UNIVERSITY OF WESTERN CAPE

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Factors Associated with Type 2 Diabetes Mellitus (T2DM) in People Living with HIV/ AIDS (PLWHA) attending Primary Health Care Centres in Rwamagana District, Rwanda

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KEY WORDS

- HIV
- AIDS
- Type 2 Diabetes Mellitus (T2DM)
- People living with HIV/AIDS
- Insulin-resistance
- HIV/AIDS co-morbidity
- Risk factors
- ARVs /ARTs
- HIV/AIDS-non-communicable disease co-morbidity
- Rwanda

Abstract

Sub-Saharan African countries including Rwanda are facing a double burden of communicable and non-communicable diseases (NCDs). As HIV and AIDS management improves, the AIDS related mortality rate is thus reduced, and people living with HIV/AIDS (PLWHA) live longer and have more risk of developing diabetes mellitus. Despite the benefits of screening for T2DM on mortality reduction among PLWHA, this practice is not routinely performed in Rwanda. Therefore, data on the burden of T2DM in PLWHA and associated factors are limited in this country. The aim of this study was to determine factors associated with T2DM: anthropometric (BMI, height, weight, WHR), lifestyles (smoking, excessive alcohol consumption, physical inactivity) and HIV-AIDs associated factors for T2DM (duration of HIV infection, CD4 count, types of ARVs, duration of ARVs taking) in PLWHA attending Primary Health Care Centres in the Rwamagana District, Rwanda.

A quantitative approach with a cross-sectional analytical study design was used. The study was conducted in seven randomly selected primary health care centres in Rwamagana district. A total of 315 participants of 18 to 65 years were sampled using a systematic sampling technique. A structured data collection instrument and fasting capillary blood glucose measurement were used to collect data from participants. Some data were obtained from participants' files including CD4 counts, types of ARVs and WHO HIV clinical stages. The remainder data were reported by the participants. Ethical clearance was sought and granted from the Biomedical Research Ethics Committee (BMREC) at UWC (130416-050) and the University of Rwanda, College of Medicine and Health Sciences Institutional Review Board (No308/CMHSIRB/2018). Participation was voluntary and all ethical principles such as justice, beneficence and non-maleficence were observed. The confidentiality and privacy of the participants were respected throughout the study.

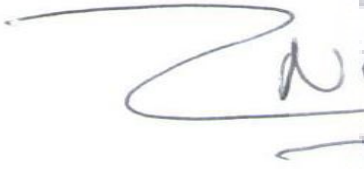
Results. A total of 292 (92.7%) participants which consisted of 200 (68.5%) females completed the survey. Of the participants, 108 (37%) were aged between 36-45 years. Furthermore, 61 (20.9%) and 88 (30.1%) had an unhealthy waist circumference and waist-to-hip ratio respectively. The prevalence of T2DM risk in PLWHA in Rwamagana district was 5.8% (n=17). Although bivariate analysis has shown that age ($\chi 2$ =15.536, df:4, p=0.014), longer duration of HIV/AIDS infection ($\chi 2$=10.056,df:1, p=0.002), longer duration on ARVs ($\chi 2$=11.573,df:1, $p \leq 0.001$) and types of ARVs ($\chi 2$=9.882, df:4, p=0.042) were associated with T2DM, the results of the multivariate analysis have shown that none of these abovementioned factors [Age (OR: 1.034, 95% CI: 0.971-1.001, p=0.298), duration of HIV/AIDS infection (OR: 0.764, 95% CI: 0.480-1.215, p=0.255) and duration on ARVs (OR: 1.508, 95%CI: 0.944-2.411, p=0.086)] were associated with T2DM.

Conclusion: The study has shown that prevalence of T2DM in PLWHA attending PHCs in Rwamagana district was 5.8%. Although bivariate analysis indicated that age, duration of HIV and AIDS, types of ARVs and duration of ARVs taking were associated with T2DM, none of the sociodemographic, lifestyle, anthropometric and HIV/AIDS related factors were associated with T2DM in PLWHA in multivariate analysis. The presence of T2DM in PLWHA supports the need to integrate regular screening of T2DM services into HIV and AIDS healthcare programs within primary health care centres in Rwamagana district, Rwanda.

Declaration

I declare that "***Factors associated with Type 2 Diabetes Mellitus (T2DM) in People Living with HIV and AIDS (PLWHA) attending Primary Health Care Centres in the Rwamagana district, Rwanda***" is my own work, that it has not been submitted for any degree or examination in any other university, and that all sources I have used or quoted have been indicated and acknowledged by complete references.

Innocent NDATEBA **Date: March 2020**



Dedication

This research is dedicated to all people who are infected and affected by HIV and AIDS and all scholars, health care providers, policy makers and funders working in collaboration to provide quality HIV and AIDS care to infected and affected people in Rwanda and beyond.

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List of Abbreviations/Acronyms

ABC	Abacavir
AIDS	Acquired Immuno-Deficiency Syndrome
ARVs	Antiretroviral (drugs)
ATV/r	Atazanavir/ritonavir
BMI	Body Mass Index
CDC	Centres for Diseases Control and prevention
CD4	T-lymphocyte cell bearing CD 4 receptor
CMHS	College of Medicine and Health Sciences
EFV	Efavirenz
HAART	Highly Active Anti-Retroviral Therapy
HIV	Human Immunodeficiency Virus
IDF	International Diabetes Federation
IRB	Institutional Review Board
NCDs	Non-Communicable Diseases
NVP	Nevirapine
PHCs	Primary Health care Centres
PLWHA	People Living with HIV and AIDS
TDF	Tenofovir
3TC	Lamivudine

T2DM	Type 2 Diabetes Mellitus
WHO	World Health Organization
WHR	Waist -Hip- Ratio

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Definitions of terms

Lifestyle factors: Lifestyle factors are defined as people's way of living which include their day to day behaviors, functions such as diet, activities, fun and tastes (Farhud, 2015). In this study, lifestyle factors refer to the smoking, alcohol consumption and exercise habits of people living with HIV/AIDS. In our study, excessive alcohol consumption: more than four drinks per day or 14 drinks per week for man and more than 3 drinks per day or 7 drinks per week for woman (one drink=8g of pure ethanol) but not more than 100 g of alcohol per week (UK Department of Health, 2016), smoking and physical inactivity are considered to be high risk lifestyle factors.

Anthropometric measurements: Anthropometric measurements refer to a set of non-invasive and quantitative body size measurements used to assess the growth, development and health parameters of a person including height, weight, head circumference and waist circumference. (CDC, 2007). In this study, anthropometric measurements include weight, height, waist and hip circumference, body mass index (BMI) and waist-hip ratio (WHR).

HIV and AIDS related factors: HIV and AIDS related factors refer to the factors which are associated with HIV and AIDS and that increase the risk of metabolic diseases (Smart, 2016). In this study, these factors include duration of HIV infection, ARVs use, and duration of ARVs use, types of ARVs and CD4 count which may increase the risk of developing T2DM.

CHAPTER 1: INTRODUCTION

1.1. Introduction and background

HIV and AIDS remains a public health challenge globally and in Southern Africa in particular (UNAIDS, 2016; Vermund, 2014). Swaziland is ranked first with a prevalence of 27.4% while South Africa has the largest population living with HIV and AIDS accounting for 5.9 million people living with HIV and AIDS (PLWHA) (Avert, 2016). In Rwanda, about 210,000 people were living with HIV and AIDS in 2013 (Rwanda Biomedical Centre, 2014) and 3, 000 AIDS-related deaths were registered in the same year (UNAIDS, 2016).

Globally, the strategies for the prevention and control of HIV and AIDS include availability and accessibility of antiretroviral therapies (ARTs/ARVs), early detection and voluntary counseling and testing (Vermund, 2014; Kalra, Kalra, Agrawal & Unnikrishnan, 2011). These strategies have contributed to the reduction of the AIDS-related mortality rate by 43% over the last 15 years worldwide (UNAIDS, 2016). At the end of June 2016, approximately 164,262 people living with HIV and AIDS representing 78% of all PLWHA in Rwanda, were receiving antiretroviral therapy (Nsanzimana *et al.,* 2017). Access to antiretroviral therapies (ARVs) and improvement of HIV and AIDS management have reduced the acute AIDS-related mortality rate and increased survival and life expectancy of PLWHA (Nsanzimana *et al.,* 2015).

Studies conducted in different parts of the world show an association between ARVs and an increase of insulin resistance, (Kiage *et al.,* 2013; Dusingize *et al.,* 2013; Young, Critchley, Johnstone & Unwin, 2009; De Wit *et al.,* 2008) abnormal adiposity (Mutimura *et al.,* 2015; Young *et al.,* 2009), high blood pressure, low High-Density Lipoproteins (HDL) cholesterol and raised triglycerides among PLWHA, glucose intolerance (Young *et al.,* 2009) and change in

glucose levels (Menezes *et al*., 2014; Mutimura, Stewart, Rheeder & Crowther, 2007). A study conducted in Rwanda among HIV uninfected and infected women indicated that increased weight was associated with a high risk of insulin resistance, while ARVs treatment was not associated with insulin resistance (Mutimura *et al.,* 2015). The same authors found that fasting glucose levels were higher in HIV positive individuals treated with ARVs than in uninfected persons (Mutimura *et al.,* 2007). Studies carried out in different countries worldwide revealed variant prevalence of diabetes mellitus among PLWHA (Abebe *et al.,* 2016; Mohammed, Shenkute & Gebisa, 2015; Moyo *et al*., 2014; Paula *et al.,* 2014). The studies conducted in high-income countries revealed that the prevalence of diabetes mellitus varied between 1% to 10% (Moyo *et al.,* 2014) while Paula *et al*. (2014) found in their study conducted in Brazil that diabetes mellitus prevalence among PLWHA was at 4.1%.

Furthermore, studies carried out in Ethiopia revealed that diabetes mellitus in PLWHA ranged between 6.4% and 10.5% (Abebe *et al.,* 2016; Mohammed *et al.,* 2015) whilst research carried out in Tanzania found that Diabetes Mellitus among PLWHA was at 24.7% (Kabati, Maurice, Msell & Urio, 2010). Diabetes mellitus is a non-communicable disease characterized by a constant elevated blood glucose level, where the human body cannot produce sufficient insulin to control glucose utilization, or the human body is not able to adequately utilize the produced glucose (International Diabetes Federation, 2017). The consequences of diabetes mellitus in HIV infected individuals include cardiovascular diseases and chronic kidney diseases resulting in an increased risk of mortality of PLWHA (Shankalala *et al.,* 2017).

1.2. Problem statement

Sub-Saharan African countries including Rwanda are facing a double burden of communicable and non-communicable diseases (Temu, Leonhard, Carter & Thiam, 2014; Young *et al*., 2009). This includes a high prevalence of HIV infection and AIDS, diabetes mellitus, cardiovascular diseases, chronic respiratory diseases and cancer (Sogarwal & Mehra, 2015). This co-morbidity of HIV/AIDS and NCDs affects quality of life and increases the economic burden of affected individuals and families (Sogarwal & Mehra, 2015). As HIV and AIDS management has improved, the AIDS-related mortality rate has reduced and PLWHA are living longer (UNAIDS, 2016; Abebe *et al*., 2016; Nsanzimana *et al*., 2015) and the risk of developing T2DM is thus also increased (Kalra *et al*., 2011).

It has been observed in local community health centres that PLWHA were diagnosed with diabetes when they developed diabetes-related complications such as hypertension and renal diseases. In addition, though it is evident that there is an association between HIV/AIDS and T2DM, routine screening of T2DM in PLWHA is not performed in Primary Health Care settings in Rwanda. Therefore, data on the prevalence and incidence of T2DM in PLWHA are not available. Furthermore, the sociodemographic and HIV/AIDS related factors associated with T2DM in PLWHA in Rwanda are also not documented. This lack of information on the prevalence of T2DM in PLWHA and its associated factors, may affect the quality of HIV and AIDS management resulting in diabetes-related deaths. There is thus a pressing need to determine the prevalence of T2DM risk and associated factors in PLWHA in Rwanda.

In addition, lifestyle factors [smoking, lack of physical exercise and excessive alcohol consumption (more than 14 drinks per week) and HIV/AIDS associated factors (CD4 counts and ARVs)] among others for T2DM in People Living with HIV and AIDS (PLWHA), attending Primary Health Care Centres in Rwamagana District, Rwanda are not known , therefore there is a need for these to be determined. The results of this study may assist health professionals and public health policy-makers with the integration of DM care into HIV and AIDS programmes at primary health care levels. Thus, early detection and diagnosis of T2DM among PLWHA will improve DM care and therefore the quality of life of PLWHA.

1.3. Aim of the study

The aim of the study was to determine the factors associated with T2DM in people living with HIV/ AIDS (PLWHA) attending Primary Health Care Centres in Rwamagana District, Rwanda.

1.4. Objectives of the study

The objectives of the study were to:

a) Determine the prevalence of T2DM risk in PLWHA attending Primary Health Care Centres in Rwamagana district
b) Determine the socio-demographic factors associated with T2DM of PLWHA attending PHCs in Rwamagana district, Rwanda
c) Determine the anthropometric factors associated with T2DM of PLWHA attending PHCs in Rwamagana district
d) Determine lifestyle factors associated with T2DM of PLWHA attending PHCs in Rwamagana district
e) Determine the HIV and AIDS related factors affecting PLWHA attending PHCs in Rwamagana district

1.5. Outline of the study

Chapter 1: Provides an introduction to the study, where background, research problem, aim and objectives of the study are described.

Chapter 2: Reviews the current literature on T2DM and HIV and AIDS as well as factors of T2DM in PLWHA worldwide.

Chapter 3: Describes the research methods used to conduct this study.

Chapter 4: Presents the findings of this study

Chapter 5: Discusses the findings of the study in relation to other studies conducted elsewhere

Chapter 6: Summarises the findings of the study and highlights the main recommendations.

CHAPTER 2: LITERATURE REVIEW

2.1. HIV/AIDS

2.1.1. Definition, aetiology and pathophysiology of HIV/AIDS

The Human Immunodeficiency Virus (HIV) is a retrovirus in the Retroviridae family (HIV-1 or HIV-2) that is transmitted through contact with infected blood, semen, cervical, vaginal fluids or blood products and breast milk (WHO, 2017a; CDC, 2017a). The main routes of HIV transmission include unprotected sexual intercourse (vaginal, oral and anal sex), sharing contaminated needles for injectable drug use, sharing contaminated surgical equipment and instruments, infected blood transfusion and mother to child transmission (WHO, 2017a). Once inhabiting the human body, HIV attacks the immune system by invading and destroying the type of T cells called CD4 (Nall, 2018). These T cells are white blood cells that play a significant role in the immunity system's fight against infections and diseases (WHO, 2017a; CDC, 2017a).

The invasion and destruction of CD4 cells weaken the immunity leading to the human body's inability to defend itself from infections and other diseases thus increasing the risk of developing opportunistic infections and cancers (Nall, 2018). These opportunistic infections and HIV-related cancers indicate that the HIV infected person has already developed the later stage of Acquired Immuno-Deficiency Syndrome (AIDS) which is the most advanced stage of an HIV infection (WHO, 2017a). World Health Organization classifies AIDS in four clinical stages (Weinberg & Kovarik, 2010; WHO, 2005).

The primary HIV infection is characterized by asymptomatic and acute retroviral syndrome (WHO, 2005). Stage I (asymptomatic stage) of the infected person may exhibit persistent generalized lymphadenopathy for less than 6 months, while stage II is characterized by mild symptoms such as unexplained body weight loss amounting to less than 10% of general body weight and some respiratory infections (Weinberg & Kovarik, 2010; WHO, 2005). Stage III is characterized by unexplained signs and symptoms such as weight loss of more than 10% of general body weight, pulmonary tuberculosis, diarrhea, meningitis and other infections, while stage IV is characterized by presence of severe signs and symptoms and AIDS-defining diseases whereby a clinician may presumptively diagnose AIDS based on clinical manifestations (Weinberg & Kovarik, 2010; WHO, 2005).

An HIV infected person with stage IV manifests an HIV wasting syndrome, repetitive infectious involving extrapulmonary tuberculosis, pneumocystis pneumonia, HIV encephalopathy, central nervous system toxoplasmosis, esophageal candidiasis, Kaposi's sarcoma, cytomegalovirus infections and extra-pulmonary cryptococcosis among others (Weinberg & Kovarik, 2010; WHO, 2005). The progression of an HIV infection to AIDS may take 5-10 years though this period can be shorter or longer (up to 10-15 years) (WHO, 2017). The progression of HIV to AIDS also depends on various factors including individual health, lifestyles and strengths of immunity (CDC, 2019). Furthermore, the treatment of an HIV infection with a combination of antiretroviral therapy drugs (ARVs) can slow the progression of HIV to AIDS by inhibiting the virus to replicate which decreases the quantity of the viruses into the blood and is known as viral load suppression (WHO, 2016a).

2.1.2. Treatment of HIV/AIDS

An HIV infected person may take a combination of two or more pills of ARVs termed as Highly Active Antiretroviral Therapy [HAART] (WHO, 2016a). The ARVs should be started as soon as possible after being tested positive regardless of the WHO clinical stage and CD4 count, and the treatment is a lifelong commitment (WHO, 2016a). World Health Organization develops and regularly updates the guidelines of HIV/AIDS treatment regimens for each category of PLWHA (WHO, 2016a). The updated protocol of ARV therapy is provided in Table 1.

Table 1: First line ARV therapy regimen

First-line ARV therapy	Preferred first-line regimens	Alternative first-line regimens
Adults	TDF+3TC (or FTC) +EFV	AZT+3TC+EFV (or NVP) TDF+3TC (or FTC) +TDG DTF+3TC (or FTC) +EFV_{400} TDF+3TC (or FTC) +NVP
Pregnant or breastfeeding women	TDF+3TC (or FTC) +EFV	AZT+3TC+EFV (or NVP) TDF+3TC (or FTC) + NVP
Adolescents	TDF+3TC (or FTC) +EFV	AZT+3TC+EFV (or NVP) TDF (or ABC) +3TC (or FTC) +DTG TDF (or ABC) + 3TC (or FTC) + EFV_{400} TDF (or ABC) +3TC (or FTC) +NVP
Children 3 years to less than 10 years	ABC+3TC+EFV	ABC+3TC+NPV AZT+3TC+EFV+ (or NVP) TDF+3TC (or FTC) +EFV (or NVP)
Children less than 3 years	ABC (or AZT) +3TC+LPV/r	ABC+ (or AZT) +3TC+NVP

(WHO, 2016a)

The first-line ARVs for adults consists of two nucleoside reverse transcriptase inhibitors (NRTI) in conjunction with a non-nucleoside reverse transcriptase inhibitor (NNRTI) or an integrase inhibitor (INSTI). As described in the previous Table 1, the preferred first option for adults includes TDF (Tenofovir) + 3TC (Lamivudine) or FTC (Emtricitabine) + EFV (Efavirenz). In case this regimen is contraindicated, the individual will receive an alternative regimen which consists of AZT (Zidovudine) + 3TC+EFV or AZT+3TC+ NVP (Nevirapine) or TDF+3TC (or FTC) +NVP. The WHO (2016a) also recommends the use of a combination of TDF+3TC (or FTC) + TDG (dolutegravir) or TDF+3TC (or FTC) + EFV_{400}mg/day (Efavirenz at a lower dose of 400mg/day) as an alternative regimen. It is also recommended to use ABC (Abacavir) or boosted protease inhibitors (ATV/r (Atazanavir-ritonavir), DRV/r (Darunavir-ritonavir), LPV/r (Lopinavir-ritonavir) for adults in special circumstances (WHO, 2016a). Due to high toxicity, d4T (stavudine) has been phased out and the current updated guidelines recommend the countries to cease its use (WHO, 2016a).

In addition, the WHO (2016a) recommends the use of 2NRTIs (2 nucleoside reverse-transcriptase inhibitors + ATV/r (boosted Atazanavir-ritonavir) or LPV/r (boosted lopinavir-ritonavir) as the first second line option in the failure of 2 NRTIs+EFV or NVP for adults, and in special circumstances, 2NRTIs+DRV/r (boosted darunavir-ritonavir) can be used. Briefly, this guideline stipulates that the failure of a combination of ABC+3TC+ or TDF+3TC (or FTC) should preferably be replaced by a combination of AZT+3TC in the second line or vice versa (WHO, 2016a). Further, the guideline specifies that if d4T or AZT was used in the first line regimen and failed, TDF+3TC (FTC)+ATV/r or LPV/r is the preferred second line regimen while the failure of the TDF based regimen in the first line is replaced by AZT++3TC+ATV/r or LPV/r (WHO, 2016a).

2.1.3. Long-term consequences of HIV/AIDS

HIV infected people experience a number of long-term HIV/AIDS-related complications which include cardiovascular diseases (Triant, 2013; Baker, Henry & Neaton, 2009), diabetes, kidney and liver diseases, numerous types of cancers and neurocognitive disorders (Triant, 2013; Chu & Selwyn, 2011). These diseases are more prevalent among HIV infected individuals compared to HIV negative people (Triant, 2013; Islam, Wu, Jansson & Wilson, 2012; Chu & Selwyn, 2011; Baker *et al.*, 2009; Triant, Lee, Hadigan & Grinspoon, 2007). The mechanism by which the HIV/AIDS causes these complications is mainly through chronic immune activation which release C-reactive protein (CRP), and prolonged inflammation (Baker *et al*., 2009).

Chronic inflammation causes repetitive injuries of endothelial vessels of heart which cause scars of heart vessels and changes in lipid profile and cholesterol metabolism resulting in atherosclerosis with subsequent cardiovascular diseases (Baker *et al.*, 2009). The main cardiovascular diseases among HIV/AIDS people comprise myocardial infarction, stroke and endocarditis (Triant, 2013; Islam *et al*., 2012; Chu & Selwyn, 2011; Triant *et al*., 2007). Furthermore, chronic inflammation of vessels not only affects heart vessels, but also affects kidney vessels and damages the kidney which explains the high risk of developing chronic kidney diseases (CKD) among PLWHA compared with HIV negative individuals (Ekrikpo *et al*., 2018).

CKD as an HIV-related complication is also caused by chronic losses of electrolytes and water due to diarrhea which is frequent in HIV infected individuals leading to acute kidney injury and subsequent CKD (Ekrikpo *et al*., 2018). In addition, changes in lipid profile and cholesterol metabolism increases the risk of developing diabetes which is a traditional risk factor for hypertension, cardiovascular diseases and CKD (Baker *et al*., 2009). HIV infection destroys the

immune system of the human body and various microbes (bacteria, fungi and viruses) take advantage of the weakened body and invade the human organism causing various opportunistic infections (Chu & Selwyn, 2011). These infections affect various parts of the body comprising the nervous system, lung, liver, skin, and gastrointestinal system (Chu & Selwyn, 2011). The most common complications of liver involve hepatitis B (HBV), hepatitis C (HCV) and non-alcoholic fatty liver diseases (NAFLD) (Kaspar & Sterling, 2017).

The invasion of microbes (e.g. Cryptococcus and Cytomegalovirus) into the nervous system causes chronic inflammation of the nervous system resulting in the development of neurocognitive disorders, neuropathy and myelopathy while damage to the lungs leads to chronic obstructive pulmonary diseases and lung cancer as long-term complications of HIV infection (Chu & Selwyn, 2011). These co-infections of hepatitis B and hepatitis C in PLWHA result in chronic liver injury, which leads to development of liver fibrosis through chronic immune activation and inflammation producing fibrogenic mediators and fibrosis (Kaspar & Sterling, 2017; Debes, Bohjanen & Boonstra, 2016). Studies have also found high risk of skin cancer, Kaposi sarcoma, liver cancer and other HIV/AIDS-related cancers. Chronic immune activation, chronic inflammation, long-term exposure to ARVs and the ageing process are implicated in long–term consequences of HIV/AIDS (Chu & Selwyn, 2011).

2.1.4. Global overview of HIV/AIDS

Globally, 36.9 million people were living with HIV and AIDS at the end of 2017 (WHO, 2018). The African region is the most affected, representing two-thirds of all people living with HIV and AIDS worldwide (WHO, 2018). About 940,000 people died of AIDS-related diseases in 2017 and 21.7 million people, accounting for 59% of all people living with HIV were accessing antiretroviral therapy (UNAIDS, 2018a). Approximately 19.6 million people, accounting for 53.1% of all PLWHA globally, are living in Eastern and Southern Africa region (UNAIDS, 2018a). In addition, about 12.9 million people, representing 65.8% of all people living with HIV/AIDS in Eastern and Southern Africa, accessed ARVs in 2017 (UNAIDS, 2018a).

The Rwanda Biomedical Centre (2014) states that about 210,000 people were living with HIV and AIDS in Rwanda in 2013, representing 3% of the general population. This prevalence of 3% remained stable for almost 15 years due to a proportional decrease of new HIV infections and AIDS-related deaths (RBC & UNAIDS, 2015).The stability of HIV prevalence in Rwanda is also attributed to various preventive strategies that are in place including voluntary HIV testing and counselling, scaling up of prevention of mother-to-child transmission (PMTCT) services across countrywide , promotion of voluntary male circumcision, behaviour change communication (awareness of the population and targeting vulnerable and high-risk population groups), availability and accessibility of condoms, testing and treating female sex workers and males who make sex with males (MSM) and HIV treatment for scaling up prevention and treatment services at all levels of health care services delivery (RBC & UNAIDS, 2015).

UNAIDS (2016) pointed out that 3, 000 people died from AIDS-related diseases in the same year in Rwanda. At the end of June 2016, around 164,262 people living with HIV and AIDS representing 78% of all PLWHA in Rwanda were receiving antiretroviral therapy (Nsanzimana *et al*., 2017).

A Swiss study conducted in Switzerland among 5, 319 PLWAH indicated that the annual average loss of productivity per patient was estimated at 22, 910 CHF (1US $=1.48 CHF) and productivity losses to society were very high (Sendi *et al*, 2004). School age children spend time caring for their HIV infected parents at home or in the hospital which affects their schooling (Ivers *et al.*, 2009). Due to healthcare costs and loss of productivity, HIV/AIDS results in household food insecurity and poverty (Ivers *et al*., 2009).

