NUTRITIONAL AND HEALTH STATUS OF HIV+ ADULTS STABLE ON HAART ATTENDING A HEALTHCARE FACILITY IN CAPE TOWN, SOUTH AFRICA

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Dissertation presented for the degree of

Master's in Medical Science in Nutrition (MMedSci Nutrition)

Faculty of Health Sciences

University of Cape Town

July 2022

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DECLARATION

I, ***Iyanuoluwa Oyedeji Oyetunji***, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgments indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I empower the university to reproduce for research either the whole or any portion of the contents in any manner whatsoever.

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ABSTRACT

Background: PLWH have twice the chances of developing cardiovascular disease (CVD) when compared to the uninfected population. This and other NCDs are important cause of non-AIDS-related mortality among PLWH, and its prevalence may increase as PLWH continue to age. Factors that may have association with the increased risk of NCDS among PLWH have been identified including the use of HAART, systemic inflammation, male gender, aging, diet, and sedentary lifestyle. The relationship between higher diet quality and a lower risk of NCDs has been reported among PLWH. Furthermore, dietary interventions have reduced the risk of NCDs among PLWH. However, studies assessing dietary intake among PLWH in South Africa are not recent and were conducted among ART-naïve participants. This dissertation contains a scoping review of literature that sought to identify the diet quality and food insecurity indices that have been used among PLWH and how these constructs are associated with the risk of developing CVD. The primary study component assessed the nutritional and health status of adults living with HIV stable on HAART attending the Heideveld CHC in Cape Town. We also investigated the association that may exist between these factors, especially diet quality, and the risks of NCDs.

Methods: For this thesis, a scoping review and primary study was conducted. For the scoping review, the frameworks of Arksey and O'Malley, the Joanna Briggs Institute's (JBI) manual for conducting scoping reviews, and the Preferred Reporting Items for Systematic review and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines were used for the scoping review. The protocol was registered on OSF registries and published in BMJ Open. Extracted data were presented in tables, followed by a descriptive summary of findings. A search strategy was developed, and a preliminary MEDLINE (via PubMed) search was conducted followed by a final search on PubMed, EbscoHost, Scopus, Web of Science, and COCHRANE library databases. The findings from the scoping review were also used to refine the protocol of the cross-sectional study.

The primary study was descriptive and cross-sectional including 247 adults receiving HAART from the Heideveld CHC. Eligible participants were HIV positive, on HAART for at least 1 year, aged 18 years or older, and able to communicate in English language, isiXhosa, or Afrikaans. Ethical approvals were obtained from the UCT ethics committee and the Department of Health. Data were collected using an interviewer-administered questionnaire and the patients' folder. Data were collected on socio-demographic variables, HIV infection-related information, anthropometry, biochemical, and clinical measures, as well as weight perception, satisfaction, and management goals. Other measures included dietary intake and habits, food security,

physical activity, self-esteem, smoking, and alcohol intake. Data were captured using Microsoft Excel (version 2180) and analyzed using RStudio Version 1.2.5033. Appropriate statistical methods were used to summarize and describe the results.

Results: A total of 31 studies were included in the scoping review after the recommended multi-level screening against the inclusion criteria. Three studies assessing food security status showed that food insecurity was high in PLWH. Six studies assessing dietary adequacy using a predefined diet quality index showed that PLWH had moderate adherence to the Healthy Eating Index (HEI) and Mediterranean Diet Score (MDS) guidelines. However, adherence to the recommendation of individual food items or nutrients was low. Other studies presented intakes of individual nutrients or food components. Two African studies were included with none using a diet quality index. The two most reported CVD risks were obesity and hypertension. The association between diet and risk of CVD reported was complex; while some studies found significant associations, some did not.

In the primary study, the majority (69.9%) were females with a median age of 46 years. The median duration of infection was 12 years, the median ART duration was 10 years, and 94.7% had a suppressed viral load. One-third of the participants had comorbidities, hypertension was the most prevalent comorbidity reported, followed by dyslipidemia and diabetes. Other comorbidities reported were CVD, renal problems, and cancer. The prevalence of obesity was 40.7% while 27.6% were overweight. Based on predefined criteria, 50.0% of the participants had high blood pressure. Food insecurity was reported by 89.0% of the participants. The median intake of fruits and vegetables was 0.9 and 1.6 servings/day respectively. Habitual consumption of SSB and processed meat on average of 1.0 servings/day was reported. Mean (SD) DASH and Alternate Healthy Eating Index (aHEI) scores were 21.6 (5.1) and 41.9 (9.8) respectively. While 80.0% did not try to gain weight in the previous year, 51.0% gained weight. However, 58.0% were happy with their present weight. There were significant differences between the three BMI categories for gender ($p<0.001$), level of education ($p<0.001$), ever being pregnant ($p=0.046$), creatinine ($p=0.002$), systolic BP ($p=0.010$), relative hand grip strength ($p<0.001$), PA ($p<0.001$), and being a smoker ($p<0.001$). There was a significant difference between those who were hypertensive and those who were not for age ($p<0.001$), level of education ($p=0.019$), and ever being pregnant ($p=0.008$). There was no significant association between aHEI score and BMI, as well as DASH score and hypertension.

Conclusions: Findings from the scoping review suggest that the majority of PLWH are affected by food insecurity and achieve only moderate adherence to recommendations for diet quality.

Few studies have used diet quality indices to assess dietary adequacy among PLWH, and the association of diet with risks of CVD is complex and needs further research.

In our primary study, the prevalence of obesity and hypertension was high among the participants, and hypertension was the most prevalent comorbidity reported. The participants were mostly middle-aged females, they were on long-term ART and most of them had an undetectable viral load. The dietary habits and consumption of participants did not conform to recommendations. Obesity was more likely among females, those who had completed high school education, women who had been previously pregnant, those who were sedentary, and less likely among those who were previous and current smokers. Hypertension had a significant positive association with age. Diet quality was not significantly different among PLWH with or without comorbidities. The findings of this study emphasize the need to incorporate holistic nutrition education into HIV care at the PHC level. More nutrition-focused research is needed among PLWH in South Africa.

ACKNOWLEDGEMENTS

"No, in all these things we are more than conquerors through Him who loved us." – ***Romans 8:37***

I would like to acknowledge the grace of our **Lord Jesus Christ**, and the divine strength given to me by the **Almighty God** without which this would not have been possible.

I also appreciate the support of the following people:

My parents - **Mr. and Mrs. Elijah Victoria Oyetunji**, and my siblings – **Ikeoluwa, Inioluwa, and Itunuoluwa** for cheering me on all through the period of my study.

My supervisors – **Dr. Janetta Harbron** for believing in me and spurring me on, and **Dr. Alastair Duncan** for always being there to listen to me. Thank you both for sharing your wealth of knowledge and your invaluable input into my career aspiration.

Dr. Tasneem Adams, other **staff of Heideveld CHC**, and the **research participants** for making the data collection possible.

Dr. Emmanuel Nwosu, **Jacob Gizamba**, and **Frissiano Honwana** for their advice and support while analyzing data and writing up the findings, and **all other colleagues and friends** who made the journey an interesting one.

Finally, I appreciate the **Mastercard Foundation** for giving me wings to fly by awarding me the comprehensive and highly prestigious Mastercard Foundation Scholarship. You made this possible, and I hope to maximize this opportunity to make a difference in our world.

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LIST OF ABBREVIATIONS

3TC	Lamivudine
ACCA	Albumin-corrected Calcium
aHEI	Alternate Healthy Eating Index
AIDS	Acquire Immunodeficiency Syndrome
ANOVA	Analysis of Variance
ART	Antiretroviral Therapy
ARVs	Antiretrovirals
BMI	Body Mass Index
CAD	Coronary Artery Disease
CD4	Cluster of Differentiation 4
CHC	Community Health Clinic
CI	Confidence Interval
CIMT	Carotid Intima-media Thickness
COPD	Chronic Obstructive Pulmonary Disease
CRP	C-Reactive Proteins
CVD	Cardiovascular Disease
DASH	Dietary Approaches to Stop Hypertension
DBP	Diastolic Blood Pressure
DM	Diabetes Mellitus
DQI	Diet Quality Index
DRI	Dietary Reference Intake
DTG	Dolutegravir
EFV	Efavirenz
FFQ	Food Frequency Questionnaire
FTC	Emtricitabine
GCP	Good Clinical Practice
GIT	Gastrointestinal Tract
HAART	Highly Active Antiretroviral Therapy
HDL-C	High-Density Lipoproteins Cholesterol
HEI	Healthy Eating Index
HGS	Hand Grip Strength
HIV	Human Immunodeficiency Virus
HRQoL	Health-related Quality of Life
IL	Interleukin
IQR	Interquartile Range
LDL-C	Low-Density Lipoproteins Cholesterol
LMIC	Low-and-middle-income Countries
MDS	Mediterranean Diet Score
MRC	Medical Research Council
MUAC	Mid-upper-arm Circumference
NCD	Non-communicable Diseases
NCEP ATP-III	National Cholesterol Education Program Adult Treatment Panel III
NNRTIs	Non-Nucleoside Reverse Transcriptase Inhibitors
NRTIs	Nucleoside/tide Reverse Transcriptase Inhibitors
NVP	Nevirapine
OI	Opportunistic Infection

OR	Odds Ratio
PA	Physical Activity
PEARLS	Prospective Evaluation of Antiretrovirals in Resource-Limited Settings
PHC	Primary Health Care
PIs	Protease Inhibitors
PLWH	People Living With HIV
PMTCT	Prevention of Mother-to-child Transmission
PUFA	Polyunsaturated Fatty Acids
RDA	Recommended Dietary Allowance
RHGS	Relative Hand Grip Strength
RNA	Ribonucleic Acid
SA	South Africa
SANHANES	South African National Health and Nutrition Examination Survey
SBP	Systolic Blood Pressure
SSA	Sub-Saharan Africa
SSB	Sugar-sweetened Beverages
TC	Total Cholesterol
TDF	Tenofovir Disoproxil Fumarate
TEE	Tenofovir-Efavirenz-Emtricitabine
TG	Triglycerides
TLD	Tenofovir-Lamivudine-Dolutegravir
UK	United Kingdom
UNAIDS	The Joint United Nations Programme on HIV/AIDS
US	United States of America
WC	Waist Circumference
WHO	World Health Organization
WHR	Waist to Hip Ratio

CHAPTER 1: INTRODUCTION

1.1 Background

Despite the worldwide awareness being created about the Human Immunodeficiency Virus (HIV), high prevalence and incidence rates of HIV infections still exist in African countries. The number of new cases recorded globally in 2020 was 1.5 million with 230 000 in South Africa (UNAIDS, 2021). UNAIDS reports that in 2020, 37.7 million people were living with HIV. The prevalence of HIV in South Africa has been the global highest for a country and stands at 7.8 million cases in 2020 (UNAIDS, 2021).

The development of Highly Active Antiretroviral Therapy (HAART) has led to a significant increase in the survival rate and life expectancy of people living with HIV (PLWH) whereas cases of acute malnutrition associated with the infection have reduced (Thuppal et al., 2017). Although the use of HAART resulted in a reduced rate of opportunistic infections (Hussen et al., 2016), other side effects such as lipoatrophy/lipohypertrophy syndrome and other morphological reactions emerged (Soares et al., 2015). Furthermore, an increasing incidence of non-communicable diseases (NCDs) including type 2 diabetes, cardiovascular diseases, and metabolic syndrome have been reported among PLWH (Martín-Cañavate et al., 2018). Therefore, HIV remains an issue of public health concern, especially in South Africa due to the prevalence of the epidemic in this population (Myezwa et al., 2018, UNAIDS, 2021).

In addition to traditional risk factors for cardiovascular disease, consistent use of HAART leading to persistent chronic inflammation and immune activation, coupled with aging has increased risk among PLWH (Deeks et al., 2013, Hsue and Waters, 2019). A modeling study conducted among the Dutch ATHENA cohort projects that by 2030, 73% of PLWH will be aged at least 50 years, and 78% of PLWH will have cardiovascular disease (Smit et al., 2015). Aside from coronary artery diseases (CAD) which were first reported post HAART use, further studies have revealed a host of other cardiovascular diseases associated with HIV infection (Barnes et al., 2017). Indeed, the systematic review and meta-analysis of globally available data by Shah et al (2018) showed that PLWH now face twice the risk of CVD compared to the uninfected population.

Nutritional status has a great influence on life expectancy, mortality rate, and inflammation for PLWH (Thuppal et al., 2017). Findings from a cohort study of the nutritional status of PLWH during the first year of HAART in two West African countries suggested that malnutrition persisted at 12 months in both cohorts across all indicators (BMI, hemoglobin, and albumin) (Sicotte et al., 2015). However, findings of recent studies conducted in South Africa (Bhargava et al., 2018) and Haiti (Rebick et al., 2016) revealed a low prevalence of underweight among PLWH on HAART.

Findings of studies in Cameroon and South Africa supported this by suggesting that BMI and other anthropometric indices significantly increased with increased duration of HAART among PLWH (Ekali et al., 2013, Myezwa et al., 2018). Obesity prevalence has also been reported among PLWH in a KwaZulu-Natal study to be 23.3% (Malaza et al., 2012) and 46.4% in Durban (Biggs and Spooner, 2018). Overweight and obesity are central to the onset of conditions including hypertension, dyslipidemia, cardiovascular diseases, and insulin resistance (Ekali et al., 2013).

The nutritional status of PLWH has been measured using several biochemical, clinical, and dietary indices. In a randomized controlled trial conducted in South Africa, Uganda, and India, Vos et al. (2018) reported increased lipid levels, insulin resistance, and cardiovascular risk over time among ART-naive PLWH over 96 weeks of HAART initiation. Dietary adequacy has been assessed either by comparing intake of a specific nutrient or food component with recommendations or assessing the overall quality of diet using a variety of methods. Diet quality, measured using the Healthy Eating Index (Guenther et al., 2008) is lower in PLWH in the US relative to uninfected individuals. Among PLWH, diet quality was found to be lower among females than males (Weiss et al., 2019). Contrary to this, Abioye et al. (2015) reported that male PLWH had poorer dietary habits and were less likely to meet nutrient recommended dietary allowance (RDA) when compared to their female counterparts. Overall, diet quality indices have shown a lower diet quality score among PLWH relative to the uninfected population. Diet quality indices have been argued to be a better indication of overall diet adequacy than intakes of single nutrients, however, they have not been used in the South African context. Our study introduces the use of the aHEI (Chiuve et al., 2012) and the DASH (Fung et al., 2008) scores to assess the dietary intake of PLWH in South Africa.

Researchers in South Africa have reported the widespread extent of food insecurity among PLWH (Kalichman et al., 2012, Pienaar et al., 2017, Steenkamp et al., 2016). According to Pienaar et al. (2017), food insecurity was more prevalent among PLWH relative to uninfected participants in both rural (46% vs 35%) and urban settlements (64% vs 59.4%). As food insecurity is associated with poor dietary intake among PLWH in the US (Muhammad et al., 2019), the increasing rates of food insecurity among PLWH in SA may be a strong indication of poor dietary intake and quality. As in the general population (Goff et al., 2014, Grundy et al., 2019, Stone et al., 2014), dietary modification and other lifestyle modification is important to manage cardiovascular diseases among PLWH. There is evidence that dietary intervention can reduce the onset of morbidity among the general population (Hjerkinn et al., 2004). It is, therefore, very important to assess the dietary intake and food insecurity status of PLWH in South Africa to inform how nutrition intervention may benefit this group.

Due to the high incidence of HIV in South Africa, several programs, policies, and strategies for its control have been put in place including the establishment of adherence clubs. These adherence clubs were first implemented in the Western Cape Province of South Africa and have been proven to be effective in sustaining retention in care (Grimsrud et al., 2017). One of the aims of these adherence clubs is to ensure that participants have quick and uninterrupted access to medications and health care services (Mukumbang et al., 2019) which include nutritional care. To provide a targeted and effective nutrition care service to PLWH, it is important to develop a greater understanding of the nutritional status and dietary quality, and how these are associated with other health parameters.

1.2 Research questions

- What is the nutritional and health status of HIV-positive individuals stable on HAART attending a primary healthcare facility in Cape Town?
- Is there an association between the diet quality and risk factors of NCDs among PLWH stable on HAART attending a primary healthcare facility in Cape Town?

1.3 Hypothesis

- Null hypothesis: There is no association between diet quality and the risk factors for NCDs among PLWH

1.4 Aims and Objectives

Aims

- To assess and describe the nutritional and health status of HIV-positive individuals stable on HAART attending a primary healthcare facility in Cape Town
- To investigate associations between diet quality and other risk factors for NCDs among HIV-positive individuals stable on HAART in Cape Town

Objectives

- To assess the following anthropometric characteristics: height, weight, mid-upper arm circumference, waist circumference, hip circumference
- To obtain and interpret the following biochemical information from patient medical files: cholesterol, CD4, and viral load.
- To assess the dietary intake (quality and habits) and food security level of respondents

- To assess clinical measures including blood pressure and handgrip strength of respondents
- To assess selected risk of CVD (smoking and alcohol intake patterns) of respondents
- To describe self-esteem, weight goals and perceptions, and preferred weight management interventions of respondents
- To assess the association between the diet quality, and anthropometric as well as biochemical indicators of HIV-positive individuals stable on HAART attending a primary healthcare facility in Cape Town

1.5 Definition of Terms

- Nutritional Status: This is the state of wellness of an individual as determined by the intake of food and the utilization of nutrients in the body. For this study, this is the anthropometric, biochemical, and clinical characteristics of respondents as well as dietary intake.
- Health status: In this research, health status indicates blood pressure, blood glucose, and total cholesterol where applicable.
- Stable on HAART is defined as a patient who has been receiving HAART successfully for at least 1 year. They have no adverse conditions, current illnesses, or pregnancy, and have a good understanding of lifelong adherence (Waldrop et al., 2016).

1.6 Outline of Chapters 2 To 6 of This Dissertation

Chapter 2 presents a review of literature on HAART, nutritional status, body weight perception, physical activity, smoking and alcohol intake, and quality of life of PLWH. Chapter 3 begins with a scoping review protocol titled “Diet quality, food insecurity and risk of cardiovascular diseases among adults living with HIV/AIDS: a scoping review protocol”. This protocol had been published (Oyetunji et al., 2021). The protocol is then followed by the scoping review findings and discussion, also in chapter 3. The topics discussed in the detail in the scoping review were not repeated in the literature review. Chapter 4 contains the first article which covers the first main aim of this study titled “Weight and Health Status of PLWH in Cape Town”. This chapter also touched on the second aim by assessing the relationship obesity has with diet quality and other variables. The second article titled “Association between Hypertension, Diet Quality, and Health Variables among PLWH in Cape Town”, contained in chapter 5 covers the rest of the second main aim. It explores the relationship between hypertension, diet quality, and other variables. Chapter 6, which is the final, presents a summary of the results found in chapters 4 and 5 as well as a general conclusion and recommendation. While chapters 4 and 5 are presented in a

non-specific journal format, there is an inevitable overlap in their content and references as they are both results from a single research project.

1.7 Candidate's Contribution to The Dissertation

The Master's candidate was responsible for:

- Conceptualizing the research study, developing the tools, and obtaining ethical approval from relevant authorities with the guidance of the supervisors
- Conducting the collection of all study data and coordinating the activities of a fieldworker who assisted with data collection
- Liaising with the facility staff at Heideveld Community Health Clinic (CHC) for successful data collection
- Managing participants' incentives, data collection equipment, and other university and facility equipment used for the study
- Capturing, and cleaning of collected data and giving regular reports to the supervisors and facility contact person
- Running statistical analyses, tests, and comparisons with consultations with biostatistician
- Compiling tables and writing all chapters of the thesis while obtaining and addressing feedback and comment from the supervisors
- Corresponding with the publisher for the publication of the scoping review protocol with oversight from the supervisors

REFERENCES

ABIOYE, A. I., ISANAKA, S., LIU, E., MWIRU, R. S., NOOR, R. A., SPIEGELMAN, D., MUGUSI, F. & FAWZI, W. 2015. Gender differences in diet and nutrition among adults initiating antiretroviral therapy in Dar es Salaam, Tanzania. *AIDS Care,* 27**,** 706-715.

BARNES, R. P., LACSON, J. C. & BAHRAMI, H. 2017. HIV Infection and Risk of Cardiovascular Diseases Beyond Coronary Artery Disease. *Curr Atheroscler Rep,* 19**,** 20.

BHARGAVA, A., BOOYSEN, F. L. R. & WALSH, C. M. 2018. Health status, food insecurity, and time allocation patterns of patients with AIDS receiving antiretroviral treatment in South Africa. *AIDS Care,* 30**,** 361-368.

BIGGS, C. & SPOONER, E. 2018. Obesity and HIV: a compounding problem. *SAJCN - South African Journal of Clinical Nutrition,* 31**,** 78-83.

CHIUVE, S. E., FUNG, T. T., RIMM, E. B., HU, F. B., MCCULLOUGH, M. L., WANG, M., STAMPFER, M. J. & WILLETT, W. C. 2012. Alternative dietary indices both strongly predict risk of chronic disease. *The Journal of nutrition,* 142**,** 1009-1018.

DEEKS, S. G., LEWIN, S. R. & HAVLIR, D. V. 2013. The end of AIDS: HIV infection as a chronic disease. *The Lancet,* 382**,** 1525-1533.

EKALI, L. G., JOHNSTONE, L. K., ECHOUFFO-TCHEUGUI, J. B., KOUANFACK, C., DEHAYEM, M. Y., FEZEU, L., NOUTHE, B., HAYES, L., UNWIN, N. C. & SOBNGWI, E. 2013. Fasting blood glucose and insulin sensitivity are unaffected by HAART duration in Cameroonians receiving first-line antiretroviral treatment. *Diabetes Metab,* 39**,** 71-7.

FUNG, T., CHIUVE, S., MCCULLOUGH, M., REXRODE, K., LOGROSCINO, G. & HU, F. 2008. Adherence to a DASH-Style diet and risk of coronary heart disease and stroke in women. *Archives Of Internal Medicine,* 168**,** 713-720.

GOFF, D. C., LLOYD-JONES, D. M., BENNETT, G., COADY, S., D'AGOSTINO, R. B., GIBBONS, R., GREENLAND, P., LACKLAND, D. T., LEVY, D. & O'DONNELL, C. J. 2014. 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Journal of the American College of Cardiology,* 63**,** 2935-2959.

GRIMSRUD, A., BARNABAS, R. V., EHRENKRANZ, P. & FORD, N. 2017. Evidence for scale up: the differentiated care research agenda. *J Int AIDS Soc,* 20**,** 22024.

GRUNDY, S. M., STONE, N. J., BAILEY, A. L., BEAM, C., BIRTCHER, K. K., BLUMENTHAL, R. S., BRAUN, L. T., DE FERRANTI, S., FAIELLA-TOMMASINO, J. & FORMAN, D. E. 2019. 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APhA/ASPC/NLA/PCNA guideline on the management of blood cholesterol: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Journal of the American College of Cardiology,* 73**,** 3168-3209.

GUENTHER, P., REEDY, J. & KREBS-SMITH, S. M. 2008. Development of the Healthy Eating Index-2005. *Journal Of The American Dietetic Association,* 108**,** 1896-1901.

HJERKINN, E. M., SANDVIK, L., HJERMANN, I. & ARNESEN, H. 2004. Effect of diet intervention on long-term mortality in healthy middle-aged men with combined hyperlipidaemia. *Journal of Internal Medicine,* 255**,** 68-73.

HSUE, P. Y. & WATERS, D. D. 2019. HIV infection and coronary heart disease: mechanisms and management. *Nat Rev Cardiol,* 16**,** 745-759.

HUSSEN, S., BELACHEW, T. & HUSSIEN, N. 2016. Nutritional status and its effect on treatment outcome among HIV infected clients receiving HAART in Ethiopia: a cohort study. *AIDS Research & Therapy,* 13**,** 1-8.

KALICHMAN, S. C., WATT, M., SIKKEMA, K., SKINNER, D. & PIETERSE, D. 2012. Food insufficiency, substance use, and sexual risks for HIV/AIDS in informal drinking establishments, Cape Town, South Africa. *J Urban Health,* 89**,** 939-51.

MALAZA, A., MOSSONG, J., NEWELL, M.-L. & BAERNIGHAUSEN, T. W. 2012. Hypertension and Obesity in Adults Living in a High HIV Prevalence Rural Area in South Africa. *PLoS ONE,* 7.

MARTÍN-CAÑAVATE, R., SONEGO, M., SAGRADO, M. J., ESCOBAR, G., RIVAS, E., AYALA, S., CASTANEDA, L., APARICIO, P. & CUSTODIO, E. 2018. Dietary patterns and nutritional status of HIV-infected children and adolescents in El Salvador: A cross-sectional study. *PLoS ONE,* 13.

MUHAMMAD, J., FERNANDEZ, J., CLAY, O., SAAG, M., OVERTON, E. & WILLIG, A. 2019. Associations of food insecurity and psychosocial measures with diet quality in adults aging with HIV. *AIDS care,* 31**,** 554-562.

MUKUMBANG, F. C., VAN WYK, B., VAN BELLE, S. & MARCHAL, B. 2019. Unravelling how and why the Antiretroviral Adherence Club Intervention works (or not) in a public health facility: A realist explanatory theory-building case study. *PLoS One,* 14**,** e0210565.

MYEZWA, H., HANASS-HANCOCK, J. & PAUTZ, N. 2018. Investigating the interaction between human immunodeficiency virus, nutrition, and disability: A cross-sectional observational study. *Afr J Prim Health Care Fam Med,* 10**,** e1-e8.

OYETUNJI, I. O., DUNCAN, A., BOOLEY, S. & HARBRON, J. 2021. Diet quality, food insecurity and risk of cardiovascular diseases among adults living with HIV/AIDS: a scoping review protocol. *BMJ open,* 11**,** e047314.

PIENAAR, M., VAN ROOYEN, F. C. & WALSH, C. M. 2017. Household food security and HIV status in rural and urban communities in the Free State province, South Africa. *Sahara j,* 14**,** 118-131.

REBICK, G. W., FRANKE, M. F., TENG, J. E., GREGORY JEROME, J. & IVERS, L. C. 2016. Food Insecurity, Dietary Diversity, and Body Mass Index of HIV-Infected Individuals on Antiretroviral Therapy in Rural Haiti. *AIDS Behav,* 20**,** 1116-22.

SHAH, A. S., STELZLE, D., LEE, K. K., BECK, E. J., ALAM, S., CLIFFORD, S., LONGENECKER, C. T., STRACHAN, F., BAGCHI, S. & WHITELEY, W. 2018. Global burden of atherosclerotic cardiovascular disease in people living with HIV: systematic review and meta-analysis. *Circulation,* 138**,** 1100-1112.

SICOTTE, M., BEMEUR, C., DIOUF, A., ZUNZUNEGUI, M. V. & NGUYEN, V.-K. 2015. Nutritional status of HIV-infected patients during the first year HAART in two West African cohorts. *Journal Of Health, Population, And Nutrition,* 34**,** 1-1.

SMIT, M., BRINKMAN, K., GEERLINGS, S., SMIT, C., THYAGARAJAN, K., VAN SIGHEM, A., DE WOLF, F. & HALLETT, T. B. 2015. Future challenges for clinical care of an ageing population infected with HIV: a modelling study. *The Lancet Infectious Diseases,* 15**,** 810-818.

SOARES, L. R., DA SILVA, D. C., GONSALEZ, C. R., BATISTA, F. G., FONSECA, L. A., DUARTE, A. J. & CASSEB, J. 2015. Discordance between body mass index and anthropometric measurements among HIV-1-infected patients on antiretroviral therapy and with lipoatrophy/lipohypertrophy syndrome. *Rev Inst Med Trop Sao Paulo,* 57**,** 105-10.

STEENKAMP, L., GOOSEN, A., VENTER, D. & BEEFORTH, M. 2016. Food insecurity among students living with HIV: Strengthening safety nets at the Nelson Mandela Metropolitan University, South Africa. *Sahara j,* 13**,** 106-112.

STONE, N. J., ROBINSON, J. G., LICHTENSTEIN, A. H., BAIREY MERZ, C. N., BLUM, C. B., ECKEL, R. H., GOLDBERG, A. C., GORDON, D., LEVY, D., LLOYD-JONES, D. M., MCBRIDE, P., SCHWARTZ, J. S., SHERO, S. T., SMITH JR, S. C., WATSON, K. & WILSON, P. W. F. 2014. 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: A report of the American college of cardiology/American heart association task force on practice guidelines. *Journal of the American College of Cardiology,* 63**,** 2889-2934.

THUPPAL, S. V., JUN, S., COWAN, A. & BAILEY, R. L. 2017. The nutritional status of HIV-infected US adults. *Current Developments in Nutrition,* 1.

UNAIDS. 2021. *Global HIV & AIDS statistics — Fact sheet* [Online]. Available: https://www.unaids.org/en/resources/fact-sheet [Accessed 2022/22/03 2022].

VOS, A. G., CHERSICH, M. F., KLIPSTEIN-GROBUSCH, K., ZUITHOFF, P., MOORHOUSE, M. A., LALLA-EDWARD, S. T., KAMBUGU, A., KUMARASAMY, N., GROBBEE, D. E., BARTH, R. E. & VENTER, W. D. 2018. Lipid levels, insulin resistance and cardiovascular risk over 96 weeks of antiretroviral therapy: a randomised controlled trial comparing low-dose stavudine and tenofovir. *Retrovirology,* 15**,** 77.

WALDROP, G., DOHERTY, M., VITORIA, M. & FORD, N. 2016. Stable patients and patients with advanced disease: consensus definitions to support sustained scale up of antiretroviral therapy. *Tropical Medicine & International Health,* 21**,** 1124-1130.

WEISS, J. J., SANCHEZ, L., HUBBARD, J., LO, J., GRINSPOON, S. K. & FITCH, K. V. 2019. Diet quality is low and differs by sex in people with HIV. *The Journal of nutrition,* 149**,** 78-87.

CHAPTER 2: LITERATURE REVIEW

2.1 Highly Active Antiretroviral Therapy

The Highly Active Antiretroviral Therapy (HAART) significantly changed the pattern of HIV infection from a terminal disease to a manageable chronic disease (Pau and George, 2014). Changes experienced include improved immune function, regression of opportunistic infection (OI), and reduced mortality (Cattelan et al., 2000, De Luca et al., 2000, Lederman et al., 1998, Palella Jr et al., 1998).

Individual antiretroviral drugs are grouped under different classes of antiretroviral therapy (ART), examples of these classes of ART available include (Dong and Imai, 2017, University of Liverpool, 2019):

- Protease Inhibitors (PIs)
- Non-Nucleoside Reverse Transcriptase Inhibitors (NNRTIs)
- Nucleoside/tide Reverse Transcriptase Inhibitors (NRTIs)
- Integrase Inhibitors
- Fixed-Dose Combinations

Table 2.1 below itemizes some examples of individual drugs in the classes of ART listed above as well as some side effects associated with them.

Table 2. 1 Examples of ARVS

Class of ARV*	Examples	Common Side Effects and Nutrition complications	Food-ARV interaction
PIs	amprenavir, tipranavir, indinavir, lopinavir, fosamprenavir, ritonavir, darunavir, atazanavir, fortovase, nelfinavir	Nausea, vomiting, diarrhea, hyperlipidemia, fat maldistribution, anemia, hyperglycemia, liver toxicity, taste alteration, hyperbilirubinemia, gas, mouth/esophageal ulcers	Most ARVs in this class are advised to be taken with food except Amprenavir and the oral suspension of Fosamprenavir. Furthermore, tablets of Lopinavir, Fosamprenavir, Ritonavir, and Indinavir+Ritonavir may be taken with or without food. Indinavir alone should be taken with fluid.
NNRTIs	etravirine, delavirdine, efavirenz, nevirapine, rilpivirine	Nausea, diarrhea, hyperlipidemia, hyperglycemia, taste alteration, liver toxicity, dry mouth, flatus, fat maldistribution, constipation, loss of appetite,	Rilpivirine must be taken with a meal. Etravirine should be taken following a meal. Efavirenz should be taken on an empty stomach. Delavirdine and Nevirapine may be taken without regard to food.
NRTIs	emtricitabine, lamivudine, zidovudine, abacavir, didanosine, tenofovir, stavudine	Nausea, vomiting, anemia, loss of appetite, vitamins or minerals deficiency, constipation, taste alterations, pancreatitis, flatus, renal issues, hyperlipidemia, lipoatrophy, pancreatitis, mouth, and esophageal ulcers,	Didanosine should be taken on an empty stomach at least two hours before or after a meal. Others may be taken without regard to food.
Integrase inhibitors	dolutegravir, raltegravir	Nausea, diarrhea, liver toxicity	Integrase inhibitors may be taken without regard to food but cannot be taken with antacids, laxatives, oral iron, or calcium supplements.
Fixed-dose combination	**Atripla** (efavirenz + tenofovir + emtrivitabine), **Complera** (emtricitabine + rilpivirine + tenofovir disoproxil fumarate) **Stribild** (elvitegravir + cobicistat + emtricitabine + tenofovir disoproxil fumarate)	Nausea, vomiting, diarrhea	Atripla should be taken on an empty stomach while Complera and Stribild must be taken with meals.

ARV: Antiretroviral, PI: Protease Inhibitors, NNRTIs: Non-Nucleoside Reverse Transcriptase Inhibitors
NRTIs: Nucleoside Reverse Transcriptase Inhibitors

*: Please note that some of these medicines are no longer in routine use due to poor efficacy or side effect burden.

The Republic of South Africa started supplying ART to the public sector but has, nevertheless, achieved a wide expansion of the treatment program since 2008. The Republic has the global highest number of persons on ART and this has brought an increase in the life expectancy of South Africans (Bekker et al., 2014). The 2019 clinical HIV guidelines in South Africa were

revised in March 2020 to reflect some updates in ART use. The following are different ART regimen options, guidelines, and conditions being used in South Africa (Republic of South Africa National Department of Health, 2019):

Table 2. 2 First-Line Regimen in South Africa

Regimen option	Example	Conditions
Integrase Strand Transfer Inhibitor (InSTI) based regimen: TDF + 3TC/FTC + DTG.	Tenofovir disoproxil fumarate-lamivudine-dolutegravir (TLD)	• Adult Men and Adolescent Boys ≥ 35 kg and ≥ 10 years of Age • Adult Women and Adolescent Girls ≥ 35 kg1 and ≥ 10 years of Age Women of childbearing potential (WOCP), including Pregnant, from 7 weeks gestation onwards, Not pregnant, and not currently desiring to become pregnant
NNRTI based regimen: TDF + 3TC/FTC + EFV/NVP	Tenofovir disoproxil fumarate-emtricitabine-efavirenz (TEE)	Pregnant, up to 6 completed weeks of gestation, or actively wanting to conceive in the near future

TDF: Tenofovir Disoproxil Fumarate, 3TC: Lamivudine, FTC: Emtricitabine, DTG: Dolutegravir, EFV: Efavirenz, NVP: Nevirapine

Second-line regimen

AZT/TDF + 3TC/FTC + (LPV/r or ATV/r or DTG)

The scale-up of HAART was not only followed by the desirable outcomes highlighted but also some undesirable outcomes such as chronic diseases. People living with HIV (PLWH) in their adult ages have been reported to have an increased risk of cardiovascular diseases, metabolic syndrome, and type 2 diabetes (Alonso et al., 2019, Yang et al., 2019). However, these risks have the potential to be reduced with optimal nutrition (Gutierrez et al., 2017, Islam et al., 2012, Thuppal et al., 2017).

2.2 Nutritional Status of PLWH

A poor nutritional status has the potential to cause or worsen infections and inflammation (Hughes and Kelly, 2006). Nutrition is an important factor in HIV treatment outcomes and poor nutritional status has been proven to be a predictor of mortality among PLWH (Tang et al., 2015). Optimal nutrition plays a vital role in the repair of worn-out tissues, immune strengthening, and slowing down the progression of HIV infection (Muthamia et al., 2015, Osei Akumiah et al., 2015).

Due to the important role played by adequate nutrition in HIV management and the evolving nature of the infection, the focus of nutritional management in HIV has shifted from merely treating acute malnutrition to providing optimal nutrition which can enhance the good quality of life and health of PLWH (Fields-Gardner, 2010). Nutritional assessment is a comprehensive and objective process of defining the nutritional status of an individual. The common methods of nutritional assessment include anthropometric, biochemical, clinical, and dietary assessments (Lee, 2010, Minocha et al., 2018).

2.2.1 Anthropometry

Nutritional anthropometry is the measurement of different body parts and forms, as well as the gross composition of the human body at different ages and stages to inform the degree of nutrition (Lieberman, 2017). Anthropometric assessment is an important method of nutritional assessment. It is useful for prognosis and to monitor the effect of nutrition in the progression of diseases or during an intervention (Madden and Smith, 2016).

2.2.1.1 Obesity

Body weight is one of the cores of anthropometry (Casadei and Kiel, 2020). Obesity is the accumulation of adipose fat and is a well-known cause of morbidity and mortality because of several weight-related complications (Garvey, 2019). Excess central body fat is associated with insulin resistance, worse still, obesity has been linked to several types of cancers and therefore has the potential to greatly reduce life expectancy (Apovian, 2016). Body Mass Index (BMI) has been generally accepted as a screening tool for obesity and overweight. However, because of the several limitations of this tool such as its inability to distinguish the weight of the lean mass, bone, and extracellular fluid from adipose as well as the distribution of adipose tissue, it must be accompanied by an appropriate physical examination when used for diagnoses (Garvey, 2019). BMI has also been criticized even more strongly because body fat can be highly determined by sex, age, and even ethnicity. Therefore, it has been argued to be unfit for some ethnic groups (Nuttall, 2015). Generally, using the BMI, individuals with values less than 18.5kg/m^2 are classified as underweight while those with values between 18.5kg/m^2 to less than 25kg/m^2 are said to be “normal”. Those with BMI between 25kg/m^2 and less than 30kg/m^2 are overweight, and those with values greater or equal to 30kg/m^2 are classified as obese (WHO, 2000). However, Caleyachetty et al (2021) found in their population-based cohort study using electronic primary care health records in England that diabetic risks that corresponds to 30kg/m^2 of BMI among White population was equivalent to 28.1kg/m^2, 26.9kg/m^2, 26.6kg/m^2, and 23.9kg/m^2 among Black African, Chinese, Arab, and South Asian populations respectively. This

further emphasizes the need to use the BMI cautiously, especially in a multi-ethnic population such as South Africa.

HIV infection has been associated with severe undernutrition during the earlier days of the epidemic, however, this has greatly changed. Weight loss and wasting are no longer common places among PLWH (Bailin et al., 2020). On the contrary, the prevalence of overweight and obesity among PLWH has progressively increased, and even beyond the prevalence in the general population in some countries (Crum-Cianflone et al., 2010, Tate et al., 2012, Wrottesley et al., 2014).

In South Africa, researchers have reported an increase in the prevalence of obesity and a gradual decline in the prevalence of undernutrition among PLWH, especially after ART initiation. Hurley et al. (2011) in their study of anthropometric changes and perceptions of body weight among Durban adults initiating ART reported a significant increase in anthropometric measures of their study participants after 12 months on ART. In this study, 230 PLWH were recruited, and data was collected on BMI, waist, and hip circumferences. In their report, the prevalence of overweight and obesity after 12 months on ART was 36% and 22% respectively compared with 21% and 12% at initiation. This amounts to not less than a 10% increase in these indices. Similarly, waist circumference increased significantly by means of 7.2cm and 7.8cm from baseline to 12 months among male and female participants respectively. In another South African study conducted by Biggs and Spooner (2018), a high prevalence of overweight and obesity was reported among participants. In this cross-sectional study conducted at Lancers Road Clinic, Durban, 84 asymptomatic ART-naive HIV-positive adults were recruited. The authors reported 26.2% and 46.4% prevalence of overweight and obesity respectively (Biggs and Spooner, 2018), the extremely high prevalence of obesity among these participants is concerning. Furthermore, there was a striking gender difference in BMI with females being more overweight and obese and males being more of normal weight and overweight. Relatively small sample size in an observational study having mostly female participant may be some limitations in the study of Biggs and Spooner; however, the results may just indicate the presence of obesity even among ART-naive PLWH.

A more recent study by Mahlangu et al. (2020) had similar findings. This study revealed the nutritional status of 480 adults on ART for at least 6 months in three primary health facilities in Gauteng province. Anthropometric measures including weight, height, waist and hip circumference were assessed to determine BMI, and waist-to-hip ratio (WHR). The prevalence of overweight and obesity was 26% and 13% respectively. Abdominal obesity was also prevalent in this population as indicated by waist circumference (WC) – 58% and WHR – 47%.

The duration of ART use among the participants of this study ranged from 6 months to more than 2 years. The participants were dichotomized by the duration of ART use into two groups: less than 2 years, and more than 2 years. Interestingly, 31% and 11% of those who have been on ART for more than 2 years were overweight and underweight respectively. Among those on ART for less than 2 years, this prevalence changed to 21% and 15% respectively. Mahlangu and colleagues reported that these differences were statistically significant. They also reported that obesity was associated with the duration of ART use (OR = 3.13; 95% CI: 1.72–5.71).

The finding of this study may not be generalized as it was conducted in one district with non-randomly selected health facilities. However, these three South African studies highlighted above strongly indicate the rising epidemic of obesity among PLWH in the republic.

Factors contributing to obesity among PLWH is both traditional and HIV/ART specific. Similar to the general population, obesity among PLWH may be a response to several metabolic and inflammatory processes (Lake, 2017). A recent review conducted by Bailin et al. (2020) brings to the fore the factors related to obesity among PLWH. In this review, Bailin and colleagues highlighted the risk factors of weight gain as well as the metabolic and other major complications that follow.

As shown in figure 1 below, Bailin and colleagues mentioned antiretroviral therapy, which is undoubtedly the major distinction between the risk factors for weight gain among PLWH and the general population. This claim is also supported by the findings of a recent systematic review and meta-analysis by Olawepo et al. (2021) which reviewed the changes in BMI of PLWH after initiating ART and staying on it for at least 6 months. Olawepo and colleagues included 30 studies in their review of which 18 was eligible for meta-analysis. All included studies showed an increase in BMI associated with HAART use with the highest BMI increase recorded in the first 6-12 months of treatment and lesser gains subsequently.

Furthermore, Bailin and colleagues highlighted an obesogenic environment as another risk factor, this includes increasing consumption of calorie-dense food and physical inactivity. Other risk factors include shifting demographics and an aging population. Other HIV-related factors that may drive weight gain not mentioned by Bailin et al. (2020) include perceptions around bigger body weight being more attractive and healthy, and a smaller body weight easily revealing one's HIV status. These are primarily driven by the stigma around HIV infection (Matoti-Mvalo and Puoane, 2011), and are explored deeper in subsequent sections.

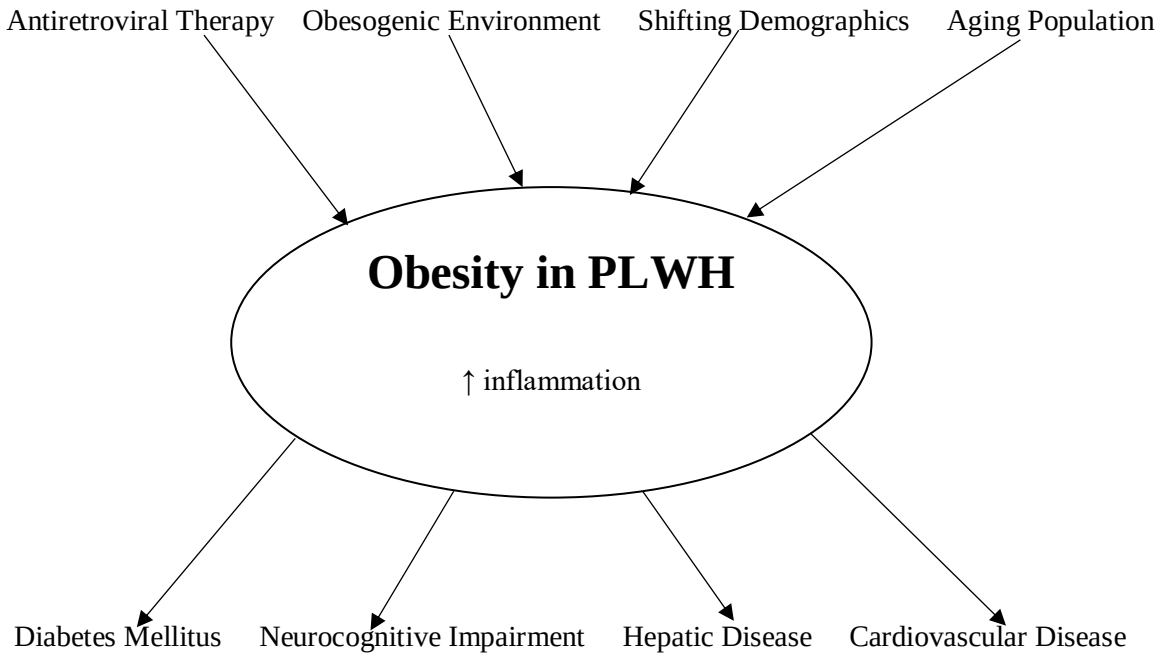

Figure 2. 1 Model of Obesity among PLWH adapted from Bailin et al. (2020)

Still from figure 2.1, Bailin and colleagues posit that this weight gain is marked by some other changes. These include increased inflammation, altered lipid, and glucose metabolism, and ectopic lipid deposition at which point the weight gain starts to become visible. This ultimately leads to established disease conditions such as diabetes mellitus (DM), neurocognitive impairment, hepatic disease, and cardiovascular diseases.

Only one study was found conducted in the Western Cape that addressed obesity among PLWH, other studies were conducted among pregnant PLWH. This study by Nguyen et al. (2016), however, described obesity phenotypes using cardio-metabolic profiles by combining BMI with other measures such as blood glucose, blood pressure, and lipid profile. This, coupled with the fact that the participants were pregnant made obesity very difficult to interpret from their findings. More research is required in the province with the increasing obesity epidemic.

In conclusion, obesity contributes to an increasing global burden of disease among PLWH. People with overweight or obesity have an increased risk of cardiovascular diseases even in the absence of other metabolic risk factors (Opio et al., 2020). This warrants continuous surveillance of all the factors that may contribute to weight gain among PLWH.

2.2.1.2 Lipodystrophy

Another anthropometric manifestation of long-term use of ART among PLWH is lipodystrophy. Lipodystrophy, sometimes called fat redistribution, is used to describe an array of metabolic syndrome including fat loss, fat gain, or a combination of both (Finkelstein et al., 2015). The loss of subcutaneous fat is called Lipoatrophy and it is usually seen around the face, buttocks, and limbs. On the other hand, visceral fat may begin to build up around the abdomen, breast, or dorsocervical region (also called buffalo hump). The buildup of visceral fat in these regions is referred to as lipohypertrophy (Mercier et al., 2009, van Griensven et al., 2007).

In a systematic review, Finkelstein et al. (2015) reported the global prevalence of lipodystrophy among PLWH using ART to be between less than 1 to 84% with a higher burden among low-and-middle-income countries (LMIC). The findings of this review should be used with caution as some included studies were case-control studies in which participants were recruited based on the presence of lipodystrophy or other metabolic conditions. A study was conducted in Brazil to determine the prevalence of self-reported HIV/HAART-associated lipodystrophy among a total of 183 PLWH. Authors found a 52.5% prevalence and reported severe lipodystrophy in more than half of the patients (Jardim et al., 2020). Interestingly, Jardim and colleagues reported that self-reported lipodystrophy was not associated with modifiable CVD risks. This study, however, failed to use any other method to diagnose the presence of lipodystrophy aside from self-report which is not reliable. It is also a cross-sectional study with no control group for comparison which is prone to the effect of confounding variables.

Bringing it close to home, a 24-month longitudinal study was conducted among a South African cohort initiating ART. The authors of this study reported an increase in the proportion of participants who developed lipoatrophy and lipohypertrophy over 24 months of ART. Lipoatrophy was reported more in men than women (Abrahams et al., 2018). This is similar to the finding of Hurley et al. (2011) in their South African cohort of 230 PLWH in Durban. Hurley reported a 35% (62/177) incidence of lipodystrophy among 177 participants who had all anthropometric data recorded. Interestingly, lipoatrophy has also been reported among prepubertal children on ART in Cape Town (Innes et al., 2013). These studies have given a hint into the presence of lipodystrophy among PLWH in South Africa. They are, however, not enough to formulate interventions and policies. Furthermore, because Hurley et al. (2011) conducted their study in a semi-private hospital which may potentially serve people from socio-economic group not typical of the South African population, and the small sample size of pre-pubertal children as well as concerns about precision of tools used by Innes et al. (2013), the finding of

these studies may not be generalizable to the South African population. This calls for more research.

Lipodystrophy is increasingly prevalent among PLWH and is correlated with some ART and the length of time on them (Alikhani et al., 2019). HIV-associated lipodystrophy has several complications including insulin resistance leading to hyperglycemia, and dyslipidemia. This increases the risk of cardiovascular diseases and has been proven to increase the odds of metabolic syndrome (Guzman and Vijayan, 2020, Berhane et al., 2012, Jantarapakde et al., 2014).

The systematic review of Finkelstein and colleagues mentioned above suggested that lipodystrophy is not well researched among PLWH in LMIC despite the high burden of HIV relative to other regions. Since the management of lipodystrophy is important in HIV care, more research needs to be done on it, especially in sub-Saharan Africa. Additionally, putting more effort into having a clearer definition, such as methods that rely less on subjective clinical procedures, and diagnosis of the sub-classes of lipodystrophy will allow more generalization of results, as there are differing definitions in literature (Cournil et al., 2010, Finkelstein et al., 2015).

