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UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

PREVALENCE AND FACTORS ASSOCIATED WITH HYPERTENSION AND DIABETES AMONG ADULTS LIVING WITH HIV IN SOUTH AFRICA

By

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Epidemiology in the field of Biostatistics and Epidemiology

School of Public Health

The University of the Witwatersrand

April 2021

DECLARATION

I, *Nicola Varaidzo Chiwandire*, affirm that this research report is my work. All resources used have been acknowledged and referenced accordingly. This research report is being submitted in partial fulfilment for the Master of Science in Epidemiology in the field of Biostatistics and Epidemiology at the University of the Witwatersrand, Johannesburg. This research report is original and has not been previously submitted for any degree at this or any other university.

Signature: 

Date: 21 April 2021

DEDICATION

I dedicate this to my mother Cleo Chiwandire, my sister Denise, and my brother Tapiwa. In trying times their love, support and encouragement have been unconditional and unwavering.

In loving memory of my late father Gregory Chiwandire.

ABSTRACT

Introduction: Hypertension and diabetes are significant risk factors for cardiovascular diseases which are the leading cause of mortality worldwide. Globally, people living with HIV on ART treatment have improved life expectancies, making them susceptible to developing these non-communicable diseases over time. These non-communicable diseases pose a public health challenge, especially in countries with high HIV prevalence rates and given that hypertension and diabetes have been recently identified as risk factors of the coronavirus disease. This study, therefore, determined the prevalence and factors associated with hypertension and diabetes in adults living with HIV in South Africa from 2005 to 2017.

Methods: This was a secondary data analysis of the 2005, 2008 and 2017 South African National HIV Prevalence, Incidence, Behaviour and Communication surveys. HIV positive participants who were above the age of 24 years were included in the study. All analyses were done on weighted data. Descriptive statistics were used to summarise the characteristics and trends of the study population. Multivariate survey logistic regression analysis was used to determine factors associated with hypertension and diabetes.

Results: The total study population of South African adults living with HIV aged 24 years and above was 978, 1023 and 2483 for 2005, 2008 and 2017 respectively. The overall prevalence of hypertension was 11.8% in 2005, 9.5% in 2008 and 14.3% in 2017 indicating an increasing trend, while that of diabetes was 3.3% in 2005, 2.8% in 2008 and 3.2% in 2017, indicating a stagnant trend. Also, 2017 had the highest median ages (interquartile range) of the three years of 48 (38 - 55) years and 49 (42 - 57) years for hypertension and diabetes. Similar to 2005 and 2008, in 2017 females (16.6%); (3.6%), the age group 45+ years (30.6%); (6.8%), Non-Black Africans (20.3%); (5.6%), urban areas (15.9%); (3.5%), Gauteng province (29.0%); (29.4%) and primary education and below (18.9%); (7.1%) were characteristics with the highest prevalence of hypertension and diabetes respectively. Factors associated with hypertension in 2017 were being female (aOR = 2.33; 95% CI = 1.60 to 3.42), being 45 years and older (aOR = 7.32; 95% CI = 4.78 to 11.21), pensioners and the sick (aOR = 2.27; 95% CI = 1.09 to 4.73), urban area living (aOR = 1.61; 95% CI = 1.16 to 2.23), high risk of hazardous alcohol consumption (aOR = 4.43; 95% CI = 1.67 to 11.76), diabetes (aOR = 5.17; 95% CI = 2.69 to 9.96), and heart disease (aOR = 3.36; 95% CI = 1.59 to 7.10). For diabetes the associated

factors in 2017 were being 45 years and older (aOR = 7.90; 95% CI = 2.11 to 29.58), poor health (aOR = 6.48; 95% CI = 1.65 to 25.41), hypertension (aOR = 4.60; 95% CI = 2.34 to 9.07) and having a secondary education and above (aOR = 0.31; 95% CI = 0.16 to 0.59).

Conclusion: From 2005 to 2017, the prevalence of hypertension increased, while the prevalence of diabetes was low and remained the same. As with other studies from different countries the odds of hypertension and diabetes was high in women, the age group 45+ years, urban areas, and individuals with heart disease. Moreover, the demonstrated elevated risk for the age group 45+ years, further increases their risk of developing severe disease due to COVID-19. Hence, the risk of hypertension and diabetes in adults living with HIV remains a cause for concern, particularly in circumstances such as the COVID-19 pandemic, where NCDs have been identified as risk factors. In summary, findings from this study not only provide population-based estimates but help in supporting the importance of the integrated chronic disease management model where chronic disease care and HIV care are provided together to reduce risk.

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LIST OF ABBREVIATIONS

ART	Anti-retroviral therapy
ALHIV	Adults living with HIV
CVDs	Cardiovascular Diseases
CRDs	Chronic Respiratory Diseases
CI	Confidence Interval
COVID-19	Coronavirus disease 2019
HIV	Human Immunodeficiency Virus
HREC	Human Research Ethics Committee
HSRC	Human Sciences Research Council
HICs	High-income countries
IDF	International Diabetes Federation
LMICs	Low- and middle-income countries
OR	Odds ratio
PLHIV	People living with HIV
NCDs	Non-communicable diseases
SA	South Africa
SABSSM	South African National HIV Prevalence, Incidence, and Behaviour
SANHANES	South African National Health and Nutrition Examination Survey
SDGs	Sustainable development goals
SSA	Sub-Saharan Africa
TB	Tuberculosis
UN	United Nations
WHO	World Health Organization

CHAPTER ONE: INTRODUCTION

This chapter provides a background to the global and South African burden of hypertension, diabetes and HIV respectively. It also discusses the double burden of NCDs and HIV, offers an in-depth overview of related literature and concludes by summarising the rationale for the study.

1.1 BACKGROUND

1.1.1 GLOBAL BURDEN OF HYPERTENSION, DIABETES AND HIV

Hypertension and diabetes are significant risk factors for cardiovascular diseases (CVDs) which are the leading cause of mortality worldwide (1, 2). Hypertension is a chronic medical condition marked by the recurrent elevated force of the flowing blood against the blood vessels (3). In 2015 the World Health Organization (WHO) estimated that 1.13 billion people worldwide had hypertension, which is a known major avoidable risk factor for premature death (3). Consequently, deaths that occurred in 2015 due to complications from hypertension were estimated to be 9.4 million (3). The burden of hypertension is considerably higher in LMICs with a prevalence of 27% in Africa compared to 18% in the Americas (3).

Diabetes, a chronic disorder that is characterised by uncontrolled high blood glucose, was recently reported by the International Diabetes Federation (IDF to have a global prevalence of diabetes for 2019 to be 9.3% which translated to 463 million people) (4, 5). They also reported that high-income countries (HICs) had a higher prevalence of 10.4% compared to LMICs which had a prevalence of 4%, however, the African region still had the highest proportion of undiagnosed diabetes (4). In any case, diabetes can be controlled successfully, much as hypertension, by a variety of acts such as balanced eating, physical activity, mental health assessment and treatment (6).

If neither hypertension nor diabetes is treated adequately, there is an elevated risk of complications, resulting in increased dependency and demand for a higher quality of care for the affected people, their families and the health system (3, 7). The global increase in hypertension and diabetes is a cause for concern, as seen above, especially in the public health

context where infectious diseases such as the human immunodeficiency virus (HIV) are still prevalent.

Accordingly, the latest HIV burden estimates, showed that 37.9 million people were living with HIV worldwide in 2018 (8). Of these, 20.6 million people were living with HIV (PLHIV) in Eastern and Southern Africa, the largest proportion of the global PLHIV population (8). In these PLHIV, 13.8 million were accessing antiretroviral treatment (ART) in Eastern and Southern Africa, while 23.3 million had access to ART globally (8). The life expectancy of PLHIV has increased and deaths due to opportunistic infections have decreased with the successful introduction of the ART program in many countries, including LMICs. This has transformed HIV infection into a chronic illness. And their risk of developing NCDs inevitably increases as a consequence of PLHIV living longer today along with other factors including chronic inflammation associated with HIV itself as well as a side effect of ART (9). Therefore, the resulting double burden of HIV and NCD co-epidemics puts significant pressure not only on the people affected but also on the struggling health systems in many African countries (10).

1.1.2 Burden of hypertension, diabetes and HIV in the South Africa population

South Africa is undergoing an epidemiological transition, with a growing prevalence of both infectious diseases, particularly HIV and NCDs, as defined by the late Professor Mayosi and colleagues (11, 12). That said, in 2016 WHO reported that in South Africa, 51% of all deaths were due to NCDs whereas communicable diseases together with other conditions accounted for 40% of all deaths (2, 13). In 2019, the IDF reported the prevalence of diabetes in the South African population to be 12.7%, while the prevalence of hypertension was reported to be between 42% and 54% by Gómez-Olivé et al. (14, 15). In spite of these reports, the figures above are anticipated to rise even further in the coming years as researchers have attributed the growing prevalence to urbanisation, ageing of the population, poverty and an increase in other risk factors (11). By comparison, the latest HIV prevalence figures show that there were 7.9 million PLHIV in South Africa in 2017, which is 14.0% of the population and thus the highest number of PLHIV in the world (16, 17). 4.4 million of these PLHIV were exposed to ART which is approximately 62.3% (16). Furthermore, the implementation of the ART programme in South Africa has seen a decline in the number of HIV/AIDS-related deaths since 2004 (18, 19). Studies have found some possible link of ART to the development of chronic diseases

stating that metabolic syndrome which is associated with many NCDs is one of the adverse side effects of ART (20). Additionally, the persistent state of inflammation due to low-level viremia as a result of ART has been linked to other chronic diseases (20). Therefore, the above evidence shows that not only are PLHIV a priority group in this newly realized environment of increasing prevalence of hypertension and diabetes but that it is key to investigate the burden of hypertension and diabetes in people living with HIV to be able to reduce the risk factors, improve quality of life, inform and improve interventions thereby alleviating the burden on the health system.

1.2 LITERATURE REVIEW

1.2.1 PREVALENCE OF HYPERTENSION AND DIABETES IN PLHIV IN SUB-SAHARAN AFRICA

Studies that have reported the prevalence of hypertension or diabetes in PLHIV in sub-Saharan Africa (SSA) are many. However, such studies have presented disparities in findings suggesting that different population groups, risk factors and study designs influence the prevalence. Accordingly, a recent meta-analysis and systematic review across SSA reported the prevalence for hypertension in PLHIV to range between 5.2% and 50.0%, while other studies reported findings in Ethiopia (12.7%), Zimbabwe (10.2%), Tanzania (28.7%), Nigeria (26.7%) and Uganda (11%) (21-26). Furthermore in Senegal, a study reported a doubling in the proportional prevalence of hypertension from 11% to 22% from 1994 to 2015 (27). The high prevalence reported in Nigeria and Tanzania was suggested to be due to HIV infection-induced inflammation resulting in atherosclerosis; and immune reconstitution inflammatory syndrome and the effect of antiretroviral (ARV) medication respectively, with the latter reason subject to further investigations (23, 26). Regarding diabetes, the meta-analysis and systematic review also reported a prevalence in PLHIV ranging between 0.5% and 36.6%. While other studies reported estimates of the prevalence of diabetes in PLHIV in Ethiopia (7.1%), Zimbabwe (2.1%), Zambia (3.5%), Swaziland (7.5%) and Nigeria (5.6%) (21-23, 25, 28, 29). Concerning diabetes prevalence, the same Nigerian study indicated that long-term ARV medication increased insulin resistance leading to diabetes (23). In light of this, the above studies continue to reiterate the conclusions made by WHO that LMICs are experiencing an increasing prevalence of hypertension and diabetes. Furthermore, due to the variation in the results, the findings may not necessarily be extrapolated to other African countries including South Africa. Nonetheless, studies done in South Africa are further described in detail below.

South African studies done to measure the burden of hypertension and diabetes in PLHIV, have been conducted in specific geographical locations or populations of interest (30-32). A study done to evaluate NCDs in HIV positive educators showed that high blood pressure had a self-reporting prevalence of 17.4% (31). Additionally, the prevalence was higher among females (40%) which was likely due to different health-seeking behaviours (31). Also, other groups which had a high hypertension prevalence were those aged between 45 and 54 years (41.1%), and those teaching in the urban informal area (48.2%) (31). Another study done in 2010 to

determine factors associated with hypertension and excess weight in rural South Africa showed that 19.5% of HIV-infected adults had hypertension (33). Other similar studies and systematic reviews have produced comparable results including a KwaZulu-Natal study done to determine the prevalence and risk factors of NCDs by HIV status. This study found that 16% of HIV positive participants had the first stage of hypertension, 8% had the second stage of hypertension and 2% had hyperglycaemia (30, 34, 35). In another study in the Western Cape Province, done at HIV clinics, the prevalence of hypertension was found to be 38.6%, which is thus far the highest reported prevalence in PLHIV (34).

Further studies including the 2012 South African National Health and Nutrition Examination Survey (SANHANES), indicated that 5% of South Africans older than 14 years had reported diabetes while 16.5% reported that they had high blood pressure (36). Similarly, a study done using data from SANHANES to assess the prevalence and associated factors of cardiovascular disease and diabetes comorbidity showed that comorbidity was more frequent in people of African descent, females, urban areas and those unemployed (37). Outside of SSA, relatively higher hypertension prevalence findings have been reported in Brazil (22.5%), Belgium (31%), and the USA (26%) amongst other studies (38-40). For diabetes, Brazil (7.14%), Belgium (5.9%), and the USA (13%) have reported a high prevalence as well (39-41). Lastly, concerning the prevalence of hypertension and diabetes with other conditions such as heart disease and tuberculosis (TB), some studies have shown this including a multi-site cross-sectional study conducted in Cape Town that found that 1.5% had TB and hypertension, and 0.2% had TB and diabetes (42).

1.2.2 FACTORS ASSOCIATED WITH HYPERTENSION AND DIABETES IN PLHIV IN SUB-SAHARAN AFRICA

The studies above have not only demonstrated varying prevalence estimates from country to country but within the same country as is the case with South Africa. Therefore, it is just as important to determine the factors that influence these differences in prevalence. Consequently, researchers have broadly identified and categorised some of these factors into sociodemographic, genetic, behavioural and metabolic groups (1, 43). Therefore, we take a further look into these groups with respect to studies done to determine factors associated with hypertension and diabetes in PLHIV in SSA.

1.2.2.1 SOCIO-DEMOGRAPHIC AND GENETIC FACTORS

With respect to socio-demographic and genetic factors, several studies have shown that conventional factors such as sex, age, race, locality, education, employment, and socio-economic status are associated with hypertension or diabetes in the general population (44, 45). Furthermore, parallel findings have been described in studies within the HIV population but either in different countries, age groups or geographical locations. As such increases in age have been shown to raise the risk of hypertension and diabetes, mainly due to vascular stiffening, increasing insulin resistance, and impaired pancreatic islet function (46-50). Thus, in the 2012 SANHANES study, older age was strongly associated with NCD comorbidity and this has been confirmed by other studies in Nigerian and Malawi (23, 37, 51). Meanwhile, for sex, there are conflicting findings in terms of risk, where many studies such as the South African study done in HIV positive educators, determined that females were at a higher risk for both NCDs citing that women have higher BMIs, are physically inactive, and have a higher waist to hip ratio (31, 52-54). On the contrary, some studies such as the abovementioned Ugandan study found that males had an increased risk of hypertension than females, but the reasons for this observation were not explained (24).

Alternatively, regarding residency or locality, there is consistent evidence that residing in urban areas increases the risk of NCDs, as was reported by a Malawian study conducted in Karonga district and Lilongwe city (55). This study found that those who lived in urban areas had an increased risk of hypertension and diabetes when compared to rural areas (55). Equally so, a separate article suggests that urbanisation affects and is associated with diets that are high in fats and a more westernised sedentary lifestyle (44, 45). Additionally, the lack of education was found to be a determinant for hypertension in a Senegal study (27). This is supported by many studies suggesting that access to education improves one's health and awareness. On the other hand, a protective association between having a higher income and good health against comorbidity was reported by a study done in South Africa (37).