Furthermore, the health care system suffers from the high burden of HIV and AIDS. The PLWHA requires additional resources including human, financial and logistic resources in the healthcare system which is already fragile due to the shortage of health personnel and high utilization of healthcare resources among infected HIV people (Mutabazi, Zarowsky & Trottier, 2017; Cleary, Boule, Castillo-riquelme & Mcintyre, 2008; WHO, 2006b). In addition, health care workers face double HIV risk factors including personal sexual and occupational risk factors (Koto & Maharaj, 2016). The health care workers are highly exposed to HIV infected blood, blood products, handling non-sterile injecting equipment and other infected body fluids, thus easily becoming infected with HIV (Koto & Maharaj, 2016) which may lead to deaths. Opportunistic infections (e.g. tuberculosis) increase among HIV infected healthcare workers due to stressful and infectious working environment, hence increasing AIDS-related mortality rate among health professionals. With high rate of HIV prevalence and AIDS-related mortality rate among health professionals and leaving the health professions due to HIV and AIDS by health professionals exacerbate the

shortage of health personnel within the healthcare system which fragilize the already weak healthcare system in sub-Saharan Africa (Koto& Maharaj, 2016; WHO, 2006b). A study conducted in USA among 342,732 PLWHA on healthcare expenditure from 2002-2011 found that the total direct expenditure for HIV/AIDS was USD 31,147 which was 800-900% higher compared to people without HIV/AIDS, or the mean aggregate cost of HIV/AIDS of USD 10.7 billion higher than the cost of others free from HIV/AIDS (Ritchwood, Bishu & Egede, 2017). The studies found that sub-Saharan African countries spent 19.4% of their healthcare expenditures on HIV/AIDS programs (Amico, Aran &Avila, 2010) while a study by Cleary *et al*. (2008) conducted in South Africa found that expenditure on HIV-related care was 26% across all healthcare activities. The costs were related to medications, hospitalization, personal costs and expenditures (Ritchwood *et al.*, 2017).

2.1.5. HIV Prevention strategies in Rwanda

HIV prevalence has been stable at 3% for almost 15 years in Rwanda (RBC & UNAIS, 2015). According to WHO (2017b), number of HIV newly infected people in 2016 was estimated to be 7,500 people. Stability of this prevalence has been achieved due to decreases of AIDS-related mortality rate and implementation of HIV prevention strategies. Voluntary HIV testing Counselling has been and is still one of the prevention measures in Rwanda (RBC & UNAIDS, 2015). HIV voluntary testing and counselling has been promoted among general population and specific population groups including couples, adolescents, Men having sex with men, female sex workers (Ingabire *et al*.,2019; Kelley *et al.*, 2016; RBC & UNAIDS, 2015). HIV testing and counselling services are almost universal coverage and are available in 99% of healthcare facilities (UNAIDS, 2017).

HIV testing and counselling services are accessed via health facilities and community outreach for key populations in hot spots and home-based testing through HIV self-testing (UNAIDS, 2017). Rwanda has also planned and implemented various strategies that aim at increasing HIV prevention and limiting its transmission including scaling up of prevention of mother-to-child transmission (PMTCT) services across countrywide. These services are available at all healthcare services delivery levels in Rwanda including primary health care centres (RBC & UNAIDS, 2015). About 96% of health facilities provide a complete package of HIV services comprising PMTCT, VTC and ARTs, and 98% of health facilities provide ARVs (UNAIDS, 2017). About 82% of HIV positive pregnant women were receiving ARVs (WHO, 2017b). Condom use has been promoted in Rwanda and annually, 20 million condoms are freely distributed for use to prevent HIV transmissions (Hakizimana, 2019). To mitigate high HIV transmission rate among sex workers, Rwanda through Rwanda Biomedical Centre has started distributing free condoms to high risk population groups in the purpose to increase availability and accessibility of these services (condoms) though condom use is still low among female sex workers (Ingabire et al.,2019; RBC & UNAIDS, 2015).

Generally,84% of female sex workers used condoms with their last client and 71% of males used condoms in their last anal sex with their male partner (WHO, 2017b). Furthermore, testing and treating female sex workers and males who make sex with males (MSM) and HIV treatment for scaling up prevention and treatment services at all levels of health care services delivery constitute other HIV prevention strategies in Rwanda (Ingabire *et al*., 2019; RBC & UNAIDS, 2015).

Behaviour change communication to increase awareness of population of HIV focusing on high risk groups such as female sex workers and males who make sex with males (Nsanzimana, personal communication February 2020; RBC & UNAIDS, 2015). Rwanda Biomedical Centre uses various

channels involving mass communication (radios), community campaigns and monthly community works (umuganda). These helps to improve population awareness on HIV prevention and available services for high risk group populations to support them. Since a decade ago, Rwanda has been promoting voluntary male circumcisions as HIV prevention measure (RBC & UNAIDS, 2015). In 2015, Rwanda had target to achieve almost 700, 000 male circumcisions as HIV prevention strategy (Mutabazi, Forrest & Mills,2014). The abovementioned strategies have helped Rwanda to maintain HIV prevalence at 3% of the general population and Ministry of Health through Rwanda Biomedical Centre has target to make Rwanda HIV free generation in the future.

2.2. Definition, aetiology and pathophysiology of Type 2 Diabetes Mellitus

Type 2 Diabetes Mellitus is a chronic metabolic disease that occurs when the pancreas is no longer able to produce insulin (the hormone that regulates the blood glucose level and its utilization by the human organism) or the body cannot effectively use the produced insulin, which is known as insulin resistance (IR) leading to a raised blood glucose level (International Diabetes Federation, 2017; WHO, 2016b). Insulin resistance or insulin deficiency can be caused by lack of physical activity, aging, overweight or obesity and genetic predisposition.

Furthermore, the fat distribution in the liver, pancreas, muscles and abdomen increases the risk of insulin resistance with subsequent type 2 diabetes mellitus (Skyler *et al.*, 2017). When there is insulin resistance the pancreatic Islet β-cells increase the insulin secretion with the purpose of maintaining normal glucose in the bloodstream and its utilization as body fuel (Kahn, Cooper & Prato, 2014). In addition, when the β-cells are not able to produce sufficient insulin to regulate glucose or the body is not responding to the increased insulin, this leads to elevated glucose levels in the blood, known as hyperglycemia or diabetes (Kahn *et al.*, 2014).

In response to the lack of glucose utilization, the organism reacts through neoglycogenesis which results in increased levels of glucose and fat metabolism. As the body continues to secrete insulin due to insulin resistance as a compensatory mechanism, this leads to the insulinemia/ hyperinsulinemia which is associated with an atherogenic plasma lipid profile (DeFronzo Ferrannini, 1991). The increase of insulin in the bloodstream as a result of IR enhances the free fatty acid levels and inflammatory cytokines from fat which are associated with the occurrence of T2DM (UpToDate, 2018).

Likewise, hyperinsulinemia increases very-low density lipoprotein (VLDL) metabolism resulting in hypertriglyceridemia (DeFronzo & Ferrannini, 1991). The continuous release of lipids and apolipoproteins from VLDL particles increases the formation of intermediate-density (IDL) and low-density lipoproteins (LDL) which are atherogenic (DeFronzo & Ferrannini, 1991).

Furthermore, the insulin increases cholesterol transport into arteriolar smooth muscle cells increasing endogenous lipid synthesis which enhances the formation of endoarterial plaques leading to atherosclerosis. These fats and lipids circulating in the bloodstream cause complications in various organs including retinopathy and other eye damage, nephropathy and kidney failure, and skin conditions can result in the need for amputations, cardiovascular diseases (stroke, coronary artery diseases, heart attack, stroke, atherosclerosis), hypertension (high blood pressure), neuropathy and erectile dysfunctions (Kahn *et al.,* 2014). Pancreatic β-cells release insulin in response to hyperglycemia which stimulates muscle and adipose tissue to store sugar and prevents the liver from releasing glucose into the bloodstream. IR occurs when glucose uptake is insufficiently stimulated and hepatic glucose release is permitted and persistent hyperglycemia results in the eventual development of T2DM (Honnapurmath & Patil, 2017).

2.3. Overview of Type 2 Diabetes Mellitus in Rwandan General Population

Type 2 Diabetes Mellitus is increasing in Rwandan general population. According to WHO (2016), 2.8% of the Rwandan populations are estimated to have diabetes while World Bank Group states that the prevalence of diabetes in 2019 among 20 to 79 years old population in Rwanda was 5.1% (World Bank Group 2019). A study conducted by Ndabarora *et al*., (2018) among 383 participants attending monthly community work in Nyamashake district, Rwanda has shown the prevalence of 8.6% of T2DM. A STEPWISE study conducted in 2012 showed high prevalences of common diabetes risk factors. That survey indicated that 19.1% of men and 7.1% of women were current tobacco smokers and low fruits and vegetables consumptions with 99.1% consuming less than five servings of fruits and/ or vegetables per day (Ministry of Health, 2015).

2.4. Global overview of T2DM among PLWHA

The prevalence of diabetes mellitus among PLWHA across the globe is becoming a public health challenge (Duncan *et al*., 2018; Njuguna *et al*., 2018; Reid, Tsima & Kirk, 2012). Studies conducted in high-income countries revealed that prevalence of diabetes mellitus in PLWHA varied from 1% to 10% (Moyo *et al.,* 2014) while a study conducted in the USA indicated that people living with HIV had four times higher risk of developing T2DM than those who were HIV negative (Njuguna *et al*., 2018).

A study conducted in the USA from a nationally representative survey conducted in 2009-2010 from the Medical Monitoring Project data and National Health and Nutrition Examination Survey found that the prevalence of T2DM among PLWHA was 10.3% (Hernandez-Romieu *et al.*, 2017).

This study found that the prevalence of T2DM was 3.8% higher in PLWHA adults compared to the general population (Hernandez-Romieu *et al.,* 2017).

Paula *et al.* (2014) in their study conducted in Brazil found that the prevalence of diabetes mellitus among PLWHA was 4.1% while Araujo *et al.* (2014) found that the prevalence of T2DM among PLWHA was 8% in Spain. Furthermore, a risk of T2DM among PLWHA was found in the Asia region. An observational cohort study conducted in Asian regions among 1, 927 patients found that 127 patients (6.6%) were diagnosed with diabetes mellitus within a median follow up of 5.9 years (Han *et al*., 2019). This study found that the incidence of diabetes mellitus among PLWHA was 1.08 per 100 person-years (Han *et al*., 2019). A Swiss HIV cohort study found that 123 of 6, 513 people were found to have diabetes mellitus with an incidence rate of 4.4 cases per 1000 person-years (Ledergerber *et al*., 2007).

2.5. T2DM in PLWHA in the African context

A systematic review and meta-analysis study conducted in African populations showed that the incidence rate of T2DM among infected individuals varied between 4 to 59 per 1, 000 person years (Prioreschi et *al.*, 2017) while Duncan, Goff and Peters (2018) reported a prevalence of 15.1% of T2DM in PLWHA in 2015 with relative risk of 2.4 compared to the general population in African populations.

Another study carried out in Jos, Nigeria by Isa *et al.* (2016) found the baseline T2DM prevalence of 2.3% while a further 5.3% developed T2DM after 12 months of ARVs initiation. Furthermore, it was found in studies carried out in Ethiopia that diabetes mellitus among PLWHA varied between 6.4% to 8% (Abebe *et al.,* 2016; Mohammed, Shenkute & Gebisa, 2015) while research carried out in Tanzania revealed that Diabetes Mellitus among PLWHA was 24.7% (Kabati *et al.*,

2010). Domo and Wunamir (2015) in their study conducted at MUBI hospital in Nigeria, found that T2DM in PLWHA was 14%.

A systematic review conducted by Haregu *et al.* (2012) revealed that the prevalence of T2DM among PLWHA varied between 2.85% to 14.9%. Maganga *et al.* (2015) in their study conducted in Tanzanian adults found a prevalence of 18% of T2DM among PLWHA compared to 5.3% of T2DM in the HIV negative population. The review conducted in sub-Saharan Africa by Njuguna *et al.* (2018) revealed that the prevalence of T2DM among PLWHA sub-Saharan Africa ranged between 1% and 26%. It can thus be concluded from these studies that there is great variability in the prevalences of T2DM among PLWHA in the African context.

2.6. T2DM in PLWHA in Rwandan context

Rwanda is experiencing a double burden of communicable and non-communicable diseases including HIV/AIDS, malaria, tuberculosis, cardiovascular diseases, diabetes, cancer, chronic obstructive pulmonary diseases and mental health problems (Rwanda Ministry of Health, 2015). Approximately 2% of the Rwanda population have diabetes (Rwanda Ministry of Health, 2015) and 3% of the Rwandan population are living with HIV/AIDS (Rwanda Biomedical Centre, 2014). Although it is recognized that non-communicable diseases are increasing among PLWHA, few studies have been conducted to estimate the prevalence of T2DM in PLWHA in Rwanda.

Studies conducted in Rwanda found that the prevalence of diabetes among PLWHA was very low. A cross-sectional study conducted among 824 HIV positive and HIV negative women in Rwanda in the past 10 years found that 0.5% of HIV positive women had diabetes (Anastos *et al.*, 2010). Another current study conducted among women attending antenatal care at public health centres

in Rwanda found that none of the HIV positive women had gestational diabetes mellitus (Meharry *et al.,* 2019).

Furthermore, Mutimura, Stewart, Rheeder and Crowther (2007) in their study carried out in Rwanda found that 18% of PLWHA with lipodystrophy and 16% of non-lipodystrophic PLWHA had impaired fasting glucose. These aforementioned studies were conducted among women, with a scarcity of data on the prevalence of T2DM in adult people living with HIV and AIDS attending primary health care centres in Rwanda where the majority of the population receive HIV /AIDS care services.

2.7. Risk factors for T2DM in PLWHA

The accessibility of antiretroviral therapy and improved management of HIV/AIDS has reduced AIDS-related deaths and increased life expectancy of PLWHA (Nsanzimana *et al.,* 2015; Kalra *et al.,* 2011). Antiretroviral drugs boost the immunity of the human body, slow down the damage caused by the HIV infection and delay the progression of HIV to AIDS, which reduces the risk for opportunistic infections and the life expectancy is thus increased in PLWHA (Trickey *et al.,* 2017; Nsanzimana *et al.,* 2015). Due to the improvement in HIV management, HIV has now become a chronic disease and the risk of developing diabetes mellitus among PLWHA has increased (Kalra *et al*., 2011).

2.7.1. HIV and AIDS-related factors associated with T2DM in PLWHA

2.7.1.1. Duration of HIV/AIDS

Studies conducted in various countries found an association between duration of HIV infection and T2DM in PLWHA (Hernandez-Romieu *et al.,* 2017; Duncan *et al.,* 2018). A large study carried out in the USA to compare the prevalence of T2DM among PLWHA and the general population reported that T2DM prevalence among PLWHA was 3.8% higher compared to the general population (Hernandez-Romieu *et al.,* 2017). This study showed that length of time since HIV infection was associated with presence of T2DM in PLWHA (Hernandez-Romieu *et al.,* 2017).

A study conducted in Ethiopia by Mohammed *et al.* (2015) found a high prevalence of diabetes among participants who were living with HIV infection for ≥ 5 years and low prevalence among those who were living with HIV infection for less than 5 years (9.3% vs 3.2%), and association of duration of HIV infection and diabetes was statistically significant.

Another cross-sectional study carried out in Tehran, Iran to assess the prevalence and associated risk factors of hyperglycemia among HIV positive individuals attending HIV care programmes found an association between duration of HIV/AIDS infection and diabetes mellitus (Rasoolinejad *et al*., 2019). This study found a high prevalence of diabetes among patients living with HIV/AIDS for ≥ 5 years (OR 2.027, 95% CI: 1.37-2.99) (Rasoolinejad *et al*., 2019). Similarly, Duncan *et al.,* (2018) in London, UK found that long duration of HIV infection was associated with development of T2DM in HIV infected individuals.

Studies suggest that the mechanism through which the duration of HIV infection contributes to the development of T2DM is through the long duration of generalized inflammation with up-regulation of chemokines involved in insulin resistance with subsequent T2DM (Dimala *et al.,* 2016; Hadigan & Kattakuzhy, 2014). A prospective study conducted by De Wit *et al.* (2008) found an association between lipodystrophy with T2DM among PLWHA.

The studies suggested that BMI increases because of the redistribution of body fat/visceral fat accumulation and body shape changes that occur after starting the ARVs (Dimala *et al.,* 2016; Flint *et al*., 2009). The appropriate fat distribution in the body contributes to the regulation of metabolic state (Fiorenza, Chou & Mantzoros, 2011), thus the redistribution of body fat contributes to the risk of developing T2DM (Fiorenza *et al.*, 2011).

The prolonged duration of HIV infection is responsible for toxicity of the adipose tissue which becomes inflamed, thus adipose tissue is not able to produce sufficient leptin and adiponectin hormones to contribute in the metabolic state resulting to the development of T2DM among PLWHA (Kumar *et al*., 2015).

2.7.1.2. Types of ARVs

An association between risk of developing diabetes mellitus in people living with HIV/AIDS and types of ARVs has been reported (Kumar & Samaras, 2018; Dimala *et al*., 2016; Mohammed *et al*., 2015). However, the benefits of using ARVs outnumber the negative consequences of these drugs. Countries use global guidelines for HIV/AIDS prevention, treatment and care in development of their own guidelines, according to their capacity to manage and monitor the negative effects of the ARVs. Table 2 indicates the protocol of antiretroviral therapy in Rwanda which includes first- and second-line regimen options (Table 2).

Table 2: Protocol of Antiretroviral Therapy for adults aged 19 years old and above in Rwanda

	Nucleoside Reverse Transcriptase Inhibitor (NRTI)	Non- Nucleoside Reverse Transcriptase Inhibitor (NNRTI)
1	Tenofovir (TDF)+ Lamivudine (3TC)	Efavirenz (EFV)
2	Tenofovir (TDF)+ Lamivudine (3TC)	Nevirapine (NVP)
3	Abacavir (ABC) + Lamivudine (3TC)	Efavirenz (EFV)
4	Abacavir (ABC)+ Lamivudine (3TC)	Nevirapine (NVP)

Source: Rwanda Ministry of Health (2016b)

The protocol stipulates that Emtricitabine (FTC) can replace Lamivudine. Also, in case of contra-indications ATZ/r (Atazanavir/ritonavir) replaces Efavirenz and LPV/r (Lopinavir/ritonavir) replaces Nevirapine when CD4 > 350, and Tenofovir can be replaced by Abacavir in case of contra-indications (Rwanda Ministry of Health, 2016b). Furthermore, the current protocol indicates the second-line option of ART regimen when the first option fails (Table 3).

Table 3: The second line regimen with specific first-line failure.

	First line regimen	Second line regimen
1	TDF+ 3TC+ EFV/NVP	AZT+3TC+ATV/r (Atazanavir/ritonavir) or LPV/r(Lopinavir/ritonavir)
2	ABC+3TC+EFV/NVP	AZT+3TC+ATV/r or LPV/r
3	AZT (Zidovudine) +3TC+EFV/NVP	TDF+3TC+ATV/r or LPV/r

Source: Rwanda Ministry of Health, 2016b

Moreover, the protocol stipulates that the third line is prescribed in case of failure of the second line regimen and it is only prescribed by an HIV expert specialized in HIV management after genotyping test. This regimen cannot be prescribed in primary health care centres. The PLWHA who has a viral load result of > 2,000 copies /ml for two consecutive tests is eligible for the third -line regimen of ART (MoH, 2016b).

The combination of the ART third-line regimen comprises of RAL/ETV+DRV/r (Raltegravir/Etravirine + Darunavir/ritonavir (Rwanda Ministry of Health, 2016b). These drugs, mainly protease inhibitors such as atazanavir, darunavir, indinavir, lopinavir/ritonavir, ritonavir are the main drugs implicated in metabolic complications including insulin resistance, lipodystrophy and dyslipidemia with subsequent development of diabetes mellitus (Das, 2011; Lv, Chu & Wang, 2015; Flint *et al.*, 2009).

In addition, some nucleoside-reverse transcriptase inhibitors (zidovudine, didanosine, lamivudine and stavudine) (Das, 2011; Flint *et al.*, 2009), and non-nucleoside reverse transcriptase inhibitors (efavirenz and nevirapine) are most cited to increase the risk of T2DM in PLWHA (Kumar & Samaras, 2018).

The mechanism by which these drugs induce T2DM is mainly through induction of insulin resistance which is involved in the pathogenesis of diabetes mellitus in HIV infected people (Kumar & Samaras, 2018; Avari & Devendra, 2017; Flint *et al.,* 2009). The ARV drugs inhibit insulin-stimulated glucose disposal blocking glucose uptake through the inhibition of glucose transporter isoform 4 (GLUC4) (Flint *et al.,* 2009). The inhibition of the GLUC4 leads to a decreased muscle uptake of glucose resulting in increased hypertriglyceridemia with subsequent insulin resistance and T2DM (Flint *et al.,* 2009).

Further, antiretroviral therapy has been shown to increase insulin resistance through their interference with insulin signaling at the cellular level and its role in lipotoxicity (Feeney & Mallon, 2011). Insulin resistance refers to the inability of body cells to respond to the insulin hormone which may later result in high blood glucose levels and pre-diabetes or diabetes mellitus (Noumegni *et al.,* 2017).

Studies suggest that chronic inflammation causes immune activation resulting in increased levels of chronic proinflammatory cytokines (tumor necrosis factor alpha and interleukins) which inhibit the insulin signaling transduction leading to a decrease of insulin sensitivity with subsequent insulin resistance in adipose tissue, skeletal muscle and the liver (Pedro *et al.*, 2018; de Luca & Olefsky, 2008). These ARVs drugs also cause insulin resistance through β-cell toxicity, decrease of insulin secretion and lipodystrophy (Avari & Devendra, 2017).

Protease inhibitors such as indinavir and ritonavir block GLUT-4 mediated glucose transport cause insulin resistance and reduction of insulin secretion (Kalra *et al*., 2011). Indinavir also increases production and release of hepatic glucose (Kalra *et al.*, 2011). Furthermore, with indinavir, the insulin loses its ability to suppress hepatic glucose production, prompting glycogenolysis and gluconeogenesis to increase (Kalra *et al.,* 2011).

Moreover, nucleoside reverse transcriptase inhibitors such as stavudine increases insulin resistance and lipodystrophy while stavudine, zidovudine and didanosine increase lactate levels leading to diabetes mellitus (Kalra *et al.,*2011). Research conducted by Noumegni *et al.* (2017) in Cameroon revealed that the prevalence of insulin resistance among HIV infected people was 47.3% and that was associated with obesity. Al-Goblan, Al-Alfi and Khan (2014) found that BMI is strongly associated with insulin resistance and type 2 diabetes mellitus. In obese people, there is an increase of non-esterified fatty acids, glycerol, hormones and cytokines which cause insulin resistance with

the subsequent development of diabetes mellitus (Al-Goblan *et al.,* 2014; Kahn, Hull & Utzschneider, 2006).

Studies conducted in different parts of the world to assess the prevalence of insulin resistance among PLWHA, showed that the prevalence of insulin resistance among PLWHA is high due to HIV infection and the use of Highly Active Antiretroviral Therapy (HAART) (Dada, Oshodi, Ajie & Onyenekwu, 2017; Takemoto *et al.,* 2017; Dusingize *et al.,* 2013; Kiage *et al*., 2013; Young *et al.,* 2009). A study conducted in Thailand indicated that the prevalence of IR in HIV-infected individuals was 6.5% which was associated with greater body mass index (Lee *et al.,* 2009). Antiretroviral drugs were found to be strongly associated with increased insulin resistance among HIV infected people (Pedro *et al*., 2018; Honnapurmath & Patil, 2017).

Another study conducted in Spain by Araujo *et al*. (2014) reported a prevalence of 21% for insulin resistance among PLWHA. Insulin resistance plays a major role in metabolic dysfunction (dysregulation of glucose metabolism) leading to metabolic disorders including diabetes mellitus (Pedro *et al*., 2018). The protease inhibitors and nucleoside reverse transcriptase inhibitors were found to be diabetogenic and diabetes mellitus was four times more common in HIV infected individuals on HAART compared to HIV negative people (Avari & Devendra, 2017).

A study conducted in the Limbe regional hospital in Cameroon by Dimala *et al.* (2016) found a high prevalence of increased diabetes risk in PLWHA on HAART and low diabetes risk in PLWHA-naïve (31% vs 17%). The research found that the odds ratio for the HAART group compared to the HAART-naïve group was 2.19 and the increased risk for developing T2DM in PLWHA on HAART than patients on HAART-naïve is due to the effects of HAART particularly zidovudine, stavudine and didanosine on the traditional risk factors of T2DM such as BMI and blood pressure (Dimala *et al*., 2016).

Another study conducted in Ethiopia by Mohammed *et al*. (2015) found a high prevalence of diabetes among participants who were using a combination of Zidovudine (AZT) + Lamivudine (3TC) + Nevirapine (NVP) and low prevalence among those who were on Tenofovir (TDF)+ 3TC+Efavirenz (EFV) (10.3% vs 7.1%), and that association between ARVs type and diabetes was statistically significant.

Furthermore, a cohort study conducted by Karamchand *et al.* (2016) in South Africa to measure an association between non-nucleoside reverse transcriptase inhibitors and T2DM found that Zidovudine and stavudine were associated with an increased risk for developing T2DM among PLWHA treated with first line ARVs regimens. Moreover, a study on Adverse Events on Anti-HIV drugs (D: A: D) study reported a strong association between zidovudine, stavudine and didanosine and diabetes risk among PLWHA (De Wit *et al*., 2008).

A ten-year cohort study conducted in France showed that diabetes occurrence among PLWHA was not associated with indinavir, stavudine and didanosine (Capeau *et al.,* 2012). In addition, a study conducted by Tshikuka *et al*. (2018) in Botswana found that the patients on first line ARVs were 2.03 times more likely to develop T2DM compared to patients on second and third line ARVs regimens, and that association was statistically significant.