2.2.2 Biochemical assessment

Biochemical assessment of nutritional status involves measuring the levels of nutritional markers in body fluid and tissue samples. This method easily reveals covert nutritional deficiencies, however, it can be expensive and invasive (Gibson, 2005, Ranjan and Nasser, 2015).

2.2.2.1 Blood lipids

Dyslipidemia is a term that refers to abnormal or excessive amounts of lipid or its derivatives such as lipoproteins in the blood. This alteration to the plasma lipid profile is usually associated with other underlying conditions such as obesity (Reiner et al., 2011). Dyslipidemia may include an imbalance in the blood concentration of any of the following: total cholesterol TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) (Stone et al., 2014). Dyslipidemia was reported as the leading global contributor to CVD and mortality (Murphy et al., 2017). Noubiap et al. (2018) conducted a systematic review and reported a high prevalence of dyslipidemia among the general adult population in Africa.

HIV dyslipidemia is a common complication, just like in the general population, it is linked to an increased incidence of CVD. HIV dyslipidemia is slightly different from in the uninfected population; in addition to HIV increasing insulin resistance, ART may also predispose PLWH to dyslipidemia as well as interfere with lipid-lowering medications (Husain and Ahmed, 2015). The common manifestations of dyslipidemia associated with PLWH, or ART use include decreased HDL-C, increased LDL-C, increased TC, and increased TG (Mallewa et al., 2009, Zou and Berglund, 2007, Husain et al., 2017).

According to the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP-III) guidelines (Expert Panel on Detection, 2001), elevated TC, LDL-C, and TG are defined as > 5.2 mmol/L, >2.5 mmol/L and > 1.7 mmol/L respectively. HDL-C < 1.0 mmol/L is defined as low. These definitions apply to all genders (Dave et al., 2016).

Management of metabolic disorders including dyslipidemia and other CVD risks among PLWH in Africa is said to be complex mainly due to limited resources (Husain et al., 2017). This is even worse with the paucity of data on HIV dyslipidemia on the continent (Dave et al., 2016). In a narrative review by Husain et al. (2017), the prevalence of dyslipidemia among PLWH in Africa was reported to be between 13% to 70%. Their report also concludes that dyslipidemia among PLWH may be because of the HIV infection itself or medications.

A cross-sectional study was conducted in Cape Town in which 406 ART-naïve and 551 ART-experienced participants with a median age of 34 (19-68) years were recruited. The study aimed to describe lipid abnormalities among adults PLWH either on ART or not. In this study, Dave et al. (2016) reported the prevalence of dyslipidemia to be 90% and 85% among ART-naïve and ART-experienced respectively. Low HDL-C was the most prevalent condition at 71% and 43% among ART-naïve and ART-experienced respectively, and this was thought to be suggestive of return to baseline HDL-C level among ART-experienced participants as clinical outcomes improve. Another South African study in even much younger participants (18-45 years) on ART for more than one year by Julius et al. (2011) revealed high TC, low HDL-C, and elevated LDL-C to be 32.2%, 45.7%, and 9.5% respectively among the participants of the study.

This increasing prevalence of dyslipidemia has also been reported in some other African countries. This was reported as 63.1% in Kenya (Manuthu et al., 2008). Nigerian researchers reported high TC, LDL-C, and TG at 28%, 24%, and 35% respectively (Lesi et al., 2009, Salami et al., 2009). Interestingly, all of the authors of these studies associated their findings with the use of ART (Husain et al., 2017), this places an urgent need to advance the study of CVD risks among PLWH in the era of expanding ART coverage.

2.2.2.2 Inflammation

Inflammation is an important part of the body's defense mechanism. Inflammation is said to occur usually when the body identifies a harmful or foreign agent, and the immune system subsequently removes it to begin the healing process. However, unchecked inflammation can lead to pathological conditions. Inflammation can be acute or chronic (Fritsch and Abreu, 2019, Michels da Silva et al., 2019, Zhang et al., 2019). Acute inflammation occurs rapidly and can be very severe but only lasts for a few days. Chronic inflammation, on the other hand, starts slowly but is long-term and may last for several months or years (Pahwa et al., 2020).

As with most other infections, chronic inflammation is a distinct feature of HIV infection. Continuous viral replication is a primary cause of inflammation in an untreated infection, among several others (Pérez et al., 2019). Apart from low-level HIV cell replication that may occur even in treated PLWH, other identified causes of inflammation in HIV infection include the synthesis of HIV RNA in the absence of replication, inactive immunoregulatory responses, translocation of microbes from the gastrointestinal tract (GIT) to the circulatory system, and other co-infections (Brenchley et al., 2006).

It is important to note that chronic infection is central to some non-infectious complications in PLWH such as CVD and some cancers. Several markers of inflammation have been identified and linked to increased CVD risk (Esser et al., 2014). Although the initiation of ART usually reduces or even totally stops HIV replication, levels of inflammatory markers have been seen to remain elevated in a long term (Pérez et al., 2019). Some examples of these inflammatory markers that have been identified among PLWH include C-reactive Proteins (CRP) especially the high sensitive (hs)-CRP, Interleukin (IL)-6 (Neuhaus et al., 2010), Tumour Necrosis Factor-alpha (TNF-α) (Wada et al., 2015).

A retrospective analysis of data from a multi-country cohort study (Wada et al., 2015) in Africa including Kenya, Nigeria, South Africa, Uganda, and Zambia was conducted by Kroeze et al. (2019) to investigate the bio-marker profile of HIV-related immune activation among PLWH (HIV-1 infected) aged 18 years and above. This analysis recruited 398 participants with an undetectable plasma viral load (<50 copies/mL) at the time of analysis. Selected plasma biomarkers include soluble scavenger receptor CD14 (sCD14), soluble CD163 (sCD163), CRP, IL-6, chemokine (C-C motif) ligand 2 (CCL2), C-X-C chemokine ligand 10 (CXCL10), C-X-C chemokine ligand 9 (CXCL9), lipopolysaccharide-binding protein (LBP) (Kroeze et al., 2019). Plasma from 90 uninfected individuals from Nigeria, South Africa, and Uganda was used as a reference.

In their findings, Kroeze and colleagues reported that all measured biomarkers have significantly higher levels in PLWH before the initiation of ART than the uninfected reference group. Although levels of all biomarkers decreased after ART initiation, CXCL10, LBP, CRP, sCD163, and sCD14 remained significantly higher during ART among PLWH than in the reference group. This is an indication of persistent immune activation, inflammation, and microbial translocation. Interestingly, CCL2, LBP, CRP, and IL-6 were expressed differently between the five countries, this could suggest the influence of geographical location and other environmental factors in the expression of inflammation (Kroeze et al., 2019). This finding further amplifies that of Manion et al. (2017) who reported that markers of inflammation vary by country of residence among their Mexican and South African ART-naïve participants. Manion and colleagues recommend further research to study how this variation may determine HIV prognosis in different regions.

Since viral suppression does not necessarily stop monocyte activation and continued inflammation among PLWH (Dirajlal-Fargo et al., 2020), there is a need for continuous assessment of inflammatory markers among this group of people. Longitudinal studies may also be important to further identify factors related to chronic inflammation among PLWH.

2.2.2.3 Nutrient levels

Vitamins and minerals (micronutrients) play an important role in the regulation of metabolism, oxidative stress, and immunologic response (Carter et al., 2015, Nunnari et al., 2012). Micronutrient deficiencies can adversely affect immune function and result in disease progression (Mahan and Raymond, 2016, Mamede et al., 2011). Micronutrient deficiency has been reported in PLWH before and even after the start of HAART use, especially in LMIC (Brenchley et al., 2006, Drain et al., 2007). This has been associated with increased morbidity and mortality, CD4+ T-cell count, and viral load (Bruno et al., 2017, Faintuch et al., 2006).

Shivakoti et al. (2016) conducted a study to determine the prevalence and risk factors of micronutrient deficiency using serum concentration among ART-naïve HIV-infected adults and to assess changes after 48 weeks of ART initiation. This study was nested in the Prospective Evaluation of Antiretrovirals in Resource-Limited Settings (PEARLS) study in 9 countries (n=1571) including South Africa (n=210). A random cohort of 270 participants (30 from each country) was selected for the analysis. The prevalence of having at least one micronutrient deficiency was 29.2% and only 13.9% had no micronutrient deficiency. Multiple micronutrient deficiencies (of any three or more micronutrients) were common among SA participants at 35%. This study shows that micronutrient deficiencies, single or multiple, are common among PLWH even on ART. The finding of the study is very important as it is a longitudinal study with participants from several countries. A major limitation in this longitudinal study is the lack of HIV-

uninfected controls and data on nutrient supplementation. However, authors hinted that the possibility of micronutrient supplementation was low in most study sites.

Micronutrient deficiency in HIV infection may be due to drug-nutrient interaction caused by some antiretroviral drugs, malabsorption, gut infection, chronic inflammation, and poor dietary intake (Bruno et al., 2017, Mahan and Raymond, 2016, Tenforde et al., 2017). Important micronutrients that have been reported deficient among PLWH include Vitamins B12, A, E, D, selenium, zinc, and Iron (Shivakoti et al., 2016, Mahan and Raymond, 2016).

Vitamin D

Vitamin D often assessed using the serum 25-hydroxyvitamin D (25(OH)D) indicator is very important in HIV infection (Norval et al., 2016). The biologically active form of this vitamin is $1,25(OH)_2D$ which is involved in the metabolism of calcium and phosphate, and the production of the parathyroid hormone (Izzedine et al., 2009). Vitamin D is useful for several physiological and immunological functions and its deficiency has been identified to be significantly associated with disease progression, and mortality in HIV infection (Mehta et al., 2010, Giacomet et al., 2013).

Some researchers have reported lower levels of serum vitamin D among PLWH when compared with the general population attributing this to factors such as inadequate exposure to sunshine, malabsorption, low dietary intake, or some HIV-related factors (Cervero et al., 2012, Meyzer et al., 2013). Some authors have also reported an association between ART regimens, especially those containing Tenofovir disoproxil fumarate (TDF), and altered vitamin D metabolism (Klassen et al., 2012, Mueller et al., 2010). However, other authors have reported that there was no evidence of a lower level among PLWH relative to the infected population (Orkin et al., 2014). Orkin and colleagues recommended more data especially from a large, controlled longitudinal study, a gap that would have been filled by Shivakoti et al. (2016) but for the lack of HIV-uninfected control in their analysis.

Serum vitamin D levels have been extensively researched among PLWH in the South African population. Overall, Hypovitaminosis D was found to be seasonal and higher during winter months, highly correlated with ultraviolet B (UVB) exposure, higher among the black population in Cape Town, and was associated with susceptibility to TB infection (Martineau et al., 2011, Coussens et al., 2015, Havers et al., 2014). Vitamin D, however, remains a very important micronutrient especially among PLWH because of its role in immunity and homeostasis and as such should be closely monitored.

Vitamin E

Just like Vitamin D, Vitamin E is another fat-soluble vitamin that is a potent antioxidant. Vitamin E helps to prevent or reduce oxidative stress by destroying free radicals (Traber and Atkinson, 2007). Vitamin E is therefore very useful in the context of chronic inflammation and immune activation common in HIV infection (Montine et al., 2004, Shishehbor et al., 2006). In a Ghanaian study aimed to assess serum levels of Vitamin E among 103 PLWH on ART, the researchers observed serum Vitamin E deficiency among 82.5% of their participants (Kpewou et al., 2021). Studies assessing serum levels of Vitamin E among PLWH in the South African population are limited. In the study of Shivakoti et al. (2016) earlier mentioned, Vitamin E deficiency is defined as serum levels of α-tocopherol <9.3 μmol/L. The prevalence of Vitamin E deficiency among their participants was 0% pre- and post-ART initiation. However, Shivakoti and colleagues posit that Vitamin E concentration could be lower among their ART-naïve participants with HIV when compared with the uninfected population. This claim could not be proven as uninfected controls were not enrolled in their study.

Assessing levels of fat-soluble vitamins have been reported to have issues which limit the standardization, interpretation, and consequently generalization of results (Albahrani and Greaves, 2016). These include stability of the metabolites which may be affected transport and storage conditions such as light exposure, temperature, and time (Clark et al., 2004, Cuerq et al., 2015). Furthermore, blood samples may be treated under different protocols depending on the acceptable practices of different clinical laboratories (Albahrani and Greaves, 2016), this necessitates and cautious and contextual interpretation of fat-soluble vitamin assays.

Minerals

Selenium and zinc are important minerals needed for antioxidative functions. They are significant in the context of HIV infection by regulating oxidative stress and enzymes needed for multiple immune functions. Some selenoproteins such as glutathione peroxidase (GPX) are the potent regulator of HIV transcription (Hoffmann and Berry, 2008, Lu and Holmgren, 2009, Prasad, 2014, Fufa et al., 2009).

Selenium

Before the wide scale-up of ART, researchers have reported low selenium concentration among PLWH which further declines with disease progression and is associated with mortality (Stone et al., 2010). However, more recent studies have shown that prolonged use of ART increases selenium concentration (Stone et al., 2010). Shivakoti et al. (2014) in their case-cohort study

reported that serum selenium deficiency was not associated with disease relapse in a multivariable model among PLWH participating in their study. Therefore, selenium supplementation should be done cautiously, especially when selenium levels are insufficient or unknown. In the study of Shivakoti et al. (2016), pre-ART prevalence of micronutrient deficiency was highest for selenium at 53.2% using a cut-off of selenium <85 µg/L to define deficiency. The highest risk of selenium deficiency was observed in participants from South Africa, Brazil, India, Malawi, Peru, and Thailand. It has been shown that the risk of selenium deficiency is associated with soil type (Phiri et al., 2019).

Zinc

There have also been reports of low plasma zinc concentration among PLWH both ART-naïve and those on ART (Jones et al., 2006, Visser et al., 2003). A study was conducted in Southern Nigeria to investigate the level of some trace minerals among PLWH and compare it with uninfected controls (Asemota et al., 2018). A sample of 100 PLWH at a teaching hospital comprising 70 ART-experienced and 30 ART naïve participants. Additionally, 50 uninfected controls were enrolled. Researchers in this study reported significantly reduced serum zinc levels among PLWH compared to uninfected controls. ART did not improve zinc status in this study sample. Similarly, Visser et al. (2003) conducted a cross-sectional study of 132 ART-naïve adults in Cape Town to determine predictors of low Vitamin A and zinc levels. Plasma zinc levels were low in 20% (<10·7 µmol/l) of the participants. However, an association has also been reported between increased zinc intake and increased risk of disease progression (Tang et al., 1993) which brings caution to the idea of zinc supplementation among PLWH. This body of evidence point to the fact that adequate attention must be given to the nutrient intake of PLWH.

Calcium

There are several health benefits of optimal calcium intake (World Health Organization, 2004, Cormick and Belizán, 2019). There is an inverse relationship between blood pressure and calcium intake. Therefore, increasing calcium intake or supplementation could reduce the risks of hypertension (Jayedi and Zargar, 2019), howbeit only significantly among people with prior suboptimal calcium levels (Cormick et al., 2015, Hofmeyr et al., 2018, Reid et al., 2010). Additionally, calcium supplementation may reduce LDL and increase HDL cholesterol (Chen et al., 2017, Vinarova et al., 2016), improve bone health especially in children and adolescents with low intakes (Moyer, 2013, Weaver et al., 2016), and reduce the risk of colorectal cancer (Bonovas et al., 2016). Interestingly, there is an emerging body of evidence suggesting an

inverse relationship between calcium and obesity, and consequently, other chronic diseases linked to obesity. However, this suggestion needs further testing (Pannu et al., 2016).

Over the years, there have been reports of the strong relationship between calcium and vitamin D and the overlap between their impact on health (Ross et al., 2011). This could be because vitamin D is an important regulator in the homeostasis of calcium (Khundmiri et al., 2016). It is therefore important to maintain optimum vitamin D levels alongside calcium.

Serum calcium accounts for only 1% of the total body calcium and is a tightly regulated indicator. Since it is very important in cellular homeostasis, serum calcium levels are not easily affected by fluctuations in the dietary intake but, bone reserves are usually mobilized to maintain it (Beto, 2015, Del Valle et al., 2011). Dietary reference intake values for calcium are high, for adults the values are between 1000mg to 1300mg depending on the reference (Ross et al., 2011, World Health Organization, 2004). Serum calcium levels are recommended not to be less than 8.8 mg/dl, below which is termed hypocalcemia. The South African National Health Laboratory Services (NHLS) gives a range of 2.20 – 2.55 mmol/l as the normal range for calcium. Hypocalcemia is, however, less common compared to hypercalcemia (Goyal et al., 2021). Albumin-corrected calcium (ACCA) was sometimes suggested as a better indicator of calcium level (Davies et al., 2016, Group, 2009), but Ridefelt and Helmersson-Karlqvist (2017) refuted this notion, claiming that the ACCA is unlikely to add any additional information.

Since the use of TDF or TDF-containing medications may affect Vitamin D levels among PLWH (Klassen et al., 2012, Mueller et al., 2010), it may also be an important consideration for calcium levels in the context of HIV infection. This notion is corroborated by Noe et al. (2018) who demonstrated that PLWH on TDF-containing medications may require a higher level of parathyroid hormone to maintain serum calcium equilibrium. A major limitation, however, in the Neo study is the retrospective study design which is prone to bias due to the unavailability of data.

As much as calcium supplementation has been demonstrated to be beneficial, evidence suggests that high levels may be associated with some cardiovascular and renal dysfunction (Drozd et al., 2014, Li et al., 2018), and as such must be taken with caution and by prescription.

Studies showing serum calcium levels among PLWH in South Africa are limited. Pillay et al. (2020) showed that electrolyte imbalance was common among their 96 black cohort of PLWH, and DM cases compared with 192 black HIV-uninfected control with DM. In their findings, Pillay and colleagues reported hypocalcemia as the most common electrolyte imbalance in both cases and control at 31.25% and 22.91% respectively. Hypocalcemia was also the only imbalance

significantly lower among PLWH compared to their uninfected control. However, it is important to note that participants in this study had comorbidities that could have easily affected their electrolyte levels.

There is a need for more research to be conducted on calcium levels among PLWH in South Africa especially as the prevalence of comorbidity is increasing. Moreover, the South African HIV and DM guidelines do not yet provide recommendations for the monitoring or supplementation of this electrolyte (Meintjes et al., 2017). More research will provide adequate information to develop guidelines for South Africa.

2.2.3 Clinical

Clinical assessment of nutritional status is focused on identifying the signs and symptoms of malnutrition through physical means.

2.2.3.1 Blood Pressure/Hypertension

The force exerted by blood on the walls of the blood vessel is referred to as blood pressure (American Heart Association, 2017). In a recent South African study (Jardim et al., 2017), hypertension was defined as mean systolic blood pressure (SBP) of at least 140 mmHg or diastolic blood pressure (DBP) of at least 90 mmHg. This is in line with the Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) (Chobanian et al., 2003).

Hypertension is the leading preventable risk factor for CVD, cause of mortality, and premature death globally (Mills et al., 2020, Lozano et al., 2012). In the US, hypertension is the leading cause of death among women, and second after smoking in men when compared with lifestyle, dietary, and metabolic risk factors (Danaei et al., 2009). Although the exact etiology of primary hypertension is not clearly understood (Lenfant et al., 2003), some risk factors for hypertension include age, obesity, family history, race, diet, and lifestyle factors such as alcohol intake and insufficient physical activity have been identified (Basile and Bloch, 2015).

In 2010, an estimated 31.1% (1.39 billion people) of the global adult population had hypertension and this estimate was higher in LMIC (Mills et al., 2020). This global prevalence is estimated to likely exceed 1.6 billion people by 2025 (Mills et al., 2016). The South African National Health and Nutrition Examination Survey-1 estimated hypertension prevalence at 30.4% with a distinct variation by geographical setting (Kandala et al., 2013, Shisana et al., 2014).

Hypertension is a growing source of concern also among PLWH, especially following the scale-up of ART (Nduka et al., 2016, Peck et al., 2014). ART-experienced PLWH are being reported to have a higher prevalence of hypertension when compared with the uninfected population (Nguyen et al., 2015, van Zoest et al., 2016). A systematic review and meta-analysis of the global prevalence of hypertension among PLWH was conducted by Xu et al. (2017). Xu and colleagues reviewed a total of 49 studies published between 2011 and 2016 with 63,544 participants. Ten of these studies were from Africa, others are from America, Europe, and Asia. The overall prevalence for all participants was 25.2%, and this was further distinguished into 34.7% among ART-experienced, and 12.7% among ART-naïve participants (Xu et al., 2017). Xu and colleagues also found that hypertension was associated with older age in their review.

This report shows an increased prevalence of hypertension among PLWH with the use of ART and corroborates the conclusion of another systematic review published earlier on the effect of ART exposure on blood pressure of PLWH by Nduka et al. (2016). Nduka and colleagues reviewed 39 studies from 21 countries with a total of 44903 participants. These studies showed the difference in the mean blood pressure and hypertension prevalence among ART-naïve PLWH and those exposed to ART. The mean ART duration was 37.5 months. Only 11% of included studies in this review were from low- and middle-income countries including one from South Africa. This may likely cause a gap in the sociodemographic characteristics between most of the participants of this review and the South African context. However, Nduka et al. (2016) found that increased systolic and diastolic blood pressure, as well as increased hypertension risk, had a significant association with ART exposure.

The findings of these studies emphasized the increased risk of hypertension facing PLWH on ART. However, some of them fail to explore the role of other HIV-specific factors such as disease severity and duration. Some also included a few studies from Africa. Since the inclusion of few studies in Africa may be caused by a paucity of evidence, more research is necessary in this area. In conclusion, blood pressure is an important CVD risk factor and must be continuously monitored especially among PLWH who have increased risk.

2.2.3.2 Hand Grip Strength

The Hand Grip Strength (HGS) is a measure of muscle endurance, strength, and overall muscle fitness. It has been associated with the risk of mortality and is a simple way of predicting cardiovascular risk in the general population (Burtin et al., 2016, Felipe et al., 2015, Leong et al., 2015). In recent studies conducted among uninfected participants, low HGS is strongly correlated with CVD and mortality (Celis-Morales et al., 2018, Park et al., 2019). The HGS is

measured using the dynamometer and is defined as the average value for grip strength of the dominant hand (Yoo et al., 2017, Yu et al., 2017).

Knowing that the loss of muscle strength is usually worsened by increased adiposity, it is important to consider a relative measure of muscle strength such as the Relative HGS (RHGS) (Ramírez-Vélez et al., 2020). The RHGS is recommended because it corrects the absolute measure of strength (HGS) for the measure of body mass such as BMI. It, therefore, eliminates the confounding effect of strength by body mass, and the health risks that are associated with increased body weight and low muscular strength (Choquette et al., 2010). The RHGS is calculated as HGS divided by BMI (Lawman et al., 2016).

A national population-based cross-sectional study was conducted in South Africa in which researchers recruited 3,840 participants aged 50 years or older. The study aimed to investigate social and health differences in hand grip strength among the participants. In this study, the mean overall HGS was 37.9kg and 31.5kg for men and women respectively. Grip strength is significantly associated with greater height and lower functional disability among all participants. Additionally, grip strength had a significant association with not being underweight and better cognitive functioning among men and women respectively (Ramlagan et al., 2014). A major limitation to the generalization of this study is the demographic of the participants; they were aged 50 years and older and HGS would have been affected by this.

Muscle strength reduces with age, and findings of studies are showing that PLWH are more prone to an earlier onset of frailty and increased vulnerability to morbidity (Bloch, 2018, Levett et al., 2016, Thurn and Gustafson, 2017). A systematic review on the physical function, grip strength, and frailty among PLWH in sub-Saharan Africa included three studies whose authors reported grip strength (Bernard et al., 2017). Two of these studies showed lower grip strength (up to 4 kg) among PLWH when compared with the uninfected population (Cournil et al., 2014, Negin et al., 2012, Olsen et al., 2015). In the study of Olsen et al. (2015), grip strength differed by age and educational status; grip strength was higher among men than women, and among those with no education than those with secondary education. On the contrary, the prevalence of frailty is similar among PLWH and the uninfected participants, although it is higher for women than men, according to a study conducted in KwaZulu-Natal, South Africa(Edwards et al., 2020). This study was conducted to compare the prevalence of frailty by HIV serostatus among older individuals. However, this study included grip strength as a measure of frailty together with other 4 measures including physical activity, mobility, fatigue, and gait speed. These other measures could have affected the results. Since more PLWH are aging and living longer with the infection,

more investigation into the HGS may help identify early frailty and its association with chronic diseases.

HGS has been measured in diverse ways and with several instruments including the Jamar hydraulic dynamometer, Martin pneumatic vigorimeter, Harpenden mechanical dynamometer, and isometric strength testing (Roberts et al., 2011). The type of equipment used, and the protocol followed in measuring HGS will largely influence the results (Roberts et al., 2011). It has therefore been difficult to agree on reference values, and researchers often treat HGS reading as a continuous variable.

2.2.4 Dietary Assessment

Diet is recognized in most regions of the world as a leading modifiable risk factor for morbidity and mortality (World Health Organization, 2015). Most chronic or non-communicable diseases are directly or indirectly related to diet (Lim et al., 2012). Poor dietary quality has been associated with an increased risk of CVD, some cancers, type 2 diabetes, and all-cause mortality (Reedy et al., 2014, Baik et al., 2013).

Among PLWH, diet has been identified as one of the predictors of disease severity (Rawat et al., 2013). Sadly, there have been reports of low diet quality among PLWH when compared with the uninfected population (Weiss et al., 2019). Muhammad et al. (2019) have also suggested a link between food insecurity and diet quality among PLWH. It is therefore important that dietary intake is regularly assessed and guided.

Since results of the biochemical assessment of nutrient levels may be subject to several homeostatic imbalances and may not provide recommendations for dietary modification, it is important to conduct a direct assessment of dietary intake (Potischman, 2003). Several dietary intake assessment methods have been used over the years, but none is without its challenge (Shim et al., 2014). Such challenges include but are not limited to the inconsistencies that are peculiar to self-reported data. (Rollo et al., 2016). Inaccurate dietary assessment may result in misleading conclusions about the association that exists between dietary factors and diseases.

Examples of dietary assessment methods include food frequency questionnaire (FFQ), 24-hour recall, dietary history, dietary record, food consumption record, duplicate diet approach, and others (Shim et al., 2014). Some of these methods use objective observation methods, and subjective measures in terms of open or close-ended questionnaires. The FFQ is arguably one of the most widely used dietary assessment methods, especially for epidemiological studies (Bhupathiraju et al., 2013, Méjean et al., 2013). It is simple, cost-effective, time-saving, has a

low-respondent burden, and is suitable in studies where the participants may not be able to complete self-reports for various reasons.

Several concepts have also been developed around diet adequacy which not only measure dietary intakes but the quality of those intakes with reference to predetermined criteria (Asghari et al., 2017, Drewnowski, 2014).

2.2.4.1 Dietary requirement

Optimum nutrient intake is important for PLWH. It helps to slow down disease progression, reduce the chances of OI, improve quality of life, and ensures adequate efficacy of medication (Rawat et al., 2013). As in the uninfected population, diet is usually modified per individual requirements based on several considerations. However, general dietary recommendations are as follows:

Energy and Fluid

PLWH generally have a higher resting energy requirement than the uninfected population, this has been estimated to be about 10%. Consequently, this may have several effects on metabolism and the presence or absence of OI (Chang et al., 2007, Mittelsteadt et al., 2013). PLWH with an OI are estimated to have about 20% - 50% increase in nutritional needs. However, those with well-controlled infections are advised to follow the guidelines for the general population (Dong and Imai, 2017).

Protein and Fat

As mentioned above, with an OI, protein requirements should be increased by 10% over the recommendation for the general population. However, protein recommendations should also be tailored to meet the specific infections present alongside HIV. Otherwise, PLWH without an OI should follow the protein requirement of the general population.

Fat oxidation increases in the context of HIV infection (Sutinen and Yki-Järvinen, 2007), therefore fat requirements may be different. Presently, PLWH are advised to follow the heart-healthy lipid guidelines with an emphasis placed on omega-3 fatty acids also because of their role in immune function (Jaca et al., 2020, Dong and Imai, 2017).

Micronutrients and Supplementation

Micronutrients are very important in HIV infection. Adults living with HIV may be at risk of micronutrient deficiency due to several reasons including inadequate intake worsened by food

insecurity (Gebrehiwot and van der Veen, 2014). This may directly cause an imbalance in CD4 count among other useful indicators of HIV infection (Aibibula et al., 2016).

The use of multiple, dual, or single micronutrient supplements has been researched and debated with conflicting results (Visser et al., 2017). An update to a previous Cochrane review published by Visser et al. (2017) concluded that no consistent clinical benefits have yet been identified with the body of research already conducted. Visser and colleagues further opined that their findings should not be a basis to deny the use of supplements for those who are nutritionally deficient. However, mega-dosing of micronutrients such as Vitamin A and Zinc have been said to have adverse effects such as disease progression (Dong and Imai, 2017).

Overall, if micronutrient supplementation is indicated for any PLWH, it should be thoroughly monitored and individualized to determine the optimal length of time for supplementation (Dong and Imai, 2017). Furthermore, supplementation is advised to not exceed the levels of DRI for each indicated nutrient (Kawai et al., 2010).

In the era of HAART, Dietary recommendations for persons with controlled HIV infection seem to be similar to that of the general population. However, not much research has been conducted in South Africa on the dietary intake of PLWH. The studies we found including Hattingh et al. (2006), Hattingh et al. (2014), and (Wrottesley et al., 2014) were all conducted among ART naïve HIV-infected women and not in the Western Cape Province. It is, therefore, necessary to assess the dietary intake of PLWH on ART, especially concerning the presence or absence of comorbidity.

2.3 Body Weight Perception

Body image perception refers to an individual's thoughts about their body image, it also entails what they perceive, or feel as an ideal body image and how this relates to their actual body image (Martinez et al., 2005). This perception is, however, not solely influenced by factors inherent within the person but by social experience and cultural inclinations (Grogan, 2016).

Body weight misperception is the discrepancy between an individual's actual body weight and what they perceive their weight to be. This may lead to such individuals holding negative feelings or attitudes toward their body including their figure, shape, stomach, or hips (Corona et al., 2019, Deschamps et al., 2015). Researchers have reported body weight misperception among PLWH with a general tendency of people to underestimate their actual body weight (Bradbeer and Bakar, 2008, Hurley et al., 2011, Matoti-Mvalo and Puoane, 2011, McCormick et al., 2014,

Sharma et al., 2007). This trend shows that weight misperception may be a motivation for weight gain and consequently increased risk of CVD among PLWH.

There is a strong association between body weight perception, desire to gain weight, and actual weight gain among PLWH. Hurley et al. (2011) reported in their Durban study that the weight perception of their sample of PLWH was not the same as their BMI. Hurley and colleagues further estimated that participants who wanted to gain weight in their study had an average weight gain of 7.8kg, which is about 2.8 times more than those who were satisfied.

Body weight misperception among PLWH may be driven by the stigma generally associated with HIV. Matoti-Mvalo and Puoane (2011) conducted a mixed-method study to explore the perception of attributing thin figures to PLWH among black South African women in Khayelitsha, Cape Town. The authors reported that 69% of the participants associated a thin figure with PLWH. Consequently, most people preferred to be overweight and at risk of CVD to being thin and perceived as being infected with HIV.

Some researchers have also proven that body weight perception is subject to ethnic considerations and norms. This may be an important consideration when planning weight management interventions among PLWH (Capili et al., 2014, Matoti-Mvalo and Puoane, 2011). It is equally necessary to research effective counseling methods applicable to different contexts and settings. This will help identify and address prejudices and biases about the weight that are present in those settings. Furthermore, because self-esteem have been seen to moderate the relationship weight perception/satisfaction and depressive symptoms (Rawana, 2013), it may be important to assess the self-esteem of PLWH as a predictor of depressive symptoms or quality of life.

2.4 Risk Factors for NCDs

2.4.1 Physical Activity

Physical inactivity is one of the leading preventable causes of death due to non-communicable diseases. An inverse linear relationship was observed between the volume of physical activity (PA) and all-cause mortality (World Health Organization, 2015, Marcus et al., 2006). About 1.9 million death was attributed to PA globally every year and this causes a large economic burden and healthcare spending (Carlson et al., 2015, Weintraub et al., 2011). The association between the world's greatest causes of death – CVD, obesity, and sedentary behaviour emphasizes the need to discuss physical activity (Lau et al., 2017).

It is recommended for adults to reach a target of at least 150 minutes of moderate-intensity aerobic PA or 75 minutes of vigorous-intensity PA per week (World Health Organization, 2010). The proportion of people meeting these recommendations is low worldwide. Although physical inactivity seems to be highest among women, resource-rich societies, and older people, it is also high among other population groups (Ozemek et al., 2019). A global PA surveillance report was published by Hallal et al. (2012) reporting PA levels of adults (15 years and above) from 122 countries. Hallal and colleagues estimated that 31.1% of global adults are physically inactive with a range of 17% - 43% in Southeast Asia and the Americas respectively. These results were similar to those reported in a more recent and largest global physical activity surveillance conducted by Guthold et al. (2018). Data from 358 surveys from 168 countries with a total of 1.9 million participants was analyzed. Guthold and colleagues estimated the prevalence of global inactivity at 27.5%. Prevalence was highest in high-income countries at 42.3% with Southeast Asia and sub-Saharan Africa at 17.6% and 17.9% respectively.

A systematic review and meta-analysis on the global physical activity level among PLWH by Vancampfort et al. (2018) reported an insufficient physical activity level which is lower than in most other population groups with chronic diseases. This review included 24 studies with 3780 participants and a mean age range of 37 - 58 years. Vancampfort and colleagues reported that about half (50.7%) of the PLWH participating in their review met the WHO physical activity requirements. They, however, indicated that half of the included studies assessed PA using subjective rather than objective methods and this is a limitation of the systematic review.

South African studies on physical activity levels among PLWH have revealed a lower level of activity among PLWH relative to the uninfected population (Godijk et al., 2020, Kinsey et al., 2008, Roos et al., 2014, Wong et al., 2016). A study that specifically measured PA among PLWH was conducted by Mabweazara et al. (2019) in healthcare facilities in Cape Town. Mabweazara and colleagues reported gender as the greatest demographic predictor of PA among PLWH, with a higher PA level in male participants. Our study will provide further information about the differences in PA levels between PLWH with and without comorbidities.

With increasing levels of physical inactivity among all population groups including PLWH, the risk of CVD is undoubtedly increasing at alarming rates. In response to this, the WHO is working towards a target of reducing physical inactivity by 10% and 15% by 2025 and 2030 respectively (World Health Organization, 2018). More research must be conducted to inform policies and interventions which will be targeted toward achieving the aim of the WHO and will be adopted by all relevant stakeholders.

2.4.2 Alcohol Intake

According to the WHO, alcohol is the third most important avoidable cause of death and disability globally, after smoking and obesity. Alcohol is an important aspect of cultural and social events as it is perceived to pleasure the user (World Health Organization, 2019a). Alcohol is usually measured in grams per day or drinks per day (Fernandez-Sola, 2015). The alcohol content of a standard drink varies by country based on government regulations. Kalinowski and Humphreys (2016) in their systematic review of alcohol standards in 37 countries including South Africa reported 10 g of alcohol as the modal standard drink size which is in line with WHO guidelines. WHO advises both men and women not to exceed two drinks per day.

The widespread socio-cultural and personal acceptance of alcohol and its ease of availability has caused extensive organ damage (Shield et al., 2014). The main sites of organ damage consequent from alcohol consumption are the liver, digestive, neurological, and cardiovascular systems (Orman et al., 2013, Williams et al., 2014, Shield et al., 2014).

The relationship between alcohol consumption and health is, however, a complex one (Roerecke and Rehm, 2012, Rehm et al., 2003). Moderate alcohol intake has been reported to have benefits on cardiovascular health including reduced mortality and lower incidence of coronary heart diseases (Sayed and French, 2016, Ronksley et al., 2011). Contrary to this opinion, Stockwell et al. (2016) in their systematic review and meta-analysis of alcohol consumption and all-cause mortality reported that studies that highlight the benefits of moderate alcohol consumption over abstinence are prone to serious measurement error. Stockwell and colleagues did not find any significant benefits of moderate alcohol consumption after adjusting for abstainer biases and quality-related characteristics of studies. Due to these conflicting findings, healthcare professionals are usually encouraged not to recommend alcohol to non-drinkers (O'Keefe et al., 2014).

Alcohol use is associated with HIV in several ways (Baliunas et al., 2010, Lan et al., 2017, Schensul et al., 2010, Probst et al., 2018). One of the numerous harmful effects of alcohol use is its effect on HIV progression. Authors of a systematic review reported that 77% of studies included in their review (n=53) show a negative association between alcohol use and one or more stages in the HIV treatment cascade (Vagenas et al., 2015). Furthermore, alcohol use can affect adherence to ART. In a Cape Town study of alcohol-related beliefs and non-adherence to ART reported, 57% of current alcohol users reported forgoing ART for alcohol (Kalichman et al., 2020). Alcohol use has also been observed to increase the incidence of HIV infection by increasing the possibility of engaging in sexual risk behaviour such as unprotected sexual

intercourse (Rehm et al., 2012, Scott-Sheldon et al., 2013, Scott-Sheldon et al., 2016, Letsela et al., 2019).

Alcohol use may further worsen the already high risk of CVD among PLWH through chronic inflammation and immune activation (Freiberg et al., 2010, Webel et al., 2017). This is a source of concern with the high rate of alcohol consumption among PLWH in SA, even among pregnant PLWH (Raggio et al., 2019). More than half (64%, n=187) of the participants in the Cape Town study on alcohol-related beliefs and non-adherence to ART earlier mentioned reported current alcohol use. In the quest to solve the increasing risk of CVD among PLWH, continued research on the rate of alcohol consumption is needed among this population group. More importantly, effective policies to regulate availability should be considered (Veld et al., 2017).

2.4.3 Smoking

Smoking is another important global health risk in the general population. It is ranked second after high blood pressure among global risk factors causing death, especially in high-income countries. It was reported that smoking is responsible for 5 million deaths annually since 1990 (Reitsma et al., 2017, Giles et al., 2018, Forouzanfar et al., 2016). Smoking is estimated to reduce the expected life duration of its users by 10 years. Long-term smoking is associated with increased morbidity and mortality, especially in cases of chronic obstructive pulmonary diseases (COPD), lung cancer, and CVD (Jha and Peto, 2014). Patients who stop smoking usually have a lower lung function decline, as well as morbidity and mortality than those who do not (Anthonisen et al., 2005, Soriano et al., 2015). This makes smoking cessation one of the most cost-effective interventions in medical practice, albeit not fully explored (Kwak et al., 2018, Tøttenborg et al., 2018).

In 2015, a systematic analysis of the global burden of disease with data from 195 countries revealed that the global age-standardized daily prevalence of smoking was 25% for men and 5.4% for women (Reitsma et al., 2017). Whilst the prevalence of cigarette smoking seems to be lower in sub-Saharan Africa compared with other countries, this prevalence is gradually increasing in Africa but falling in other countries (World Health Organization, 2019b). A systematic review of tobacco smoking in sub-Saharan Africa (SSA) showed that the prevalence of smoking was high in Eastern and Southern African men than in other groups (Brathwaite et al., 2015).

Tobacco use, both in form of smoking and smokeless tobacco (SLT), has been reported to be higher among PLWH in high-income countries compared to uninfected populations (Helleberg et al., 2015, Mdodo et al., 2015, Regan et al., 2016). A similar finding has been reported in SSA.

An analysis of the demographic health survey data in 25 SSA countries including South Africa showed that PLWH (both men and women) are more likely to smoke a cigarette as well as use SLT than the uninfected population (Murphy et al., 2019). In their findings, Murphy and colleagues reported that smoking prevalence was significantly higher among HIV-positive men than uninfected men (25.90% vs 16.09%; $p < .0001$), as well as among HIV-positive women than uninfected women (1.15% vs 0.73%; $p < .001$). This increased prevalence is also supported by findings from a recent systematic review of globally available data on smoking prevalence among PLWH. This finding was still prevalent after sub-group analysis for men, women, and WHO regions with available data (Johnston et al., 2021).

Apart from the increased risk of CVD and other chronic diseases attributed to ART use and HIV infection (Rawdanowicz et al., 2013), smoking predisposes PLWH to even great risk. Risks of CVD (Anne-Lise et al., 2015, Freiberg et al., 2013), cancers (Farahani et al., 2017, Park et al., 2016), and some respiratory illnesses (Bigna et al., 2018, Triplette et al., 2016) are higher among PLWH who smoke. This is very concerning with the increased life expectancy of PLWH. The findings of a recent study on the use of tobacco and quality of life among PLWH with depression on ART in Cape Town show the prevalence of habitual tobacco use to be 23.9% (48.1% in men, 15.5% in women), which is high (Stanton et al., 2021). Stanton and colleagues further reported that habitual tobacco use was associated with decreased cognitive functioning in their sample. This study is one of the few investigating smoking and its implications among PLWH in the era of increased co-morbidity in Cape Town. However, it was conducted among PLWH seeking to treat depression and may not be representative of all PLWH. It is important to investigate further into the smoking patterns of PLWH in Cape Town and its association with NCDs.

2.5 Quality of Life

The WHO defines health as “a state of complete physical, mental and social well-being and not merely the absence of disease and infirmity” (WHO, 1985). This definition underscores the fact that health is affected by physical, mental, and social factors. The health-related quality of life (HRQoL) is a complex term which is usually overlapping with other concepts such as health status, and quality of life (QoL). Karimi and colleagues compared and contrasted these terms while critiquing existing definitions of each (Karimi and Brazier, 2016). We can, however, define the HRQoL as an individual’s perception of their wellbeing and functioning as impacted by their health (Clayson et al., 2006).

HRQoL emphasizes the need to differentiate between the objective state of health (i.e., the signs and symptoms of disease) and the subjective experience of the individual concerning that

state of health. However, both objective and subjective evaluation is necessary to fully evaluate the individual's feelings and reality (Sosnowski et al., 2017). Although the majority of PLWH are now living a virologically controlled and immunologically stable life with respect to HIV infection, according to a UK study, they are prone to having a lower HRQoL than the general population (Miners et al., 2014).

The reason for this is not far-fetched; aside from the underlying HIV infection, other important life factors such as relationship issues, comorbidities, social circumstances, and stigma often challenge PLWH (Drewes et al., 2013). A challenging social phenomenon faced by PLWH is HIV-related stigma which consequently results in adverse health outcomes such as non-adherence to medication use or visit schedules, depression, and overall low QoL. Furthermore, the behaviour, cognition, and emotions of PLWH are adversely influenced by social stigma (Helms et al., 2017, Katz et al., 2013, Sweeney and Vanable, 2016, Turan et al., 2017, Haines et al., 2019). It has been reported that PLWH often internalizes this social stigma leading to highly self-deprecating outcomes such as shame, low self-esteem or self-worth, embarrassment, and self-blame (Kalichman, 2013, Person et al., 2009). In Addition, worsening nutritional status among PLWH may also account for lower QoL in this population group (De Carvalho et al., 2017). Fifty-one participants were enrolled in this study, De Carvalho and colleagues reported lower QoL scores among individuals with inadequate energy intakes, high waist circumference, and those who reported weight loss. This association was statistically significant after adjusting for confounders.

A systematic review of reviews conducted to appraise measures of HRQoL that have been used among PLWH in peer-reviewed literature revealed the need for more input from PLWH in the design and validation of measures. It, however, concluded that the ultimate choice of a measure above the other will be based on the purpose of the research and the specific domain relevant to the context (Cooper et al., 2017).

South Africa leads in terms of research productivity in the aspect of HRQoL among PLWH after the USA (Tran et al., 2020). Marsh and Truter (2020) published a systematic review to provide insights into the status of HRQoL research in South Africa. They identified 104 studies since the first article was published in 1996. Forty-six studies have been conducted in the Western Cape and 24 among PLWH. Although there seems to be a range of studies in South Africa on the HRQoL within the context of HIV infection, since PLWH tend to live longer due to the use of effective ART, the need to ensure constant monitoring and improvement of their QoL through more research and intervention is emphasized.

2.6 Concluding Remarks

The changes brought to the HIV infection following the invention of HAART necessitate continuous monitoring and modification of the health care provided to PLWH. There are reports of increasing comorbidities that affect the quality of life of aging PLWH. Obesity is an increasing epidemic not only among PLWH and is central to other chronic diseases, this raises a need for thorough research to check and plan intervention. However, only one study was found in the Western Cape province describing obesity among non-pregnant PLWH on ART. Similarly, only one study investigating lipodystrophy among PLWH was found in Western Cape but was conducted among children. More research is needed in the province to substantiate the findings of past research and give more evidence to plan interventions.

Lipid profile has been continuously reported to be distorted among PLWH especially and as often been attributed to ART. As the coverage of the therapy is expanding daily, especially in South Africa, more research needs to be conducted to monitor how the lipid profile of aging PLWH respond. Similarly, chronic inflammation is one of the hallmarks of HIV infection and is a trigger of some chronic diseases such as CVD. Although HIV replication may be halted by ART, studies have shown that some levels of inflammation continue to occur in PLWH. Moreover, inflammatory markers have been reported to vary by geographical location. This calls for more research in South Africa to strengthen the body evidence available on chronic inflammation during HIV infection and provide a pedestal for planning intervention.

Micronutrients are very important in HIV infection due to their active roles in regulating metabolism and oxidation among others. Studies have shown that several other factors apart from HIV-related ones may affect the serum levels of some micronutrients. It is important to continue to clinically screen for deficiency of micronutrients that are significant in HIV infection such as calcium, selenium, and vitamins D and E among others, especially because routine biochemical test in clinical setting is expensive and not feasible.

Blood pressure and HGS are important clinical measures. Hypertension is central to many other chronic diseases while HGS can predict the risk of mortality and CVD. Hypertension is an ever-growing concern, particularly among PLWH in South Africa and must continuously be measured and researched to identify more factors associated with it.

Dietary intake among PLWH has not been well researched in South Africa, we only found studies that were conducted among ART naïve participants and not in the Western Cape Province. It is important to assess the dietary intake of PLWH in the era of HAART to identify any relationship it may have with the growing risk of chronic diseases.

Lifestyle factors such as body weight perception, physical activity, smoking, and alcohol intake all contribute to disease progression and directly affect the quality of life of PLWH. Body weight perception may be driven by social norms. It is important to under the cultural norms of a group of PLWH to correctly propose individualized intervention for weight management. Physical activity is decreasing in sub-Saharan Africa and influencing the increased risk of CVD. PLWH with whom the risk of CVD is higher needs to be monitored and sensitized on the benefits of physical activity to their health. The rates of smoking and alcohol use are high in South Africa, research has shown that PLWH may choose alcohol or smoking over their ART. This may be a driver of increased CVD risks among PLWH and must be researched.

In this study, the factors listed above will be combined to assess the nutritional and health status of adults living with HIV and stable on HAART in a healthcare facility in Cape Town. In addition, the association between these variables and chronic disease risk will be explored.

REFERENCES

ABRAHAMS, Z., MAARTENS, G., LEVITT, N. & DAVE, J. 2018. Anthropometric definitions for antiretroviral-associated lipodystrophy derived from a longitudinal South African cohort with serial dual-energy X-ray absorptiometry measurements. *Int J STD AIDS,* 29**,** 1194-1203.

AIBIBULA, W., COX, J., HAMELIN, A.-M., MAMIYA, H., KLEIN, M. B. & BRASSARD, P. 2016. Food insecurity and low CD4 count among HIV-infected people: a systematic review and meta-analysis. *AIDS care,* 28**,** 1577-1585.

ALBAHRANI, A.A. AND GREAVES, R.F., 2016. Fat-soluble vitamins: clinical indications and current challenges for chromatographic measurement. The Clinical Biochemist Reviews, 37(1), p.27.

ALIKHANI, A., MORIN, H., MATTE, S., ALIKHANI, P., TREMBLAY, C. & DURAND, M. 2019. Association between lipodystrophy and length of exposure to ARTs in adult HIV-1 infected patients in Montreal. *BMC infectious diseases,* 19**,** 1-6.

ALONSO, A., BARNES, A. E., GUEST, J. L., SHAH, A., SHAO, I. Y. & MARCONI, V. 2019. HIV infection and incidence of cardiovascular diseases: an analysis of a large healthcare database. *Journal of the American Heart Association,* 8**,** e012241.

AMERICAN HEART ASSOCIATION. 2017. *What is high blood pressure?* [Online]. Available: https://dc.statelibrary.sc.gov/bitstream/handle/10827/25131/DHEC_What_is_High_Blood_Pressure_2017-07.pdf [Accessed 06-07-2021 2021].

ANNE-LISE, P., CHANG, C.-C. H., SO-ARMAH, K. A., BUTT, A. A., LEAF, D. A., BUDOFF, M., RIMLAND, D., BEDIMO, R., GOETZ, M. B. & RODRIGUEZ-BARRADAS, M. C. 2015. Human immunodeficiency virus infection, cardiovascular risk factor profile and risk for acute myocardial infarction. *Journal of acquired immune deficiency syndromes (1999),* 68**,** 209.

ANTHONISEN, N. R., SKEANS, M. A., WISE, R. A., MANFREDA, J., KANNER, R. E. & CONNETT, J. E. 2005. The effects of a smoking cessation intervention on 14.5-year mortality: a randomized clinical trial. *Annals of internal medicine,* 142**,** 233-239.

