findings of this study, stating further, that the effect of alcohol on lipid metabolism depended largely on the type of alcoholic beverage being consumed (Huang et al., 2017). When PLHIV consume alcohol in great amounts, there is risk of developing complications including hypertriglyceridaemia and dyslipidaemia.

Exercise was identified as a factor that is associated with developing dyslipidaemia. In this study, it was reported that PLHIV who did not engage in exercises were two times more likely to develop dyslipidaemia compared to those who engaged in exercises. Some studies have recommended specific exercises that can be engaged in, including gardening and walking (Hamasaki, 2016). Consistent with the findings of this study, it has been documented that exercising goes a long way to improve the lipid levels in the body, as well as provide a positive effect on PLHIV who have dyslipidaemia (Y. Wang & Xu, 2017). To improve dyslipidaemia levels, aerobic exercises have been proposed. Aerobic exercises pertain to physical activities that increase heart rate and respiratory volume to provide for the oxygen requirements of specific muscle tissues (Y. Wang & Xu, 2017). Further, it has been documented that engaging in vigorous exercises tends to reduce postprandial lipids. This reduces the postprandial triglyceride level, and provides a strong prognosis for people with cardiovascular conditions (Y. Wang & Xu, 2017). The findings of this study can be attributed to the fact that majority of the PLHIV who were involved in the study are farmers. Farming is a rather vigorous exercise which involves movement of most parts of the body.

Previous studies have posited that although exercise provides the opportunity for improvement of co-morbid conditions among PLHIV, engaging in exercises is not a daily practice. This has been attributed to the fact that PLHIV usually have little amounts of energy left in them to carry out any form of exercise (Hamasaki, 2016).

As was identified among obese PLHIV pertaining to developing diabetes, PLHIV who had higher BMI were recorded to be more likely to develop dyslipidaemia, compared to those who had normal BMI. Consequently, PLHIV who have higher BMI have a 20% risk of developing dyslipidaemia. It has been established that the association between BMI measure of obesity and dyslipidaemia is found to be when insulin resistance sets in, among the peripheral tissues (Klop, Elte, & Cabezas, 2013). BMI measures the body fat composition of individuals. An obese is prone to developing such conditions as diabetes and hypertension. These are cardio-metabolic conditions that are associated with increase in BMI. Thus, the finding of this study is consistent with existing literature. Consequently, it has been documented that the risk of developing dyslipidaemia among PLHIV is strongly associated with hypertension and diabetes (Putcharoen et al., 2017). According to this, the findings of this study have been consistent, in relation to findings on hypertension and diabetes.

5.10 Association between IDDS (diet quality) and CVD risk factors

Some studies in the past have evaluated the relationship between diet quality and CVD risk factors. In this study, CVD risk factors that were evaluated were diabetes, hypertension and dyslipidaemia. Diet quality was measured by IDDS levels. In relation to IDDS and diabetes, it was observed from the results that IDDS did not play any role in the risk of developing diabetes. Respondents in the

study who did not have diabetes were noted to have lower IDDS levels. Low IDDS levels are indicative of poor dietary quality. Thus, these findings can be attributed to the fact that most PLHIV in this study had poor eating habits. Risk of developing diabetes is associated with excess diet. Thus, to reduce the risk of developing diabetes, dietary modifications are imperative (Ojo, 2019). Few respondents consumed fruits and vegetables in this study.

In this study PLHIV who were hypertensive were found to be associated with IDDS levels. The study reported that IDDS levels had an influence over risk of developing hypertension. Similar to the risk of developing diabetes, the risk of hypertension relates to dietary modifications. Normotensive PLHIV who were involved in the study were reported to have rather lower IDDS levels. Generally, most respondents in the study were reported as having poor diet quality. It is imperative that counselling and educational sessions are provided for PLHIV on quality diet consumption. Concerning risk of developing dyslipidaemia and IDDS levels, the results of the study proved that there was no significant association. This finding can also be attributed to the fact that most respondents were noted to have poor diet quality.

5.11 10-year CVD risk among the PLHIV

In this study, the overall proportion of PLHIV who were noted to have high risk of CVDs were 1.4%. A Chinese study reported a rather high proportion of 4.5% (Guo et al., 2017). Further, a study that was conducted in Taiwan reported a high CVD risk of 30.6% based on FRS (Wu et al., 2019). In a study that was conducted in South Africa, a proportion of about 3.6% of PLHIV were noted to have high risk of CVDs based on FRS (Rabkin et al., 2015). The differences in values can

be attributed to the different age groups that were considered during each of these studies. For instance, the Taiwanese study included a lot of elderly people in their study (Wu et al., 2019).