In the study by Tshikuka *et al*. (2018), the first line consisted of one of this combination: AZT+3TC+EFV or TDF+3TC+EFV; AZT+3TC+NVP or ABC+3TC+DTG; AZT+DDI+EFV; AZT+DDI+NVP while the second line consisted of: TDF+FTC+ALU; CBV+ALU; TDF+FTC=ALU (Tshikuka *et al*., 2018). However, other studies did not find an association between diabetes and type of ARVs (Divala e*t al*., 2016; Maganga *et al*., 2015). Divala *et al.* (2016) in their study conducted in Malawi found that diabetes was associated with the current

regimen other than tenofovir/lamivudine/efavirenz and zidovudine/lamivudine and nevirapine. Likewise, Maganga *et al*. (2015) in their study conducted in Tanzania found that neither use of protease inhibitor, nevirapine, efavirenz, tenofovir, stavudine nor zidovudine use was associated with glucose metabolic disorders including T2DM in PLWA. Although conflicting findings are observed in these studies, their methodologies are different. Studies that used strong study designs mainly cohort studies demonstrated an association between ARVs in particular zidovudine and stavudine, and risk of T2DM while few studies which used a cross-sectional study design did not find an association between ARVs and risk of T2DM among PLWHA.

2.7.1.3. Duration of taking ARVs

Studies conducted in different parts of the world showed contradictory conclusions in regard to association between duration on ARVs and T2DM (Nduka, Stranges, Kimani, Sarki & Uthman, 2017; Isa *et al.*, 2016; Maganga *et al*., 2015; Mohammed *et al*., 2015; Kagaruki *et al.*, 2014). Samad *et al.* (2017) in their study conducted in British Columbia, Canada found that a long exposure to ARVs was associated with high risk of developing diabetes. Similar results were reported in the study by De Wit *et al.* (2008) who found that the incidence of new onset of T2DM in PLWHA increased with a cumulative exposure of ARVs.

A study conducted by Maganga *et al.* (2015) in Tanzania found that being on ARVs for ≥ 2 years was associated with a 6-fold increase in the odds of having a glucose metabolism disorder including T2DM in PLWHA. Mohammed *et al.* (2015) in their study conducted in Ethiopia found a high prevalence of T2DM among participants who were on ARVs for ≥ 5 years and a low prevalence of diabetes among those who were on ARVs for less than 5 years (11.6% vs 2.1%), and the association between duration on ARVs and diabetes was indeed statistically significant.

Furthermore, a study by Nduka *et al*. (2017) assessed an association between fasting plasma glucose concentration and exposure to ARVs using pooled data from epidemiological studies and found an association between increased fasting plasma glucose concentration level and exposure to ARVs for ≥ 18 months. A cross-sectional study carried out by Duncan *et al.* (2018) in London, UK found that long duration of taking ARVs was associated with presence of T2DM in HIV infected individuals. The long duration of exposure to these drugs causes insulin resistance which is involved in the interference of glucose transport, thus leading to glucose deregulation and subsequent diabetes mellitus (Dagogo-Jack, 2008).

The prolonged duration of HAART use is responsible for toxicity of the adipose tissue which become inflamed and is not able to produce sufficient leptin and adiponectin hormones to contribute in a normal metabolic state, resulting in the development of T2DM among PLWHA (Kumar *et al*., 2015). However, a study conducted in Eastern Ethiopia did not find an association between the duration of taking ARVs and T2DM among PLWHA (Ataro *et al*., 2018). Although that association was not statistically significant, a high prevalence was found among those who were on ARVs for ≥5 years compared to those with > 5 years [8.6% vs 4.7%] (Ataro *et al*., 2018).

2.7.2. Sociodemographic factors associated with T2DM in PLWHA

Studies carried out in various countries found an association between sociodemographic factors and T2DM risk in PLWHA (Hernandez-Romieu, Garg, Rosenberg, Thompson-Paul & Skarbinski, 2017; Isa *et al.*, 2016; Capeau *et al.*, 2012; Butt *et al.*, 2009). Studies conducted in Harare, Zimbabwe, Cameroon and Nigeria found that people aged >40 years old were more likely to develop T2DM than those younger than 40 years and that age was associated with the risk for T2DM in PLWHA (Chimbetete *et al*., 2017; Rhee *et al.*, 2016; Isa *et al*., 2016).

Furthermore, Maganga *et al.* (2015) in the study conducted in Tanzania, found that age was associated with T2DM in PLWA. Mohammed *et al.* (2015) found that older age was associated with T2DM in people living with HIV/ AIDS in Ethiopia. A Swiss HIV cohort study found that incidence of T2DM in participants < 50 years was 2.09/1000 patient-years; 4.65/1000 patient-years in participants of 50-64 years and 8.56/1000 patient-years of follow up in participants of ≥65 years (Hasse *et al.,* 2011). This study found a 3.6-fold increase of T2DM incidence for patients of >50 years (Hasse *et al*., 2011).

In addition, the ten-year study conducted in France found that older age was associated with T2DM in PLWA. The study found a 2.13-fold and 3.63-fold increases when the patient is 40-49 years and ≥50 years respectively (Capeau *et al.,* 2012). Moreover, Hernandez-Romieu *et al.* (2017) found that the prevalence of T2DM was highest among those aged ≥60 years old and lowest among those aged 20-44 years old and this association was statically significant. Another study conducted in Iran among HIV positive patients found a high prevalence of diabetes mellitus among PLWHA with >40 years old compared to those with ≤ 40 years old and that association was statistically significant (Rasoonelijad *et al*., 2019).

Gender was also found to be associated with T2DM among PLWHA. Studies conducted in Nigeria, Tanzania and Zimbabwe found that gender was associated with T2DM among PLWHA (Chimbetete *et al*., 2017; Isa *et al*., 2016; Maganga *et al.,* 2015). Chimbetete *et al.* (2017) found that males were more likely to develop T2DM compared to females. Moreover, studies conducted in other countries found that male gender was associated with an increased risk of diabetes among PLWHA (De Wit *et al.,* 2008; Butt *et al.,* 2009).

A study conducted in Iran by Rasoolinejad *et al*., (2019) found that male gender (OR: 1.55; CI 95%: 1.04-2.31) was associated with a high prevalence of diabetes mellitus in PLWHA. These studies indicate that both male and female are at risk of developing diabetes mellitus though many studies found a higher risk in females compared to males.

2.7.3. Anthropometric factors associated with T2DM in PLWHA

2.7.3.1. BMI

BMI is a known traditional risk factor of T2DM in the general population (Gray, Picone, Sloan & Yashkin, 2015; WHO, 2016). This risk factor remains significant among PLWHA (Njuguna *et al.*, 2018; Hernandez-Romieu *et al*., 2017; Chimbetete *et al.*, 2017; Isa *et al.*, 2016; Capeau *et al.*, 2012). A prospective study conducted by De Wit *et al.* (2008) found an association of lipodystrophy with T2DM among people living with HIV and AIDS. The studies suggested that BMI increases because of the redistribution of body fat/visceral fat accumulation and body shape changes that occur after starting ARVs (Dimala *et al.*, 2016; Flint *et al*., 2009).

The appropriate fat distribution in the body contributes in the regulation of metabolic state (Fiorenza, Chou & Mantzoros, 2011), thus redistribution of body fat contributes to the risk of developing T2DM (Fiorenza *et al.*, 2011). Chimbetete *et al.* (2017) found that obesity (BMI >30kg/m^2) was associated with the risk for developing T2DM in PLWHA while the study conducted by Isa *et al.* (2016) in Nigeria indicated that BMI > 25kg/m^2 was associated with T2DM in PLWHA.

Another study conducted in Iran among HIV positive patients found a high prevalence of diabetes mellitus among PLWHA with BMI > 25kg/m^2: OR; 1.706, CI 95%: 1.149-3.247) compared to those with BMI ≤ 25 kg/m years old. This association was found to be statistically significant (Rasoonelijad *et al*., 2019). Furthermore, the study conducted by Hernandez-Romieu *et al*. (2017) found a high prevalence of T2DM (18.9%) among those with BMI ≥30kg/m^2 and the lowest prevalence among those <30kg/m^2, and this association was statistically significant.

Moreover, the study conducted in Tanzania by Maganga *et al.* (2015) found that high BMI was associated with the prevalence of T2DM among PLWHA. Butt *et al.* (2009) in their study found similar findings where they found that increased BMI was associated with increased T2DM in PLWHA. In addition, Ataro *et al*. (2018) in Ethiopia found an association between increased baseline BMI and diabetes mellitus among PLWHA.

2.7.3.2. Waist circumference

Central obesity as defined by waist circumference ≥94cm for male and ≥80 cm for female (IDF, 2006) was associated with glucose metabolism disorders including T2DM (Maganga *et al.,* 2015; Rhee *et al.,* 2016). Rhee *et al*. (2016) found that a large abdominal circumference (1 cm increase of abdominal circumference) was associated with increased T2DM in PLWHA. Further, Kumar and Samaras (2018) found that a large waist circumference increased the risk of developing diabetes mellitus in HIV infected people.

In a cross-sectional study conducted in the South West Regional Hospital of Cameroon among people living with HIV/AIDS found that participants with central obesity (waist circumference ≥94cm for males and ≥80cm for females) had a high prevalence of T2DM compared to those with

normal waist circumference (14.7% vs 7.1%) and this association was statistically significant (Ngu, Choukem, Dimala, Ngu & Monekosso, 2018).

Although the prevalence of diabetes among PLWHA was high among those with a high waist circumference compared to those with normal circumference (8.3% vs 5.4%), the findings of the study conducted in Jugal, Eastern Ethiopia did not find an association between diabetes and waist circumference (Ataro *et al.*, 2018).

Moreover, Neves *et al.* (2018) found an association between presence of diabetes and increased waist circumference. Finally, a study conducted in Germany by Hartwig *et al*. (2015) found an annual increase of waist circumference and this increase was associated with increased risk of developing diabetes among HIV infected people.

2.7.3.3. Waist-to-hip ratio

The waist-to-hip ratio is a traditional risk factor for the general population and remains relevant for people living with HIV/AIDS (Murphy & McKay, 2013). Studies conducted in many countries found an association between waist-to-hip ratio and glucose metabolic disorders including diabetes mellitus (Neves *et al*., 2018; Maganga *et al*., 2015; Kalra *et al*., 2011). Neves *et al*. (2018) found that a high waist-to-hip ratio was associated with diabetes mellitus among HIV infected individuals and this association remained statistically significant after an adjustment of age and gender. In this study, a high prevalence of diabetes mellitus was found in people with high waist-to-hip ratio compared to those with normal waist-to-hip ratio (Neves *et al*., 2018).

Another ten-year prospective study conducted among 1, 046 HIV infected people by Capeau *et al.* (2012) in France found that 111 patients developed diabetes mellitus and a high waist–to–hip ratio was associated with development of diabetes (Capeau *et al*., 2012). A study conducted among

10,258 participants from 4 prospective population-based cohort studies in Germany to assess association between various anthropometric measures and T2DM risk found that an association between waist-to-hip ratio and T2DM among HIV infected (HR: 1.55 for women and 1.64 for men in pooled samples and HR: 1.83 for women and 2.29 for men in other national surveys) (Hartwig *et al*., 2016). The aforementioned studies indicated that increased waist-to-hip ratio is associated with T2DM in HIV infected people.

2.8. Impact of Type 2 Diabetes Mellitus

2.8.1. Impact of T2DM on health-related quality of life

Poor health-related quality of life in people suffering from diabetes has been established in the literature (Kokiwar *et al.,* 2017; Thommasen & Zhang, 2006). A study conducted in the Bella Coola Valley, BC, Canada, showed that people with diabetes experienced a significant poor health-related quality of life (Thommasen & Zhang, 2006). The presence of diabetes-related complications such as retinopathy, amputation, hypertension, cardiovascular diseases, nephropathy and pain contributed to the poor health-related quality of life among these people (Thommasen & Zhang, 2006).

The study indicated that the duration of diabetes was associated with a decline in physical functioning while a greater number of diabetes-related complications was associated with declines of general health and poor sleep days (Thommasen & Zhang, 2006). The same authors found that the use of insulin was associated with decreased physical functioning, increased body pain, poor general health and poor social functioning, a greater number of unhealthy physical days, unhealthy mental days and with days limited by health (Thommasen & Zhang, 2006).

A systematic review which included more than one million published papers indicated that the health-related quality of life of people living with diabetes was negatively affected by the presence of co-morbidity of chronic diseases, sexual dysfunction, and family and social dysfunction as a consequence of diabetes (Trikkalinou, Papazafiropoulou & Melidonis, 2017). A study conducted in an urban slum in India revealed that frequent urination and the inability to fulfil one's roles and responsibilities as required affected the quality of life of diabetic patients (Kokiwar *et al.*, 2017).

Research performed in Ghana showed that the quality of life of 12% and 52% of diabetic participants were severely and moderately affected respectively (Osei-Yeboah *et al*, 2016). Sexual dysfunction, renal insufficiency, social overload in addition to worries and anxiety were found to negatively affect the participants' overall quality of life most (Osei-Yeboah *et al.*, 2016).

Another study by Bosić-Zivanović, Medić-Stojanoska and Kovacev-Zavisić (2012) conducted in Serbia found that patients with T2DM had a lower quality of life compared to the people without diabetes. The study revealed that educational level had an impact on physical and psychosocial domains, and that co-morbidity negatively influenced the health-related quality of life (Bosić-Zivanović et al., 2012) while a study conducted in South Africa by Daya, Bayat and Raal (2016) found that sexual function, anxiety and worry and diabetes control were the major factors influencing health-related quality of life.

Moreover, Thomas *et al.* (2017) found low health-related quality of life among people diagnosed with HIV who were not taking ARVs in South Africa. It was found that HIV positive status was significantly associated with worse physical and mental health-related quality of life (Langebeek *et al*., 2017). The initiation of ARVs contributed to improvement of the quality of life of people living with HIV and AIDS (Thomas *et al*., 2017).

2.8.2. Socio-economic burden of T2DM in PLWHA

The management of T2DM focuses on pharmacological and non-pharmacological approaches. Metformin (Biguanides) and insulin are the main drugs used in the management of T2DM while diet and physical exercise constitute the non-pharmacological approaches used in T2DM management (Brunetti & Kalabalik, 2012).

The financial burden of diabetes is very high in the USA where it was found that the cost related to diabetes in 2017 was USD 327 billion, equivalent to around 274 trillion Rwandan francs (USD 1=838.6623 RwF in 2017). This includes USD 237 billion for direct medical costs and USD 90 billion related to reduced productivity (American Diabetes Association, 2018). This cost is estimated to reach approximately USD336 billion in 2034 (Huang, Basu, O'Grady & Capretta, 2009).

A study conducted in the USA found that health-related expenditure is 2.3 times higher for persons diagnosed with diabetes (American Diabetes Association, 2018). Another study conducted in the United Arabe Emirates (UAE), found that the direct annual treatment costs of T2DM without complications in Al-Ain, UAE was USD 1,605 (=138,379 RwF). This was 3.2 times higher than the per capita expenditure for health care in the UAE (USD 497) and increased 2.2 times with micro- complications, 6.4 times with macro-complications and 9.4 times with presence of both micro and macro-complications (Al-Maskari, El-Sadig & Nagelkerke, 2010). The cost increased with hospitalization and with the type of treatment (either insulin or oral treatment) (Al-Maskari *et al.,* 2010). The costs are also related to the direct costs of treatments, laboratory tests and indirect costs (Mutyambizi, Pavlova, Chola, Hongoro & Groot, 2018; Davari, Boroumand, Amini, Aslani & Hosseini, 2016; Al-Maskari *et al.,* 2010).

A study conducted in India revealed that the total average cost of a diabetic patient was Rs. 8, 695 (113,035 RwF; 1 Rs. =13 RwF) without complications, and Rs12,960 (168,480 RwF) with macro-complications; while the total cost of a diabetic patient with micro-complications was Rs11,039 (147,507 RwF) (Sangam, Anifa, Swathi, Venkateswarlu & Ram, 2017). The same study found that the cost of treating a diabetic patient with both macro-and micro-complications was as much as Rs.16,658 (216554 RwF) (Sangam *et al.*, 2017).

Diabetes and its complications bring about a significant economic burden and poverty to the individual patients, families, healthcare system and societies due to economic loss from direct and indirect medical costs, loss of productivity and work, hospitalizations, premature deaths and treatment of diabetes-related complications (WHO, 2016; Davari *et al.*,2016). These studies showed that the economic burden of diabetes increases with the presence of complications and co-morbidities (WHO, 2016; Davari *et al.*, 2016; Li *et al.*, 2013). A systematic review indicated that diabetes poses a high economic burden in sub-Saharan African countries where the direct national cost per year varied between 3.5 and 4.5 billion USD (2.935 and 3.774 trillion RwF) (Mutyambizi *et al.*, 2018). The healthcare costs include drug, diagnostic, medical supply, disposals and consultation costs (Mutyambizi *et al.*, 2018).

2.9. Impact of HIV/AIDS and T2DM co-morbidity

HIV/AIDS comorbidity increases the costs of care of PLWHA (Cammarota, Citarella, Manzoli, Flacco & Perruti, 2018; Zingmond, Arfer, Gildner & Leibowitz, 2017). A study conducted in California, USA in 2010, has shown that the median costs of HIV/AIDS care was USD 47,036 and the mean cost of T2DM and HIV/AIDS co-morbidity reached USD 66,275 and USD 92,992 for uncomplicated and complicated diabetes respectively (Zingmond *et al.*, 2017). The report of New

Zealand's cost-of-illness studies on long-term conditions indicated that the societal cost of each long-term condition amounted to USD100 million, which include direct, indirect and intangible costs (New Zealand Ministry of Health, 2009). The costs were related to medical care, hospitalizations, drugs and frequent medical visits as outpatients (Zingmond *et al.*, 2017).

Addressing HIV and type 2 diabetes mellitus in sub-Saharan Africa places a high burden on healthcare systems to avail human, infrastructure, medical and diagnostic technology resources (Nuche-Berenguer & Kupfer, 2018). Furthermore, often HIV/AIDS co-exists with tuberculosis and diabetes increases the risks of developing tuberculosis three-fold which is associated with poor health outcomes (Peer, Kengne, Motala & Mbanya, 2014).

A study conducted in California indicated that 17.8% of PLWHA had T2DM co-morbidity and this was significantly associated with low physical health-related quality of life (Rodriguez-Penney *et al.*, 2013). HIV/AIDS and T2DM co-morbidity poses challenges and complexity in the healthcare and management of these two conditions (Samaras, 2012). For example, the interaction of some HAART drugs (Tenofovir and Stavudine) and diabetic drugs (Metformin) can cause serious complications including risk of lactic acidosis (Samaras, 2012).

A study by Kim *et al*. (2011) suggests that the rate of albuminuria among PLWHA with T2DM co-morbidity is more than twice that of people living with HIV/AIDS without T2DM (34% vs 13%). Furthermore, T2DM increases the risk of developing end-stage of renal disease (ESRD) among PLWHA at 70% (Samaras, 2012). Another study conducted in KwaZulu-Natal, South Africa showed that HIV infected patients with T2DM had a high incidence of neuropathy and nephropathy (Pillay, Aldous & Mahomed, 2016).

A prospective study conducted in France among 376 PLWHA showed that 12.5% stopped working and the risk of work cessation was significantly higher among PLWHA with diabetes co-morbidity compared to their counterparts without diabetes co-morbidity, which places the individuals and their families in critical socio-economic conditions (Dray-Spira *et al.*, 2012).

2.10. Conclusion

The literature used for this study reviewed various studies conducted on T2DM among PLWHA. It was found that T2DM varied from 1% to 26%. Age, duration of HIV infection, duration of ARVs and types of ARVs, lipid profiles, malnutrition at initiation of ARVs, and increased BMI were factors commonly associated with T2DM in HIV infected individuals.

CHAPTER 3: METHODOLOGY

3.1. Introduction

The process and methods used to conduct this study will be discussed in this chapter.

3.2. Study setting

The Rwamagana district is one of 30 administrative districts in Rwanda and is located in the Eastern Province with a total population of 318,000 people. Women represent 52.2% of the total population and about 82% of the population are younger than 40 years of age (National Institute of Statistics of Rwanda, 2012). A total of 18% and 12% of Rwamagana population live in poverty and extreme poverty respectively. A total of 14.7% and 36.5% of the Rwamagana population walk between 60-119 minutes or more than 2 hours to the nearest health centre respectively (National Institute of Statistics of Rwanda, 2012).

The Rwamagana district has 14 primary health care centres, one prison dispensary, five private dispensaries, one private clinic and one provincial hospital (Rwanda Ministry of Health, 2016a; Ministry of Health, 2016c) and 16 health posts (Director of Nursing, Rwamagana hospital, personal communication, July 12, 2019). The last health survey found that the total fertility rate was 4.4 and that the under 5-mortality rate was 74/100000 (Rwanda Demographic and Health Survey, 2014-2015). The same survey revealed that more than 90% of the Rwamagana population were aware of HIV preventive methods and 63.2% of Rwamagana women and 76.6% of men had comprehensive knowledge concerning AIDS. Furthermore, about 52% of women aged 15-49 years old had challenges accessing health care when needed. Approximately, 81.8% of Rwamagana households had health insurance (Rwanda Demographic and Health Survey, 2014-2015).

3.3. Study design

The study used a quantitative approach with an observational cross-sectional analytical study design. Creswell (2014) stated that the quantitative approach is used when the researcher desires to collect numerical information through pre-determined variables which are measurable and quantifiable. The purpose of the cross-sectional analytical study design is to observe and describe the status of a phenomenon and relationship among the particular aspects of that phenomenon during a specific period of data collection (Polit & Beck, 2008).

3.4. Population and Sampling

3.4.1. Study population

The study was conducted in the Rwamagana district's primary health care centres (PHCs). The population included in this study was all HIV-positive adult males and females aged 18-65 years old attending the fourteen (14) health care centres in the Rwamagana district (Rwanda Ministry of Health, 2016a). These health centres offer health services to approximately 5,600 people living with HIV and AIDS. There are 30 districts in Rwanda, however it was not possible to carry out research in all these districts due to financial constraints. Rwamagana was thus the district randomly selected for conducting this research.

3.4.2. Sample size

The systematic random sampling approach was chosen for this study. This sampling approach is simple to implement and helps to obtain a highly representative sample of the population without a random number generator as it guarantees that the population is evenly sampled (Alvi, 2016). During systematic random sampling, a researcher selects elements of a sample based on the systematic rule and fixed interval or pattern, and the first subject to be included in the sample is

selected using simple random sampling (Elfil & Negida, 2017). A random sampling approach was used to select seven health centres from the 14 primary health care centres in the Rwamagana district, thus representing 50% of all health centres. Rubona, Nyagasambu, Rwamagana, Avega-Rwamagana, Gishali, Ruhunda and Munyaga health centres were randomly selected. Within each of the seven health centres, a proportionate random sample of PLWHA was drawn. The sample size from each of the seven health centres was determined according to the health centre's proportion. For this study, the sample size was calculated as follows: expected prevalence of T2DM among PLWHA based on previous studies conducted elsewhere in Africa (Kabati et al., 2010); two-sided significance level at is 95%, a precision of 5% (1-alpha: 0.05) and power (1–beta) of 80%. The formula of Hajian-Tilaki (2011) was used to calculate sample size. $[Z^2_{(1-\alpha)}\ \sigma^2\ {}^*_{P(1-P)}]/d^2$

$\mathbf{Z^2_{(1-\alpha)}}$ is the standard normal distribution which is 1.96 for 95% confidence interval while **d** refers to the precision: 0.05 for 95% confidence interval. **P** is expected prevalence based on previous studies. In this study, expected prevalence of T2DM among PLWHA is 24.7% based on research of Kabati *et al*. (2010), thus, the sample size of this study is $\frac{1.96^2 * 0.247\ (1-0.247)}{0.05^2}$= **286.**

A 10% anticipated non-response rate was added. A final sample size of **315** participants was used in this study. The patients with HIV/AIDS use separate clinics in the PHC and their files are kept separate from the general service user population. All files of people living with HIV and AIDS attending the seven primary health care centres were identified. A proportionate sample for each health centre was calculated based on the number of files of PLWHA from the seven PHCs.

A proportionate sample was drawn from each primary health care centre using the systematic random sampling technique. After selecting the files proportionally from each health centre, the individuals were contacted via phone to request their participation in the study.

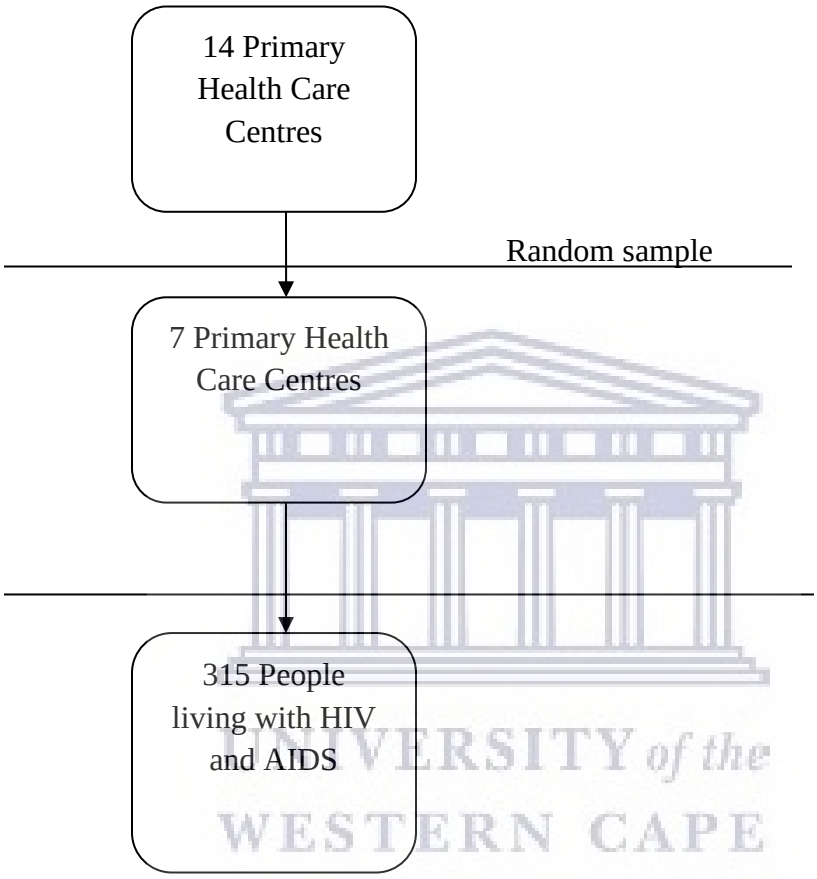

Figure 1: Process of study setting selection and sampling process

The table 4 below indicates the sample of each health centre

Table 4: Distribution of samples in each study sites

Health centre	Population	Representative population %	Representative sample
Rwamagana	842	28.3	90
Avega-Rwamagana	482	16.2	51
Nyagasambu	312	10.5	33
Rubona	480	16.1	50
Ruhunda	356	11.9	38
Munyaga	210	7	22
Gishali	302	10	31
Total	2984	100	315

Inclusion criteria: Males and females living with HIV and AIDS aged 18 years and older who had access to cell phones and networks. **Exclusion criteria:** Pregnant women were excluded in the study as it was impossible to capture accurate anthropometric measurements.