APOVIAN, C. M. 2016. Obesity: definition, comorbidities, causes, and burden. *Am J Manag Care,* 22**,** s176-85.

ASEMOTA, E. A., OKAFOR, I. M., OKOROIWU, H. U., EKONG, E. R., ANYANWU, S. O., EFIONG, E. E. & UDOMAH, F. 2018. Zinc, copper, CD4 T-cell count and some hematological parameters of HIV-infected subjects in Southern Nigeria. *Integrative Medicine Research,* 7**,** 53-60.

ASGHARI, G., MIRMIRAN, P., YUZBASHIAN, E. & AZIZI, F. 2017. A systematic review of diet quality indices in relation to obesity. 117**,** 1055-1065.

BAIK, I., CHO, N., KIM, S. H. & SHIN, C. 2013. Dietary information improves cardiovascular disease risk prediction models. *European journal of clinical nutrition,* 67**,** 25-30.

BAILIN, S. S., GABRIEL, C. L., WANJALLA, C. N. & KOETHE, J. R. 2020. Obesity and weight gain in persons with HIV. *Current HIV/AIDS Reports,* 17**,** 138-150.

BALIUNAS, D., REHM, J., IRVING, H. & SHUPER, P. 2010. Alcohol consumption and risk of incident human immunodeficiency virus infection: a meta-analysis. *International journal of public health,* 55**,** 159-166.

BASILE, J. & BLOCH, M. J. 2015. Overview of hypertension in adults. *UpToDate, Waltham, MA*.

BEKKER, L. G., VENTER, F., COHEN, K., GOEMARE, E., VAN CUTSEM, G., BOULLE, A. & WOOD, R. 2014. Provision of antiretroviral therapy in South Africa: the nuts and bolts. *Antivir Ther,* 19 Suppl 3**,** 105-16.

BERHANE, T., YAMI, A., ALEMSEGED, F., YEMANE, T., HAMZA, L., KASSIM, M. & DERIBE, K. 2012. Prevalence of lipodystrophy and metabolic syndrome among HIV positive individuals on Highly Active Anti-Retroviral treatment in Jimma, South West Ethiopia. *Pan African Medical Journal,* 13.

BERNARD, C., DABIS, F. & DE REKENEIRE, N. 2017. Physical function, grip strength and frailty in people living with HIV in sub-Saharan Africa: systematic review. *Tropical Medicine & International Health,* 22**,** 516-525.

BETO, J. A. 2015. The role of calcium in human aging. *Clinical nutrition research,* 4**,** 1-8.

BHUPATHIRAJU, S. N., WEDICK, N. M., PAN, A., MANSON, J. E., REXRODE, K. M., WILLETT, W. C., RIMM, E. B. & HU, F. B. 2013. Quantity and variety in fruit and vegetable intake and risk of coronary heart disease. *The American journal of clinical nutrition,* 98**,** 1514-1523.

BIGGS, C. & SPOONER, E. 2018. Obesity and HIV: a compounding problem. *SAJCN - South African Journal of Clinical Nutrition,* 31**,** 78-83.

BIGNA, J. J., KENNE, A. M., ASANGBEH, S. L. & SIBETCHEU, A. T. 2018. Prevalence of chronic obstructive pulmonary disease in the global population with HIV: a systematic review and meta-analysis. *The Lancet Global Health,* 6**,** e193-e202.

BLOCH, M. 2018. Frailty in people living with HIV. *AIDS research and therapy,* 15**,** 1-5.

BONOVAS, S., FIORINO, G., LYTRAS, T., MALESCI, A. & DANESE, S. 2016. Calcium supplementation for the prevention of colorectal adenomas: A systematic review and meta-analysis of randomized controlled trials. *World journal of gastroenterology,* 22**,** 4594.

BRADBEER, C. & BAKAR, M. A. 2008. Perceptions of obesity amongst a mixed HIV cohort in London, UK–Slim is no longer Slim. *Journal of the International AIDS Society,* 11**,** 1-2.

BRATHWAITE, R., ADDO, J., SMEETH, L. & LOCK, K. 2015. A systematic review of tobacco smoking prevalence and description of tobacco control strategies in Sub-Saharan African countries; 2007 to 2014. *PloS one,* 10**,** e0132401.

BRENCHLEY, J. M., PRICE, D. A., SCHACKER, T. W., ASHER, T. E., SILVESTRI, G., RAO, S., KAZZAZ, Z., BORNSTEIN, E., LAMBOTTE, O. & ALTMANN, D. 2006. Microbial translocation is a cause of systemic immune activation in chronic HIV infection. *Nature medicine,* 12**,** 1365-1371.

BRUNO, R., SCUDERI, D., LOCATELLI, M., PAMPALONI, A. & PINZONE, M. 2017. Prevalence of micronutrients deficiencies in a cohort of HIV-positive individuals on ART. *Age (years),* 46**,** 39-54.

BURTIN, C., TER RIET, G., PUHAN, M. A., WASCHKI, B., GARCIA-AYMERICH, J., PINTO-PLATA, V., CELLI, B., WATZ, H. & SPRUIT, M. A. 2016. Handgrip weakness and mortality risk in COPD: a multicentre analysis. *Thorax,* 71**,** 86-87.

CALEYACHETTY, R., BARBER, T.M., MOHAMMED, N.I., CAPPUCCIO, F.P., HARDY, R., MATHUR, R., BANERJEE, A. AND GILL, P., 2021. Ethnicity-specific BMI cutoffs for obesity based on type 2 diabetes risk in England: a population-based cohort study. The Lancet Diabetes & Endocrinology, 9(7), pp.419-426.

CAPILI, B., ANASTASI, J. K., CHANG, M. & OGEDEGBE, O. 2014. Barriers and facilitators to engagement in lifestyle interventions among individuals with HIV. *The Journal of the Association of Nurses in AIDS Care: JANAC,* 25**,** 450.

CARLSON, S. A., FULTON, J. E., PRATT, M., YANG, Z. & ADAMS, E. K. 2015. Inadequate physical activity and health care expenditures in the United States. *Progress in cardiovascular diseases,* 57**,** 315-323.

CARTER, G. M., INDYK, D., JOHNSON, M., ANDREAE, M., SUSLOV, K., BUSANI, S., ESMAEILI, A. & SACKS, H. S. 2015. Micronutrients in HIV: A Bayesian Meta-Analysis. *PLOS ONE,* 10**,** e0120113.

CASADEI, K. & KIEL, J. 2020. *Anthropometric measurement* [Online]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. Available: https://www.ncbi.nlm.nih.gov/books/NBK537315/ [Accessed 07/07/2021 2021].

CATTELAN, A. M., CALABRO, M. L., GASPERINI, P., AVERSA, S. M., ZANCHETTA, M., MENEGHETTI, F., DE ROSSI, A. & CHIECO-BIANCHI, L. 2000. Acquired immunodeficiency syndrome-related Kaposi's sarcoma regression after highly active antiretroviral therapy: biologic correlates of clinical outcome. *JNCI Monographs,* 2000**,** 44-49.

CELIS-MORALES, C. A., WELSH, P., LYALL, D. M., STEELL, L., PETERMANN, F., ANDERSON, J., ILIODROMITI, S., SILLARS, A., GRAHAM, N. & MACKAY, D. F. 2018. Associations of grip strength with cardiovascular, respiratory, and cancer outcomes and all cause mortality: prospective cohort study of half a million UK Biobank participants. *Bmj,* 361.

CERVERO, M., AGUD, J. L., GARCÍA-LACALLE, C., ALCÁZAR, V., TORRES, R., JUSDADO, J. J. & MORENO GUILLÉN, S. 2012. Prevalence of vitamin D deficiency and its related risk factor in a Spanish cohort of adult HIV-infected patients: effects of antiretroviral therapy. *AIDS research and human retroviruses,* 28**,** 963-971.

CHANG, E., SEKHAR, R., PATEL, S. & BALASUBRAMANYAM, A. 2007. Dysregulated energy expenditure in HIV-infected patients: a mechanistic review. *Clinical infectious diseases,* 44**,** 1509-1517.

CHEN, C., GE, S., LI, S., WU, L., LIU, T. & LI, C. 2017. The effects of dietary calcium supplements alone or with vitamin D on cholesterol metabolism: a meta-analysis of randomized controlled trials. LWW.

CHOBANIAN, A. V., BAKRIS, G. L., BLACK, H. R., CUSHMAN, W. C., GREEN, L. A., IZZO JR, J. L., JONES, D. W., MATERSON, B. J., OPARIL, S. & WRIGHT JR, J. T. 2003. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. *Jama,* 289**,** 2560-2571.

CHOQUETTE, S., BOUCHARD, D., DOYON, C., SÉNÉCHAL, M., BROCHU, M. & DIONNE, I. J. 2010. Relative strength as a determinant of mobility in elders 67–84 years of age. a nuage study: nutrition as a determinant of successful aging. *The journal of nutrition, health & aging,* 14**,** 190-195.

CLARK, S., YOUNGMAN, L.D., CHUKWURAH, B., PALMER, A., PARISH, S., PETO, R. AND COLLINS, R., 2004. Effect of temperature and light on the stability of fat-soluble vitamins in whole blood over several days: implications for epidemiological studies. International journal of epidemiology, 33(3), pp.518-525.

CLAYSON, D. J., WILD, D. J., QUARTERMAN, P., DUPRAT-LOMON, I., KUBIN, M. & COONS, S. J. 2006. A comparative review of health-related quality-of-life measures for use in HIV/AIDS clinical trials. *Pharmacoeconomics,* 24**,** 751-765.

COOPER, V., CLATWORTHY, J., HARDING, R. & WHETHAM, J. 2017. Measuring quality of life among people living with HIV: a systematic review of reviews. *Health and quality of life outcomes,* 15**,** 1-20.

CORMICK, G. & BELIZÁN, J. M. 2019. Calcium Intake and Health. *Nutrients,* 11**,** 1606.

CORMICK, G., CIAPPONI, A., CAFFERATA, M. L. & BELIZÁN, J. M. 2015. Calcium supplementation for prevention of primary hypertension. *Cochrane Database of Systematic Reviews*.

CORONA, R., HOOD, K. & HAFFEJEE, F. 2019. The Relationship Between Body Image Perceptions and Condom Use Outcomes in a Sample of South African Emerging Adults. *Prevention Science,* 20**,** 147-156.

COURNIL, A., COUDRAY, M., KOUANFACK, C., ESSOMBA, C. N., TONFACK, C. A. D., BIWOLÉ-SIDA, M., DELAPORTE, E., BORK, K. & LAURENT, C. 2010. Short communication Reduced dose of stavudine and lipoatrophy in HIV-infected patients in Cameroon. *Antiviral therapy,* 15**,** 1039-1043.

COURNIL, A., EYMARD-DUVERNAY, S. & DIOUF, A. 2014. Bone aging and frailty syndrome after 10 years of ARV treatment in Senegal. *Bulletin de la Societe de pathologie exotique (1990),* 107**,** 238-240.

COUSSENS, A. K., NAUDE, C. E., GOLIATH, R., CHAPLIN, G., WILKINSON, R. J. & JABLONSKI, N. G. 2015. High-dose vitamin D3 reduces deficiency caused by low UVB exposure and limits HIV-1 replication in urban Southern Africans. *Proc Natl Acad Sci U S A,* 112**,** 8052-7.

CRUM-CIANFLONE, N., ROEDIGER, M. P., EBERLY, L., HEADD, M., MARCONI, V., GANESAN, A., WEINTROB, A., BARTHEL, R. V., FRASER, S. & AGAN, B. K. 2010. Increasing rates of obesity among HIV-infected persons during the HIV epidemic. *Plos one,* 5**,** e10106.

CUERQ, C., PERETTI, N., CHIKH, K., MIALON, A., GUILLAUMONT, M., DRAI, J. AND BLOND, E., 2015. Overview of the in vitro stability of commonly measured vitamins and carotenoids in whole blood. Annals of clinical biochemistry, 52(2), pp.259-269.

DANAEI, G., DING, E. L., MOZAFFARIAN, D., TAYLOR, B., REHM, J., MURRAY, C. J. & EZZATI, M. 2009. The preventable causes of death in the United States: comparative risk assessment of dietary, lifestyle, and metabolic risk factors. *PLoS medicine,* 6**,** e1000058.

DAVE, J. A., LEVITT, N. S., ROSS, I. L., LACERDA, M., MAARTENS, G. & BLOM, D. 2016. Anti-retroviral therapy increases the prevalence of dyslipidemia in South African HIV-infected patients. *PloS one,* 11**,** e0151911.

DAVIES, S. L., HILL, C., BAILEY, L. M., DAVISON, A. S. & MILAN, A. M. 2016. The impact of calcium assay change on a local adjusted calcium equation. *Annals of clinical biochemistry,* 53**,** 292-294.

DE CARVALHO, B. F., POLICARPO, S. & MOREIRA, A. C. 2017. Nutritional status and quality of life in HIV-infected patients. *Nutr Hosp,* 34**,** 923-933.

DE LUCA, A., GIANCOLA, M. L., AMMASSARI, A., GRISETTI, S., PAGLIA, M. G., GENTILE, M., CINGOLANI, A., MURRI, R., LIUZZI, G. & MONFORTE, A. D. A. 2000. The effect of potent antiretroviral therapy and JC virus load in cerebrospinal fluid on clinical outcome of patients with AIDS-associated progressive multifocal leukoencephalopathy. *The Journal of infectious diseases,* 182**,** 1077-1083.

DEL VALLE, H. B., YAKTINE, A. L., TAYLOR, C. L. & ROSS, A. C. 2011. Dietary reference intakes for calcium and vitamin D.

DESCHAMPS, V., SALANAVE, B., CHAN-CHEE, C., VERNAY, M. & CASTETBON, K. 2015. Body-weight perception and related preoccupations in a large national sample of adolescents. *Pediatric obesity,* 10**,** 15-22.

DIRAJLAL-FARGO, S., YU, J., ALBAR, Z., SATTAR, A., MAHTAB, S., JAO, J., MYER, L., ZAR, H. J. & MCCOMSEY, G. A. 2020. Monocyte activation and gut barrier dysfunction in South African youth on antiretroviral therapy and their associations with endothelial dysfunction. *Aids,* 34**,** 1615-1623.

DONG, K. R. & IMAI, C. M. 2017. Medical Nutrition Therapy for HIV and AIDS. *In:* MAHAN, L. K. & RAYMOND, J. L. (eds.) *Krause's Food and The Nutrition Care Process.* 14th ed. Canada: Elsevier.

DRAIN, P. K., KUPKA, R., MUGUSI, F. & FAWZI, W. W. 2007. Micronutrients in HIV-positive persons receiving highly active antiretroviral therapy. *The American journal of clinical nutrition,* 85**,** 333-345.

DREWES, J., GUSY, B. & RÜDEN, U. V. 2013. More than 20 years of research into the quality of life of people with HIV and AIDS—a descriptive review of study characteristics and methodological approaches of published empirical studies. *Journal of the International Association of Providers of AIDS Care (JIAPAC),* 12**,** 18-22.

DREWNOWSKI, A., ET AL. (1996). "DIET QUALITY AND DIETARY DIVERSITY IN FRANCE: IMPLICATIONS FOR THE FRENCH PARADOX." JOURNAL OF THE AMERICAN DIETETIC ASSOCIATION **96**(7): 663-669.ALKERWI, ALA'A 2014. Diet quality concept. *Nutrition,* 30**,** 613-618.

DROZD, M., CUBBON, R., GIERULA, J., JAMIL, H., CROSSFIELD, S., KEARNEY, M. & WITTE, K. 2014. 54 Calcium Supplementation in Patients with Chronic Heart Failure: Is it Safe? *Heart,* 100**,** A31-A31.

EDWARDS, A., SIEDNER, M. J., NASH, S., NEUMAN, M., DANAVIAH, S., SMIT, T., GARETA, D., KOWAL, P. & SEELEY, J. 2020. HIV serostatus, inflammatory biomarkers and the frailty phenotype among older people in rural KwaZulu-Natal, South Africa. *African Journal of AIDS Research,* 19**,** 177-185.

ESSER, N., LEGRAND-POELS, S., PIETTE, J., SCHEEN, A. J. & PAQUOT, N. 2014. Inflammation as a link between obesity, metabolic syndrome and type 2 diabetes. *Diabetes research and clinical practice,* 105**,** 141-150.

EXPERT PANEL ON DETECTION, E. 2001. Executive summary of the third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). *Jama,* 285**,** 2486-2497.

FAINTUCH, J., SOETERS, P. B. & OSMO, H. G. 2006. Nutritional and metabolic abnormalities in pre-AIDS HIV infection. *Nutrition,* 22**,** 683-690.

FARAHANI, M., MULINDER, H., FARAHANI, A. & MARLINK, R. 2017. Prevalence and distribution of non-AIDS causes of death among HIV-infected individuals receiving antiretroviral therapy: a systematic review and meta-analysis. *International journal of STD & AIDS,* 28**,** 636-650.

FELIPE, C., BARTOLOME, C., MIGUEL, D. & VICTOR, P.-P. 2015. Longitudinal changes in handgrip strength, hyperinflation, and 6-minute walk distance in patients with COPD and a control group. *Chest,* 148**,** 986-994.

FERNANDEZ-SOLA, J. 2015. Cardiovascular risks and benefits of moderate and heavy alcohol consumption. *Nature Reviews Cardiology,* 12**,** 576-587.

FIELDS-GARDNER, C. 2010. Position of the American Dietetic Association: nutrition intervention and human immunodeficiency virus infection. *Journal of the American Dietetic Association,* 110**,** 1105-1119.

FINKELSTEIN, J. L., GALA, P., ROCHFORD, R., GLESBY, M. J. & MEHTA, S. 2015. HIV/AIDS and lipodystrophy: implications for clinical management in resource-limited settings. *Journal of the International AIDS Society,* 18**,** 19033.

FOROUZANFAR, M. H., AFSHIN, A., ALEXANDER, L. T., ANDERSON, H. R., BHUTTA, Z. A., BIRYUKOV, S., BRAUER, M., BURNETT, R., CERCY, K. & CHARLSON, F. J. 2016. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The lancet,* 388**,** 1659-1724.

FREIBERG, M. S., CHANG, C. C., KULLER, L. H., SKANDERSON, M., LOWY, E., KRAEMER, K. L., BUTT, A. A., BIDWELL GOETZ, M., LEAF, D., OURSLER, K. A., RIMLAND, D., RODRIGUEZ BARRADAS, M., BROWN, S., GIBERT, C., MCGINNIS, K., CROTHERS, K., SICO, J., CRANE, H., WARNER, A., GOTTLIEB, S., GOTTDIENER, J., TRACY, R. P., BUDOFF, M., WATSON, C., ARMAH, K. A., DOEBLER, D., BRYANT, K. & JUSTICE, A. C. 2013. HIV infection and the risk of acute myocardial infarction. *JAMA Intern Med,* 173**,** 614-22.

FREIBERG, M. S., MCGINNIS, K. A., KRAEMER, K., SAMET, J. H., CONIGLIARO, J., ELLISON, R. C., BRYANT, K., KULLER, L. H. & JUSTICE, A. C. 2010. The association between alcohol consumption and prevalent cardiovascular diseases among HIV infected and uninfected men. *Journal of acquired immune deficiency syndromes (1999),* 53**,** 247.

FRITSCH, J. & ABREU, M. T. 2019. The Microbiota and the Immune Response: What Is the Chicken and What Is the Egg? *Gastrointestinal endoscopy clinics of North America,* 29**,** 381-393.

FUFA, H., UMETA, M., TAFFESSE, S., MOKHTAR, N. & AGUENAOU, H. 2009. Nutritional and immunological status and their associations among HIV-infected adults in Addis Ababa, Ethiopia. *Food and nutrition bulletin,* 30**,** 227-232.

GARVEY, W. T. 2019. Clinical Definition of overweight and obesity. *In:* GONZALEZ-CAMPOY JM, HURLEY DL & WT, G. (eds.) *Bariatric Endocrinology: Evaluation and Management of Adiposity, Adiposopathy and Related Diseases.* Cham: Springer; 121-143.

GEBREHIWOT, T. & VAN DER VEEN, A. 2014. Coping with food insecurity on a micro-scale: Evidence from Ethiopian rural households. *Ecology of food and nutrition,* 53**,** 214-240.

GIACOMET, V., VIGANO, A., MANFREDINI, V., CERINI, C., BEDOGNI, G., MORA, S., BORELLI, M., TRABATTONI, D. & ZUCCOTTI, G. V. 2013. Cholecalciferol supplementation in HIV-infected youth with vitamin D insufficiency: effects on vitamin D status and T-cell phenotype: a randomized controlled trial. *HIV clinical trials,* 14**,** 51-60.

GIBSON, R. S. 2005. *Principles of nutritional assessment*, Oxford university press, USA.

GILES, M. L., GARTNER, C. & BOYD, M. A. 2018. Smoking and HIV: what are the risks and what harm reduction strategies do we have at our disposal? *AIDS research and therapy,* 15**,** 1-5.

GODIJK, N. G., VOS, A. G., JONGEN, V. W., MORABA, R., TEMPELMAN, H., GROBBEE, D. E., COUTINHO, R. A., DEVILLÉ, W. & KLIPSTEIN-GROBUSCH, K. 2020. Heart Rate Variability, HIV and the Risk of Cardiovascular Diseases in Rural South Africa. *Glob Heart,* 15**,** 17.

GOYAL, A., ANASTASOPOULOU, C., NGU, M. & SINGH, S. 2021. Hypocalcemia. *StatPearls.* Treasure Island (FL): StatPearls Publishing

GROGAN, S. 2016. Body Image: Understanding Body Dissatisfaction in Men, Women and Children, 3rd Edition. Beaverton: Ringgold Inc.

GROUP, K. D. I. G. O. C.-M. W. 2009. KDIGO clinical practice guideline for the diagnosis, evaluation, prevention, and treatment of Chronic Kidney Disease-Mineral and Bone Disorder (CKD-MBD). *Kidney international. Supplement***,** S1-S130.

GUTHOLD, R., STEVENS, G. A., RILEY, L. M. & BULL, F. C. 2018. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *The Lancet Global Health,* 6**,** e1077-e1086.

GUTIERREZ, J., ALBUQUERQUE, A. L. A. & FALZON, L. 2017. HIV infection as vascular risk: a systematic review of the literature and meta-analysis. *PloS one,* 12**,** e0176686.

GUZMAN, N. & VIJAYAN, V. 2020. *HIV-associated Lipodystrophy* [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK493183/ [Accessed 2021/06/24 2021].

HAINES, C., LOADES, M. E., COETZEE, B. J. & HIGSON-SWEENEY, N. 2019. Which HIV-infected youth are at risk of developing depression and what treatments help? A systematic review focusing on Southern Africa. *Int J Adolesc Med Health*.

HALLAL, P. C., ANDERSEN, L. B., BULL, F. C., GUTHOLD, R., HASKELL, W. & EKELUND, U. 2012. Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet,* 380**,** 247-257.

HATTINGH, Z., LE ROUX, M., NEL, M. & WALSH, C. 2014. Assessment of the physical activity, body mass index and energy intake of HIV-uninfected and HIV-infected women in Mangaung, Free State province. *South African Family Practice,* 56**,** 196-200.

HATTINGH, Z., WALSH, C. M., VELDMAN, F. J. & BESTER, C. J. 2006. Macronutrient intake of HIV-seropositive women in Mangaung, South Africa. *Nutrition Research,* 26**,** 53-58.

HAVERS, F., SMEATON, L., GUPTE, N., DETRICK, B., BOLLINGER, R. C., HAKIM, J., KUMARASAMY, N., ANDRADE, A., CHRISTIAN, P. & LAMA, J. R. 2014. 25-Hydroxyvitamin D insufficiency and deficiency is associated with HIV disease progression and virological failure post-antiretroviral therapy initiation in diverse multinational settings. *The Journal of infectious diseases,* 210**,** 244-253.

HELLEBERG, M., MAY, M. T., INGLE, S. M., DABIS, F., REISS, P., FÄTKENHEUER, G., COSTAGLIOLA, D., D'ARMINIO, A., CAVASSINI, M. & SMITH, C. 2015. Smoking and life expectancy among HIV-infected individuals on antiretroviral therapy in Europe and North America. *AIDS (london, England),* 29**,** 221.

HELMS, C. B., TURAN, J. M., ATKINS, G., KEMPF, M.-C., CLAY, O. J., RAPER, J. L., MUGAVERO, M. J. & TURAN, B. 2017. Interpersonal mechanisms contributing to the association between HIV-related internalized stigma and medication adherence. *AIDS and Behavior,* 21**,** 238-247.

HOFFMANN, P. R. & BERRY, M. J. 2008. The influence of selenium on immune responses. *Molecular nutrition & food research,* 52**,** 1273-1280.

HOFMEYR, G. J., LAWRIE, T. A., ATALLAH, Á. N. & TORLONI, M. R. 2018. Calcium supplementation during pregnancy for preventing hypertensive disorders and related problems. *Cochrane database of systematic reviews*.

HUGHES, S. & KELLY, P. 2006. Interactions of malnutrition and immune impairment, with specific reference to immunity against parasites. *Parasite immunology,* 28**,** 577.

HURLEY, E., COUTSOUDIS, A., GIDDY, J., KNIGHT, S. E., LOOTS, E. & ESTERHUIZEN, T. M. 2011. Weight evolution and perceptions of adults living with HIV following initiation of antiretroviral therapy in a South African urban setting. *SAMJ - South African Medical Journal,* 101**,** 645-650.

HUSAIN, N. E., NOOR, S. K., ELMADHOUN, W. M., ALMOBARAK, A. O., AWADALLA, H., WOODWARD, C. L., MITAL, D. & AHMED, M. H. 2017. Diabetes, metabolic syndrome and dyslipidemia in people living with HIV in Africa: re-emerging challenges not to be forgotten. *HIV/AIDS (Auckland, N.Z.),* 9**,** 193-202.

HUSAIN, N. E. O. & AHMED, M. H. 2015. Managing dyslipidemia in HIV/AIDS patients: challenges and solutions. *HIV/AIDS (Auckland, NZ),* 7**,** 1.

INNES, S., SCHULTE-KEMNA, E., COTTON, M. F., ZÖLLNER, E. W., HAUBRICH, R., KLINKER, H., SUN, X., JAIN, S., EDSON, C., VAN NIEKERK, M., INNES, E. R., RABIE, H. & BROWNE, S. H. 2013. Biceps skin-fold thickness may detect and predict early lipoatrophy in HIV-infected children. *Pediatr Infect Dis J,* 32**,** e254-62.

ISLAM, F., WU, J., JANSSON, J. & WILSON, D. 2012. Relative risk of cardiovascular disease among people living with HIV: a systematic review and meta-analysis. *HIV medicine,* 13**,** 453-468.

IZZEDINE, H., HARRIS, M. & PERAZELLA, M. A. 2009. The nephrotoxic effects of HAART. *Nature Reviews Nephrology,* 5**,** 563-573.

JACA, A., DURÃO, S. & HARBRON, J. 2020. Omega-3 fatty acids for the primary and secondary prevention of cardiovascular disease. *S Afr Med J,* 110**,** 1158-1159.

JANTARAPAKDE, J., PHANUPHAK, N., CHATURAWIT, C., PENGNONYANG, S., MATHAJITTIPHAN, P., TAKAMTHA, P., DUNGJUN, N., PINYAKORN, S., PIMA, W. & PRASITHSIRIKUL, W. 2014. Prevalence of metabolic syndrome among antiretroviral-naive and antiretroviral-experienced HIV-1 infected Thai adults. *AIDS patient care and STDs,* 28**,** 331-340.

JARDIM, T. V., CARDOSO, R. D. C., SANTOS, A. S., DE CARVALHO, A., FALCO, M. D. O. & SILVEIRA, E. A. 2020. Self-reported HIV/HAART-associated lipodystrophy and modifiable risk factors for cardiovascular disease. *International Journal of Cardiovascular Sciences,* 33**,** 606-615.

JARDIM, T. V., REIGER, S., ABRAHAMS-GESSEL, S., GOMEZ-OLIVE, F. X., WAGNER, R. G., WADE, A., BÄRNIGHAUSEN, T. W., SALOMON, J., TOLLMAN, S. & GAZIANO, T. A. 2017. Hypertension management in a population of older adults in rural South Africa. *Journal of hypertension,* 35**,** 1283.

JAYEDI, A. & ZARGAR, M. S. 2019. Dietary calcium intake and hypertension risk: A dose–response meta-analysis of prospective cohort studies. *European journal of clinical nutrition,* 73**,** 969-978.

JHA, P. & PETO, R. 2014. Global effects of smoking, of quitting, and of taxing tobacco. *N Engl J Med,* 370**,** 60-8.

JOHNSTON, P. I., WRIGHT, S. W., ORR, M., PEARCE, F. A., STEVENS, J. W., HUBBARD, R. B. & COLLINI, P. J. 2021. Worldwide relative smoking prevalence among people living with and without HIV. *AIDS,* 35**,** 957-970.

JONES, C. Y., TANG, A. M., FORRESTER, J. E., HUANG, J., HENDRICKS, K. M., KNOX, T. A., SPIEGELMAN, D., SEMBA, R. D. & WOODS, M. N. 2006. Micronutrient levels and HIV disease status in HIV-infected patients on highly active antiretroviral therapy in the Nutrition for Healthy Living cohort. *JAIDS Journal of Acquired Immune Deficiency Syndromes,* 43**,** 475-482.

JULIUS, H., BASU, D., RICCI, E., WING, J., KUSARI BASU, J., POCATERRA, D. & BONFANTI, P. 2011. The burden of metabolic diseases amongst HIV positive patients on HAART attending The Johannesburg Hospital. *Current HIV research,* 9**,** 247-252.

KALICHMAN, S. C. 2013. The harms of internalized AIDS stigma: a comment on Tsai et al. *Annals of Behavioral Medicine,* 46**,** 256-257.

KALICHMAN, S. C., MATHEWS, C., BANAS, E. & KALICHMAN, M. O. 2020. Alcohol-related beliefs and non-adherence to antiretroviral therapy in Cape Town, South Africa. *J Behav Med,* 43**,** 764-772.

KALINOWSKI, A. & HUMPHREYS, K. 2016. Governmental standard drink definitions and low-risk alcohol consumption guidelines in 37 countries. *Addiction,* 111**,** 1293-1298.

KANDALA, N. B., TIGBE, W., MANDA, S. O. & STRANGES, S. 2013. Geographic variation of hypertension in sub-saharan Africa: a case study of South Africa. *Am J Hypertens,* 26**,** 382-91.

KARIMI, M. & BRAZIER, J. 2016. Health, health-related quality of life, and quality of life: what is the difference? *Pharmacoeconomics,* 34**,** 645-649.

KATZ, I. T., RYU, A. E., ONUEGBU, A. G., PSAROS, C., WEISER, S. D., BANGSBERG, D. R. & TSAI, A. C. 2013. Impact of HIV-related stigma on treatment adherence: systematic review and meta-synthesis. *Journal of the International AIDS Society,* 16**,** 18640.

KAWAI, K., KUPKA, R., MUGUSI, F., ABOUD, S., OKUMA, J., VILLAMOR, E., SPIEGELMAN, D. & FAWZI, W. W. 2010. A randomized trial to determine the optimal dosage of multivitamin supplements to reduce adverse pregnancy outcomes among HIV-infected women in Tanzania. *The American journal of clinical nutrition,* 91**,** 391-397.

KHUNDMIRI, S. J., MURRAY, R. D. & LEDERER, E. 2016. PTH and Vitamin D. *Compr Physiol,* 6**,** 561-601.

KINSEY, K., MCVEIGH, J. & CHANTLER, I. 2008. Habitual physical activity levels are positively correlated with CD4 counts in an HIV-positive South African population. *African Journal of AIDS Research,* 7**,** 237-242.

KLASSEN, K., MARTINEAU, A. R., WILKINSON, R. J., COOKE, G., COURTNEY, A. P. & HICKSON, M. 2012. The effect of tenofovir on vitamin D metabolism in HIV-infected adults is dependent on sex and ethnicity. PLoS ONE 7(9): e44845. https://doi.org/10.1371/journal.pone.0044845

KPEWOU, D. E., MENSAH, F. O., APPIAH, C. A., ALIDU, H. W. & BADII, V. S. 2021. Serum Vitamin E Deficiency among HIV-Infected Individuals Undergoing Antiretroviral Therapy at Ho Teaching Hospital, Ghana. *Heliyon***,** e07339.

KROEZE, S., WIT, F., ROSSOUW, T., STEEL, H., KITYO, C., SIWALE, M., AKANMU, S., MANDALIYA, K., DE JAGER, M., ONDOA, P., REISS, P., RINKE DE WIT, T., KOOTSTRA, N. & HAMERS, R. 2019. Plasma biomarkers of HIV-related systemic inflammation and immune activation in sub-Saharan Africa before and during suppressive antiretroviral therapy. *The Journal of infectious diseases,* 220**,** 1029-1033.

KWAK, M. J., KIM, J., BHISE, V., CHUNG, T. H. & PETITTO, G. S. 2018. National trends in smoking cessation medication prescriptions for smokers with chronic obstructive pulmonary disease in the United States, 2007-2012. *Journal of Preventive Medicine and Public Health,* 51**,** 257.

LAKE, J. E. 2017. The fat of the matter: obesity and visceral adiposity in treated HIV infection. *Current HIV/AIDS Reports,* 14**,** 211-219.

LAN, C.-W., SCOTT-SHELDON, L. A. J., CAREY, K. B., JOHNSON, B. T. & CAREY, M. P. 2017. Prevalence of Alcohol Use, Sexual Risk Behavior, and HIV Among Russians in High-Risk Settings: a Systematic Review and Meta-Analysis. *International Journal of Behavioral Medicine,* 24**,** 180-190.

LAU, W. B., OHASHI, K., WANG, Y., OGAWA, H., MUROHARA, T., MA, X.-L. & OUCHI, N. 2017. Role of adipokines in cardiovascular disease. *Circulation Journal,* 81**,** 920-928.

LAWMAN, H. G., TROIANO, R. P., PERNA, F. M., WANG, C.-Y., FRYAR, C. D. & OGDEN, C. L. 2016. Associations of Relative Handgrip Strength and Cardiovascular Disease Biomarkers in U.S. Adults, 2011–2012. *American Journal of Preventive Medicine,* 50**,** 677-683.

LEDERMAN, M. M., CONNICK, E., LANDAY, A., KURITZKES, D. R., SPRITZLER, J., ST. CLAIR, M., KOTZIN, B. L., FOX, L., HEATH CHIOZZI, M. & LEONARD, J. M. 1998. Immunologic responses associated with 12 weeks of combination antiretroviral therapy consisting of zidovudine, lamivudine, and ritonavir: results of AIDS Clinical Trials Group Protocol 315. *Journal of Infectious Diseases,* 178**,** 70-79.

LEE, R. D. 2010. *Nutritional assessment/Robert D. Robert, David C. Nieman*, New York [etc.]: McGraw-Hill, 2003.

LENFANT, C., CHOBANIAN, A. V., JONES, D. W. & ROCCELLA, E. J. 2003. Seventh report of the Joint National Committee on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) resetting the hypertension sails. Am Heart Assoc.

LEONG, D. P., TEO, K. K., RANGARAJAN, S., LOPEZ-JARAMILLO, P., AVEZUM JR, A., ORLANDINI, A., SERON, P., AHMED, S. H., ROSENGREN, A. & KELISHADI, R. 2015. Prognostic value of grip strength: findings from the Prospective Urban Rural Epidemiology (PURE) study. *The Lancet,* 386**,** 266-273.

LESI, O. A., SOYEBI, K. S. & EBOH, C. N. 2009. Fatty liver and hyperlipidemia in a cohort of HIV-positive Africans on highly active antiretroviral therapy. *Journal of the National Medical Association,* 101**,** 151-155.

LETSELA, L., WEINER, R., GAFOS, M. & FRITZ, K. 2019. Alcohol Availability, Marketing, and Sexual Health Risk Amongst Urban and Rural Youth in South Africa. *AIDS Behav,* 23**,** 175-189.

LEVETT, T. J., CRESSWELL, F. V., MALIK, M. A., FISHER, M. & WRIGHT, J. 2016. Systematic review of prevalence and predictors of frailty in individuals with human immunodeficiency virus. *Journal of the American Geriatrics Society,* 64**,** 1006-1014.

LI, K., WANG, X.-F., LI, D.-Y., CHEN, Y.-C., ZHAO, L.-J., LIU, X.-G., GUO, Y.-F., SHEN, J., LIN, X. & DENG, J. 2018. The good, the bad, and the ugly of calcium supplementation: a review of calcium intake on human health. *Clinical interventions in aging,* 13**,** 2443.

LIEBERMAN, L. S. 2017. *Nutritional anthropometry and body composition*.

LIM, S. S., VOS, T., FLAXMAN, A. D., DANAEI, G., SHIBUYA, K., ADAIR-ROHANI, H., ALMAZROA, M. A., AMANN, M., ANDERSON, H. R. & ANDREWS, K. G. 2012. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The lancet,* 380**,** 2224-2260.

LOZANO, R., NAGHAVI, M., FOREMAN, K., LIM, S., SHIBUYA, K., ABOYANS, V., ABRAHAM, J., ADAIR, T., AGGARWAL, R. & AHN, S. Y. 2012. Global and regional mortality from 235 causes of death for

20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *The lancet,* 380**,** 2095-2128.

LU, J. & HOLMGREN, A. 2009. Selenoproteins. *Journal of Biological Chemistry,* 284**,** 723-727.

MABWEAZARA, S. Z., LEACH, L. L., LEY, C., ONAGBIYE, S. O., DAVE, J. A., LEVITT, N. S. & LAMBERT, E. V. 2019. Demographic and socio-economic predictors of physical activity among people living with HIV of low socio-economic status. *Health SA,* 24**,** 1127.

MADDEN, A. & SMITH, S. 2016. Body composition and morphological assessment of nutritional status in adults: a review of anthropometric variables. *Journal of human nutrition and dietetics,* 29**,** 7-25.

MAHAN, L. K. & RAYMOND, J. L. 2016. *Krause's food & the nutrition care process-e-book*, Elsevier Health Sciences.

MAHLANGU, K., MODJADJI, P. & MADIBA, S. The Nutritional Status of Adult Antiretroviral Therapy Recipients with a Recent HIV Diagnosis; A Cross-Sectional Study in Primary Health Facilities in Gauteng, South Africa. Healthcare, 2020. Multidisciplinary Digital Publishing Institute, 290.

MALLEWA, J., HIGGINS, S., GARBETT, S., SAXENA, N. & VILAR, F. 2009. Cardiovascular disease risk management in HIV patients, experiences from Greater Manchester. *International journal of STD & AIDS,* 20**,** 425-426.

MAMEDE, A. C., TAVARES, S. D., ABRANTES, A. M., TRINDADE, J., MAIA, J. M. & BOTELHO, M. F. 2011. The role of vitamins in cancer: a review. *Nutrition and cancer,* 63**,** 479-494.

MANION, M., ANDRADE, B. B., DERSIMONIAN, R., GU, W., RUPERT, A., MUSSELWHITE, L. W., SIERRA-MADERO, J. G., BELAUNZARAN-ZAMUDIO, P. F., SANNE, I., LEDERMAN, M. M. & SERETI, I. 2017. Country of residence is associated with distinct inflammatory biomarker signatures in HIV-infected patients. *J Virus Erad,* 3**,** 24-33.

MANUTHU, E. M., JOSHI, M. D., LULE, G. N. & KARARI, E. 2008. Prevalence of dyslipidemia and dysglycaemia in HIV infected patients. *East Afr Med J,* 85**,** 10-7.

MARCUS, B. H., WILLIAMS, D. M., DUBBERT, P. M., SALLIS, J. F., KING, A. C., YANCEY, A. K., FRANKLIN, B. A., BUCHNER, D., DANIELS, S. R. & CLAYTOR, R. P. 2006. Physical activity intervention studies: what we know and what we need to know: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity); Council on Cardiovascular Disease in the Young; and the Interdisciplinary Working Group on Quality of Care and Outcomes Research. *Circulation,* 114**,** 2739-2752.

MARSH, S. E. & TRUTER, I. 2020. Fit for the future? Status of health-related quality of life research in South Africa. *Int J Technol Assess Health Care,* 36**,** 508-517.

MARTINEAU, A. R., NHAMOYEBONDE, S., ONI, T., RANGAKA, M. X., MARAIS, S., BANGANI, N., TSEKELA, R., BASHE, L., DE AZEVEDO, V., CALDWELL, J., VENTON, T. R., TIMMS, P. M., WILKINSON, K. A. & WILKINSON, R. J. 2011. Reciprocal seasonal variation in vitamin D status and tuberculosis notifications in Cape Town, South Africa. *Proc Natl Acad Sci U S A,* 108**,** 19013-7.

MARTINEZ, S. M., KEMPER, C. A., DIAMOND, C. & WAGNER, G. 2005. Body image in patients with HIV/AIDS: assessment of a new psychometric measure and its medical correlates.(Author Abstract). *AIDS Patient Care and STDs,* 19**,** 150.

MATOTI-MVALO, T. & PUOANE, T. 2011. Perceptions of body size and its association with HIV/AIDS. *South African Journal of Clinical Nutrition,* 24.

MCCORMICK, C. L., FRANCIS, A. M., ILIFFE, K., WEBB, H., DOUCH, C. J., PAKIANATHAN, M. & MACALLAN, D. C. 2014. Increasing obesity in treated female HIV patients from Sub-Saharan Africa: potential causes and possible targets for intervention. *Frontiers in immunology,* 5**,** 507.

MDODO, R., FRAZIER, E. L., DUBE, S. R., MATTSON, C. L., SUTTON, M. Y., BROOKS, J. T. & SKARBINSKI, J. 2015. Cigarette smoking prevalence among adults with HIV compared with the general adult population in the United States: cross-sectional surveys. *Annals of internal medicine,* 162**,** 335-344.

MEHTA, S., GIOVANNUCCI, E., MUGUSI, F. M., SPIEGELMAN, D., ABOUD, S., HERTZMARK, E., MSAMANGA, G. I., HUNTER, D. & FAWZI, W. W. 2010. Vitamin D status of HIV-infected women and its association with HIV disease progression, anemia, and mortality. *PloS one,* 5**,** e8770.

MEINTJES, G., MOORHOUSE, M. A., CARMONA, S., DAVIES, N., DLAMINI, S., VAN VUUREN, C., MANZINI, T., MATHE, M., MOOSA, Y. & NASH, J. 2017. Adult antiretroviral therapy guidelines 2017. *Southern African journal of HIV medicine,* 18**,** 1-24.

MÉJEAN, C., DROOMERS, M., VAN DER SCHOUW, Y. T., SLUIJS, I., CZERNICHOW, S., GROBBEE, D. E., BUENO-DE-MESQUITA, H. B. & BEULENS, J. W. 2013. The contribution of diet and lifestyle to socioeconomic inequalities in cardiovascular morbidity and mortality. *International journal of cardiology,* 168**,** 5190-5195.

MERCIER, S., GUEYE, N. F., COURNIL, A., FONTBONNE, A., COPIN, N., NDIAYE, I., DUPUY, A. M., CAMES, C., SOW, P. S., NDOYE, I., DELAPORTE, E. & SIMONDON, K. B. 2009. Lipodystrophy and metabolic disorders in HIV-1-infected adults on 4- to 9-year antiretroviral therapy in Senegal: a case-control study. *J Acquir Immune Defic Syndr,* 51**,** 224-30.

MEYZER, C., FRANGE, P., CHAPPUY, H., DESSE, B., VEBER, F., LE CLÉSIAU, H., FRIEDLANDER, G., BLANCHE, S., SOUBERBIELLE, J.-C. & TRÉLUYER, J.-M. 2013. Vitamin D deficiency and insufficiency in HIV-infected children and young adults. *The Pediatric infectious disease journal,* 32**,** 1240-1244.

MICHELS DA SILVA, D., LANGER, H. & GRAF, T. 2019. Inflammatory and Molecular Pathways in Heart Failure-Ischemia, HFpEF and Transthyretin Cardiac Amyloidosis. *International journal of molecular sciences* [Online], 20. Available: http://europepmc.org/abstract/MED/31083399 [Accessed 2021/06].

MILLS, K. T., BUNDY, J. D., KELLY, T. N., REED, J. E., KEARNEY, P. M., REYNOLDS, K., CHEN, J. & HE, J. 2016. Global Disparities of Hypertension Prevalence and Control: A Systematic Analysis of Population-Based Studies From 90 Countries. *Circulation,* 134**,** 441-50.

MILLS, K. T., STEFANESCU, A. & HE, J. 2020. The global epidemiology of hypertension. *Nature Reviews Nephrology,* 16**,** 223-237.

MINERS, A., PHILLIPS, A., KREIF, N., RODGER, A., SPEAKMAN, A., FISHER, M., ANDERSON, J., COLLINS, S., HART, G. & SHERR, L. 2014. Health-related quality-of-life of people with HIV in the era of combination antiretroviral treatment: a cross-sectional comparison with the general population. *The lancet HIV,* 1**,** e32-e40.

MINOCHA, P., SITARAMAN, S., CHOUDHARY, A. & YADAV, R. 2018. Subjective global nutritional assessment: a reliable screening tool for nutritional assessment in cerebral palsy children. *The Indian Journal of Pediatrics,* 85**,** 15-19.

MITTELSTEADT, A. L., HILEMAN, C. O., HARRIS, S. R., PAYNE, K. M., GRIPSHOVER, B. M. & MCCOMSEY, G. A. 2013. Effects of HIV and antiretroviral therapy on resting energy expenditure in adult HIV-infected women—a matched, prospective, cross-sectional study. *Journal of the Academy of Nutrition and Dietetics,* 113**,** 1037-1043.

MONTINE, K. S., QUINN, J. F., ZHANG, J., FESSEL, J. P., ROBERTS II, L. J., MORROW, J. D. & MONTINE, T. J. 2004. Isoprostanes and related products of lipid peroxidation in neurodegenerative diseases. *Chemistry and Physics of Lipids,* 128**,** 117-124.

MOYER, V. A. 2013. Vitamin D and calcium supplementation to prevent fractures in adults: US Preventive Services Task Force recommendation statement. *Annals of internal medicine,* 158**,** 691-696.

MUELLER, N. J., FUX, C. A., LEDERGERBER, B., ELZI, L., SCHMID, P., DANG, T., MAGENTA, L., CALMY, A., VERGOPOULOS, A. & BISCHOFF-FERRARI, H. A. 2010. High prevalence of severe vitamin D deficiency in combined antiretroviral therapy-naive and successfully treated Swiss HIV patients. *Aids,* 24**,** 1127-1134.

MUHAMMAD, J., FERNANDEZ, J., CLAY, O., SAAG, M., OVERTON, E. & WILLIG, A. 2019. Associations of food insecurity and psychosocial measures with diet quality in adults aging with HIV. *AIDS care,* 31**,** 554-562.

MURPHY, A., FARIA-NETO, J. R., AL-RASADI, K., BLOM, D., CATAPANO, A., CUEVAS, A., LOPEZ-JIMENEZ, F., PEREL, P., SANTOS, R. & SNIDERMAN, A. 2017. World heart federation cholesterol roadmap. *Global heart,* 12**,** 179-197. e5.

MURPHY, J. D., LIU, B. & PARASCANDOLA, M. 2019. Smoking and HIV in sub-Saharan Africa: a 25-country analysis of the Demographic Health Surveys. *Nicotine and Tobacco Research,* 21**,** 1093-1102.

MUTHAMIA, O. G., MWANGI, A. M. & MBUGUA, S. K. 2015. The effects of nutritional knowledge on the dietary practices of people living with HIV in Kayole divis ion, Nairobi-Kenya.

NDUKA, C., STRANGES, S., SARKI, A., KIMANI, P. & UTHMAN, O. 2016. Evidence of increased blood pressure and hypertension risk among people living with HIV on antiretroviral therapy: a systematic review with meta-analysis. *Journal of human hypertension,* 30**,** 355-362.

NEGIN, J., MARTINIUK, A., CUMMING, R. G., NAIDOO, N., PHASWANA-MAFUYA, N., MADURAI, L., WILLIAMS, S. & KOWAL, P. 2012. Prevalence of HIV and chronic comorbidities among older adults. *AIDS (london, England),* 26**,** S55.

NEUHAUS, J., JACOBS JR, D. R., BAKER, J. V., CALMY, A., DUPREZ, D., LA ROSA, A., KULLER, L. H., PETT, S. L., RISTOLA, M. & ROSS, M. J. 2010. Markers of inflammation, coagulation, and renal function are elevated in adults with HIV infection. *The Journal of infectious diseases,* 201**,** 1788-1795.

NGUYEN, K. A., PEER, N., DE VILLIERS, A., MUKASA, B., MATSHA, T. E., MILLS, E. J. & KENGNE, A. P. 2016. The Distribution of Obesity Phenotypes in HIV-Infected African Population. *Nutrients,* 8.

NGUYEN, K. A., PEER, N., MILLS, E. J. & KENGNE, A. P. 2015. Burden, determinants, and pharmacological management of hypertension in HIV-positive patients and populations: a systematic narrative review. *AIDS Rev,* 17**,** 83-95.

NOE, S., HELDWEIN, S., WIESE, C., PASCUCCI, R., VON KROSIGK, A., SCHABAZ, F., JONSSON-OLDENBUETTEL, C., JAEGER, H. & WOLF, E. 2018. Tenofovir Disoproxil Fumarate Is Associated with a Set-Point Variation in the Calcium-Parathyroid Hormone-Vitamin D Axis: Results from a German Cohort. *Adv Pharmacol Sci,* 2018**,** 6069131.