5.12 Factors associated with CVD risk among the PLHIV

Among males and females, the risk of developing CVDs based on FRS was found to be 6.8% and 0.5% respectively. This means that less females than males are at high risk of developing CVDs over a 10-year period. Studies have established that both males and females tend to experience vascular dysfunction with increasing age (X. Xu et al., 2017). Thus, similar proportion of risk among males and females could have been expected from this study. Similar findings were made for medium risk and low risk of CVDs among PLHIV based on FRS, with males being at a higher risk of developing CVDs than females. These findings imply that the female gender is protective against developing CVDs.

Several factors were found to be associated with CVD risk based on FRS from this study. These include, gender, level of education, cigarette smoking, exercise, age group, and chronic conditions as diabetes status, hypertension status and dyslipidaemia status. These are discussed below.

Pertaining to gender, as noted early on, more males than females were noted to be at higher risk of developing CVDs based on FRS. It has been reported that mortality among males and females in 2013 were predominantly as a result of CVDs (Collaborators, 2015). This finding has been attributed to the fact that signs and symptoms of CVDs are dissimilar among males and females (Bots, Peters, & Woodward, 2017). Over the years, CVD morbidity and mortality among males and females have been found to be higher in males than in females (Bots et al., 2017).

In relation to level of education, PLHIV who had attained higher levels of education, from secondary/SHS and higher, were noted to be at a higher risk of developing CVDs based on FRS. Those who had received only as much as primary education were noted to have a lesser risk of developing CVDs. Other studies have reported diverse results from that observed in this study. A reduced incidence of CVD was noticed among participants of a study who had university education (Dégano et al., 2017). This can be attributed to the fact that higher education is expected to come with higher nutritional and behavioural knowledge which ensures individuals are less at risk of developing chronic conditions.

PLHIV in this study who reported to have never smoked were discovered to have a higher risk of developing CVDs, compared to those who had ever smoked. This finding is not coherent with other studies that have been done in this area. It has been reported that smoking and excessive alcohol intake results in developing dyslipidaemia, hypertension and diabetes (Ramezankhani et al., 2019), which are all risk factors of developing CVDs. Thus, the expected finding was to establish high CVD risk among PLHIV who also smoked. This contrary finding can be considered as a confounding variable because other factors, including alcohol intake, was observed among PLHIV in this study. Another study reported no significant relationship between smoking and risk of developing CVDs (Dégano et al., 2017). This was explained to be because of other strong predictors of CVDs which were present among respondents of that study (Dégano et al., 2017).

In addition, participants who reported to be exercising were noted to have high risk for developing CVDs compared to those who did not exercise. This is not consistent with findings from other studies. Hamasaki (2016) reported that physical activity is necessary in managing chronic conditions as diabetes and hypertension. When PLHIV who have diabetes engage in exercise, it is associated with good prognosis (Hamasaki, 2016). Further, it has been established that aerobic

exercises tend to improve the quality of life of PLHIV (Jaggers & Hand, 2014). It is unclear the results of this study. However, it can be attributed to the fact that there are other confounding factors which tend to influence risk of developing CVDs in addition to exercise.

Among different age groups, FRS indicated that the proportion for high risk of CVDs was highest among elderly individuals aged 35 years and above, but reduced among individuals aged 18 – 34 years of age. Similar to this finding, a study that was conducted in Taiwan reported higher risk of developing CVD among PLHIV who were between 40 – 75 years of age (Wu et al., 2019). In African studies, it was reported that there is an increased risk of developing CVDs among the elderly population, compared to the younger population (Alinda G. Vos et al., 2020). These findings can be attributed to the fact that with increasing age, there is evidence that there is vascular dysfunction, which results in structural and functional changes in blood vessels of the elderly (X. Xu et al., 2017). In a study that was conducted in South Africa, the researchers reported higher risk of CVD was associated with age 30 years and older, and further increased with increasing age (Alinda G. Vos et al., 2020). Contrary to the findings of this study, however, a study reported lower risk of CVD among respondents 40 years and above (Guo et al., 2017).

As has been discussed, hypertension status, diabetes status and dyslipidaemia status were observed to have higher risk of developing CVDs based on FRS. Different prevalence rates of dyslipidaemia have been reported among several African countries. In Ethiopia, a rate of 4.5% among PLHIV was reported (Tadewos et al., 2012). In Tanzania, a rather high prevalence of 67% was reported (Armstrong et al., 2011). With regards to hypertension, a study in Senegal reported a prevalence of 22% (Noelle A. Benzekri et al., 2019), compared to the results of a Chinese study which reported 25.2% (Y. Xu et al., 2017). Similar findings have been made pertaining to diabetes status. These

three chronic diseases are reported to be common among PLHIV because of their altered nutritional status and lifestyle patterns (Ojo, 2019).