3.5. Data Collection

Permission to conduct the study was sought and granted from the Mayor of the Rwamagana district and the heads of the healthcare centres. Data collection was carried out during August to October 2018 after permission was obtained from the heads of the health centres or the Mayor of the district. The research assistants, who were trained nurses, selected files of PLWHA in each of the health centres to obtain their contact numbers only. Those who could not be reached, they were excluded from the study. The individuals whose files were selected were contacted via mobile cell phone. The research purpose was explained to the participants and they were informed that participation is voluntary and that they had the right to withdraw at any time without fear of negative consequences.

The data were collected using a questionnaire that was adapted from different sources (Abebe *et al.,* 2016; Mohammed *et al.,* 2015; Mutimura *et al.,* 2015; Dusingize *et al.,* 2013; Haregu *et al.,* 2012). Experts' comments were also incorporated into the study instrument. The instrument was composed of socio-demographic variables [age, sex, marital status, educational level, wealth status, social-economic category (Ubudehe category)], lifestyles status such as physical exercise status, smoking status and alcohol drinking status.

The questionnaire also contained variables related to anthropometric measurement including weight, height, waist circumference and hip circumference. The HIV and AIDS, and ARVs–related variables that were included in the questionnaire were: duration in years the person is living with HIV and AIDS and realized that he/she had contracted HIV, history of diabetes, ARVs regimen and duration of ARVs taking, CD4 counts and WHO HIV clinical stage. The questionnaire was piloted with 10 PLWHA from another health centre, which was not part of the study setting. The participants who agreed to participate in the study met with the researcher or research assistants during their appointment dates. They were requested to fast from midnight the day before the appointment (>8 hours) until their fasting capillary blood glucose level was taken in the morning. The participants were reminded of their participation one day before the appointment date.

Socio-demographic characteristics of the participants [age, sex, marital status, educational level, wealth status, social-economic category (Ubudehe category)], lifestyles status such as physical exercise status, smoking status, alcohol drinking status and history of diabetes, was obtained from participants by the completion of the questionnaire. This self-report questionnaire was translated into the mother tongue, Kinyarwanda. For those who could not read and write a trained research assistant or the researcher interviewed the participants and completed the questionnaire.

The researcher trained the research assistants on data collection. The data that were collected from the participants' files (ARVs regimen and types of ARVs, CD4 counts and WHO HIV clinical stage) were recorded by the researcher or the research assistants. Finally, fasting capillary blood glucose level was measured by the researcher or research assistants.

Anthropometric measurement: Anthropometric measurements were taken by the researcher or the research assistants. The weight was measured using a calibrated digital weighting scale (SECA®877) with the participant standing upright without shoes or heavy clothes and looking straight ahead with their arms relaxed along the body (CDC, 2017b). The scale was set to zero before the participant stepped on to the platform. The reading was taken to the nearest 0.1kg decimal. Two readings were taken to ensure consistency in the measurements. The height was measured with the participant standing upright without shoes and hat, looking straight ahead with arms relaxed along the body using a portable stadiometer (SECA®213). The reading was taken to the nearest 0.5cm. Body Mass Index (BMI) was calculated as weight in kilograms (Kg), divided by the height in meters squared (CDC, 2017b). BMI < 18.5kg/m^2 was considered as underweight, BMI 18.5-24.9kg/m^2 was considered as normal, 25-29.5kg/m^2 was considered as overweight while BMI ≥ 30kg/m^2 was considered as obese (CDC, 2017b).

The waist circumstance was measured with the participant standing up, exhale with the measurement tape parallel to the floor and snug to the participant's body, but not too tight. During the measurement, the participant was requested to exhale to produce a relaxed abdomen (CDC, 2017b).

The participant was asked to take off his/her clothes above the waist to avoid any measurement interference. Standing on the participant's right side, the area left and right of the iliac crest was felt while the hip area was palpated to locate the right ilium of the pelvis (CDC, 2017b). After that, a horizontal line was marked just above the uppermost lateral border of the right ilium, and this mark was crossed at the mid-axillary line extending from the armpit down the side of the torso (CDC, 2017b). Then, the measuring tape was extended around the waist by positioning the tape in a horizontal plane at the marked line of measurement (CDC, 2017b).

Measurement was recorded to the nearest 0.1cm at the end of expiration and the marked was removed with clean water (CDC, 2017b). The measurement was taken at mid-point between the lowest palpable rib and the top of the iliac crest. A measurement of < 80 cm for women was considered as normal/good while ≥80cm was considered as unhealthy/abnormal (WHO, 2011). A measurement of < 94 cm for men was considered as normal/good while ≥94 cm was considered as bad/abnormal (WHO, 2011). The hip was measured with the participant standing up and relaxed. The participant was asked to relax their buttock muscles and the measuring tape was placed around the point of maximum circumference over the buttocks. The clothes were removed except underwear (this was done in a private room). The participant stood with feet close together in such way that weight was equally distributed on both legs (CDC, 2017b). The waist-hip ratio (WHR) was calculated by waist measurement (cm) divided by the hip measurement (cm) (WHO, 2011). The WHR of > 0.90 cm for men and WHR > 0.85cm for women was considered as bad while lower values were considered as healthy or normal (WHO, 2011).

Fasting capillary blood glucose level was measured using a glucometer (ACCU-CHEK Active®) as it is used in the PHCs facilities in Rwanda for diabetes diagnosis. The fingertip of the non-dominant hand was cleaned with ethyl alcohol and dried. The fingertip was then pricked with a lancet. The first drop of blood was allowed to fall into a container and the second drop of blood was allowed to drop onto the test strip without a strong squeezing of the pricked finger. The researcher or researcher assistants recorded the result once it appeared. The instructions of the glucometer and its test strips were followed correctly. The participants with a capillary blood glucose level of > 6.51mmol/l were considered to have diabetes (Zhao *et al.,* 2013) and measurement was repeated 48 hours later for confirmation.

3.6. Data analysis

The data was coded, checked and cleaned and then entered into SPSS 21 (Statistical Package for the Social Sciences) (Blumenthal, 2010) by the researcher. The categorical variables were descriptively analyzed using frequency and percentage while the numerical data was descriptively analyzed using mean, median and standard deviation and interquartile range. The numerical variables were further transformed into the categorized variables.

Socio-demographic data: Sociodemographic data with categorical variables including gender, marital status, educational background and history of diabetes were analyzed using frequency and percentage. Socio-demographic data with numerical variables such as age was analyzed using mean, median, mode and standard deviation. Cross-tabulation was done to test association between socio-demographic data and diabetes status using inferential analysis. Chi-square was used to test association between two categorical variables.

The total physical activity MET-minute/week were calculated using the following formula: [(P2*P3*8) + (P5*P6*4) + (P8*P9*4) + (P11*P12*8) + (P14*P15*4)] (WHO, n.d). The MET-minute/week ≥600 was categorized as physically active (Yes) while < 600 MET-minute/week was categorized as physically inactive (No) (WHO, n.d).

Lifestyle variables: The lifestyle variables such as smoking, alcohol consumption and exercise were analyzed using frequency, percentage and are presented in tables. Cross-tabulation with chi-square test was used to test for association between lifestyle variables and diabetes.

Anthropometric measurements: The anthropometric measures were analyzed using frequency and percentage and are presented in the tables. Association between these anthropometric measurements and diabetes was computed using cross-tabulation. Chi-square tests was computed to test for association.

HIV/AIDS related variables: WHO HIV clinical stages, ARVs regimen, ARVs types were descriptively analyzed using frequency and proportions while the numerical variables including CD4 count were also transformed into categorical variables and analyzed using frequency and proportion. The HIV infection duration and duration of ARVs treatment were also analyzed using mean, median, and standard deviation and further categorized as <5 years, 5-10 years, 10.01-15 years and >15 years. The association between HIV/AIDS-related variables and diabetes was analyzed using cross-tabulation and chi-square test was used to test for association. The participant was considered to have diabetes mellitus when the average of two fasting blood glucose levels was >6.51mmol/l (117.18 mg/dl).

Univariate and multivariate analysis was used to test association between various variables. The variables which were associated with T2DM in bivariate analysis (age, duration of HIV/AIDS, duration of ARVs taking and types of ARVs) were entered into a logistic regression model to determine factors associated with T2 DM. The statistical significance level was set at <0.05.

3.7. Validity and Reliability

Validity of the study instrument refers to the extent to which the study instrument is measuring what it is supposed to measure (Pannucci & Wilkins, 2010; Brink, 2006). The validity was assured by ensuring that variables of the instrument were matched with study objectives. Training of research assistants was provided by the researcher to ensure that they had the necessary skills to collect data that were standardized. A data collection instrument was translated into Kinyarwanda (the Rwandan mother tongue) to ensure that the participants understood the questions and to enhance the validity of the instrument. The views and comments of experts were incorporated into the final questionnaire. In addition, the instrument was constructed based on literature and other researches on co-morbidity of HIV and AIDS that have been conducted elsewhere.

The reliability of the instrument refers to the ability of the instrument to yield similar results consistently when it is used at different times or by different researchers (Brink, 2006). A pilot study was conducted among 10 PLWHA in one of the health centres, which was not part of the study setting. The results of the pilot study were not considered in the final data analysis, rather the results were used to refine the data collection instrument.

Lifestyle information: The lifestyle information has been included in the questionnaire based on literature and expert views and comments.

Anthropometric measurements: The weight was measured twice using the same measurement scale by the same researcher or research assistants to ensure that the measurement scale yielded the same readings. The height, waist and hip circumferences were measured using the same measurement tape twice by the same researcher or research assistant to ensure that the measurement tape yielded consistent results.

HIV/AIDS related variables: The HIV/AIDS related factors were included in the questionnaire based on literature on co-morbidity of HIV/AIDS and metabolic diseases.

Capillary blood glucose level: One type of glucometer manufactured by the same company was used for capillary fasting blood glucose measurement following company instructions. The two readings were recorded by the researcher or assistant researchers. The second reading was recorded after 48 hours and the average of the two results was considered in the final analysis. Furthermore, the same trained research assistants were used in data collection to avoid variability and ensure consistency in the collection of the data.

Pilot study

The instrument was piloted with 10 people living with HIV and AIDS to test whether variables were clear and to test feasibility and applicability of instrument. Corrections were made accordingly. This practice enhanced validity of the instrument.

3.8. Generalizability

The sample size of the study was selected using probability sampling from 50% of 14 primary health care centres within Rwamagana district, which indicates that the sample was representative of the population, the findings of this study can therefore be generalized to people living with HIV and AIDS attending primary health care centres in Rwamagana district. The living conditions of PLWHA attending primary health care centres were the same for all primary health care centres in Rwamagana district. However, the results cannot be generalized to the whole country as the sample was drawn from only one district.

3.9. Ethics Considerations

Ethics clearance was sought from the Biomedical Research Ethics Committee (BMREC) at UWC and from the University of Rwanda, College of Medicine and Health Sciences Institutional Review Board as required for students pursuing studies outside Rwanda. The researcher respected all principles of research ethics when conducting the current study.

Respect for others as an ethical guiding principle was observed throughout the study. Permission to conduct the research was sought from the heads of the selected primary health care centres and / or the Mayor of the Rwamagana district. The study was conducted after ethical approval and permissions were granted from the respective institutions. The files of prospective participants were only accessed after permission was obtained from the heads of Primary Health Care Centres. The purpose, benefits and risks of the study were explained to the participants in Kinyarwanda (the Rwandan language).

The participation was voluntary and participants were allowed to withdraw at any time for any reason without fear of negative consequences. Consent was obtained from the participants to access their files. Signed, written informed consent was sought from the participants who agreed to participate in the study. An amount of 500 (five hundred) Rwandan francs were provided to the participants for the retesting of blood capillary glucose.

Beneficence and non-maleficence: The confidentiality, anonymity and privacy of the participants were guaranteed by using codes instead of names or personal identifiers. The participants who were diagnosed with diabetes mellitus were referred to the same health centres where testing was done for care and better management after counselling. The data was entered into a computer and their access required a code which is held by only the researcher.

Furthermore, it was anticipated that the participants diagnosed with diabetes mellitus would be psychologically affected, which is a harmful risk. The counsellors were prepared to provide emotional support and counselling for those who displayed psychological and emotional problems. Although the participants diagnosed with T2DM were counselled, they did not display any sign of psychological effect. A new sterile needle for each person was used to avoid infection.

Justice: The selection of participants in the study used random sampling methods to avoid unfairness in the participation. Furthermore, no inducement was given to the participants since transport money was not an attractive incentive to them. The people living with HIV and AIDS benefited from the results of the study as the results were used to inform them about screening services of T2DM in non-communicable disease clinics in health centres. The participants were informed about the availability of these services and the advantages of regular uptake of screening.

The results will be used to improve HIV and AIDS health care service delivery in primary health care centres thus improving their quality of life. Furthermore, all participants had equal opportunities to access health care services when diagnosed with diabetes mellitus and to access appropriate management.

Data management: The completed questionnaires were sealed in envelopes and kept in a locked cupboard only accessible by the researcher. Glucose testing sticks were immediately destroyed. The database is locked in a computer for five years and can only be accessed using a code. Only researcher and supervisors can access the database. After five years, the data will be destroyed. Furthermore, the final report of research will be submitted to the School of Public Health, UWC and UWC library for reference. The findings will be shared with respective health centres. The results will be presented at international and national conferences. Moreover, the research findings will be published in peer reviewed journals.

CHAPTER 4: RESULTS

4.1. Introduction

The results of the study will be described in this chapter. The aim of the study was to determine the factors associated with T2DM in PLWHA attending primary health care centres in Rwamagana district, Rwanda. The objectives of the study were to: (1) determine the prevalence of T2DM risk in PLWHA attending Primary Health Care Centres in Rwamagana district; (2) determine the socio-demographic factors associated with T2DM of PLWHA attending PHCs in Rwamagana district, Rwanda; (3) determine the anthropometric factors associated with T2DM of PLWHA attending PHCs in Rwamagana district; (4) determine lifestyle factors associated with T2DM of PLWHA attending PHCs in Rwamagana district; and (5) determine the HIV and AIDS related factors of PLWHA attending PHCs in Rwamagana district.

4.2. Socio-demographic characteristics of the participants

A total of 292 people participated in the study. The sociodemographic study sample is presented in Table 5.

Table 5: Socio-demographic characteristics of participants (n=292)

Variables	Characteristic	Frequency (%)
Gender	Male	92 (31.5)
	Female	200 (68.5)
Marital status	Single	35 (12)
	Married	145 (49.7)
	Divorced/ separated	71 (24.3)
	Widow/widower	41 (14)
Educational level	No schooling	84 (28.8)
	Primary	170 (58.2)
	Secondary school	34 (11.6)
	University /college	4 (1.4)
Age	18-25 years	16 (5.5)
	26-35 years	77 (26.4)
	36-45 years	108 (37)
	46-55 years	65(22.3)
	56-65 years	26 (8.9)
Residence	Rural	252 (86.3)
	Urban	40 (13.7)
Employment status	Civil/professional servant or work with NGOs	6 (2.1)
	Self-employed	185 (63.4)
	Not employed /no job	100 (34.2)
	Retired	1 (0.3)
Income per month	<25800 RwF	261 (89.4)
	25800-64500 RwF	21 (7.2)
	>64500 RwF	10 (3.4)

Variables	Characteristic	Frequency (%)
Socio-economic categories (Ubudehe category)	Ubudehe1	48 (16.4)
	Ubudehe 2	158 (54.1)
	Ubudehe3	85 (29.1)
	Ubudehe4	1 (0.3)
Is there any health professional who told you that you have diabetes?	Yes	8 (2.7)
	No	268 (91.8)
	I do not know	16 (5.5)
Family member with diabetes	Yes	20 (6.8)
	No	221 (75.7)
	I do not know	51 (17.5)

The study showed that the majority of participants were female representing 68.5% of the study participant, and 49.7% were married followed by separated/divorced participants representing 34.3%. Furthermore, 58.2% of participants had undertaken primary school while 28.8% did not attend any school. It was found in this study that 86.3% lived in rural areas and 63.4% were self-employed while 2.1% worked for government, private companies or non-government organizations.

In addition, the majority of participants representing 70.5% (16.4% of socioeconomic category I and 54.1% of socioeconomic category II) were poor. A significant number of participants representing 89.4% earned less than 25,800 RwF per month (< 1 US USD per day) while only 3.4% earned at least 64,500RwF per month equivalent to 2.5 USD or more per day. The median income was 9,500RwF per month, Q1 was 3,000Rwf and Q3 was 15,000Rwf while IQR was 12,000 RwF. The minimum income was 0 RwF while the maximum was 150,000RwF (860Rwf= 1USD).

The study found that the majority of participants representing 37% were between the ages of 36-45 years old, followed by those aged 26 to 35-year-old at a proportion of 26.4%. Finally, only 2.7% of participants were informed by a health professional that they had diabetes. Almost 7% of participants were aware of a family member who had diabetes.

4.3. Prevalence of Type 2 Diabetes Mellitus risk among participants

The prevalence of Type 2 Diabetes Mellitus risk among participants is presented in Table 6.

Table 6: Prevalence of Type 2 Diabetes Mellitus risk among participants

Diabetes status	**Frequency (%)**	**95% CI**
Negative	275 (94.2)	90.8-96.6
Positive	17 (5.8)	3.4-9.2
Total	**292 (100%)**	

The study found that 17 (5.8%) participants had T2DM risk while 275 (94.2%) did not have T2DM risk.

4.4. Sociodemographic factors associated with T2DM among participants

The socio-demographic factors associated with T2DM among participants are presented in Table 7.

Table 7: Socio-demographic factors associated with T2DM among participants (n=292)

Socio-demographic factors	**T2DM**		***DF**	****χ2**	*****P*-value**
	Negative **Freq. (%)**	Positive **Freq. (%)**			
Gender			1	0.037	0.848
Male	87 (94.6%)	5 (5.4%)			
Female	188 (94%)	12 (6%)			
Marital status					
Single	35 (100)	0 (0%)	3	5.655	0.13
Married	138 (95.2%)	7 (4.8%)			
Divorced/ separated	66 (93%)	5 (7%)			
Widow/widower	36 (87.8%)	5 (12.2%)			
Educational level					
No schooling	78 (92.9%)	6 (7.1%)	3	0.601	0.986
Primary	161 (94.7%)	9 (5.3%)			
Secondary school	32 (94.1%)	2 (5.9%)			
University /college	4 (100%)	0 (0%)			
Age					
18-25 years	14 (87.5%)	2 (12.5%)			
26-35 years	76 (98.7%)	1 (1.3%)	4	12.536	0.014***
36-45 years	105 (97.2%)	3 (2.8%)			
46-55 years	57 (87.7%)	8 (12.3%)			
56-65 years	23 (88.5%)	3 (11.5%)			

Socio-demographic factors	**T2DM**		***DF**	****χ2**	*****P*-value**
	Negative **Freq. (%)**	Positive **Freq. (%)**			
Residence			1	0.933	0.334
Rural	236 (93.7%)	16 (6.3%)			
Urban	39 (97.5%)	1 (2.5%)			
Employment status					
Civil/professional servant or work with NGOs	6 (100%)	0 (0%)			
Self-employed			3	0.444	0.931
Not employed /no job	174 (94.1%)	11 (5.9%)			
Retired	94 (94%)	6 (6%)			
	1 (100%)	0 (0%)			
Income per month					
<25,800 RwF	247 (94.6%)	14 (5.4%)			
25,800-64500 RwF	19 (90.5%)	2 (9.5%)	2	0.943	0.624
>64,500 RwF	9 (90%)	1 (10%)			
Socio-economic category (Ubudehe category)					
Ubudehe1	45 (93.8%)	3 (6.3%)			
Ubudehe2	147 (93%)	11 (7%)			
Ubudehe3	82 (96.5%)	3 (3.5%)	3	1.267	0.737
Ubudehe4	1 (100%)	0 (0%)			
Told by health professionals that has diabetes					
Yes	8 (100%)	0 (0%)			

Socio-demographic factors	**T2DM**		***DF**	****χ2**	*****P*-value**
	Negative **Freq. (%)**	Positive **Freq. (%)**			
No I do not know	254 (94.8%) 13 (81.3%)	14 (5.2%) 3 (18.7%)	2	5.547	0.062
Family member with diabetes Yes No I do not know	18 (90%) 211 (95.5%) 46 (90.2%)	2 (10%) 10 (4.5%) 5 (9.8%)	2	2.790	0.248

*DF: Degree of Freedom
**χ2: Chi-square
***P-value: P <0.05: Significant

The study found that 5.4% of male participants had T2DM risk compared to 6% of female participants. This difference was however not statistically significant (χ2: 0.037; df: 1; p-value: 0.848). It was also found that 12.2% of widowed participants had T2DM compared to 7%, 4.8% and 0% of separated/divorced, married and single participants respectively. However, this difference was not statistically significant (χ2:5.655; df: 3; p-value: 0.13).

Furthermore, the study showed that 7.1% of participants who did not attend school had T2DM compared to 5.3%, 5.9% and 0% of participants who did primary, secondary and university education respectively. However, this difference was not statistically significant (χ2:0.601; df: 3; p-value: 0.986).

Moreover, 11.5% of participants aged 55-65 years old had T2DM risk and 12.5% of participants of 46-55 years old had T2DM compared to 2.8% of participants of 36-45 years old and 1.3% of participants of 26-35 years old. This difference was statistically significant (χ2:12.536; df: 4; p-value: 0.014). Hence, age was associated with T2DM among PLWHA.

In addition, it was found that 6.3% of participants in socio-economic category 1 (ubudehe1) had T2DM compared to 7% of participants in Ubudehe 2, 3.5% and 0% of Ubudehe 3 and Ubudehe 4 respectively. This difference, however, was not statistically significant (χ2:1.267; df: 3: p-value: 0.737). Thus, socio-economic category was not associated with T2DM.

Finally, the study showed that 10% of participants who had a family member living with diabetes had T2DM compared with 4.5% of those who did not have a family member with diabetes and 9.8% of those who did not know. Again, this difference was not statistically significant (χ2:2.790; df: 2; p-value: 0.248). Age was thus the only sociodemographic factor associated with T2DM (P-value 0.014).

4.5. Lifestyle characteristics of participants

4.5.1. Lifestyle characteristics of participants

The lifestyle characteristics of the participants are presented in Table 8.

Table 8: Lifestyle characteristics of participants (n=292)

Variables	Characteristics	Frequency (%)
Current smoking of tobacco products: pipe, cigar, cigarette and chews	Yes	50 (17.1)
	No	242 (82.9)
Ever smoked tobacco products	Yes	110 (37.7)
	No	182 (62.3)
Current number of tobacco products the participant smokes per day	0	242 (82.9)
	1-2	22 (7.5)
	3-5	24 (8.2)
	6 -12	4 (1.4)
Number of years the participant smoked	0 (Never smoked)	182 (62.3)
	<1 year	2 (0.7)
	1-5 years	57 (19.5)
	6-10 years	20 (6.8)
	11-15 years	3 (1)
	16-20 years	12 (4.1)
	21-45 years	16 (5.5)
Current alcohol consumption	Yes	137 (46.9)
	No	155 (53.1)
Ever drunk a drink containing alcohol	Yes	159 (54.5)
	No	133 (45.5)
Number of days of alcohol consumption per week	Always (every day)	17 (5.8)
	Very often (4-6 days)	12 (4.1)
	Sometimes (1-3 days)	108 (37)
	Never (0 days)	155 (53.1)
Physical Activity	Yes	10 (3.4)
	No	282 (96.6)

The results of the study showed that 50 (17.1%) participants were currently smokers whilst 242 (82.9%) were not currently smokers, including 182 who have never smoked and 60 who had quit smoking. It was indicated that 110 (37.7%) participants had ever smoked tobacco products including cigars, cigarettes, chews, pipes, etc. whilst 182 (62.3%) have never smoked. Furthermore, 24 (8.2%) participants smoked between 3-5 tobacco products per day while 22 (7.5%) participants smoked 1-2 tobacco products per day.

The majority of participants, 57 (19.5%) participants smoked between 1-5 years whilst 20 (6.8%) participants smoked 6-10 years. It was found that 16 (5.5%) participants smoked 21-45 years whilst 12 (4.1%) smoked between 16-20 years. Moreover, 159 (54.5%) participants have ever drunk alcohol and 137 (46.9%) participants were alcohol consumers. In addition, 108 (37%) participants consumed alcohol 1-3 days per week while 17 (5.8%) participants were always consuming alcohol. A total of 12 (4.1%) participants declared taking a drink containing alcohol very often. Finally, it was found that the majority of participants, 282 (96.6%) were physically inactive.