NORVAL, M., COUSSENS, A. K., WILKINSON, R. J., BORNMAN, L., LUCAS, R. M. & WRIGHT, C. Y. 2016. Vitamin D status and its consequences for health in South Africa. *International journal of environmental research and public health,* 13**,** 1019.

NOUBIAP, J. J., BIGNA, J. J., NANSSEU, J. R., NYAGA, U. F., BALTI, E. V., ECHOUFFO-TCHEUGUI, J. B. & KENGNE, A. P. 2018. Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis. *The Lancet Global Health,* 6**,** e998-e1007.

NUNNARI, G., COCO, C., PINZONE, M. R., PAVONE, P., BERRETTA, M., DI ROSA, M., SCHNELL, M., CALABRESE, G. & CACOPARDO, B. 2012. The role of micronutrients in the diet of HIV-1-infected individuals. *Front Biosci (Elite Ed),* 4**,** 2442-2456.

NUTTALL, F. Q. 2015. Body mass index: obesity, BMI, and health: a critical review. *Nutrition today,* 50**,** 117.

O'KEEFE, J. H., BHATTI, S. K., BAJWA, A., DINICOLANTONIO, J. J. & LAVIE, C. J. 2014. Alcohol and Cardiovascular Health: The Dose Makes the Poison…or the Remedy. *Mayo Clinic Proceedings,* 89**,** 382-393.

OLAWEPO, J. O., PHARR, J. R., CROSS, C. L., KACHEN, A., OLAKUNDE, B. O. & SY, F. S. 2021. Changes in body mass index among people living with HIV who are new on highly active antiretroviral therapy: a systematic review and meta-analysis. *AIDS Care,* 33**,** 326-336.

OLSEN, M., KÆSTEL, P., TESFAYE, M., ABDISSA, A., YILMA, D., GIRMA, T., MØLGAARD, C., FAURHOLT-JEPSEN, D., CHRISTENSEN, D. & BRAGE, S. 2015. Physical activity and capacity at initiation of antiretroviral treatment in HIV patients in Ethiopia. *Epidemiology & Infection,* 143**,** 1048-1058.

OPIO, J., CROKER, E., ODONGO, G. S., ATTIA, J., WYNNE, K. & MCEVOY, M. 2020. Metabolically healthy overweight/obesity are associated with increased risk of cardiovascular disease in adults, even in the absence of metabolic risk factors: A systematic review and meta-analysis of prospective cohort studies. *Obesity Reviews,* 21**,** e13127.

ORKIN, C., WOHL, D. A., WILLIAMS, A. & DECKX, H. 2014. Vitamin D deficiency in HIV: a shadow on long-term management? *AIDS reviews,* 16**,** 59-74.

ORMAN, E. S., ODENA, G. & BATALLER, R. 2013. Alcoholic liver disease: pathogenesis, management, and novel targets for therapy. *Journal of gastroenterology and hepatology,* 28**,** 77-84.

OSEI AKUMIAH, P., AKUAMOAH SARFO, L., AGYEKUM, O., ASARE, K., AZUMAH NAYEMBIL, D., OFOSU AGYAPONG, G., OSEI FRIMPONG, K. & AZUWIE AWENLIE AKANZERIBA, A. 2015. Nutritional Knowledge, Attitude and Intake among HIV Patients: A Study at Agogo Presbyterian Hospital, Ghana.

OZEMEK, C., LAVIE, C. J. & ROGNMO, Ø. 2019. Global physical activity levels - Need for intervention. *Progress in Cardiovascular Diseases,* 62**,** 102-107.

PAHWA, R., GOYAL, A., BANSAL, P. & JIALAL, I. 2020. *Chronic Inflammation*, In: StatPearls. StatPearls Publishing, Treasure Island (FL).

PALELLA JR, F. J., DELANEY, K. M., MOORMAN, A. C., LOVELESS, M. O., FUHRER, J., SATTEN, G. A., ASCHMAN, D. J., HOLMBERG, S. D. & INVESTIGATORS, H. O. S. 1998. Declining morbidity and mortality among patients with advanced human immunodeficiency virus infection. *New England Journal of Medicine,* 338**,** 853-860.

PANNU, P. K., CALTON, E. K. & SOARES, M. J. 2016. Calcium and Vitamin D in Obesity and Related Chronic Disease. *Adv Food Nutr Res,* 77**,** 57-100.

PARK, L. S., HERNÁNDEZ-RAMÍREZ, R. U., SILVERBERG, M. J., CROTHERS, K. & DUBROW, R. 2016. Prevalence of non-HIV cancer risk factors in persons living with HIV/AIDS: a meta-analysis. *Aids,* 30**,** 273-91.

PARK, S., CHO, J., KIM, D., JIN, Y., LEE, I., HONG, H. & KANG, H. 2019. Handgrip strength, depression, and all-cause mortality in Korean older adults. *BMC geriatrics,* 19**,** 1-8.

PAU, A. K. & GEORGE, J. M. 2014. Antiretroviral therapy: current drugs. *Infect Dis Clin North Am,* 28**,** 371-402.

PECK, R. N., SHEDAFA, R., KALLUVYA, S., DOWNS, J. A., TODD, J., SUTHANTHIRAN, M., FITZGERALD, D. W. & KATARAIHYA, J. B. 2014. Hypertension, kidney disease, HIV and antiretroviral therapy among Tanzanian adults: a cross-sectional study. *BMC medicine,* 12**,** 1-11.

PÉREZ, P. S., ROMANIUK, M. A., DUETTE, G. A., ZHAO, Z., HUANG, Y., MARTIN-JAULAR, L., WITWER, K. W., THÉRY, C. & OSTROWSKI, M. 2019. Extracellular vesicles and chronic inflammation during HIV infection. *Journal of extracellular vesicles,* 8**,** 1687275.

PERSON, B., BARTHOLOMEW, L. K., GYAPONG, M., ADDISS, D. G. & VAN DEN BORNE, B. 2009. Health-related stigma among women with lymphatic filariasis from the Dominican Republic and Ghana. *Social Science & Medicine,* 68**,** 30-38.

PHIRI, F.P., ANDER, E.L., BAILEY, E.H., CHILIMA, B., CHILIMBA, A.D., GONDWE, J., JOY, E.J., KALIMBIRA, A.A., KUMSSA, D.B., LARK, R.M. AND PHUKA, J.C., 2019. The risk of selenium deficiency in Malawi is large and varies over multiple spatial scales. Scientific Reports, 9(1), pp.1-8.

PILLAY, P., PILLAY, S. & MCHUNU, N. 2020. The spectrum of electrolyte abnormalities in black African people living with human immunodeficiency virus and diabetes mellitus at Edendale Hospital, Pietermaritzburg, South Africa. *South Afr J HIV Med,* 21**,** 1095.

POTISCHMAN, N. 2003. Biologic and methodologic issues for nutritional biomarkers. *The Journal of nutrition,* 133**,** 875S-880S.

PRASAD, A. S. 2014. Impact of the discovery of human zinc deficiency on health. *Journal of trace elements in medicine and biology,* 28**,** 357-363.

PROBST, C., PARRY, C. D. H. & REHM, J. 2018. HIV/AIDS mortality attributable to alcohol use in South Africa: a comparative risk assessment by socioeconomic status. *BMJ Open,* 8**,** e017955.

RAGGIO, G. A., PSAROS, C., FATCH, R., GOODMAN, G., MATTHEWS, L. T., MAGIDSON, J. F., AMANYIRE, G., CROSS, A., ASIIMWE, S., HAHN, J. A. & HABERER, J. E. 2019. High Rates of Biomarker-Confirmed Alcohol Use Among Pregnant Women Living With HIV in South Africa and Uganda. *J Acquir Immune Defic Syndr,* 82**,** 443-451.

RAMÍREZ-VÉLEZ, R., PÉREZ-SOUSA, M. Á., GARCÍA-HERMOSO, A., ZAMBOM-FERRARESI, F., MARTÍNEZ-VELILLA, N., SÁEZ DE ASTEASU, M. L., CANO-GUTIÉRREZ, C. A., RINCÓN-PABÓN, D. & IZQUIERDO, M. 2020. Relative handgrip strength diminishes the negative effects of excess adiposity on dependence in older adults: a moderation analysis. *Journal of clinical medicine,* 9**,** 1152.

RAMLAGAN, S., PELTZER, K. & PHASWANA-MAFUYA, N. 2014. Hand grip strength and associated factors in non-institutionalised men and women 50 years and older in South Africa. *BMC Research Notes,* 7**,** 8.

RANJAN, S. & NASSER, J. A. 2015. Nutritional status of individuals with autism spectrum disorders: do we know enough? *Advances in Nutrition,* 6**,** 397-407.

RAWANA, J.S., 2013. The relative importance of body change strategies, weight perception, perceived social support, and self-esteem on adolescent depressive symptoms: Longitudinal findings from a national sample. Journal of Psychosomatic Research, 75(1), pp.49-54.

RAWAT, R., MCCOY, S. I. & KADIYALA, S. 2013. Poor diet quality is associated with low CD4 count and anemia and predicts mortality among antiretroviral therapy–naive HIV-positive adults in Uganda. *JAIDS Journal of Acquired Immune Deficiency Syndromes,* 62**,** 246-253.

RAWDANOWICZ, J., PIKTO-PIETKIEWICZ, W. & MARCZYNSKA, M. 2013. Cardiovascular diseases associated with HIV infection and their management. *Kardiologia Polska,* 71**,** 1183-1187.

REEDY, J., KREBS-SMITH, S. M., MILLER, P. E., LIESE, A. D., KAHLE, L. L., PARK, Y. & SUBAR, A. F. 2014. Higher diet quality is associated with decreased risk of all-cause, cardiovascular disease, and cancer mortality among older adults. *The Journal of nutrition,* 144**,** 881-889.

REGAN, S., MEIGS, J. B., GRINSPOON, S. K. & TRIANT, V. A. 2016. Determinants of smoking and quitting in HIV-infected individuals. *PLoS One,* 11**,** e0153103.

REHM, J., ROOM, R., MONTEIRO, M., GMEL, G., GRAHAM, K., REHN, N., SEMPOS, C. T. & JERNIGAN, D. 2003. Alcohol as a risk factor for global burden of disease. *European addiction research,* 9**,** 157-164.

REHM, J., SHIELD, K. D., JOHARCHI, N. & SHUPER, P. A. 2012. Alcohol consumption and the intention to engage in unprotected sex: Systematic review and meta-analysis of experimental studies. *Addiction,* 107**,** 51-59.

REID, I. R., AMES, R., MASON, B., BOLLAND, M. J., BACON, C. J., REID, H. E., KYLE, C., GAMBLE, G. D., GREY, A. & HORNE, A. 2010. Effects of calcium supplementation on lipids, blood pressure, and body composition in healthy older men: a randomized controlled trial. *The American journal of clinical nutrition,* 91**,** 131-139.

REINER, Ž., CATAPANO, A. L., DE BACKER, G., GRAHAM, I., TASKINEN, M.-R., WIKLUND, O., AGEWALL, S., ALEGRIA, E., CHAPMAN, M. J. & DURRINGTON, P. 2011. ESC/EAS Guidelines for the management of dyslipidaemias: the Task Force for the management of dyslipidaemias of the European Society of Cardiology (ESC) and the European Atherosclerosis Society (EAS). *European heart journal,* 32**,** 1769-1818.

REITSMA, M. B., FULLMAN, N., NG, M., SALAMA, J. S., ABAJOBIR, A., ABATE, K. H., ABBAFATI, C., ABERA, S. F., ABRAHAM, B. & ABYU, G. Y. 2017. Smoking prevalence and attributable disease burden in 195 countries and territories, 1990–2015: a systematic analysis from the Global Burden of Disease Study 2015. *The Lancet,* 389**,** 1885-1906.

REPUBLIC OF SOUTH AFRICA NATIONAL DEPARTMENT OF HEALTH 2019. 2019 ART Clinical Guidelines for the Management of HIV in Adults, Pregnancy, Adolescents, Children, Infants and Neonates.

RIDEFELT, P. & HELMERSSON-KARLQVIST, J. 2017. Albumin adjustment of total calcium does not improve the estimation of calcium status. *Scandinavian journal of clinical and laboratory investigation,* 77**,** 442-447.

ROBERTS, H. C., DENISON, H. J., MARTIN, H. J., PATEL, H. P., SYDDALL, H., COOPER, C. & SAYER, A. A. 2011. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. *Age and Ageing,* 40**,** 423-429.

ROERECKE, M. & REHM, J. 2012. Alcohol intake revisited: risks and benefits. *Current atherosclerosis reports,* 14**,** 556-562.

ROLLO, M. E., WILLIAMS, R. L., BURROWS, T., KIRKPATRICK, S. I., BUCHER, T. & COLLINS, C. E. 2016. What are they really eating? A review on new approaches to dietary intake assessment and validation. *Current Nutrition Reports,* 5**,** 307-314.

RONKSLEY, P. E., BRIEN, S. E., TURNER, B. J., MUKAMAL, K. J. & GHALI, W. A. 2011. Association of alcohol consumption with selected cardiovascular disease outcomes: a systematic review and meta-analysis. *Bmj,* 342**,** d671.

ROOS, R., MYEZWA, H., VAN ASWEGEN, H. & MUSENGE, E. 2014. Effects of an Education and Home-Based Pedometer Walking Program on Ischemic Heart Disease Risk Factors in People Infected with HIV: A Randomized Trial. *JAIDS Journal of Acquired Immune Deficiency Syndromes,* 67.

ROSS, A. C., MANSON, J. E., ABRAMS, S. A., ALOIA, J. F., BRANNON, P. M., CLINTON, S. K., DURAZO-ARVIZU, R. A., GALLAGHER, J. C., GALLO, R. L. & JONES, G. 2011. The 2011 report on dietary reference intakes for calcium and vitamin D from the Institute of Medicine: what clinicians need to know. *The Journal of Clinical Endocrinology & Metabolism,* 96**,** 53-58.

SALAMI, A., AKANDE, A. & OLOKOBA, A. 2009. Serum lipids and glucose abnormalities in HIV/AIDS patients on antiretroviral therapies. *West African journal of medicine,* 28.

SAYED, B. A. & FRENCH, M. T. 2016. To your health!: Re-examining the health benefits of moderate alcohol use. *Social Science & Medicine,* 167**,** 20-28.

SCHENSUL, J. J., SINGH, S., GUPTA, K., BRYANT, K. & VERMA, R. 2010. Alcohol and HIV in India: a review of current research and intervention. *AIDS and Behavior,* 14**,** 1-7.

SCOTT-SHELDON, L. A., WALSTROM, P., CAREY, K. B., JOHNSON, B. T., CAREY, M. P. & TEAM, M. R. 2013. Alcohol use and sexual risk behaviors among individuals infected with HIV: a systematic review and meta-analysis 2012 to early 2013. *Current Hiv/aids Reports,* 10**,** 314-323.

SCOTT-SHELDON, L. A. J., CAREY, K. B., CUNNINGHAM, K., JOHNSON, B. T., CAREY, M. P. & THE, M. R. T. 2016. Alcohol Use Predicts Sexual Decision-Making: A Systematic Review and Meta-Analysis of the Experimental Literature. *AIDS and Behavior,* 20**,** 19-39.

SHARMA, A., HOWARD, A., KLEIN, R., SCHOENBAUM, E., BUONO, D. & WEBBER, M. 2007. Body image in older men with or at-risk for HIV infection. *AIDS care,* 19**,** 235-241.

SHIELD, K. D., PARRY, C. & REHM, J. 2014. Chronic diseases and conditions related to alcohol use. *Alcohol research: current reviews,* 35**,** 155.

SHIM, J.-S., OH, K. & KIM, H. C. 2014. Dietary assessment methods in epidemiologic studies. *Epidemiology and health,* 36**,** e2014009-e2014009.

SHISANA, O., LABADARIOS, D., REHLE, T., SIMBAYI, L., ZUMA, K., DHANSAY, A., REDDY, P., PARKER, W., HOOSAIN, E. & NAIDOO, P. 2014. The South African National Health and Nutrition Examination Survey, 2012: SANHANES-1: the health and nutritional status of the nation.

SHISHEHBOR, M. H., ZHANG, R., MEDINA, H., BRENNAN, M.-L., BRENNAN, D. M., ELLIS, S. G., TOPOL, E. J. & HAZEN, S. L. 2006. Systemic elevations of free radical oxidation products of arachidonic acid are associated with angiographic evidence of coronary artery disease. *Free Radical Biology and Medicine,* 41**,** 1678-1683.

SHIVAKOTI, R., CHRISTIAN, P., YANG, W.-T., GUPTE, N., MWELASE, N., KANYAMA, C., PILLAY, S., SAMANEKA, W., SANTOS, B. & POONGULALI, S. 2016. Prevalence and risk factors of micronutrient deficiencies pre-and post-antiretroviral therapy (ART) among a diverse multicountry cohort of HIV-infected adults. *Clinical Nutrition,* 35**,** 183-189.

SHIVAKOTI, R., GUPTE, N., YANG, W.-T., MWELASE, N., KANYAMA, C., TANG, A. M., PILLAY, S., SAMANEKA, W., RIVIERE, C. & BERENDES, S. 2014. Pre-antiretroviral therapy serum selenium concentrations predict WHO stages 3, 4 or death but not virologic failure post-antiretroviral therapy. *Nutrients,* 6**,** 5061-5078.

SORIANO, L. C., JOHANSSON, S., STEFANSSON, B. & RODRÍGUEZ, L. A. G. 2015. Cardiovascular events and all-cause mortality in a cohort of 57,946 patients with type 2 diabetes: associations with renal function and cardiovascular risk factors. *Cardiovascular diabetology,* 14**,** 1-15.

SOSNOWSKI, R., KULPA, M., ZIĘTALEWICZ, U., WOLSKI, J. K., NOWAKOWSKI, R., BAKUŁA, R. & DEMKOW, T. 2017. Basic issues concerning health-related quality of life. *Central European journal of urology,* 70**,** 206.

STANTON, A. M., LEE, J. S., WIRTZ, M. R., ANDERSEN, L. S., JOSKA, J., SAFREN, S. A., VAN ZYL-SMIT, R. & O'CLEIRIGH, C. 2021. Tobacco Use and Health-Related Quality of Life Among Individuals with Depression Who Are Receiving Treatment for HIV in Cape Town, South Africa. *Int J Behav Med,* 28**,** 417-430.

STOCKWELL, T., ZHAO, J., PANWAR, S., ROEMER, A., NAIMI, T. & CHIKRITZHS, T. 2016. Do "Moderate" Drinkers Have Reduced Mortality Risk? A Systematic Review and Meta-Analysis of Alcohol Consumption and All-Cause Mortality. *Journal of Studies on Alcohol and Drugs,* 77**,** 185-198.

STONE, C. A., KAWAI, K., KUPKA, R. & FAWZI, W. W. 2010. Role of selenium in Hiv infection. *Nutrition Reviews,* 68**,** 671-681.

STONE, N. J., ROBINSON, J. G., LICHTENSTEIN, A. H., BAIREY MERZ, C. N., BLUM, C. B., ECKEL, R. H., GOLDBERG, A. C., GORDON, D., LEVY, D. & LLOYD-JONES, D. M. 2014. 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Journal of the American College of Cardiology,* 63**,** 2889-2934.

SUTINEN, J. & YKI-JÄRVINEN, H. 2007. Increased resting energy expenditure, fat oxidation, and food intake in patients with highly active antiretroviral therapy-associated lipodystrophy. *Am J Physiol Endocrinol Metab,* 292**,** E687-92.

SWEENEY, S. M. & VANABLE, P. A. 2016. The association of HIV-related stigma to HIV medication adherence: a systematic review and synthesis of the literature. *AIDS and Behavior,* 20**,** 29-50.

TANG, A.M., GRAHAM, N.M., KIRBY, A.J., MCCALL, L.D., WILLETT, W.C. AND SAAH, A.J., 1993. dietary micronutrient intake and risk of progression to Acquired Immunodeficiency Syndrome (AIDS) in Human Immunodeficiency Virus Type 1 (HIV-1)-infected homosexual men. American Journal of Epidemiology, 138(11), pp.937-951.

TANG, A. M., QUICK, T., CHUNG, M. & WANKE, C. A. 2015. Nutrition Assessment, Counseling, and Support (NACS) interventions to improve health-related outcomes in people living with HIV/AIDS: a systematic review of the literature. *Journal of acquired immune deficiency syndromes (1999),* 68**,** S340.

TATE, T., WILLIG, A. L., WILLIG, J. H., RAPER, J. L., MONEYHAM, L., KEMPF, M.-C., SAAG, M. S. & MUGAVERO, M. J. 2012. HIV infection and obesity: where did all the wasting go? *Antiviral therapy,* 17**,** 1281.

TENFORDE, M. W., YADAV, A., DOWDY, D. W., GUPTE, N., SHIVAKOTI, R., YANG, W. T., MWELASE, N., KANYAMA, C., PILLAY, S., SAMANEKA, W., SANTOS, B., POONGULALI, S., TRIPATHY, S., RIVIERE, C., BERENDES, S., LAMA, J. R., CARDOSO, S. W., SUGANDHAVESA, P., CHRISTIAN, P., SEMBA, R. D., CAMPBELL, T. B. & GUPTA, A. 2017. Vitamin A and D Deficiencies Associated With Incident Tuberculosis in HIV-Infected Patients Initiating Antiretroviral Therapy in Multinational Case-Cohort Study. *J Acquir Immune Defic Syndr,* 75**,** e71-e79.

THUPPAL, S. V., JUN, S., COWAN, A. & BAILEY, R. L. 2017. The nutritional status of HIV-infected US adults. *Current Developments in Nutrition,* 1.

THURN, M. & GUSTAFSON, D. R. 2017. Faces of frailty in aging with HIV infection. *Current Hiv/aids Reports,* 14**,** 31-37.

TØTTENBORG, S. S., CLARK, A. J., THOMSEN, R. W., JOHNSEN, S. P. & LANGE, P. 2018. Socioeconomic inequality in the use of prescription medications for smoking cessation among patients with COPD: a nationwide study. *International journal of chronic obstructive pulmonary disease,* 13**,** 1775.

TRABER, M. G. & ATKINSON, J. 2007. Vitamin E, antioxidant and nothing more. *Free radical biology and medicine,* 43**,** 4-15.

TRAN, B. X., VU, G. T., HA, G. H., PHAN, H. T., LATKIN, C. A., CS, H. H. & HO, R. C. M. 2020. Global Mapping of Interventions to Improve the Quality of Life of People Living with HIV/AIDS: Implications for Priority Settings. *AIDS Rev,* 23**,** 91-102.

TRIPLETTE, M., CROTHERS, K. & ATTIA, E. 2016. Non-infectious pulmonary diseases and HIV. *Current HIV/AIDS Reports,* 13**,** 140-148.

TURAN, B., BUDHWANI, H., FAZELI, P. L., BROWNING, W. R., RAPER, J. L., MUGAVERO, M. J. & TURAN, J. M. 2017. How does stigma affect people living with HIV? The mediating roles of internalized and anticipated HIV stigma in the effects of perceived community stigma on health and psychosocial outcomes. *AIDS and Behavior,* 21**,** 283-291.

UNIVERSITY OF LIVERPOOL. 2019. *Food Considerations for Antiretrovirals* [Online]. Available: https://liverpool-hiv-hep.s3.amazonaws.com/prescribing_resources/pdfs/000/000/037/original/Food_ARVs_2019_Jul.pdf?1632405810 [Accessed 2021-10-07 2021].

VAGENAS, P., AZAR, M. M., COPENHAVER, M. M., SPRINGER, S. A., MOLINA, P. E. & ALTICE, F. L. 2015. The Impact of Alcohol Use and Related Disorders on the HIV Continuum of Care: a Systematic Review. *Current HIV/AIDS Reports,* 12**,** 421-436.

VAN GRIENSVEN, J., DE NAEYER, L., MUSHI, T., UBARIJORO, S., GASHUMBA, D., GAZILLE, C. & ZACHARIAH, R. 2007. High prevalence of lipoatrophy among patients on stavudine-containing first-line antiretroviral therapy regimens in Rwanda. *Trans R Soc Trop Med Hyg,* 101**,** 793-8.

VAN ZOEST, R. A., WIT, F. W., KOOIJ, K. W., VAN DER VALK, M., SCHOUTEN, J., KOOTSTRA, N. A., WIERSINGA, W. J., PRINS, M., VAN DEN BORN, B.-J. H. & REISS, P. 2016. Higher prevalence of hypertension in HIV-1-infected patients on combination antiretroviral therapy is associated with changes in body composition and prior stavudine exposure. *Clinical infectious diseases,* 63**,** 205-213.

VANCAMPFORT, D., MUGISHA, J., DE HERT, M., PROBST, M., FIRTH, J., GORCZYNSKI, P. & STUBBS, B. 2018. Global physical activity levels among people living with HIV: a systematic review and meta-analysis. *Disability and Rehabilitation,* 40**,** 388-397.

VELD, D. H. I., PENGPID, S., COLEBUNDERS, R., SKAAL, L. & PELTZER, K. 2017. High-risk alcohol use and associated socio-demographic, health and psychosocial factors in patients with HIV infection in three primary health care clinics in South Africa. *Int J STD AIDS,* 28**,** 651-659.

VINAROVA, L., VINAROV, Z., TCHOLAKOVA, S., DENKOV, N. D., STOYANOV, S. & LIPS, A. 2016. The mechanism of lowering cholesterol absorption by calcium studied by using an in vitro digestion model. *Food & function,* 7**,** 151-163.

VISSER, M., MAARTENS, G., KOSSEW, G. & HUSSEY, G. 2003. Plasma vitamin A and zinc levels in HIV-infected adults in Cape Town, South Africa. *British Journal of Nutrition,* 89**,** 475-482.

VISSER, M. E., DURAO, S., SINCLAIR, D., IRLAM, J. H. & SIEGFRIED, N. 2017. Micronutrient supplementation in adults with HIV infection. *Cochrane Database Syst Rev,* 5**,** Cd003650.

WADA, N. I., JACOBSON, L. P., MARGOLICK, J. B., BREEN, E. C., MACATANGAY, B., PENUGONDA, S., MARTÍNEZ-MAZA, O. & BREAM, J. H. 2015. The effect of HAART-induced HIV suppression on circulating markers of inflammation and immune activation. *AIDS (London, England),* 29**,** 463.

WEAVER, C., GORDON, C., JANZ, K., KALKWARF, H., LAPPE, J., LEWIS, R., O'KARMA, M., WALLACE, T. & ZEMEL, B. 2016. The National Osteoporosis Foundation's position statement on peak bone mass development and lifestyle factors: a systematic review and implementation recommendations. *Osteoporosis international,* 27**,** 1281-1386.

WEBEL, A. R., SATTAR, A., FUNDERBURG, N. T., KINLEY, B., LONGENECKER, C. T., LABBATO, D., ALAM, S. K. & MCCOMSEY, G. A. 2017. Alcohol and dietary factors associate with gut integrity and inflammation in HIV-infected adults. *HIV Med,* 18**,** 402-411.

WEINTRAUB, W. S., DANIELS, S. R., BURKE, L. E., FRANKLIN, B. A., GOFF JR, D. C., HAYMAN, L. L., LLOYD-JONES, D., PANDEY, D. K., SANCHEZ, E. J. & SCHRAM, A. P. 2011. Value of primordial and primary prevention for cardiovascular disease: a policy statement from the American Heart Association. *Circulation,* 124**,** 967-990.

WEISS, J. J., SANCHEZ, L., HUBBARD, J., LO, J., GRINSPOON, S. K. & FITCH, K. V. 2019. Diet Quality Is Low and Differs by Sex in People with HIV. *J Nutr,* 149**,** 78-87.

WHO 1985. *Constitution*, Geneva: World Health Organization.

WHO, C. 2000. Obesity: preventing and managing the global epidemic. *World Health Organ Tech Rep Ser,* 894.

WILLIAMS, J. A., MANLEY, S. & DING, W.-X. 2014. New advances in molecular mechanisms and emerging therapeutic targets in alcoholic liver diseases. *World journal of gastroenterology: WJG,* 20**,** 12908.

WONG, M., SHIAU, S., YIN, M. T., STREHLAU, R., PATEL, F., COOVADIA, A., MICKLESFIELD, L. K., KUHN, L. & ARPADI, S. M. 2016. Decreased Vigorous Physical Activity in School-Aged Children with Human Immunodeficiency Virus in Johannesburg, South Africa. *J Pediatr,* 172**,** 103-9.

WORLD HEALTH ORGANIZATION 2004. *Vitamin and mineral requirements in human nutrition*, World Health Organization.

WORLD HEALTH ORGANIZATION 2015. *Global status report on noncommunicable diseases 2014*, World Health Organization.

WORLD HEALTH ORGANIZATION 2018. Global action plan on physical activity 2018-2030: more active people for a healthier world: at-a-glance. World Health Organization.

WORLD HEALTH ORGANIZATION 2019a. *Global status report on alcohol and health 2018*, World Health Organization.

WORLD HEALTH ORGANIZATION. 2019b. *WHO report on the global tobacco epidemic 2019: offer help to quit tobacco use* [Online]. Available: https://www.who.int/publications/i/item/9789241516204 [Accessed 16/July/2021 2021].

WORLD HEALTH ORGANIZATION, T. 2010. *Global recommendations on physical activity for health*, World Health Organization.

WROTTESLEY, S. V., MICKLESFIELD, L. K., HAMILL, M. M., GOLDBERG, G. R., PRENTICE, A., PETTIFOR, J. M., NORRIS, S. A. & FEELEY, A. B. 2014. Dietary intake and body composition in HIV-positive and-negative South African women. *Public health nutrition,* 17**,** 1603-1613.

XU, Y., CHEN, X. & WANG, K. 2017. Global prevalence of hypertension among people living with HIV: a systematic review and meta-analysis. *Journal of the American Society of Hypertension,* 11**,** 530-540.

YANG, H.-Y., BEYMER, M. R. & SUEN, S.-C. 2019. Chronic Disease Onset Among People Living with HIV and AIDS in a Large Private Insurance Claims Dataset. *Scientific Reports,* 9**,** 18514.

YOO, J.-I., CHOI, H. & HA, Y.-C. 2017. Mean hand grip strength and cut-off value for sarcopenia in Korean adults using KNHANES VI. *Journal of Korean medical science,* 32**,** 868.

YU, R., ONG, S., CHEUNG, O., LEUNG, J. & WOO, J. 2017. Reference values of grip strength, prevalence of low grip strength, and factors affecting grip strength values in Chinese adults. *Journal of the American Medical Directors Association,* 18**,** 551. e9-551. e16.

ZHANG, X., WU, X., HU, Q., WU, J., WANG, G., HONG, Z., REN, J., LAB FOR, T. & SURGICAL, I. 2019. Mitochondrial DNA in liver inflammation and oxidative stress. *Life sciences,* 236**,** 116464.

ZOU, W. & BERGLUND, L. 2007. HIV and highly active antiretroviral therapy: dyslipidemia, metabolic aberrations, and cardiovascular risk. *Preventive cardiology,* 10**,** 96-103.

CHAPTER 3: SCOPING REVIEW

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3.1 SCOPING REVIEW PROTOCOL

TITLE: DIET QUALITY, FOOD INSECURITY AND RISK OF CARDIOVASCULAR DISEASES AMONG ADULTS LIVING WITH HIV/AIDS: A SCOPING REVIEW PROTOCOL

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ABSTRACT

Introduction: Cardiovascular diseases (CVD) are the single greatest contributor to global mortality. The successful introduction and scale-up of antiretroviral therapy (ART) delivered a reduction in HIV mortality. Consequently, an association was found between the scale-up of ART and an increased prevalence of comorbidities among People Living with HIV (PLWH) such as hypertension, and dyslipidemia. A higher quality diet can delay the onset of comorbidities related to HIV infection. Diet quality and its methods of assessment are not fully established among PLWH. This review will identify the diet quality and food insecurity indices that have been used among PLWH and how these constructs are associated with risk of developing CVD.

Methods and analysis: The frameworks recommended by Arksey and O'Malley and the Joanna Briggs Institute's (JBI) manual for conducting scoping reviews will be adopted. The Preferred Reporting Items for Systematic review and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines will be used for reporting. A search strategy was developed using keywords related to the topic. A preliminary MEDLINE (via PubMed) search was conducted on 11th November 2020 to develop a comprehensive search strategy. The final search will be conducted on PubMed, EbscoHost, Scopus, Web of Science and COCHRANE library databases. Titles and abstracts of retrieved records will be screened independently by two reviewers. Data will be extracted from records that meet the inclusion criteria using a predesigned charting tool. Discrepancies in decisions made by reviewers will be resolved by consensus or the decision of a third reviewer. Extracted data will be presented in tables or chart. A descriptive summary of the charts or tables will follow.

Ethics and dissemination: Ethical approval is not required for a scoping review. Findings will inform other studies currently underway and will be presented at conferences and published in peer-reviewed journals.

Registration number: https://osf.io/7k3ja

Keywords: HIV infections, diet quality, food insecurity, cardiovascular diseases

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This will be the first scoping review to explore the diet quality and food security status of PLWH with or at risk of CVD
- The Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews will be used, this will ensure transparent reporting of findings.
- The scoping review will be based on a comprehensive search strategy that was designed in collaboration with a research librarian and includes sources from seven databases and the grey literature.

- A major limitation of our review the inclusion of only studies published in English language.
- Only published articles in peer reviewed journals and databases of grey literature will be included.

INTRODUCTION

Globally, cardiovascular diseases (CVD) are the leading cause of death,(World Health Organization, 2019, Naghavi et al., 2017) with hypertension, diabetes, and dyslipidemia identified as principal risk factors for the development of CVD (World Health Organization, 2017). In people living with HIV (PLWH), a three-fold increase in the global burden of HIV-related CVD has been reported over the last two decades. A systematic review concluded that PLWH are twice as likely to develop CVD compared to their HIV-negative counterparts (Shah et al., 2018). This finding could be explained by several contributing factors including the infection itself and its treatment.

It is known that the successful introduction and scale-up of effective Highly Active Antiretroviral Therapy (HAART) brought about a reduction in HIV mortality rates, and an ageing cohort of PLWH (Mutevedzi and Newell, 2014). This, however, has been followed by a higher risk of morbidity, and increased prevalence of comorbidities including obesity, hyperglycemia dyslipidemia, hypertension, and other cardiovascular diseases among PLWH (Weiss et al., 2019, Rasmussen et al., 2015). Furthermore, certain CVD risk factors such as lipodystrophy, increased central adiposity, insulin resistance, and diabetes have also directly been linked with the use of HAART (Bozkurt, 2004, Rawdanowicz et al., 2013). HIV infection and HAART use have, therefore, been reported to significantly increase the risk for CVD (Nou et al., 2016, Nduka et al., 2015). Cardiovascular risks are also affected by other lifestyle factors such as dietary intake, smoking and physical activity (Dutra et al., 2012).

Similarly, to the general population, lifestyle modification is an essential first step in the management of CVD among PLWH. Dietary interventions have been demonstrated to reduce the risk of CVD among the HIV-uninfected population (Estruch et al., 2018, Grundy et al., 2019) and PLWH (Lazzaretti et al., 2012, Stradling et al., 2021). However, there is an absence of HIV-specific dietary recommendations for the reduction of CVD risks among PLWH (Feinstein et al., 2019).

Diet Quality

Diet quality is a concept that is not clearly defined; no consensus has been reached to have a specific meaning that can be applied in all contexts (Drewnowski et al., 1996). Diet quality indices are generally developed to reflect how much an individual or population's food consumption conforms to dietary guidelines and recommendations within a context (Drewnowski et al., 1996). Diet quality is being increasingly adopted in nutritional epidemiology surveys to assess dietary patterns and evaluate the effectiveness of a specific dietary

intervention. Since a relationship has been established and understood between food and human physiological function, diet quality has also been used as a proxy to predict mortality and risk of chronic diseases (Alkerwi, 2013, Miller et al., 2020).

Diet quality has been measured in diverse ways. Some studies have assessed and compared the intake of a specific nutrient or food components with recommended dietary standards or guidelines (Abioye et al., 2015, Aibana et al., 2019). However, it has been argued that overall dietary pattern or the consumption of food groups is a better indication of diet quality compared to the intake of a single nutrient(Coulston, 2001, Patterson et al., 1994). Diet quality indices have been, therefore, designed as a tool to connect food and nutrient intake to the incidence of chronic diseases, mortality, and morbidity (Coulston, 2001). Most epidemiological studies have, since then, measured diet quality using scientifically robust indices enabling standardized assessment (Drewnowski et al., 1996, Asghari et al., 2017, Fransen and Ocké, 2008).

Diet quality Indices

Several diet quality indices have been developed and used over the years. Some have been used to evaluate adherence to dietary guidelines while others monitor changes in dietary patterns over time (Fransen and Ocké, 2008). Diet quality indices have also been used to identify unfavourable patterns of intake (Wirt and Collins). Components assessed in diet quality indices include intake of specific macro or micronutrients, adherence to recommended serving sizes of food groups, or inclusion of predefined healthy food items (Drewnowski et al., 1996, Wirt and Collins, 2009). In summary, diet quality has been used to measure both inclusion of specific foods and nutrients, and variety of diet.

Examples of diet quality indices include:

- Healthy Eating Index (HEI) which was designed based on the Dietary Guidelines for Americans and other dietary patterns set by the United States Department of Agriculture (USDA) (Reedy et al., 2018, Guenther et al., 2014, Krebs-Smith et al., 2018).
- Mediterranean Diet Score (MDS) assessing degree of adherence to Mediterranean dietary guidelines among adults including the elderly (Trichopoulou et al., 1995).
- Diet Quality Index (DQI) designed to reflect risk of common diet-related diseases,(Patterson et al., 1994), further updated and renamed as Diet Quality Index-International (DQI-I) (Kim et al., 2003).
- Recommended Food Score (RFS) which contains 23 food items and measures overall food quality (Kant et al., 2000).

- Dietary Diversity Score (DDS),(Jayawardena et al., 2013) and Food Variety Score (FVS),(Hatløy et al., 1998) which are the total count of food groups and food items consumed respectively by a unit of population (household or individual) over a specified period of time. This does not put into account the quantity of food or food groups.
- Dietary Approaches to Stop Hypertension (DASH) diet score which is based on eight food and nutrient components and high in fruits and vegetables (Fung et al., 2008).
- Dietary Inflammatory Index (DII) which predicts level of inflammatory markers and their outcome on health (Shivappa et al., 2014).

Due to the complex and dynamic nature of diet quality, several reviews investigating associations between diet quality indices and disease risks have been conducted in the general population (Asghari et al., 2017, Fransen and Ocké, 2008, Wirt and Collins, 2009, Zaragoza-Martí et al., 2018, Schwingshackl et al., 2018, Waijers et al., 2007). Poor diet quality increases the risk of mortality and morbidity in the HIV-uninfected population (Olstad et al., 2019), Some studies have also evaluated diet quality among PLWH (Weiss et al, 2019, Duran and Jaime, 2009, Henderson, 2013, Kadiyala and Rawat, 2013, Palermo et al, 2013, Sackey et al, 2019, Sackey et al, 2018, Stanner et al, 2019). Researchers from Boston in the United States conducted a cross-sectional study using the HEI tool, and reported that diet quality was lower among PLWH and significantly lower among women living with HIV when compared to HIV-negative controls (Weiss et al., 2019). This study did not link results with risk of CVD.

Food insecurity

Food insecurity is defined as limited availability of and access to sufficient, safe, and nutritious food to support healthy living (Eaton et al., 2014, Goosen et al., 2016). The Food and Agriculture Organization (FAO), in the most recent report on the state of global food security and nutrition, estimated that 690 million people are hungry, equivalent to 8.9 percent of the world population. The FAO projects that the Covid-19 pandemic will exacerbate global food insecurity through disrupting social and economic systems, potentially resulting in up to an additional 132 million people experiencing undernutrition in 2020 (FAO et al., 2020).

Socioeconomic factors such as food insecurity can influence diet quality. Muhammad et al. (Muhammad et al.) reported that 55% of their sample of PLWH in the USA (aged 50 years and older) are food insecure, and that food insecurity was linked to lower diet quality, irrespective of income (Muhammad et al.). This finding is supported by evidence in the general population,(Hanson and Connor, 2014), and corroborated by the FAO report (Henderson).

Given the current food security situation and the link with diet quality, we will include studies that assess food security status in our review.

Measures of Food Security

Food security has been assessed by several indicators at national, household, and individual levels. Some indicators measure food consumption adequacy while others gather additional information on experiences and behavioural responses (Cafiero et al., 2014). There have been several paradigms in the concept of food security which have influenced the formulation of new indices. Focus has shifted from global and national food security measures alone to include additional household and individual measures (Maxwell, 1996).

Food security indicators may include:

- Food Consumption Score (FCS) which is used to assess food security and vulnerability by the World Food Program (Programme, 2008).
- Household Dietary Diversity Score (HDDS) which is seen as the simplest possible measure at the household level (Swindale and Bilinsky, 2006).
- Household Food Security Survey Module (HFSSM) developed by the United States Department of Agriculture (USDA) (Bickel et al., 2000).
- Household Food Insecurity Access Scale,(Eaton et al.) used by the Food and Nutrition Technical Assistance-II (FANTA-II) initiative (Cafiero et al., 2014).
- Food Insecurity Experience Scale (FIES) developed by FAO (Ahmadi and Melgar-Quiñonez, 2018).

The extent to which diet quality and food security status have been assessed in the context of HIV is not known. This scoping review is necessary to aggregate information on the depth of research on diet quality and HIV.

Aims

The aims of this review include:

- To determine the diet quality and food security status of PLWH with or at risk of CVD.
- To identify the range and utility of diet quality and food security indices among PLWH with or at risk of CVD.

METHODS AND ANALYSIS

The use of scoping reviews to synthesize evidence has increased over the years. As with other forms of literature reviews, they serve general functions of collection, evaluation, and presentation of available research evidence (Arksey and O'Malley, 2005). Scoping reviews can also be termed “scoping studies” and “mapping reviews” (Anderson et al., 2008, Ehrich et al., 2002).

There are several reasons why conducting a scoping review is appropriate to answer our research aims. The scoping review could be a step leading to a full systematic review (Munn et al., 2018). In this case, it will identify the feasibility of a systematic review and meta-analysis, the availability of sources of evidence, and previous systematic reviews that have been conducted (Arksey and O'Malley, 2005). In line with suggestions made by several authors about the value of scoping reviews, this scoping review will inform us about the current state of knowledge and types of evidence available on our topic of interest,(Arksey and O'Malley, 2005), as well as illuminate knowledge gaps (CHRASTINA, 2019, Munn et al., 2018). Furthermore the review will also summarize how research is conducted in the field of interest,(Munn et al., 2018); appropriate study populations, research designs, and tools can be identified (CHRASTINA, 2019). Finally, key concepts and their definitions will be identified (Munn et al., 2018). These concepts can be classified based on how they relate; their similarities and differences can be identified and yield a “concept map” (CHRASTINA, 2019). An example of a recent scoping review explained the concept of formative peer assessment in a healthcare education programme (Stenberg et al., 2018).

Scoping reviews are useful when the field of study is broadly heterogeneous,(Stenberg et al., 2018); diet quality has different indices that are broadly used to appraise various components of dietary intake. Similarly, food security has been measured using a variety of indices. This review will specifically provide a summary of the extent to which diet quality and food security have been explored among PLWH while identifying tools that have been used to evaluate these constructs. Given the emerging concerns of risks of CVD among PLWH, we will identify how much of this concept has been explored within the context of diet quality and food security. This could identify grey areas among these concepts of diet quality, food insecurity, and risks of CVD among PLWH, and potentially inform areas for future research. All the above reasons justify the use of scoping review methodology for this study (Anderson et al., 2008, Arksey and O'Malley, 2005, CHRASTINA, 2019, Ehrich et al., 2002, Munn et al., 2018, Tricco et al., 2016).

The methodology proposed by Arksey and O’Malley,(Arksey and O'Malley, 2005) will form the bedrock for this scoping review. Input from Levac et al. (2010), Peters et al. (2017) will also be

incorporated. The Joanna Briggs Institute (JBI) manual recommends that a protocol stating a stepwise approach to the scoping review be designed and that a set of criteria for including or excluding studies should be determined *a priori.* These criteria must reflect the aim as well as the questions of the review (Oduwole et al., 2019).

The framework proposed by Arksey and O'Malley consists of six stages of which five are mandatory. The stages are:

1. Identifying a research question;
2. Identifying relevant studies;
3. Study selection;
4. Charting the data;
5. Collating, summarizing and reporting the results;
6. Consultation exercise (optional).

Stage six will be omitted as this scoping review is not intended to provide evidence to inform clinical decisions. It will however provide an overview of the literature on dietary components related to risks of CVD in PLWH and give an indication whether the type of data is appropriate for meta-analyses. Given the increased risk of CVD in PLWH, this review will also inform how best to assess dietary intake in this cohort.

Stage 1: Identifying the review question

Common to all review methodologies, scoping reviews start with the formulation of a well-defined research topic that helps to clarify the search strategy (Khan et al., 2001). Guidelines recommend a broad approach to develop a scoping review question, enabling generation of the required depth (Arksey and O'Malley, 2005). A review question should identify the population, concept, and context (PCC) of the study, as recommended by the JBI (Peters et al., 2017).

This review will be carried out to map the breadth of research on diet quality, food security, and risk of CVD among PLWH. The primary review question is:

- What is the current diet quality and food insecurity status of PLWH with or at risk of CVD?

The introduction of highly active antiretroviral therapy (HAART) in the late 1990s,(Pau and George, 2014) brought a significant change to the health outcomes of PLWH (Weldehaweria et al., 2017). The word "current" has been included as studies published since 1998 will be considered for the purpose of this scoping review. This time-period has been selected based on the recorded time for the global scale-up of HAART.

In addition to the main question this scoping review also seeks to answer the following secondary questions:

- What methodologies have been used to assess the dietary quality and food security of PLWH with or at risk of CVD?

Stage 2: Identifying relevant studies

It is recommended that a scoping review should exhaustively include all sources of evidence, published, or unpublished that can provide insights into the research question (Arksey and O'Malley, 2005). A three-stage systematic approach will be adopted for this scoping review. This ensures all peer-reviewed published sources of evidence as well as grey literature are captured (Peters et al., 2017). The first stage is a preliminary search of at least two databases to identify and analyze keywords, text words, index terms and Medical Subject Headings (MeSH) terms related to the search. This was completed on MEDLINE (PubMed) and CINAHL (EBSCOhost) as recommended (Peters et al., 2017). During this stage, key search components and other words that relate to them were identified. The MeSH terms obtained from databases will enable linking other terms related to our search components which have not been identified. Abbreviations of key search terms such as “PLWH” and “PLWHIV” were identified during the preliminary search of articles. Search terms and abbreviations related to various diet quality indices were also identified from published articles.

In the second stage, a full and comprehensive search strategy was developed from the information retrieved and modified to suit each database. The databases that will be searched include, PubMed, Africa wide, CINAHL, APA Psyc info (via EBSCOhost), Scopus, Web of Science, COCHRANE library, and databases for grey literature such as ProQuest and AHRQ Agency for Healthcare Research and Quality. Table 3.1 contains an example of a preliminary full search strategy for MEDLINE.

Table 3. 1 Full search strategy for MEDLINE conducted on 11/11/2020

#	Searches	Records retrieved
1	(((HIV positive OR Human Immuno Deficiency Virus OR People Living with HIV OR PLWH OR PLWHA OR PLWHIV OR PLHIV OR AIDS OR HAART OR Highly Active Antiretroviral OR ART OR Antiretrovirals OR Antiretroviral Therapy) OR (HIV infections[MeSH Terms])) OR (HIV[MeSH Terms])) OR (antiretroviral therapy, highly active[MeSH Terms])	595,201
2	(Diet quality OR Mediterranean Diet Score OR MDS OR Healthy Eating Index score OR HEI OR DASH diet score OR Diet Quality Index score OR DQI OR Diet Diversity Score OR Dietary Diversity OR DDS OR Food Insecurity) OR (Diet[MeSH Terms])	365,364
3	((((Blood pressure OR High blood pressure OR Lipid Profile OR Hyperlipidemia OR Dyslipidemia OR Hypercholesterolemia OR Hyperglyceridemia OR Low HDL Cholesterol OR Low High-Density Lipoprotein OR Elevated LDL Cholesterol OR Elevated Low-Density Lipoprotein OR Cardiovascular disease OR Hypertension) OR (Blood Pressure[MeSH Terms])) OR (Hypertension[MeSH Terms])) OR (Dyslipidemia[MeSH Terms])) OR (Cardiovascular disease[MeSH Terms])	3,208,278
4	(Adults OR Adult) OR (adult[MeSH Terms])	7,941,617
5	(Pregnancy[MeSH Terms]) OR (pregnant women[MeSH Terms])	901,700
6	#1 AND #2 AND #3 AND #4	162
7	#6 NOT #5	159
8	Animals[MeSH Terms]	23,585,166
9	Humans[MeSH Terms]	18,829,206
10	#8 NOT #9	4,755,960
11	#7 NOT #10	156
12	#11 (Filters: from 1998 – 2020)	145

The first two steps of the search were conducted with the assistance of a research librarian. The final step is a manual search of the reference list of all identified sources of evidence that meet the inclusion criteria to locate additional studies.

Inclusion criteria

JBI recommends an agreement between the title, review questions and inclusion criteria, and further points out the PCC guidelines for topic and review questions. JBI recommends that the participants, concepts, context and types of evidence sources be clearly defined *a priori* and considered when designing the inclusion criteria (Peters et al., 2017). In contrast, Arksey and

O'Malley designed their inclusion criteria *post hoc* using "type of study, type of intervention care recipient group and caregiver group" based on their review objective. The JBI recommendation is adopted here because stating the inclusion criteria from the start will give clarity to the process of screening articles.