PLHIV who had been using ARV medications for a period of less than 6 months were noted to have a lower likelihood of being in CVD high risk category. Again, PLHIV who had been on ARV medications for a period of 1 – 3 years were noted to also have a lower likelihood of being in CVD high risk category. Increased duration of using ARV medications have been associated with increased risk of developing CVDs. In a study, it was reported that this phenomenon is as a result of dyslipidaemia, specific factors to use of ARVs, and diabetes mellitus among PLHIV that complicate their risk of developing CVDs with prolonged use of ARVs (Bavinger et al., 2013). Other findings have found no association between ARV medications and risk of CVDs (Lang et al., 2010). Thus, mixed findings have been documented pertaining to duration of ARV medications and risk of developing CVDs.

This study revealed that being of normal weight or underweight was protective against high risk CVD category. Obesity, however, was associated with high risk of developing CVD. Poor eating habits result in gain of excess weight which leaves PLHIV with obesity. Obesity has been identified with risk of developing dyslipidaemia, and consequently CVDs (Klop et al., 2013). Obesity is a measure of the body's distribution of fat. Fat lining in the vasculature results from excess fat intake which causes vascular dysfunction, leading to CVDs (X. Xu et al., 2017).

Finally, blood pressure was found to be related to risk of high-risk CVD category. It was noted in the study that having a lower BP was found to be protective of developing CVD. High blood pressure is what is diagnosed as hypertension. This means that as with the results pertaining to hypertension, similar was observed with BP measurements. Among Africans, the burden of

hypertension coupled with HIV infection is reported to be on the rise (Bain & Gwain, 2019). Thus, when PLHIV have their blood pressure controlled, risk of developing CVD is reduced.

5.13 Generalizability and transferability of the study findings

5.13.1 Generalizability

Several strategies were applied to ensure quality to be able to generalize the finding of this study. The protocol was peer reviewed for its methodological rigorousness. The reliability of the tool was also estimated using recommended scientific methods. An overall data handling approach was carried out with scientific strategies throughout the work. Regarding the methodology, participants were recruited to achieve a well representative sample using pre-defined eligibility criteria to minimize selection bias.

The study participants' allocation into two different groups were carried out prior to starting the data collection. Furthermore, same data collection tools and research assistants were used at the pretest and during the survey.

Appropriate statistical methods were applied to handle confounding effects of some variables, and to control the over estimation of the effect size. Binary and ordinal logistic regressions were appropriately used. In addition. Hence, the findings of the present study are so generalizable to the target population and applicable in other similar settings.

5.13.2 Transferability

This study used a rigorous quantitative research approach that are transferable of the findings. The qualitative data were collected using multi-method; systematic review and meta-analysis, field survey, blood sample collection, and body composition/anthropometric. The collected data were,

coded, analyzed using SPSS version 20. Therefore, the present study is transferable to other similar settings.

5.14 Strengths and limitations of the study

5.14.1 Strengths of the study

a. **Evidence and context-based research**: This research has been proposed through the systematic assessment of research findings available in the poor resource setting in the developing countries. A systematic review and meta-analysis have been done that includes an overview of the prevalence, associated factors and researchers' recommendation. In addition, the author (principal investigator) had a discussion with stakeholders about CVD risk factors among PLHIV in the study area to assess the situation.

b. **Facility-based study**: This study used a facility-based survey to assess the level of CVD risk factors among PLHIV. Facility-based research is very crucial to digging out problems in specific population for the appropriate generalization of the finding to inform policy.

c. **Applied multi-method*:*** This study used a multi-method of systematic review and meta-analysis and facility-based analytical cross-sectional study design (quantitative) to access the level of CVD risk factors among PLHIV and its associated factors. This multi-method approach will boost findings' transferability.

d. **Adequate sample size**: This study has an adequate sample size which has been achieved using scientifically sound methodology based on the major outcome variables (significance level, power, design effect).

5.13.2 Limitations of the study

Although this study has used several strong approaches to generate scientifically sound evidence, it had passed through different limitations. Some of the limitations are:

a. **A proxy method was used to assess diet quality**: The Individual Dietary Diversity Score (IDDS) used to assess the diet quality of study participants focuses more on variety of food groups, and food quantities consumed is not incorporated, which is also important in determining the quality of a diet.

b. The study failed to compare CVD risk factors among study population to HIV-negative population: Because of time and limited budget constraints, the study did not include participants who are HIV-negative. That would have allowed the PI to compare CVD risk among the PLHIV to CVD risk among HIV-negative individuals.

c. Overestimation or underestimation of self-reported CVD risk factors: The self-report method for determining smoking, alcohol consumption, exercise, and even dietary intakes may have led to participants over-reporting or under-reporting as participants may want to look/appear good. It could also result from participants' recall bias.

5.15 Lessons learned from fieldwork about feasibility

In the present study, the reception and humble cooperation from facility managers; doctors, nurses, and Voluntary Counselling and Testing (VCT) personnel were inspirational for the facility-based survey. Study participants' willingness, motivation to listen and give information, and over all reception were so encouraging for further research studies in those facilities and among the study population. The attitude of the managements of the two facilities used in this study towards research on CVDs and HIV has played a pivotal role in different manners at different levels/hierarchies.