1.2.2.2 BEHAVIOURAL AND METABOLIC FACTORS

With respect to behavioural and metabolic factors, many studies also found a significant association with hypertension and diabetes. Alcohol consumption which is considered a behavioural factor was associated with hypertension in HIV positive people, in a prevalence study done at a clinic in Zimbabwe (56). Furthermore, a Brazilian cross-sectional study

conducted to investigate alcohol consumption in the general population versus HIV positive patients, found that hypertension was associated with heavy drinking in patients infected with HIV (57). Suggestions to explain the relationship between alcohol and hypertension include that chronic ingestion of alcohol is linked to an increase in cholesterol and a decrease in vasodilators due to inflammation and damage to blood vessels (58, 59).

Meanwhile, in an Ethiopian study on PLHIV, elevated blood pressure was found to be significantly correlated with raised waist to hip ratio, high blood glucose, high total cholesterol, high body mass index, longer duration on ART and drinking alcohol (22). Alternatively, factors that were associated with diabetes included high blood triglyceride and high body mass index (22). Similarly, in a Malawian study ARV medication, specifically, protease inhibitors, was correlated with an increased risk of diabetes (51). In addition, two USA studies found an association between hypertension or diabetes and heart disease, suggesting that over time the effect of hypertension and diabetes on the decline of the integrity of the blood vessels and heart muscle eventually leads to heart disease (60, 61). While another USA study, that used data from the National Health Interview Survey and a longitudinal study done in South Africa, found that psychological distress was associated with hypertension (62). Ojike et al., further reported that psychological distress may result in the individual making poor health decisions resulting in hypertension over time (62). Similarly, a South African study suggested a link between psychological distress and alcohol abuse and/or smoking, citing the levels of unemployment and subsequent social isolation as potential risk factors (63).

With this in mind, the recent emergence of the coronavirus disease 2019 (COVID-19) pandemic has led to the identification of hypertension and diabetes as risk factors of the disease. Subsequently, a recent systematic and meta-analysis revealed that those who had diabetes and hypertension were at a significantly greater risk of developing severe disease (64). Another systematic review, including PLHIV, reported that older PLHIV who had comorbidities including hypertension and diabetes were again at a higher risk of mortality than PLHIV without comorbidities (65). These PLHIV appeared to have a higher severity of the disease as well (65). These findings, therefore, highlight the implication of not only collecting hypertension and diabetes prevalence estimates concerning PLHIV but also adequately addressing multimorbidity in PLHIV and ensuring adequate availability of treatment to reduce risk.

In summary, the above studies provide insight into the prevalence of hypertension and diabetes in different groups of PLHIV, thereby yielding information in areas to improve or explore to ensure adequate interventions. However, it should be noted that these studies are not comprehensive, as specific prevalence studies in all PLHIV in South Africa including younger ages between 25 and 65 years at the population level require further exploration. Therefore, this study sought to determine the prevalence, characteristics, distribution, trends, and factors associated with hypertension and diabetes among adults living with HIV in South Africa.

1.3 PROBLEM STATEMENT

The burdens of hypertension and diabetes in PLHIV are a major public health concern as they have potential implications on society, the health system and the economy (43). Even though NCDs are largely preventable, lower to middle-income countries continue to be the most impacted and witness premature deaths as a result of early exposure to the risk factors of NCDs (43). Despite this, not much is known about the prevalence of hypertension and diabetes in PLHIV or any associated factors thereof in South Africa at the population level. Therefore, an improved understanding of the prevalence and associated factors of hypertension and diabetes in PLHIV is important for informing public health interventions in the country.

1.4 JUSTIFICATION

As mentioned above South Africa is in an epidemiological transition characterised by the presence of multiple disease, disorder and condition burdens (11). Resultantly, the high HIV burden and NCD morbidity rates are overwhelming the current health systems and this will consequently affect South Africa's third sustainable development goal (SDG) to assure healthy lives and endorse well-being for all by 2030. Furthermore, there is a paucity of data on the national burden of hypertension and diabetes among PLHIV and that includes factors that are associated with it as data from previous studies have been restricted by geographical location or populations of interest. Therefore, the findings often do not represent the whole population. Hence, the findings from our analysis will fill the knowledge gap, and strengthen the argument for the integration, refinement, and implementation of NCD programmes with HIV programmes. Also, the information will assist key stakeholders to advocate for health policy changes.

1.5 RESEARCH QUESTIONS

What is the prevalence, trend, distribution, and characteristics of hypertension and diabetes among adults (> 24 years) living with HIV in South Africa in 2005, 2008 and 2017? What are the factors associated with hypertension and diabetes among adults (> 24 years) living with HIV in South Africa in 2005, 2008 and 2017?

1.6 AIM

To determine the prevalence, trend, distribution, characteristics, and associated factors of hypertension and diabetes in adults (> 24 years) living with HIV in South Africa in 2005, 2008 and 2017.

1.7 OBJECTIVES

1. To determine the prevalence of hypertension and diabetes among adults (> 24 years) living with HIV in South Africa in 2005, 2008 and 2017.
2. To describe the characteristics, distribution, and trends of hypertension and diabetes among adults (> 24 years) living with HIV in South Africa in 2005, 2008 and 2017.
3. To determine factors associated with hypertension and diabetes among adults (> 24 years) living with HIV in South Africa in 2005, 2008 and 2017.

CHAPTER TWO: METHODOLOGY

This chapter briefly explains the methods and materials of the survey data used in the study, while defining the survey design and sampling in detail. Also, the methodologies used for performing the secondary data analysis are explained.

2.1 SECONDARY STUDY

2.1.1 STUDY DESIGN AND SUBSAMPLE

This study was a secondary data analysis of cross-sectional surveys undertaken by the HSRC for the 2005, 2008 and 2017 South African National HIV Prevalence, Incidence and Behaviour surveys. The analysis focused on adults living with HIV older than 24 years who responded to the questions on the two main outcomes i.e. hypertension and diabetes. Therefore, participants who tested HIV negative or had missing HIV test results were excluded from the analysis.

2.2 PRIMARY STUDY

2.2.1 STUDY DESIGN AND SAMPLING

The primary studies were conducted nationwide in 2005, 2008 and 2017 in South Africa using a "cross-sectional population-based household survey" to determine the prevalence, behaviour and incidence of HIV (16, 66-68). The design used for the surveys was multi-stage stratified random cluster sampling (Figure 2.1 & 2.2). In surveys before 2012 "a systematic probability sample of fifteen households was selected at random from a thousand enumeration areas (EAs) which were chosen at random from 86 000 EAs established from the national sampling frame published by Statistics South Africa in 2001 and revised in 2011" (69, 70). The 2017 survey used a new sampling frame of small area layers (SALs) instead of EAs (71), and again in this survey, fifteen households or visiting points were chosen systematically from a thousand randomly selected SALs.

Stratified sampling of EAs and SALs was done provincially and by locality type (16, 66-68). A limit of three people was chosen at random in each household to take part in the study, for the 2005 and 2008 surveys, each reflecting the age classes 2–14 years, 15–24 years and 25

years and older (66, 67). For surveys carried out in 2012 and 2017, all consenting household members defined as “all individuals who slept there the night before the interview” were eligible to take part (16, 68). Data collection tools for these surveys included four types of questionnaires namely “household, parent or guardian of children under 12 years, children between 12 and 14 years; and people older than 14 years” with different sexual, behavioural and health indicators of interest (16, 68). For our study, the primary data collected using the questionnaire for people older than 14 years was used for the secondary analysis. Dried blood spot samples were also obtained from participants who gave consent and were tested for HIV antibodies. Further testing for antiretroviral drugs in 2012 and drug tolerance in 2017 was carried out on positive samples.

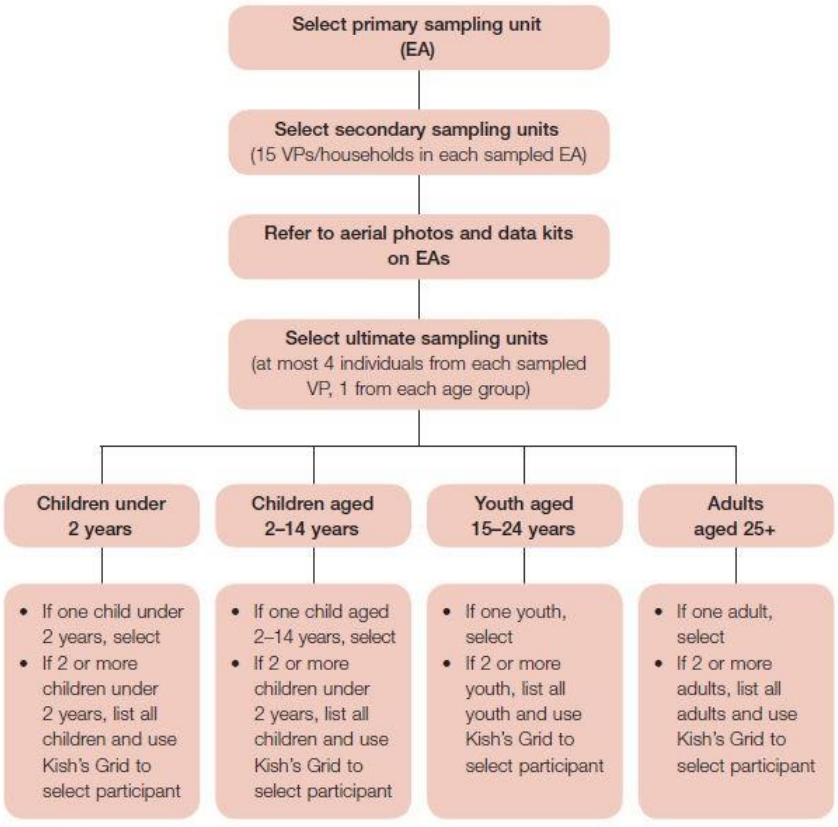


Figure 2.1: Sampling strategy steps taken for 2005 and 2008 surveys (66, 67)

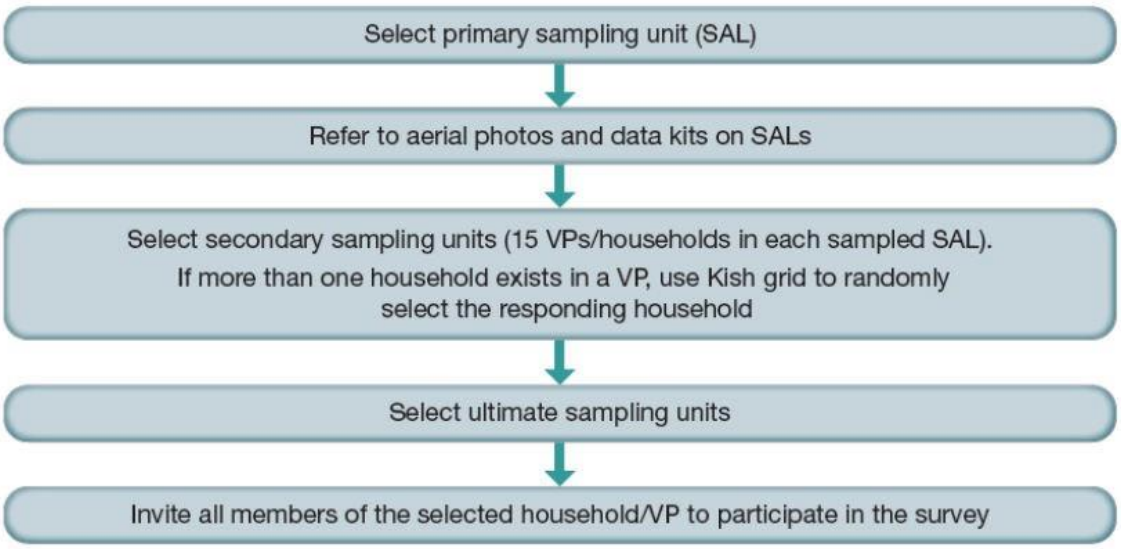


Figure 2.2: Sampling strategy steps taken for 2012 and 2017 surveys (68, 72)

2.3 MEASUREMENT OF VARIABLES

2.3.1 MAIN OUTCOME VARIABLES

The two main outcome variables were hypertension and diabetes. These were derived from the survey question "Do you currently have any of the following illnesses?" of which the list of responses included the primary outcome variables for this study.

2.3.2 EXPLANATORY VARIABLES

The explanatory variables used in the statistical analysis were grouped into three categories as follows:

1. Socio-demographic factors – sex, age, race, marital status, employment status, educational level, locality type and province.
2. Behavioural factors – Hazardous alcohol consumption using the AUDIT (Alcohol Use Disorders Identification Test) score. Hazardous alcohol consumption is characterised as a habit or amount of alcohol intake that raises the risk of adverse health effects (73).
3. Health-related factors – exposure to ARVs, viral load suppressed, the perception of general health, cancer, mental distress, tuberculosis, heart disease, hypertension/diabetes, health care access.

2.4 DATA MANAGEMENT AND ANALYSIS

2.4.1 DATA MANAGEMENT

The data was extracted from the HSRC Research Data Repository and data cleaning was performed to check for missing values, duplicates, and any other inconsistencies. Missing values and duplicates were excluded from all analyses. Recoding and transformation of variables was performed to suit the current study, and a summary of the final variables used is illustrated in Table 2.1. The first main outcome variable, hypertension, was coded 1 for the presence of hypertension or coded 0 for the absence of hypertension. The second main outcome variable, diabetes, was coded 1 for the presence of diabetes or coded 0 for the absence of diabetes. The explanatory variables included continuous and categorical variables. The continuous variable was treated as numerical data and statistical assumptions were tested. The remaining categorical variables were re-categorised and recoded to suit the current analysis. The statistical software, Stata version 15, was used for data analysis (74). Sample weights were included to adjust and account for complex survey design and any bias due to non-response.

Sensitivity analysis was performed for 2008 survey data as the sample population and the proportions of the outcomes were lower than for 2005. Firstly, unweighted, and weighted proportions of key demographic variables stratified by the outcomes were compared. In overall, the proportions did not vary greatly between unweighted and weighted data. Secondly, three survey adjusted regression models were compared namely, a model which had the original outcome (i.e. hypertension or diabetes), a model with missing data in the outcome coded as yes or present and a model with the missing data in the outcome coded as no or absent. Again, the odds ratios did not vary greatly from the model with the original outcome variable. Lastly, multiple imputations were performed to impute for missing data and again the odds ratios did not vary greatly from the model with the original outcome variable. Therefore, the original outcome variables were used in the analysis, using the Stata default which is complete case analysis. See Appendix 5 for the Stata output of the above sensitivity analysis done.

Table 2.1: Coding and generation of study variables for analysis

Variable	Categories in Survey Data	Categories in Secondary Analysis
Outcome variables		
Hypertension	1 Yes 2 No	0 No 1 Yes
Diabetes	1 Yes	0 No

	2 No	1 Yes
Explanatory variables		
Sex	1 Male 2 Female	0 Male 1 Female
Age		0 25 - 34 yrs. 1 35 - 44 yrs. 2 45+ yrs.
Race	1 African 2 White 3 Coloured 4 Indian	0 Non- Black African (White, Coloured, Indian) 1 Black African
Marital status	1 Single 2 Married or cohabit 3 Widowed 4 Divorced or separated 5 Other	0 Never married 1 Ever married
Employment status	13 categories	0 Unemployed 1 Employed 2 Other (incl. old age pensioner, sick/disabled and unable to work)
Educational level	1 No school 2 Primary 3 Secondary 4 Matric 5 Tertiary	0 No or up to Primary 1 Secondary and above
Locality type for 2005 & 2008 data	1 Urban formal 2 Urban informal 3 Tribal area/Rural informal 4 Rural formal	1 Urban formal 2 Urban informal 3 Tribal area/Rural informal 4 Rural formal
Locality type for 2017 data	1 Urban 2 Tribal area 3 Rural formal	0 Urban 1 Tribal area 2 Rural formal
Hazardous alcohol consumption (using the AUDIT score)		0 No risk (Do not drink alcohol) 1 Low risk (0 – 7) 2 Medium risk (8 – 15) 3 High risk (16 – 19) 4 Addiction likely (20 – 40)
Perception of general health	1 Excellent 2 Good 3 Fair 4 Poor	0 Excellent 1 Good 2 Fair 3 Poor
Cancer	1 Yes 2 No	0 No 1 Yes
Mental distress (incl. depression, anxiety and/or Kessler score)		0 No 1 Yes
Tuberculosis	1 Yes 2 No	0 No 1 Yes
Heart disease	1 Yes 2 No	0 No 1 Yes
Health care access	7 categories	0 Public care 1 Private care
Province	1 Western Cape 2 Eastern Cape 3 Northern Cape 4 Free State 5 KwaZulu-Natal 6 North-West 7 Gauteng	1 Western Cape 2 Eastern Cape 3 Northern Cape 4 Free State 5 KwaZulu-Natal 6 North-West 7 Gauteng

	8 Mpumalanga 9 Limpopo	8 Mpumalanga 9 Limpopo

2.4.2 STATISTICAL ANALYSIS

2.4.2.1 DESCRIPTIVE ANALYSIS

Objective 1 & 2: Prevalence, trend, distribution, and characteristics of hypertension and diabetes in South Africa among adults (> 24 years) living with HIV in South Africa in 2005, 2008 and 2017.