Participants

Studies involving adults living with HIV, non-pregnant, and who are either on HAART or treatment naive will be considered.

Concept

This review is designed to identify the risk of CVD among adults living with HIV using dietary quality estimates. Dietary quality has been defined above as the degree of adherence to specific dietary guidelines (in this case, guidelines to reduce the risk of CVD) (Drewnowski et al., 1996). Therefore, all studies that assess diet quality using either diet quality scores or through the intake of a specific nutrient or food component that relate to the risk of CVD will be included. All diet quality indices will be included in the search strategy. Since it has been established that food insecurity is related to diet quality,(Muhammad et al., 2019), studies that assess food insecurity will also be included.

Food insecurity has been measured using the indices enumerated above. For this review, we will make use of the food insecurity/hunger score or results given by the included sources of evidence.

The risks of CVD that will be considered as the main outcome are hypertension and dyslipidemia. Since the main exposure we are interested in is diet quality, studies that investigate the risk of CVD without assessing diet quality will not be included.

Context

Research on dietary recommendations and how they affect health and diseases have expanded over the years. The use of HAART has also changed the narratives of HIV infection. It is therefore ideal to include only recent studies in this review. As stated above, studies published earlier than 1998 will be excluded.

Types of Sources

All primary studies and reviews conducted on human subjects will be included. Laboratory studies, research conducted on biochemical substances and studies that are not published in English will be excluded.

Stage 3: Study selection

After the search has been conducted, the identified and collated citations will be exported into EndNote X9 (Clarivate, Analytics, PA, USA) to remove duplicates. The new citations will be uploaded to Rayyan QCRI (Copenhagen: The Nordic Cochrane Centre, Cochrane),(Ouzzani et al., 2016) where titles and abstracts will be assessed independently against the inclusion criteria by two members of the research team. Disagreements on screened citations will be discussed and resolved by consensus or the intervention of a third reviewer when necessary. This approach is consistent with methodology previously developed and used (Arksey and O'Malley, 2005, Armstrong et al., 2011, Peters et al., 2017).

Full text reports of studies that passed the initial stage of screening will be retrieved and screened to verify their conformance with the inclusion criteria. Articles that fail to meet the inclusion criteria here will be excluded and reasons will be included in the final report.

A full report of the search will be presented in a Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Review (PRISMA-ScR) flow chart and included in the final report. Details of excluded studies and reasons for their exclusion will be compiled from a predefined list, those suggested and agreed on by the reviewers during the process of review will also be included. This list of exclusion criteria will be classified and included in the final report.

Stage 4: Charting the data

Following recommendations, a pre-designed tabulated data extraction tool template will be piloted on ten included studies (Peters et al., 2017). JBI identified that there usually is a need to chart additional data unforeseen from the time of study design, therefore any modification made to the tool will be detailed in the full report of this review (Peters et al., 2017). This chart helps the reviewers to easily keep track of each source of evidence and gives the reader a quick and logical overview of the results that answer the review questions (Arksey and O'Malley, 2005, Ouzzani et al., 2016).

Data extracted will be tabulated as follows: first author/year of publication, country, aim of the study, population/sample size, study design, participant recruitment, duration of study, diet quality index used and/or food insecurity measure used, outcome, risk of the CVD reported and prevalence, key findings that relate to the review questions, author's conclusion, interpretation, and recommendations.

Stage 5: Collating, summarizing and reporting the results

Quantitative data extracted will be presented in tables or charts (as appropriate) in line with the review questions. An integrated descriptive summary and interpretation of the charts or tables will follow. Qualitative data will be presented thematically, pre-identified themes that may be reported include types of diet quality index, risk of CVD reported, diet quality status by gender, diet quality status by geographical location. Other themes identified while collating data will also be included. Meta-analysis of data or qualitative evaluation of included studies will not be conducted for this review. This review is intended to give a descriptive overview of diet quality, food insecurity status and risk of CVD of adults living with HIV.

Stage 6: Consultation

This stage is optional and is not planned to be conducted for this scoping review.

Patient and Public Involvement

No patient involved

ETHICS AND DISSEMINATION

The review will not require any generation of primary data; all documents will be retrieved from the public domain. This review, therefore, does not require ethical approval. It forms part of dissertation towards a Master of Medical Science in Nutrition (MMedSci Nutrition) which is underway. Results will be presented at conferences and published in a peer-reviewed journal. This protocol is registered on Open Science Framework (OSF) with registration number: https://osf.io/7k3ja

ACKNOWLEDGEMENT

The authors acknowledge and appreciate the effort of Namhla Madini of the Bongani Mayosi Health Sciences Library, the University of Cape Town for the assistance she provided with the preliminary search and developing the search strategy.

CONTRIBUTORS

All authors were involved in the conceptualization of the scoping review protocol. IOO led the process, drafted the protocol and wrote the manuscript under the supervision of JH, SB, and AD. All authors approved the publishing of this protocol.

COMPETING INTEREST

None declared

FUNDING

The Mastercard Foundation Scholars Program funds the degree of IOO. This work does not reflect the views of the funder, but the views of the authors based on research findings.

REFERENCES

ABIOYE, A. I., ISANAKA, S., LIU, E., MWIRU, R. S., NOOR, R. A., SPIEGELMAN, D., MUGUSI, F. & FAWZI, W. 2015. Gender differences in diet and nutrition among adults initiating antiretroviral therapy in Dar es Salaam, Tanzania. *AIDS Care,* 27**,** 706-715.

AHMADI, D. & MELGAR-QUIÑONEZ, H. 2018. Use of the Food Insecurity Experience Scale to assess food security status in Ireland, 2014–17: a cross-sectional analysis. *The Lancet,* 392**,** S16-S16.

AIBANA, O., HUANG, C.-C., ABOUD, S., ARNEDO-PENA, A., BECERRA, M. C., BELLIDO-BLASCO, J. B., BHOSALE, R., CALDERON, R., CHIANG, S., CONTRERAS, C., DAVAASAMBUU, G., FAWZI, W. W., FRANKE, M. F., GALEA, J. T., GARCIA-FERRER, D., GIL-FORTUÑO, M., GOMILA-SARD, B., GUPTA, A., GUPTE, N., HUSSAIN, R., IBORRA-MILLET, J., IQBAL, N. T., JUAN-CERDÁN, J. V., KINIKAR, A., LECCA, L., MAVE, V., MESEGUER-FERRER, N., MONTEPIEDRA, G., MUGUSI, F. M., OWOLABI, O. A., PARSONNET, J., ROACH-POBLETE, F., ROMEU-GARCÍA, M. A., SPECTOR, S. A., SUDFELD, C. R., TENFORDE, M. W., TOGUN, T. O., YATACO, R., ZHANG, Z. & MURRAY, M. B. 2019. Vitamin D status and risk of incident tuberculosis disease: A nested case-control study, systematic review, and individual-participant data meta-analysis. *Plos Medicine,* 16**,** e1002907-e1002907.

ALKERWI, A. A. 2013. Diet quality concept. *Nutrition,* 30**,** 613-618.

ANDERSON, S., ALLEN, P., PECKHAM, S. & GOODWIN, N. 2008. Asking the right questions: scoping studies in the commissioning of research on the organisation and delivery of health services. *Health research policy and systems,* 6**,** 1-12.

ARKSEY, H. & O'MALLEY, L. 2005. Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology,* 8**,** 19-32.

ARMSTRONG, R., HALL, B. J., DOYLE, J. & WATERS, E. 2011. 'Scoping the scope'of a cochrane review. *Journal of public health,* 33**,** 147-150.

ASGHARI, G., MIRMIRAN, P., YUZBASHIAN, E. & AZIZI, F. 2017. A systematic review of diet quality indices in relation to obesity. 117**,** 1055-1065.

BICKEL, G., NORD, M., PRICE, C., HAMILTON, W. & COOK, J. 2000. Guide to measuring household food security. Revised.

BOZKURT, B. 2004. Cardiovascular toxicity with highly active antiretroviral therapy. *Cardiovascular Toxicology,* 4**,** 243-60.

CAFIERO, C., MELGAR-QUIÑONEZ, H. R., BALLARD, T. J. & KEPPLE, A. W. 2014. Validity and reliability of food security measures. *Annals of the New York Academy of Sciences,* 1331**,** 230-248.

CHRASTINA, J. 2019. Systematic Review And (Aystematic) Scoping Review: Similarities Or Differences?

CLAUDIA DANIELE TAVARES, D., ANNY KARULINNY MESQUITA, M., DANIELE ALMEIDA, S., ROSA MARIA, D., SANDRO HENRIQUE DE SOUZA DANTAS, O., ANDRÉA DAS GRAÇAS FERREIRA, F. & ROSANA MARIA FEIO, L. 2012. RISK FACTORS FOR CARDIOVASCULAR DISEASES IN PATIENTS WITH HIV LIPODYSTROPHIC SYNDROME. *Revista Gestão & saúde (Brasília),* 3**,** 836-851.

COULSTON, A. M. 2001. The search continues for a tool to evaluate dietary quality. *The American journal of clinical nutrition,* 74**,** 417.

DREWNOWSKI, A., HENDERSON, S. A., SHORE, A., FISCHLER, C., PREZIOSI, P. & HERCBERG, S. 1996. Diet Quality and Dietary Diversity in France: Implications for the French Paradox. *Journal of the American Dietetic Association,* 96**,** 663-669.

Duran, A. C., & Jaime, P. C. (2009). Diet quality of people living with HIV/AIDS: associated factors. *Revista Chilena de Nutrición*, *36*, 388.

EATON, L. A., CAIN, D. N., PITPITAN, E. V., CAREY, K. B., CAREY, M. P., MEHLOMAKULU, V., SIMBAYI, L. C., MWABA, K. & KALICHMAN, S. C. 2014. Exploring the relationships among food insecurity, alcohol use, and sexual risk taking among men and women living in South African townships. *The Journal of Primary Prevention,* 35**,** 255-265.

EHRICH, K., FREEMAN, G. K., RICHARDS, S. C., ROBINSON, I. C. & SHEPPERD, S. 2002. How to do a scoping exercise: continuity of care. *Research, Policy and Planning,* 20**,** 25-29.

ESTRUCH, R., ROS, E., SALAS-SALVADÓ, J., COVAS, M.-I., CORELLA, D., ARÓS, F., GÓMEZ-GRACIA, E., RUIZ-GUTIÉRREZ, V., FIOL, M., LAPETRA, J., LAMUELA-RAVENTOS, R. M., SERRA-MAJEM, L., PINTÓ, X., BASORA, J., MUÑOZ, M. A., SORLÍ, J. V., MARTÍNEZ, J. A., FITÓ, M., GEA, A., HERNÁN, M. A. & MARTÍNEZ-GONZÁLEZ, M. A. 2018. Primary Prevention of Cardiovascular Disease with a Mediterranean Diet Supplemented with Extra-Virgin Olive Oil or Nuts. *New England Journal of Medicine,* 378**,** e34.

FAO, IFAD, UNICEF, WFP & WHO 2020. *The State of Food Security and NUtrition in the World 2020,* Rome, Italy, FAO, IFAD, UNICEF, WFP, WHO.

FEINSTEIN, M. J., HSUE, P. Y., BENJAMIN, L. A., BLOOMFIELD, G. S., CURRIER, J. S., FREIBERG, M. S., GRINSPOON, S. K., LEVIN, J., LONGENECKER, C. T. & POST, W. S. 2019. Characteristics, Prevention, and Management of Cardiovascular Disease in People Living With HIV: A Scientific Statement From the American Heart Association. *Circulation (New York, N.Y.),* 140**,** e98-e124.

FRANSEN, P. H. & OCKÉ, C. M. 2008. Indices of diet quality. *Current Opinion in Clinical Nutrition and Metabolic Care,* 11**,** 559-565.

FUNG, T., CHIUVE, S., MCCULLOUGH, M., REXRODE, K., LOGROSCINO, G. & HU, F. 2008. Adherence to a DASH-Style diet and risk of coronary heart disease and stroke in women. *Archives Of Internal Medicine,* 168**,** 713-720.

GOOSEN, A., VENTER, D., BEEFORTH, M., STEENKAMP, L., VENTERC, D., BEEFORTHD, M. & NELSON MANDELA METROPOLITAN UNIVERSITY, S. A. 2016. Food insecurity among students living with HIV: Strengthening safety nets at the Nelson Mandela Metropolitan University, South Africa. *Sahara Journal of the Social Aspects of HIV/AIDS,* 13**,** 106-111.

GRUNDY, S. M., STONE, N. J., BAILEY, A. L., BEAM, C., BIRTCHER, K. K., BLUMENTHAL, R. S., BRAUN, L. T., DE FERRANTI, S., FAIELLA-TOMMASINO, J. & FORMAN, D. E. 2019. 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APhA/ASPC/NLA/PCNA guideline on the management of blood cholesterol: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Journal of the American College of Cardiology,* 73**,** 3168-3209.

GUENTHER, P., KIRKPATRICK, S., REEDY, J., KREBS-SMITH, S., BUCKMAN, D., DODD, K., CASAVALE, K. & CARROLL, R. 2014. The Healthy Eating Index-2010 Is a Valid and Reliable Measure of Diet Quality According to the 2010 Dietary Guidelines for Americans1-3. *The Journal of Nutrition,* 144**,** 399-407.

HANSON, K. & CONNOR, L. 2014. Food insecurity and dietary quality in US adults and children: a systematic review. *American Journal Of Clinical Nutrition,* 100**,** 684-692.

HATLØY, A., TORHEIM, L. E. & OSHAUG, A. 1998. Food variety--a good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa. *European journal of clinical nutrition,* 52**,** 891.

HENDERSON, C. 2013. Study Results from International Food Policy Research Institute Provide New Insights into Public Health (Food access and diet quality independently predict nutritional status among people living with HIV in Uganda). *AIDS Weekly***,** a70.

JAYAWARDENA, R., BYRNE, N., SOARES, M., KATULANDA, P., YADAV, B. & HILLS, A. P. 2013. High dietary diversity is associated with obesity in Sri Lankan adults: an evaluation of three dietary scores. *Bmc Public Health,* 13.

Kadiyala, S. and Rawat, R., 2013. Food access and diet quality independently predict nutritional status among people living with HIV in Uganda. *Public health nutrition*, *16*(1), pp.164-170.

KANT, A., SCHATZKIN, A., GRAUBARD, B. & SCHAIRER, C. 2000. A prospective study of diet quality and mortality in women. *JAMA,* 283**,** 2109-15.

KHAN, K. S., TER RIET, G., GLANVILLE, J., SOWDEN, A. J. & KLEIJNEN, J. 2001. *Undertaking systematic reviews of research on effectiveness: CRD's guidance for carrying out or commissioning reviews*, NHS Centre for Reviews and Dissemination.

KIM, S., HAINES, P. S., SIEGA-RIZ, A. M. & POPKIN, B. M. 2003. The Diet Quality Index-International (DQI-I) provides an effective tool for cross-national comparison of diet quality as illustrated by China and the United States. *The Journal of nutrition,* 133**,** 3476-3484.

KREBS-SMITH, S. M., PANNUCCI, T. E., SUBAR, A. F., KIRKPATRICK, S. I., LERMAN, J. L., TOOZE, J. A., WILSON, M. M. & REEDY, J. 2018. Update of the Healthy Eating Index: HEI-2015. *Journal of the Academy of Nutrition and Dietetics,* 118**,** 1591-1602.

LAZZARETTI, R. K., KUHMMER, R., SPRINZ, E., POLANCZYK, C. A. & RIBEIRO, J. P. 2012. Dietary intervention prevents dyslipidemia associated with highly active antiretroviral therapy in human immunodeficiency virus Type 1–infected individuals: a randomized trial. *Journal of the American College of Cardiology,* 59**,** 979-988.

LEVAC, D., COLQUHOUN, H. & O'BRIEN, K. K. 2010. Scoping studies: advancing the methodology. *Implementation science,* 5**,** 69.

MAXWELL, S. 1996. Food security: a post-modern perspective. *Food Policy,* 21**,** 155-170.

MILLER, V., WEBB, P., MICHA, R. & MOZAFFARIAN, D. 2020. Defining diet quality: a synthesis of dietary quality metrics and their validity for the double burden of malnutrition. *The Lancet Planetary Health,* 4**,** e352-e370.

MUHAMMAD, J., FERNANDEZ, J., CLAY, O., SAAG, M., OVERTON, E. & WILLIG, A. 2019. Associations of food insecurity and psychosocial measures with diet quality in adults aging with HIV. *AIDS care,* 31**,** 554-562.

MUNN, Z., PETERS, M. D., STERN, C., TUFANARU, C., MCARTHUR, A. & AROMATARIS, E. 2018. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC medical research methodology,* 18**,** 143.

MUTEVEDZI, P. C. & NEWELL, M.-L. 2014. The changing face of the HIV epidemic in sub-Saharan Africa.(Report). *Tropical Medicine and International Health,* 19**,** 1015.

NAGHAVI, M., ABAJOBIR, A. A., ABBAFATI, C., ABBAS, K. M., ABD-ALLAH, F., ABERA, S. F., ABOYANS, V., ADETOKUNBOH, O., AFSHIN, A., AGRAWAL, A., AHMADI, A., AHMED, M. B., AICHOUR, A. N., AICHOUR, M. T. E., AICHOUR, I., AIYAR, S., ALAHDAB, F., AL-ALY, Z., ALAM, K. & ALAM, N. 2017. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet,* 390**,** 1151-1210.

NDUKA, C., SARKI, A., UTHMAN, O. & STRANGES, S. 2015. Impact of antiretroviral therapy on serum lipoprotein levels and dyslipidemias: A systematic review and meta-analysis. *International Journal of Cardiology,* 199**,** 307-318.

NOU, K. E., LO, K. J. & GRINSPOON, K. S. 2016. Inflammation, immune activation, and cardiovascular disease in HIV. *AIDS,* 30.

ODUWOLE, E. O., PIENAAR, E. D., MAHOMED, H. & WIYSONGE, C. S. 2019. Current tools available for investigating vaccine hesitancy: a scoping review protocol. *BMJ Open,* 9.

OLSTAD, D., CAMPBELL, N. & RAINE, K. 2019. Diet quality in Canada: policy solutions for equity. *Canadian Medical Association. Journal,* 191**,** E100-E102.

OUZZANI, M., HAMMADY, H., FEDOROWICZ, Z. & ELMAGARMID, A. 2016. Rayyan — a web and mobile app for systematic reviews. *Systematic Reviews***,** 210.

Palermo, T., Rawat, R., Weiser, S.D. and Kadiyala, S., 2013. Food access and diet quality are associated with quality of life outcomes among HIV-infected individuals in Uganda. *PloS one*, *8*(4), p.e62353.

PATTERSON, R. E., HAINES, P. S. & POPKIN, B. M. 1994. Diet quality index: Capturing a multidimensional behavior. *Journal of the American Dietetic Association,* 94**,** 57-64.

PAU, A. K. & GEORGE, J. M. 2014. Antiretroviral Therapy. *Infectious Disease Clinics of North America,* 28**,** 371-402.

PETERS, M. D., GODFREY, C., MCINERNEY, P., BALDINI SOARES, C., KHALIL, H. & PARKER, D. 2017. Chapter 11: scoping reviews. *Joanna Briggs Institute Reviewer's Manual. The Joanna Briggs Institute*.

PROGRAMME, W. F. 2008. Food consumption analysis: Calculation and use of the food consumption score in food security analysis. World Food Programme Rome, Italy.

RASMUSSEN, L. D., MAY, M. T., KRONBORG, G., LARSEN, C. S., PEDERSEN, C., GERSTOFT, J. & OBEL, N. 2015. Time trends for risk of severe age-related diseases in individuals with and without HIV

infection in Denmark: a nationwide population-based cohort study. *The Lancet HIV,* 2**,** e288-e298.

RAWDANOWICZ, J., PIKTO-PIETKIEWICZ, W. & MARCZYNSKA, M. 2013. Cardiovascular diseases associated with HIV infection and their management. *Kardiologia Polska,* 71**,** 1183-1187.

REEDY, J., LERMAN, J. L., KREBS-SMITH, S. M., KIRKPATRICK, S. I., PANNUCCI, T. E., WILSON, M. M., SUBAR, A. F., KAHLE, L. L. & TOOZE, J. A. 2018. Evaluation of the Healthy Eating Index-2015. *Journal of the Academy of Nutrition and Dietetics,* 118**,** 1622-1633.

SACKEY, J., WANG, G., WANKE, C., TANG, A. AND KNOX, T., 2019. Socio-Demographic factors associated with diet quality among a cohort of people living with HIV (P04-075-19). *Current Developments in Nutrition*, *3*(Supplement_1), pp.nzz051-P04.

SACKEY, J., ZHANG, F.F., ROGERS, B., ARYEETEY, R. AND WANKE, C., 2018. Food security and dietary diversity are associated with health related quality of life after 6 months of follow up among people living with HIV in Accra, Ghana. *AIDS care*, *30*(12), pp.1567-1571.

SCHWINGSHACKL, L., BOGENSBERGER, B. & HOFFMANN, G. 2018. Diet Quality as Assessed by the Healthy Eating Index, Alternate Healthy Eating Index, Dietary Approaches to Stop Hypertension Score, and Health Outcomes: An Updated Systematic Review and Meta-Analysis of Cohort Studies. *Journal of the Academy of Nutrition and Dietetics,* 118**,** 74-100.e11.

SHAH, A. S., STELZLE, D., LEE, K. K., BECK, E. J., ALAM, S., CLIFFORD, S., LONGENECKER, C. T., STRACHAN, F., BAGCHI, S. & WHITELEY, W. 2018. Global burden of atherosclerotic cardiovascular disease in people living with HIV: systematic review and meta-analysis. *Circulation,* 138**,** 1100-1112.

SHIVAPPA, N., STECK, S. E., HURLEY, T. G., HUSSEY, J. R., MA, Y., OCKENE, I. S., TABUNG, F. & HÉBERT, J. R. 2014. A population-based dietary inflammatory index predicts levels of C-reactive protein in the Seasonal Variation of Blood Cholesterol Study (SEASONS). 17**,** 1825-1833.

STANNER, H., RADLER, D.R. AND SACKEY, J., 2019. The association between diet quality and fasting blood glucose in people living with HIV (P08-051-19). *Current Developments in Nutrition*, *3*(Supplement_1), pp.nzz044-P08.

STENBERG, M., MANGRIO, E., BENGTSSON, M. & CARLSON, E. 2018. Formative peer assessment in healthcare education programmes: protocol for a scoping review. *BMJ Open,* 8.

STRADLING, C., THOMAS, G.N., HEMMING, K., TAYLOR, S. AND TAHERI, S., 2021. Randomized parallel-group pilot trial (Best foods for your heart) comparing the effects of a Mediterranean Portfolio diet with a low saturated fat diet on HIV dyslipidemia. Clinical Nutrition, 40(3), pp.860-869.

SWINDALE, A. & BILINSKY, P. 2006. Household dietary diversity score (HDDS) for measurement of household food access: indicator guide. *Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development*.

TRICCO, A. C., LILLIE, E., ZARIN, W., O'BRIEN, K., COLQUHOUN, H., KASTNER, M., LEVAC, D., NG, C., SHARPE, J. P. & WILSON, K. 2016. A scoping review on the conduct and reporting of scoping reviews. *BMC medical research methodology,* 16**,** 15.

TRICHOPOULOU, A., KOURIS-BLAZOS, A., WAHLQVIST, M. L., GNARDELLIS, C., LAGIOU, P., POLYCHRONOPOULOS, E., VASSILAKOU, T., LIPWORTH, L. & TRICHOPOULOS, D. 1995. Diet And Overall Survival In Elderly People. *BMJ: British Medical Journal,* 311**,** 1457-1460.

WAIJERS, P. M. C. M., FESKENS, E. J. M. & OCK, M. C. 2007. A critical review of predefined diet quality scores. *British Journal of Nutrition,* 97**,** 219-231.

WEISS, J. J., SANCHEZ, L., HUBBARD, J., LO, J., GRINSPOON, S. K. & FITCH, K. V. 2019. Diet quality is low and differs by sex in people with HIV. *The Journal of nutrition,* 149**,** 78-87.

WELDEHAWERIA, N. B., ABREHA, E. H., WELDU, M. G. & MISGINA, K. H. 2017. Psychosocial correlates of nutritional status among people living with HIV on antiretroviral therapy: A matched case-control study in Central zone of Tigray, Northern Ethiopia. *PLoS ONE,* 12.

WIRT, A. & COLLINS, C. E. 2009. Diet quality – what is it and does it matter? *Public Health Nutrition,* 12**,** 2473-2492.

WORLD HEALTH ORGANIZATION. 2017. *Cardiovascular diseases* [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds) [Accessed 2020/06/10 2020].

WORLD HEALTH ORGANIZATION. 2019. *Hypertension* [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/hypertension [Accessed 2020/06/10 2020].

ZARAGOZA-MARTÍ, A., CABAÑERO-MARTÍNEZ, M. J., HURTADO-SÁNCHEZ, J. A., LAGUNA-PÉREZ, A. & FERRER-CASCALES, R. 2018. Evaluation of Mediterranean diet adherence scores: A systematic review. *BMJ Open,* 8.

3.2 SCOPING REVIEW FINDINGS

RESULTS

Search results

As shown in figure 3.1 below, a total of 761 studies were retrieved using the search strategy defined. These include 693 peer-reviewed articles and 68 from the grey literature. A search for duplicates, conducted on Endnote, identified 155 duplicate articles, which were subsequently removed. Screening of title and abstract was conducted on Rayyan by two independent reviewers – IO and JH, 564 articles were excluded based on the defined criteria yielding 42 articles eligible for full-text review. A total of 31 studies passed the full-text screening. Reasons for excluding nine studies at the level of full-text screening are a non-dietary method of accessing nutrient levels (five studies), a prospective study design that compared dietary changes over time (three studies), foreign language (one study), unpublished (one study), and unavailable full texts (one study).

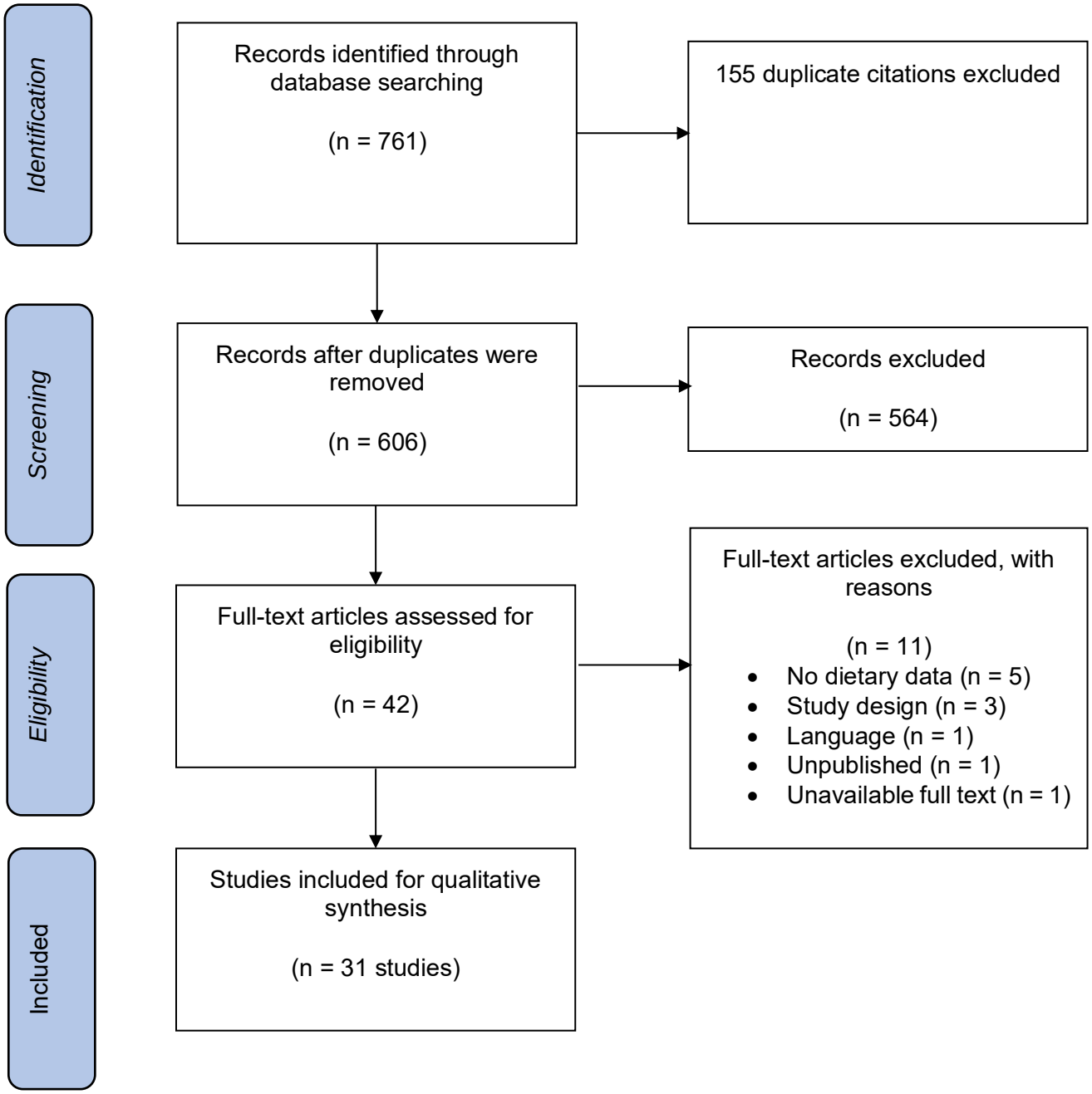

Figure 3. 1 PRISMA flow chart for study selection

Characteristics of included studies as shown in Table 3.2 below

Study design: Studies included were cross-sectional except for one with a prospective cohort design (Joy et al., 2007). This study was however included because the diet was assessed as cross-sectional data. Four studies included uninfected controls (Capili and Anastasi, 2008, Policarpo et al., 2017, Silva et al., 2010, Turcinov et al., 2009), other articles included only PLWH.

Country of origin: Eleven of these were from the USA (Capili and Anastasi, 2008, Gavrila et al., 2003, Hadigan et al., 2001, Hendricks et al., 2006, Joy et al., 2007, Noble, 2019, Shah et al., 2005, Sirotin et al., 2014, Tsiodras et al., 2009, Webel et al., 2020, Wright and Epps, 2014); four from Brazil (da Cunha et al., 2020, da Silva et al., 2014, Leite and Sampaio, 2010, Silva et al., 2010); three from Croatia (Turcinov and Begovac, 2011, Turcinov et al., 2009, Višković et al., 2013); two from each of Cambodia (Chhoun et al., 2017, ChhounPheak et al., 2017), Nepal (Poudel-T and ukar, 2016, Upreti, 2014), and Thailand (Jantarapakde et al., 2014, Pongthananikorn et al., 2018); and one from each of Australia (Samaras et al., 2009), Canada (Arendt et al., 2008), Malawi (Muronya et al., 2011), Malaysia (Hejazi et al., 2013), Poland (Jackiewicz et al., 2019), Portugal (Policarpo et al., 2017), and Uganda (Kazooba et al., 2017).

Sample

ART: Twelve studies included both ART-naïve and ART-experienced participants (Arendt et al., 2008, Chhoun et al., 2017, ChhounPheak et al., 2017, Hendricks et al., 2006, Jantarapakde et al., 2014, Joy et al., 2007, Leite and Sampaio, 2010, Policarpo et al., 2017, Poudel-T and ukar, 2016, Upreti, 2014, Hadigan et al., 2001, Silva et al., 2010). The authors of two studies did not indicate ART usage among the participants (Sirotin et al., 2014, Wright and Epps, 2014). The remaining 17 studies included only ART-experienced participants.

Age range: The authors of 26 studies reported age range either as part of the inclusion criteria or results. While some provided only lower limits, generally the reported age ranges were between 15 to 70 years. Five studies did not have an age range, but only the mean (SD) of age was shown in their results (Arendt et al., 2008, Hendricks et al., 2006, Noble, 2019, Shah et al., 2005, Sirotin et al., 2014).

Quality

Scoping reviews do not require a quality appraisal; thus, we did not appraise the quality of included studies. However, the following points may be important to note.

Research Ethics: The authors of the three studies did not mention obtaining ethical approval from an ethics committee. However, two studies referred to a parent study (Hendricks et al., 2006, Turcinov et al., 2009), while the authors of the third study mentioned obtaining informed consent from the participants (Jackiewicz et al., 2019). All 28 other studies were approved by an ethics review committee.

Table 3. 2 Table of included studies with selected characteristics

Authors/year	Country of origin	Aim	Sample	Study design	ART use: Yes, No or both	Control group	Dietary assessment	Main result	Conclusion
Arendt et al. (2008)	Canada	• To assess dietary intake and physical activity in a population of male PLWH and metabolic abnormalities • To compare the data to Canadian recommendations	• 65 PLWH men • at least one MetSyn • On ART • Mean age: 47years	Cross-sectional	Both	No	• 7-day Food protocol • Validated Food Portion Visual 2.0 Chart. • Dietary data were analyzed using a software. • Intakes were compared to DRI	• Low energy and fiber • adequate protein • high fat intake • Dietary intake of most micronutrients was low.	• Patients follow a typical western diet. • This could be associated with the development of metabolic disorders and HIV disease progression.
Capili and Anastasi (2008)	USA	• To examine the differences in nutritional intake and BMI in PLWH with chronic diarrhea via secondary analysis of patients' nutritional diaries • To evaluate the quality of diets against national dietary guidelines	• 75 ambulatory PLWH • ON ART • Age ≥18 years • Experienced a minimum of three episodes of loose, watery, or liquid stools in a 24-h period for ≥ 3 weeks.	Cross-sectional	Yes	No	• 7-day food diaries including portions, quantity, and method of preparation. • The food diary was analyzed using a software to yield nutrient intakes. • Intake of food groups was computed. • Nutrient intakes were compared with NCEP guidelines, 2000 DGA, and the Food Guide Pyramid.	• High mean intakes of fat, SFA, and Chol • Low mean intakes of MUFAs, PUFAs	The NCEP guidelines regarding intakes of fiber, saturated fat, sugar, and cholesterol were not met.
Chhoun et al. (2017)	Cambodia	To determine the prevalence of DM, HTN, and hypercholesterolemia and associated risk factors in PLWH in Cambodia	• 510 PLWH for at least 12 months • And/or on ART for ≥ 6 months • 21 years or older	Cross-sectional	Both	No	• Servings of F&V, type of oil used • Questionnaire modified from WHO STEPS	• Eating fewer fruits, and using lard for cooking increased the risk of HTN • Eating fewer fruits increased DM	• The prevalence of NCDs reported was high • Screening should be integrated into routine HIV care
ChhounPheak et al. (2017)	Cambodia	To explore the prevalence of DM, HTN, hyperlipidemia, and related risk factors in PLWH in Cambodia	• 510 PLWH for at least 12 months • And/or on ART for ≥ 6 months 21 years or older	Cross-sectional	Both	No	• Dietary behaviours/habits • WHO STEP-Wise Approach to Surveillance	• PLWH consumed on average 1.8 servings/day of fruits for 2.5 days/week, and 2.0 servings/day of vegs for 5.6 days/week.	• Consumption of F&V remained low • The prevalence of NCDs was high

								• The majority (92.4%) prepared meals at home. • The majority (95.3%) used veg oil.	
da Cunha et al. (2020)	Brazil	• To estimate the prevalence of DM in PLWH • To assess the associated risk factors	• 168 PLWH • ≥ 18 years old • On ART ≥3 months	• Cross-sectional • Descriptive	Yes	No	• Daily food consumption • The dietary data collection tool was not adequately described but was part of the data collection form • "the form already validated in previous research had three parts... daily food consumption"	• No fruit consumption - 29.8% • No vegetable consumption - 28.0% • 45.2% ate fats and fried foods • 51.8% ate sweets and sugary foods	Inadequate diet was a risk factor for diabetes.
da Silva et al. (2014)	Brazil	To assess the relationship between dietary intake and use of protease inhibitors (PIs) with anthropometric and biochemical parameters in PLWH	• 50 PLWH • On ART for ≥ 2 months • > 18 years old	• Descriptive • Cross-sectional	Yes	No	• Non-quantified FFQ from Food and Nutrition Surveillance System of the Brazilian Ministry of Health. • 10 food groups over the last 7 days • Data was split into terciles for classification	• "Good" food consumption – 37% • "Regular" food consumption - 28% • "Poor" food consumption - 35% • The greatest inadequacies were represented by groups of vegs & dairy products.	• "Good" food consumption group obtained better levels of HDL-C than the "poor" group • Use of PI ARVs was associated with higher VLDL-C and TG levels
Gavrila et al. (2003)	USA	To investigate the relationship among habitual exercise, diet, and the presence of metabolic abnormalities (FR, dyslipidemia, IR)	• 120 PLWH • ≥16 years of age • ≥6 months of ART.	Cross-sectional	Yes	No	• A previously validated self-administered quantified FFQ. – no further description • Consumption of food groups, and nutrients in the preceding year	• Generally high fat, low carbs intakes. • Subjects with Fat wasting consumed the highest kcal • Subjects with fat accumulation consumed the lowest fat	Vitamin E intake is inversely associated with diastolic blood pressure in PLWH

Hadigan et al. (2001)	USA	To assess the relationship between dietary intake, body composition, and metabolic parameters	• 85 PLWH with fat redistribution • 18-60 years • On ART for ≥ 6 weeks	Cross-sectional	Both	No	• Modified Burke diet history technique • Intake within the past month • Used food models, cups, and measuring tools to estimate portion sizes. • Energy and macronutrient consumption was reported	• Low fiber, high cholesterol, high kcal/kgBw • Dietary habits, energy, and macronutrient intake did not differ among those with or without FR	• PUFAs, fiber, and alcohol are strongly associated with IR and hyperlipidemia • It may be an important target for dietary modification
Hejazi et al. (2013)	Malaysia	To determine the prevalence of HTN & associated risk factors among PLWH	• 340 PLWH • on ARV for ≥ 3 months • ≥ 18years old	Cross-sectional	Yes	No	• Two 24-hour dietary recalls. • Weekday and weekend days. • Average was used for analysis. • Classification of macronutrient requirements were adapted from the Technical Subcommittee (TSC) on energy and macronutrients	• HTN had an association with ↑ % energy from protein intake • Normal BP had an association with ↑ % energy from carbohydrate intake	• More efforts are needed to assist PLWH to embrace a healthy practice. • Essential information on diet, PA, and weight management should be provided.
Hendricks et al. (2006)	USA	• To describe the prevalence of obesity among a cohort of PLWH • To determine differences in dietary intake among those subjects who are normal weight, overweight, and obese	321 PLWH	Cross-sectional	both	No	• 3-day food records including 1 weekend day. • A food scale and a ruler were given to participants to estimate portion sizes • Food records were analyzed using a software • Intakes were compared with DRI	• Total kcal and fiber reduced with increasing BMI • Mean total fat and SFA were above recommendation • Micronutrients were below DRI • Obese women had higher Kcal from SFA than RDA, lower fiber	• Obesity and diet in PLWH need to be addressed • Diet quality may affect MetSyn, CVD and other weight-related health risks.
Jackiewicz et al. (2019)	Poland	To determine if • The amount and quality of dietary fats consumed had an effect on total, LDL and HDL cholesterol and TG • GL had an effect on TG concentration • The quality of consumed fats had	• 80 PLWH • 18-70 years old • on stable ART for ≥ 12 months.	Cross-sectional	Yes	No	• Three 24-hour dietary recalls. • Two weekdays and one weekend day. • This was analyzed using a software, and the data were compared with WHO guidelines	• Intakes showed high fat, high meat vs fish (high SFA), high sweet drinks, snacks, and added sugar. LDL levels correlated: • Positively with dietary SFA	• Diet modification may affect HIV treatment • A dietitian is necessary in HIV care • The ratio of n6/n3 fatty acids was significantly and postively associated with CVD risk

		an impact on CVD risk						• Negatively with dietary PUFA TC levels correlated: • Positively with n6/n3 FA • Negatively with GL of diet 10-year risk of CVD: • High - 3.75% • Medium - 12.5% • Low - 83.75%	
Jantarapakde et al. (2014)	Thailand	To examine the prevalence of MetSyn and its related factors among ART-naıve and ART-experienced PLWH in Thailand	• 580 PLWH • Aged > 18 years	Cross-sectional	Both	No	• 24-h recall • The number of times is not indicated. • Nutrient intakes were compared with DRI for Thais in 2003.	• Median energy intake: 1301kcal • ↑ energy intake - 15.3% • ↑ carbs intake - 34.7% • ↓ protein intake - 28.8% • ↑ fat intake - 13.3% • Diet of PLWH on ART was not significantly different from ART-naive • 22.2% had MetSyn • Those on ART had ↑ MetSyn than ART-naive	• MetSyn was common among HIV+ adults in Thailand • Early screening and ART modification among aging PLWH on long term treatment may ↓ reduce MetSyn and other CVD
Joy et al. (2007)	USA	To evaluate dietary intake and its relationship to lipid parameters in PLWH with metabolic abnormalities	• 356 HIV PLWH and 162 community-derived HIV-negative controls 18-60 years old • For subjects on ART, must not be less than 6 weeks before evaluation	Prospective cohort (included because the diet was reported cross-sectionally).	Both	Yes	• 4-day food record (3 weekdays, 1 weekend) or one 24hr-recall. • Nutrient intake was then computed using a software. • Intakes were compared with the 2005 USDA recommended dietary guidelines. • Items used to estimate portion size include food models, cups, and household measures	• Intakes of total Kcal, carbs, protein, MUFA and PUFA were not significantly different between the two groups • Fiber intake was significantly lower among PLWH • PLWH had higher intakes of	• ↑ dietary SFA is associated with hypertriglyceridemia among PLWH with metabolic abnormalities. • Dietary modification should target ↓ SFA in this population

								total fat, SFA, Chol, and % kcal from SFA and Trans fat • SFA intake was positively associated, and Total fat was negatively associated with TG level among PLWH. • PLWH had higher chol, TG, WHR, and lower HDL than controls. • No significant associations between dietary SFA, total fat, trans fat, or chol intake and total chol or HDL • MetSyn was significantly higher among PLWH than in controls	
Kazooba et al. (2017)	Uganda	To investigate the prevalence, predictors of, and effect of ART regimen on cardiometabolic risk among PLWH in Uganda at enrolment into a prospective cohort to study the Complications of Long-Term ART (CoLTART).	• 1024 PLWH • On ART • 18 years old and above	Cross-sectional	Yes	No	Consumption of animal protein >3 days a week	• Animal protein intake >3 days/week - 27.8% • Animal protein intake >3 days/week was ↑ among men than women • PLWH who consumed animal proteins ≥ 3 days/week had a higher mean TC, LDL, FBG, FHS, TC: HDL ratio, and AIP	• ART use = ↑ cardiometabolic risk. • Cardiometabolic risk should be regularly assessed • HIV care should include intervention programs especially in settings with limited resources

Leite and Sampaio (2010)	Brazil	to assess the relationship between dietary calcium, dairy food intake, and metabolic parameters in PLWH	• 100 PLWH • 22-65 years of age	Cross-sectional	Both	No	• One 24-h dietary recall and a validated semi-quantified FFQ • FFQ was used to differentiate between dairy and non-dairy calcium intake • Calcium intakes were compared with the guidelines of the Institute of Medicine, 1997 • Dietary fiber intakes were compared with the guidelines of the Brazilian Society of Cardiology, 2007	• Mean (SD) Calcium intake = 559.25 (298.84) mg/day • Dairy consumption = 1.73 servings/day • ↓ calcium intake - 92 % of participants • Dietary fat goals for prevention of CVD were not met by high % of PLWH • Milk was the most important dairy food • ↑ intake dairy foods (≥ 2 servings/day) was associated with ↓ BMI, WC, and BP levels. • ↓ calcium intake was associated with 2-fold chances of MetSyn and HTN.	• ↑ intake of Calcium and F&V may = ↓ abdominal obesity and HTN among PLWH. • Calcium or dairy product intake was ↓ for most participants
Muronya et al. (2011)	Malawi	To obtain initial data on multiple NCD and CVD risk factors in adult Malawian ART patients in an urban setting	• 174 PLWH • Aged 18-69 years • On long-term ART (>1 year)	Cross-sectional	Yes	No	• F&V consumption (WHO STEPS) • Insufficient consumption: <5 servings/day of F&V	An insufficient diet with regards to F&V was reported by 67.6% of the patients	CVD risk factors were common among PLWH on long-term ART in Malawi
Noble (2019)	USA	to examine the experiences of people in terms of their food insecurity, diet quality, adherence to antiretroviral therapy (ART), and mental health		• Cross-sectional • Mixed methods	Yes	-	• USDA Household Food Security Scale Module • 24-hour dietary recall (no further info)	Food Security: • Low -19% • Very low -35%	
Policarpo et al. (2017)	Portugal	to assess PLWH's adherence to the MedDiet and its	• 571 PLWH	Cross-sectional	Both	No	• MD using the MDS questionnaire	• Overall adherence to the MD was	• The MD was moderately adhered to.

		relationship with nutritional status and CVR	• 18 - 65 years old,				• Scores ranged from 0 to 55 • ↑ scores indicated ↑ adherence • Individuals were grouped into tertiles of MDS as there are no cut-offs • How the authors arrived at the MDS was not further explained.	moderate with a 27.5 mean score. • 40.3% were overweight or obese • 33.9% had MetSyn • 41.9% had WC ↑ than cut-off point, and had an association with being female CVR: • 53.2% low • 30.1% moderate • 16.6% high	• Having a BMI ≥ 25 kg/m2, MetSyn, and moderate to high CVR was associated with ↑ adherence. • Findings suggest that the MD pattern may have been adopted in the presence of comorbidities
Pongthananikorn et al. (2018)	Thailand	To evaluate the prevalence and risk factors of MetSyn in PLWH on ART	• 135 PLWH • ≥ 18 years of age • on HAART for ≥ 12 months	Cross-sectional	Yes	No	• One 24-hour recall (no further info) • Total dietary energy and energy distribution from carbohydrate, protein, and fat were estimated • Compared to DRIs	• Mean total kcal was 1454.2 kcal/day • MetSyn group consumed more carbohydrates than the non-MetSyn group. • 30.3% dyslipidemia, 16.3% HTN, 6.0% DM, 18.5% MetSyn • Hypertriglyceridemia was the most frequent metabolic abnormality found • Participants had hypertriglyceridemia with normal HDL-C levels	• MetSyn could be found in PLWH on HAART • Dietary modification should be included in patient care for the management of metabolic problems
Poudel-Tukar (2016)	Nepal	To assess the association between dietary B vitamin intake and depressive symptoms in a cohort	• 314 PLWH • Aged 18-60 years	Cross-sectional	Both	No	• Two 24-h dietary recalls (1 week apart, on different weekdays). • Portion sizes were estimated using standard household items.	• B vitamin intake was not different by gender • Intake of B-vitamins was lower than EAR	• It is possible that the ranges of B-vitamin intake were too small to show an association with depression

		of HIV-infected persons					• Indian food tables were used to calculate daily intake of B vitamins • Intake of B-vitamins was adjusted for energy, classified into tertiles, and compared with EARs	for the majority of participants • Energy intake was higher in men • The risks of depression ↑ with ↓ intake of riboflavin in all participants • No association was seen between depression and other B vitamins.	• Future studies or trials should verify the association between B-vitamins and depression among PLWH
Samaras et al. (2009)	Australia	To determine whether dietary intake influences total body fat, visceral fat, insulin resistance, glucose metabolism, lipid metabolism, and circulating inflammatory markers in PLWH with lipodystrophy	• 106 male PLWH with lipodystrophy • on HAART • aged >17 years	Cross-sectional	Yes	No	• Semi-quantified FFQ. • Serving sizes were specified as pints, teaspoons, slices or simply defined as portions • FFQ validation info not stated • After analyzing the dietary data, energy under-reporters were excluded from further analysis.	• Diet composition was not associated with %body fat, BMI and visceral adiposity • SFA related to % total body fat • PUFA had a significant positive relationship with BMI • Dietary fat intake was not associated with fasting insulin, adiponectin, TC, leptin, HOMA-IR, HDL-C, glucose, or TG. • No association between fat subtype and fasting insulin, IR, TC, HDL, TG, glucose, adiponectin	• SFA intake was weakly associated with adiposity in PLWH with lipodystrophy • Nutrient intake was not associated with visceral adiposity, glucose metabolism, IR, or adipokines. • Interventional, prospective studies may show if nutrition can ameliorate metabolic complications related to HIV lipodystrophy • Nutritional studies in PLWH should utilize precise measures of adiposity if possible.
Shah et al. (2005)	USA	To investigate the role of dietary macronutrients, exercise and smoking	45 male and 6 female PLWH with Lipodystrophy on PIs were recruited	Cross-sectional	Yes	No	• 3-day food record • Two week days, and one weekend day.	• Diet was high in chol and % energy from SFA and trans	↑ intake of trans-fat, total, and animal protein, trans-fat, as well as ↓ soluble fiber contribute

		in contributing to dyslipidaemia in LDHIV individuals on PI					• Nutrient intake was analyzed using a software.	fats, and low in soluble fiber compared with guidelines. • % Energy from total and animal protein intakes was positively associated with TC and non-HDL-C • % Energy from trans-fat had positive association with TG • Soluble fiber had negative association with non-HDL-C	to dyslipidaemia among LDHIV participants using PI ARVs
Silva et al. (2010)	Brazil	To describe the nutritional and clinical status and the quality of diet of PLHA.	• 314 PLWH • Aged 20 - 70 years	Cross-sectional	Both	No	• Semi-Quantitative FFQ was used to assess consumption in the past 12 months. • FFQ contains 47 food items categorized into 2 groups: “protective” and “not protective” food based on the nutritional composition of the food item Basic ingredients were considered in the case of mixed preparations. • FFQ validation info not stated	• High chol, sat and trans-fat, sodium, and simple carbs intakes. • Serum TC, TG, and glycemia were ↑ in the group on HAART • WHR was ↑ among men on HAART than those not on it	• Risks of CVD was higher among PLWH on HAART • Health interventions is important for PLWH to control CV risk factors before the outcome
Sirotin et al. (2014)	USA	To determine the relationship between food insecurity and obesity in this cohort of urban, PLWH and –uninfected but at risk women	• 231 PLWH and 119 HIV-negative • Mean age: 48.9years	Cross-sectional	-	Yes	• The USDA Food Security Survey Module. • It has 18 and 10 questions for a household with children and without children respectively. • Classifies household into Food secure, food insecure without hunger, and food insecure with hunger.	• 31% Food insecurity • 13% were food insecure with hunger • Odds of obesity was ↑ among women suffering from food insecurity with hunger • PLWH had lower odds of	Food insecurity with hunger was related to obesity among PLWH and –uninfected women in this population.