In addition, this study and approach (mixed-method) were very important to give local as well as regional/global CVD risk levels. This will bring to light the magnitude of the CVD risk level for the appropriate and necessary interventions to be made.

On the other hand, there were hindering factors or several challenges faced during the survey period. One of the main hindering factors was COVID-19. Field work was abruptly halted for two months due to COVID-19. This affected the study period. In addition, the staff at the ART clinics of the two facilities wanted to be remunerated by the PI for their facilitation in participants' recruitment, which was a huge challenge.

5.16 What is new from this research; and Implication of the study finding

Although CVD among PLHIV is a recognized public health issue, robust scientific evidence is needed to inform stakeholders. CVDs are a major problem among PLHIV but they are often perceived as minor side effects and so not taken as seriously as they ought to. They are known to have a devastating consequence on the health of PLHIV, even resulting in mortality. They also put a lot of burden on the healthcare system, especially in the developing countries. Hence, generating evidence is very crucial for further corrective actions by responsible bodies.

This multi-method research has provided insight into the level of CVD risk factors among PLHIV and its associated factors. Specifically, the cardiovascular risk score among PLHIV has been identified and quantified, which hitherto was not known. Again, the impact of making interventions targeting the various risk factors of CVD has been quantified such that one can have an idea to what extend the risk of CVD among PLHIV will reduce if they were to focus on improving physical activity (exercise) among the PLHIV in Ghana. These are clearly new findings

and additions that the thesis brings to bare. The finding from this study is consistent with previous studies conducted in several low- and middle-income countries. This finding has a great implication for Ghana, where prevalence of CVDs is generally on the rise.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

This chapter finalizes and summarizes the findings of the study presented in three thematic sections as per the broad objectives of this research. They are herein referred to as the study's conclusions. Following these are the recommendations the researcher intends to communicate to fellow researchers, the Ministry of Health/Ghana Health Services, and other stakeholders.

6.1 Conclusions

6.1.1 Diet quality and CVD risk factors among PLHIV

1. This study demonstrates that most of the PLHIV did not consume a good diet which may have an implication on their immune system, as it is already under attack by the HIV itself, and probably emerging new infectious diseases such as COVID-19.
2. The dietary diversity scores indicated that most PLHIV need to improve their diet. Very few participants consumed good quality diet. Most of them had poor diets.
3. The poor diet quality consumed by the participants as indicated above can be attributed to the fact that starchy staples were the most consumed diet among respondents, whereas fruits and vegetable consumption was considered to be unsatisfactory.
4. Female respondents had better diet quality as compared with their male counterparts.
5. Farming, occupation, and type of ART were associated with diet quality.
6. The associated factors accounted for about 16% of the variation in the diet quality of study participants

7. With respect to cardiovascular disease risk factors (diabetes, hypertension, and dyslipidemia), among the participants, hypertension is the only one that showed significant association with diet quality, where hypertensive PLHIV were found to have a better average diet quality than the non-hypertensive ones. This indicates that there are other factors besides diet quality that influence the risk of CVD.

6.1.2 Prevalence of CVD risk factors (diabetes, hypertension, dyslipidemia)

1. Investigations on the prevalence of diabetes, hypertension, and dyslipidemia among the PLHIV revealed very high prevalence rates of these risk factors. It is noteworthy that the prevalence rates are higher than both regional and national prevalence rates.
2. Prevalence of both hypertension and dyslipidemia are comparable between males and females, but prevalence of diabetes is markedly high among males.
3. Factors associated with the prevalence of diabetes were percentage body fat, level of education, and exercise. These factors explain about 13 percent of the variation in the risk of developing diabetes among the PLHIV.
4. Hypertension also had some related factors which included occupation, obesity, high percentage body fat, and high percentage muscle mass. Prevalence of hypertension was also highest among married people. These factors accounted for 20 percent of the changes in the risk of hypertension.
5. Prevalence of dyslipidemia was the highest among the three major risk factors of CVD (diabetes, hypertension, dyslipidemia).
6. Factors associated with dyslipidemia were occupation, smoking, alcohol intake, and obesity explaining about 24 percent of the variation in the risk of developing hypertension.

6.1.3 Assessment of 10-year CVD risk among the PLHIV

1. This investigation on a 10-year cardiovascular disease risk among PLHIV has revealed that significant proportion of the study participants had the risk of developing a CVD within the next 10 years. Majority of the PLHIV however had low risk of developing a CVD.
2. Males have a higher risk of developing CVD in compared with females. Other factors associated with the risk of CVDs among the study participants included, gender, level of education, cigarette smoking, exercise, age group, and chronic conditions such as diabetes status, hypertension status and dyslipidaemia status.
3. Close to half of the variation in CVD risk among the study participants was explained by the associated factors.