The prevalence of hypertension and diabetes among ALHIV was summarised using frequencies and row percentages by the socio-demographic, behavioural, and health-related characteristics. Trends in hypertension and diabetes prevalence were presented as line graphs for 2005, 2008 and 2017 and stratified by age groups. The distribution was presented provincially using bar graphs. Age was also summarised as a continuous covariate using medians and interquartile ranges as means are influenced by outliers and skewed data.

2.4.2.2 INFERENTIAL ANALYSIS

Objective 3: Factors associated with hypertension and diabetes among adults (> 24 years) living with HIV in South Africa in 2005, 2008 and 2017.

Bivariate analysis was performed for all categorical explanatory variables against the two main outcomes i.e. hypertension or diabetes separately using the survey adjusted Pearson's Chi-Squared test. Explanatory variables having a p-value < 0.25 were included in the multivariate survey logistic regression model. Natural confounders and variables of clinical importance such as age, race and sex which may have had a p-value > 0.25 were included in the working model. The importance of each explanatory variable was tested using the Wald test. A variable that was not statistically significant with a p-value > 0.05 was removed from the working model.

A new model without the variable was refitted, and again each explanatory variable was tested using the Wald test while also observing the odds ratios of the other variables and comparing these to the previous model (75). This process which included removing, refitting, and

verifying the importance of the variable was repeated until all important variables were kept in the final main effects model. Variables that had very wide confidence intervals were also removed from the models. Following this, interaction terms including sex and age, sex and race, and race and age were checked for their importance in the model and insignificant interactions terms were removed. Additionally, the Variance Inflation Factor (VIF) test was done to check for multicollinearity at a cut off level of 5 (76).

Afterwards, survey logistic regression was fitted using the preliminary final model. A post-estimation test using the Hosmer-Lemeshow Goodness of Fit test was done to test whether the final model was a good fit (75). If the Goodness of Fit test failed multiple times, the preliminary final model was used instead. The magnitude and direction of any significant association established was reported in adjusted odds ratios (aOR), 95% confidence intervals (CI) and p-values. Statistical significance was determined at p-values less than or equal to 0.05.

2.5 ETHICAL CONSIDERATIONS

Ethical clearance for this study was sought from the University of the Witwatersrand Human Research Ethics Committee (HREC). Unconditional approval for the study was granted and a clearance certificate was issued bearing the certificate number M191181. The data accessed was password protected and stored on a secure external hard drive. Ethical clearance for the primary study was approved by the HSRC Research Ethics Committee and by the "Centers for Disease Control and Prevention Associate Director of Science of the National Center for HIV and AIDS, Viral Hepatitis, STD and TB Prevention" (16, 66, 67).

CHAPTER THREE: RESULTS

This chapter presents the results of the entire study, according to the objectives outlined earlier. First, the characteristics and distribution of the study population are summarised using frequency percentages and absolute numbers. Lastly, the associated factors determined by the survey adjusted Chi-Squared bivariate tests and multivariate logistic regression analyses are shown.

3.1 BASELINE STUDY POPULATION CHARACTERISTICS

The total number of qualifying participants aged above 24 years in the sample was 978 for 2005, 1023 for 2008 and 2483 for 2017 (Table 3.1). In 2005 and 2008, the median age (interquartile range, IQR) of the respondents was 34 (29 - 41) years, compared to 38 (32 - 46) years in 2017. The age group 25 – 34 years constituted the highest number of participants for 2005 (50.3%), 2008 (50.8%) and 2017 (37.6%). Overall, above 60% of the participants were female for all three years, and over 95% of the participants were Black African. In 2005 and 2008, more than 40% of respondents lived in an urban formal area, while in 2017, 64.6% lived in an urban area. Most participants were from KwaZulu Natal at 24.4% in 2005 and 27.3% in 2008, while 25.2% came from Gauteng in 2017 (Figure 3.1).

Table 3.1: Baseline study population characteristics in 2005, 2008 and 2017

	2005		2008		2017	
Study population characteristics	**n**	**Weighted %**	**n**	**Weighted %**	**n**	**Weighted %**
Overall	**978**		**1023**		**2483**	
Sex						
Female	658	61.1%	705	66.1%	1762	65.3%
Male	320	38.9%	318	33.9%	721	34.7%
Age						
Median (IQR)	34 (29 - 41)		34 (29 - 40)		38 (32 - 46)	
25 – 34 years	436	50.3%	441	50.8%	852	37.6%
35 – 44 years	338	32.6%	344	31.6%	789	33.1%
45+ years	204	17.1%	164	17.6%	842	29.3%
Race						
Non-Black African	84	2.5%	64	2.0%	218	3.6%
Black African	893	97.4%	959	98.0%	2265	96.4%
missing	1	0.1%	0	0.0%	0	0.0%
Marital status						
Never married	488	50.4%	581	62.9%	1485	62.2%
Ever married	473	46.5%	395	33.3%	852	33.1%
missing	17	3.1%	47	3.8%	146	4.6%
Educational level						
None or Primary	387	37.3%	336	27.4%	544	18.6%

Secondary and above	575	59.8%	637	68.8%	1459	64.6%
missing	16	2.9%	50	3.8%	480	16.8%
Employment status						
Unemployed	533	56.2%	483	52.9%	1456	59.8%
Employed	334	32.3%	385	34.5%	818	33.1%
Other (incl. old age pensioner. sick/disabled and unable to work)	94	8.4%	110	9.1%	61	2.4%
missing	17	3.1%	45	3.5%	148	4.7%
Locality						
Urban formal	400	43.8%	387	42.5%	1340	64.6%
Urban informal	222	14.9%	267	18.4%		
Tribal area/Rural informal	274	35.4%	272	32.4%	781	30.1%
Rural formal	82	5.9%	97	6.6%	362	5.3%
Hazardous alcohol consumption						
No risk	659	68.3%	655	68.1%	1627	64.8%
Low risk	202	19.5%	208	17.6%	491	21.3%
Medium risk	65	6.3%	69	6.2%	150	6.5%
High risk	13	1.1%	16	1.3%	31	1.5%
Addiction likely	13	1.2%	13	1.5%	30	1.1%
missing	26	3.6%	62	5.3%	154	4.8%
Exposure to ARVs						
ARV exposed					1471	62.1%
ARV naive					742	33.3%
missing					270	4.6%
Viral load suppressed						
Yes					1582	63.2%
No					874	35.6%
missing					27	1.2%
Perception of general health						
Excellent	95	9.9%	167	18.3%	415	17.3%
Good	560	61.5%	497	48.2%	1322	54.3%
Fair	240	20.5%	241	22.6%	479	18.8%
Poor	68	5.2%	71	7.2%	117	4.8%
missing	15	2.9%	47	3.7%	150	4.8%
Diabetes						
Yes	34	3.2%	29	2.7%	87	3.0%
No	907	93.2%	937	92.6%	2242	92.0%
missing	37	3.7%	57	4.7%	154	5.0%
Hypertension						
Yes	126	11.4%	107	9.1%	372	13.6%
No	820	85.2%	859	86.5%	1955	81.3%
missing	32	3.4%	57	4.3%	156	5.1%
Heart disease						
Yes			20	1.8%	48	2.4%
No			946	93.2%	2272	92.4%
missing			57	5.0%	163	5.2%
Cancer						
Yes	5	0.6%	6	0.4%	8	0.3%
No	939	96.0%	959	94.7%	2315	94.5%
missing	34	3.4%	58	5.0%	160	5.2%
Mental distress						
Yes	552	58.2%	36	3.3%	789	31.6%
No	409	38.9%	928	91.6%	1694	68.4%
missing	17	3.0%	59	5.1%	0	0.0%
Tuberculosis						
Yes	67	7.1%	50	4.8%	76	3.5%

No	881	89.7%	917	90.5%	2247	91.4%
missing	30	3.3%	56	4.8%	160	5.1%
Health care access						
Public	800	82.8%	749	74.4%	2109	85.8%
Private	139	11.8%	202	18.9%	210	8.8%
missing/excluded	39	5.4%	72	6.7%	164	5.4%

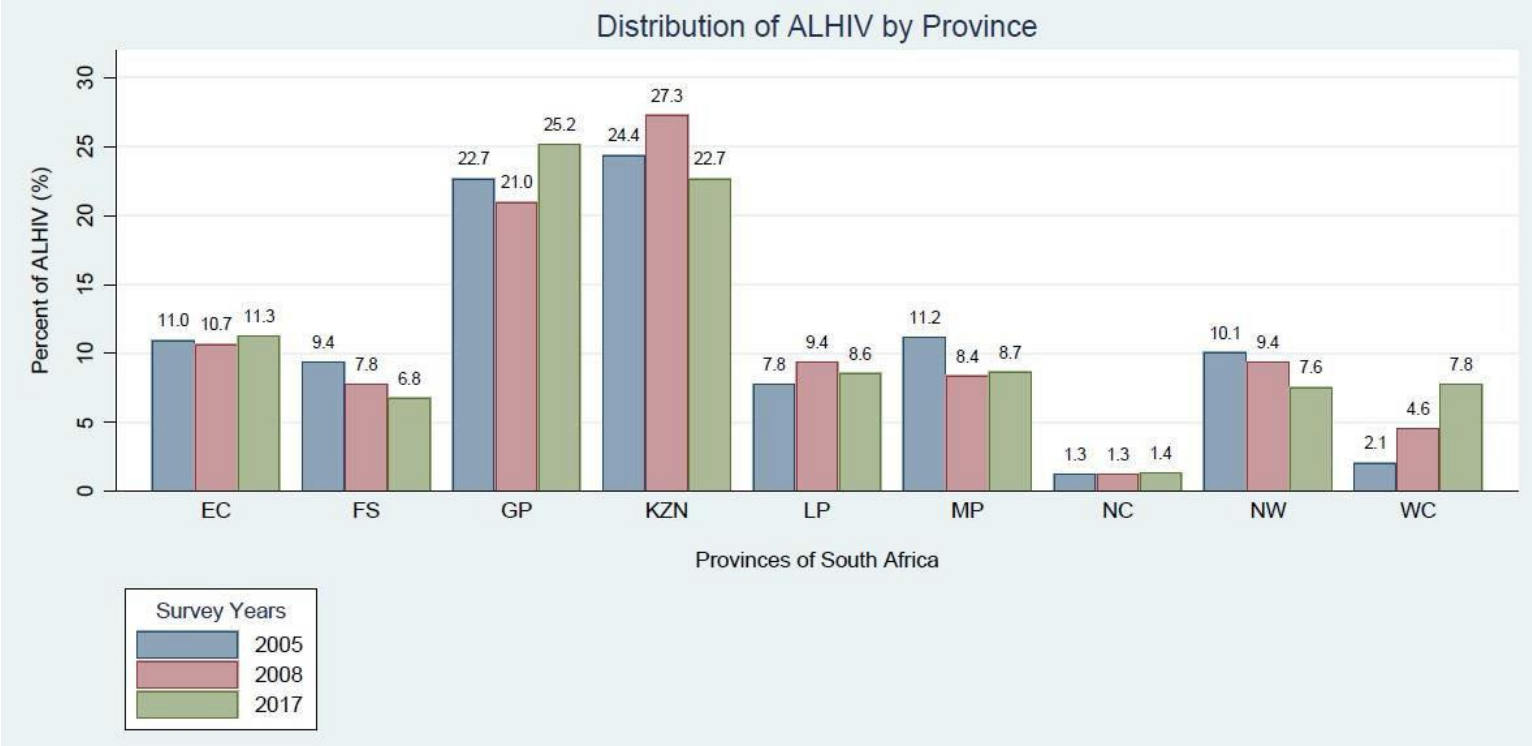


Figure 3.1: Distribution of study participants by province in 2005, 2008 & 2017

3.2 PREVALENCE, CHARACTERISTICS, DISTRIBUTION, AND TREND OF HYPERTENSION AND DIABETES

The overall prevalence of hypertension was 11.8% in 2005, 9.5% in 2008 and 14.3% in 2017. Whereas the overall prevalence of diabetes was 3.3% in 2005, 2.8% in 2008 and 3.2% in 2017 (Table 3.2 & 3.3). Generally, the trend for hypertension increased while that of diabetes remained the same from 2005 to 2017 (Figure 3.4). The median age (IQR) for hypertensive participants increased over the years from 37 (33 - 47) years in 2005 to 44 (34 - 50) years in 2008 and 48 (38 - 55) years in 2017. For diabetes, the median age (IQR) increased from 35 (29 - 44) years in 2005 to 47 (37 - 53) years in 2008 and 49 (42 - 57) years in 2017. Additionally, while there was a decreased trend in hypertension and diabetes in the 25–34 age group over the three years, the trend in the 45+ years age group increased (Figure 3.5).

Furthermore, in 2005, 2008 and 2017 females had a higher prevalence of hypertension at 13.9%, 12.8% and 16.6% respectively compared to males. However, males had a higher prevalence of diabetes in 2005 at 4.5%, while females had a higher prevalence in 2008 and 2017 at 3.5% and 3.6% respectively. Similarly, Black Africans had the highest prevalence of hypertension at 11.8% in 2005 whereas, Non- Black Africans had the highest prevalence of hypertension at 13.9% and 20.3% respectively in 2008 and 2017. The prevalence estimates for diabetes were as follows: Black Africans with 3.3% in 2005, Non-Black Africans with 8.0% in 2008 and Non-Black Africans with 5.6% in 2017. In 2017, those who were exposed to ARVs had a high prevalence of hypertension at 15.1% and a marginally lower prevalence of diabetes at 3.2% compared to those who were naïve to ARVs.

Geographically, the prevalence distribution among those who were hypertensive was highest in KwaZulu Natal at 37.0% in 2005, and in 2008 and 2017, Gauteng had the highest proportion of 27.6% and 29.0% respectively (Figure 3.2). The prevalence of diabetes was highest in KwaZulu Natal in 2005 and 2008 at 25.5% and 28.2% respectively, and in 2017, Gauteng had the highest estimation at 29.4% (Figure 3.3).