4.5.2. Characteristics of participants who have ever smoked

The characteristics of participants who have ever smoked are presented in Table 9.

Table 9: Characteristics of participants who have ever smoked (n=110)

Variable	Characteristics	Frequency (%)
Number of years of smoking	< 1 year	2 (1.8)
	1-5 years	57 (51.8)
	6-10 years	20 (18.2)
	11-15 years	3 (2.7)
	16-20 years	12 (10.9)
	21-45 years	16 (14.6)
Number of current smoked tobacco products per day	0	60 (54.6)
	1-2	22 (20)
	3-5	24(21.8)
	6-12	4 (3.6)
Number of smoked tobacco products per day among those who currently smoke	1-2	22 (44)
	3-5	24 (48)
	6-12	4 (8)
	Total	**50**

The results of the research indicated that 57 (51.8%) of participants who had ever smoked tobacco products, smoked for 1-5 years while 20 (18.2%) smoked for 6-10 years. Furthermore, it was found that 16 (14.6%) smoked for between 21-45 years. It was also found that 60 (54.6%) of participants who ever smoked quit smoking whilst 45.4% of those who ever smoked were still smoking. The majority of currently smoking participants, 24 (48%) smoked between 3-5 tobacco products per day, 22 (44%) smoked between 1-2 tobacco products whilst 4 (8%) smoked between 6-12 tobacco products per day.

4.6. Lifestyle factors associated with T2DM among participants

Lifestyle factors associated with T2DM among participants are presented in Table 10.

Table 10: Lifestyle factors associated with T2DM among participants (n=292)

Variables	**T2DM**		***DF**	****χ2**	*****P*-value**
	Negative **Freq. (%)**	Positive **Freq. (%)**			
Current smoking of tobacco products: pipes, cigar, cigarette, chews etc.					
Yes	50 (100%)	0 (0%)	1	3.730	0.053
No	225 (93%)	17 (7%)			
Ever smoked tobacco products			1	0.677	0.410
Yes	102 (92.7%)	8 (7.3%)			
No	173 (95.1%)	9 (4.9%)			
Number of tobacco products the participant smokes per day					
No smoking	225 (93%)	17 (7%)			
1-2 tobacco products per day	22 (100%)	0 (0%)			
3-5 tobacco products per day	24 (100%)	0 (0%)	3	3.730	0.292
6 -12 tobacco product per day	4 (100%)	0 (0%)			
Number of years the participant smoked					
Never smoked	172 (94.5%)	10(5.5%)			
<1 year	2 (100%)	0 (0%)			
1-5 years	53 (93%)	4 (7%)			
6-10 years	19 (95%)	1 (5%)			
11-15 years	3 (100%)	0 (0%)	6	0.661	0.995
16-20 years	11 (91.7%)	1 (8.3%)			
21-45 years	15 (93.8%)	1 (6.3%)			

Variables	**T2DM**		***DF**	****χ2**	*****P*-value**
	Negative **Freq. (%)**	Positive **Freq. (%)**			
Current alcohol consumption					
Yes	128 (93.4%)	9 (6.6%)	1	0.263	0.608
No	147 (94.8%)	8 (5.2%)			
Ever alcohol consumption					
Yes	149 (93.7%)	10 (6.3%)	1	0.139	0.709
No	126 (94.7%)	7 (5.3%)			
Number of days of alcohol consumption per week					
Always (every day)	16 (94.1%)	1 (5.9%)	3	0.347	0.951
Very often (4-6 days)	11 (91.7%)	1 (8.3%)			
Sometimes (1-3 days)	101 (93.5%)	7 (6.5%)			
Never (0 day)	147 (94.8%)	8 (5.2%)			
Total Physical activity					
Physical activity	10 (100%)	0 (0%)	1	0.640	0.424
Physical inactivity	265 (94%)	17 (6%)			

**DF: Degree of Freedom*

*** **χ2:** Chi-square*

****P-value :< 0.05: Statistically significant*

The study showed that 7% of participants who were current smokers had T2DM compared to 0% of those who were not currently smoking. This difference, however, was not statistically significant (**χ2:**3.730; df: 1; p-value: 0.053). Thus, current smoking was not associated with T2DM among PLWHA. The research also showed that 7.3% of participants who had ever smoked tobacco product had T2DM compared to 4.9% of those who have never smoked. Again, this difference was not statistically significant (χ2:0.677; df: 1; p-value: 0.410).

The study found that 6.3% of participants who ever consumed alcohol had T2DM compared to 5.3% of participants who have never consumed alcohol. This difference however was not statistically significant (χ2:0.139; df: 1; p-value: 0.709). Therefore, alcohol consumption was not associated with T2DM among PLWHA. Finally, the study found that 6% of participants with physical inactivity had T2DM compared to 0% of participants with physical activity. However, this difference was not statistically significant (χ2:0.640; df: 1; p-value: 0.424). Therefore, total physical activity was not associated with T2DM among PLWHA. Briefly, bivariate analysis found that none of the lifestyle factors was associated with T2DM among participants.

4.7. Anthropometric measurement characteristics among participants

4.7.1. Participants' Body Mass Index (BMI)

The BMI of participants are presented in Table 11.

Table 11: Participants' Body Mass Index (n=292)

BMI	Frequency (%)
Underweight (<18.5 Kg/m$^{2)}$	48 (16.4)
Normal weight (18.5-24.99Kg/m^2)	210 (71.9)
Overweight (25-29.99Kg/m^2)	26 (8.9)
Obese (≥30Kg/m^2)	8 (2.7)

The majority of participants (n=210; 71.9%) had normal weight. It was furthermore revealed that 48 (16.4%) were underweight, 26 (8.9%) were overweight while 8 (2.7%) were obese.

4.7.2. Waist circumference among participants

The waist circumference of participants is presented in Table 12.

Table 12: Waist circumference among participants

Waist circumferences	Frequency (%)		
	Male	Female	Total
Healthy/normal waist circumference: ≤ 94cm for male and ≤ 80cm for female	90 (97.8)	141(70.5)	231 (79.1)
Unhealthy waist circumference: > 94cm for male and > 80 cm for female	2 (2.2)	59 (29.5)	61 (20.9)
Total	**92**	**200**	**292**

The majority of male participants, 90 (97.8%) had a normal/healthy waist circumference while 2 (2.2%) had an unhealthy waist circumference. Furthermore, a significant number of female participants 141 (70.5%) had a healthy/normal waist circumference while 59 (29.5%) female participants had an unhealthy waist circumference. Moreover, the majority of participants, 231(79.1%) had a healthy/normal waist circumference while 61(20.9%) had an unhealthy waist circumference.

4.7.3. Waist-hip ratio (WHR) among participants

The waist-hip ratio (WHR) of participants are presented in Table13.

Table 13: Waist-hip ratio among participants

Waist-hip ratio circumferences	**Frequency (%)**		
	Male	Female	Total
Healthy/normal WHR (≤ 0.90cm for male and ≤ 0.85cm for female)	82 (89.1)	122 (61)	204 (69.9)
Unhealthy WHR (>0.90cm for male and > 0.85 cm for female)	10 (10.9)	78 (39)	88 (30.1)
Total	**92**	**200**	**292**

The majority of male participants, 82 (89.1%) had normal/healthy waist-hip ratio while 10 (10.9%) had an unhealthy waist-hip ratio. Furthermore, a large number of female participants, 122 (61%) had a normal/healthy waist-hip ratio while 79 (39%) had an unhealthy waist-hip ratio. Generally, the majority of participants, 204 (69.9%) had a healthy/normal waist-hip ratio while 88 (30.1%) had an unhealthy waist-hip ratio.

4.8. Anthropometric measurement factors associated with T2DM among participants

The results of bivariate analysis are presented in table 14.

Table 14: Anthropometric measurement factors associated with T2DM among participants (n=292)

Anthropometric measurement factor	**T2DM**		***DF**	****χ2**	*****P-value**
	Negative **Freq. (%)**	Positive **Freq. (%)**			
Body Mass Index (BMI)					
Underweight (<18.5 Kg/$m^{2)}$	45 (93.8%)	3 (6.3%)			
Normal weight (18.5-24.99Kg/m^2)	19 (94.3%)	12 (5.7%)			
Overweight (25-29.99Kg/m^2)	25 (96.2%)	1 (3.8%)			
Obese (≥ 30Kg/m^2)	7 (87.5%)	1 (12.5%)	3	0.856	0.836
Waist circumference for male(cm)					
Healthy/normal waist circumference <=94cm	85 (94.4%)	5 (5.6%)	1	0.117	0.732
Unhealthy waist circumference >94cm	2 (100%)	0(0%)			
Waist circumference for female(cm)					
Healthy/normal waist circumference <=80cm	131(92.9%)	10 (7.1%)	1	1.011	0.315
Unhealthy waist circumference >80cm	57 (96.6%)	2 (3.4%)			
Waist-hip ratio for male (cm)					
Healthy waist-hip ratio (≤ 0.90cm)	77 (93.9%)	5 (6.1%)			
Unhealthy waist-hip ratio (>.90cm	10 (100%)	0 (0%)	1	0.645	0.422
Waist-hip ratio for female (cm)					
Healthy waist-hip ratio (≤.85cm)	114 (93.4%)	8 (6.6%)	1	0.172	0.678
Unhealthy waist-hip ratio (>.85cm	74 (94.9%)	4 (5.1%)			

***DF**: Degree of Freedom; ****χ2:** Chi-square; ***** P-value:** <0.05: Statistically significant

The study showed that 6.3% of underweight participants had T2DM compared to 5.7% of participants with normal weight, 3.8% of overweight participants and 12.5% of obese participants. This difference however was not statistically significant (χ2:0.856; df: 3; p-value: 0.836). Therefore, BMI was not associated with T2DM among PLWHA. It was further found that 5.6% of male participants with a normal/healthy waist circumference had T2DM compared to 0% of male participants with an unhealthy waist circumference. However, this difference was not statistically significant (χ2:0.117; df: 1; p-value: 0.732). In addition, 7.1% of female participants with a normal/healthy waist circumference had T2DM compared to 3.4% of female participants having an unhealthy waist circumference. Nonetheless, this difference was not statistically significant (χ2:1.011; df:1; p-value:0.315).

Moreover, the study revealed that 6.1% of male participants with a healthy/normal waist-hip ratio had T2DM compared to 0% of male participants with an unhealthy WHR. Nevertheless, this difference was not statistically significant (χ2:0.645; df:1; p-value:0.422). As well, 6.6% of female participants with normal WHR had T2DM compared to 5.1% of female participants with an unhealthy WHR, but this difference was not statistically significant (χ2: 0.172; df:1; p-value:0.678). In summary, the study found that none of the anthropometric measurement factors was associated with T2DM among participants as the difference of prevalence of T2DM across anthropometric measurements was not statistically significant.

4.9. HIV/AIDS related characteristics among participants

The results of HIV/AIDS related characteristics are presented in Table 15.

Table 15: HIV/AIDS related characteristics among participants (n=292)

HIV/AIDS related factor	Characteristics	Frequency (%)
Duration of HIV infection in years	< 5 years	95 (32.5)
	5.00-10 years	97 (33.5)
	10.01-15 years	69 (23.6)
	15.01-20 years	20 (6.8)
	20.01 year-28 years	11 (3.8)
Duration of HIV infection in years	< 10 years	160 (54.8)
	≥ 10 years	132 (45.2)
ARVs taking	Yes	292 (100)
Duration of ARVs taking in years	< 5 years	111 (38)
	5.01-10 years	108 (37)
	10.01-15 years	52 (17.8)
	15.01-22 years	21 (7.2)
Duration of ARVs taking in years	< 10 years	182 (62.3)
	≥ 10 years	110 (37.7)
Types of ARVs	TDF/3TC-EFV	166 (56.8)
	TDF/3TC-NVP	66 (22.6)
	ABC/3TC-NVP	33 (11.3)
	TDF/3TC-ATV/r	12 (4.1)
	ABC/3TC-EFV	15 (5.1)
CD4 counts	<200	50 (17.1)
	200-499	123 (42.1)
	≥500	119 (40.8)

HIV/AIDS related factor	Characteristics	Frequency (%)
WHO HIV clinical stages	Stage I	241(82.5)
	Stage II	40 (13.7)
	Stage III	11 (3.8)
	Stage IV	0 (0)

The majority of participants, 97 (33.5%) had known their HIV infection status for 5-10 years while 95 (32.5%) who had HIV infection for less than 5 years did not know their status. It was also revealed that 69 (23.6%) have known their infection status for 10.01-15 years whilst 20 (6.8%) have known their HIV infection for 15.01- 20 years and 11 (3.8%) participants have known their HIV infection for 20.01-28 years. In brief, 160 (54.8%) and 132 (45.2%) have known their HIV infection status for less than 10 years and 10 years and above respectively with an average of 8.2 years with known HIV infection. All participants, 292 (100%) took antiretroviral therapy drugs (ARVs).

Furthermore, a large number of participants, 111 (38%), had taken ARVs for less than 5 years and 108 (37%) had taken ARVs for 5.01-10 years. It was revealed that 52 (17.8%) had taken ARVs for 10.01-15 years and 21 (7.2%) had taken ARVs for 15.01-22 years. It was indicated that 182 (62.3%) and 110 (37.7%) had taken ARVs for less than 10 years and 10 years and above respectively with an average of taking ARVs for 7 years with a median of 6 years. Moreover, the majority of participants, 166 (56.8%), were on a combination of TDF/3TC-EFV (Tenofovir-Lamivudine-Efavirenz), 66 (22.6%) were on TDF/3TC-NVP (Tenofovir-Lamivudine-Nevirapine) and 15 (5.1%) were on ABC/3TC-EFV (Abacavir-Lamivudine-Efavirenz) while 12 (4.1%) were on TDF/3TC-ATV/r (Tenofovir-Lamivudine- Atanavir/ritonavir).

The study showed that the majority of participants, 123 (42.1%) had CD4 counts between 200-500cells/mm^3. It was also indicated that 119 (40.8%) had CD4 counts 500cells/^{1}mm^3 and above while a small number of participants, 50 (17.1%) had CD4 counts below 200 cells/mm^3. The majority (n=241; 82.5%) of the participants were classified as WHO HIV clinical stage I; 13.7% (n=40) as WHO HIV clinical stage II and 3.8% (n=11) as WHO HIV clinical stage III.

4.10. HIV/AIDS related factors associated with T2DM among participants

The HIV/AIDS related factors associated with T2DM among participants are presented in Table 16.

Table 16: HIV/AIDS related factors associated with T2DM among participants (n=292)

HIV/AIDS related factor	**T2DM**		***DF**	****χ2**	*****P-value**
	Negative	Positive			
	Freq. (%)	**Freq. (%)**			
Duration of HIV/AIDS in years					
< 5 years	92 (96.8%)	3 (3.2%)			
5.00-10 years	95 (97.9%)	2 (2.1%)			
10.01-15 years	63 (91.3%)	6 (8.7%)			
15.01-20 years	16 (80%)	4 (20%)			
20.01-28 years	9 (81.8%)	2 (18.2%)	4	15.167	0.004***
Duration of HIV/AIDS in years			1	10.056	0.002*
<10 years	157 (98.1)	3 (1.9)			
≥ 10 years	118 (89.4)	14 (10.6)			

HIV/AIDS related factor	**T2DM**		***DF**	****χ2**	*****P-value**
	Negative **Freq. (%)**	Positive **Freq. (%)**			
Duration of ARVs taking in years					
< 5 years	108 (97.3%)	3 (2.7%)			
5.00-10 years	105 (97.2%)	3 (2.8%)			
10.01-15 years	47 (90.4%)	5 (9.6%)	3	24.982	<0.001***
15.01-22 years	15 (71.4%)	6 (28.6%)			
Duration of taking ARVs in years			1	11.573	0.001*
<10 years	178 (97.8)	4 (2.2)			
≥ 10 years	97 (88.2)	13 (11.8)			
Types of ARVs					
TDF/3TC-EFV	159 (95.8%)	7 (4.2%)			
TDF/3TC-NVP	58 (87.9%)	8 (12.1%)			
ABC/3TC-NVP	33 (100%)	0 (0%)	4	9.882	0.042***
TDF/3TC-ATV/r	12 (100%)	0 (0%)			
ABC/3TC-EFV	13 (86.7%)	2 (13.3%)			
CD4 counts					
<200	48 (96%)	2 (4%)			
200-499	115 (93.5%)	8 (6.5%)			
>=500	112 (94.1%)	7 (5.9%)	2	0.408	0.816
WHO HIV clinical stages					
Stage I	226(93.8%)	15 (6.2%)	2	0.800	0.670
Stage II	38 (95%)	2 (5%)			
Stage III	11 (100%)	0 (0%)			

*****DF: Degree of Freedom, **χ2: Chi-square; ***P-value :< 0.05 (Statistically significant)

The study found that 18.2% (n=2) of the participants who had known their HIV/AIDS infection status for 20.01-28 years had T2DM compared to 20% (n=4) of those who had known their HIV/AIDS infection status for 15.01-20 years. It was also found that 2.1% (n=2) of the participants who had known their HIV/AIDS infection status for 5-10 years had T2DM compared to 3.2% (n=3) and 8.7% (n=6) of those who had known their HIV infection status for less than 5 years and between 10.01-15 years respectively. The difference of T2DM prevalence across the duration of HIV infection was statistically significant ($\chi 2$:15.167; df: 4; p-value: 0.004). Considering an interval of 10 years, 10.6% (n=14) of those who had known their HIV infection status for 10 years and above had T2DM compared to those who had known their HIV infection status for less than 10 years (1.9%; n=3). This difference was also statistically significant ($\chi 2$:10.056; df: 1; p-value: 0.002). Therefore, the duration of HIV/AIDS infection was associated with T2DM among PLWHA.

Furthermore, the duration of taking ARVs was associated with T2DM. The study found that 28.6% (n=6) of participants who were on ARVS for 15.01-22 years had T2DM compared to 9.6% (n=5) of those who were on ARVs for 10.01-15 years. It was also found that 2.7% (n=3) of participants who were on ARVs for less than 5 years and 2.8% (n=3) of those who were on ARVs between 5-10 years had T2DM. The difference of prevalence of T2DM across the years on ARVs was statistically significant ($\chi 2$:24.984; df: 3; p-value < 0.001). Considering the interval of 10 years, it was found that 11.8 % (n=13) of those with 10 years and above on ARVs had T2DM risk compared to those who were on ARVs for less than 10 years (2.2%; n=4) and this was also statistically significant ($\chi 2$:11.573; df: 1; p-value: 0.001). The duration on ARVs was thus associated with T2DM among PLWHA (Table 16).

Moreover, the study found that the type of ARVs was associated with T2DM among participants. It was found that 13.3% (n=2) of participants who were on ABC/3TC-EFV had T2DM compared to 12.1% (n=8) of those who were on TDF/3TC-NVP and 4.2% (n=7) of those who were on TDF/3TC-EFV. However, none of those who were on ABC/3TC-NVP and TDF/3TC-ATV/r (ritonavir-boosted Atazanavir) had T2DM. This difference of T2DM prevalence across the types of ARVs was statistically significant (χ2:9.882; df: 4; p-value of 0.042). Thus, types of ARVs were associated with T2DM among PLWHA.

4. 11. Predictors of T2DM among participants

The multivariate logistic regression analysis was performed to determine predictors of T2DM among participants. The results are presented in Table 17.

Table 17: Predictors T2DM among participants

Variables	B	S.E	Wald	df	Sig.	Exp(B)	95%CI for Exp(B)	
							Lower	Upper
Age	.034	.032	1.082	1	.298	1.034	.971	1.102
Duration of HIV/AIDS in years	-.270	.237	1.297	1	.255	.764	.480	1.215
ABC/3TC-EFV (reference)			3.053	4	.549			
TDF/3TC-EFV (1)	.973	.574	2.875	1	.090	2.645	.859	8.141
TDF/3TC-NVP (2)	-18.111	6594.583	.000	1	.998	.000	.000	.
ABC/3TC-NVP (3)	-18.287	10931.967	.000	1	.999	2.343	.000	.
TDF/3TC-ATZ/r (4)	.851	.933	.832	1	.362	.086	.376	14.595
Duration of ARVs taking in years	.411	.239	2.950	1	.086	1.508	.944	2.411
Constant	-12.570	2553.401	.000	1	.996	.000		

The study found that as age increases by 1 year, the odds of having T2DM increases by 3.4%. This however was not statistically significant (OR: 1.034; CI 95%:0.971-1.102; P-value: .298). It was also found that as duration of HIV/AIDS infection increases by 1 year, the odds of participants having T2DM decreases by 23.6%. However, this was not statistically significant (OR: 0.764; 95%CI: 0.480-1.215; p-value: 0.255). Moreover, as duration of taking ARVs increases by 1 year, the odds of having T2DM increases by 50.8%. Again, this was not statistically significant (OR: .1.508; 95%CI: 0.944-2.411; P-value: 0. 086).

Finally, the participants who were on TDF/3TC-EFV were 2.645 times more likely to have T2DM compared to those who were taking ABC/3TC-EFV (OR: 2.645; 95%CI: .859-8.141; P-value: 0.90) and participants who were taking ABC/3TC-NVP were 2.343 more likely to have T2DM compared to participants who were on ABC/3TC-EFV (p-value: .999). However, these findings were not statistically significant. In summary, multivariate analysis found that none of the sociodemographic, lifestyle, anthropometric and HIV and AIDS related factors was associated with T2DM among participants as none was statistically significant in multivariate analysis.

CHAPTER FIVE: DISCUSSION

5.1. Introduction

In chapter five the results of the current study are discussed. The main aim of the study was to determine factors associated with T2DM in people living with HIV/AIDS (PLWHA) attending primary health care centres (PHCs) in Rwamagana district, Rwanda. The discussion is also focused on key findings related to the study objectives: to determine the prevalence of T2DM risk in PLWHA attending Primary Health Care Centres in Rwamagana district; to determine the socio-demographic factors associated with T2DM of PLWHA attending PHCs in Rwamagana district, Rwanda; to determine the anthropometric factors associated with T2DM of PLWHA attending PHCs in Rwamagana district; to determine lifestyle factors associated with T2DM of PLWHA attending PHCs in Rwamagana district and finally to determine the HIV and AIDS-related factors of PLWHA attending PHCs in Rwamagana district.

5.2. Prevalence of Type 2 Diabetes Mellitus risk among participants

Studies conducted in various countries have found that the prevalence of T2DM among PLWHA ranged from 1% to 26% (Njuguna *et al.*, 2018; Duncan *et al.*, 2018; Kabati *et al.*, 2010). These prevalences are especially pertinent because of the numerous diabetes-related complications in PLWHA including cardiovascular diseases, nephropathy, and neuropathy that complicate HIV/AIDS management and lead to poor healthcare outcomes for PLWHA with T2DM co-morbidity (Duncan *et al.*, 2018; Dimala *et al.*, 2016; Hadigan *et al.*, 2014). Thus, early screening of T2DM in PLWHA is important.

Our cross-sectional study found that 17 (5.8%) of PLWHA had T2DM risk. The findings of this study indicate that the prevalence of T2DM risk is lower than that reported in studies conducted in Tanzania and London, UK (Duncan *et al*., 2018; Kabati *et al.*, 2010). These authors found in their study that 24.7% of HIV infected individuals in Tanzania had T2DM while Duncan *et al.* (2018) found that the prevalence of T2DM was 15.1%. In the current study, the cut-off value for the fasting blood glucose level was different from these studies. In the current study, the cut-off point was 6.51mmol/L, while Duncan *et al.* (2018) used a cut-off point of 6mmol/L. In addition, the current study used fasting capillary blood glucose while other studies have used fasting plasma glucose measurements.

The plasma glucose values estimate the glucose level after glucose is used by tissues (Patel &Patel, 2015) while the capillary blood glucose values represent circulating blood glucose (Patel &Patel, 2015). Capillary blood glucose values are higher than plasma blood glucose values due to their close proximity to arteries (Yang, Chang & Lin, 2012), thus capillary blood glucose may overestimate the prevalence of diabetes in the studied population. A fasting plasma glucose level cut-off point of ≥126g/dl (7.0 mmol/L) is a worldwide accepted standard for the diagnosis and screening of diabetes mellitus (American Diabetes Association, 2019; WHO, 2006). Due to the disadvantages of using the fasting plasma glucose measurement such as high cost, delays in receiving laboratory results and the pain involved, the capillary blood glucose measurement is the preferred and accepted method being practical, cheap and easy to administer in most rural communities (Patel & Patel, 2015; Foss-Freitas *et al*., 2010). Capillary blood glucose measurement by a glucometer is considered as an alternative to venous plasma glucose estimation for diabetes mellitus diagnosis (Patel & Patel, 2015).

Even though capillary blood glucose measurement by a glucometer is practical and often used in rural communities for diagnosis and monitoring of diabetes, the WHO has not established its cut-off point for diagnosing diabetes (Patel & Patel, 2015). A cut-off point of 6.51mmol/L for capillary blood glucose measurements had an 82.5% sensitivity and a 98.3% specificity for identifying diabetes mellitus (Zhao *et al*., 2013). It has also been found to predict diabetes and pre-diabetes, as does the fasting plasma glucose test (Zhao *et al*., 2013).

In this study, the prevalence of T2DM compares well to the findings of studies carried out in Ethiopia at the Jimma University Specialized Hospital in Southwest Ethiopia and at the University of Gondar Hospital in Northwest Ethiopia, where the prevalences of T2DM among PLWHA was 6.4% and 8% respectively (Mohammed *et al.*, 2015; Abebe *et al.,* 2016). The similarity of prevalences in these studies and the prevalence in the current study seems reasonable because of the similar populations in terms of gender, age and BMI distribution. In this study, 2.7% of the participants were obese while 2.8% of the participants in the study by Abebe *et al*. (2016) were obese.