6.2 Recommendations

The findings of the study have crucial contributions and implications for prompt action from a public health perspective in Ghana, especially in the Eastern Region of Ghana. Dissemination of these research findings could inform the deep-rootedness of healthcare for PLHIV. Sustainable intervention is important from programs perspective to reduce the risk of CVD among PLHIV. Therefore, the following recommendations are proffered to the concerned bodies accordingly.

6.2.1 Recommendation for policy makers

1. Periodic nutritional screening should be done among PLHIV to detect malnutrition cases early for timely intervention by the facilities.
2. A regular dietary counselling sessions should be organized by the facilities for PLHIV to help improve the diet quality of PLHIV.

3. PLHIV should be encouraged to consume fruits and vegetables on daily basis. This should be lead by Ghana Health Service.
4. Specific micronutrient supplementation as appropriate should also be given by the facilities to PLHIV who show signs and symptoms of micronutrients deficiency.
5. Again, in the light of the above findings, routine screening for cardiovascular diseases and risk factors is highly recommended for the facilities.
6. Innovative integration of CVD in the management protocol for PLHIV by Ghana Health Service will be helpful.
7. The Ministry of Health and other stakeholders should continue to support HIV clinics/ART centers by providing trainings, infrastructure and motivation to enable health facilities provide the necessary care to PLHIV.

6.2.2 Recommendation for future research

In conducting this study, a number of research gaps were identified which could not be filled as they were not part of the objectives of the study. In this respect, the study puts forth the following suggestions that future researches could take up.

1. Further longitudinal studies with multiple follow-up data collection time points, as well as deployment of methodologically robust analytic techniques to control for possible confounding factors, and also with a larger sample size may shed further light on this issue.
2. Again, research could be done to compare the risk of CVD among PLHIV on ART, PLHIV who are ART-naive, and HIV negative individuals.
3. A qualitative research method such as focused group discussions and in-depth interviews can be done to ascertain psychological factors and their influence on CVD risk among the

PLHIV. That will allow them the opportunity to share their experiences with more details that could also help inform decision making or policy

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APPENDICES

Appendix 1: Normality test

Variables	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Age	.245	5	.200
BMI	.305	5	**.033**
% Body Fat	.184	5	.200
% Muscle Mass	.284	5	.200
Visceral Fat	.254	5	.200
Basal Metabolic Rate	.249	5	.200
Metabolic Age	.209	5	.200
Systolic BP	.225	5	.200
Diastolic	.331	5	**.041**
Fasting Blood Sugar	.241	5	.200
Random Blood Sugar	.288	5	.200
IDDS	.246	5	.200
Total Cholesterol	.228	5	.200
HDL Cholesterol	.264	5	.200
Triglyceride	.296	5	.175
LDL Cholesterol	.306	5	.142
VLDL Chol	.172	5	.200

df – degree of freedom

Appendix 2: Information Sheet

INFORMATION SHEET

Title of Study: Diet Quality and Cardiovascular Disease Risk Factors among People Living with HIV

Introduction: My name is Kasim Abdulai, a PhD student at the Department of Population, Family and Reproductive Health, School of Public Health, University of Ghana. I am the Principal Investigator (PI) for this study, and can be contacted on Tel: 0245899006, Email: kasimabdulai7735@gmail.com.

Nature of research: This study aims at understanding the diet quality and cardiovascular disease risk factors among people living with HIV. The study will ascertain the influence of diet quality on other cardiovascular diseases risk factors such as hypertension, diabetes, dyslipidemia, and antiretroviral medications. Four hundred and forty **(**440) adults living with HIV randomly selected from two hospitals; Agormanya (St. Martins De Porres Hospital) and Atua (Atua Government Hospital) in the Lower Manya Krobo Municipality of the Eastern Region will be selected for this study. You have been selected to participate in this study because the study has an eligibility criteria that spells out who the participants should be. Anyone who will be selected to take part will be by random selection. That is how you are selected**.**

Participant's involvement:

- **Duration /what is involved:** Participant's involvement will last for about 20 to 30 minutes. Participant will assist to complete a set of questionnaire, their blood pressure will be taken, and a drop of blood will be taken by pricking your finger to test for lipid profile, omega-3 fatty acid, and fasting blood sugar. Your weight and height will also be measured.
- **Potential Risks:** The only potential risk involved in this study will be the discomfort that will be caused as a result of the finger prick.
- **Benefits:** Participants will know their blood pressure, weight and height, and their lipid profile. The study will provide data on the diet quality and nutritional status of PLHIV. The relationship between lipid parameters, omega-3 fatty acids, diet quality, and CVD risk factors will be documented. And data from this study may provide better insight that may assist in formulating a more holistic CVD risk screening criteria and nutrition intervention policies for PLHIV in Ghana. Any abnormal test results observed by study team will be made available to participants and also participants referred to see a doctor or a psychologist, or both for management.
- **Costs**: The only cost to participants will be their time spent during the study.
- **Compensation:** Participants will be given GHC 20.00 as an incentive for their time spent during the study
- **Confidentiality:** Confidentiality will be maintained at all stages in the research. Only ID numbers will be used to identify participants. And no result or data will be shared with a third party.