Table 3.2: Association between hypertension and characteristics of study participants for 2005, 2008 and 2017 [1]

Population characteristics	2005 Hypertension	2005 No hypertension	p-value	2008 Hypertension	2008 No hypertension	p-value	2017 Hypertension	2017 No hypertension	p-value
Overall	**126 (11.8%)**	**820 (88.2%)**		**107 (9.5%)**	**859 (90.5%)**		**372 (14.3%)**	**1955 (85.7%)**	
Sex									
Female	97 (13.9%)	542 (86.1%)	0.057	93 (12.8%)	578 (87.2%)	<0.001	289 (16.6%)	1365 (83.4%)	<0.001
Male	29 (8.2%)	278 (91.8%)		14 (3.0%)	281 (97.0%)		83 (10.1%)	590 (89.9%)	
Age									
Median (IQR)	37 (33 - 47)	34 (29 - 39)		44 (34 - 50)	34 (29 - 39)		48 (38 - 55)	36 (31 - 44)	
25 – 34 years	30 (8.6%)	396 (91.4%)		21 (4.9%)	396 (95.1%)		48 (5.8%)	761 (94.3%)	
35 – 44 years	37 (12.0%)	288 (88.0%)	0.009	31 (7.9%)	296 (92.1%)	<0.001	84 (9.8%)	647 (90.2%)	<0.001
45+ years	59 (21.3%)	136 (78.7%)		55 (26.1%)	167 (73.7%)		240 (30.6%)	547 (69.4%)	
Race									
Non-Black African	15 (10.4%)	65 (89.6%)	0.757	4 (13.9%)	54 (86.1%)	0.476	41 (20.3%)	153 (79.7%)	0.087
Black African	111 (11.8%)	754 (88.2%)		103 (9.4%)	805 (90.6%)		331 (14.1%)	1802 (85.9%)	
Marital status									
Never married	41 (9.5%)	437 (90.5%)	0.121	54 (8.5%)	524 (91.6%)	0.154	192 (11.9%)	1288 (88.1%)	<0.001
Ever married	84 (14.3%)	380 (85.7%)		53 (11.7%)	332 (88.3%)		180 (18.9%)	667 (81.1%)	
Highest educational qualification									
None or Primary	68 (15.1%)	315 (84.9%)	0.147	56 (13.4%)	274 (86.6%)	0.072	101 (18.9%)	441 (81.1%)	0.002
Secondary and above	58 (9.74%)	503 (90.3%)		50 (8.0%)	580 (92.0%)		199 (12.3%)	1253 (87.7%)	
Employment status									
Unemployed	59 (9.9%)	462 (90.1%)	0.108	54 (9.9%)	423 (90.1%)	0.314	249 (15.4%)	1199 (84.6%)	<0.001
Employed	40 (13.0%)	291 (87.0%)		34 (7.9%)	345 (92.1%)		99 (11.0%)	718 (89.0%)	
Other (incl. old age pensioner. sick/disabled and unable to work)	26 (20.3%)	64 (79.7%)		19 (13.4%)	90 (86.6%)		23 (33.7%)	37 (66.3%)	
Locality									
Urban formal	57 (12.7%)	326 (87.3%)	0.491	47 (12.4%)	323 (87.6%)	0.072	236 (15.9%)	1027 (84.1%)	0.008
Urban informal	34 (14.2%)	180 (85.8%)		30 (10.3%)	208 (89.7%)				
Tribal area/Rural informal	28 (10.7%)	239 (89.3%)		25 (6.1%)	238 (93.9%)		99 (11.6%)	636 (88.4%)	
Rural formal	7 (6.2%)	75 (93.8%)		5 (5.9%)	90 (94.1%)		37 (10.1%)	292 (89.9%)	
Hazardous alcohol consumption									
No risk	88 (13.2%)	558 (86.8%)	0.085	73 (9.7%)	574 (90.3%)		261 (14.1%)	1359 (85.9%)	

Low risk	24 (6.7%)	175 (93.3%)		25 (11.4%)	181 (88.6%)		83 (16.8%)	407 (83.2%)	
Medium risk	12 (16.4%)	52 (83.6%)		6 (5.2%)	62 (94.8%)	0.230	13 (7.1%)	137 (92.9%)	0.078
High risk	1 (5.5%)	11 (94.5%)		1 (1.2%)	15 (98.8%)		8 (22.6%)	23 (77.4%)	
Addiction likely	1 (4.4%)	11 (95.6%)		1 (1.7%)	12 (98.3%)		4 (9.3%)	25 (90.7%)	
Exposure to ARVs									
ARV exposed							234 (15.1%)	1150 (84.9%)	0.478
ARV naive							107 (13.0%)	600 (87.0%)	
Viral load suppressed									
Yes							254 (15.9%)	1231 (84.1%)	0.033
No							116 (11.9%)	703 (88.1%)	
Perception of general health									
Excellent	5 (7.3%)	88 (92.7%)		5 (2.2%)	161 (97.8%)		42 (10.0%)	371 (90.0%)	
Good	55 (9.0%)	498 (91.0%)	0.003	48 (9.9%)	444 (90.1%)	0.006	186 (13.2%)	1134 (86.8%)	<0.001
Fair	50 (19.3%)	182 (80.7%)		43 (14.5%)	194 (85.5%)		105 (18.4%)	370 (81.6%)	
Poor	15 (22.9%)	51 (77.1%)		11 (10.0%)	59 (90.0%)		39 (27.1%)	78 (72.9%)	
Diabetes									
Yes	20 (56.1%)	14 (43.9%)	<0.001	17 (54.0%)	10 (46.0%)	<0.001	49 (52.7%)	35 (47.3%)	<0.001
No	103 (10.3%)	804 (89.7%)		88 (7.7%)	849 (92.3%)		322 (13.1%)	1919 (86.9%)	
Heart disease									
Yes				7 (28.8%)	12 (71.2%)	0.008	23 (41.8%)	25 (58.2%)	<0.001
No				99 (8.7%)	845 (91.3%)		346 (13.6%)	1922 (86.4%)	
Cancer									
Yes	3 (54.5%)	2 (45.5%)	0.009	3 (65.5%)	3 (34.5%)	<0.001	4 (66.2%)	4 (33.8%)	<0.001
No	120 (11.5%)	816 (88.5%)		102 (8.8%)	855 (91.2%)		365 (14.2%)	1946 (85.8%)	
Mental distress									
Yes	71 (18.2%)	327 (81.8%)	0.004	5 (8.6%)	31 (91.4%)	0.951	128 (16.1%)	512 (83.9%)	0.230
No	53 (7.52%)	491 (92.5%)		99 (8.9%)	826 (91.1%)		244 (13.7%)	1443 (86.3%)	
Tuberculosis									
Yes	9 (15.4%)	54 (84.6%)	0.467	5 (7.6%)	44 (92.5%)	0.757	16 (19.5%)	60 (80.5%)	0.257
No	114 (11.5%)	766 (88.5%)		100 (9.0%)	815 (91.0%)		352 (14.1%)	1891 (85.9%)	
Health care access									
Public	109 (12.7%)	675 (87.3%)	0.113	90 (10.6%)	649 (89.4%)	0.104	337 (14.7%)	1766 (85.3%)	0.296
Private	15 (7.1%)	122 (92.9%)		15 (6.3%)	186 (93.7%)		35 (12.7%)	164 (87.3%)	

[1] Analysis was done on weighted data and weighted percentages are presented

Table 3.3: Association between diabetes and characteristics of study participants for 2005, 2008 and 2017 [2]

Population characteristics	2005			2008			2017		
	Diabetes	**No diabetes**	**p-value**	**Diabetes**	**No diabetes**	**p-value**	**Diabetes**	**No diabetes**	**p-value**
Overall	**34 (3.3%)**	**907 (96.7%)**		**29 (2.8%)**	**937 (97.2%)**		**87 (3.2%)**	**2242 (96.8%)**	
Sex									
Female	22 (2.5%)	614 (97.5%)	0.198	26 (3.5%)	645 (96.5%)	0.227	63 (3.6%)	1592 (96.4%)	0.208
Male	12 (4.5%)	293 (95.5%)		3 (1.5%)	292 (98.5%)		24 (2.5%)	650 (97.5%)	
Age									
Median (IQR)	35 (29 - 44)	34 (29 - 40)		47 (37 - 53)	34 (29 - 40)		49 (42 - 57)	37 (32 - 46)	
25 – 34 years	10 (3.1%)	415 (96.9%)		5 (1.1%)	411 (98.9%)		4 (0.7%)	804 (99.3%)	
35 – 44 years	12 (3.1%)	312 (96.9%)	0.866	9 (2.2%)	317 (97.8%)	<0.001	21 (2.8%)	710 (97.2%)	<0.001
45+ years	12 (4.1%)	180 (95.9%)		15 (9.2%)	209 (90.8%)		62 (6.8%)	728 (93.2%)	
Race									
Non-Black African	3 (0.9%)	76 (99.1%)	0.030	3 (8.0%)	55 (92.0%)	0.103	10 (5.6%)	183 (94.4%)	0.184
Black African	31 (3.3%)	830 (96.7%)		26 (2.7%)	882 (97.3%)		77 (3.1%)	2059 (96.9%)	
Marital status									
Never married	11 (3.2%)	465 (96.8%)	0.944	11 (2.0%)	566 (98.0%)	0.097	38 (2.8%)	1441 (97.2%)	0.250
Ever married	23 (3.3%)	438 (96.7%)		18 (4.5%)	368 (95.5%)		49 (3.9%)	801 (96.1%)	
Highest educational qualification									
None or Primary	12 (3.0%)	370 (97.0%)	0.915	12 (4.5%)	318 (95.5%)	0.157	34 (7.1%)	509 (92.9%)	<0.001
Secondary and above	22 (3.5%)	535 (96.5%)		16 (2.2%)	614 (97.9%)		37 (1.7%)	1416 (98.3%)	
Employment status									
Unemployed	17 (3.0%)	501 (97.0%)		17 (2.4%)	460 (97.6%)		56 (3.4%)	1394 (96.6%)	
Employed	13 (3.7%)	317 (96.3%)		9 (2.9%)	370 (97.1%)		29 (3.0%)	788 (97.0%)	
Other (incl. old age pensioner. sick/disabled and unable to work)	4 (3.4%)	85 (96.6%)	0.915	3 (5.0%)	106 (95.0%)	0.528	2 (1.4%)	58 (98.6%)	0.582
Locality									
Urban formal	18 (4.2%)	361 (95.8%)		11 (3.1%)	359 (96.9%)		56 (3.5%)	1209 (96.5%)	
Urban informal	10 (4.8%)	203 (95.2%)		6 (2.0%)	231 (98.0%)				
Tribal area/Rural informal	6 (2.1%)	261 (97.9%)	0.271	9 (2.5%)	255 (97.53%)	0.797	24 (2.8%)	711 (97.2%)	0.241
Rural formal	0 (0.0%)	82 (100%)		3 (4.6%)	92 (95.4%)		7 (1.4%)	322 (98.6%)	
Hazardous alcohol consumption									
No risk	22 (3.4%)	623 (96.7%)	0.040	22 (3.2%)	625 (96.8%)	0.679	62 (3.2%)	1559 (96.9%)	
Low risk	5 (1.1%)	191 (98.9%)		5 (1.9%)	201 (98.1)		19 (3.0%)	472 (97.0%)	0.548

Medium risk	6 (9.6%)	57 (90.4%)		0 (0.0%)	68 (100%)		4 (5.3%)	146 (94.7%)	
High risk	0 (0.0%)	12 (100%)		1 (2.4%)	15 (97.6%)		1 (0.2%)	30 (99.8%)	
Addiction likely	1 (6.0%)	11 (94.0%)		0 (0.0%)	13 (100%)		0 (0.0%)	29 (100%)	
Exposure to ARVs									
ARV exposed							56 (3.2%)	1331 (96.8%)	0.675
ARV naive							26 (3.3%)	680 (96.7%)	
Viral load suppressed									
Yes							56 (3.0%)	1430 (97.0%)	0.392
No							30 (3.5%)	790 (96.5%)	
Perception of general health									
Excellent	1 (1.5%)	92 (98.5%)		1 (0.9%)	165 (99.1%)		6 (1.2%)	406 (98.8%)	
Good	14 (1.8%)	537 (98.2%)	0.001	10 (2.0%)	481 (98.0%)	0.031	42 (2.6%)	1278 (97.5%)	<0.001
Fair	15 (8.4%)	214 (91.6%)		15 (6.2%)	223 (93.8%)		22 (4.1%)	457 (95.9%)	
Poor	4 (3.9%)	62 (96.1%)		3 (2.7%)	67 (97.3%)		17 (13.9%)	99 (86.1%)	
Hypertension									
Yes	20 (15.6%)	103 (84.4%)	<0.001	17 (16.1%)	88 (83.9%)	<0.001	49 (11.3%)	322 (88.7%)	<0.001
No	14 (1.6%)	804 (98.4%)		10 (1.4%)	849 (98.7%)		35 (1.7%)	1919 (98.3%)	
Heart disease									
Yes				5 (22.1%)	15 (77.9%)	<0.001	4 (5.5%)	44 (94.5%)	0.298
No				23 (2.4%)	920 (97.6%)		83 (3.1%)	2188 (96.9%)	
Cancer									
Yes	3 (54.5%)	2 (45.5%)	<0.001	2 (48.7%)	4 (51.3%)	<0.001	3 (41.5%)	5 (58.5%)	<0.001
No	31 (2.9%)	905 (97.1%)		25 (2.3%)	933 (97.7%)		84 (3.1%)	2230 (96.9%)	
Mental distress									
Yes	19 (5.0%)	376 (95.0%)	0.061	3 (8.9%)	33 (91.1%)	0.053	25 (3.4%)	615 (96.6%)	0.789
No	15 (2.1%)	527 (97.9%)		24 (2.3%)	902 (97.7%)		62 (3.1%)	1627 (96.9%)	
Tuberculosis									
Yes	4 (7.4%)	57 (92.6%)	0.134	4 (7.1%)	45 (92.9%)	0.116	8 (5.9%)	68 (94.1%)	0.142
No	30 (3.0%)	850 (97.0%)		24 (2.5%)	892 (95.5%)		79 (3.1%)	2168 (96.9%)	
Health care access									
Public	28 (3.2%)	753 (96.8%)	0.559	21 (2.3%)	719 (97.7%)	0.190	69 (2.8%)	2034 (97.2%)	0.002
Private	6 (4.4%)	130 (95.6%)		7 (5.1%)	193 (94.9%)		17 (8.1%)	184 (91.9%)	

[2] Analysis was done on weighted data and weighted percentages are presented

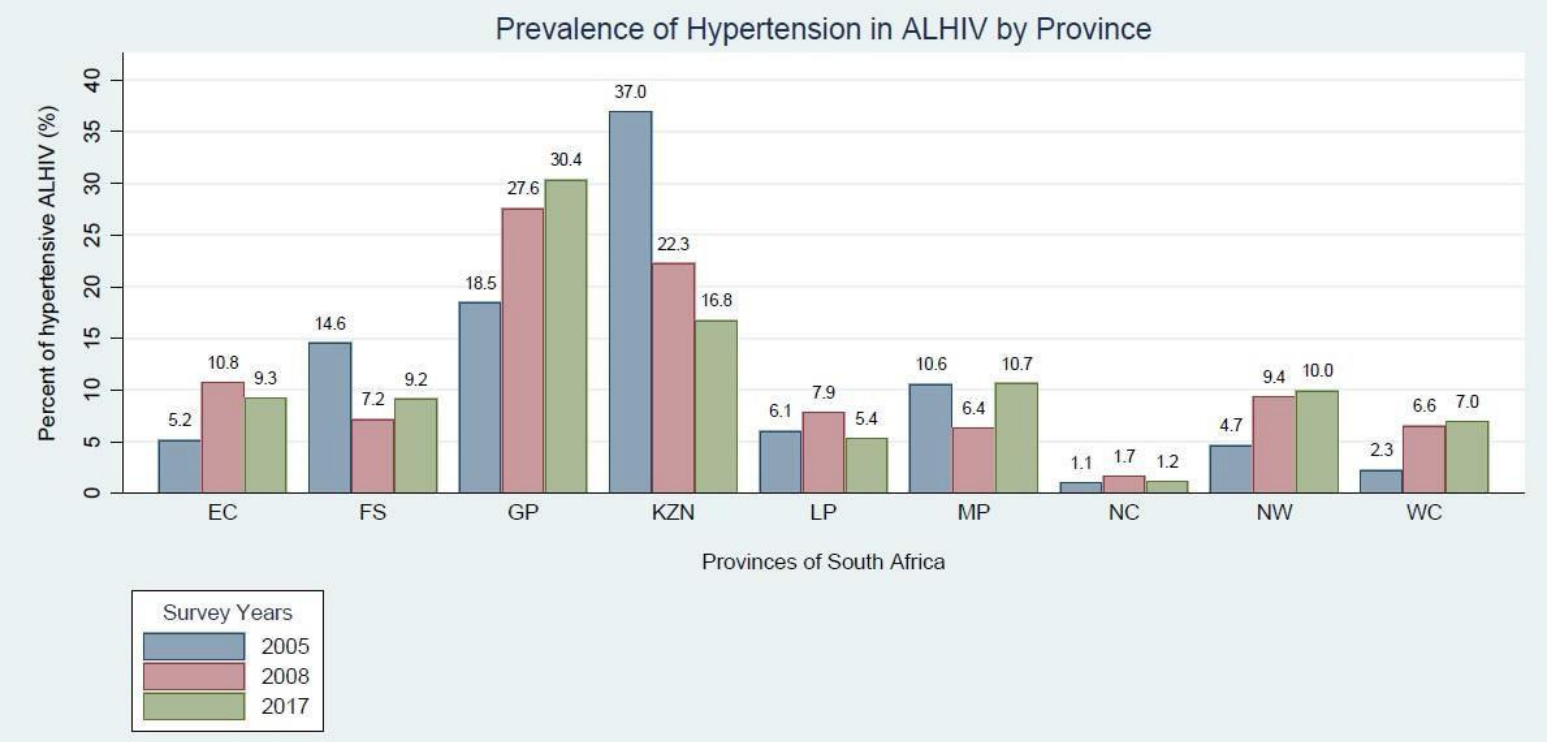


Figure 3.2: Proportion of hypertension among ALHIV by provinces in 2005, 2008 & 2017