								obesity as compared to HIV-negative women	
Tsiodras et al. (2009)	USA	To investigate whether closer adherence to an MD pattern is associated with metabolic aspects of the HAART-induced MetSyn (FR, IR, dyslipidemia) in PLWH.	• 227 PLWH • ≥6 months of cumulative exposure ART • age ≥16 years	Cross-sectional	Yes	No	• MDS • Dietary intake for the preceding year was assessed using a validated FFQ and to compute the MDS • Scores ranged from 0 to 55 • ↑ scores indicate closer adherence to the MD pattern.	• Intakes of poultry, and red meat/red meat products were ↑ among subjects in the FR group. compared to the non-FR group • MDS had a weak inverse association with IR • MDS had positive correlation with HDL-c and negative association with circulating TG levels	Adherence to a MD pattern favoured ↓ cardiovascular risk factors among PLWH with FR
Turcinov et al. (2009)	Croatia	To investigate the association of adherence to the Mediterranean diet and other risk factors for dyslipidemia in Croatian PLWH during the first year of (HAART)	• 117 participants • On HAART for ≥ 1 year • ≥18 years of age	Cross-sectional	Yes	No	• MDS • A 150-item semi-quantified FFQ was used • The FFQ yielded an average monthly intake which was then converted into daily portions. • FFQ was adapted from a previously published study. • Food items were classified into 12 food groups. • The ratio of MUFA to PUFA was calculated. • The MDS was also computed. Scores below the median (4) were classified as low adherence, the median score was classified as moderate, and scores above the median were classified as high adherence to the MDS	• Moderate or high adherence to the MD: 67% • The values of TC, HDL-C, LDL-C, and TG increased in the first 3 to 6 months after initiating HAART • Baseline TC, HDL-C, LDL-C, or TG did not differ among participants with or without adherence to the MD	• MD was not related to plasma lipid changes during the 1st year of HAART • The protective effects of the MD are not related to serum TC, LDL-C, or HDL-C but to plasma fatty acid changes
Turcinov and Begovac (2011)	Croatia	• To estimate the prevalence and risk factors associated	• 130 PLWH • With no major past CV event	Cross-sectional	Yes	No	• MDS	• MS was found more frequently	Although the MD is related to longevity, no association was found

		with the predicted 10-year CHD in participants without an established CV event. • To examine the association of HIV disease parameters (CD4+ T-cell counts, HIV viral load, and AIDS diagnosis), antiretroviral medications, lipodystrophy, adherence to the Mediterranean diet, and the presence of the MetSyn to the Framingham risk score	• On cART for ≥ 1 year • Age: >18 years				• A 150-item semi-quantified FFQ was used to estimate the MDS • FFQ was adapted from a previously published study • The MDS with a scale of 0 -9 was dichotomized. Scores below the median (4) were classified as low adherence, the median score was classified as moderate, and scores above the median were classified as high adherence to the MDS	in females than in males • Abdominal obesity was more common in females than males • Dichotomized CHD risk score did not relate to adherence to the MD, consumption of olive oil, family history of CHD, energy expenditure ≥ 8.6 MET-h/days, and current smoking. • 10-year CHD risk of≥ 10% was more likely among those aged ≥ 43 years, with alcohol consumption ≥ 10 g/day, as well as with a CD4 count of < 50/microliter + history of AIDS diagnosis.	between adherence to the MD and ↓ CHD risk using the Framingham equation.
Upreti (2014)	Nepal	To survey the nutritional status, habitual diet, dietary knowledge, and demographic characteristics of PLWH in Nepal.	• 601 PLWH • Aged 15-49 years • diagnosed positive for > 6 months	• Cross-sectional • Mixed-methods	both	No	• A validated 45-item semi-quantified FFQ was used. • Energy and nutrient intakes were calculated • Intakes were compared to DRIs	• Participants ate a typical plant-based diet • Low animal products intake • Low micronutrient intake than DRI • Vit C intake was satisfactory	Food and nutrient intakes by PLWH in Nepal were not adequate and did not meet dietary recommendations
Višković et al. (2013)	Croatia	• To evaluate the influence of food habits, specifically adherence to the	• 110 PLWH on ART and 131 non-HIV-	Cross-sectional	Yes	Yes	• MDS • A previously validated 14-point food item questionnaire was used to compute MDS.	Patients with subclinical atherosclerosis	• ↓ adherence to the MD was associated with ↑ risk of

		MD, on CIMT and the presence of plaques in HIV-infected patients taking ART and non-HIV-infected • To determine if HIV infection contributes independently to subclinical atherosclerosis	infected participants • > 18 years of age				• The composite dietary score was dichotomized at the median. Low adherence to the MDS was defined as a score of <4.	had lower median MDS	subclinical atherosclerosis • A risk factor for subclinical atherosclerosis in older individuals was treated HIV infection
Webel et al. (2020)	USA	To examine how HIV status influences knowledge, beliefs, and perception of risk for ASCVD and ASCVD prevention behaviors	• 105 PLWH and 86 demographically similar HIV-uninfected adults • Age: 30 years or more	• Observational • Mixed methods	Yes	Yes	• Three standardized 24-hour dietary • A trained dietitian conducted recall interviews on 2 weekdays and 1 weekend day • The HEI was computed with a score ranging from 0 to 100	• Mean (SD) HEI score = 45.4 (11.1) • Diet composition did not differ between groups • Perceived lack of ASCVD prevention benefits was inversely related to HEI score • 0.57 ↓ HEI score per 1 unit ↑ in perceived lack of ASCVD prevention benefits	• Perceptions of ASCVD risk influence some behaviours • Some additional barriers and insufficient cues to action result in ↓ PA, diet, and rates of smoking.
Wright and Epps (2014)	USA	To describe the nutritional status and complications of PLWH	• 107 PLWH • Aged 19-70	• Descriptive • cross-sectional	-	No	• Food insecurity is assessed using 1 question—"Do you have adequate access to food?" • Not validated but commonly used in HIV clinics across the country.	• Food insecurity: 46% • At nutritional risk: 42% • Malnourished: 12% • Food insecurity accounted for an additional 3.8% of unique variance in risk status • Food insecurity was a significant predictor of nutrition risk even after a myriad of other	• PLWH face risk of complex nutritional complications. • It is important to continue nutritional screening and intervention • The complications most predictive of nutritional risk were food insecurity, weight loss, lipoatrophy, poor appetite, diarrhea, nausea, and diabetes

								predictors were taken into account	

AIP= Atherogenic Index for Plasma, ART= Antiretroviral Therapy, ASCVD= Atherosclerotic Cardiovascular Disease, BP= Blood Pressure, CHD= Coronary Heart Disease, Chol= Cholesterol, CIMT= Carotid Intima-Media Thickness, CVD= Cardiovascular Disease, CVR= Cardiovascular Risk, DGA= Dietary Guidelines for Americans, DM= Diabetes Mellitus, DRI= Dietary Reference Intakes, EAR= Estimated Average Requirements, F&V= Fruits and Vegetables, FA= Fatty acid, FFQ= Food Frequency Questionnaire, FGB= Fasting Blood Glucose, FHS= Framingham Risk Score, FR= Fat Redistribution, GL= Glycemic Load, HAART= Highly Active Antiretroviral Therapy, HDL-C= High Density Lipoprotein Cholesterol, HEI= Healthy Eating Index, HOMA-IR= Homeostatic Model Assessment of Insulin Resistance, HTN= Hypertension, Kcal/KgBw= Kilocalories per Kilogram Body Weight, LDHIV= Lipodystrophy in HIV Infected, LDL-C= Low Density Lipoprotein Cholesterol, MD= Mediterranean Diet, MDS= Mediterranean Diet Score, MetSyn= Metabolic Syndrome, MUFA= Monounsaturated Fatty Acid, NCD= Non-communicable Disease, NCEP= National Cholesterol Education Program, PA= Physical Activity, PI= Protease Inhibitors, PLWH= People Living With HIV, PUFA= Polyunsaturated Fatty Acid, RDA= Recommended Dietary Allowance, SFA= Saturated Fatty Acid, TG= Triglyceride, USDA= United States Department of Agriculture, VLDL-C= Very Low-Density Lipoprotein Cholesterol, WC= Waist Circumference.

Findings

Diet Quality / Food Security methods used:

As shown in Table 3.2 only three studies included a measure of food security (Noble, 2019, Sirotin et al., 2014, Wright and Epps, 2014), of these, only one has both diet adequacy and food security, while the other two only assessed food security in the context of HIV and NCDs.

Food Security: The measures used to assess food security status included the USDA household food security scale module (Noble, 2019), USDA household food security survey module (Sirotin et al., 2014), and a one-item questionnaire that is not validated (Wright and Epps, 2014).

Dietary Intake Assessment Methods:

Dietary intake was measured using a 24-hour recall in nine studies (Hejazi et al., 2013, Jackiewicz et al., 2019, Jantarapakde et al., 2014, Joy et al., 2007, Leite and Sampaio, 2010, Noble, 2019, Pongthananikorn et al., 2018, Poudel-T and ukar, 2016, Webel et al., 2020), FFQ in nine studies (da Silva et al., 2014, Gavrila et al., 2003, Leite and Sampaio, 2010, Samaras et al., 2009, Silva et al., 2010, Tsiodras et al., 2009, Turcinov and Begovac, 2011, Turcinov et al., 2009, Upreti, 2014), food records/nutritional diaries/food protocol in five studies (Hendricks et al., 2006, Joy et al., 2007, Shah et al., 2005, Arendt et al., 2008, Capili and Anastasi, 2008), and diet history in one study (Hadigan et al., 2001). The 24-hour recall was repeated three times in two studies, two times in two studies, and was done only once in three studies, while the remaining two studies did not provide this information. Seven out of nine studies that used FFQ indicated that their FFQs were previously validated, the remaining two did not provide this information. The FFQs consisted of a list of food items ranging from 10 to 150. Food records/nutritional diaries/food protocol were recorded for three days in two studies, four days in one study, and seven days in two studies. Diet history was recorded for the past month. The data from the dietary intake methods were then used to calculate diet quality indices in six studies or compared to standards to report adequacy of dietary intake in 11 studies.

Diet Quality Index: One study assessed diet quality using the Healthy Eating Index (HEI) score (Webel et al., 2020), and five studies used the Mediterranean Diet Score (MDS) (Policarpo et al., 2017, Tsiodras et al., 2009, Turcinov and Begovac, 2011, Turcinov et al., 2009, Višković et al., 2013).

Dietary Adequacy: Macro- and micronutrient intakes were compared with various dietary guidelines in different studies. Two studies included questions that assessed intakes of fruits

and vegetables (Chhoun et al., 2017, Muronya et al., 2011), one study assessed dietary behaviour/ habits (ChhounPheak et al., 2017), and one study assessed animal protein consumption>3 days a week (Kazooba et al., 2017), one study assessed the type of cooking oil used (Chhoun et al., 2017), and compared them with the standard.

Outcome

Food security: The three studies included assessing food security status were conducted in the USA (two in Florida, and one in New York). These studies all indicated a high level of food insecurity among the participants within similar proportions, including 31% (Sirotin et al., 2014), 46% (Wright and Epps, 2014), and 54% (Noble, 2019). One of these studies was retrieved as part of a doctoral thesis (Noble, 2019). This study showed that 19% of the participants have low food security while 35% have very low food security accounting for over half (54%) of 131 participants of this study suffering a varying degree of food insecurity. Although three out of every four participants of this study relied on the Supplemental Nutrition Assistance Program (SNAP) to meet their needs, 60% reported that it was not enough to meet their household need. Another included study with similar finding (Sirotin et al., 2014) surveyed 231 HIV-infected and 119 uninfected women. This study showed that 31% of all women who participated in the study were food insecure over the past six months, and 13% of these women reporting food insecurity with hunger. The study showed no significant difference in food insecurity with hunger status among HIV-infected (14.3%) and uninfected (11.8%) women in this study.

Wright et al., 2014 assessed 107 PLWH, and reported 46% as food insecure based on the results of a one-item question that asks: “Do you have adequate access to food”.

Diet quality: Policarpo et al. (2017) assessed diet quality using the MDS among 571 PLWH in Portugal. The authors used tertiles of the score to group participants into low adherence (<25 points), medium adherence (25-30 points), and high adherence (>30 points) out of a total of 55 points. Although the mean score indicated moderate adherence (27.5 ± 5.5 points), most of the recommendation for the individual food items that make up the score was followed very small percentage of the participants. The authors, however, did not report the adherence by the percentage of participants in each tertile.

Three studies in Croatia also used the MDS to assess the diet quality of 117 PLWH Turcinov and Begovac (2011), Turcinov et al. (2009), and 110 PLWH and 131 un-infected adults (Višković et al., 2013). The scores were dichotomized to give a range of 0-9 and classified as low adherence if scores <4 or scores 4 and above as moderate to high adherence. Turcinov et al. (2009) reported that 67% of the participants had moderate to high adherence to the

Mediterranean diet while Višković et al. (2013) found that PLWH had higher adherence to MDS than the uninfected population with median (range) scores of 5 (3 – 7) and 3 (2 -5) respectively. No further information concerning adherence to the diet score was reported. Tsiodras et al. (2009) who also used the MDS did not report a direct result of the score.

Webel et al. (2020) assessed 105 PLWH and 86 uninfected individuals in the US. They assessed diet quality using the HEI which has a maximum score of 100. The overall HEI score for all participants was 45.4 (11), this score and the individual diet component score did not significantly differ between groups (p-value >0.05)

Others: Studies that either did not use a pre-defined diet quality index or assess food security status compared intakes of the participants with standards such as Dietary Reference Intakes (DRIs) and NCEP guidelines, while some did not specify this. Most of these studies have similar findings. The most prominent themes emerging from the finding of these studies are high fat and energy intake, low consumption of fruits, vegetables, dietary fiber, and sources of micronutrients. The authors of one of the studies described this as "…a typical high fat, low fiber Western diet with suboptimal intake of many micronutrients…" (Arendt et al., 2008). Joy et al. (2007) compared intakes of PLWH with uninfected controls, this study equally showed that fat consumption was higher, and fiber lower among PLWH compared to the controls. Some studies also compared intakes by gender; the authors of two studies reported that energy intake was higher among men than women.

Fat: Generally, high consumption of total fat, energy from fat, cholesterol, saturated, and trans-fat was reported (Arendt et al., 2008, Capili and Anastasi, 2008, Gavrila et al., 2003, Hendricks et al., 2006, Jackiewicz et al., 2019, Shah et al., 2005, Silva et al., 2010). While consumption of essential fat was reported low. Overall, almost all the studies assessing dietary intake showed that fat recommendations were not met by the participants.

Proteins: Four studies had protein intake in their results. Jackiewicz et al. (2019) reported that PLWH in Poland consumed more meat than fish which consequently increased their saturated fat intake. Leite and Sampaio (2010) assessed dietary calcium and dairy food intake among PLWH in Brazil. Although, they reported that milk was the most important dairy product consumed, only 56% consumed up to 1-2 servings per day. Tsiodras et al. (2009) compared protein intakes of PLWH and fat redistribution (FR) with PLWH without FR. They reported that the group with FR consumed more protein and red meat products than the group without. They, however, did not report the quantity of intake for any group. Upreti (2014) reported a contrary report in their Nepali study; they reported that the participants typically eat a plant-based diet and have low intakes of animal products.

Micronutrients: Authors of all studies with micronutrient intake information reported low intakes, except for Sodium (Silva et al., 2010) and vitamin C (Upreti, 2014). Specific nutrients mentioned having low intake levels were Calcium (Leite and Sampaio, 2010), B-vitamins (Poudel-T and ukar, 2016), Iron (Upreti, 2014), Magnesium, Vitamins A and E (Arendt et al., 2008). A study showed that Vitamin C intake was satisfactory (Upreti, 2014), while two studies revealed a high intake of sodium among the participants (Arendt et al., 2008, Silva et al., 2010). Arendt et al. (2008) specifically reported that diet alone did not meet the micronutrient requirement of PLWH.

Others: Other dietary components mentioned are fiber; fruits and vegetables; alcohol; sweet drinks, snacks, and added sugars. All the studies that assessed fiber (Arendt et al., 2008, Capili and Anastasi, 2008, Hadigan et al., 2001, Shah et al., 2005), fruits, and vegetables (ChhounPheak et al., 2017, Muronya et al., 2011) recorded a low intake among the participants. One study showed a lower intake of alcohol by PLWH than in control but did not quantify the intake (Joy et al., 2007). Finally, two studies included the intake of sweet drinks, snacks, and added sugars (da Cunha et al., 2020, Jackiewicz et al., 2019). Jackiewicz and colleagues reported a high intake of this among their study participants.

Risk of CVD reported

Twenty-eight studies included one or more risks of CVD in their report, only three studies did not. As shown in Table 3.3 below, the risks of CVD reported are lipodystrophy/fat redistribution (eight studies), obesity/overweight (11 studies), central obesity (six studies), hypertension (11 studies), dyslipidemia (nine studies), insulin resistance/hyperglycemia/diabetes (nine studies), metabolic syndrome (seven studies), 10-year risk estimation using the Framingham scale (three studies), and subclinical atherosclerosis using the Carotid Intima-Media Thickness (CIMT) (one study).

Muronya et al. (2011) highlighted that CVD risks were more common among PLWH on long-term ART while Turcinov and Begovac (2011) showed that metabolic syndrome was more frequent in females than in males.

It is important to note that six studies recruited the participants based on the presence of the risk of CVD of their interest (Arendt et al., 2008, Capili and Anastasi, 2008, Hadigan et al., 2001, Joy et al., 2007, Samaras et al., 2009, Shah et al., 2005). The findings of these studies might not be representative; they were, however, included in our review because of our primary outcome of interest – diet quality. Similarly, as mentioned above, some studies recruited some HIV uninfected participants (Joy et al., 2007, Sirotin et al., 2014, Višković et al., 2013, Webel et

al., 2020). Table 3.3 shows the ranges of the prevalence of each risk and the number of studies from which the ranges were generated:

Table 3. 3 Risks of CVD reported and their association with diet

	Risk	References with CVD data	References with CVD data	Range of prevalence	Association of risk with diet
1	Lipodystrophy	5	• Gavrila et al. (2003) • Tsiodras et al. (2009) • Policarpo et al. (2017) • Jantarapakde et al. (2014) • Wright and Epps (2014)	• 57.0% • 25.7% • 44.4% • 45.2% • 31.0%	Only vitamin E intake had an inverse relationship (Gavrila et al., 2003). Inverse relationship with MDS (Tsiodras et al., 2009). No association with MDS (Policarpo et al., 2017). Energy intake (kcal/kg) was significantly higher among participants with lipoatrophy than those with lipohypertrophy or mixed lipodystrophy (Hadigan et al., 2001).
2	Obesity/overweight	6	• Hendricks et al. (2006) • Turcinov and Begovac (2011) • da Cunha et al. (2020) • da Silva et al. (2014) • Jackiewicz et al. (2019) • Muronya et al. (2011)	• 12.5% Ob • 8.0% Ob • 63.7% Ov • 20.0% Ob • 7.5% Ob • 2.3% Ob	Obese women had higher Kcal from SFA and fat than RDA, and lower fiber and micronutrients than DRI (Hendricks et al., 2006). Adherence to the MD was not associated with the dichotomized CHD risk score (Turcinov and Begovac, 2011). No statistically significant difference in the dietary intake of normal weight and overweight/obese participants (Arendt et al., 2008). Fiber intake was lower among obese participants, but not statistically significant (Capili and Anastasi, 2008). Food insecurity with hunger had an association with obesity among PLWH and uninfected participants (Sirotin et al., 2014).
3	Central Obesity	5	• da Cunha et al. (2020) • da Silva et al. (2014) • Kazooba et al. (2017) • Muronya et al. (2011) • Turcinov and Begovac (2011)	• 48.2% AC • 66.9% WC • 52.6% • 45.4% WHR • 32%	
4	Hypertension	10	• Chhoun et al. (2017) • Hejazi et al. (2013) • ChhounPheak et al. (2017) • da Cunha et al. (2020) • Jantarapakde et al. (2014) • Kazooba et al. (2017) • Muronya et al. (2011) • Pongthananikorn et al. (2018) • Silva et al. (2010) • Turcinov and Begovac (2011)	• 15.1% • 45.6% • 15.1% • 20.2% • 26.2% • 22.6% • 45.9% • 16.3% • 18.3% • 43.0%	Eating fewer fruits and using lard for cooking increased the risk of HTN (Chhoun et al., 2017). Greater % energy from protein intake was associated with HTN. Higher % energy from carbohydrate intake was associated with normal BP (Hejazi et al., 2013).

5	Insulin resistance/Diabetes/Hyperglycaemia	8	• Chhoun et al. (2017) • da Cunha et al. (2020) • ChhounPheak et al. (2017) • Jantarapakde et al. (2014) • Kazooba et al. (2017) • Muronya et al. (2011) • Pongthananikorn et al. (2018) • Turcinov and Begovac (2011)	• 8.8% DM • 7.1% DM • 9.4% DM • 20.7% IR • 3.5% HG • 1.2% HG • 6.0% DM • 9.0% HG	Eating fewer fruits was associated with DM (Chhoun et al., 2017). DM in PLWH was associated with inadequate diet and drinking alcoholic beverages (da Cunha et al., 2020).
6	Metabolic Syndrome	6	• Leite and Sampaio (2010) • Policarpo et al. (2017) • Pongthananikorn et al. (2018) • Turcinov and Begovac (2011) • Jantarapakde et al. (2014) • Muronya et al. (2011)	• 52.0% • 33.9% • 18.5% • 21% • 22.2% • 13.2%	Those with a dietary calcium intake lower were two-fold more likely to have MetSyn and HTN than those who consumed higher (Leite and Sampaio, 2010). Higher adherence to the MD was associated with individuals with a BMI ≥ 25 kg/m2, those with MS, and patients with moderate to high cardiovascular risk, **suggesting the adoption of this food pattern in the presence of comorbidities** (Policarpo et al., 2017). A higher carbohydrate intake was reported in the group with MetSyn compared to the group without (Pongthananikorn et al., 2018). No association was found between adherence to the Mediterranean diet and lower CHD risk calculated by the Framingham equation (Turcinov and Begovac, 2011).
7	Subclinical atherosclerosis	1	• Višković et al. (2013)	33.6%	Patients with subclinical atherosclerosis had lower median MDS Višković et al. (2013).
8	At least 1 risk (unnamed)	1	• Silva et al. (2010)	88%	
9	Established CVD	1	• da Cunha et al. (2020)	53.7%	
10	Dyslipidemia	6	• Chhoun et al. (2017) • ChhounPheak et al. (2017) • da Silva et al. (2014) • Muronya et al. (2011) • Jantarapakde et al. (2014) • Kazooba et al. (2017)	• 34.7% HC • 33.7% HL • 76% • 31% HC • Multiple • Multiple	The saturated fat intake had a significant positive association, and total fat had a significant inverse association with triglyceride level (Joy et al., 2007). Dietary fat intake (% energy) had no association with TC, HDL-c, and TG (Samaras et al., 2009). “Increased intake of total protein, animal protein and trans-fat, and reduced soluble fiber consumption contribute to dyslipidaemia in PLWH with lipodystrophy on PIs” (Shah et al., 2005).

AC= Abdominal Circumference, BP= Blood Pressure, CHD= Coronary Heart Disease, CVD= Cardiovascular Disease, DM= Diabetes Mellitus, HC= Hypercholesterolemia, HDL-c= High Density Lipoprotein Cholesterol, HG= Hyperglycemia, HL= Hyperlipidemia, HTN= Hypertension, IR= Insulin Resistance, kcal/kg= Kilocalorie per kilograms, LIMD= Mediterranean Diet, MDS= Mediterranean Diet Score, MetSyn= Metabolic Syndrome, Ob= Obesity, Ov= Overweight, PLWH= People Living With HIV, RDA= Recommended Dietary Allowance, SFA= Saturated Fatty Acid, TC= Total cholesterol, TG= Triglyceride, WC= Waist Circumference, WHR= Waist-to-Hip Ratio.

Lipodystrophy: Studies reporting all forms of fat redistribution among PLWH were included.

Obesity/overweight: Studies estimating BMI categories were included. One study reported a prevalence of underweight at 29% (Upreti, 2014).

Central obesity: Studies estimating Waist or abdominal circumference, as well as waist-to-hip ratio, were included

Hypertension: Studies reporting high values of systolic, diastolic, or both pressures.

Discussion

This scoping review aimed to determine the diet quality and food security status of PLWH with or at risk of CVD and to identify the range and utility of diet quality and food security indices among PLWH with or at risk of CVD. With just two studies from Africa, and none reporting dietary adequacy using a diet quality index, this scoping review shows the dearth of nutrition-focused research among PLWH in Africa. The higher risk of CVD among PLWH (Shah et al., 2018), and the possibility of dietary intervention reducing this risk (Stradling et al., 2021) emphasize the need for research evidence among PLWH in Africa.

The use of a wide range of methodologies to assess dietary adequacy and food insecurity made it very difficult to aggregate the findings of the included studies. Dietary intake was assessed using several methods and compared with different quality standards based on the objectives of each study. Despite the high level of heterogeneity in the included studies, similar themes regarding food insecurity and dietary intake were reported. Food insecurity level was high and dietary quality ranged from low to medium adherence to quality standards. Even when diet quality had overall medium adherence to quality standards, adherence to the recommendation of individual food items was generally low. Overall, results from included study reflect poor food security, moderate adherence to diet quality indices recommendations (MDS and HEI), and poor adherence to DRIs and other guidelines. This finding underscores the importance of continued nutritional screening and intervention among PLWH. We recommend that this be integrated into primary health care systems that are in contact with PLWH.

Diet quality assessment using a predefined diet quality index, which is the primary outcome of this review, was reported in six studies. Overall dietary pattern or consumption of food groups better reflects the dietary quality and is a more efficient way of assessing the association that may exist between diet and chronic diseases (Coulston, 2001, Patterson et al., 1994). This is often assessed using predefined diet quality indices. The HEI and MDS were used in one and

five studies respectively, however, other available indices that could also be used include Recommended Food Score, Dietary Diversity Score, Diet Quality Index, and Dietary Inflammatory Index (Oyetunji et al., 2021). We recommend that researchers employ the use of these diet quality indices to assess the dietary adequacy of PLWH when possible. This will also facilitate easy comparison between studies and highlight the need for nutritional intervention in a specific population.

Globally, CVD has been identified as the leading cause of mortality (Naghavi et al., 2017). The most-reported risks of CVD in the included studies were obesity and hypertension, followed by diabetes and dyslipidemia. This is good because the global prevalence of hypertension has been projected to rise above 1.6 billion people in 2025 (Mills et al., 2016). This calls for a continued screening and monitoring of CVD risks especially among PLWH as they face a higher risk (Gutierrez et al., 2017).

The association between diet and the risks of CVD reported in the included studies is complex. Most studies had findings suggesting that a diet that adheres to the quality standard used in the study may reduce the risk of CVD (Chhoun et al., 2017, da Cunha et al., 2020, Gavrila et al., 2003, Hejazi et al., 2013, Hendricks et al., 2006, Leite and Sampaio, 2010, Pongthananikorn et al., 2018, Višković et al., 2013, Tsiodras et al., 2009). While a few had findings that suggested no association between diet and risk of CVD (Policarpo et al., 2017, Turcinov and Begovac, 2011), others did not report any association between diet and the risk of CVD. We opine that this variation in the association between the risk of CVD and diet may be largely due to the heterogeneity in the methodology and possibly in the study population. Additionally, this may be because the articles included in this scoping review were cross-sectional, observational study which is prone to confounding. This is especially true as previous dietary interventions have been shown to reduce the risk of CVD among PLWH (Lazzaretti et al., 2012, Stradling et al., 2021). Again, we recommend that researchers use a standardized method of dietary assessment within their context, and report overall dietary patterns with reference to the risk of CVD when possible.

Conclusions

PLWH continue to be at nutritional risk and complication which necessitates nutritional screening and intervention (Wright and Epps, 2014). While being affected by food insecurity, the diet quality of PLWH has medium adherence to recommendations. More standardized methods of dietary assessment should be employed by researchers to facilitate easy comparison.

The treatment outcome of PLWH may be strongly affected by the dietary intervention (Jackiewicz et al., 2019). Therefore, it is important to include a dietitian in the treatment continuum of PLWH, especially at the PHC level.

REFERENCES

ARENDT, B. M., AGHDASSI, E., MOHAMMED, S. S., FUNG, L. Y., JALALI, P., SALIT, I. E. & ALLARD, J. P. 2008. Dietary intake and physical activity in a Canadian population sample of male patients with HIV infection and metabolic abnormalities. *Curr HIV Res,* 6**,** 82-90.

CAPILI, B. & ANASTASI, J. K. 2008. Body mass index and nutritional intake in patients with HIV and chronic diarrhea: A secondary analysis. *Journal of the American Academy of Nurse Practitioners,* 20**,** 463-470.

CHHOUN, P., TUOT, S., HARRIES, A. D., KYAW, N. T. T., PAL, K., MUN, P., BRODY, C., MBURU, G. & YI, S. 2017. High prevalence of non-communicable diseases and associated risk factors amongst adults living with HIV in Cambodia. *PLoS ONE,* 12.

CHHOUNPHEAK, NGIN, C., TUOT, S., PAL, K., STEEL, M., DIONISIO, J., PEARSON, H., MBURU, G., BRODY, C. & YI, S. 2017. Non-communicable diseases and related risk behaviors among men and women living with HIV in Cambodia: findings from a cross-sectional study. *International journal for equity in health,* 16**,** 125-125.

COULSTON, A. M. 2001. The search continues for a tool to evaluate dietary quality. *The American journal of clinical nutrition,* 74**,** 417.

DA CUNHA, G. H., FRANCO, K. B., GALVÃO, M. T. G., LIMA, M. A. C., FONTENELE, M. S. M., SIQUEIRA, L. R., RAMALHO, A. K. L. & FECHINE, F. V. 2020. Diabetes mellitus in people living with HIV/AIDS: prevalence and associated risk factors. *AIDS Care - Psychological and Socio-Medical Aspects of AIDS/HIV,* 32**,** 600-607.

DA SILVA, T. A., BARBOZA, R. R., DE ANDRADE, R. D., DE MEDEIROS, R. C., DE MEDEIROS, J. A., DE SOUZA, H. A., LEITE, L. D. & DANTAS, P. M. 2014. Relationship between dietary intake and use of protease inhibitors with anthropometric and biochemical parameters of lipodystrophy in people living with hiv. *Nutr Hosp,* 30**,** 935-40.

GAVRILA, A., TSIODRAS, S., DOWEIKO, J., NAGY, G. S., BRODOVICZ, K., HSU, W., KARCHMER, A. W. & MANTZOROS, C. S. 2003. Exercise and vitamin E intake are independently associated with metabolic abnormalities in human immunodeficiency virus-positive subjects: a cross-sectional study. *Clin Infect Dis,* 36**,** 1593-601.

GUTIERREZ, J., ALBUQUERQUE, A. L. A. & FALZON, L. 2017. HIV infection as vascular risk: a systematic review of the literature and meta-analysis. *PloS one,* 12**,** e0176686.

HADIGAN, C., JESTE, S., ANDERSON, E. J., TSAY, R., CYR, H. & GRINSPOON, S. 2001. Modifiable dietary habits and their relation to metabolic abnormalities in men and women with human immunodeficiency virus infection and fat redistribution. *Clin Infect Dis,* 33**,** 710-7.

HEJAZI, N., HUANG, M. S., LIN, K. G. & CHOONG, L. C. 2013. Hypertension among HIV-infected adults receiving highly active antiretroviral therapy (HAART) in Malaysia. *Glob J Health Sci,* 6**,** 58-71.

HENDRICKS, K. M., JONES, C. Y., HENDRICKS, K. M., HOUSER, R., HENDRICKS, K. M. & WILLIS, K. 2006. Obesity in HIV-Infection: Dietary Correlates. *Journal of the American College of Nutrition,* 25**,** 321-331.

JACKIEWICZ, A., CZARNECKI, M., PRZELIORZ-PYSZCZEK, A. & KNYSZ, B. 2019. Effect of fatty acid content in the diet on lipid profile in HIV-infected patients treated with antiretroviral drugs. *Hiv & Aids Review,* 18**,** 25-32.

JANTARAPAKDE, J., PHANUPHAK, N., CHATURAWIT, C., PENGNONYANG, S., MATHAJITTIPHAN, P., TAKAMTHA, P., DUNGJUN, N., PINYAKORN, S., PIMA, W., PRASITHSIRIKUL, W. & PHANUPHAK, P. 2014. Prevalence of metabolic syndrome among antiretroviral-naive and antiretroviral-experienced HIV-1 infected Thai adults. *AIDS Patient Care STDS,* 28**,** 331-40.

JOY, T., KEOGH, H. M., HADIGAN, C., LEE, H., DOLAN, S. E., FITCH, K., LIEBAU, J., LO, J., JOHNSEN, S., HUBBARD, J., ANDERSON, E. J. & GRINSPOON, S. 2007. Dietary fat intake and relationship to serum lipid levels in HIV-infected patients with metabolic abnormalities in the HAART era. *Aids,* 21**,** 1591-600.

KAZOOBA, P., KASAMBA, I., MAYANJA, B. N., LUTAAKOME, J., NAMAKOOLA, I., SALOME, T., KALEEBU, P. & MUNDERI, P. 2017. Cardiometabolic risk among HIV-POSITIVE Ugandan adults: prevalence, predictors and effect of long-term antiretroviral therapy. *The Pan African medical journal,* 27**,** 40-40.

LAZZARETTI, R. K., KUHMMER, R., SPRINZ, E., POLANCZYK, C. A. & RIBEIRO, J. P. 2012. Dietary intervention prevents dyslipidemia associated with highly active antiretroviral therapy in human immunodeficiency virus Type 1–infected individuals: a randomized trial. *Journal of the American College of Cardiology,* 59**,** 979-988.

LEITE, L. H. & SAMPAIO, A. B. 2010. Dietary calcium, dairy food intake and metabolic abnormalities in HIV-infected individuals. *J Hum Nutr Diet,* 23**,** 535-43.

MILLS, K. T., BUNDY, J. D., KELLY, T. N., REED, J. E., KEARNEY, P. M., REYNOLDS, K., CHEN, J. & HE, J. 2016. Global Disparities of Hypertension Prevalence and Control: A Systematic Analysis of Population-Based Studies From 90 Countries. *Circulation,* 134**,** 441-50.

MURONYA, W., SANGA, E., TALAMA, G., KUMWENDA, J. J. & VAN OOSTERHOUT, J. J. 2011. Cardiovascular risk factors in adult Malawians on long-term antiretroviral therapy. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* 105**,** 644-649.

NAGHAVI, M., ABAJOBIR, A. A., ABBAFATI, C., ABBAS, K. M., ABD-ALLAH, F., ABERA, S. F., ABOYANS, V., ADETOKUNBOH, O., AFSHIN, A., AGRAWAL, A., AHMADI, A., AHMED, M. B., AICHOUR, A. N., AICHOUR, M. T. E., AICHOUR, I., AIYAR, S., ALAHDAB, F., AL-ALY, Z., ALAM, K. & ALAM, N. 2017. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet,* 390**,** 1151-1210.

NOBLE, C. A. 2019. *Least of My Worries: Food Security, Diet Quality, and Antiretroviral Adherence among People Living with HIV.* University of South Florida.

OYETUNJI, I. O., DUNCAN, A., BOOLEY, S. & HARBRON, J. 2021. Diet quality, food insecurity and risk of cardiovascular diseases among adults living with HIV/AIDS: a scoping review protocol. *BMJ open,* 11**,** e047314.

PATTERSON, R. E., HAINES, P. S. & POPKIN, B. M. 1994. Diet quality index: Capturing a multidimensional behavior. *Journal of the American Dietetic Association,* 94**,** 57-64.

POLICARPO, S., RODRIGUES, T., MOREIRA, A. C. & VALADAS, E. 2017. Adherence to Mediterranean diet in HIV infected patients: Relation with nutritional status and cardiovascular risk. *Clin Nutr ESPEN,* 18**,** 31-36.

PONGTHANANIKORN, S., JANTARATHANEEWAT, K., SOMNIKHA, P., JATURAPULLARP, S. & MEKSAWAN, K. 2018. Prevalence and Risk Factors of Metabolic Syndrome in HIV-Infected Patients Receiving the Highly Active Antiretroviral Therapy. *Topics in Clinical Nutrition,* 33**,** 41-49.

POUDEL-T & UKAR, K. 2016. Dietary B vitamins and depression in persons with human immunodeficiency virus infection: The positive living with HIV (POLH) study. *Journal of Nutritional Science and Vitaminology,* 62**,** 388-396.

SAMARAS, K., , H., LAW, M., EMERY, S., COOPER, D. A. & CARR, A. 2009. Dietary intake in HIV-infected men with lipodystrophy: Relationships with body composition, visceral fat, lipid, glucose and adipokine metabolism. *Current HIV Research,* 7**,** 456-461.

SHAH, A. S., STELZLE, D., LEE, K. K., BECK, E. J., ALAM, S., CLIFFORD, S., LONGENECKER, C. T., STRACHAN, F., BAGCHI, S. & WHITELEY, W. 2018. Global burden of atherosclerotic cardiovascular disease in people living with HIV: systematic review and meta-analysis. *Circulation,* 138**,** 1100-1112.

SHAH, M., TIERNEY, K., ADAMS-HUET, B., BOONYAVARAKUL, A., JACOB, K., QUITTNER, C., DINGES, W., PETERSON, D. & GARG, A. 2005. The role of diet, exercise and smoking in dyslipidaemia in HIV-infected patients with lipodystrophy. *HIV Med,* 6**,** 291-8.

SILVA, E. F., LEWI, D. S., VEDOVATO, G. M., GARCIA, V. R., TENORE, S. B. & BASSICHETTO, K. C. 2010. Nutritional and clinical status, and dietary patterns of people living with HIV/AIDS in ambulatory care in Sao Paulo, Brazil. *Rev Bras Epidemiol,* 13**,** 677-88.

SIROTIN, N., HOOVER, D. R., SHI, Q., ANASTOS, K. & WEISER, S. D. 2014. Food insecurity with hunger is associated with obesity among HIV-infected and at risk women in Bronx, NY. *PLoS One,* 9**,** e105957.

STRADLING, C., THOMAS, G.N., HEMMING, K., TAYLOR, S. AND TAHERI, S., 2021. Randomized parallel-group pilot trial (Best foods for your heart) comparing the effects of a Mediterranean Portfolio diet with a low saturated fat diet on HIV dyslipidemia. Clinical Nutrition, 40(3), pp.860-869.

TSIODRAS, S., POULIA, K. A., YANNAKOULIA, M., CHIMIENTI, S. N., WADHWA, S., KARCHMER, A. W. & MANTZOROS, C. S. 2009. Adherence to Mediterranean diet is favorably associated with metabolic parameters in HIV-positive patients with the highly active antiretroviral therapy-induced metabolic syndrome and lipodystrophy. *Metabolism,* 58**,** 854-9.

TURCINOV, D. & BEGOVAC, J. 2011. Predicted coronary heart disease risk in croatian HIV infected patients treated with combination antiretroviral therapy. *Coll Antropol,* 35**,** 115-21.

TURCINOV, D., STANLEY, C., CANCHOLA, J. A., RUTHERFORD, G. W., NOVOTNY, T. E. & BEGOVAC, J. 2009. Dyslipidemia and adherence to the Mediterranean diet in Croatian HIV-infected patients during the first year of highly active antiretroviral therapy. *Coll Antropol,* 33**,** 423-30.

UPRETI, D. 2014. *Diet and Nutritional Assessment of People Living with HIV/AIDS in Nepal (Kathmandu Valley and Terai Highway).* University of Aberdeen (United Kingdom).

VIŠKOVIĆ, K., RUTHERFORD, G. W., SUDARIO, G., STEMBERGER, L., BRNIĆ, Z. & BEGOVAC, J. 2013. Ultrasound measurements of carotid intima-media thickness and plaque in HIV-infected patients on the Mediterranean diet. *Croat Med J,* 54**,** 330-8.

WEBEL, A., HORVAT DAVEY, C., SCHEXNAYDER, J., CURRIE, J., AL BATTASHI, H., CHANG, J. & LONGENECKER, C. T. 2020. Impact of Perceived Cardiovascular Risk on Cardiovascular Disease Prevention Behaviors in People With and Without HIV Infection. *Journal of acquired immune deficiency syndromes (1999),* 83**,** 513-521.

WRIGHT, L. & EPPS, J. B. 2014. Nutrition Risk and Complications in HIV/AIDS. *Topics in Clinical Nutrition,* 29**,** 288-293.

CHAPTER 4: NUTRITONAL AND HEALTH STATUS OF PLWH IN CAPE TOWN

INTRODUCTION

There has been a change in the treatment narratives and an improvement in the nutritional status of PLWH over the years. This is evident in the increase in BMI and other anthropometric indices being reported by researchers among PLWH (Ekali et al., 2013, Myezwa et al., 2018). Unlike before, there have been reports of low prevalence of underweight, and higher prevalence of overweight/obesity among PLWH on HAART (Mahlangu et al., 2020, Rebick et al., 2016).

Several factors have been associated with these changes, the most reported one being the use of HAART (Tshikuka et al., 2020). In their findings, it is important to note that Tshikuka et al. (2020) reported that no specific ART regimen nor the length of time on the program was a better predictor of weight gain among PLWH. However, Hurley et al. (2011) reported an increased prevalence of overweight and obesity among the participants after 12 months of ART initiation. Undoubtedly, HAART use is associated with weight gain among PLWH.

Although not specific to HIV infection, other factors that may contribute to weight gain among PLWH include shifting demographics, an obesogenic environment including an increasingly sedentary lifestyle, and consumption of calorie-dense food (Bailin et al., 2020). Additionally, weight perception, weight satisfaction, and the notion that being “big” indicates good health has been identified as a driver of weight gain among PLWH (Matoti-Mvalo and Puoane, 2011). This may be a result of fears surrounding HIV stigma and the psychological effect surrounding it.

Nutritional and health status are directly affected by dietary intake, and dietary information has often been used in the prediction of CVD risk (Baik et al., 2013). Traditionally, studies often assess the adequacy of dietary intake by comparing the intake of a nutrient or food component of interest to reference standards (Abioye et al., 2015, Aibana et al., 2019). However, scientists have argued that an overall measure of dietary patterns or consumption of food groups may be a better indication of the relationship between diet and chronic diseases, mortality, as well as morbidity. Hence the introduction of the diet quality concept (Coulston, 2001, Patterson et al., 1994).

Diet quality of PLWH using the Healthy Eating Index (HEI) score (Krebs-Smith et al., 2018) has been reported in Brazil (Duran et al., 2008). The researchers reported that the diet of the majority of the participants needed improvement. Similarly in the US, the diet quality of PLWH was reported to be lower than that of the uninfected population (Weiss et al., 2019). Unfortunately, dietary reports among PLWH in SA are few, not in the Western Cape province, were among ART-naïve participants, and no diet quality index has been used (Hattingh et al., 2014, Hattingh et al., 2006, Wrottesley et al., 2014). It is therefore important to assess the diet quality of PLWH

in SA using an appropriate diet quality index. Since food insecurity has been found to be associated with diet quality (Muhammad et al., 2019), it is also important to assess food security status of PLWH as it may increase the health risk posed by poor diet quality.

Remarkably, the improvement in the anthropometric indices recorded was also followed by a tremendous increase in the life expectancy and the quality of life of PLWH. PLWH could now live a life with reduced mortality, free from opportunistic infections, and which is virologically controlled (May et al., 2014, Trickey et al., 2017). However, the increasing prevalence of obesity may be posing a new risk to the health and well-being of PLWH.

The compounding problem of obesity among asymptomatic, apparently well PLWH may be silently increasing the risk of morbidity among this population group (Biggs and Spooner, 2018). The new face of increasing obesity among PLWH is marked by altered lipid or glucose metabolism, increased inflammation, and increased ectopic lipid deposition. This often leads to conditions such as cardiovascular diseases, diabetes mellitus, hepatic diseases, or neurocognitive impairment (Bailin et al., 2020). Even in the absence of other metabolic risk factors, obesity increases the risk of cardiovascular diseases in the general population (Opio et al., 2020). Given increasing BMI and other anthropometric indices among PLWH, it is important to continue to monitor the situation and research what factors may be responsible for this.

This paper aims to describe the nutritional and health status of adults living with HIV on stable HAART attending a primary health facility in Cape Town. This paper will also explore the association that exists between BMI and diet quality and other important variables.

METHODS

Study Design

This paper is based on a descriptive and cross-sectional study. Data was collected once, and we describe the nutritional and health status of our respondence and its association with risk factors of NCDs.

Study Population and Recruitment

The study population was all adults with HIV that are stable on HAART, enrolled, and attending the adherence clubs at the Heideveld Community Health Clinic (CHC). To be classified as stable on HAART, participants must have been receiving HAART successfully with controlled viral load for at least 1 year. This health care facility was selected because it has a well-established HIV adherence club structure and serves a diverse population of both locals and people from outside the community. Heideveld is a Cape Flats community. The study population is representative of the population that attends the CHC and not a reflection of the SA population and we interpreted the results accordingly.

The majority of the participants were recruited on the day they were scheduled to collect their medication or attend the facility for their annual blood sample collection. A trained fieldworker approached patients in the waiting area to provide an overview of the study and invite them to participate. Patients who showed their interest to learn more about the study procedures were attended to in a private room. They were informed about the study in more detail and asked to volunteer to participate. Patients were eligible to participate if they were HIV positive on stable HAART for at least 1 year, aged 18 years or older, and able to communicate in Afrikaans, English language, or isiXhosa. Participants were excluded if they were pregnant, are not physically or psychologically fit to answer questions, or did not give consent.

The study of Muhammad et al. (2019) who investigated the associations of food insecurity and psychosocial measures with diet quality in adults aging with HIV was used to determine the sample size using G*Power (version 3.1.9.7). Muhammad et al. (2019) reported a diet quality score of 46.78±11.73 using the Alternate Healthy Index score that was initially designed by McCullough et al. (2002). This was used together with a 95% confidence level and a power of 90%.

The required sample size calculated was 234 participants. We recruited a total of 247 participants, and 1 participant was excluded during data cleaning due to extensive missing clinical data. Participants were recruited between December 2021 and January 2022.

Permission and Ethical considerations

Ethical approval was granted by the Human Research Ethics Committee of the Faculty of Health Sciences, University of Cape Town (Ref: 413/2021) (Appendix D). Approval was also obtained from the Western Cape Province Department of Health (Ref: WC_202110_011) (Appendix E). Participants' recruitment commenced only after ethical clearance was obtained and continued until the required sample size was reached. Participants signed an informed consent form before any assessment was conducted. There was a low probability of risk for participants in this study. They understood that they could exit the study at any point without giving any reason. The Declaration of Helsinki (Goodyear et al., 2007), Good Clinical Practice, and the laws of South Africa were the guiding principles of this study.

Measures

An interviewer-administered questionnaire (Addendum1), developed for this study, as well as the patients' folder, were used to collect data for this study. Data was collected on socio-demographic variables, HIV infection-related information, anthropometry, biochemical, and clinical measures, as well as weight perception, satisfaction, and management goals. Other measures include diet, food security, physical activity, self-esteem, smoking, and alcohol intake.

<u>Socio-demographic assessments</u>

Socio-demographic characteristics were obtained during an interview with the participants using the questionnaire. We obtained information on participants' highest level of education as seen in addendum 1 which was reclassified into "no high school" (below grade 8 in South Africa), "some high school" (between grade 8 to 11 in South Africa), and "high school completed" (grade 12). As a very small percentage of the participants had post-high school (tertiary) education, they were included in the "high school completed" category. Other variables include marital status (unmarried or married), employment status (employed or unemployed), social grant (yes or no), and pregnancy history. Date of birth and gender (male or female) were obtained from the folder.

HIV infection-related information

We obtained data on the year of HIV diagnosis and ART initiation from the folder and calculated the duration of infection and ART use from this data. Information on previous ART, current ART, and the number of comorbidities (if any) was also obtained from the folder.