- **Voluntary participation/withdrawal:** Participation in this study is voluntary and participants have the right to decline to participate and also withdraw from the study at any time without penalty and without having to give any reasons.
- **Outcome and Feedback:** Results of lipid profile test, fasting blood sugar, as well as measurement of weight and height will be explained to the participants.
- **Feedback to participant**: Overall findings of the research will be communicated to the participants through a durbar.
- **Funding information:** This study is funded by the Principal Investigator (PI).
- **Sharing of participants Information/Data:** The data that will be generated from the study will solely be for the principal investigator.
- **Provision of Information and Consent for participants:** A copy of the Information sheet and Consent form will be given to you after it has been signed or thumb-printed to keep.

Who to Contact for Further Clarification/Questions:

Kasim Abdulai

Department of Population, Family and Reproductive Health

School of Public Health

0245899006

Kasimabdulai7735@gmail.com

For any issues on your right as a participants, please contact:

Ms. Hannah Frimpong

The Administrator

Ghana Health Service Ethical Review Committee

233 302 682709/233 302 687821

info@ghsmail.org

Appendix 3: Medical Report Form

UNIVERSITY OF GHANA

SCHOOL OF PUBLIC HEALTH

DEPARTMENT OF POPULATION, FAMILY AND REPRODUCTIVE HEALTH

A STUDY ON DIET QUALITY AND CARDIOVASCULAR DISEASE RISK FACTORS AMONG PEOPLE LIVING WITH HIV

PARTICIPANT'S REFERRAL FORM

Name of Patient:……

Age: …….. Sex: …….. Marital Status:……

Occupation of Patient: …….....

Date & Time of Referral:…….....

Name of receiving Health Institution:……

Findings:

B/P:…… Pulse:…….... FBS……..

LDL…….. HDL …….. TG…….

Total Cholesterol……

Provisional Diagnosis:……..

Purpose of referral:……

Name of Officer Referring……..

Signature:……. Date:…….

Appendix 4: Ghana Health Service Ethical Clearance Letter

GHANA HEALTH SERVICE ETHICS REVIEW COMMITTEE

In case of reply the number and date of this Letter should be quoted.

MyRef. GHS/RDD/ERC/Admin/App 19|562
Your Ref. No.

Research & Development Division
Ghana Health Service
P. O. Box MB 190
Accra
GPS Address: GA-050-3303
Tel: +233-302-681109
Fax + 233-302-685424
Email: ghserc@gmail.com

10th September, 2019

Kasim Abdulai
Department of Population,
Family and Reproductive Health
University of Ghana
P. O. Box LG 13
Legon - Accra

The Ghana Health Service Ethics Review Committee has reviewed and given approval for the implementation of your Study Protocol.

GHS-ERC Number	**GHS-ERC 007/07/19**
Project Title	Diet Quality and Cardiovascular risk factors among people living with HIV
Approval Date	10th September, 2019
Expiry Date	9th September, 2020
GHS-ERC Decision	**Approved**

This approval requires the following from the Principal Investigator

- Submission of yearly progress report of the study to the Ethics Review Committee (ERC)
- Renewal of ethical approval if the study lasts for more than 12 months,
- Reporting of all serious adverse events related to this study to the ERC within three days verbally and seven days in writing.
- Submission of a final report after completion of the study
- Informing ERC if study cannot be implemented or is discontinued and reasons why
- Informing the ERC and your sponsor (where applicable) before any publication of the research findings.
- Please note that any modification of the study without ERC approval of the amendment is invalid.

The ERC may observe or cause to be observed procedures and records of the study during and after implementation.

Kindly quote the protocol identification number in all future correspondence in relation to this approved protocol

SIGNED.....
Dr. Cynthia Bannerman
(GHS-ERC Chairperson)

Cc: The Director, Research & Development Division, Ghana Health Service, Accra

Appendix 5: Letter of Introduction, St. Martins Hospital

UNIVERSITY OF GHANA
DEPARTMENT OF POPULATION, FAMILY AND REPRODUCTIVE HEALTH
SCHOOL OF PUBLIC HEALTH

Ref. No.:.....