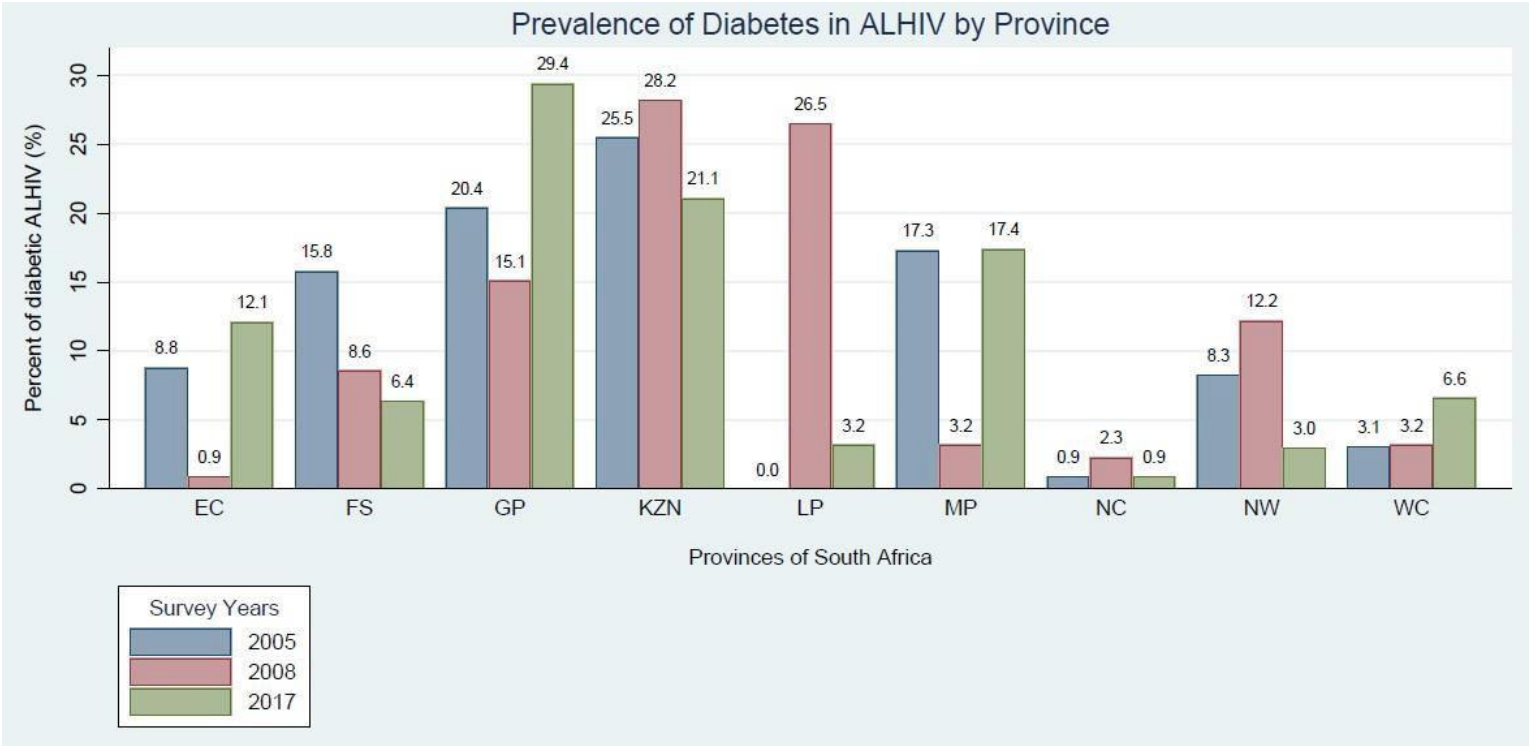
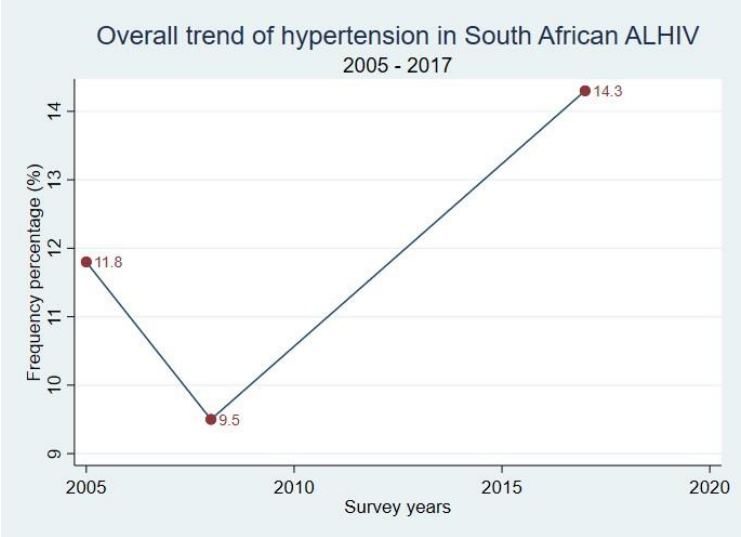


Figure 3.3: Proportion of diabetes among ALHIV by provinces in 2005, 2008 & 2017



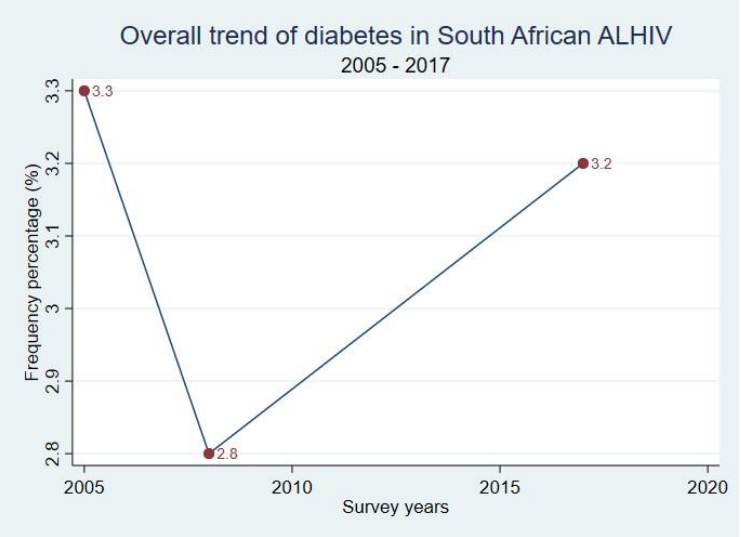
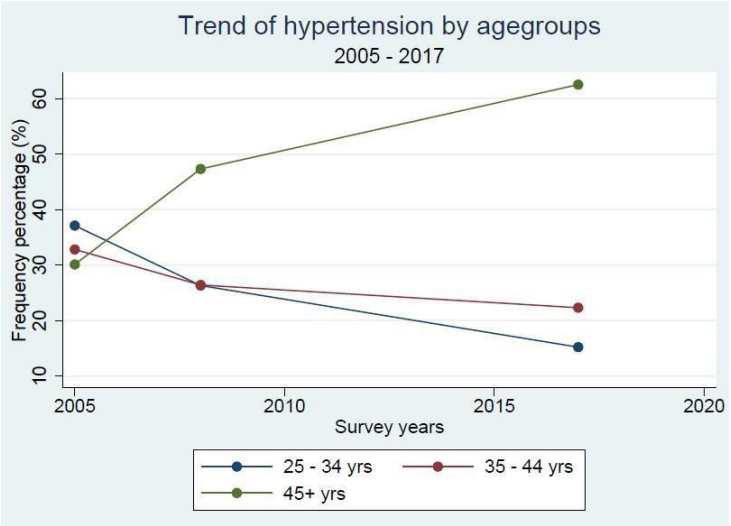


Figure 3.4: Overall trends of hypertension and diabetes



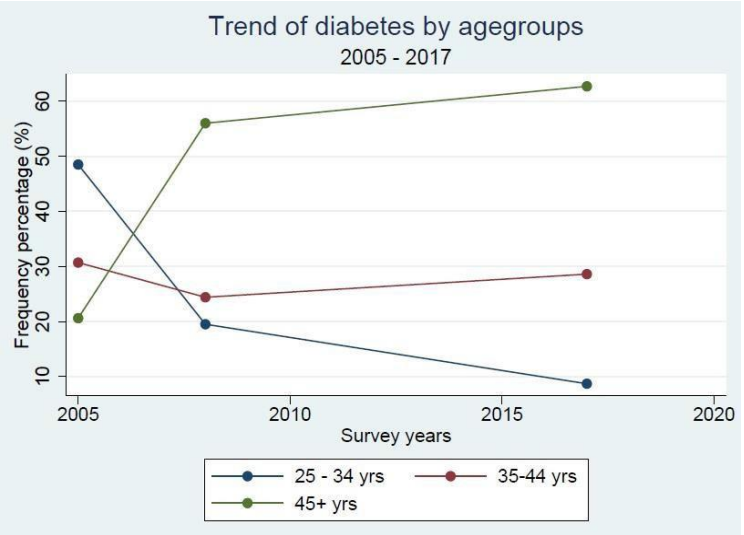


Figure 3.5: Trend of hypertension and diabetes by age groups

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3.3 FACTORS ASSOCIATED WITH HYPERTENSION & DIABETES AMONG ALHIV IN SOUTH AFRICA IN 2005, 2008 & 2017

Table 3.4: Factors associated with hypertension among ALHIV in SA for 2005

Variables in the model	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Sex				
Male	Reference		Reference	
Female	1.81 (0.98 – 3.37)	.060	2.59 (1.26 – 5.32)	0.010
Age groups				
25 – 34 years	Reference		Reference	
35 – 44 years	1.46 (0.73 – 2.92)	.285	1.72 (0.81 – 3.64)	0.155
45+ years	2.90 (1.43 – 5.885)	.003	4.03 (1.96 – 8.28)	<0.001
Race				
Non-Black African	Reference		Reference	
Black African	1.15 (0.47– 2.85)	.757	0.96 (0.34 – 2.81)	0.941
Hazardous alcohol consumption				
No risk	Reference		Reference	
Low risk	0.47 (0.23 – 0.95)	.037	0.56 (0.26 – 1.24)	0.152
Medium risk	1.28 (0.55 – 2.98)	.561	1.48 (0.60 – 3.69)	0.396
High risk	0.38 (0.05 – 3.18)	.372	0.38 (0.04 – 3.37)	0.387
Addiction likely	0.29 (0.03 – 2.44)	.254	0.18 (0.01 – 2.92)	0.225
Diabetes				
No	Reference		Reference	
Yes	11.16 (4.14 – 30.05)	<0.001	11.73 (4.02 – 34.20)	<0.001
Mental distress				
No	Reference		Reference	
Yes	2.73 (1.54 – 4.85)	.001	2.97 (1.59 – 5.54)	0.001

In 2005, factors that were significantly associated with hypertension were being female, in the age group 45+ years, having diabetes and mental distress. Generally, females had higher odds of hypertension (aOR = 2.59; 95% CI = 1.26 to 5.32) than males. The odds of hypertension increased with increasing age, with the age group 45+ years having the highest odds (aOR = 4.03; 95% CI = 1.96 to 8.28) than the age group 25 – 34 years. Having other medical conditions such as diabetes (aOR = 11.73; 95% CI = 4.02 to 34.20), and mental distress (aOR = 2.97; 95% CI = 1.59 to 5.54) increased the odds of also having hypertension.

Table 3.5: Factors associated with diabetes among ALHIV in SA for 2005

Variables in the model	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Sex				
Male	Reference		Reference	
Female	0.55 (0.22 – 1.39)	0.204	0.41 (0.14 – 1.20)	0.105
Age groups				
25 – 34 years	Reference		Reference	
35 – 44 years	1.00 (0.35 – 2.89)	0.993	0.88 (0.29 – 2.66)	0.824
45+ years	1.32 (0.44 – 3.93)	0.617	0.58 (0.19 – 7.75)	0.333
Race				
Non-Black African	Reference		Reference	
Black African	3.77 (1.04 – 13.65)	0.043	5.70 (1.10 – 29.44)	0.038
Perception of general health				
Excellent	Reference		Reference	
Good	1.20 (0.15 – 9.78)	0.864	1.41 (0.26 – 7.62)	0.687
Fair	5.91 (0.71 – 48.97)	0.099	5.16 (0.92 – 29.01)	0.062
Poor	2.61 (0.25 – 27.00)	0.421	2.30 (0.33 – 16.05)	0.400
Hypertension				
No	Reference		Reference	
Yes	11.16 (4.14 – 30.05)	<0.001	11.71 (3.78 – 36.29)	<0.001
Mental distress				
No	Reference		Reference	
Yes	2.47 (0.93 – 6.54)	0.069	1.09 (0.40 – 2.92)	0.869
Health facility of choice				
Private	Reference		Reference	
Public	0.73 (0.25 – 2.14)	0.560	0.42 (0.15 – 1.11)	0.075

In 2005, factors that were significantly associated with diabetes were being Black African and having hypertension. Black Africans had five times the odds of having diabetes when compared to Non-Africans (aOR = 5.70; 95% CI = 1.10 to 29.44). Having hypertension (aOR = 11.71; 95% CI = 3.78 to 36.29) was significantly associated with and had higher odds of diabetes in 2005.