Furthermore, 68.5% of the participants were females in the current study while 66.9% of the participants were female in the study by Mohammed *et al*. (2015). Among the various factors, BMI and gender have been identified as risk factors for T2DM in PLWHA (Mohammed *et al*., 2015; Abebe *et al.*, 2016). The prevalence seen in this study was higher than that in the study by Anastos *et al*. (2010) in Rwanda where the prevalence was 0.5% among PLWHA. The different prevalences could be partly explained by the different exposures to antiretroviral (ARVs) therapy drugs that have been identified as predictors of T2DM among PLWHA (Han *et al*., 2019; Rogalska-Płońska *et al.,* 2018).

The study by Anastos *et al*. (2010) was conducted almost 10 years ago when ARVs were less popular and accessible in Rwanda, while our study was conducted when the participants had been exposed to ARVs for years and had easy access to them which have been found to be associated with T2DM in PLWHA (Kumar & Samaras, 2018).

The results of our study indicated that the prevalence of T2DM in PLWHA is higher than that of the general population in Rwanda [2%] (Rwanda Ministry of Health, 2015). The high prevalence of T2DM among PLWHA compared to the general population has been reported in other studies conducted elsewhere (Duncan *et al*., 2018; Hernandez-Romieu *et al.,* 2017). This may support the link between HIV infection and T2DM (Hernandez-Romieu *et al*., 2017; Avari & Devendra, 2017) though the association of HIV or ARVs with T2DM remains controversial (Hernandez-Romieu *et al.,* 2017; Prioreschi *et al.,* 2017).

5.3. Sociodemographic profile of participants and socio-demographic factors associated with T2DM in PLWHA

In Sub-Saharan Africa, 75% of new infections among adolescents aged 15-19 years are girls while young women 15-24 years of age are twice as likely to be living with HIV/AIDS as men (UNAIDS, 2018b). In Rwanda, females are most affected by HIV/AIDS, and women are two times more likely to be living with HIV than men (4% vs 2%) (National Institute of Statistics of Rwanda, 2016).

Women are more exposed to HIV and AIDS compared to their male counterparts because of their vulnerability caused by unequal cultural and socioeconomic situations including sexual violence, poverty, prostitution and the unbalanced power dynamics in regard to sexual practices between males and females (Avert, 2017). The current study also found a difference in the gender

distribution among participants, with females representing 68.5% (200) and males representing 31.5% (92). The over-representation of females in this study may also reflect the current gender distribution in the Rwandan general population and the HIV infected population where females comprise 52% of the general population (National Institute of Statistics of Rwanda, 2016) and 61.9% of the HIV infected population (UNAIDS, 2018b).

The results of this study are congruent with the findings of studies conducted in Ethiopia such as researches conducted at the Gondar University Hospital and the Jimma University Specialized Hospital in Northwest Ethiopia and Southwest Ethiopia (Abebe *et al.*, 2016; Mohammed *et al.*, 2015). In the Northwest Ethiopia study, 69.3% of the participants were female and 30.1% were male, and in the Southwest Ethiopia study, 66.9% were female and 33.1% were male.

Gender and being male has been found to be associated with T2DM in PLWHA (Chimbetete *et al.*, 2017; De Wit *et al.*, 2008; Butt *et al.*, 2009). Although our study did not find any association between gender and T2DM in PLWHA, a high prevalence of T2DM was found among females compared to their male counterparts (6%; n=12 vs 5.4%; n= 5). Educational attainment is a key social determinant of health (Mursal & Dong, 2018; WHO & UNICEF, 1978) and the lack of education is associated with poor health and adherence to healthcare treatments for several diseases (e.g. insulin for diabetes) resulting in poor healthcare outcomes (Burch *et al.*, 2016). Our results showed that 58.2% of the participants completed primary school, 11.6% completed secondary school, 1.4% completed university/college and 28.8% did not attend school.

The findings of this study are similar to that of Mohammed *et al*. (2015) in Ethiopia who found that illiterate participants constituted 21.6% of their sample. Nevertheless, these results differed from the findings of the Rwanda demographic and health survey of 2014-2015 where

approximately 12.3% of the sample had no education (National Institute of Statistics of Rwanda, 2016). This may partly be due to HIV infection, fear of stigmatization and discrimination at school that had a negative impact on the enrolment of children who were HIV positive in school, which lead to drop-out (Kimera *et al.*, 2019; Guo, Li & Sherr, 2012).

The Socioeconomic situation is also an important social determinant of health (WHO & UNICEF, 1978) and socioeconomic disadvantage is associated with poor health status and low adherence to healthcare treatment. Chronic diseases, in particular, may result in poor healthcare outcomes (Burch *et al.*, 2016). Socioeconomic disadvantage would limit the access to preventive healthcare services (Stevens *et al.*, 2014), exacerbating inequity and poor health outcomes. In the present study 89.4% of the participants earned less than <25,800 RwF per month (< 30.4 USD per month).

In addition, 70.5% (16.4% in socioeconomic category I=Ubudehe 1 and 54.1% in Ubudehe 2) were poor. Ubudehe is categorization of households which is based on their social-economic status and their property in terms of land and other belongings (Government of the Republic of Rwanda, 2017). Ubudehe category 1: Families who do not have their own house and hardly afford basic needs while Ubudehe category 2: Families who have a dwelling on their own or can rent one but rarely get a full-time job (Government of the Republic of Rwanda, 2017). These categories (I&II) are classified as poor and mainly get government assistance.

Ubudehe category 3: Families who have job and farmers who produce a surplus for selling beyond subsistence farming. This category includes small and medium enterprises that can offer employment to some people while category 4 comprises families with a large-scale business, individuals working with international and industrial organizations, and public servants (Government of the Republic of Rwanda, 2017). Chhoun *et al*. (2017) found different findings in

Cambodia where participants' mean income was 60 ± 75 USD for women and 69.6±74.5 USD for men. In any case, these studies were conducted in different contexts, which may explain the difference. Our study was conducted in the rural community with most participants living in rural areas and 34.5% were unemployed, while 60% of the participants in the Cambodian study were from urban areas and only 24.3% were unemployed.

Although educational and socioeconomic levels were not associated with T2DM risk in PLWHA in our study, most of participants with T2DM had a low education level (no education or only primary schooling) and low socioeconomic status (Ubudehe I&II) with 6.3% (n=15) and 7.3%; (n=14) respectively. These results are in line with those of the study in Northeast Ethiopia that found a statistically significant high prevalence of T2DM in PLWHA participants with low education and low prevalence of T2DM in PLWHA participants with higher education level (11.2% vs 5.4%) (Fiseha & Belete, 2019). The lower socioeconomic status as measured by low education level and income/poverty was strongly associated with a lack of access to healthcare services for chronic diseases prevention (e.g. preventive services and lack of control over healthy lifestyles), thus increasing the risk of developing T2DM and poor healthcare outcomes (Burch *et al.*, 2016).

Older age was found to be strongly associated with the risk of developing T2DM in PLWHA (Maganga *et al.,* 2015; Mohammed *et al.,* 2015; Capeau *et al.,* 2012). Our findings showed that most of the participants, 108 (37%), were in the 36-45 years old group while 77 (26.4%) were 26 to 35 years old. Approximately 63.4% of the participants were aged 26 and 45 years while 31.2% were aged > 45 years old. We also found a statistically significant association between age and T2DM risk in PLWHA across all age groups.

The findings of the present study are consistent with the research of Abebe *et al.* (2016) in Ethiopia who reported that 68.9% of their participants were in the range of 25-44 years old group. Furthermore, our results are also in line with various studies conducted in other areas where age was found to be associated with T2DM among PLWHA (Hernandez-Romieu *et al.*, 2017; Isa *et al.*, 2016; Capeau *et al.*, 2012; Butt *et al.*, 2009).

Isa *et al.* (2016) in Nigeria and Chimbetete *et al.* (2017) in Zimbabwe found that being older than 40 years of age was associated with a risk of developing T2DM in PLWHA while a ten-year study by Capeau *et al.* (2012) conducted in France found that an older age was associated with T2DM in PLWA. The study found a 2.13-fold and 3.63-fold increase when the patient is 40-49 years and ≥50 years respectively (Capeau *et al.*, (2012). The similarity of the current study to other studies conducted in other areas may be partly due to the similar characteristics of studied population in term of age distribution, which is already a traditional risk factor of T2DM in the general population. Although the multivariate analysis did not show any association between age and T2DM, metabolic conditions like T2DM would likely be related to the ageing processes or metabolic dysfunctions, thus influencing the occurrence of T2DM (Suastika, Dwipayana, Semadi & Kuswardhani, 2012).

The prevention and control of HIV/AIDS and NCD co-morbidities like HIV/AIDS and T2DM require large scale resources and pose a threat to the healthcare systems in developing countries that are already fragile (Haregu, Setswe, Elliott & Oldenburg, 2014). Urban dwellers tend to receive higher quality healthcare services from better healthcare providers and enjoy better healthcare outcomes (Yu, Chung, Wei, Chien & Hou, 2016), while people living in rural areas lack many opportunities to access better healthcare providers (Yu, Hou, Tung & Chung, 2016), because a high proportion of qualified and specialized healthcare professionals work in urban areas and

serve fewer people (Behera, Prutinyo, Sirichotiratana & Viwatwongkasem, 2017). In Rwanda, 84% of the population lives in rural areas (National Institute of Statistics of Rwanda, 2016). Our research found similar findings where a high proportion of the study participants (86.3%) live in rural areas. Our findings were incongruent with those of Chhoun *et al.* (2017) who conducted a study in Cambodia and found that 60.2% of the participants were living in urban while 39.8% were living in rural areas. A probable explanation for this difference may be due to the different research settings. Our study was conducted in rural areas specifically primary health care settings, while the study in Cambodia was conducted in the city.

5.4. Lifestyle-related factors associated with T2DM among participants

Smoking, alcohol consumption and physical inactivity as factors that increase the risk of developing T2DM in the general population are well established (WHO, 2000). This conclusion may also be applicable to PLWHA, given that these risk factors are commonly found in PLWHA. The present research showed that 17.1% of the participants smoked and 46.9% consumed alcohol. The results of the current study are slightly incongruent with the findings reported by Chhoun *et al.* (2017) who found that 14.7% of the participants smoked and 76.3% consumed alcohol.

Furthermore, our results are inconsistent with the findings of Abebe *et al.* (2016) who conducted a study in Northwest Ethiopia indicating that 25.9% of the participants smoked and 38.1% consumed alcohol. Cooperman (2016) conducted a review and found that the prevalence of smoking in PLWHA was high compared to the general population, ranging from 40-84%. The different prevalences of smoking and alcohol consumption may be due to cultural differences in the different populations since alcohol consumption is considered as cultural practice in many countries (Taylor *et al*., 2017; Savic, Room, Mugavin, Pennay & Livingston, 2016; Christopoulou

& Lillard, 2015). Nevertheless, in Rwanda, some religions prohibit smoking and alcohol consumption while others prohibit only smoking. This might also explain the difference in prevalences for smoking and alcohol consumption, though this aspect was not explored further in these studies.

Tobacco smoking and alcohol consumption have been shown to be associated with T2DM in HIV infected individuals (Chhoun *et al*., (2017). In our study, the association between alcohol drinking, smoking tobacco products and T2DM risk was not statistically significant. In any case, we observed a high prevalence of T2DM in participants who were former tobacco product smokers (7.3%) and current alcohol consumers (6.6%), compared to those who had never smoked tobacco products (4.9%) or were not currently consuming alcohol (5.2%). This suggests a possible role for these traditional risk factors in the development of T2DM in HIV infected people (WHO, 2000). Since alcohol consumption causes liver injury, leading to chronic liver inflammation that can alter liver function (Justice, Sullivan & Fiellin, 2010), this could affect glucose metabolism and the subsequent development of diabetes.

Physical activity is recommended as a preventive and control strategy to counter non-communicable diseases including T2DM across all ages of population including PLWHA (Frantz & Murenzi, 2013; WHO, 2010). Our findings further showed that 96.6% of the participants were physically inactive, which is somewhat surprising since most of our study participants were rural communities where people rely on physical activities such as working in the agricultural sector for survival (National Institute of Statistics of Rwanda, Ministry of Finance and Economic Planning & Ministry of Health, 2016).

Some studies have found a high prevalence of physical activities while others have reported a low prevalence of physical activities among PLWHA (Dang *et al*., 2018; Chhoun *et al.,* 2017). Dang *et al.* (2018), for example, in their study in Vietnam found that 16% of PLWHA had a low level of physical activity. This difference may be explained partly by specific differences between the studied populations. Our sample population was older than the sample of other authors (40 vs 35 years), and as age increases, physical activity tends to decrease (Sagatun, Kolle, Anderssen, Thoresen & Søgaard, 2008).

Furthermore, the findings of this study are in line with the study conducted in Rwanda that found that 70% of PLWHA were physically inactive (Frantz & Murenzi, 2013). The consistency of these results may reflect similar lifestyles of the two populations. PLWHA may develop body weaknesses and psychological effects that cause them to lose interest in physical activity possibly for fear of aggravating their diseases (Frantz & Murenzi, 2013).

Low physical activity may put PLWHA at a higher risk for developing T2DM. Previous studies have found that physical inactivity was associated with various chronic metabolic conditions including T2DM (Dang *et al.*, 2018; Quiles, Ciccolo & Garber, 2017; Brugnara *et al.,* 2016). Although our results did not show an association between physical inactivity and T2DM, all 17 participants with T2DM risk were physically inactive.

5.5. Anthropometric factors associated with T2DM among participants

A high body mass index (BMI) and waist circumference are implicated in the increase of T2DM in PLWHA, especially as lipodystrophy that occurs after ARVs initiation affects this specific population much more and can contribute to insulin resistance leading to development of T2DM (Rogalska-Płońska *et al*., 2018; Hernandez-Romieu *et al.*, 2017; Isa *et al.*, 2016; Rhee *et al.*, 2016; Maganga *et al.*, 2015). These traditional risk factors for T2DM in the general population remain relevant in PLWHA (Njuguna *et al*., 2018). Our findings have shown that 8.9% of the participants were overweight while 2.7% were obese. Similar results have been reported by Abebe *et al.* (2016) in their study in Northwest Ethiopia where 9.6% of the participants were overweight and 2.8% were obese. The similarity may be partly explained by the similar population characteristics. The general population of Ethiopia and Rwanda tend to be slim.

Nevertheless, our results are incongruent with those of a study conducted in Rwanda that found that 40% of the participants were obese and 40% were overweight (Frantz & Murenzi, 2013). Furthermore, the results of the current study are inconsistent with the studies conducted elsewhere (Chhoun *et al*.,2017; Isa *et al*., 2016; Rhee *et al*.,2016). Rhee *et al*. (2016) for example, investigated participants in Cameroon and found that 40% of the PLWHA participants were overweight or obese. Moreover, Chhoun *et al.* (2017) in Cambodia found that 17.3% of the participants were overweight and 4.1% were obese. Isa *et al.* (2016) in a study in Jos, Nigeria found that 32.4% of the PLWHA participants had BMI $\geq 25 kg/m^2$. These findings differ from our results may be due to different study settings. Our study was conducted in the rural community whereas these studies were conducted in urban settings, and urbanization has been found to be associated with an increased BMI (Troy, Bonnell & Littenberg, 2018; Eckert & Kohler, 2014) in particular due to changes in population lifestyles.

Although previous studies have established an association between BMI and T2DM among PLWHA (Hernandez-Romieu *et al.*,2017; Isa *et al.,* 2016; Abebe *et al.,* 2016; Capeau *et al.,* 2012; Butt *et al.,* 2009), our study found that BMI was not associated with T2DM among PLWHA. The distribution of T2DM across BMI categories was very low, which may have prevented the establishment of an association between T2DM risk and BMI. In addition, Duncan *et al.* (2018) in their study, did not find an association between BMI and T2DM in HIV infected individuals.

The present study showed that 2 (2.2%) of male and 59 (29.5%) of female participants had a high waist /unhealthy circumference while 10 (10.9%) of male and 78 (39%) of female participants had a high/unhealthy waist-hip ratio. In general, 20.9% and 30.1% of participants had an unhealthy waist sizes and unhealthy waist-hip ratio respectively. These results are inconsistent with the study conducted in Rwanda that found that 31% and 43% of the participants had a high risk of waist circumference and a high risk of waist-to-hip ratio respectively (Frantz & Murenzi, 2013). The different findings of these studies might be partly explained by the different study settings. Our study was conducted in the rural community while Frantz and Murenzi's (2013) study was conducted in the urban setting. Urbanization has been shown to affect lifestyles resulting in increased risk for more extreme anthropometric measurements (Ojiambo *et al*., 2012).

The findings of the current study are also incongruent with the findings of the study conducted in Poland by Rogalska-Płońska *et al.* (2018) who found that 29% of the participants had unhealthy waist circumferences. These differing findings may be due to the different population being studied. Our study was conducted in an African Black population while Rogalska-Płońska *et al.'s* (2018) study was conducted in a Caucasian population. These two populations differ in terms of lifestyle and geographical environment which may affect the participants' anthropometric measurements.

Rogalska-Płońska *et al.* (2018) found a strong association between unhealthy waist circumference and metabolic syndrome including T2DM in both male and female HIV infected individuals. In our study however, an association between waist circumference and waist-hip ratio with T2DM was not statistically significant. Nevertheless, we observed a high prevalence of T2DM among those with an unhealthy waist circumference (5.6% vs 0% for males; 7.1% vs 3.4% for females) and waist-hip ratio (6.1% vs 0% for males and 6.6% vs 5.1% for females). This suggests the possible role of these anthropometric measurement in the development of T2DM among PLWHA. High anthropometric measurements (BMI, central obesity, high WHR) may decrease the insulin sensitivity and cause insulin resistance with the increased risk of developing T2DM (Duncan *et al.*, 2018; Dimala *et al.*, 2016).

5.6. HIV/AIDS-related factors associated with T2DM among participants

The findings of the current study showed that 32.5% of the participants had known their HIV infection status for less than 5 years; 33.5% of the participants had known their HIV infection status for 5.01-10 years and 23.6% had known their HIV infection status for 10.01-15 years. Moreover, a small number of participants (10.6%) had known their HIV infection status for more than 15 years (6.8% for 15.01-20 years and 3.8% for 20.01 years and more). Overall, the participants were aware of their HIV infection status for an average of 8.2 years. The findings also showed that all participants 292 (100%) were on ARVs. These results may explain the effectiveness of voluntary counselling and testing services implemented by the Government of Rwanda which has increased the number of people who became aware of their HIV infection status. Moreover, the "TREAT ALL" HIV+ policy in Rwanda has increased the access to ARVs for HIV infected individuals (Rwanda Biomedical Centre, 2016).

Our findings showed that T2DM was more prevalent among those who had HIV infection for more than 10 years compared to those with less than 10 years of HIV infection (10.6% vs 1.9%) and the prevalence was greater for those who were on the ARVs for more than 10 years compared to those who were on ARVs for less than 10 years (11.8% vs 2.2%). Even though the association was not statistically significant in the multivariate analysis, the bivariate analysis revealed that the duration of HIV infection and the duration of taking ARVs were associated with T2DM risk among the participants.

Our study findings are in line with the results reported by Mohammed *et al.* (2015) in Southwest Ethiopia where T2DM was associated with long duration of HIV infection and long duration of being on ARVs. These authors found that T2DM was significantly more prevalent in participants with more than 5 years of HIV infection and more than 5 years on ARVs (Mohammed *et al.*, 2015). Nevertheless, Mohammed *et al.* (2015) found that about 72.3% were on ARVs while 51.9% knew of their HIV infection for more than 5 years. In Ethiopia, about 57.6% were on ARVs (Federal Ministry of Health, 2017) while 79% of PLWHA who knew their HIV infection in 2017 were on ARVs in Rwanda (UNAIDS, 2018b). Other studies further supported the association of T2DM with duration of HIV infection (Duncan *et al.*, 2018; Hernandez-Romieu *et al.*, 2017) and the duration of being on ARVs (Lin *et al.*, 2018; Duncan *et al.*, 2018; Isa *et al.*, 2016; Mohammed *et al.*, 2015; Kagaruki *et al.*, 2014).

Our study findings suggest an increased risk of developing T2DM for individuals with a long-standing HIV infection and for those taking ARVs for a long period. The duration of HIV infection and ARVs are implicated in the pathogenesis of T2DM in PLWHA due to the inflammatory process that results from long-term HIV infection and ARVs (Han *et al.*, 2019; Rogalska-Płońska *et al.*, 2018).

Previous studies have found that HIV infection is associated with a persistent disturbed inflammatory response and immune dysfunction giving rise to insulin resistance and subsequent metabolic diseases including T2DM (Han *et al*., 2019; Rogalska-Płońska *et al.,* 2018). Furthermore, ARVs are associated with an increased BMI and waist circumference in PLWHA which increase with the duration of ARVs use (Dimala *et al.,* 2016). BMI increases because of the redistribution of body fat/visceral fat accumulation and body shape changes that occurs after starting ARV therapy (Duncan *et al.*,2018; Dimala *et al.,* 2016). This leads to the development of T2DM through a mechanism involving insulin resistance (Dimala *et al.*,2016).

Prioreschi *et al.* (2017) found that the duration of HIV infection and the duration of being on ARVs were not associated with T2DM in PLWHA. Importantly, the methods used in different studies are different. The research by Prioreschi and colleagues had a high heterogeneity. Although the possible association between duration of HIV infection, duration on ARVs and T2DM among PLWHA was not statistically significant, Prioreschi *et al.* (2017) found that the relative risk of developing T2DM was higher among those treated with ARVs compared to those without ARVs.

Previous studies showed that ARV therapy drugs are associated with the development of T2DM in PLWHA (Han *et al.,* 2019; Njuguna *et al.,* 2018; Lin *et al.,* 2018). Certain ARV drugs are associated with lipodystrophy and others can inhibit the glucose transporter isoform 4 (GLUT4), which leads to insulin resistance (Han *et al*., 2019; Lin *et al*., 2018). The waist, waist-to-hip ratio and weight increase after ARVs initiation; such changes are associated with body fat accumulation leading to increased circulating cytokines levels with subsequent T2DM through insulin resistance mechanism in PLWHA (Abrahams, Dave, Maartens & Levitt, 2015). Zidovudine and Stavudine for instance are often implicated in the development of T2DM in PLWHA (Han *et al*., 2019; Njuguna *et al.,* 2018; Dimala *et al.,* 2016).

Bivariate analysis in our study found a statistically significant association between types of ARVs and T2DM in PLWHA. Other studies in different areas have also found an association between ARVs drug types and T2DM among PLWHA. Capeau *et al.* (2012) in France found that indinavir, Stavudine, and Zidovudine were associated with a risk of developing T2DM among HIV infected people while Rasmussen *et al.* (2012) who studied Danish PLWHA found that Indinavir, Saquinavir, Stavudine, and Didanosine were associated with a risk in developing T2DM.

Our findings showed that 56.8% were on TDF/3TC+EFV while 22.6% were on TDF/3TC+NVP. Moreover, 13.3% of PLWHA on ABC/3TC+EFV were diabetic, 4.2% on TDF/3TC+EFV were diabetic and 12.1% on TDF/3TC+NVP were diabetic. ARV drugs inhibit insulin-stimulated glucose disposal blocking glucose uptake through the inhibition of glucose transporter isoform 4 (GLUC4) (Flint *et al.*, 2009). The inhibition of the GLUC4 then leads to a decreased muscle uptake of glucose resulting in increased hypertriglyceridemia with subsequent insulin resistance and T2DM (Flint *et al.*, 2009).

In Rwanda, many changes have occurred in regard to the ARV drug regimens. This study was not able to establish the trends of drugs the participants were exposed to, thus it was not possible to determine which drug might be associated with T2DM.We found a high prevalence of T2DM risk among people taking ABC/3TC+ EFV compared to those taking TDF/3TC+EFV, suggesting a possible association between nucleoside reverse transcriptase inhibitors and T2DM among HIV infected individuals (Lin *et al*., 2018; Ledergerber *et al*., 2007). Despite the lack of association between types of ARVs and T2DM in PLWH in the multivariate analysis, these factors may still compound other factors to increase the risk of developing T2DM.

The findings of this research are inconsistent with those of Mohammed *et al*. (2015) who found that 10.3% of PLWHA on AZT/3TC/NVP were diabetic, 7.3% on TDF/3TC/NVP were diabetic, 7.1% on TDF/3TC/EFV were diabetic, and 6.9% of PLWHA on AZT/3TC/EFV were diabetic. Our findings are also incongruent with the results of Isa *et al.*,(2016) who found that 45.9% of the participants were on 3TC/ZDV+NVP, 31.4% were on 3TC or FTC/TDF+EFV, 11.6% were on 3TC+NVP+DTF, 2.1% were on 3TC+ZDV+EFV and 2.5% were on ATV/RTV-based PI. These different findings may be explained by the variations in the implementation of HIV/AIDS treatments and the care guidelines used in different countries (Rwanda Ministry of Health, 2016; Nigeria Federal Ministry of Health, 2014). Nevertheless, these studies found an association between types of ARVs and T2DM among PLWHA. The results thus appear to support the conclusions that PLWHA have a risk in developing T2DM.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The aim of the study was to determine the factors associated with T2DM in people living with HIV and AIDS (PLWHA) attending Primary Health Care Centres (PHCs) in Rwamagana district, Rwanda.

The objectives of the study were: (1) To determine the prevalence of T2DM risk in PLWHA attending primary health care centres in Rwamagana district; (2) To determine the sociodemographic factors associated with T2DM of PLWHA attending PHCs in the Rwamagana district; (3) To determine anthropometric factors associated with T2DM in PLWHA attending PHCs in the Rwamagana district; (4) To determine lifestyle factors associated with T2DM in PLWHA attending PHCs in the Rwamagana district and (5) to determine the HIV and AIDS-related factors associated with T2DM in PLWHA attending PHCs in Rwamagana district.