Anthropometric measurements

Anthropometric characteristics including weight, height, MUAC, waist circumference, and hip circumference were measured according to (Lee, 2013) using a calibrated scale, stadiometer, and non-stretchable measuring tape where applicable. Weight was recorded to the nearest 0.01kg while others were recorded to the nearest 0.1cm.

Weight and height were measured with participants wearing light clothing with no shoes, hat, or headdress. Weight was taken on an evenly flat and hard surface, and height was taken with participants in anatomical position with the head in a Frankfort plane. Body Mass Index (BMI) was calculated as weight (kg)/ height (m^2). BMI classification was done according to World Health Organization (2006). We classified those with BMI <18.5, between 18.5-24.9, 25-29.9, and 30 and above as underweight, normal, overweight, and obese respectively.

Waist and hip circumference were measured while participants stood in a relaxed position with arms folded across the thorax. Waist circumference was measured at the narrowest or midpoint between the 10th rib and the iliac crest. Hip circumference was measured at the largest posterior protuberance of the buttocks (Lee, 2013).

Waist to Hip Ratio (WHR) was calculated as waist (cm)/ hip (cm). Waist circumference above 94cm and 80cm for males and females respectively were classified as indicating an increased risk of metabolic complications, while values above 102cm and 88cm indicate a substantially increased risk of metabolic complications for males and females respectively. WHR values above 0.90 and 0.85 indicated a higher risk of metabolic complications for male and female participants respectively. Waist circumference and WHR were classified according to World Health Organization (2008).

Biochemical and clinical measures

The most recent viral load (copied/ml), total cholesterol (mmol/L), and creatinine measures were obtained from the folder. At the clinic, total cholesterol is tested only for individuals diagnosed with hypertension, therefore, we only have this result for this subset of the study population.

Total cholesterol values below 5.17 mmol/L, from 5.17 – 6.18, and above 6.18 were classified as desirable, borderline high, and high respectively.

Blood pressure history for the past 5years (if available), from 2017 to 2021 was obtained from the medical folder. A systolic pressure between 120-129 mmHg or diastolic pressure between 80-84 mmHg was classified as normal, systolic pressure between 130-139 mmHg or diastolic pressure between 85-89 mmHg was classified as high normal while systolic pressure from 140 mmHg or a diastolic pressure from 90 mmHg was classified as hypertension. Blood pressure was classified according to the Hypertension guideline working group (2014).

Hand grip strength (HGS) was measured according to Santos et al. (2019) using a Smedley III digital dynamometer. Participants stood upright and held the device parallel to the body with their non-dominant hand or the hand free from pain, arthritis, or surgery in the past three months. Participants who have undergone surgery or have had any form of pain in both hands in the past three months were excluded from this measurement. Relative hand grip strength (RHGS) was calculated by dividing hand grip strength (kg) by BMI (kg/m^2). RHGS has an association with cardiovascular risk profile (Lawman et al., 2016, Lee et al., 2016, Li et al., 2018).

Dietary Assessment

The dietary intake of respondents over the past month was assessed using a quantified food frequency questionnaire (FFQ). A list of 44 food items from different groups including grains/starch, dairy and drinks, fruits and vegetables, proteins/meat, and others was included in the FFQ. The food list was compiled by an expert panel of registered dietitians using existing FFQs that assessed the dietary intake of educators from low socio-economic areas in the Western Cape (Seme, 2013), HIV patients attending an outpatient clinic in Groote Schuur Hospital, Western Cape (unpublished data, Harbron J) and pregnant women from low socio-economic areas in Western Cape (unpublished data, PASS study). The FFQ proposed in the Dietary Assessment and Education Kit (DAEK) (Steyn and Senekal, 2004) was adapted for this study. We employed the use of food cards which contained the photos of food items on the FFQ list to ensure easy identification of food consumed and accuracy by our respondents. Participants were asked to identify the food items they have consumed in the past month by selecting the food cards containing these food items. Items consumed were separated from food items never consumed or not during the past month by placing the former on one pile, and the latter on another pile.

The field worker obtained information from each respondent on the frequency of consumption and the portion sized consumed for the food items in the “consumed” photo pile. Household

utensils and measures, as well as food models, were used to assist participants to estimate portion sizes easily. Participants could indicate whether they consumed one, half, twice, or more than twice the portion for each item on the FFQ. The portion sizes consumed by participants were converted to the gram amount of the food item using the MRC food quantities manual. The daily gram amount of each line item consumed was calculated by multiplying the portion size with the selected frequency. The data was analyzed using the FoodFinder software which is linked to the latest MRC food quantities manual and South African Food composition tables.

To assess diet quality, the Alternate Healthy Eating Index (aHEI) score was calculated according to Chiuve et al. (2012). The aHEI is strongly associated with chronic disease risk. The index compiles and calculates scores from the following food groups and components: vegetables, fruits, sugar-sweetened beverages, nuts and legumes, red/processed meat, trans fat, polyunsaturated fatty acids, sodium, and alcohol. An average score of 5 was given to all participants for trans fat because of the unavailability of trans fat data in the South African nutrient database. Details on how this score was calculated are shown in Table 4.1 below.

Weight Management

Data were obtained on participants' weight perception, satisfaction, and management history in the past 12 months using our questionnaire. Questions were asked about how happy they were with their weight (happy, somewhat happy, or unhappy), their perceived BMI (underweight, normal weight, or overweight), their weight intention (to weigh more, less, or the same), weight compared to the previous year (more, less or the same), any previous attempt at weight loss or gain, their willingness to be included in a weight-management program and the type of program they would prefer program (group or individual counseling). We also included questions asking if they skip meals or not and the meal they skip most often.

Table 4. 1 Criteria for Scoring the Alternate Healthy Eating Index Score (aHEI)

GROUP	DESCRIPTION	FOOD ITEMS FROM FFQ	CRITERIA FOR MINIMUM SCORE (0)	CRITERIA FOR MAXIMUM SCORE (10)
Vegetables (servings/day)	• All vegetables, except potatoes. • 5 servings/day is ideal • 1 serving is ½ cups of vegs or 1cup of green leafy vegs • 1cup = 236.59 g	17 20 21 22	0	≥5
Fruits (servings/day)	• No fruit juices • 1 serving is 1 medium piece of fruit or ½ cups of berries • 1 cup = 236.59 g	16	0	≥4
Whole Grains (servings/day)	• 5 servings/day is ideal for women • 6 servings/day is ideal for men	1 6 8	0	5 servings/day (for women), 6 servings/day (for men)
Sugar-Sweetened Beverages and Fruit juice (servings/day)	1 serving is 200ml	12 13 14 15	≥1	0
Nuts and Legumes (servings/day)	1 serving is 1 tablespoon (15 g) of peanut or peanut butter.	7 36	0	≥1
Red/processed meat (servings/day)	• <1 serving/month was considered ideal • an upper limit of ≥1.5 servings/day was set • 1 serving is 90g unprocessed meat or 1 piece processed meat	25 27 28 29	≥1.5	0
Trans fat (% of energy)	An average score was given to all participants due to missing data on trans-fat in the South African database		≥4	≤0.5
PUFA (% of energy)	Highest score was given to participants with ≥10% of total energy intake from PUFA.		≤2	≥10
Sodium (mg/day)	Sodium cut-offs were based on deciles of intake distribution in the population		Highest decile	Lowest decile
Alcohol (drinks/d)	• Highest score was given to moderate drinker • Worst score to heavy drinkers • A score of 2.5 was given to non-drinkers received • Gender-specific cut-offs were used because the health effects of alcohol consumptions are seen in ↓quantities in women than in men. • One drink is 1 tot of spirits, 1 small glass of liqueur, 1 can of beer, or 1 glass of wine	From the alcohol intake questionnaire	≥2.5 for women ≥3.5 for men	0.5-1.5 for women and 0.5-2.0 for men
TOTAL			0	

Food Security

Food security was assessed using a validated 2-item Food Security Questionnaire (Young et al., 2009). This tool was extracted from an original 6-item questionnaire (Blumberg et al., 1999). The score ranges from 0 – 2. Participants with scores of 0 were classified as “food secure” while others were classified as “food insecure”.

Physical Activity

Physical activity was assessed using the Baecke physical activity questionnaire developed by Baecke et al. (1982) with a predefined scoring. This is a closed-ended questionnaire that elicits responses on habitual physical activity in the previous 12 months. It comprises 16 questions: 8 on the work activity index; 4 on the sports activity index; and 4 on leisure (and locomotive) activity indices. The Baecke questionnaire was validated to be used for PLWH by Florindo et al. (2006). Responses on the frequency of activities are mostly rated on a 5point Likert scale with lowest (1) for never and highest (5) for always or very often. Responses on the intensity of physical activity are also rated on a 5-point Likert scale ranging from 1 (much lighter) and 5 (much heavier).

Self-esteem

Self-esteem was assessed with the Rosenberg self-esteem Scale (RSES). The RSES measures global feelings of self-worth or self-acceptance and was originally developed by Rosenberg (1965). The self-report questionnaire consists of 10 items for which participants can choose one of four possible responses that best describes their present and recent feelings. Responses are based on a 4-point Likert scale as follows: Strongly disagree, agree, disagree, and strongly disagree. Questions 1, 2, 4, 6, and 7 attract a score of 3, 2, 1, and 0 if a participant responds Strongly disagree, agree, disagree, and strongly disagree respectively. This scoring is reversed for questions 3, 5, 8, 9, and 10. A total score between 0 and 30 can be obtained and higher scores reflect higher self-esteem. This score was further classified into three categories: scores between 0-15, 15-25, and 25-30 were classified as low, normal, and high self-esteem respectively.

According to Silber and Tippett (1965), the scale has a good reliability with test-retest correlations of 0.85 after a 2-week interval. The RSES also was found to have good validity with a coefficient alpha of 0.88 (Fleming and Courtney, 1984).

Smoking and Alcohol Intake

The study questionnaire included questions on the smoking status of the participants. Participants were asked if they had previously smoked a cigarette (Yes or no), if they currently smoke (daily, less than daily, or no), how long they have been smoking regularly (number of months/years), and the average number of cigarette they smoke each day. Smoking pack-years, defined as the number of years an individual has smoked one packet of cigarette (10 cigarettes) per day, was calculated by dividing participants' average cigarette smoked per day by their duration of smoking (years) (Klug et al., 2018).

Alcohol intake was assessed using questions extracted from the South African National Health and Nutrition Examination Survey – SANHANES (Shisana, 2009). Participants were asked how often they took a drink containing alcohol in the past 12 months, how many of these drinks they take on a typical day, and how often they took beyond the recommendation of 5 and 4 drinks per day for men and women respectively. They were shown pictures of standard alcoholic drinks.

Statistical methods

Data were captured into a Microsoft Excel (version 2180) spreadsheet daily during data collection. Data were checked, cleaned, and analyzed using RStudio Version 1.2.5033. The distribution of numerical variables was explored for normality using box and whisker plots, and Shapiro-Wilk's test.

Numerical variables with parametric distribution were summarized using mean and standard deviation while those with a non-parametric distribution were summarized using the median and interquartile range. Categorical variables were summarized using count and proportions.

Participants were categorized into three groups by BMI: normal (<25kg/m^2), overweight (25kg/m^2- 29.9kg/m^2), and obese (30kg/m^2 and above). Those with BMI within the underweight category were merged with those in the normal group for descriptive analysis. Analysis of variance (ANOVA) was used to test for differences in numerical variables with a parametric distribution between the three groups while the Kruskal-Wallis test was used for numeric variables with a non-parametric distribution. Chi-squared test was used to test differences in categorical variables between the three groups.

A multivariate linear regression model was fitted to identify the predictors of BMI among the participants. All results with a p-value <0.05 were described as statistically significant.

RESULTS

Sociodemographic and Socioeconomic Information

The majority of participants were female (69.9%) and above 40 years old (74.8%) with a median age of 46 years (Table 4.2). A smaller proportion of the participants did not have high school education (15.9%) compared with those who had some high school education (41.5%) and those who completed high school education (42.7%). More than half of the participants claimed to be unmarried (61.8%), unemployed (56.1%), and did not receive any form of social grant (62.6%). We recruited 172 female participants of which 94.2% reported to have been previously pregnant. Among the 162 female participants who had been previously pregnant, 28.4% had one live birth, 36.4% had two live births, and 31.5% had three or more (Table 4.2).

A hundred (40.7%) participants were classified as obese while 68 (27.6%) were overweight and 31.7% were normal weight. There were no significant differences between normal weight, overweight and obese participants for their median age (p=0.771), age categories (p=0.761), marital status (p=0.951), employment status (p=0.495), or whether they were social grant recipients (p=0.853) (Table 4.2). There were significant differences between the three BMI categories for gender, level of education and ever being pregnant. More than half (56%) of participants who were in the normal BMI category were male while the majority of participants classified as overweight (69%) or obese (91%) were females (p<0.001). A higher proportion of those who were in the normal BMI category had no high school education (28.2%), while 52.9% of those who were overweight and 46.0% of those who were obese completed their high school education (p<0.001). The proportion of those who had been pregnant increased from 85.3% to 95.7% and 96.7% among those in the normal, overweight, and obese BMI categories respectively (p=0.046).

Table 4. 2 Sociodemographic and Socioeconomic Information

	Total	***Normal***	***Overweight***	***Obese***	***P-value***
	(N=246)	***N (%) = 78 (32%)***	***N (%) = 68 (28%)***	***N (%) = 100 (41%)***	
Age (years)					0.771[1]
Median [IQR]	46.0 [39.0, 53.0]	46.0 [39.0, 56.8]	46.0 [40.0, 51.0]	46.0 [39.8, 53.0]	
Age categories, years [n (%)]					0.761[2]
< 40	62 (25.2)	21 (26.9)	16 (23.5)	25 (25.0)	
40 – 49	98 (39.8)	27 (34.6)	31 (45.6)	40 (40.0)	
50 and above	86 (35.0)	30 (38.5)	21 (30.9)	35 (35.0)	
Sex [n (%)]					**<0.001**[2]
Male	74 (30.1)	44 (56.4)	21 (30.9)	9 (9.0)	
Female	172 (69.9)	34 (43.6)	47 (69.1)	91 (91.0)	
Level of Education [n (%)]					**<0.001**[2]
No High School	39 (15.9)	22 (28.2)	3 (4.4)	14 (14.0)	
Some high school	102 (41.5)	33 (42.3)	29 (42.6)	40 (40.0)	
High school completed	105 (42.7)	23 (29.5)	36 (52.9)	46 (46.0)	
Marital Status [n (%)					0.951[2]
Unmarried	152 (61.8)	49 (62.8)	41 (60.3)	62 (62.0)	
Married	94 (38.2)	29 (37.2)	27 (39.7)	38 (38.0)	
Employment Status [n (%)]					0.495[2]
Employed	108 (43.9)	30 (38.5)	31 (45.6)	47 (47.0)	
Unemployed	138 (56.1)	48 (61.5)	37 (54.4)	53 (53.0)	
Social Grant [n (%)]					0.853[2]
Yes	92 (37.4)	31 (39.7)	24 (35.3)	37 (37.0)	
No	154 (62.6)	47 (60.3)	44 (64.7)	63 (63.0)	
Have you ever been pregnant? [n (%)] n=172					**0.046**[2]
Yes	162 (94.2)	29 (85.3)	45 (95.7)	88 (96.7)	
No	10 (5.8)	5 (14.7)	2 (4.3)	3 (3.3)	
Gravidity [n (%)] n= 172					0.425[2]
0	10 (5.8)	5 (14.7)	2 (4.3)	3 (3.3)	
1	37 (21.5)	6 (17.6)	11 (23.4)	20 (22.0)	
2	58 (33.7)	12 (35.3)	18 (38.3)	28 (30.8)	
3	39 (22.7)	7 (20.6)	9 (19.1)	23 (25.3)	
4 or more	28 (16.3)	4 (11.8)	7 (14.9)	17 (18.7)	
Live births [n (%)] n=162					0.921[2]
0	6 (3.7)	1 (3.4)	2 (4.4)	3 (3.4)	
1	46 (28.4)	7 (24.1)	11 (24.4)	28 (31.8)	
2	59 (36.4)	13 (44.8)	16 (35.6)	30 (34.1)	
3 or more	51 (31.5)	8 (27.6)	16 (35.6)	27 (30.7)	

[1]: Kruskal-Wallis Test, [2]: Pearson's Chi-squared Test, IQR = Interquartile Range

Disease-related Information

The median duration of HIV infection among the participants was 12 years, and they had been treated with ART for a median duration of 10 years. In terms of ART, 171 participants had data indicating that their regimen was changed at least once. The majority of these were previously on Tenofovir-Emtricitabine-Efavirenz (TEE) (75.4%), while the rest were on other regimens including those containing Nevirapine, Lamivudine, Zidovudine, or Alluvia. Among 245 participants whose current ART treatment data were available, 144 (58.8%) were on Tenofovir-Lamivudine-Dolutegravir (TLD), and 68 (27.8%) were on TEE and the rest were on other regimens.

The presence of comorbidity was reported among 87 (35.4%) participants. Among these participants, 19.5% had two or more comorbidities. Hypertension was the most prevalent comorbidity which was reported among 81.6% of the 87 participants with comorbidity and 38.6% of the total sample. Other comorbidities reported were dyslipidemia (13.8%), diabetes (10.4%), cardiovascular disease (8.1%), and others including renal problems and cancer (8.1%)

There were no statistically significant differences between any of these disease-related variables and the BMI categories (Table 4.3).

Table 4. 3 Disease-related Information

	Total	*Normal*	*Overweight*	*Obese*	*P-value*
	(N=246)	*N (%) = 78 (32%)*	*N (%) = 68 (28%)*	*N (%) = 100 (41%)*	
Duration of HIV infection (years) n=237					
Median [IQR]	12.0 [8.0, 15.0]	11.5 [9.0, 13.0]	11.0 [8.0, 15.0]	13.0 [9.0, 16.0]	0.247[1]
Duration of ART use (years) n=243					
Median [IQR]	10.0 [7.0, 13.0]	10.0 [6.0, 12.0]	10.0 [7.0, 13.0]	10.0 [7.0, 14.0]	0.556[1]
Previous ART [n (%)] n=171					
TEE	129 (75.4)	42 (72.4)	38 (76.0)	49 (77.8)	0.786[2]
Others	42 (24.6)	16 (27.6)	12 (24.0)	14 (22.2)	
Current ART [n (%)] n=245					
TLD	144 (58.8)	47 (60.3)	41 (60.3)	56 (56.6)	0.791[2]
TEE	68 (27.8)	19 (24.4)	17 (25.0)	32 (32.3)	
Others	33 (13.5)	12 (15.4)	10 (14.7)	11 (11.1)	
Number of Comorbidities [n (%)] n=87					
1	70 (80.5)	18 (75.0)	19 (76.0)	33 (86.8)	0.416[2]
2 or more	17 (19.5)	6 (25.0)	6 (24.0)	5 (13.2)	
Hypertension [n (%)] n=233					
No	143 (61.4)	48 (66.7)	36 (53.7)	59 (62.8)	0.275[2]
Yes	90 (38.6)	24 (33.3)	31 (46.3)	35 (37.2)	

[1]: Kruskal-Wallis Test, [2]: Pearson's Chi-squared Test

TEE = Tenofovir/Emtricitabine/Efavirenz, TLD =Tenofovir/Lamivudine/Dolutegravir, IQR = Interquartile Range

Anthropometry, Biochemical and Clinical Assessment

The median mid-upper arm circumference (MUAC) was 32.5cm. MUAC of normal weight, overweight, and obese participants differed significantly ($p<0.001$) with median values being 28.0cm, 32.5cm, and 36.5cm respectively (Table 4.4).

More than half (56.1%) had a waist circumference that falls within the groups with a substantially increased metabolic risk (>102cm for men, and >88cm for women). About 27% had low metabolic risk as shown by their waist circumference while the rest (17%) had an increased metabolic risk. The majority of those in the normal BMI group had low metabolic risk as shown by their waist circumference (71.8%) while about 7.7% had a substantially increased risk. Half of those in the overweight BMI category had a substantially increased metabolic risk as shown by their waist circumference. This proportion took a huge jump to 98.0% among those in the obese BMI category. None of the obese participants had a waist circumference that could be classified as indicating a low metabolic risk. The difference between the waist circumference of the BMI categories was statistically significant ($p<0.001$).

Similarly, more than half (59.8%) had a waist-to-hip ratio (WHR) which indicates a high risk of metabolic complications while the rest had a low risk. The majority of those in the normal BMI

category had WHR indicating low metabolic risk (64.1%) while about 35.9% had high risk. The proportion of those with high metabolic risk shown by WHR increased to 60.3% and 78.0% among the overweight and obese participants respectively. Only about a fifth (2.02%) of those in the obese BMI category had a low risk of metabolic complications as shown by WHR. The difference in the WHR between the three BMI groups was statistically significant ($p<0.001$).

Overall median hand grip strength (HGS) was 23.9 kg. The median HGS among those in the normal BMI category was higher than the overall median at 27.9 kg. This reduced to 24.6 kg and 22.2 kg among overweight and obese participants respectively. There was a statistically significant difference in the HGS between the BMI groups (p-value of 0.018. Similarly, the overall median relative hand grip strength (RHGS) was 0.81. Median RHGS among those in the normal, overweight, and obese BMI categories was 1.30, 0.88, and 0.59 respectively. There was a statistically significant difference in the RHGS between the BMI groups ($p<0.001$).

The majority (94.7%) of participants had suppressed viral load (<50 copies/ml), while 66.5% (155) of these had a viral load lower than Detectable Limits (LDL). Total cholesterol tests are only carried out annually on HIV adherence club members being treated for confirmed hypertension comorbidity at the facility. Seventy-one of the participants were being treated for hypertension but only 80.3% (57 participants) of these had a total cholesterol result in 2021. More than half (61.4%) of these 57 participants had a desirable total cholesterol level (<5.17 mmol/L). Borderline high level (5.17 mmol/L – 6.18 mmol/L) was recorded among 28.1%, and 10.5% had high levels (>6.18 mmol/L). Viral load and serum cholesterol were not significantly different between BMI categories (Table 4.4).

The median systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 133 mmHg and 77 mmHg respectively. The lowest and highest SBP (125 mmHg and 136 mmHg) were recorded among participants in the normal and overweight BMI groups respectively. Obese participants had a median SBP of 132 mmHg. There was a statistically significant difference in the SBP ($p=0.010$), but not DBP ($p=0.136$), between the three BMI groups. Post-hoc analyses indicated that overweight participants had a significantly higher SBP compared to normal-weight participants.

Table 4. 4 Anthropometry, Biochemical and Clinical Assessment

	Total	***Normal***	***Overweight***	***Obese***	***P-value***
	(N=246)	***N (%) = 78 (32%)***	***N (%) = 68 (28%)***	***N (%) = 100 (41%)***	
ANTHROPOMETRY					
MUAC (cm)					
Median [IQR]	32.5 [29.4, 36.0]	28.0 [26.0, 29.9][a]	32.5 [30.5, 33.4][b]	36.5 [33.9, 39.0][c]	**<0.001**[1]
Waist Circumference (cm)					
Low metabolic risk	67 (27.2)	56 (71.8)	11 (16.2)	0 (0)	**<0.001**[2]
Increased metabolic risk	41 (16.7)	16 (20.5)	23 (33.8)	2 (2.0)	
Substantially increased risk	138 (56.1)	6 (7.7)	34 (50.0%)	98 (98.0)	
WHR Categories [n (%)]					
High metabolic risk	147 (59.8)	28 (35.9)	41 (60.3)	78 (78.0)	**<0.001**[2]
Low metabolic risk	99 (40.2)	50 (64.1)	27 (39.7)	22 (22.0)	
Hand Grip Strength (kg)					
Median [IQR]	23.9 [17.9, 29.7]	27.9 [17.8, 37.2][a]	24.6 [18.8, 29.4][a,b]	22.2 [17.6, 30.0][b]	**0.018**[1]
Relative Hand Grip Strength (HGS/BMI)					
Median [IQR]	0.81 [0.59, 1.15]	1.30 [0.82, 1.76]	0.88 [0.67, 1.07]	0.59 [0.47, 0.78]	**<0.001**[1]
BIOCHEMICAL					
Viral Load, copies/ml [n (%)]					
Suppressed (<50)	233 (94.7)	71 (91.0)	65 (95.6)	97 (97.0)	0.195[2]
Unsuppressed (≥50)	13 (5.3)	7 (9.0)	3 (4.4)	3 (3.0)	
Total cholesterol categories, mmol/L [n (%)] n=57					
Desirable (<5.17)	35 (61.4)	10 (58.8)	11 (57.9)	14 (66.7)	0.765[2]
Borderline high (5.17 – 6.18)	16 (28.1)	4 (23.5)	6 (31.6)	6 (28.6)	
High (>6.18)	6 (10.5)	3 (17.6)	2 (10.5)	1 (4.8)	
CLINICAL					
Systolic Blood Pressure (mmHg) n=233					
Median [IQR]	133.0 [120.0, 144.0]	125.0 [116.8, 140.0].0[a]	136.0 [127.0, 149.0][b]	132.0 [121.0, 146.8][a,b]	**0.010**[1]
Diastolic Blood Pressure (mmHg) n=232					
Median [IQR]	77.0 [70.0, 86.0]	77.0 [71.0, 84.0]	81.0 [72.0, 90.5]	75.0 [67.0, 86.0]	0.136[1]

[1]: Kruskal-Wallis Test, [2]: Pearson's Chi-squared Test, MUAC= Mid Upper Arm Circumference, WHR= Waist-to-Hip Ratio, HGS=Hand Grip Strength, IQR= Interquartile Range. Medians with the same alphabet do not differ significantly in the pairwise test.

Weight Perception and Satisfaction

Almost 57.7% of the participants were happy with their present weight while 32.5% were unhappy. There was a statistically significant difference among those who were happy and unhappy with their present weight between the BMI categories (p=0.015). The percentage of participants who were happy with their current weight was highest amongst those in the overweight BMI category (70.6%), followed by those in the normal weight (61.5%) and obese (46.0%) BMI categories. Almost half of those in the obese BMI category were unhappy with their present weight (44.0%), while the percentage for participants in the normal and overweight BMI categories were 26.9% and 22.1% respectively.

About a half (53.3%) of the participants thought their weight was normal, 29.7% thought they were overweight while 17.1% thought they were underweight (Table 4.5). There was a statistically significant difference between the three BMI categories as far as the perception of their weight is concerned (p<0.001). Just more than half (53.8%) of the participants with an actual normal weight perceived their weight correctly as normal, while 38.5% thought they were underweight. Two-thirds (66.2%) of participants who were overweight thought they had a normal weight. Almost half of those who were obese, incorrectly perceived their weight to be normal (44.0%) or underweight (4.0%).

Among the participants, 43.1% said they would like their weight to stay the same, 29.7% would like to weigh more and 27.2% would like to weigh less. There was a statistically significant difference in the weight intention of the participants between the three BMI categories (p<0.001). More than half (55%) of those who were obese would like to weigh less, while 17.6% among the overweight and no participant in the normal weight category reported an intention to weigh less. Conversely, 64.1% of those with a normal weight and 26.5% of those who were overweight would like to weigh more. More participants from the overweight than those in the obese and normal BMI categories would like their weight to stay the same as reported by 55.9%, 40.0%, and 35.9% respectively.

Half (50.8%) of the participants said they now weigh more than last year, 25.2% said they weigh less while 24% said they weigh the same. There was no statistically significant difference in this variable between the BMI categories (p=0.495).

The majority (71.1%) of the participants had never tried to lose weight. The normal BMI group had the highest proportion of participants who had never tried losing weight followed by the overweight and obese BMI categories with 88.5%, 75.0%, and 55.0% respectively. The obese BMI group had the highest proportion of participants who had tried losing weight followed by the

overweight and normal BMI categories with 45.0%, 25.0%, and 11.5% respectively. These observed differences were statistically significant ($p<0.001$).

Almost eighty percent (79.7%) of the participants did not try to lose weight in the previous 12 months. Almost all the participants (93.6%) in the normal weight category did not try to lose weight in the previous 12 months, this was higher than 82.4% and 67% reported among the overweight and obese participants respectively. Thirty-three percent of those in the obese category tried to lose weight in the past 12 months, this was higher than 17.6% and 6.4% of those in the overweight and normal BMI categories respectively. These differences were statistically significant ($p<0.001$).

The majority (80.1%) of the participants did not try to gain weight in the previous 12 months while 19.9% reported having tried to gain weight in the same period. Forty-one percent of those in the normal BMI category tried to gain weight in the past 12 months, this was higher than 17.6% and 5% of those in the overweight and obese categories respectively. These differences between the BMI categories for these variables were statistically significant ($p<0.001$).

The majority (86.2%) of the participants showed interest in a program on healthy lifestyle and how to best manage weight if it was available at the clinic while 13.8% were not interested. More than half (62.7%) of the 212 participants who were interested in an intervention program chose the group option while the remaining 37.3% would prefer individual sessions.

Table 4. 5 Weight Perception and Satisfaction

	Total	*Normal*	*Overweight*	*Obese*	*P-value*
	(N=246)	*N (%) = 78 (32%)*	*N (%) = 68 (28%)*	*N (%) = 100 (41%)*	
How happy are you with your present weight [n (%)]					
Happy	142 (57.7)	48 (61.5)	48 (70.6)	46 (46.0)	**0.015**[2]
Somewhat Happy	24 (9.8)	9 (11.5)	5 (7.4)	10 (10.0)	
Unhappy	80 (32.5)	21 (26.9)	15 (22.1)	44 (44.0)	
Do you think you are…? [n (%)]					
Normal	131 (53.3)	42 (53.8)	45 (66.2)	44 (44.0)	**<0.001**[2]
Overweight	73 (29.7)	6 (7.7)	15 (22.1)	52 (52.0)	
Underweight	42 (17.1)	30 (38.5)	8 (11.8)	4 (4.0)	
Would you like to weigh…? [n (%)]					
Less	67 (27.2)	0 (0)	12 (17.6)	55 (55.0)	**<0.001**[2]
More	73 (29.7)	50 (64.1)	18 (26.5)	5 (5.0)	
Same	106 (43.1)	28 (35.9)	38 (55.9)	40 (40.0)	
Compared with last year do you weigh…? [n (%)]) n=242					
Less	61 (25.2)	22 (28.9)	16 (24.2)	23 (23.0)	0.495[2]
More	123 (50.8)	33 (43.4)	33 (50.0)	57 (57.0)	
Same	58 (24.0)	21 (27.6)	17 (25.8)	20 (20.0)	
Have you ever tried to lose weight? [n (%)]					
No	175 (71.1)	69 (88.5)	51 (75.0)	55 (55.0)	**<0.001**[2]
Yes	71 (28.9)	9 (11.5)	17 (25.0)	45 (45.0)	
During the past 12 months have you tried to lose weight [n (%)]					
No	196 (79.7)	73 (93.6)	56 (82.4)	67 (67.0)	**<0.001**[2]
Yes	50 (20.3)	5 (6.4)	12 (17.6)	33 (33.0)	
During the past 12 months have you tried to gain weight? [n (%)]					
No	197 (80.1)	46 (59.0)	56 (82.4)	95 (95.0)	**<0.001**[2]
Yes	49 (19.9)	32 (41.0)	12 (17.6)	5 (5.0)	
Would you be interested to take part in a program about a healthy lifestyle and how to best manage weight if it was available here at the clinic? [n (%)]					
No	34 (13.8)	15 (19.2)	7 (10.3)	12 (12.0)	0.234[2]
Yes	212 (86.2)	63 (80.8)	61 (89.7)	88 (88.0)	
Type of program you would prefer [n (%)] n=212					
Group	133 (62.7)	34 (54.0)	37 (60.7)	62 (70.5)	0.109[2]
Individual	79 (37.3)	29 (46.0)	24 (39.3)	26 (29.5)	

[2]: Pearson's Chi-squared Test

Food Security

The majority of the participants answered sometimes or always true to the first question (The food you/your household members bought just did not last, and you didn't have money to get more) in the food security questionnaire (82.5%), while only 17.5% said it was never true. The second question (You/your household members couldn't afford to eat balanced meals) had 76.0% answering sometimes or always true, and 24.0% answering never true for them in the

previous 12 months. The calculated food security score indicated that 89.0% of the participants were food insecure while only 11.0% had food security. Responses to the food security questions, and the food security score were not significantly different between BMI categories (Table 4.6).

Physical Activity and Self-esteem

About half (50.8%) of the participants did not engage in sports or exercise while 49.2% did. This was not significantly different between BMI groups (p=0.497). About half (43.1) reported watching television, using a computer (not for work), or phones very often during their leisure time. Others said they do this often (29.3%), sometimes (24%), seldom (2%), and said (1.6%). This shows that a higher percentage of the participants engaged in these sedentary activities than those who did not (Table 4.6). Comparing the three BMI groups, those in the obese group seemed to have engaged in these activities more than other groups while those in the normal BMI group seemed to have engaged less often. The difference in the frequency of engaging in these sedentary activities between BMI categories was statistically significant (p=0.045). The median total physical activity score of the participants was 7.9. The median total physical activity score between the BMI groups was not significantly different (p=0.062).

Overall median physical activity scores for work and sport indices among the participants were 3.1 and 2.0. Work and sport index scores were not significantly different between BMI categories (Table 4.6). The overall median physical activity score for the leisure index recorded was 2.5. The scores recorded among the overweight and obese participants were 2.5 which was lower than the 2.8 recorded among those in the normal category. The difference observed in this score between BMI groups was statistically significant (p<0.001).

The overall median self-esteem score among the participants was 19. When the self-esteem score was categorized, the majority (74.8%) of the participants had normal self-esteem, 17.5% had high and 7.7% had low self-esteem. Median self-esteem scores and categories were not significantly different between the BMI groups (Table 4.6).

Table 4. 6 Food Security, Physical Activity, and Self-esteem

	Total	***Normal***	***Overweight***	***Obese***	***P-value***
	(N=246)	***N (%) = 78 (32%)***	***N (%) = 68 (28%)***	***N (%) = 100 (41%)***	
FOOD SECURITY (in the last 12 months)					
The food you/your household members bought just did not last, and you didn't have money to get more. [n (%)]					
Never true	43 (17.5)	14 (17.9)	11 (16.2)	18 (18.0)	0.946[2]
Sometimes/always true	203 (82.5)	64 (82.8)	57 (83.8)	82 (82.0)	
You/your household members couldn't afford to eat balanced meals. [n (%)]					
Never true	59 (24.0)	23 (29.5)	12 (17.6)	24 (24.0)	0.247[2]
Sometimes/always true	187 (76.0)	55 (70.5)	56 (82.4)	76 (76.0)	
FS Score [n (%)]					
Secure	27 (11.0)	10 (12.8)	6 (8.8)	11 (11.0)	0.804[2]
Insecure	219 (89.0)	68 (87.2)	62 (91.2)	89 (89.0)	
PHYSICAL ACTIVITY					
Do you engage in sports or exercise? [n (%)]					
No	125 (50.8)	36 (46.2)	34 (50.0)	55 (55.0)	0.497[2]
Yes	121 (49.2)	42 (53.8)	34 (50.0)	45 (45.0)	
During leisure time I watch television, I use my computer (not for work) or phone (screen time). [n (%)]					
Never	4 (1.6)	3 (3.8)	1 (1.5)	0 (0)	**0.045**[2]
Seldom	5 (2.0)	1 (1.3)	2 (2.9)	2 (2.0)	
Sometimes	59 (24.0)	18 (23.1)	18 (26.5)	23 (23.0)	
Often	72 (29.3)	32 (41.0)	12 (17.6)	28 (28.0)	
Very often	106 (43.1)	24 (30.8)	35 (51.5)	47 (47.0)	
Physical Activity Score – Total					
Mean (SD)	7.9 (1.28)	8.1 (1.28)	8.0 (1.37)	7.6 (1.19)	0.062[1]
Median [IQR]	7.9 [7.0, 8.6]	8.0 [7.3, 8.8]	8.0 [7.1, 8.6]	7.5 [6.9, 8.5]	
Physical Activity Score – Work					
Mean (SD)	3.1 (0.73)	3.04 (0.80)	3.1 (0.73)	3.1 (0.66)	0.977[1]
Median [IQR]	3.1 [2.8, 3.6]	3.1 [2.7, 3.6]	3.0 [2.7, 3.6]	3.1 [2.8, 3.5]	
Physical Activity Score – Sport					
Mean (SD)	2.2 (0.72)	2.2 (0.72)	2.2 (0.80)	2.1 (0.66)	0.510[1]
Median [IQR]	2.0 [1.8, 2.5]	2.0 [1.8, 2.7]	2.0 [1.8, 2.6]	2.0 [1.5, 2.5]	
Physical Activity Score – Leisure					
Mean (SD)	2.6 (0.57)	2.8 (0.57)	2.7 (0.47)	2.5 (0.57)	**<0.001**[1]
Median [IQR]	2.5 [2.3, 3.0]	2.8 [2.5, 3.2][a]	2.5 [2.3, 3.0][a,b]	2.5 [2.2, 2.8][b]	
SELF-ESTEEM					
Self-esteem Score					
Mean (SD)	19.9 (4.25)	19.2 (3.78)	20.0 (4.19)	20.5 (4.57)	0.227[1]
Median [IQR]	19.0 [17.0, 23.0]	19.0 [16.0, 22.0]	19.0 [17.0, 23.0]	20.0 [17.0, 24.0]	
Self-esteem Categories [n (%)]					
Low	19 (7.7)	7 (9.0)	2 (2.9)	10 (10.0)	0.052[2]
Normal	184 (74.8)	64 (82.1)	53 (77.9)	67 (67.0)	
High	43 (17.5)	7 (9.0)	13 (19.1)	23 (23.0)	

[1]: Kruskal-Wallis Test, [2]: Pearson's Chi-squared Test, FS = Food Security.
Medians with the same alphabet do not differ significantly in the pairwise test.

Smoking and Alcohol intake

More than half (63.4%) of the participants had never smoked (Table 4.7). Twenty-four percent of the obese participants previously smoked, compared to those who are overweight (30.9%) and normal weight (57.7%). The obese group had the highest proportion of those who had never smoked while the normal BMI group had the highest proportion of those who previously smoked. This difference in the proportion of those who had previously smoked or not between the BMI groups was statistically significant ($p<0.001$).

The majority (75.2%) of the participants do not currently smoke, 21.5% reported currently smoking daily while only 3.3% said they currently smoke but less than daily. About half (57.7%) of participants in the normal BMI category do not currently smoke, this proportion was lower than 77.9% and 87.0% recorded among overweight and obese participants respectively. Only 10.0% of those in the obese group currently smoke daily, this increased to 17.6% and 39.7% among the participants in the overweight and normal BMI groups respectively. The normal BMI group had a higher proportion of people who currently smoke, and the obese group had a higher proportion of those who currently do not smoke than other groups. This difference in proportions of those who currently smoke between the BMI groups was statistically significant ($p<0.001$).

The overall mean smoking duration among 61 of the participants who currently smoke was 269.7 months. Among the 61 participants who currently smoke, the median number of cigarettes smoked on a typical day was 7 sticks. The median smoking pack-year among the 61 participants who currently smoke was 6. There was no statistically significant difference in these variables between the BMI categories (Table 4.7).

More than half (63.8%) of the participants did not consume alcohol in the previous 12 months, 19.9% of them took alcohol either monthly or less than monthly while 16.3 took alcohol more than monthly in the same period. Eighty-nine (36.2%) participants took alcohol in the previous 12 months, of these, 31.5%, 33.7%, and 34.8% took 1-2, 3-4, and 5 or more drinks of alcohol respectively on a typical day. Almost half (44.9%) of the participants reported having never taken, on one occasion, 5 and 4 drinks or more for men and women respectively. Thirty-seven percent took this monthly or less while only 18% took it weekly or more. There was no statistically significant difference in these variables between the BMI categories (Table 4.7).

Table 4. 7 Smoking and Alcohol intake

	Total	***Normal***	***Overweight***	***Obese***	***P-value***
	(N=246)	***N (%) = 78 (32%)***	***N (%) = 68 (28%)***	***N (%) = 100 (41%)***	
SMOKING					
Previously smoked cigarette? [n (%)]					
Yes	90 (36.6)	45 (57.7)	21 (30.9)	24 (24)	**<0.001**[2]
No	156 (63.4)	33 (42.3)	47 (69.1)	76 (76.0)	
Currently smoke cigarette? [n (%)]					
Daily	53 (21.5)	31 (39.7)	12 (17.6)	10 (10.0)	**<0.001**[2]
Less than daily	8 (3.3)	2 (2.6)	3 (4.4)	3 (3.0)	
No	185 (75.2)	45 (57.7)	53 (77.9)	87 (87.0)	
Smoking duration (month) n=61					
Mean (SD)	269.7 (168.74)	301.1 (176.96)	279.2 (165.00)	179.1 (123.98)	0.083[3]
Number of cigarettes smoked on a typical day n=61					
Median [IQR]	7.00 [4, 10]	5.00 [4, 10]	9.00 [4, 11]	8.00 [4, 10]	0.529[1]
Smoking pack-year n=61					
Median [IQR]	6.0 [2.4, 14.5]	4.6 [2.4, 15.0]	7.7 [4.2, 12.5]	6.4 [1.0, 14.0]	0.795[1]
ALCOHOL INTAKE					
Alcohol consumption in the past 12 months [n (%)]					
Never	157 (63.8)	43 (55.1)	46 (67.6)	68 (68.0)	0.162[2]
Monthly or less	49 (19.9)	16 (20.5)	12 (17.6)	21 (21.0)	
More than Monthly	40 (16.3)	19 (24.4)	10 (14.7)	11 (11.0)	
Drinks of alcohol on a typical day [n (%)] n=89					
1 to 2	28 (31.5)	7 (20.0)	8 (36.4)	13 (40.6)	0.378[2]
3 to 4	30 (33.7)	15 (42.9)	7 (31.8)	8 (25.0)	
5 or more	31 (34.8)	13 (37.1)	7 (31.8)	11 (34.4)	
Alcohol overconsumption* [n (%)] n=89					
Never	40 (44.9)	16 (45.7)	10 (45.5)	14 (43.8)	0.208[2]
Monthly or less	33 (37.1)	9 (25.7)	9 (40.9)	15 (46.9)	
Weekly or more	16 (18.0)	10 (28.6)	3 (13.6)	3 (9.4)	

[1]: Kruskal-Wallis Test, [2]: Pearson's Chi-squared Test, [3]: ANOVA

Diet quality – aHEI score

Table 4.8 above shows the median (IQR) intake of the different food components of the aHEI score by the participants. The median (IQR) intake was presented for all the participants. Results were presented in servings per day except for PUFA and sodium which were presented in percentage of total energy, as well as for sodium, which was presented in grams per day.

The median intakes for vegetables, fruits, and whole grains were 1.68 servings/day, 0.86 servings/day, and 2.07 servings/day respectively. The median intake of SSB and fruit juices was 1.01 servings/day, for nuts and legumes was 0.43 servings/day, and for red and processed meat was 1.01 servings/day. The median intake of PUFA was 7.57% of total energy. The median intake of sodium was 1.70 g/day and for alcohol was 0 drinks/day.

Table 4. 8 Median intake of aHEI score components

Component	***Total Median (IQR) Intake***
Vegetables (serving/day)	1.68 (0.86, 2.70)
Fruits (serving/day)	0.86 (0.29, 2.00)
Whole grains (serving/day)	2.07 (0.57, 3.07)
Sweetened beverages and fruit juices (serving/day)	1.01 (0.50, 2.52)
Nuts and legumes (serving/day)	0.43 (0.14, 0.86)
Red and processed meat (serving/day)	1.01 (0.34, 1.72
PUFA (% of energy)	7.57 (6.27, 9.01)
Sodium (g/day)	1.70 (1.10, 2.33)
Alcohol (drinks/day)	0.00 (0.00, 0.12)

Table 4. 9 aHEI Score

Component	***Median (IQR) aHEI Score***	***Mean (SD) aHEI Score***
Fruits	**2.50 (0.00, 5.00)**	3.30 (1.9)
Vegetables	**2.00 (0.00, 4.00)**	3.58 (2.5)
Nuts and legumes	**4.00 (0.00, 8.00)**	4.53 (3.8)
Whole grains	**3.00 (0.00, 6.00)**	3.37 (2.8)
SSB	**0.00 (0.00, 4.00)**	2.63 (3.5)
Sodium	**4.95 (0.00, 7.70)**	4.96 (3.2)
Red and processed meat	**3.00 (0.00, 7.00)**	3.73 (3.7)
Trans fat	**5.00 (5.00, 5.00)**	5.00 (0)
PUFA	**7.50 (0.00, 8.75)**	7.25 (2.1)
Alcohol	**2.50 (2.50, 4.00)**	3.60 (2.0)
TOTAL	40.92 (17.00, 48.42)	**41.94 (9.8)**

Table 4.9 shows the average score for each component of the aHEI index, and the total score of the participants. The minimum score for each category is 0 and the maximum is 10. This score had 10 categories, thus, the total minimum and maximum score obtainable is 0 and 100 respectively. The mean scores show that SSB contributed the least while PUFA contributed the most to the total aHEI score. The total mean (SD) aHEI score of the participants was 41.94 (9.8). The mean (SD) aHEI Score of those in the normal weight category was higher than that of the overweight and obese participants [43.76 (10.3), 42.22 (9.2), and 40.32 (9.5) respectively]. However, this difference was not statistically significant (p=0.063).

Predictors of Increased BMI

A multivariate linear regression model was fitted to identify the predictors of increased BMI among the participants. Many variables were initially added to this model based on our knowledge of the field, some were then removed due to multicollinearity with other variables. The final model fitted to identify the predictors of increased BMI included the following independent variables: Sex (Male or female), “Do you receive social grant?” (Yes or No), “Do you want to weigh…?” (Same, Less, or More), current smoking frequency (No, Daily, or Less than daily), Total physical activity score, ART duration, Creatinine, Hand grip strength, and

MUAC. For categorical independent variables, the first categories in the list above for each variable were made the reference category.

Table 4. 10 Predictors of BMI

Coefficients	*Estimate (95% CI) (kg/m^2)*	*p-value*
Sex – Female	4.60 (2.58 - 6.62)	**<0.001**
Social Grant – No	-0.11 (-1.39 – 1.18)	0.872
Do you want to weigh…?		
• *Less*	4.17 (2.54 – 5.79)	**<0.001**
• *More*	-3.46 (-4.96 - -1.95)	**<0.001**
Current Smoking Frequency		
• *Daily*	-0.62 (-2.23 – 0.987)	0.447
• *Less than daily*	2.74 (-0.66 – 6.13)	0.113
Total Physical Activity Score	-0.79 (-1.28 - -0.30)	**<0.001**
ART Duration	0.03 (-0.12 – 0.17)	0.707
Creatinine	-0.004 (-0.04 – 0.03)	0.815
Hand Grip Strength	0.06 (-0.03 – 0.14)	0.199
Mid-Upper Arm Circumference (MUAC)	0.45 (0.34 – 0.56)	**<0.001**

CI = Confidence Interval

As shown in Table 4.10, in the multivariate model, only sex, weight intention, total physical activity score, and MUAC had a significant association with BMI, holding other variables constant. When controlling for other variables, sex is significantly associated with obesity; women weigh 4.60 units of BMI heavier than men ($p<0.001$). On average, participants who said they want to weigh less than they currently weigh 4.17 units of BMI heavier than those who expressed the desire to remain weight stable ($p<0.001$). Similarly, those who wanted to weigh more weighed 3.46 units of BMI lighter than those who expressed the desire to remain weight stable ($p<0.001$). Each unit increase in total physical activity score was associated with a decrease in BMI of 0.79 units ($p=0.002$). Each centimeter increase in MUAC was independently associated with an increase in BMI of 0.45 units ($p=0.001$). The overall p-value of the model was < 0.001, and the adjusted R2 was 0.624. This indicates a moderate accuracy of the regression model.

DISCUSSION

This study aimed to assess the nutritional and health status of PLWH on stable HAART in a primary health facility in Cape Town while identifying factors that may increase the risk of obesity among the participants. The prevalence of obesity among the participants was 40.7% while overweight was 27.6%. A similar prevalence has been reported among ART-naïve PLWH in KwaZulu-Natal (46.4%) (Biggs and Spooner, 2018), and among those on ART in the Western Cape (33.7%) (Nguyen et al., 2016), but a lower prevalence (13.0%) was reported among those on ART in Gauteng province (Mahlangu et al., 2020). Similar to the findings of Biggs and colleagues, the prevalence of obesity and overweight was disproportionately higher among female participants than males in the current study. Female participants had more than double the prevalence of both indicators found among males. This is also supported by the findings of Mahlangu et al. (2020). In our study, the association between gender and BMI remained statistically significant in the multivariate linear regression model. The increasing trends of BMI had also been reported among the general South African population, and this increase was greater among females (Cois and Day, 2015, Sartorius et al., 2015). The association between obesity and the female gender is complex and multifactorial, several possible reasons for a higher prevalence of obesity especially among African women have been suggested. These include a preference for a larger body size (Puoane et al., 2005), which is driven by culture and societal values (Matoti-Mvalo and Puoane, 2011). Childhood malnutrition, as well as having a high socioeconomic status have also been identified (Case and Menendez, 2009). However, the appropriateness of BMI among the non-European population within which it was developed and tested has been questioned (Razak et al., 2007).

In recent South African studies among PLWH (Biggs and Spooner, 2018, Mahlangu et al., 2020), the proportion of female participants was higher than males. This was further corroborated by the findings of our research with 70% females and 30% males. UNAIDS reported the number of new HIV infections to be 63% among women and girls in sub-Saharan Africa (UNAIDS, 2021). The burden of obesity among women living with HIV is a compounding problem with the increased prevalence of HIV among them. Adequate interventions specific to this population group are needed.