Table 3.6: Factors associated with hypertension among ALHIV in SA for 2008

Variables in the model	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Sex				
Male	Reference		Reference	
Female	4.81 (2.10 – 11.02)	<0.001	4.31 (1.94 – 9.58)	<0.001
Age groups				
25 – 34 years	Reference		Reference	
35 – 44 years	1.68 (0.76 – 3.71)	0.202	2.22 (0.99 – 4.97)	0.052
45+ years	6.95 (3.34 – 14.45)	<0.001	8.44 (3.92 – 18.15)	<0.001
Race				
Non-African	Reference		Reference	
African	0.65 (0.19 – 2.17)	0.479	0.67 (0.14 – 3.28)	0.616
Locality				
Tribal area/Rural informal	Reference		Reference	
Rural formal	0.96 (0.25 – 3.66)	0.955	0.93 (0.35 – 2.46)	0.877
Urban informal	1.77 (0.90 – 3.51)	0.099	2.40 (1.06 – 5.43)	0.036
Urban formal	2.20 (1.13 – 4.28)	0.021	2.95 (1.34 – 6.53)	0.008
Hazardous alcohol consumption				
No risk	Reference		Reference	

Low risk	1.20 (0.61 – 2.36)	0.602	1.44 (0.66 – 3.12)	0.357
Medium risk	0.50 (.018 – 1.42)	0.196	0.78 (0.26 – 2.35)	0.660
High risk	0.11 (0.01 – 0.97)	0.047	0.15 (0.01 – 1.78)	0.134
Addiction likely	0.16 (0.02 – 1.47)	0.106	0.25 (0.03 – 1.97)	0.186
Perception of general health				
Excellent	Reference		Reference	
Good	4.92 (1.49 – 16.22)	0.009	3.72 (1.00 – 13.81)	0.050
Fair	7.56 (2.33 – 24.58)	0.001	5.44 (1.40 – 21.12)	0.015
Poor	4.95 (1.30 – 18.80)	0.019	4.82 (1.05 – 22.20)	0.043
Diabetes				
No	Reference		Reference	
Yes	14.03 (5.27 – 37.35)	<0.001	6.16 (1.68 – 22.59)	0.006
Heart disease				
No	Reference		Reference	
Yes	4.26 (1.33 – 13.70)	0.015	1.13 (0.23 – 5.52)	0.881
Health care access				
Private	Reference		Reference	
Public	1.76 (0.88 – 3.51)	0.108	2.58 (1.02 – 6.51)	0.045

In 2008, factors that were significantly associated with hypertension were being female, in the age group 45+ years, living in an urban formal area, reporting having good, fair or poor health, diabetes and accessing public health care. Females were four times (aOR = 4.31; 95% CI = 1.94 to 9.58) as likely to have hypertension compared to their male counterparts. In addition, older participants were more likely to have hypertension with the age group 45 years and older having the highest odds (aOR = 8.44; 95% CI = 3.92 to 18.15). Those who perceived their general health to be good had three times the odds (aOR = 3.72; 95% CI = 1.00 to 13.81), whereas those who regarded it to be fair had five times the odds (aOR = 5.44; 95% CI = 1.40 to 21.12), and those who said poor had four times the odds of hypertension (aOR = 4.82; 95% CI = 1.05 to 22.20), as opposed to those who judged their health to be excellent. Those who

lived in an urban formal area (aOR = 2.95; 95% CI = 1.34 to 6.53) and those that reported having diabetes (aOR = 6.16; 95% CI = 1.68 to 22.59) also had high odds of having hypertension. Those who accessed public health care services had more than two times the odds of having hypertension when compared to those who accessed private health care (aOR = 2.58; 95% CI = 1.02 to 6.51).

Table 3.7: Factors associated with diabetes among ALHIV in SA for 2008

Variables in the model	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Sex				
Male	Reference		Reference	
Female	2.31 (0.57 – 9.32)	0.239	1.28 (0.28 – 5.77)	0.747
Age groups				
25 – 34 years	Reference		Reference	
35 – 44 years	2.03 (0.46 – 8.98)	0.352	1.95 (0.43 – 8.86)	0.383
45+ years	9.14 (2.67 – 31.27)	0.001	4.44 (1.00 – 19.73)	0.050
Race				
Non-African	Reference		Reference	
African	0.32 (0.08 – 1.35)	0.122	0.39 (0.09 – 1.81)	0.231
Hypertension				
No	Reference		Reference	
Yes	14.03 (5.27 – 37.35)	<0.001	7.56 (2.29 – 24.92)	<0.001
Heart disease				
No	Reference		Reference	
Yes	11.71 (3.02 – 45.39)	<0.001	6.92 (1.62 – 29.62)	0.009

In 2008, factors that were significantly associated with diabetes were being in the age group 45+ years, having hypertension and having heart disease. Those who were aged 45 years and older (aOR = 4.44; 95% CI = 1.00 to 19.73), reported having hypertension (aOR = 7.56; 95% CI = 2.29 to 24.92) and reported having heart disease (aOR = 6.92; 95% CI = 1.62 to 29.62) had high odds of having diabetes.

Table 3.8: Factors associated with hypertension among ALHIV in SA for 2017

Variables in the model	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Sex				
Male	Reference		Reference	
Female	1.76 (1.29 – 2.41)	<0.001	2.33 (1.60 – 3.42)	<0.001
Age groups				
25 – 34 years	Reference		Reference	
35 – 44 years	1.78 (1.11 – 2.83)	0.016	1.83 (1.12 – 3.00)	0.017
45+ years	7.24 (4.88 – 10.74)	<0.001	7.32 (4.78 – 11.21)	<0.001
Race				
Non-Black African	Reference		Reference	
Black African	0.65 (0.39 – 1.07)	0.090	0.61 (0.33 – 1.13)	0.116
Employment status				
Unemployed	Reference		Reference	
Employed	0.68 (0.48 – 0.98)	0.037	0.76 (0.50 – 1.15)	0.193
Other (incl. old age pensioner, sick/disabled and unable to work)	2.80 (1.45 – 5.40)	0.002	2.27 (1.09 – 4.73)	0.029
Locality				
Rural informal	Reference		Reference	
Rural (farms)	0.85 (0.51 – 1.42)	0.538	1.58 (0.86 – 2.90)	0.143
Urban	1.44 (1.08 – 1.91)	0.013	1.61 (1.16 – 2.23)	0.004
Exposure to ARVs				
ARV naive	Reference		Reference	
ARV exposed	1.20 (0.85 – 1.68)	0.295	0.97 (0.67 – 1.40)	0.861
Hazardous alcohol consumption				
No risk	Reference		Reference	
Low risk	1.23 (0.88 – 1.71)	0.229	1.26 (0.83 – 1.93)	0.277
Medium risk	0.47 (0.24 – 0.91)	0.025	0.61 (0.29 – 1.30)	0.200
High risk	1.78 (0.57 – 5.57)	0.319	4.43 (1.67 – 11.76)	0.003
Addiction likely	0.78 (0.31 – 1.94)	0.593	1.10 (0.43 – 2.78)	0.845
Diabetes				
No	Reference		Reference	
Yes	7.38 (4.41 – 12.35)	<0.001	5.17 (2.69 – 9.96)	<0.001
Heart disease				
No	Reference		Reference	
Yes	4.57 (2.35 – 8.88)	<0.001	3.36 (1.59 – 7.10)	0.002

In 2017, factors that were significantly associated with hypertension were being female, in the age groups 35 – 44 years and 45+ years, pensioners and the sick, living in an urban area, high risk for hazardous alcohol consumption, diabetes and heart disease. Females had higher odds (aOR = 2.33; 95% CI = 1.60 to 3.42) compared to the males. As with the previous years, the odds of having hypertension increased with increasing age. Those who were 45 years and older had the highest odds (aOR = 7.32; 95% CI = 4.78 to 11.21) of hypertension when compared to those who were between 25 and 34 years. Pensioners and the sick (aOR = 2.27; 95% CI = 1.09 to 4.73) had increased odds of hypertension compared to those unemployed. Living in an urban area (aOR = 1.61; 95% CI = 1.16 to 2.23) increased one's odds of hypertension. Those who had a high risk of hazardous alcohol consumption had (aOR = 4.43; 95% CI = 1.67 to 11.76) high odds of hypertension when compared to those who had no risk or were non-drinkers.

Those who were diabetic (aOR = 5.17; 95% CI = 2.69 to 9.96) or had heart disease (aOR = 3.36; 95% CI = 1.59 to 7.10) also had high odds of having hypertension.

Table 3.9: Factors associated with diabetes among ALHIV in SA for 2017

Variables in the model	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Sex				
Male	Reference		Reference	
Female	1.47 (0.80 – 2.70)	0.210	1.80 (0.86 – 3.78)	0.121
Age groups				
25 – 34 years	Reference		Reference	
35 – 44 years	3.88 (1.01 – 14.93)	0.049	6.38 (1.80 – 22.62)	0.004
45+ years	9.88 (2.96 – 32.95)	<0.001	7.90 (2.11 – 29.58)	0.002
Race				
Non-African	Reference		Reference	
African	0.54 (0.211 – 1.36)	0.190	0.52 (0.15 – 1.82)	0.300
Educational level				
None or Primary	Reference		Reference	
Secondary and above	0.22 (0.13 – 0.39)	<0.001	0.31 (0.16 – 0.59)	<0.001
Exposure to ARVs				
ARV naive	Reference		Reference	
ARV exposed	0.98 (0.54 – 1.77)	0.934	0.94 (0.47 – 1.85)	0.848
Perception of general health				
Excellent	Reference		Reference	
Good	2.18 (0.86 – 5.52)	0.101	1.15 (0.41 – 3.26)	0.788
Fair	3.56 (1.30 – 9.81)	0.014	1.04 (0.32 – 3.35)	0.947
Poor	13.46 (4.63 – 39.15)	<0.001	6.48 (1.65 – 25.41)	0.007
Hypertension				
No	Reference		Reference	
Yes	7.38 (4.41 – 12.35)	<0.001	4.60 (2.34 – 9.07)	<0.001
Heart disease				
No	Reference		Reference	
Yes	1.79 (0.59 – 5.46)	0.305	0.77 (0.18 – 3.31)	0.722
Healthcare access				
Private	Reference		Reference	
Public	0.34 (0.17 – 0.70)	0.003	0.25 (0.11 – 0.60)	0.002

In 2017, factors that were significantly associated with diabetes were being in the age groups 35 – 44 years and 45+ years, having secondary and above education, reporting having poor health, hypertension and accessing public health care. Participants who were 45 years and older had the highest odds (aOR = 7.90; 95% CI = 2.11 to 29.58) of having diabetes when compared with those who were 25 to 34 years. Those who reported having poor health (aOR = 6.48; 95% CI = 1.65 to 25.41) and having hypertension (aOR = 4.60; 95% CI = 2.34 to 9.07) also had higher odds of having diabetes. Those who had secondary and above education (aOR = 0.31; 95% CI = 0.16 to 0.59) and those who accessed public health care (aOR = 0.25; 95% CI = 0.11 to 0.60) had lower odds of having diabetes.

CHAPTER FOUR: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This chapter discusses and compares the findings to previous studies. Furthermore, limitations experienced in the conduct of the present study, recommendations for further research and conclusion are included.

4.1 DISCUSSION

In this study, we assessed the prevalence, characteristics, distribution, trends, and factors associated with hypertension and diabetes among adults living with HIV in South Africa over three national surveys conducted in 2005, 2008 and 2017 respectively.

4.1.1 OVERALL PREVALENCE AND DISTRIBUTION OF HYPERTENSION AND DIABETES

The overall prevalence of hypertension was 14.3% in 2017, indicating an upward trend from 9.5% in 2008 and 11.8% in 2005. While that of diabetes was 3.2% in 2017, 2.8% in 2008 and 3.3% in 2005, revealing a fairly stagnant trend across the years. This hypertension prevalence of 14.3% is comparable to other studies including a Ugandan (11%), Ethiopian (12.7%), Zimbabwean (10.2%) and South African studies (16%, 17.4%) (22, 24, 30, 31, 36). Whereas, the diabetes prevalence is lower than previously reported in Nigeria (5.6%), Ethiopia (7.1%), the USA (13%) and the IDF estimate for South Africa (12.8%) but comparable to studies done in Zimbabwe (2%) and South Africa (5%) (15, 22, 23, 25, 30, 39).

The high prevalence of hypertension may be due to issues of a lack of awareness, nonadherence to medication and/or poor implementation of guidelines in health facilities (77). ALHIV are likely to interact with the health system more, where screening for hypertension is routine and where case finding should occur (78). On the other hand, the low diabetes prevalence reported in our study may indicate a lack of awareness of this disease in ALHIV or underreporting by the participants. As mentioned above, ALHIV are more likely to engage with the health system than those who are not, however routine vital checks at health facilities do not usually include

testing for diabetes unless patients have been previously diagnosed and appear “unwell” (78). Therefore, the self-reported estimates will underestimate the true prevalence.

With respect to the overall provincial distribution of the two NCDs, this study showed that in 2005 most hypertensive and diabetic participants were from the KwaZulu Natal province. However, for 2017, the Gauteng province had the highest proportions of both NCDs. As to the reason for this shift, a literature search at the time of this study did not yield any findings that could be used for comparison at the provincial level in South Africa. Nonetheless, the likely explanation for the 2005 results is that according to the 2005 SABSSM survey, KwaZulu Natal had a significantly higher number of people living with HIV compared to the other provinces (66). While concerning the shift in 2017, possible reasons include urbanisation, migration and a rise in the elderly population due to ART in PLHIV (70).

4.1.2 POPULATION CHARACTERISTICS OF HYPERTENSION AND DIABETES

Regarding common population characteristics observed across the years, we see that females, the age group 45+ years, and those who had primary level education or less had a high prevalence of hypertension and diabetes. These findings are in line with published studies suggesting that women tend to have better health-seeking behaviour compared to men due to their increased interaction with the health system through reproductive health services and are also more likely to report their health status leading to the underestimation in men (24, 25, 31, 36, 38, 41). Furthermore, those who resided in an urban area in 2017, an urban formal area in 2008 or an urban informal area in 2005 had a higher prevalence for both NCDs too. Such results are supported by the 2012 SANHANES study and the South African cross-sectional study on HIV positive educators which suggested that urban living leads to easy access to unhealthy diets and a sedentary lifestyle (31, 36). In 2008 and 2017, we further see that those who had primary education and below also had a high prevalence of hypertension and diabetes. Additionally, the presence of comorbidities was also evident with higher proportions of individuals with cancer, heart disease, TB and mental distress reporting having hypertension or diabetes. This is consistent with studies that observed similar findings globally and in Africa (6, 36, 62, 63). This could potentially mean that PLHIV who have comorbidity need to be closely monitored and followed to ensure that their health conditions are effectively regulated. And in doing so this thereby reduces their risk of acquiring more NCDs.

4.1.3 FACTORS ASSOCIATED WITH HYPERTENSION AND DIABETES

In 2005, 2008 and 2017 the common associated factors that increased the odds of hypertension included being female, the age group 45+ years, and diabetes. This is comparable to previous research and WHO reports suggesting that increased odds in females were mostly due to women having higher BMI's and hip to weight ratios than men and women being more physically inactive (31, 33, 38). Increased odds for those in the age group 45+ years were attributed to gradual vascular stiffening and to an extent the use of ART particularly protease inhibitors which play a role in the development of hypertension-related vascular reactive oxygen species (26, 48, 49). Whereas the increased odds for those who had diabetes is consistent with published findings, indicating that hypertension is linked to insulin resistance due to multiple pathophysiological mechanisms influencing microvascular and endothelial functioning (49, 50). In 2005 mental distress also significantly increased the odds of high blood pressure, in addition to the reasons listed above. Evidence of this has been verified in previous research such as a US study which found that one's mental health affects their ability to maintain a healthy lifestyle, seek early treatment of comorbid conditions, or consistently adhere to treatment programmes (62). Another factor that significantly increased the odds of hypertension in 2008 and 2017 was living in an urban area. And in line with other studies conducted in the general population, it was reported that urbanisation and the associated lifestyle including poor diet and low physical activity were risk factors of hypertension (55).

Furthermore, having a high risk of hazardous alcohol consumption or having heart disease were also additional factors found in 2017. Alcohol consumption has been documented to increase the risk of hypertension in several studies including a Zimbabwean and a Brazilian study, however, there have been several hypotheses proposed as to why this is the case (56, 57). Some researchers have been able to characterise the pathogenesis of harmful alcohol drinking, citing that it leads to a reduction in vasodilators like nitric oxide resulting in an inflammatory lack of relaxation and oxidative injury of the blood vessels (58). Other researchers have suggested that there is a link between harmful alcohol consumption and the accumulation of triglycerides and total cholesterol, of which the latter two factors have been linked to hypertension (59). Hypertension and diabetes have long been documented to be major modifiable risk factors for heart disease due to the progressive damage to the heart that occurs over time (60, 61). Lastly in 2017, the employment category "other" which included pensioners, sick and disabled people, was also associated with hypertension. The reasoning for this includes that pensioners are

presumably older hence the effect of age may have contributed to this finding; also, sick and disabled people are more likely to be non-mobile and physically inactive, all of which have been documented as risk factors for hypertension.