A total of 292 participants (92.7%), comprised of 200 (68.5%) females and 92 (32.5%) males completed the questionnaire. Most of the participants, 108 (37%), were between 36 and 45 years of age and 77 (26.4%) were between 26 and 35 years of age; the mean age was 40 years. In this study, 17 (5.8%) of the PLWHA attending primary healthcare centres in Rwamagana district, Rwanda had T2DM risk. In the bivariate analysis, age was the only sociodemographic factor associated with T2DM in PLWHA ($\chi 2=15.536$; df =4; p= 0.014) and none of the lifestyle factors that were investigated (e.g. smoking, alcohol use and physical activity) were associated with T2DM in this group.

In addition, none of the anthropometric factors were associated with T2DM. Duration of HIV infection was however found to be associated with T2DM. A high prevalence of T2DM risk was found among the participants who had known their HIV infection status for 10 years and more (10.6%) compared to those with less than 10 years of HIV infection (1.9%); $\chi 2=10.056$; df=1; $p<0.001$). The duration on ARVs was also associated with T2DM. A high prevalence of T2DM risk was found among the participants who had been on ARVs for 10 years and longer (11.8%) compared to those who had been on ARVs for less than 10 years (2.2%); $\chi^2=11.573$; df=1; $p<0.001$.

The findings also showed that the type of ARVs being used was associated with T2DM A high prevalence of T2DM risk was found among those taking TDF+3TC+NVP (12.1%) compared to those taking TDF+3TC+EFV (4.2%) and others; ($\chi^2=9.882$; df=4; p=0.042). Nevertheless, the multivariate analysis revealed that none of the sociodemographic, anthropometric, lifestyle or HIV/AIDS-related factors were associated with T2DM.

6.2. Recommendations and limitations

In light of the results of this study, the following recommendations are made:

6.2.1. Recommendations regarding the Ministry of Health

- Integrate screening and management of T2DM in HIV and AIDS programmes; prevalence of non-communicable diseases is common among HIV infected people; thus, there is a need to integrate screening and treatment of NCDs using standard guidelines in HIV care and treatment programmes (Kansiime, Mwesigire & Mugerwa, 2019; Achwoka *et al*., 2019; Khutsoane, 2017; Kalra *et al*.,2011). In the absence of systematic screening, NCD burden is likely underestimated in the PLWHA population (Achwoka et al.,2019). Integrating screening and treatment of NCDs in HIV services enhances screening uptake and care for HIV infected people, and patient care outcome for PLWHA (Njuguna *et al.,* 2018; Lamptey, Dirks, Torpey, & Mastro, 2016).

- Develop guidelines for T2DM diagnosis, with specific cut-off points for every diagnostic tool, including fasting capillary blood measurements to make the process affordable and cost-effective in the primary health care centres. The diagnostic procedure should be simple, economically affordable and evidence-based (Balaji, Madhuri, Paneerselvam, Arthi & Seshiah,2012). Fasting Capillary blood measurement is affordable and requires less skilled professional to perform the test (Ignell &Berntorp, 2011). Capillary Blood Glucose value which is equivalent to WHO criteria for diabetes diagnosis may be recommended for diabetes diagnosis in healthcare centres of developing countries where laboratory technology is not available (Balaji *et al.*,2012; Miranda *et al*.,2011).

6.2.2. Recommendations regarding intervention programmes

- Implement health education programmes for PLWHA with diabetes prevention measures, including risk factors for clients who attend HIV and AIDS programmes. People Living with HIVAIDS in Sub-Saharan African Countries have low knowledge on T2DM risk factors and their associated complications (Kagaruki *et al.*,2018), and there is a need to improve awareness of T2DM, risk factors, prevention strategies and complications (Kagaruki *et al.*,2018). Evidence has shown that advice on physical activity reduces the risk of developing T2DM among PLWHA (Duncan, Peters, Rivas & Goff, 2019).

6.2.3. Recommendations for people living with HIV and AIDS in Rwamagana district

- Uptake regular screening practices for T2DM at the existing non-communicable disease clinics in the health centres. It is important for routine diabetes screening among HIV infected people (Han et al.,2019), as improving screening services in primary health care practices increases early detection of diabetes (Spigt et al.,2009) and non-communicable disease clinics can help in detecting undiagnosed diabetes among PLWHA (Jerene et al.,2017). Regular screening for diabetes helps the individual to take measures for prevention if he/she is identified to be at high risk and prevent complications and management when early diagnosed with diabetes (Ephraim et al., 2019; US Department of Health and Human Services, 2004).

- Adopt healthy lifestyles including physical exercise, non-smoking and non-alcohol consumption habits. Evidence has shown that adopting healthy lifestyles such as physical activity decreases the risk of developing diabetes among PLWHA (Duncan et al., 2019) and lifestyle modification strategies for smoking cessation and increased physical activity among PLWHA are cornerstone for prevention CVD risk factors such as diabetes (Quin, 2014; Stein et al.,2008).

6.2.4. Recommendations for future research opportunities

- Studies need to be undertaken with a case-control study design to determine the association of HIV/AIDS with T2DM in HIV infected people in the Rwamagana district or a prospective study design should be used to determine the incidence of T2DM in PLWHA; a cross-sectional study design that was used in this study cannot determine causal relationship (cause-effect) between exposure and outcomes (Sedguick,2014), HIV and T2DM in this study, therefore, we cannot ascertain which comes first between HIV and T2DM. In prospective study design, an outcome of interest or disease-free population is first identified by the exposure (HIV infected people) and followed in time until outcome of interest occurs (T2DM) and this study design has capability to provide scientific strongest evidence and determine relationship in terms of causality (Song & Chung, 2010), HIV and T2DM in this study. Since diabetes may take long time to develop, case control study design is also recommended as it has potential to identify whether outcome (T2DM) was associated with HIV (Exposure) (Song & Chung, 2010).

- It is recommended to conduct other studies using screening and diagnostic tests for diabetes such as the oral glucose tolerance test (OGTT) and fasting plasma glucose (American Diabetes Association, 2019; WHO, 2003).

6.3. Limitations of the study

The study used a cross-sectional design; therefore, the researcher was unable to determine the cause-effect of the HIV infection and ARVs in the development of T2DM. This design has limited the ability of the study to determine whether or not HIV infection or ARVs caused T2DM in PLWHA. In Rwanda, various changes have occurred in ARVs and we could not track the exposure trends of participants on different types of ARVs; we were limited to only the current ARV drugs. Furthermore, lipid profiles may also be associated with diabetes mellitus risk, but, due to financial challenges, we were unable to measure lipid profiles.

In addition, a glycohemoglobin (HbA1c) test would have helped in our attempt to measure average blood glucose levels over a given period among PLWHA, but this was not possible due to financial constraints. Dietary habits were also not explored since they were beyond the scope of this study. We used capillary fasting blood glucose instead of the WHO's recommendations; capillary fasting blood glucose may have overestimated the prevalence of T2DM risk in PLWHA. In any case, we used the cut-off point of 6.51mmol/L in this study which was found to predict T2DM prevalence in the same manner as the WHO recommendations. Finally, the results of this study cannot be generalized to the whole country as the sample was limited to one district.

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APPENDICES

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Appendix 1: Participant information sheet

Dear participant,

Thank you for your willingness to participate in this study.

Project Title: Factors Associated with T2DM in people living with HIV/ AIDS (PLWHA) attending Primary Health Care Centres in Rwamagana District, Rwanda

This is a research project being conducted by **Innocent NDATEBA** at the University of the Western Cape as requirement of master's degree in Public Health. We are inviting you to participate in this research project because the research is being conducted among people living with HIV and AIDS.

The aim of this research project: The aim of this study is to determine factors associated with T2DM in People Living with HIV and AIDS (PLWHA) attending Primary Health Care centres in Rwamagana district, Rwanda. In addition, the lifestyle factors (smoking, physical exercise and alcohol consumption) and HIV/AIDS associated factors (CD4 count, ARVs, etc.) for T2DM in People Living with HIV and AIDS (PLWHA), attending Primary Health Care Centres in the Rwamagana District, Rwanda will be determined. The results of this study will help health professionals to integrate DM care into HIV and AIDS programmes at primary health care level. Thus, early detection and diagnosis of T2DM among PLWHA will improve DM care and therefore the quality of life of people living with HIV and AIDS.

Description of study procedure and your participation

You will be asked to answer questions on socio-demographic, your HIV and AIDS history and some measurements such as weight, height, waist and hip circumferences will be taken by the nurse who will be assisting in data collections. The study will be conducted at health centres in private room and a drop of blood sample will be drawn to measure your blood glucose level. You will be requested to fast for at least 8 hours before the blood sample is taken. Also, you will be requested to fast for the second measurement of blood glucose level for confirmation of your glucose blood level. The overall participation will take about 10 minutes.

Confidentiality

The confidentiality is guaranteed. Your names will be kept confidential. The data will be locked in computer using codes. The codes will be used in database of software data analysis instead of using names. While writing report, your names will not appear anywhere. After completion of the research, the data will be destroyed after five years. None will access the participants 'information except researcher and supervisor. The research assistants will be required to sign confidentiality agreement.

Voluntary participation

The participation in this study is totally voluntary. In case, you feel uncomfortable, you are allowed to withdraw without fearing any negative consequences. You may also choose not to answer some questions in this study.

Risks for participation in this study

The participation in this study brings some risks. As you will be asked to fast, you will delay taking drinks or food which will cause feeling of hungry. Furthermore, you will feel pain while taking blood sample using needle. A new sterile needle will be used to avoid infection. Moreover, you may develop psychological emotions or affects when you get diagnosed with diabetes mellitus. There is a counselor who is prepared and ready to provide psychological and emotional support when you feel discomfort due to new diagnosis of chronic diseases. The counselling will be conducted in privately in counselor 's office. There is a counsellor in health centre who is ready to provide psychological and emotional support. Additionally, answering questions and time for

taking other measurement may lead to the fatigue. The researcher or research assistant has secured a safe place where you will meet with him/her after capillary blood glucose level test. Finally, you may experience discomfort and embarrassment during anthropometric measurements, there is a private room where these measurements can be performed for your intimacy and privacy. Finally, when the results indicate that you have diabetes, you will be referred to health facility for appropriate care.

Benefits for participation in this study

Although there are no direct benefits for participating in this study, your participation will help us to determine the presence of diabetes mellitus among people living with HIV and AIDS and results will be used to develop and implement appropriate interventions for prevention and control of diabetes mellitus among PLWHA, thus improving their health status and quality of life. Furthermore, it will help you to recognize your health status in regard to diabetes and you will take necessary measures to remain negative or will be referred to health care facility for early management in case you positively diagnosed diabetes mellitus and prevent further complications.

Informed consent

You will be requested to sign a consent form if you agree to participate in this study before research assistant or researcher starts data collection.

Questions

The research is being conducted by Innocent NDATEBA at School of Public Health, University of Western Cape. If you have any questions please feel free to contact the researcher on the following address:

Innocent NDATEBA

Mob: 0788520514

E-mail: ndateba2@gmail.com

Should you have any questions regarding this study and your rights as a research participant or if you wish to report any problems you have experienced related to the study, please feel free to contact my supervisors on the following address:

Dr. Nasheetah Solomons

Email: nsolomons@uwc.ac.za

Or

Dr. Ernesta Kunneke

Email: ekunneke@uwc.ac.za

School of Public Health

University of Western Cape

Also, you may contact the biomedical research ethics committee office on the following address:

Biomedical Research Ethics Committee Office

University of the Western Cape

Private Bag x17

Bellville

7535

Tel: +27 959 2988

Email: research-ethics@uwc.ac.za

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Tel: +250788520514

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Appendix 2: Informed consent

Title of Research Project: ***Factors associated with T2DM in People Living with HIV/AIDS attending Primary Health Care Centres in Rwamagana District, Rwanda***

The study has been described to me in language that I understand. My questions about the study have been answered. I understand what my participation will involve and I agree to participate of my own choice and free will. I understand that my identity will not be disclosed to anyone. I understand that I may withdraw from the study at any time without giving a reason and without fear of negative consequences or loss of benefits.

Participant's name……..

Participant's signature…….

Date……

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APPENDIX 3: CONFIDENTIALITY BINDING FORM/AGREEMENT

Title of Research Project: ***Factors associated with T2DM in People Living with HIV/AIDS attending Primary Health Care Centres in Rwamagana District, Rwanda***

The study has been described to me in language that I understand. My questions about the study have been answered. I understand what my participation will involve and I agree to participate of my own choice and free will. I understand that my identity will not be disclosed to anyone by the researchers. I understand that I may withdraw from the study at any time without giving a reason and without fear of negative consequences or loss of benefits. I understand that confidentiality is dependent on participants in confidentiality.

I hereby agree to uphold the confidentiality of the discussions by not disclosing the identity of participants or any aspects of their contributions to members or others outside of the group.

Participant's name……..

Participant's signature……..

Date……

Appendix 4: Data collection instrument

Dear participant,

Thank you for your willingness to participate in this study. You are required to answer some questions while other items will be measured by the researcher or assistant researcher. Please, tick (√**)** in the box which describes your characteristics.

Variable Nº	**Variable names**	**Characteristics**	**Tick (√) where appropriate**
1. Socio-demographic information			
V001	Gender	**1.** Male	
		2. Female	
V002	Marital status	**1)** Single	
		2) Married	
		3) Divorced/Separated	
		4) Widow /Widower	
V003	What is your highest level of education?	1) Not attended school	
		2) Primary education	
		3) Secondary education	
		4) University education	
V004	Where do you live?	1. Rural areas	
		2. Urban areas	
V005	In average, how much money do you earn per month?		

V006	Employment status	1. Government/non-government organization	
		2. Self-employed	
		3. Unemployed	
		4. Retired	
V007	Which is your socioeconomic (Ubudehe) category?	1. Category 1	
		2. Category 2	
		3. Category 3	
		4. Category 4	
V008	Age in years		
V009	Do you have diabetes?	1. Yes	
		2. No	
		3. I do not know	
V010	Do you have a family member suffering from diabetes?	**1.** Yes	
		2. No	
		3. I do not know	
2.Anthropometric measurement information			
V011	Height in cm		
	Weight in kg		
	BMI		
V012	Fasting Blood glucose level (mg/dl)	1st reading:	
		2nd reading:	
		Average	

V013	Hip circumference (cm)		
	Waist circumference (cm)		
	Waist-hip ratio (WHR)		
3. **Lifestyles information**			
V014	Have you ever smoked tobacco products e.g. cigar, cigarettes, pipes, chews, etc?	1. Yes	
		2. No	
V015	Do you currently smoke tobacco product e.g. cigars, cigarettes, pipes, chews, etc?	1. Yes	
		2. No	
V016	How many tobacco cigarettes, pipes do you smoke per day?		
V017	How many years did you smoke?		
V018	Do you currently drink alcohol?	1. Yes	
		2. No	
V019	Have you ever drunk a drink containing alcohol?	1. Yes	
		2. No	
V020	How many days do you drink alcohol per week?	1. Every day	
		2. Very often (4-6 days)	
		3. Sometimes (1-3 days)	
		4. Never (0 day)	

V021 **P1**	Does your work involve vigorous-intensity activities that cause large increases in breathing or heart rate like carrying, lifting heavy loads, digging or construction work for at least 10 minutes continuously?	1. Yes	
		2. No	
V022 **P2**	In your work, how many days do you do vigorous intensity activities?		
V023 **P3**	How much times do you spend doing vigorous intensity activities in a day	Hours:	
		Minutes:	
V024 **P4**	Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate like walking, carrying/ lifting light loads for at least 10 minutes continuously?		
V025 **P5**	In your work, how many days do you do moderate intensity activities?		
V026 **P6**	How much time do you spend doing moderate-intensity activities in a day	Hours:	
		Minutes:	
V027 **P7**	Do you walk or use a bicycle (pedal) for at least 10 minutes continuously to get to and from places?	1. Yes	
		2. No	

V028 **P8**	How many days do you walk or use a bicycle for at least 10 minutes continuously to get to and from paces?		
V029 **P9**	How much time do you spend walking or bicycling for travel on a typical day?	Hours:	
		Minutes:	
V030 **P10**	Do you do any vigorous-intensity sports, fitness or recreational (leisure) activities that cause large increases in breathing or heart rate like (running or football) for at least 10 minutes continuously?	1. Yes	
		2. No	
V031 **P11**	How many days do you vigorous-intensity sports, fitness or recreational (leisure) activities that cause large increases in breathing or heart rate like (running or football) for at least 10 minutes continuously?		
V032 **P12**	How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?	Hours:	
		Minutes:	

V033 **P13**	Do you do any moderate-intensity sports, fitness or recreational (leisure) activities that cause a small breathing or heart rate such cycling, swimming, volleyball for at least 10 minutes continuously?	1. Yes	
		2. No	
V034 **P14**	In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (leisure) activities that cause a small breathing or heart rate such cycling, swimming, volleyball for at least 10 minutes continuously?		
V035 **P15**	How much time do you spend doing moderate-intensity sports, fitness or recreational activities on a typical day?	Hours:	
		minutes:	
V036 **P16**	How much time do you usually spend sitting or reclining on a typical day like sitting with friends, traveling in a car or bus, reading, playing cards, watching television, using computer, going handcraft, resting?		
4.HIV/AIDS and ARVs related information			
V037 count	CD4		

V038	How long have you recognized that you have HIV infection? (in years)		
V039	WHO HIV clinical stage	1. Stage I	
		2. Stage II	
		3. Stage III	
		4. Stage IV	
V040	Do you take ARVs?	1. Yes	
		2. No	
V041	How long have you used ARVs? (in years)		
V042	What types of ARVs do you take?		

Thank you very much for participating in this study!!!

IMIGERAKA MU KINYARWANDA

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APPENDIX 5 : UMUGEREKA WA 5

Ubusobanuro bw'ubushakashatsi

Muvandimwe,

Mbashimiye ko mwemeye kugira urahere muri ubu bushakashatsi.

Izina ry'ubushakashatsi:

Ubu bushakashatsi buri gukorwa na **Innocent NDATEBA** wiga muri Kaminuza ya Western Cape kugira ngo arangize icyiciro ya gatatu cya Kaminuza mu buzima rusange. Tukaba tubatumiye kugira uruhare muri ubu bushakashatsi buri gukorwa kubantu babana n'ubwandu bwa gakoko gatera SIDA.

Intego y'umushinga w'ubushakashatsi: Uyu mushinga w'ubushakashatsi ufite intego yo kugarakaza uko indwara y'igisukari ihagaze mubantu babana n'ubwandu bw'agakoko gatera SIDA no kureba ibituma ibaho mu bigo ndera buzima byo mu Akarere ka Rwamagana. Uruhare rwanyu muri ubu bushakashatsi bizatuma tumenye iko indwaya y'igisukari ingana n'ibituma ibaho, noneho ibyavuyemo bizifashishwa n'inzego z'ubuzima mu kuvura neza abantu babana n'ubwandu ba'agakoko Gatera SIDA bityo barusheho kugira ubuzima bwiza.

Uko ubu bushakashatsi buzakowa n'uko mwabugiramo uruhare

Murasabwa gusubiza ibibazo bimwe bijyanye biberekeyeho ndetse n'ibindi bibazo bijyanye n'amakuru arebana n'ubwandu bw'agakoko gatera SIDA. Ibindi bizakorwa n'umushakashatsi cyangwa se umuhagarariye. Ibi byose bizajya bikorerwa mu cyumba cyabugenewe kuburyo nta wundi muntu umenya ibiri gukorwa usibye wowe n'umushakashatsi. Murasabwa kutagira icyo mufata cyaba ikinyobwa cyangwa ibiribwa nibura amasaha umunani kuva nijoro kugeza tumaze gufata amaraso mu gatoki.

Ibanga

Ibanga muri ubu bushakashatsi rirubahirizwa. Nta hantu nahamwe hazagaragara amazina yanyu, tuzakoresha gusha inyuguti zibanza ndetse n'ibimenyetso. Amakuru azinjizwa mu mashini azafungwa kuburyo nta wundi wayageraho keretse umushakashatsi wenyine cyangwa se mwarimu umukurikirana. Mugutangaza ibyavuye mubushakashatsi, nta mazina yanyu azagaragara kandi nyuma y'imyaka itanu (5) impapuro zose zakoreshejwe zitwakwa.

Ubushake

Kugira uruhare muri ubu bushakashatsi ni ubushake , kandi igihe mwakumva mugize ikibazo mwarekeraho gusubiza ibibazo nta nkurikizi mugize. Mushobora kandi guhitamo gusubiza ibibazo bimwe ibindi mukabyihorera nta kibazo byabatera.

Ingaruka

Kwemera kugira uruhare muri ubu bushakashatsi bifite ingaruka nke. Uzasabwa kudafata amafunguro kuva nijoro kugeza tumaze gupima amaraso bityo bishobora kubatera inzara cyangwa inyota muri icyo gihe cyose umara utegereje. Gupima amaraso ku gatoki bishobora kugutera ububabare n'ubwo budatinda. Kugira ngo twirinde utundi dukoko twatera indwara, tuzajya dukoresha agashinge gashyashya kuri buri muntu. Ikindi kandi ushobora kumva utameze neza igihe wamenya ko ufite indwara y'igisukari, hari umuvuzi wagufasha kugirango udahungabana.

Ntabwo twakwibagirwa umwanya wawe ufata usubiza ibibazo byabajijwe, bishobora kugutera umunaniro, umushakashatsi cyangwa umuhagarariye aragushakira aho waruhukira. Turamutse dusanze ufite indwara y'igisukari turagusaba ko wagaruka nyuma y'amasaha 24 ukongera

ukamara amasaha 8 ntacyo wafashe cy'amafunguro cyangwa cyo kunywa tukongera tukareba ko isukari yo mumaraso iri hejuru noneho tukaguha urwandiko rukujyana ku ivuriro kugirango bakuvure neza.

Inyungu zo kugira uruhare muri ubu bushakashatsi

Nubwo nta nyungu zihita zigaragara mu kugira uruhare muri ubu bushakashatsi , kwemwe kujyamo bifite inyungu nyinshi nziza kuko bizadufasha kugaragza uko indwara y'igisukari ingana ndetse n'ibindi bituma bigira uruhare kugira ngo ibeho mubantu babana n'ubwandu bw'agakoko gatera SIDA , noneho ibizavamo bizifashishwa mu gushyiraho ingamba n'uburyo buboneye bwo kuvura abantu babana n'ubwandu bw'agakoko gatera SIDA, bityo bitumen bashobora gukomeza gukira ubuzima bwiza. Ikindi kwipimisha biratuma umenya uko uhagaze kubirebana n'indwara y'igisukari , ufate ingamba zo gukomeza kwirinda. Niba kandi dusanze ufite iyo ndwara, turakohereza kwa muganga hakiri kare wivuze bitumen wirinda ingaruka zikomeye z'ubwo burwayi.

Kwemera kugira uruhare mubushakashatsi k'ubushake

Igihe mwaba mwemeye kugira uruhare muri ubu bushakashatsi, burasabwa gusinya urupapuro rwerekana ko mwabyemeye kubushake kandi mwasobanuriwe mbere yo y'uko umushakashatsi cyangwa se umuhagarariye atangira gufata amakuru.

Ibibazo

Ubu bushakashatsi buri gukorwa na Innocent NDATEBA wo mu ishuri ry'ubuzima rusange muri Kaminuza ya Western Cape. Uramutse ufite ikibazo ntugire impungenge zo kumubaza kuri aha hakurikira:

Innocent NDATEBA

Mob: 0788520514

E-mail: ndateba2@gmail.com

Ufite ikibazo kijyanye nubu bushakashatsi cyangwa se uburenganzira bwawe nkuwabugizemo uruhare cyangwa se ushaka kugaragaza ikibazo wahuye nacyo muri ubu bushakashatsi, ntutinye kubaza abarimu banjye bankurikirana muri ubu bushakashatse kuri aha hakurikira:

Dr.Nasheetah Solomons

Email: nsolomons@uwc.ac.za

cyangwa se

Dr. Ernesta Kunneke

Email: ekunneke@uwc.ac.za

School of Public Health

University of Western Cape

Mushobora kandi kubaza ibiro bishinzwe imyitwarire y'ubushakashatsi mu byubuzima kuri aha hakurikira:

Biomedical Research Ethics Committee Office

University of the Western Cape

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7535

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APPENDIX 6: Umugereka wa 2: KUGIRA URUHARE MU BUSHAKASHATSI K'UBUSHAKE

Title of Research Project: ***Factors associated with T2DM in People Living with HIV/AIDS attending Primary Health Care Centres in Rwamagana District, Rwanda***

Ubu bushakashatsi bwansobanuriwe neza mu rurimi numva . Ibibazo byanjye birebana nubushakashatsi nabisubijwe. Ndumva neza icyo bisaba kugira uruhare muri ubu bushakashatsi kandi nemeye kubushake bwanjye ntawe umpase kugira uruhare muri ubu bushakashatsi. Ndumva neza ko ntawe uzavuga ibinyerekeyeho byose kundi muntu uwariwe wese. Nzi ko nshobora kuva muri ubu bushakashatsi igihe icyo aricyocyose ntangaruka bingizeho , ntanubwoba mfite ko hari icyo nabura kandi ntatanze ibisobanuro.

Amazina……..

Umukono…….

Italiki……

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APPENDIX 7: Umugereka wa 3: Kwemeranya kugira ibanga

Title of Research Project: ***Factors associated with T2DM in People Living with HIV/AIDS attending Primary Health Care Centres in Rwamagana District, Rwanda***

Ubu bushakashatsi bwansobanuriwe neza mu rurimi numva . Ibibazo byanjye birebana nubushakashatsi nabisubijwe. Ndumva neza icyo bisaba kugira uruhare muri ubu bushakashatsi kandi nemeye kubushake bwanjye ntawe umpase kugira uruhare muri ubu bushakashatsi. Ndumva neza ko ntawe uzavuga ibinyerekeyeho byose kundi muntu uwariwe wese. Nzi ko nshobora kuva muri ubu bushakashatsi igihe icyo aricyocyose ntangaruka bingizeho , ntanubwoba mfite ko hari icyo nabura kandi ntatanze ibisobanuro.