10th July, 2019

The Administrator
St Martins De-Porres Hospital
Agomanya
Odumasi-Krobo

Dear Sir/Madam,

LETTER OF INTRODUCTION
KASIM ABDULAI

This is to introduce **Kasim Abdulai**, a Doctor of Philosophy (PhD) student with the Department of Population, Family and Reproductive Health, University of Ghana, School of Public Health, Legon.

As part of the requirement for the fulfillment of his PhD award, he is conducting a research on **'Diet Quality and Cardiovascular Disease Risk Factors among People Living with HIV.''**

In the preparation of the research protocol, he is required to have the most recent information possible regarding his study.

Any assistance you can offer him to obtain this information will be greatly appreciated.

Yours faithfully,

Prof. Kwasi Torpey
Head of Department

Approved
Attn: Area team,
Please kindly provide the necessary help.
15/11/19
Dr. Asfaw,

Attn Med Dir
Pls assist.
01/11/19.

COLLEGE OF HEALTH SCIENCES
P. O. Box LG 13, Legon, Accra, Ghana.
• Telephone: +233 (0) 289 109 021 | 0289 109 022 • Email: pfrh@ug.edu.gh • Website: www.publichealth.ug.edu.gh

INTEGRI PROCEDAMUS

Appendix 6: Consent Form

CONSENT FORM

STUDY TITLE: Diet Quality and Cardiovascular Disease Risk Factors among People Living With HIV.

PARTICIPANTS' STATEMENT

I acknowledge that I have read or have had the purpose and contents of the Participants' Information Sheet read and satisfactorily explained to me in a language I understand (Twi/Ga/Krobo**).** I fully understand the contents and any potential implications as well as my right to change my mind (i.e. withdraw from the research) even after I have signed this form.

I voluntarily agree to be part of this research.

Name or Initials of Participant……..

Participant's Signature/Thumb Print……

Date:……

Appendix 7: Interpreter's Statement

INTERPRETERS' STATEMENT

I interpreted the purpose and contents of the Participants' Information Sheet to the afore named participant to the best of my ability in the (**Twi/Ga/Krobo)** language to his proper understanding.

All questions, appropriate clarifications sort by the participant and answers were also duly interpreted to his/her satisfaction.

Name of Interpreter……

Signature of Interpreter…….. Date:……

Contact Details

Appendix 8: Investigator Statement and Signature

INVESTIGATOR STATEMENT AND SIGNATURE

I certify that the participant has been given ample time to read and learn about the study. All questions and clarifications raised by the participant have been addressed.

Researcher's name…….

Signature …….

Date…….

Appendix 9: Statement of Witness

STATEMENT OF WITNESS

I was present when the purpose and contents of the Participant Information Sheet was read and explained satisfactorily to the participant in the language he/she understood (**Twi/Ga/Krobo)**.

I confirm that he/she was given the opportunity to ask questions/seek clarifications and same were duly answered to his/her satisfaction before voluntarily agreeing to be part of the research.

Name:……

Signature…….. OR Thumb Print ……..

Date:……

Appendix 10: Questionnaire

UNIVERSITY OF GHANA

SCHOOL OF PUBLIC HEALTH

Project Tittle: Diet Quality and Cardiovascular Risk Factors among People Living with HIV

STUDY QUESTIONNAIRE

Respondent's ID:…… **Researcher's name:……..**

Date of interview (dd/mm/yy):……...

SECTION A: SOCIO-DEMOGRAPHIC CHARACTERISTICS			
No.	**Question**	**Code category**	**Response**
A1	Sex of respondent	1=Female 2=Male	
A2	How old were you when you last celebrated your birthday?		
A3	What is you level of education?	0=None 1=Primary 2=Middle/JHS 3=Secondary/SHS 4=Higher	
A4	What is your marital status?	1=Single 2=Married 3=Divorced 4=Widowed 5=Separated 6=Cohabiting	
A5	What is your occupation?	Unemployed 2. Farmer 3. Artisan 4. Public Sector 5. Private Sector 6. Trading 7. Others (specify)_____	
A6	To which ethnic group do you belong?	1=Akan 2=Ga/Dangme 3=Ewe 4=Krobo 5=Mole-Dagbani 6=Others (specify)_____	
A7	What is your religion?	1=Christianity 2=Islam	

		3=Traditional religion 4=Other (specify)_____	
SECTION B: LIFESTYLE FACTORS			
B1	Do you smoke cigarette?	1=Yes 2=No	
	If yes, how often?	1=Daily 2=Twice a week 3=Weekly 4=Twice per month 5=Monthly	
B2	Do you take alcohol?	1=Yes 2=No	
	If yes, how often?	1=Daily 2=Twice a week 3=Weekly 4=Twice per month 5=Monthly	
B3	Do you exercise?	1=Yes 2=No	
	If yes, how often?	1=Daily 2=Twice a week 3=Weekly 4=Twice per month 5=Monthly	
B4	Do you eat outside of home?	1=Yes 2=No	
	If yes, how often?	1=Daily 2=Twice a week 3=Weekly 4=Twice per month 5=Monthly	
SECTION C: MEDICAL HISTORY			
C1	Which of the following antiretroviral medications do you take?	1=NRTIs Abacavir (ABC) Didanosine (ddI) Lamivudine (3TC) Stavudine (d4T) Zidovudine (ZDV, AZT) Tenofovir (TDF) NtRTI Emtricitabine (FTC) 2=NNRTIs	