Regarding diabetes, the common significant factor across the years was having hypertension and the supporting reasons and studies are identical to those mentioned above. In 2008 other additional factors included being 45 years and above and having heart disease; both established risk factors in other studies (55). Lastly in 2017 being 45 years and above, and reporting poor health were significantly associated with diabetes in the study population. Whereas having secondary education and above lowered one's odds of having diabetes. And other studies with a similar finding reported that education increased awareness and therefore the individuals were more likely to make better health-related decisions (24). In spite of the above study findings, some variables surprisingly did not have an association with hypertension. These included the Black African race for all three years and heart disease in 2008. A likely explanation for "race" was that due to the nature of the study data, almost more than 95% of participants were Black African. As such, no variability was present leading to such a finding. As far as the reason for heart disease is concerned, this was most likely due to underreporting bias as we then see an association in the 2017 data. For diabetes, a surprising factor that was not associated with it was age in 2005. The probable explanation for this is that due to the low median age for ALHIV, being 35 years in 2005 versus 47 years in 2008 and 49 years in 2017 this may have contributed to the non-association. Additionally, one could argue that an aspect of survival rates due to the stage of the HIV pandemic in 2005 only a year after the introduction of ART, may have also contributed to this (19).

4.2 LIMITATIONS AND STRENGTHS

This study had a few limitations. Owing to the cross-sectional nature of the surveys, causality cannot be determined. The questionnaire data used were self-reported and thus vulnerable to social desirability and recall bias. The analysis did not account for unmeasured and unreported risk factors and other confounders that may have had an impact on the outcome variables. Also, as hypertension and diabetes were not diagnostically determined, misclassification bias may have been introduced. The self-reported diabetes outcome was not clearly distinguished between type 1 and type 2 diabetes mellitus. The lack of data on the duration on ART and the type of ART regimen may have explained further effects on hypertension. Combining data sets

for the three years of the survey was considered, however, the complexity of having to weigh each data set to the mid-year estimates of each survey year of the study was deemed to be complex and too extensive for this current project. The comment is noted and future secondary analysis using the same datasets will attempt to implement this suggestion. Not combining the data from the three years to formally conduct a trend analysis the data is another limitation of this study. Lastly, wide confidence intervals for certain variables were observed and this may have been as a result of a small sample answering particular questions, therefore, conclusions drawn from the data need to be replicated with a larger sample size. However, apart from these limitations this study also had strengths. Sampling methods ensured that selection bias was minimised. The study was based on a nationally representative sample, and the findings can be generalised to the South African adult population 15 years and older.

4.3 CONCLUSION

In conclusion, our study reported a 2017 prevalence for hypertension and diabetes in PLHIV of 14.3% and 3.2% respectively and these results are largely consistent with findings from other SSA countries. The importance of population-based estimates for making sound health decisions and policies is reiterated. To the best of our knowledge, this has been the first population wide-based study to determine the prevalence and factors of hypertension and diabetes in ALHIV.

4.4 RECOMMENDATIONS

While these findings have contributed to the pool of knowledge, a more robust study using measured hypertension, measured diabetes and more patient characteristics would be useful in increasing validity. Nonetheless, these results can be used by researchers and policymakers to suggest and encourage further examination into, and/or overall adjustment of the integrated chronic disease management model. It is also advised that health care providers actively screen and educate PLHIV about the risks of developing hypertension and diabetes, which are associated with ageing and also being on ART for a prolonged period. Also, population-level or community-based awareness campaigns promoting healthy lifestyles and a positive body image as well as addressing beliefs associated with gaining weight and obesity in PLHIV, are recommended. This is key as, according to a study conducted in Khayelitsha, when a person living with HIV loses excessive weight and their body starts to waste, they also experience

stigma associated with AIDS. When the opposite occurs and they gain weight, the stigma is reduced; however, they may continue to deliberately gain weight by overeating to show that they are well (79). In general, a review of existing education and strategies for the prevention, regulation, and raising awareness of hypertension and diabetes in PLHIV, as well as their implementation, should be considered.

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APPENDICES

APPENDIX 1: PLAGIARISM DECLARATION FORM

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

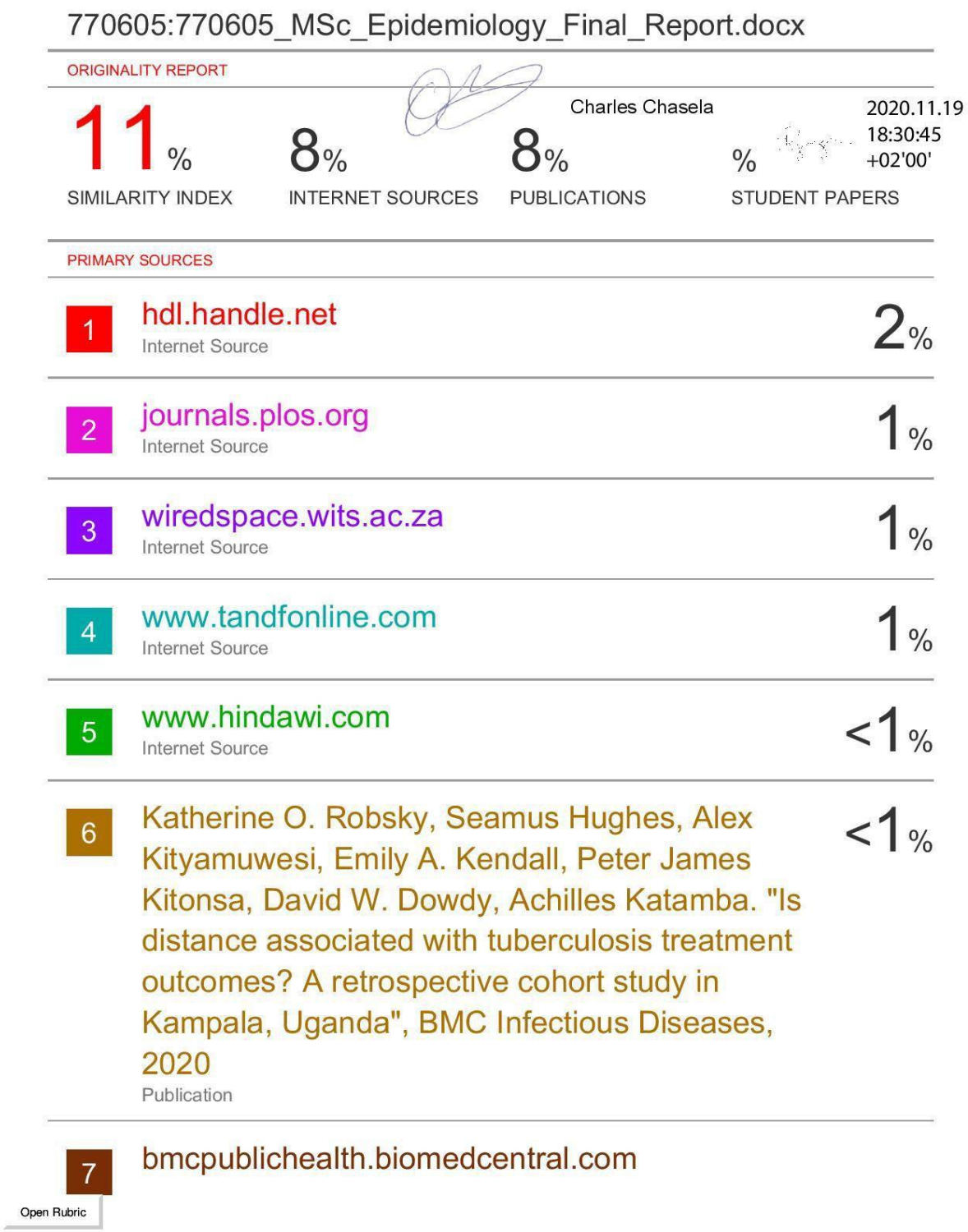
I **Nicola Varaidzo Chiwandire** (Student number: **770605**) am a student registered for the degree of **Master of Science in Epidemiology in the field of Epidemiology and Biostatistics** in the academic year **2019**.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature:  Date: **30th of November 2020**

APPENDIX 2: TURNITIN REPORT SIGNED BY SUPERVISORS



770605:770605_MSc_Epidemiology_Final_Report.docx

ORIGINALITY REPORT

Charles Chasela

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APPENDIX 3: ETHICS CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Ms N Chiwandire

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M191181

NAME: (Principal Investigator)	Ms N Chiwandire
DEPARTMENT:	School of Public Health Division of Epidemiology and Biostatistics
PROJECT TITLE:	Prevalence and factors associated with hypertension and diabetes among adults living with HIV in South Africa
DATE CONSIDERED:	2019/11/29
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Professor C Chasela and Dr N Zungu
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2019/12/17

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the 3rd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **November** and will therefore reports and re-certification will be due early in the month of **November** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

18/12/2019
Date

PLEASE QUOTE THE CLEARANCE CERTIFICATE NUMBER IN ALL ENQUIRIES

APPENDIX 4: APPROVAL OF CHANGE OF TITLE

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

20 April 2020
Person No: 770605
PAG

Miss NV Chiwandire
22 Aberdeen Street
Westdene
2092
South Africa

Dear Miss Nicola Chiwandire

Master of Science in Epidemiology: Approval of Title

We have pleasure in advising that your proposal entitled *Prevalence and factors associated with hypertension and diabetes among adults living with HIV in South Africa*. has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

APPENDIX 5: SENSITIVITY ANALYSIS

Comparison of unweighted and weighted data.

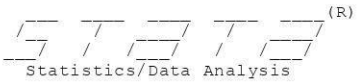
Table A1: Sensitivity analysis of hypertension data in ALHIV for 2005, 2008 and 2017

Sensitivity analysis of Hypertension in ALHIV						
	2005		2008		2017	
All variables	Unweighted %	Weighted %	Unweighted %	Weighted %	Unweighted %	Weighted %
Overall	**13,3**	**11,8**	**11,1**	**9,5**	**14,8**	**14,3**
Sex						
Male	9,5	8,2	4,8	3	10,5	10,1
Female	15,2	13,9	13,9	12,8	16,3	16,6
Age						
25-34	7	8,6	5	4,9	5,1	5,8
35-44	11,4	12	9,5	7,9	10,4	9,8
45+	30,3	21,3	24,8	26,3	29,8	30,6
Race						
Black African	12,8	11,8	11,3	9,4	14,5	20,3
Non-Black African	18,8	10,4	6,9	13,9	21,2	14,1
Locality						
Urban formal	14,9	12,7	12,7	12,4	17,7	15,9
Urban informal	15,9	14,2	12,6	10,3		
Tribal area/Rural informal	10,5	10,7	9,5	6,1	12,6	11,6
Rural formal	8,5	6,2	5,3	5,9	11,2	10,1
Province						
Western Cape	8,8	12,3	11,1	14,8	14,8	13,2
Eastern Cape	9,7	5,5	13,2	9,2	12,8	12,1
Northern Cape	12,8	11,6	13,6	12,2	15,9	14,5
Free State	21,5	17,9	13,7	9,6	20,6	19
KwaZulu-Natal	19,9	17,3	9,2	7,9	12,3	10,8
North-West	8,1	5,3	11,6	9,5	18,7	19
Gauteng	9,9	10,4	12,2	12,4	19,9	16,9
Mpumalanga	9,6	11	8,6	7	14,6	17,1
Limpopo	11	8,8	8,3	7,7	11,6	9

Table A2: Sensitivity analysis of diabetes data in ALHIV for 2005, 2008 and 2017

Sensitivity analysis of Diabetes in ALHIV						
	2005		2008		2017	
All variables	Unweighted %	Weighted %	Unweighted %	Weighted %	Unweighted %	Weighted %
Overall	**3,6**	**3,3**	**3**	**2,8**	**3,4**	**3,2**
Sex						
Male	4	4,5	1	1,5	2,9	2,5
Female	3,5	2,5	3,9	3,5	3,5	3,6

Age						
25-34	2,4	3,1	1,2	1,1	0,4	0,7
35-44	3,7	3,1	2,8	2,2	2,4	2,8
45+	6,3	4,1	6,7	9,2	7,6	6,8
Race						
Black African	3,6	3,3	2,9	2,7	3,3	3,1
Non-Black African	3,8	0,9	5,2	8	5,1	5,6
Locality						
Urban formal	4,8	4,2	3	3,1		
Urban informal	4,7	4,8	2,5	2	4,1	3,5
Tribal area/Rural informal	2,3	2,1	3,4	2,5	2,9	2,8
Rural formal	0	0	3,2	4,6	2,2	1,4
Province						
Western Cape	5,9	4,6	1,9	2,1	2,7	2,8
Eastern Cape	3,6	2,6	0,9	0,2	3,3	3,5
Northern Cape	2,6	2,9	5,1	4,8	4,4	2,5
Free State	4,7	5,3	5,9	3,3	3	2,9
KwaZulu-Natal	5,5	3,3	1,9	3	3,3	3
North-West	2,7	2,6	3,2	3,6	2,1	1,3
Gauteng	3,3	3,2	2,7	2,1	3,9	3,6
Mpumalanga	2,6	5	1,9	1	2,1	6,2
Limpopo	0	0	6	7,7	3,9	1,2




```
      name:  <unnamed>
       log:  C:\Users\nchiwandire\Desktop\Report submission\01 Row percentages\Sensitivity anal
  log type:  smcl
 opened on:   3 Aug 2020, 21:08:02

. do "C:\Users\NCHIWA~1\AppData\Local\Temp\STDe8c_000000.tmp"

. svyset [pweight=ibreal12], strata(prov) psu(ea)

      pweight: ibreal12
          VCE: linearized
  Single unit: missing
     Strata 1: prov
         SU 1: ea
        FPC 1: <zero>

. svydescribe

Survey: Describing stage 1 sampling units

      pweight: ibreal12
          VCE: linearized
  Single unit: missing
     Strata 1: prov
         SU 1: ea
        FPC 1: <zero>
```

			#Obs per Unit		
Stratum	#Units	#Obs	min	mean	max
1	33	64	1	1.9	6
2	65	116	1	1.8	5
3	31	59	1	1.9	6
4	54	112	1	2.1	5
5	88	221	1	2.5	6
6	50	99	1	2.0	5
7	67	159	1	2.4	10
8	43	106	1	2.5	6
9	47	87	1	1.9	5
9	478	1,023	1	2.1	10

```
. 
end of do-file

.  do "C:\Users\NCHIWA~1\AppData\Local\Temp\STDe8c_000000.tmp"

. **********Sensitivity analysis********
. gen hyp_all = .
(1,023 missing values generated)

. replace hyp_all = 0 if hypertension ==2
(859 real changes made)

. replace hyp_all = 1 if hypertension ==1 | hypertension == .
(164 real changes made)

. label value hyp_all noyes
```

```
11 . gen hyp_none = .
(1,023 missing values generated)

12 . replace hyp_none = 0 if hypertension ==2 | hypertension == .
(916 real changes made)

13 . replace hyp_none = 1 if hypertension ==1
(107 real changes made)

14 . label value hyp_none noyes

15 . gen diab_all = .
(1,023 missing values generated)

16 . replace diab_all = 0 if diabetes ==2
(937 real changes made)

17 . replace diab_all = 1 if diabetes ==1 | diabetes == .
(86 real changes made)

18 . label value diab_all noyes

19 . gen diab_none = .
(1,023 missing values generated)

20 . replace diab_none = 0 if diabetes ==2 | diabetes == .
(994 real changes made)

21 . replace diab_none = 1 if diabetes ==1
(29 real changes made)

22 . label value diab_none noyes

23 .
24 . svy linearized, subpop(if hivstat == 1): tab hypertension2, cell ci obs percent format(%11.3g
(running tabulate on estimation sample)

Number of strata   =         9                  Number of obs     =       966
Number of PSUs     =       461                  Population size   =  2,944,291
                                                Subpop. no. obs   =       966
                                                Subpop. size      =  2,944,291
                                                Design df         =       452
```

RECODE of hypertension (Q13_7e1: Do you currently have any of the following illne	percentage	lb	ub	obs
no	90.5	87.6	92.7	859
yes	9.51	7.27	12.4	107
Total	100			966