Ndumva neza ko kugira ibanga ari ingenzi ndetse ko ntagomva no gutangaza ibyerekeye kubo twahuriye muri ubu bushakashatsi. Nemeye kugira ibanga kubirebana nibyo namenye kubandi muri ubu bushakashatsi kandi ntabwo ngomba kugira uwo mbwira kubirebana n'abandi twahuriye muri ubu bushakashatsi cyangwa se uruhare rwabo muri ubu bushakashatsi kubandi batari bari muri ubu bushakashatsi.

Amazina……..

Umukono……..

Italiki……

APPENDIX 8: UMUGEREKA WA 4: Igikoresho cyo gukusanya amakuru y'ubushakashatsi

Muvandimwe,

Mbashimiye ko mwemeye gufata umwanya wanyu mukagira uruhare muri ubu bushakashatsi. Murasabwa gusubiza ibibazo bimwe bigaragara kuri izi mpapuro, ibindi birafatwa n'umushakashatsi cyangwa se umuhagarariye. Murahitamo kimwe muri ibi bisubizo cyabgwa se mwandike igisubizo kijyanye n'ikibazo mwabajijwe. Mushyire akamenyetso imbere y'igisubizo nyacyo **(√).** Murakoze cyane!

Variable Nº	**Variable names**	**Characteristics**	**Shyira akamenyetso ku gisubizo gikwiye (√)**
1. Irangamimerere/ Socio-demographic information			
V001	Igitsina	1. Gabo	
		2. Gore	
V002	Irangamimerere ryawe ni irihe?	1. Ingaragu	
		2. Narashatse	
		3. Natandukanye n'uwo twashakanye/ntabwo mbana n'uwo twashakanye	
		4. Uwo twashakanye yitabye Imana	
V003	Ni ayahe mashuri asumba andi wize?	1. Ntabwo nigeze niga	
		2. Amashuri abanza	
		3. Amashuri yisumbuye	

		4. Amashuri makuru	
V004	Utuye he?	1. Mu cyaro	
		2. Mu mujyi	
V005	Muri rusange, mwinjiza amafaranga angahe ku kwezi?		
V006	Ni uwuhe murimo ukora	1. Umukozi wa Leta cyangwa cyangwa imiryango itegamiye kuri Leta	
		2. Ndikorera	
		3. Nta kazi ngira	
		4. Nagiye mukiruhuko cyizabukuru/pensiyo	
V007	Uri mukihe cyiciro cy'ubudehe?	1. Icyiciro cya mbere (1)	
		2. Icyiciro cya kabiri (2)	
		3. Icyiciro cya gatatu (3)	
		4. Icyiciro cya kane (4)	
V007	Haba hari umuganga wakubwuye ko urwaye indwara y'igisukari (diyabete)?	1. Yego	
		2. Oya	
		3. Ntabwo mbizi	
V008	Mufite imyaka ingahe?		
V009	Haba hari umuntu wo mumuryango wawe urwaye indwara y'igisukari (diyabetes)?	1. Yego	
		2. Oya	
		3. Ntabwo mbizi	
V010		1. Yego	

	Hari umuntu wo mu muryango wawe urwaye indwara y'igisukari (diyabetes)?	2. Oya	
		3. Ntabwo mbizi	
2.Umubyimba/ Anthropometric measurement information			
V011	Uburebure muri cm (Height)		
	Ibiro muri Kg (Weight)		
	BMI (uko umubyibuho ungana)		
V012	Uko isukari yo mumaraso ingana (Fasting Blood Glucose level) (mg/dl)	Igisubizo cya 1:	
		Igisubizo cya 2:	
		Impuzandengo	
V013	Uko amatako angana (cm) (Hip circumference		
	Uko munda hangana (cm) (Waist circumference)		
	Ikigereranyo cyo munda n'amatako Waist-Hip ratio		
3.Lifestyles information (amakuru ku myitwarire)			
V014	Waba warigeze unywa itabi cyangwa ibikomoka kw'itabi nk'isigara,itabi ryo munkono, ubugoro n'ibindi?.	1. Yego	
		2. Oya	
V015		1. Yego	

	Ubu waba unywa itabi cyangwa ibikomoka kw'itabi nk'isigara, isigareti, itabi ryo munkono, ubugoro n'ibindi?	2. Oya	
V016	Unywa amatabi angahe kumunsi?		
V017	Ugereranyije wanyoye itabi imyaka ingahe?		
V018	Ubu waba unywa inzoga cyangwa ikinyobwa gisindisha nk'icupa cyangwa ikirahure cya byeri, urwagwa,divayi wisiki cyangwa indi nzoga iyariyo yose?	1. Yego	
		2. Oya	
V019	Waba warigeze unywa inzoga cyangwa ikinyobwa gisindisha nk'icupa cyangwa ikirahure cya byeri, urwagwa,divayi wisiki cyangwa indi nzoga iyariyo yose?	1. Yego	
		2. Oya	
V020	Ugereranyije, waba unywa inzoga cyangwa ikindi kinyobwa gisindisha iminsi ingahe mu cyumweru?	1. Buri munsi	
		2. Inshuro nyinshi (hagati y'iminsi 4 kugera kuri 6 mu cyumweru	
		3. Rimwe na rimwe (iminis hagati y'umwe kugera kuri 3 mu cyumwer)	
		4. Nta narimwe (0)	

V021 **P1**	Ese akazi ukora kagusaba imbaraga nyinshi zituma uhumeka cyane kandi bigatuma umutima wawe utera cyane nko guterura ibintu biremereye, kutwara ibintu biremereye, guhinga cyangwa gucukura mugihe cy'iminota 10 yukurikiranya cyangwa irenga ?	1. Yego	
		2. Oya	
V022 **P2**	Mukazi kawe ukora buri munsi, ni iminsi ingahe mu cyumweru ukora akazi kagusaba imbaraga nyinshi nko guhinga, gucukura, gutwara cyangwa se guterura ibintu biremereye?		
V023 **P3**	Umara amasaha angahe ukora akazi kagusaba imbaraga ku munsi? (Nko gguhinga cyangwa gucukra, kuterura cyangwa gutwara ibintu biremereye)	Amasaha:	
		iminota:	

V024 **P4**	Ese akazi ukora kagusaba imbaraga ziri murugero zongera uguhumeka biri murugero kandi bigatuma umutima wawe utera buri murugero nko guterura cyangwa gutwara ibintu byoroheje, kugenda n'amaguru mugihe nibura cy'iminota 10 yukurikiranya cyangwa irenga ?	1. Yego	
		2. Oya	
V025 **P5**	Mukazi kawe ukora buri munsi, ni iminsi ingahe mu cyumweru ukora akazi kagusaba imbaraga ziri murugero nko gugendesha amaguru, guterura cyangwa gutwara ibintu byoroheje mugihe cy'imonota icumi cyangwa irenga?		
V026 **P6**	Kumunsi, ukoresha igihe kingana iki ukora akazi kagusaba imbaraga ziri mu rugero	Amasaha :	
		iminota:	
V027 **P7**	Ujya ugenda n'amaguru cyangwa utwara igare nibura iminota icumi cyangwa irenga iyo ugize aho ujya?	1. Yego	
		2. Oya	
V028 **P8**	Ni iminsi ingahe ugenda n'igare cyangwa n'amaguru ujya cyangwa uva ahantu hatandukanye?		
V029		Amasaha:	

P9	Nko kumunsi,waba ukoresha igihe kingana gute ugenda n'amaguru cyangwa utwaye igare iyo ugize aho ujya?	iminota:	
V030 **P10**	Waba ukora imyitozo ngororamubiri nibura iminota icumi yikurikiranya bituma habaho guhumeka cyane cyangwa umutima utera cyane nko kwiruka cyangwa gutera umupira w'amaguru?	1. Yego	
		2. Oya	
V031 **P11**	Ni iminsi ingahe mu cyumweru ukora imyitozo ngororamubiri nibura iminota icumi yikurikiranya bituma habaho guhumeka cyane cyangwa umutima utera cyane nko kwiruka cyangwa gutera umupira w'amaguru?		
V032 **P12**	Ni igihe kingana gute ku munsi ukora imyitozo ngororamubiri nibura iminota icumi yikurikiranya bituma habaho guhumeka cyane cyangwa umutima utera cyane nko kwiruka cyangwa gutera umupira w'amaguru?	Amasaha:	
		iminota:	
V033 **P13**	Waba ukora imyitozo ngororamubiri yoroheje nibura iminota icumi yikurikiranya bituma habaho guhumeka byoroheje cyangwa umutima utera byoroheje nko koga,gukina umupira w'amaboko cyangwa kwiruka byoroheje	1. yego	
		2. Oya	

V034 **P14**	Ni iminsi ingahe mu cyumweru waba ukora imyitozo ngororamubiri yoroheje nibura iminota icumi yikurikiranya bituma habaho guhumeka byoroheje cyangwa umutima utera byoroheje nko koga,gukina umupira w'amaboko cyangwa kwiruka byoroheje		
V035 **P15**	Ni igihe kingana iki ku munsi waba ukora imyitozo ngororamubiri yoroheje bituma habaho guhumeka byoroheje cyangwa umutima utera byoroheje nko koga,gukina umupira w'amaboko cyangwa kwiruka byoroheje	Amasaha: Iminota:	
V036 **P16**	Ni igihe kinga iki umara wicaye(uganira n'inshuti, uru kugenda mu modoka, kwipikipiki, igare, usoma ,ukoresha imashini, ukina amakarita cyangwa igisoro, ureba televiziyo, uruhuka cyangwa ukora uduseke?		
3. **Amakuru arebana n'ubwandu/HIV/AIDS and ARVs related information**			
V037	CD4 count		
V038	Umaze igihe kingana gute umenye ko wanduye agakoko gatera SIDA?		

V039	Icyiciro cy'uko ubwandu bwagakoko gatera SIDA bungana ugendeye k'umuryango mpuzamahanga wo kwita k'ubuzima	1. Icyiciro cya 1	
		2. Icyiciro cya 2	
		3. Icyiciro cya 3	
		4. Icyiciro cya 4	
V40	Ufata imiti igabanya ubukana?	1. Yego	
		2. Oya	
V041	Umaze igihe kingana gute ufata imiti igabanya ubukana?		
V042	Ni ubuhe bwoko bw'imiti ufata igabanya ubukana bw'agakoko gatera SIDA		

Mbashimiye uruhare mugize muri ubu bushakashatsi !!!

Appendix 9: Permission letter from AVEGA-Rwamagana health centre

Approved
le 6/8/2018

CENTRE DE SANTE AVEGA · DISTRICT RWAMAGANA

Innocent NDATEBA

Rwamagana district

Eastern Province

Mob: 0788520514

Email.:ndateba2@gmail.com

6th August 2018

To: Manager of Health Centre

AVEGA-Rwamagana.

Dear Mrs.,

RE: Requesting permission to conduct research project in health centre

I humbly write to you requesting a permission to conduct a research project in the health centre which responsibilities are entrusted to you.

In fact, I am a student at University of Western Cape-School of Public Health pursuing Master's program in Public Health (MPH). As requirement of the degree, I have to conduct a research project related to public health. It is in this background that I would like to request permission to conduct research project entitled "Factors Associated with Type II Diabetes Mellitus (T2DM) in people living with HIV/ AIDS (PLWHA) attending Primary Health Care Centres in Rwamagana District, Rwanda" in AVEGA-Rwamagana health centre. Should you have any questions regarding this study, you may contact me on above address or contact my supervisors on the following address: Dr. Nasheetah Solomons via email: nsolomons@uwc.ac.za Or Dr. **Ernesta Kunneke** on email: ekunneke@uwc.ac.za

I look forward to hearing from you.

Sincerely yours

Innocent NDATEBA

Appendix 10: Permission letter from Rwamagana health centre

Innocent NDATEBA
Rwamagana district
Eastern Province
Mob: 0788520514
Email.:ndateba2@gmail.com
6th August 2018

Received and approved, 6/08/2018
Rwamagana Hc Manager
Diaspora Habiyaremye

To: Manager of Health Centre
Rwamagana.
Dear Sir,

RE: Requesting permission to conduct research project in health centre

I humbly write to you requesting a permission to conduct a research project in the health centre which responsibilities are entrusted to you.

In fact, I am a student at University of Western Cape-School of Public Health pursuing Master's program in Public Health (MPH). As requirement of the degree, I have to conduct a research project related to public health. It is in this background that I would like to request permission to conduct research project entitled "Factors Associated with Type II Diabetes Mellitus (T2DM) in people living with HIV/ AIDS (PLWHA) attending Primary Health Care Centres in Rwamagana District, Rwanda" in Rwamagana health centre. Should you have any questions regarding this study, you may contact me on above address or contact my supervisors on the following address: Dr. Nasheetah Solomons via email: nsolomons@uwc.ac.za Or Dr. **Ernesta Kunneke** on email: ekunneke@uwc.ac.za

I look forward to hearing from you.

Sincerely yours

Innocent NDATEBA

Appendix 11: Letter requesting permission of data collection from Mayor of Rwamagana district

Innocent NDATEBA
Rwamagana district
Eastern Province
Mob: 0788520514
Email.:ndateba2@gmail.com
18th September 2018

RWAMAGANA DISTRICT
CENTRAL SECRETARIAT
Date of Reception 27/09/2018
N° of Received Doc.
Orientation
Signature

To: Mayor
Rwamagana District.

Dear Sir,

RE: Requesting permission to conduct research project in health centres

I humbly write to you requesting a permission to conduct a research project in the health centres of Rwamagana district.

In fact, I am a student at University of Western Cape-School of Public Health pursuing Master's program in Public Health (MPH). As requirement of the degree, I have to conduct a research project related to public health. It is in this background that I would like to request permission to conduct research project entitled "Factors Associated with Type II Diabetes Mellitus (T2DM) in people living with HIV/ AIDS (PLWHA) attending Primary Health Care Centres in Rwamagana District, Rwanda" in selected health centres of Rwamagana district. Should you have any questions regarding this study, you may contact me on above address or contact my supervisors on the following address: Dr. Nasheetah Solomons via email: nsolomons@uwc.ac.za Or Dr. **Ernesta Kunneke** on email: ekunneke@uwc.ac.za

Attached is the list of selected health centres and ethical clearances.

I look forward to hearing from you.

Sincerely yours

Innocent NDATEBA

Appendix 12: Permission letter from Mayor of Rwamagana district

REPUBULIKA Y'U RWANDA

Rwamagana,kuwa ..15.../...10.../2018
Nº..26.4.6.1 05-01

INTARA Y'IBURASIRAZUBA
AKARERE KA RWAMAGANA
B.P:24 RWAMAGANA

Bwana Innocent NDATEBA
University of Rwanda
07885220514

Impamvu : Gusubiza Ibaruwa yanyu

Bwana ,

Nshingiye ku ibaruwa yawe yo ku wa 27/09/2018 yatugezeho kuwa 15/10/2018 wanditse usaba gufata amakuru mu bigo nderabuzima,ajyanye n'indwara ya Diabete mu barwayi babana n'agakoko ka Sida,mu rwego rwo kurangiza ubushakashatsi bwawe.

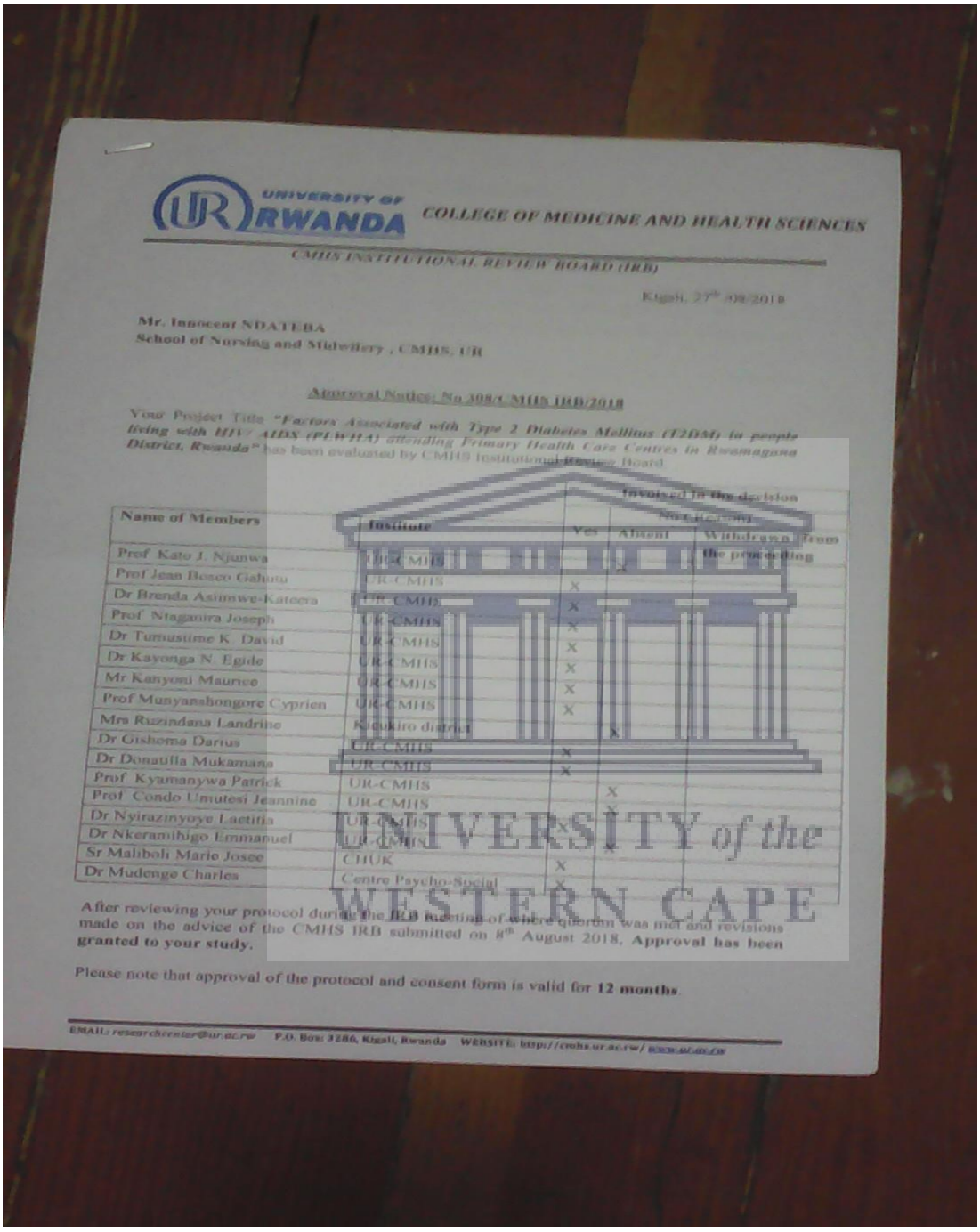
Nkwandikiye nkumenyesha ko wemerewe gufata ayo makuru,ariko ugakurikiza amabwiriza ya Minisiteri y'ubuzima ajyanye no gufata amakuru mu bigo by'ubuzima.

Ugire amahoro .

MBONYUMUVUNYI Radjab
Umuyobozi w'Akarere ka Rwamagana

Bimenyeshejwe:
- Umuyobozi w'Akarere wungirije ushinzwe imibereho myiza y'abaturage
- Umuyobozi w'ikigo nderabuzima cya Rubona,Ruhunda,Gishari,Nyagasambu,Rwamagana,Avega na Munyaga

Appendix 13: Ethical Approval from University of Rwanda-CMHS-IRB



UNIVERSITY OF RWANDA — COLLEGE OF MEDICINE AND HEALTH SCIENCES

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 27th /08/2018

Mr. Innocent NDATEBA
School of Nursing and Midwifery , CMHS, UR

Approval Notice: No 308/ CMHS IRB/2018

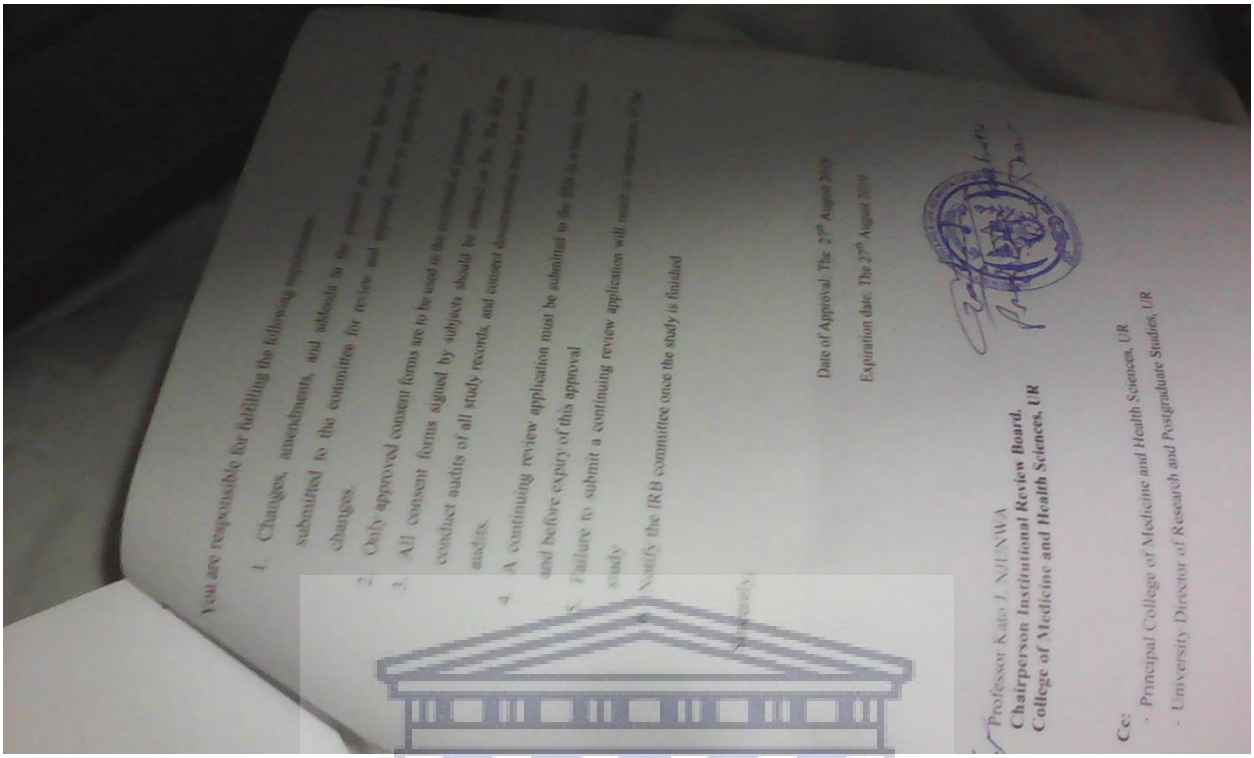
Your Project Title *"Factors Associated with Type 2 Diabetes Mellitus (T2DM) in people living with HIV/ AIDS (PLWHA) attending Primary Health Care Centres in Rwamagana District, Rwanda"* has been evaluated by CMHS Institutional Review Board

Name of Members	Institute	Involved in the decision: Yes	Absent	Withdrawn from the proceeding
Prof Kato J. Njunwa	UR-CMHS	X		
Prof Jean Bosco Gahutu	UR-CMHS	X		
Dr Brenda Asimwe-Kateera	UR-CMHS	X		
Prof Ntaganira Joseph	UR-CMHS	X		
Dr Tumustime K. David	UR-CMHS	X		
Dr Kayonga N. Egide	UR-CMHS	X		
Mr Kanyoni Maurice	UR-CMHS	X		
Prof Munyanshongore Cyprien	UR-CMHS	X		
Mrs Ruzindana Landrine	Kicukiro district		X	
Dr Gishoma Darius	UR-CMHS	X		
Dr Donatilla Mukamana	UR-CMHS	X		
Prof Kyamanywa Patrick	UR-CMHS		X	
Prof Condo Umutesi Jeannine	UR-CMHS	X		
Dr Nyirazinyoye Laetitia	UR-CMHS	X		
Dr Nkeramihigo Emmanuel	UR-CMHS	X		
Sr Maliboli Marie Josee	CHUK	X		
Dr Mudenge Charles	Centre Psycho-Social	X		

After reviewing your protocol during the IRB meeting of which quorum was met and revisions made on the advice of the CMHS IRB submitted on 8th August 2018, **Approval has been granted to your study.**

Please note that approval of the protocol and consent form is valid for **12 months**.

EMAIL: researchcenter@ur.ac.rw P.O. Box: 3286, Kigali, Rwanda WEBSITE: http://cmhs.ur.ac.rw/



You are responsible for fulfilling the following requirements:

1. Changes, amendments, and addenda to the protocol or study must be submitted to the committee for review and approval prior to implementing changes.
2. Only approved consent forms are to be used in the conduct of research.
3. All consent forms signed by subjects should be made available for IRB audits.
4. A continuing review application must be submitted to the IRB a month before and before expiry of this approval
5. Failure to submit a continuing review application will result in suspension of study
6. Notify the IRB committee once the study is finished

Date of Approval: The 27th August 2019

Expiration date: The 27th August 2020

Professor Kafu J. NJUNWA
Chairperson Institutional Review Board.
College of Medicine and Health Sciences, UR

Cc:
- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate Studies, UR

Appendix 14: Ethical approval from University of Western Cape-Research Ethics Committee

OFFICE OF THE DIRECTOR: RESEARCH
RESEARCH AND INNOVATION DIVISION

Private Bag X17, Bellville 7535
South Africa
T: +27 21 959 4111/2948
F: +27 21 959 3170
E: research-ethics@uwc.ac.za
www.uwc.ac.za

13 August 2018

Ms I Ndateba
School of Public Health
Faculty of Community and Health

Ethics Reference Number: BM18/6/4

Project Title: Factors associated with type 2 diabetes mellitus (T2DM) in people living with HIV/AIDS (PLWHA) attending primary health care centres in Rwamagana District, Rwanda.

Approval Period: 03 August 2018 – 03 August 2019

I hereby certify that the Biomedical Science Research Ethics Committee of the University of the Western Cape approved the extension of the research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit a progress report in good time for annual renewal.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

PROVISIONAL REC NUMBER -130416-050

FROM HOPE TO ACTION THROUGH KNOWLEDGE.