		Delavirdine (DLV) Doravirine, (DOR) Efavirenz (EFV) Etravirine (ETR) Nevirapine (NVP) Rilpivirine (RPV) 3=PIs Atazanavir (ATV) Darunavir (DRV) Fosamprenavir (FPV) Indinavir (IDV) Lopinavir + ritonavir (LPV/r) Nelfinavir (NFV) Ritonavir (RTV) Saquinavir (SQV) Tipranavir (TPV)	
C2	For how long have you been taking it?	1=< 6 months 2=6 months - <12 months 3=1 – < 4 years 4=4 years and above	
C3	Do you have high cholesterol?	1=Yes 2=No	
C4	Do you have diabetes?	1=Yes 2=No	
C5	Do you have high blood pressure?	1=Yes 2=No	
C6	CD4 Count		
SECTION D: BODY COMPOSITION/ANTHROPOMETRY			
D1	Height		
D2	Weight		
D3	Body Mass Index (BMI)		
D4	% Body Fat		
D5	% Muscle Mass		
D6	Visceral Fat		
D7	Basal Metabolic Rate (BMR)		
D8	Metabolic Age		
SECTION E: BIOCHEMICAL DATA			
E1	Total Cholesterol		
E2	Triglycerides (TG)		
E3	High Density Lipoprotein (HDL)		
E4	Low Density Lipoprotein (LDL)		
E5	Fasting Blood Sugar (FBS)		

SECTION F:

24 HOUR RECALL WEEKDAY

MEAL TIMING	MEAL/FOOD	QUANTITY/ SERVING SIZE	QUANTITY/ GRAMS
Breakfast ( )			
Mid-Morning Snack ( )			
Lunch ( )			
Mid-Afternoon Snack ( )			
Supper ( )			
Evening Snack ( )			

24 HOUR RECALL WEEKEND

MEAL TIMING	MEAL/FOOD	QUANTITY/ SERVING SIZE	QUANTITY/ GRAMS
Breakfast ( )			
Mid-Morning Snack ( )			
Lunch ( )			
Mid-Afternoon Snack ( )			
SUPPER ( )			
Evening Snack ( )			

Interviewers should use the first 24 hour dietary recall to fill up the dietary diversity scores below

Question number	Food group	Examples	1=Yes 2=No
1	Cereal	Corn/maize, rice, wheat, sorghum, millet or any other grains or foods made from these (e.g. bread, noodles, porridge or other grain products), kooko, banku, kenkey, tua zaafi.	
2	White roots and tubers	white potatoes, white yam, white cassava, cocoyam, white sweet potato or other foods made from roots	
3	Vitamin A rich vegetables and tubers	pumpkin, carrot, squash, or sweet potato that are orange inside + other locally available vitamin A rich vegetables	
4	Dark green leafy vegetables	dark green leafy vegetables, including wild forms + locally available vitamin A rich leaves such asalefu, ayoyo, cassava leaves, spinach, cocoyam leaves	
5	Other vegetables	other vegetables (e.g. tomato, onion, eggplant) + other locally available vegetables	
6	Vitamin rich fruits	ripe mango, cantaloupe, apricot (fresh or dried), ripe papaya, dried peach, and 100% fruit juice made from these + other locally available vitamin A rich fruits, palm nut fruits	
7	Other fruits	other fruits, including wild fruits and 100% fruit juice made from these	
8	Organ meats	liver, kidney, heart or other organ meats or blood-based foods	
9	Flesh meats	beef, pork, lamb, goat, rabbit, game, snail, chicken, duck, other birds, insects	
10	Eggs	eggs from chicken, duck, guinea fowl or any other egg	
11	Fish and seafood	fresh or dried fish or shellfish	
12	Legumes, nuts and seeds	dried beans, dried peas, lentils, nuts, seeds, 'werewere' or foods made from these (eg.peanut butter), soy milk, non-dairy milk	
13	Milk and milk products (dairy)	milk, cheese, yogurt or other milk products	
14	Oils and fats	oil, fats or butter added to food or used for cooking	
15	Sweets	sugar, honey, sweetened soda or sweetened juice drinks, sugary foods such as chocolates, candies, cookies and cakes	
16	Spices, condiments and beverages	spices (black pepper, salt), tomato paste, condiments (soy sauce, hot sauce), beverages (coffee, tea, alcoholic)	