Key: percentage = **cell percentage**
lb = **lower 95% confidence bound for cell percentage**
ub = **upper 95% confidence bound for cell percentage**
obs = **number of observations**

```
25 . svy linearized, subpop(if hivstat == 1): tab hyp_all , cell ci obs percent format(%11.3g)
(running tabulate on estimation sample)

Number of strata   =         9                  Number of obs     =       1,023
Number of PSUs     =       478                  Population size   =   3,076,350
                                                Subpop. no. obs   =       1,023
                                                Subpop. size      =   3,076,350
                                                Design df         =         469
```

hyp_all	percentage	lb	ub	obs
No	86.6	83	89.5	859
Yes	13.4	10.5	17	164
Total	100			1023

Key: percentage = **cell percentage**
lb = **lower 95% confidence bound for cell percentage**
ub = **upper 95% confidence bound for cell percentage**
obs = **number of observations**

```
26 . svy linearized, subpop(if hivstat == 1): tab hyp_none  , cell ci obs percent format(%11.3g)
(running tabulate on estimation sample)

Number of strata   =         9                  Number of obs     =       1,023
Number of PSUs     =       478                  Population size   =   3,076,350
                                                Subpop. no. obs   =       1,023
                                                Subpop. size      =   3,076,350
                                                Design df         =         469
```

hyp_none	percentage	lb	ub	obs
No	90.9	88.2	93.1	916
Yes	9.1	6.95	11.8	107
Total	100			1023

Key: percentage = **cell percentage**
lb = **lower 95% confidence bound for cell percentage**
ub = **upper 95% confidence bound for cell percentage**
obs = **number of observations**

```
27 .
28 . svy linearized, subpop(if hivstat == 1): tab diabetes2, cell ci obs percent format(%11.3g)
(running tabulate on estimation sample)

Number of strata   =         9                  Number of obs     =         966
Number of PSUs     =       461                  Population size   =   2,931,995
                                                Subpop. no. obs   =         966
                                                Subpop. size      =   2,931,995
                                                Design df         =         452
```

RECODE of diabetes (Q13_7f1: Do you currently have any of the following illnesses	percentage	lb	ub	obs
no	97.2	95.4	98.3	937
yes	2.84	1.72	4.65	29
Total	100			966

Key: percentage = **cell percentage**
lb = **lower 95% confidence bound for cell percentage**

```
        ub          =  upper 95% confidence bound for cell percentage
        obs         =  number of observations

29 . svy linearized, subpop(if hivstat == 1): tab diab_all , cell ci obs percent format(%11.3g)
(running tabulate on estimation sample)

Number of strata   =         9                  Number of obs      =       1,023
Number of PSUs     =       478                  Population size    =   3,076,350
                                                Subpop. no. obs    =       1,023
                                                Subpop. size       =   3,076,350
                                                Design df          =         469

------------------------------------------------------------------------------
   diab_all |  percentage          lb          ub          obs
------------+-----------------------------------------------------------------
         No |        92.6        89.2          95          937
        Yes |         7.4        4.99        10.8           86
            |
      Total |         100                                 1023
------------------------------------------------------------------------------
  Key:  percentage  =  cell percentage
        lb          =  lower 95% confidence bound for cell percentage
        ub          =  upper 95% confidence bound for cell percentage
        obs         =  number of observations

30 . svy linearized, subpop(if hivstat == 1): tab diab_none , cell ci obs percent format(%11.3g)
(running tabulate on estimation sample)

Number of strata   =         9                  Number of obs      =       1,023
Number of PSUs     =       478                  Population size    =   3,076,350
                                                Subpop. no. obs    =       1,023
                                                Subpop. size       =   3,076,350
                                                Design df          =         469

------------------------------------------------------------------------------
  diab_none |  percentage          lb          ub          obs
------------+-----------------------------------------------------------------
         No |        97.3        95.6        98.4          994
        Yes |        2.71        1.64        4.44           29
            |
      Total |         100                                 1023
------------------------------------------------------------------------------
  Key:  percentage  =  cell percentage
        lb          =  lower 95% confidence bound for cell percentage
        ub          =  upper 95% confidence bound for cell percentage
        obs         =  number of observations

31 .
32 . **********Comparison of Logistic Regression Models********
33 . **Number 1: With Original Data for Hypertension
34 . svy: logistic hypertension2 i.sex2 i.age5groups3 i.african ///
> ib3.geotype i.alc_audit i.general_health2  ///
> i.diabetes2 i.heart_disease2 i.healthcare_access2
(running logistic on estimation sample)

Survey: Logistic regression

Number of strata   =         9                  Number of obs      =         919
Number of PSUs     =       453                  Population size    =   2,770,915
                                                Design df          =         444
                                                F(  17,    428)    =        7.51
                                                Prob > F           =      0.0000
```

hypertension2	Odds Ratio	Linearized Std. Err.	t	P>|t|	[95% Conf.	Int
sex2						
male	1	(base)				
female	4.31025	1.752551	3.59	0.000	1.938462	9.
age5groups3						
25 - 34 yrs	1	(base)				
35 - 44 yrs	2.223016	.9095432	1.95	0.052	.9947708	4.
45+ yrs	8.43971	3.288159	5.47	0.000	3.924534	18
african						
No	1	(base)				
Yes	.665585	.5399725	-0.50	0.616	.1351318	3.
geotype						
Urban formal	2.953105	1.192086	2.68	0.008	1.335775	6.
Urban informal	2.400492	.9977254	2.11	0.036	1.060584	5.
Tribal area	1	(base)				
Rural formal	.9258837	.4613007	-0.15	0.877	.3477805	2.
alc_audit						
No risk	1	(base)				
Low risk	1.438467	.5672301	0.92	0.357	.6627177	3.
Medium risk	.7810239	.4378433	-0.44	0.660	.2595225	2.
High risk	.15498	.192456	-1.50	0.134	.0135006	1.
Addiction likely	.2461766	.260366	-1.33	0.186	.0307979	1.
general_health2						
Excellent	1	(base)				
Good	3.716776	2.481739	1.97	0.050	1.000587	13
Fair	5.439705	3.754174	2.45	0.015	1.401261	21
Poor	4.824777	3.746642	2.03	0.043	1.048761	22
diabetes2						
no	1	(base)				
yes	6.158192	4.072679	2.75	0.006	1.678719	22
heart_disease2						
no	1	(base)				
yes	1.128345	.9117443	0.15	0.881	.2305474	5.
healthcare_access2						
Private hospital, clinic or doctor	1	(base)				
Public hospital, clinic or doctor	2.575327	1.214286	2.01	0.045	1.019501	6.
_cons	.0010502	.0016737	-4.30	0.000	.0000458	.0

Note: **_cons** estimates baseline odds.

```
35 .
36 . **Number 2: With Missing Data coded yes for Hypertension
37 . svy: logistic hyp_all i.sex2 i.age5groups3 i.african ///
> ib3.geotype i.alc_audit i.general_health2  ///
> i.diabetes2 i.heart_disease2 i.healthcare_access2
(running logistic on estimation sample)

Survey: Logistic regression

Number of strata   =         9                  Number of obs      =       920
Number of PSUs     =       453                  Population size    =  2,772,953
                                                Design df          =       444
                                                F(  17,    428)    =      7.57
                                                Prob > F           =    0.0000
```

hyp_all	Odds Ratio	Linearized Std. Err.	t	P>|t|	[95% Conf.	Int
sex2						
male	1	(base)				
female	4.310963	1.753426	3.59	0.000	1.938265	9.
age5groups3						
25 - 34 yrs	1	(base)				
35 - 44 yrs	2.223731	.9111081	1.95	0.052	.9939721	4.
45+ yrs	8.469125	3.297643	5.49	0.000	3.940018	1
african						
No	1	(base)				
Yes	.6671588	.5444494	-0.50	0.620	.1341804	3.
geotype						
Urban formal	2.922139	1.174135	2.67	0.008	1.326623	6.
Urban informal	2.366029	.9795928	2.08	0.038	1.04867	5.
Tribal area	1	(base)				
Rural formal	.9073893	.4489612	-0.20	0.844	.3431485	2.
alc_audit						
No risk	1	(base)				
Low risk	1.438129	.5676874	0.92	0.358	.6620269	3.
Medium risk	.7853267	.4403946	-0.43	0.667	.2608614	2.
High risk	.1539428	.1914329	-1.50	0.133	.013365	1.
Addiction likely	.2475224	.2620478	-1.32	0.188	.0309029	1.
general_health2						
Excellent	1	(base)				
Good	3.704021	2.475061	1.96	0.051	.9961809	13
Fair	5.420935	3.742753	2.45	0.015	1.39565	21
Poor	4.768293	3.704515	2.01	0.045	1.035742	
diabetes2						
no	1	(base)				
yes	6.432596	4.194551	2.85	0.005	1.785746	23
heart_disease2						
no	1	(base)				
yes	1.260616	.9394677	0.31	0.756	.2914039	5.
healthcare_access2						
Private hospital, clinic or doctor	1	(base)				
Public hospital, clinic or doctor	2.605253	1.237669	2.02	0.044	1.024158	6
_cons	.0010462	.0016734	-4.29	0.000	.0000451	.0

Note: **_cons** estimates baseline odds.

```
38 .
39 . **Number 3: With Missing Data coded no for Hypertension
40 . svy: logistic hyp_none i.sex2 i.age5groups3 i.african ///
> ib3.geotype i.alc_audit i.general_health2  ///
> i.diabetes2 i.heart_disease2 i.healthcare_access2
(running logistic on estimation sample)

Survey: Logistic regression

Number of strata   =         9                  Number of obs      =       920
Number of PSUs     =       453                  Population size    =  2,772,953
                                                Design df          =       444
                                                F(  17,    428)    =      7.71
                                                Prob > F           =    0.0000
```

hyp_none	Odds Ratio	Linearized Std. Err.	t	P>|t|	[95% Conf.	Int
sex2						
male	1	(base)				
female	4.310504	1.752293	3.59	0.000	1.938895	9.
age5groups3						
25 - 34 yrs	1	(base)				
35 - 44 yrs	2.222575	.9070777	1.96	0.051	.9965852	4.
45+ yrs	8.381701	3.277558	5.44	0.000	3.886608	18
african						
No	1	(base)				
Yes	.6591587	.5254444	-0.52	0.601	.1375958	3.
geotype						
Urban formal	3.032513	1.226818	2.74	0.006	1.369316	6.
Urban informal	2.490041	1.030001	2.21	0.028	1.10445	5
Tribal area	1	(base)				
Rural formal	.9716294	.4858253	-0.06	0.954	.3636865	2.
alc_audit						
No risk	1	(base)				
Low risk	1.439631	.5666182	0.93	0.355	.6642245	3.
Medium risk	.7703014	.4319466	-0.47	0.642	.2558849	2.
High risk	.1572579	.1946746	-1.49	0.136	.0138039	1.
Addiction likely	.2429331	.2561369	-1.34	0.180	.0305892	1.
general_health2						
Excellent	1	(base)				
Good	3.745275	2.497629	1.98	0.048	1.009921	13
Fair	5.482905	3.783433	2.47	0.014	1.41267	21
Poor	4.964976	3.838881	2.07	0.039	1.086365	22
diabetes2						
no	1	(base)				
yes	5.562217	3.585357	2.66	0.008	1.567007	19
heart_disease2						
no	1	(base)				
yes	.8461225	.7157707	-0.20	0.844	.1604714	4.
healthcare_access2						
Private hospital, clinic or doctor	1	(base)				
Public hospital, clinic or doctor	2.507353	1.166173	1.98	0.049	1.005168	6.
_cons	.0010608	.0016743	-4.34	0.000	.0000477	.0

Note: **_cons** estimates baseline odds.

```
41 .
42 .
43 . **********Comparison of Logistic Regression Models********
44 . **Number 1: With Original Data for Diabetes
45 . svy: logistic diabetes2 i.sex2 i.age5groups3 i.african ///
> i.hypertension2 i.heart_disease2
(running logistic on estimation sample)

Survey: Logistic regression

Number of strata   =         9                  Number of obs     =       962
Number of PSUs     =       460                  Population size   =  2,918,473
                                                Design df         =       451
                                                F(   6,     446)   =     10.30
                                                Prob > F          =    0.0000
```

diabetes2	Odds Ratio	Linearized Std. Err.	t	P>|t|	[95% Conf.	Interval]
sex2						
male	1	(base)				
female	1.280354	.9814013	0.32	0.747	.2838717	5.774817
age5groups3						
25 - 34 yrs	1	(base)				
35 - 44 yrs	1.94811	1.488548	0.87	0.383	.4339718	8.745117
45+ yrs	4.438182	3.369044	1.96	0.050	.9984249	19.72853
african						
No	1	(base)				
Yes	.3927152	.3058043	-1.20	0.231	.08501	1.814201
hypertension2						
no	1	(base)				
yes	7.558776	4.587652	3.33	0.001	2.293196	24.91505
heart_disease2						
no	1	(base)				
yes	6.922962	5.120423	2.62	0.009	1.618171	29.61824
_cons	.0150594	.0117348	-5.38	0.000	.0032564	.0696429

Note: **_cons** estimates baseline odds.

```
46 .
47 . **Number 2: With Missing Data coded yes for Diabetes
48 . svy: logistic diab_all i.sex2 i.age5groups3 i.african ///
> i.hypertension2 i.heart_disease2
(running logistic on estimation sample)

Survey: Logistic regression

Number of strata   =         9                  Number of obs     =         963
Number of PSUs     =       460                  Population size   =   2,919,315
                                                Design df         =         451
                                                F(   6,    446)   =       10.39
                                                Prob > F          =      0.0000
```

diab_all	Odds Ratio	Linearized Std. Err.	t	P>|t|	[95% Conf.	Interval]
sex2						
male	1	(base)				
female	1.291032	.9890836	0.33	0.739	.2864579	5.818528
age5groups3						
25 - 34 yrs	1	(base)				
35 - 44 yrs	2.018178	1.514961	0.94	0.350	.461614	8.823481
45+ yrs	4.382448	3.326423	1.95	0.052	.9860257	19.47805
african						
No	1	(base)				
Yes	.3976026	.3103995	-1.18	0.238	.0857328	1.843959
hypertension2						
no	1	(base)				
yes	7.789151	4.69745	3.40	0.001	2.381055	25.48066
heart_disease2						
no	1	(base)				
yes	6.834765	5.051901	2.60	0.010	1.599068	29.21328
_cons	.0146933	.0115222	-5.38	0.000	.0031465	.0686139

Note: **_cons** estimates baseline odds.

```
49 .
50 . **Number 3: With Missing Data coded no for Diabetes
51 . svy: logistic diab_none i.sex2 i.age5groups3 i.african ///
> i.hypertension2 i.heart_disease2
(running logistic on estimation sample)

Survey: Logistic regression

Number of strata   =         9                  Number of obs     =         963
Number of PSUs     =       460                  Population size   =   2,919,315
                                                Design df         =         451
                                                F(   6,     446)  =       10.29
                                                Prob > F          =      0.0000
```

diab_none	Odds Ratio	Linearized Std. Err.	t	P>|t|	[95% Conf.	Interval]
sex2						
male	1	(base)				
female	1.27917	.9810233	0.32	0.748	.2833782	5.774174
age5groups3						
25 - 34 yrs	1	(base)				
35 - 44 yrs	1.940303	1.484409	0.87	0.387	.4314337	8.726197
45+ yrs	4.444481	3.372898	1.97	0.050	1.000252	19.74843
african						
No	1	(base)				
Yes	.3921699	.3051593	-1.20	0.230	.0849858	1.809682
hypertension2						
no	1	(base)				
yes	7.533311	4.568339	3.33	0.001	2.287771	24.80614
heart_disease2						
no	1	(base)				
yes	6.932976	5.128502	2.62	0.009	1.620204	29.66674
_cons	.0151008	.0117629	-5.38	0.000	.0032671	.0697968

```
Note: _cons estimates baseline odds.

52 .
end of do-file

53 . log close
      name:  <unnamed>
       log:  C:\Users\nchiwandire\Desktop\Report submission\01 Row percentages\Sensitivity anal
  log type:  smcl
 closed on:   3 Aug 2020, 21:08:57
```