The median age of the participants was 46 years, and this was similar across all BMI categories. This is higher than the average age of PLWH in recent studies conducted in Cape Town which was 36 years (Kalichman et al., 2020), and 38.2 years (Stanton et al., 2021). These studies randomly sampled participants who were on ART and aged 18 years and above, with the data being collected in 2018 (Kalichman et al., 2020, Stanton et al., 2021). This discrepancy in the

average age of the participants and those of other recent studies in Cape Town may be attributed to the unique demographics of those who receive treatment from our study site. It may also be supporting the evidence that PLWH are aging and consequently face an increased risk of chronic diseases partly due to changing demographics (Hontelez et al., 2011, Mahy et al., 2014).

The majority of the participants had some high school education or had completed high school. This figure is higher than reported by OECD (2019) which showed that 59% of South Africans between the ages of 25-64 years had an upper high school education as the highest level of education attained. We believe that this difference among our population is because of the inclusion of younger adults from 18 years in our study. Furthermore, our finding was consistent with the findings of Mabweazara et al. (2019) whose study participants' educational attainment was grade 11-12 on average. Furthermore, 8.5% of the participants had any form of post-secondary education (data not shown). Similarly, Barnabas et al. (2020) reported that 3% of their PLWH included in their South African and Ugandan participants had tertiary education. This confirms the finding of Mabaso et al. (2019) who reported an association between lower HIV prevalence and tertiary education.

About half of the participants were unemployed, and about a third received some form of social grant. This is similar to the expanded uemployement rate in South Africa for Q2:2022 which is reported as 44.1% (Stats sa, 2022). On the other hand, Mahlangu et al. (2020) reported that 63% of their participants were unemployed and 77% received some form of social grant. However, the Mahlangu study was conducted in Gauteng province. In Cape Town, Stanton et al. (2021) reported that 77.9% of their participants were unemployed which is higher than in this study. It is important to note that the Stanton study was conducted in Khayelitsha and among PLWH who had been positively screened for current major depressive disorder. These differences in demographic may explain the higher level of unemployment observed in the study. Mabweazara et al. (2019) in their secondary analysis of data from Dave et al. (2011) collected among PLWH in Cape Town reported that most of their participants were employed.

Apart from the difference in the demography of our study location from other studies, the discrepancy in unemployment data reported in studies conducted in Cape Town may be one of the challenges with the definition of being employed. It is important to encourage higher educational attainment and increase employment opportunities among the population (Shisana et al., 2014). This will help to reduce poverty, relieve the effect of the rising cost of living and improve the overall quality of life of PLWH.

The majority (94.2%) of the 172 female participants in our study had been pregnant before. This may be an indication of the high proportion of PLWH who may potentially be pregnant. Although the successful implementation of the prevention of mother-to-child transmission (PMTCT) guidelines in South Africa had been reported (Tait et al., 2020), there is a need for continued advocacy and awareness of ART adherence among PLWH at all levels. Obesity was higher (96.7%) among female participants who had been pregnant than those who had not. Prevalence of obesity at baseline was high (44%) among a cohort of HIV-infected and uninfected pregnant women in Gugulethu (Madlala et al., 2020), and was higher among HIV-infected women (46% vs 42%). BMI increased in the cohort during pregnancy, obesity was also associated with an increased risk of adverse birth outcomes in the cohort. Adequate attention should be given to pre and post-natal weight changes among women living with HIV. Furthermore, they should be encouraged to maintain a healthy weight, while being informed about the benefits.

The median duration of HIV infection among the participants was 12 years, and the median duration of ART use was 10 years. Duration of HIV infection and ART use did not have any association with BMI among the participants. This is in contrast to the findings of most other studies that had found an association between BMI or obesity and ART duration or use (Mahlangu et al., 2020, Malaza et al., 2012). Mahlangu et al. (2020) studied participants aged 18-49, compared to the age range of 18-80 years in this study. It is known that the effect of ART on body weight is highest usually around 12 months post ART initiation (Hurley et al., 2011). The participants in the Mahlangu study had a highest ART duration of 4 years which was less than half of the median ART duration in our study. The association reported by Mahlangu and colleagues may be due to the younger age of their participants who were in their earlier years of ART use compared to participants in this study.

Although we would have expected the opposite, Malaza et al. (2012) reported a lower BMI among HIV-infected participants on ART when compared to those, not on ART. It was noted, however, that one of the inclusion criteria in the Malaza study was a CD4 count < 200 cells/uL, whereas we recruited PLWH stable on ART. The association between ART use and BMI may be a complex one, it may be influenced by other factors such as the health status of the participants.

Most of the participants were previously on TEE, and more than half were presently on TLD. This reflects a gradual shift to the most recent revision of the HIV clinical guidelines in South Africa which allows the use of TLD for eligible individuals (Republic of South Africa National Department of Health, 2019). This is not surprising as the participants were PLWH who were stable on HAART.

Eighty-seven (35.4%) of the participants were being treated for at least one comorbidity. The majority had only one comorbidity, and the most prevalent comorbidity was hypertension followed by dyslipidemia and dysglycemia. A trend analysis conducted by Gallant et al. (2017) among PLWH in the US supports this finding. This is also reported in a study conducted in Cape Town by George et al. (2019) who reported diabetes and hypertension as the most prevalent comorbidity among their participant. These findings emphasize the need for actions targeted at reducing the risk of chronic diseases among PLWH.

Waist circumference, WHR, and MUAC were all associated with BMI. Central obesity was prevalent among the participants with more than half of the participants at high metabolic risk using both waist circumference and WHR measures. Mahlangu et al. (2020) similarly reported a high prevalence of central obesity in their study. This is another important finding that confirms the increased risk of chronic diseases among PLWH, as central obesity is closely associated with metabolic syndrome (Bailin et al., 2020). This is a public health concern and calls for urgent action.

PLWH who are being successfully treated with ART can live a virologically controlled life (May et al., 2014). Our finding reflects this as about 95% of the participants had suppressed viral load. Only 5.3% had a viral load of 50 copies/mL or above which is defined as not suppressed. This may be an indication of adherence to treatment (Ford et al., 2019), and may suggest a road to achieving the treatment target set for eradicating the HIV epidemic (UNAIDS, 2014). It is important to continue the awareness of the importance of adherence to ART among PLWH.

Hypercholesterolemia is usually observed with hypertension, pointing to an association that exists between them (Ivanovic and Tadic, 2015). Fifty-seven (23%) of the participants were being treated for hypertension. More than half of these had a desirable level of total cholesterol, while 10.5% had a high cholesterol level. This may indicate a good control of the comorbidity among the participants. Regular screening of PLWH for comorbidity, as well monitoring of those who are already diagnosed is needed.

Median systolic blood pressure (SBP) was significantly higher in overweight participants. However, diastolic blood pressure (DBP) was not associated with BMI. Alana et al. (2018) reported a lower SBP and DBP among their South African cohort. However, this cohort was comprised of PLWH who were at ART initiation. This may be supporting the finding of Nduka et al. (2016a) who found an association between ART use and increased blood pressure, as well as the risk of hypertension. Mbuthia et al. (2021), on the other hand, did not find an association between hypertension and ART use, but with obesity/overweight. The association between

hypertension and BMI raises the need for adequate weight management among PLWH, especially those at risk of hypertension.

HGS is a measure of strength and may be used to predict the risk of cardiovascular disease and mortality (Burtin et al., 2016). HGS and RHGS had a significant inverse relationship with BMI, with significantly higher values recorded among participants in the normal BMI category. The association between lower grip strength and increased adiposity among the participants is expected and agrees with the finding of Kim et al. (2017).

Furthermore, the median HGS among the participants was lower than that reported among males and females in a South African population-based cross-sectional study despite the study recruiting only participants who were aged 50 years and above (Ramlagan et al., 2014). It is important to note that grip strength measurement is affected by the specific instrument and protocol used for assessment which limits the ability to compare results between studies (Roberts et al., 2011). However, this finding may confirm reports of grip strength being lower among PLWH when compared with uninfected individuals (Kitilya et al., 2022). The increased risk of cardiovascular disease facing PLWH is exacerbated by a possibly lower grip strength, which is affected by increased adiposity. There is a need for consensus on the measurement of HGS to allow ease of comparison between studies.

While people may perceive their actual body weight incorrectly according to BMI, there is a strong association between weight perception, desire to gain weight, and actual weight gain among PLWH (Hurley et al., 2011). Among the participants, the overweight category had the highest percentage of those who were happy with their weight, those who thought their weight was normal, and those who wanted their weight to stay the same. This was higher than the proportion among those in the normal BMI category and reveals that overweight participants thought their weight was normal. This concurs with the findings of Matoti-Mvalo and Puoane (2011) who reported that black South African women in their study preferred to be overweight than being thin and perceived to be living with HIV. The desire to gain weight may therefore be driven by stigma and may raise concerns of poor mental health among PLWH (Martins et al., 2020). The desire to gain/lose weight was significantly associated with BMI in the multivariate regression model. On average, participants that expressed interest in weighing less actually had a higher BMI, and those who wanted to weigh more had a lower BMI compared with those who wanted to remain weight stable.

Although only about a fifth of the participants tried to gain weight in the past 12 months, more than half gained weight within the same period. Moreso, the percentage of those who gained weight in the past 12 months was not statistically different among the three BMI categories. This

shows that weight has increased among the participants without a deliberate attempt to gain weight. Furthermore, while over two-thirds of the participants were classified as overweight or obese, less than 30% reported having ever tried to lose weight. Nduka et al. (2016b) had earlier suggested that routine HIV care should include weight management and obesity prevention programs. Our findings further underscore a need for education on the importance of continuous and deliberate weight management interventions among PLWH on HAART.

The majority (86%) of the participants expressed a desire to participate in a weight management program if it was available at the clinic, and most of them would prefer a group program. This was consistent across all BMI categories. Group intervention programs, such as the adherence clubs in South Africa, have been identified to be able to keep participants motivated and retained in care (Mukumbang et al., 2019). Kwon et al. (2021), suggested that group-based models of medication delivery may be applicable for the management of CVD due to the past success of such models. The success of group programs underscores the importance of social support as reported by (Munro et al., 2017) in the US cohort of veterans living with HIV. We suggest the adoption of a group-based weight management program aimed at the reduction of CVD risks.

Food insecurity was highly prevalent (89%) among the participants, and was similar across all BMI categories. This was significantly higher than the prevalence reported by Sirotin et al. (2014) and Wright and Epps (2014) among PLWH in the US. Although 45.6% of the general South African population was reportedly food secure (Shisana et al., 2014) amounting to about 54% food insecurity, a higher food insecurity prevalence (65-71%) was recorded among university students in Eastern Cape (Goosen et al., 2016). Association between food insecurity with sexual risk behaviours and increased incidence of new HIV infection has been reported among PLWH (Eaton et al., 2014, Weiser et al., 2011). Our findings emphasize the high prevalence of food insecurity, especially among PLWH, and the need for a public health approach to increase access to food among them.

PLWH were less physically active compared with uninfected individuals in a South African study (Godijk et al., 2020). Seeing that 50% of the participants engaged in sports or exercise, and the majority engaged in sedentary behaviours during leisure, our findings may support the report of Godijk and colleagues. We noted that the PA score during leisure was significantly different among those in normal and obese BMI categories. Furthermore, those in the normal BMI category were less likely to engage in sedentary activities during leisure than those who were overweight and obese. Total physical activity score had a significant inverse relationship with BMI in the multivariate regression model. There are other complex biological and demographic factors affecting the level of PA among PLWH (Vancampfort et al., 2018).

The levels of PA related to sport and leisure were lower than that related to work. This may reflect a lack of adequate knowledge regarding sport, or exercise during leisure time. Malambo et al. (2017) reported a significant association between some neighbourhood attributes with domains of physical activity in some rural and urban settings in South Africa, with significant rural vs urban differences in these attributes. Considering the demographics of the participants, we posit that the low level of PA could be influenced by a possible inequitable distribution of infrastructure or access to the built environment that encourages PA. The way the built environment may affect PA among PLWH in South Africa needs to be further explored to inform policy development.

Most of the participants had normal to high self-esteem. This may reflect a successful HIV treatment among the participants as it had been reported that low self-esteem was associated with viral non-suppression in a South African setting (Filiatreau et al., 2021). High self-esteem may be an indication of a lower risk of anxiety, depressive symptoms, and other mental health challenges among the participants (Small et al., 2022). This seemingly less challenging social phenomenon among the participants may also translate to a higher quality of life. There had also been an association reported between low self-esteem and transactional sex among young women in rural South Africa (Giovenco et al., 2020). The provision of support for improving the self-esteem of PLWH will result in significant public health benefits.

The prevalence of tobacco smoking among South African adults had been reported to be 17.6% (95% CI = 6.3-18.9). The Western Cape accounts for about a third of the nation's current smokers with a 32.9% prevalence (Reddy et al., 2015). The percentage of those who had previously smoked and currently smoked among the participants was 36.6% and 24.8% respectively. Those who currently smoke were significantly less likely to be obese. This is similar to the prevalence reported among PLWH in the study of Stanton et al. (2021) in Cape Town, and Murphy et al. (2019) in sub-Saharan Africa. Median smoking pack-year was not associated with BMI among current smokers in our study and was double the value reported in the South African study of Gupte et al. (2017). This may be explained by the difference in the age range between our study and that of Gupte and colleagues. Furthermore, the latter only recruited black South Africans living with HIV while our study included eligible PLWH from all ethnicity.

Although our study confirms that smoking is more likely among those who are in the normal BMI category, smoking continues to increase the risk of other chronic diseases such as cancers (Park et al., 2016), respiratory illnesses (Bigna et al., 2018), and CVD (Anne-Lise et al., 2015). The relatively higher proportions of previous smokers than current smokers among the participants may indicate a good number of people who are quitting smoking. The majority of

the current smokers reported by Reddy et al. (2015) said they noticed the health warning on their cigarette packs, and half reported that they are considering quitting. Furthermore, Hillyer et al. (2020) in their South African study among HIV-uninfected men, reported that 78.9% of the participants wanted to quit smoking and more than almost 60% had tried to quit at least once. Therefore there is a need to support advocacy and legislation that will encourage smoking cessation, especially among PLWH.

Contrary to previous studies (Kalichman et al., 2020, Raggio et al., 2019), the percentage of the participants who currently use alcohol was less than 30%. This result should be interpreted with caution as we could not verify if this was a case of under-reporting. However, it could also be an indication of increasing health awareness among PLWH, especially with ART use. This, indeed, may be true, as 71% of PWLH who do not currently drink alcohol reported quitting alcohol use at the initiation of ART (Kalichman et al., 2020). Furthermore, only about a fifth of those who currently take alcohol use more than four drinks (for women) or five drinks (for men) on an occasion in our study. Alcohol use did not have any association with BMI, this may be due to a small number of current alcohol users among the participants and should be further explored with a larger sample.

Alcohol is one of the factors that interfere with adherence to ART (Ammon et al., 2018). Some PLWH, while believing and telling others that it is harmful to take alcohol with ART, tend to forgo ART for alcohol use (Kalichman et al., 2020). Alcohol use also had an association with increased inflammation, and consequently an increased risk of CVD (Webel et al., 2017). We support the opinion of O'Keefe et al. (2014) discouraging healthcare practitioners from recommending alcohol to non-drinkers. Alcohol regulations should be enforced to prevent excessive drinking of alcohol among users.

The mean (SD) aHEI score of the participants was 41.94 (9.8). We could not identify a study that has assessed diet quality using the aHEI among PLWH. However, Webel et al. (2020), using the similar Healthy Eating Index (HEI) reported a similar mean (SD) score of 45.4 (11) among their US cohort of HIV-infected and uninfected participants. Furthermore, Webel and colleagues reported that the HEI score, although lower among PLWH, was not significantly different from the uninfected participants. The paucity of data on diet quality in South Africa, and the unavailability of a reference cut-off for diet quality scores make it difficult to interpret this finding with a specific context. However, since the total score obtained on the aHEI used is 100, we could conclude that a score of 41.94 reflects that the diet quality of the participants was below medium adherence to the aHEI recommendation.

The aHEI (Chiuve et al., 2012) as a measure of diet quality was reported to have a stronger association with chronic disease risk especially diabetes and coronary heart disease than the original Healthy Eating Index designed by McCullough et al. (2002). Although we saw that a lower aHEI score was associated with a higher BMI among the participants, this association was not statistically significant. This may indeed suggest that the diet quality of PLWH in our study does not differ between BMI categories. The findings of this study will provide more evidence on the changing face of health risks facing PLWH, especially in South Africa. It will also provide insights for healthcare professionals on how to mitigate these risks among PLWH attending primary healthcare facilities.

STRENGTHS AND LIMITATIONS

While some studies would have a maximum age limit, an important strength of our study is the inclusion of non-pregnant adults of all ages living with HIV stable on HAART. This enabled us to explore the correlations between age and some important factors related to HIV infection. Some data were obtained from the medical folder, although this may indicate the validity and thus contribute to the strength of our study, the data may also not reflect the current state of the participants. This is indeed true as some participants do not have recent data because they had missed some visits before our study. This is the first study to assess the diet quality of PLWH using a diet quality index in South Africa.

A major limitation of this paper is the categorization of the participants using the BMI tool alone. The BMI has several limitations that may also affect our study including not accounting for the amount and distribution of body fat (Kok et al., 2004). Furthermore, we only recruited participants from a clinic which makes the sample not representative. Although some demography information such as employment and educational level reported in this study were relatively similar to the South African population, the diversity of people who attend the clinic may not be a good reflection of the country. Unfortunately we do not have any justifiable motivation to allow the Human Research Ethics Committee to permit the collection of information on ethnicity which is also another limitation to this study.

Comprehensive assessment of biochemical indicator was limited to what was already available in the medical folder partly due to cost and the COVID-19 restriction on data collection. This, for example, limited us to have data only for participants who were being treated for specific conditions and not all. The use of self-reported data including diet, physical activity, smoking, and alcohol intake patterns is subject to recall bias and may affect accuracy of findings. Furthermore, we did not include uninfected control for comparison in this study, it is therefore important that the finding of this study be confirmed in further case-control or intervention

studies. Finally, another limitation that require cautious interpretation of our finding is the likelihood of false positive with multiple variable testing (Groenwold et al., 2021). This along with the fact that statistical significance does not imply clinical significance (Wasserstein and Lazar, 2016) should be borne in mind while using the finding of this study.

CONCLUSION

The findings of our study revealed that PLWH who receive HAART from the Heideveld CHC are mostly overweight/obese middle-aged women, the majority of whom attained the level of high school education. Less than half were married, employed, and received a social grant. Participants have been infected with HIV for an average of 12 years, and have been on HAART for an average of 10 years, with just above a half currently on TLD. Furthermore, the majority were virologically controlled with a viral load lower than the detectable limit. Our study also revealed that hypertension was the most prevalent comorbidity among those who were being treated for one.

Although more than half had abdominal obesity, the majority were happy with their present weight, and almost all participants had normal to high self-esteem. We also found that while the majority has never tried to gain weight in the previous 12 months, about half gained weight. Over four-fifths of this sample were interested in an intervention program, and most of them preferred a group type. Food insecurity was high, about half did not engage in sports or exercise, and most of the participants engaged in sedentary behaviour during their leisure. Less than a third of the participants currently smoke, and the median smoking pack-year was 6. Most of them had not consumed alcohol in the previous 12 months. Among those who consumed alcohol, about half drank beyond the daily recommendation. The diet quality of PLWH in this study was below medium adherence and did not have a significant association with the BMI category.

Factors that were significantly different between BMI categories include gender, level of education, previous pregnancy, anthropometric characteristics, serum creatinine, systolic blood pressure, hand grip strength, physical activity, smoking status, and weight perception. People who were overweight/obese were more likely to be females who had completed high school education and had previously been pregnant. They were also more likely to have a higher MUAC, WHR, WC, and SBP, as well as lower serum creatinine, and grip strength. Obese participants were more likely to be unhappy with their weight, less likely to engage in PA during their leisure, and less likely to be smokers. Since most of them were interested in a group weight management program, we could argue that the role of peer and social support is vital in the lifestyle management of obesity.

REFERENCES

ABIOYE, A. I., ISANAKA, S., LIU, E., MWIRU, R. S., NOOR, R. A., SPIEGELMAN, D., MUGUSI, F. & FAWZI, W. 2015. Gender differences in diet and nutrition among adults initiating antiretroviral therapy in Dar es Salaam, Tanzania. *AIDS Care,* 27**,** 706-715.

AIBANA, O., HUANG, C.-C., ABOUD, S., ARNEDO-PENA, A., BECERRA, M. C., BELLIDO-BLASCO, J. B., BHOSALE, R., CALDERON, R., CHIANG, S., CONTRERAS, C., DAVAASAMBUU, G., FAWZI, W. W., FRANKE, M. F., GALEA, J. T., GARCIA-FERRER, D., GIL-FORTUÑO, M., GOMILA-SARD, B., GUPTA, A., GUPTE, N., HUSSAIN, R., IBORRA-MILLET, J., IQBAL, N. T., JUAN-CERDÁN, J. V., KINIKAR, A., LECCA, L., MAVE, V., MESEGUER-FERRER, N., MONTEPIEDRA, G., MUGUSI, F. M., OWOLABI, O. A., PARSONNET, J., ROACH-POBLETE, F., ROMEU-GARCÍA, M. A., SPECTOR, S. A., SUDFELD, C. R., TENFORDE, M. W., TOGUN, T. O., YATACO, R., ZHANG, Z. & MURRAY, M. B. 2019. Vitamin D status and risk of incident tuberculosis disease: A nested case-control study, systematic review, and individual-participant data meta-analysis. *Plos Medicine,* 16**,** e1002907-e1002907.

ALANA, T. B., LISE, J., NIGEL, J. C., MATTHEW, P. F., JAYA, A. G., KAITLYN, M. B., ANDREW, S., MHAIRI, M., IAN, S., LAWRENCE, L., NASEEM, C. & SYDNEY, R. 2018. Prevalence, incidence, predictors, treatment, and control of hypertension among HIV-positive adults on antiretroviral treatment in public sector treatment programs in South Africa. *PLoS ONE,* 13**,** e0204020.

AMMON, N., MASON, S. & CORKERY, J. 2018. Factors impacting antiretroviral therapy adherence among human immunodeficiency virus–positive adolescents in Sub-Saharan Africa: a systematic review. *Public health,* 157**,** 20-31.

ANNE-LISE, P., CHANG, C.-C. H., SO-ARMAH, K. A., BUTT, A. A., LEAF, D. A., BUDOFF, M., RIMLAND, D., BEDIMO, R., GOETZ, M. B. & RODRIGUEZ-BARRADAS, M. C. 2015. Human immunodeficiency virus infection, cardiovascular risk factor profile and risk for acute myocardial infarction. *Journal of acquired immune deficiency syndromes (1999),* 68**,** 209.

BAECKE, J. A., BUREMA, J. & FRIJTERS, J. E. 1982. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. *The American Journal of Clinical Nutrition,* 36**,** 936-942.

BAIK, I., CHO, N., KIM, S. H. & SHIN, C. 2013. Dietary information improves cardiovascular disease risk prediction models. *European journal of clinical nutrition,* 67**,** 25-30.

BAILIN, S. S., GABRIEL, C. L., WANJALLA, C. N. & KOETHE, J. R. 2020. Obesity and weight gain in persons with HIV. *Current HIV/AIDS Reports,* 17**,** 138-150.

BARNABAS, R. V., SZPIRO, A. A., VAN ROOYEN, H., ASIIMWE, S., PILLAY, D., WARE, N. C., SCHAAFSMA, T. T., KROWS, M. L., VAN HEERDEN, A. & JOSEPH, P. 2020. Community-based antiretroviral therapy versus standard clinic-based services for HIV in South Africa and Uganda (DO ART): a randomised trial. *The Lancet Global Health,* 8**,** e1305-e1315.

BIGGS, C. & SPOONER, E. 2018. Obesity and HIV: a compounding problem. *SAJCN - South African Journal of Clinical Nutrition,* 31**,** 78-83.

BIGNA, J. J., KENNE, A. M., ASANGBEH, S. L. & SIBETCHEU, A. T. 2018. Prevalence of chronic obstructive pulmonary disease in the global population with HIV: a systematic review and meta-analysis. *The Lancet Global Health,* 6**,** e193-e202.

BLUMBERG, S. J., BIALOSTOSKY, K., HAMILTON, W. L. & BRIEFEL, R. R. 1999. The effectiveness of a short form of the Household Food Security Scale. *American journal of public health,* 89**,** 1231-1234.

BURTIN, C., TER RIET, G., PUHAN, M. A., WASCHKI, B., GARCIA-AYMERICH, J., PINTO-PLATA, V., CELLI, B., WATZ, H. & SPRUIT, M. A. 2016. Handgrip weakness and mortality risk in COPD: a multicentre analysis. *Thorax,* 71**,** 86-87.

CASE, A. & MENENDEZ, A. 2009. Sex differences in obesity rates in poor countries: evidence from South Africa. *Economics & Human Biology,* 7**,** 271-282.

CHIUVE, S. E., FUNG, T. T., RIMM, E. B., HU, F. B., MCCULLOUGH, M. L., WANG, M., STAMPFER, M. J. & WILLETT, W. C. 2012. Alternative dietary indices both strongly predict risk of chronic disease. *The Journal of nutrition,* 142**,** 1009-1018.

COIS, A. & DAY, C. 2015. Obesity trends and risk factors in the South African adult population. *BMC obesity,* 2**,** 1-10.

COULSTON, A. M. 2001. The search continues for a tool to evaluate dietary quality. *The American journal of clinical nutrition,* 74**,** 417.

DAVE, J. A., LAMBERT, E. V., BADRI, M., WEST, S., MAARTENS, G. & LEVITT, N. S. 2011. Effect of Nonnucleoside Reverse Transcriptase Inhibitor–Based Antiretroviral Therapy on Dysglycemia and Insulin Sensitivity in South African HIV-Infected Patients. *JAIDS Journal of Acquired Immune Deficiency Syndromes,* 57**,** 284-289.

DURAN, A., ALMEIDA, L., SEGURADO, A. & JAIME, P. 2008. Diet quality of persons living with HIV/AIDS on highly active antiretroviral therapy. *Journal of Human Nutrition and Dietetics,* 21**,** 346-350.

EATON, L. A., CAIN, D. N., PITPITAN, E. V., CAREY, K. B., CAREY, M. P., MEHLOMAKULU, V., SIMBAYI, L. C., MWABA, K. & KALICHMAN, S. C. 2014. Exploring the relationships among food insecurity, alcohol use, and sexual risk taking among men and women living in South African townships. *The Journal of Primary Prevention,* 35**,** 255-265.

EKALI, L. G., JOHNSTONE, L. K., ECHOUFFO-TCHEUGUI, J. B., KOUANFACK, C., DEHAYEM, M. Y., FEZEU, L., NOUTHE, B., HAYES, L., UNWIN, N. C. & SOBNGWI, E. 2013. Fasting blood glucose and insulin sensitivity are unaffected by HAART duration in Cameroonians receiving first-line antiretroviral treatment. *Diabetes Metab,* 39**,** 71-7.

FILIATREAU, L. M., PETTIFOR, A., EDWARDS, J. K., MASILELA, N., TWINE, R., XAVIER GÓMEZ-OLIVÉ, F., HABERLAND, N., KABUDULA, C. W., LIPPMAN, S. A. & KAHN, K. 2021. Associations Between Key Psychosocial Stressors and Viral Suppression and Retention in Care Among Youth with HIV in Rural South Africa. *AIDS Behav,* 25**,** 2358-2368.

FLEMING, J. S. & COURTNEY, B. E. 1984. The dimensionality of self-esteem: II. Hierarchical facet model for revised measurement scales. *Journal of personality and social psychology,* 46**,** 404.

FLORINDO, A. A., DE OLIVEIRA LATORRE, M. D. R. D., DOS SANTOS, E. C. M., NEGRÃO, C. E., AZEVEDO, L. F. & COTRIM SEGURADO, A. A. 2006. Validity and reliability of the Baecke questionnaire for the evaluation of habitual physical activity among people living with HIV/AIDS. *Cadernos de saúde pública,* 22**,** 535-541.

FORD, N., ORRELL, C., SHUBBER, Z., APOLLO, T. & VOJNOV, L. 2019. HIV viral resuppression following an elevated viral load: a systematic review and meta-analysis. *Journal of the International AIDS Society,* 22**,** e25415.

GALLANT, J., HSUE, P. Y., SHREAY, S. & MEYER, N. 2017. Comorbidities Among US Patients With Prevalent HIV Infection—A Trend Analysis. *The Journal of Infectious Diseases,* 216**,** 1525-1533.

GEORGE, S., MCGRATH, N. & ONI, T. 2019. The association between a detectable HIV viral load and non-communicable diseases comorbidity in HIV positive adults on antiretroviral therapy in Western Cape, South Africa. *BMC infectious diseases,* 19**,** 1-11.

GIOVENCO, D., KAHN, K., HUGHES, J. P., MACPHAIL, C., WAGNER, R. & PETTIFOR, A. 2020. Self-Esteem as an Indicator of Transactional Sex Among Young Women in Rural South Africa (HPTN 068). *AIDS Behav,* 24**,** 823-826.

GODIJK, N. G., VOS, A. G., JONGEN, V. W., MORABA, R., TEMPELMAN, H., GROBBEE, D. E., COUTINHO, R. A., DEVILLÉ, W. & KLIPSTEIN-GROBUSCH, K. 2020. Heart Rate Variability, HIV and the Risk of Cardiovascular Diseases in Rural South Africa. *Glob Heart,* 15**,** 17.

GOODYEAR, M. D., KRLEZA-JERIC, K. & LEMMENS, T. 2007. The declaration of Helsinki. British Medical Journal Publishing Group.

GOOSEN, A., VENTER, D., BEEFORTH, M., STEENKAMP, L., VENTERC, D., BEEFORTHD, M. & NELSON MANDELA METROPOLITAN UNIVERSITY, S. A. 2016. Food insecurity among students living with HIV: Strengthening safety nets at the Nelson Mandela Metropolitan University, South Africa. *Sahara Journal of the Social Aspects of HIV/AIDS,* 13**,** 106-111.

GROENWOLD, R. H. H., GOEMAN, J. J., CESSIE, S. L., AND DEKKERS, O. M. (2021). Multiple testing: when is many too much?. *European Journal of Endocrinology* 184, 3, E11-E14, available from: < https://doi.org/10.1530/EJE-20-1375> [Accessed 21 October 2022]

GUPTE, A. N., WONG, M. L., MSANDIWA, R., BARNES, G. L., GOLUB, J., CHAISSON, R. E., HOFFMANN, C. J. & MARTINSON, N. A. 2017. Factors associated with pulmonary impairment in HIV-infected South African adults. *PLoS One,* 12**,** e0184530.

HATTINGH, Z., LE ROUX, M., NEL, M. & WALSH, C. 2014. Assessment of the physical activity, body mass index and energy intake of HIV-uninfected and HIV-infected women in Mangaung, Free State province. *South African Family Practice,* 56**,** 196-200.

HATTINGH, Z., WALSH, C. M., VELDMAN, F. J. & BESTER, C. J. 2006. Macronutrient intake of HIV-seropositive women in Mangaung, South Africa. *Nutrition Research,* 26**,** 53-58.

HILLYER, G. C., MAPANGA, W., JACOBSON, J. S., GRAHAM, A., MMOLEDI, K., MAKHUTLE, R., OSEI-FOFIE, D., MULOWAYI, M., MASUABI, B., BULMAN, W. A., NEUGUT, A. I. & JOFFE, M. 2020. Attitudes toward tobacco cessation and lung cancer screening in two South African communities. *Glob Public Health,* 15**,** 1537-1550.

HONTELEZ, J. A. C., LURIE, M. N., NEWELL, M.-L., BAKKER, R., TANSER, F., BÄRNIGHAUSEN, T., BALTUSSEN, R. & DE VLAS, S. J. 2011. Ageing with HIV in South Africa. *AIDS (London, England),* 25**,** 1665-1667.

HURLEY, E., COUTSOUDIS, A., GIDDY, J., KNIGHT, S. E., LOOTS, E. & ESTERHUIZEN, T. M. 2011. Weight evolution and perceptions of adults living with HIV following initiation of antiretroviral therapy in a South African urban setting. *SAMJ - South African Medical Journal,* 101**,** 645-650.

HYPERTENSION GUIDELINE WORKING GROUP 2014. South African hypertension practice guideline 2014 [correction appears in Cardiovasc J Afr 2015; 26: 90.]. *Cardiovasc J Afr,* 25**,** 288-94.

IVANOVIC, B. & TADIC, M. 2015. Hypercholesterolemia and hypertension: two sides of the same coin. *American journal of cardiovascular drugs,* 15**,** 403-414.

KALICHMAN, S. C., MATHEWS, C., BANAS, E. & KALICHMAN, M. O. 2020. Alcohol-related beliefs and non-adherence to antiretroviral therapy in Cape Town, South Africa. *J Behav Med,* 43**,** 764-772.

KIM, S., LENG, X. I. & KRITCHEVSKY, S. B. 2017. Body composition and physical function in older adults with various comorbidities. *Innovation in aging,* 1**,** igx008.

KITILYA, B., PRAYGOD, G., PECK, R., CHANGALUCHA, J., JEREMIAH, K., KAVISHE, B. B., FRIIS, H., FILTEAU, S., FAURHOLT-JEPSEN, D., KROGH-MADSEN, R., BRAGE, S. & OLSEN, M. F. 2022. Levels and correlates of physical activity and capacity among HIV-infected compared to HIV-uninfected individuals. *PLoS One,* 17**,** e0262298.

KLUG, E., RAAL, F. J., MARAIS, A. D., SMUTS, C. M., SCHAMROTH, C., JANKELOW, D., BLOM, D. J. & WEBB, D. A. 2018. South African dyslipidaemia guideline consensus statement: 2018 update A joint statement from the South African Heart Association (SA Heart) and the Lipid and Atherosclerosis Society of Southern Africa (LASSA). *S Afr Med J,* 108**,** 973-1000.

KOK, P., SEIDELL, J.C. AND MEINDERS, A.E., 2004. The value and limitations of the body mass index (BMI) in the assessment of the health risks of overweight and obesity. Nederlands tijdschrift voor geneeskunde, 148(48), pp.2379-2382.

KREBS-SMITH, S. M., PANNUCCI, T. E., SUBAR, A. F., KIRKPATRICK, S. I., LERMAN, J. L., TOOZE, J. A., WILSON, M. M. & REEDY, J. 2018. Update of the Healthy Eating Index: HEI-2015. *Journal of the Academy of Nutrition and Dietetics,* 118**,** 1591-1602.

KWON, C., WEBSTER, R., SANTO, K. & ATKINS, E. 2021. Community Group-Based Models of Medication Delivery: Applicability to Cardiovascular Diseases. *Glob Heart,* 16**,** 36.

LAWMAN, H. G., TROIANO, R. P., PERNA, F. M., WANG, C.-Y., FRYAR, C. D. & OGDEN, C. L. 2016. Associations of relative handgrip strength and cardiovascular disease biomarkers in US adults, 2011–2012. *American journal of preventive medicine,* 50**,** 677-683.

LEE, R. D. 2013. *Nutritional assessment,* New York, NY, McGraw Hill.

LEE, W.-J., PENG, L.-N., CHIOU, S.-T. & CHEN, L.-K. 2016. Relative handgrip strength is a simple indicator of cardiometabolic risk among middle-aged and older people: a nationwide population-based study in Taiwan. *PLoS One,* 11**,** e0160876.

LI, D., GUO, G., XIA, L., YANG, X., ZHANG, B., LIU, F., MA, J., HU, Z., LI, Y. & LI, W. 2018. Relative handgrip strength is inversely associated with metabolic profile and metabolic disease in the general population in China. *Frontiers in physiology,* 9**,** 59.

MABASO, M., MAKOLA, L., NAIDOO, I., MLANGENI, L. L., JOOSTE, S. & SIMBAYI, L. 2019. HIV prevalence in South Africa through gender and racial lenses: results from the 2012 population-based national household survey. *Int J Equity Health,* 18**,** 167.

MABWEAZARA, S. Z., LEACH, L. L., LEY, C., ONAGBIYE, S. O., DAVE, J. A., LEVITT, N. S. & LAMBERT, E. V. 2019. Demographic and socio-economic predictors of physical activity among people living with HIV of low socio-economic status. *Health SA,* 24**,** 1127.

MADLALA, H. P., MALABA, T. R., NEWELL, M. L. & MYER, L. 2020. Elevated body mass index during pregnancy and gestational weight gain in HIV-infected and HIV-uninfected women in Cape Town, South Africa: association with adverse birth outcomes. *Tropical Medicine & International Health,* 25**,** 702-713.

MAHLANGU, K., MODJADJI, P. & MADIBA, S. The Nutritional Status of Adult Antiretroviral Therapy Recipients with a Recent HIV Diagnosis; A Cross-Sectional Study in Primary Health Facilities in Gauteng, South Africa. Healthcare, 2020. Multidisciplinary Digital Publishing Institute, 290.

MAHY, M., AUTENRIETH, C. S., STANECKI, K. & WYND, S. 2014. Increasing trends in HIV prevalence among people aged 50 years and older: evidence from estimates and survey data. *AIDS (London, England),* 28 Suppl 4**,** S453-S459.

MALAMBO, P., KENGNE, A. P., LAMBERT, E. V., DE VILLERS, A. & PUOANE, T. 2017. Association between perceived built environmental attributes and physical activity among adults in South Africa. *BMC Public Health,* 17**,** 213.

MALAZA, A., MOSSONG, J., NEWELL, M.-L. & BAERNIGHAUSEN, T. W. 2012. Hypertension and Obesity in Adults Living in a High HIV Prevalence Rural Area in South Africa. *PLoS ONE,* 7.

MARTINS, C., COELHO, F., PINHEIRO, R. T., MOTTA, J., DE SOUZA, L. D. M., PINHEIRO, C. A. T., KELBERT, E. F., SOUZA, M. S., PINHEIRO, L. M. S. & PINHEIRO, K. A. T. 2020. People living with HIV/AIDS: body image and its important associations with mental health and BMI. *Psychol Health Med,* 25**,** 1020-1028.

MATOTI-MVALO, T. & PUOANE, T. 2011. Perceptions of body size and its association with HIV/AIDS. *South African Journal of Clinical Nutrition,* 24.

MAY, M. T., GOMPELS, M., DELPECH, V., PORTER, K., ORKIN, C., KEGG, S., HAY, P., JOHNSON, M., PALFREEMAN, A. & GILSON, R. 2014. Impact on life expectancy of HIV-1 positive individuals of CD4+ cell count and viral load response to antiretroviral therapy. *AIDS (London, England),* 28**,** 1193.

MBUTHIA, G. W., MAGUTAH, K. & MCGARVEY, S. T. 2021. The Prevalence and Associated Factors of Hypertension among HIV Patients. *Int J Hypertens,* 2021**,** 5544916.

MCCULLOUGH, M. L., FESKANICH, D., STAMPFER, M. J., GIOVANNUCCI, E. L., RIMM, E. B., HU, F. B., SPIEGELMAN, D., HUNTER, D. J., COLDITZ, G. A. & WILLETT, W. C. 2002. Diet quality and major

chronic disease risk in men and women: moving toward improved dietary guidance. *The American journal of clinical nutrition,* 76**,** 1261-1271.

MUHAMMAD, J., FERNANDEZ, J., CLAY, O., SAAG, M., OVERTON, E. & WILLIG, A. 2019. Associations of food insecurity and psychosocial measures with diet quality in adults aging with HIV. *AIDS care,* 31**,** 554-562.

MUKUMBANG, F. C., VAN WYK, B., VAN BELLE, S. & MARCHAL, B. 2019. Unravelling how and why the Antiretroviral Adherence Club Intervention works (or not) in a public health facility: A realist explanatory theory-building case study. *PLoS One,* 14**,** e0210565.

MUNRO, S., DINATALE, E., HARTLEY, S., ST JACQUES, M. & OURSLER, K. A. 2017. Barriers and Health Beliefs Related to Weight Management Among Veterans With Human Immunodeficiency Virus. *Mil Med,* 182**,** e1596-e1602.

MURPHY, J. D., LIU, B. & PARASCANDOLA, M. 2019. Smoking and HIV in sub-Saharan Africa: a 25-country analysis of the Demographic Health Surveys. *Nicotine and Tobacco Research,* 21**,** 1093-1102.

MYEZWA, H., HANASS-HANCOCK, J. & PAUTZ, N. 2018. Investigating the interaction between human immunodeficiency virus, nutrition, and disability: A cross-sectional observational study. *Afr J Prim Health Care Fam Med,* 10**,** e1-e8.

NDUKA, C., STRANGES, S., SARKI, A., KIMANI, P. & UTHMAN, O. 2016a. Evidence of increased blood pressure and hypertension risk among people living with HIV on antiretroviral therapy: a systematic review with meta-analysis. *Journal of human hypertension,* 30**,** 355-362.

NDUKA, C. U., UTHMAN, O. A., KIMANI, P. K. & STRANGES, S. 2016b. Body Fat Changes in People Living with HIV on Antiretroviral Therapy. *AIDS Rev,* 18**,** 198-211.

NGUYEN, K. A., PEER, N., DE VILLIERS, A., MUKASA, B., MATSHA, T. E., MILLS, E. J. & KENGNE, A. P. 2016. The Distribution of Obesity Phenotypes in HIV-Infected African Population. *Nutrients,* 8.

OECD. 2019. *Education at a Glance 2019* [Online]. Available: https://www.oecd.org/education/education-at-a-glance/EAG2019_CN_ZAF.pdf. [Accessed 21/10/2022].

O'KEEFE, J. H., BHATTI, S. K., BAJWA, A., DINICOLANTONIO, J. J. & LAVIE, C. J. Alcohol and cardiovascular health: the dose makes the poison… or the remedy. Mayo Clinic Proceedings, 2014. Elsevier, 382-393.

OPIO, J., CROKER, E., ODONGO, G. S., ATTIA, J., WYNNE, K. & MCEVOY, M. 2020. Metabolically healthy overweight/obesity are associated with increased risk of cardiovascular disease in adults, even in the absence of metabolic risk factors: A systematic review and meta-analysis of prospective cohort studies. *Obesity Reviews,* 21**,** e13127.

PARK, L. S., HERNÁNDEZ-RAMÍREZ, R. U., SILVERBERG, M. J., CROTHERS, K. & DUBROW, R. 2016. Prevalence of non-HIV cancer risk factors in persons living with HIV/AIDS: a meta-analysis. *Aids,* 30**,** 273-91.

PATTERSON, R. E., HAINES, P. S. & POPKIN, B. M. 1994. Diet quality index: Capturing a multidimensional behavior. *Journal of the American Dietetic Association,* 94**,** 57-64.

PUOANE, T., FOURIE, J., SHAPIRO, M., ROSLING, L., TSHAKA, N. & OELEFSE, A. 2005. 'Big is beautiful'-an exploration with urban black community health workers in a South African township. *South African Journal of Clinical Nutrition,* 18**,** 6-15.

RAGGIO, G. A., PSAROS, C., FATCH, R., GOODMAN, G., MATTHEWS, L. T., MAGIDSON, J. F., AMANYIRE, G., CROSS, A., ASIIMWE, S., HAHN, J. A. & HABERER, J. E. 2019. High Rates of Biomarker-Confirmed Alcohol Use Among Pregnant Women Living With HIV in South Africa and Uganda. *J Acquir Immune Defic Syndr,* 82**,** 443-451.

RAMLAGAN, S., PELTZER, K. & PHASWANA-MAFUYA, N. 2014. Hand grip strength and associated factors in non-institutionalised men and women 50 years and older in South Africa. *BMC Research Notes,* 7**,** 8.

RAZAK, F., ANAND, S. S., SHANNON, H., VUKSAN, V., DAVIS, B., JACOBS, R., TEO, K. K., MCQUEEN, M. & YUSUF, S. 2007. Defining obesity cut points in a multiethnic population. *Circulation,* 115**,** 2111-2118.

REBICK, G. W., FRANKE, M. F., TENG, J. E., GREGORY JEROME, J. & IVERS, L. C. 2016. Food Insecurity, Dietary Diversity, and Body Mass Index of HIV-Infected Individuals on Antiretroviral Therapy in Rural Haiti. *AIDS Behav,* 20**,** 1116-22.

REDDY, P., ZUMA, K., SHISANA, O., JONAS, K. & SEWPAUL, R. 2015. Prevalence of tobacco use among adults in South Africa: results from the first South African National Health and Nutrition Examination Survey. *South African Medical Journal,* 105**,** 648-655.

REPUBLIC OF SOUTH AFRICA NATIONAL DEPARTMENT OF HEALTH 2019. 2019 ART Clinical Guidelines for the Management of HIV in Adults, Pregnancy, Adolescents, Children, Infants and Neonates.

ROBERTS, H. C., DENISON, H. J., MARTIN, H. J., PATEL, H. P., SYDDALL, H., COOPER, C. & SAYER, A. A. 2011. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. *Age and Ageing,* 40**,** 423-429.

ROSENBERG, M. 1965. Rosenberg self-esteem scale (RSE). *Acceptance and commitment therapy. Measures package,* 61**,** 18.

SANTOS, F. B., CONCEIÇÃO-MACHADO, M., SAMPAIO, E. J., RAMOS, L. B. & BARRETO-MEDEIROS, J. M. 2019. Reduction of relative handgrip strength and cardiometabolic risk in individuals with HIV/AIDS. *Rev Soc Bras Med Trop,* 52**,** e20180405.

SARTORIUS, B., VEERMAN, L. J., MANYEMA, M., CHOLA, L. & HOFMAN, K. 2015. Determinants of obesity and associated population attributability, South Africa: Empirical evidence from a national panel survey, 2008-2012. *PloS one,* 10**,** e0130218.

SEME, Z. B. 2013. *Formative assessment of teachers of grade four to six learners to advise the development of the teacher focus of a multi-component primary school-based intervention programme for the prevention of non-communicable diseases.* University of Cape Town.

SHISANA, O. 2009. *South African national HIV prevalence, incidence, behaviour and communication survey, 2008: a turning tide among teenagers?*

SHISANA, O., LABADARIOS, D., REHLE, T., SIMBAYI, L., ZUMA, K., DHANSAY, A., REDDY, P., PARKER, W., HOOSAIN, E. & NAIDOO, P. 2014. The South African National Health and Nutrition Examination Survey, 2012: SANHANES-1: the health and nutritional status of the nation.

SILBER, E. & TIPPETT, J. S. 1965. Self-esteem: Clinical assessment and measurement validation. *Psychological reports,* 16**,** 1017-1071.

SIROTIN, N., HOOVER, D. R., SHI, Q., ANASTOS, K. & WEISER, S. D. 2014. Food insecurity with hunger is associated with obesity among HIV-infected and at risk women in Bronx, NY. *PLoS One,* 9**,** e105957.

SMALL, L. A., HUYNH, A. K. & PARCHMENT, T. M. 2022. The association between self-Esteem, stigma, and mental health among South African youth living with HIV: the need for integrated HIV care services. *AIDS Care,* 34**,** 86-94.

STANTON, A. M., LEE, J. S., WIRTZ, M. R., ANDERSEN, L. S., JOSKA, J., SAFREN, S. A., VAN ZYL-SMIT, R. & O'CLEIRIGH, C. 2021. Tobacco Use and Health-Related Quality of Life Among Individuals with Depression Who Are Receiving Treatment for HIV in Cape Town, South Africa. *Int J Behav Med,* 28**,** 417-430.

STATS SA. 2022. *Quarterly Labour Force Survey (QLFS) - Q2:2022* [Online]. Available: https://www.statssa.gov.za/?p=15685#:~:text=The%20total%20number%20of%20persons,the%20second%20quarter%20of%202022. [Accessed 21/10/2022].

STEYN, N. P. & SENEKAL, M. 2004. *A guide for the use of the dietary assessment and education kit (DAEK)*, Medical Research Council.

TAIT, C. L., PETERS, R. P., MCINTYRE, J. A., MNYANI, C. N., CHERSICH, M. F., GRAY, G., BUCHMANN, E. J., STRUTHERS, H. & VIOLARI, A. 2020. Implementation of a PMTCT programme in a high HIV prevalence setting in Johannesburg, South Africa: 2002–2015. *Southern African Journal of HIV Medicine,* 21**,** 1-7.

TRICKEY, A., MAY, M. T., VEHRESCHILD, J.-J., OBEL, N., GILL, M. J., CRANE, H. M., BOESECKE, C., PATTERSON, S., GRABAR, S. & CAZANAVE, C. 2017. Survival of HIV-positive patients starting antiretroviral therapy between 1996 and 2013: a collaborative analysis of cohort studies. *The lancet HIV,* 4**,** e349-e356.

TSHIKUKA, J. G., MAGAFU, M. G. M. D., RANKGOANE-PONO, G., MWITA, J. C., MASUPE, T., HAMDA, S. G., TAPERA, R., MOLEFI, M., TSHIBANGU, J. & TLHAKANELO, J. T. 2020. Overweight and obesity among recipients of antiretroviral therapy at HIV clinics in Gaborone, Botswana: Factors Associated with Change in Body Mass Index. *AIDS research and treatment,* 2020.

UNAIDS. 2014. *90-90-90 An ambitious treatment target to help end the AIDS epidemic* [Online]. Available: https://www.unaids.org/sites/default/files/media_asset/90-90-90_en.pdf [Accessed 23/04/2022 2022].

UNAIDS. 2021. *Global HIV & AIDS statistics — Fact sheet* [Online]. Available: https://www.unaids.org/en/resources/fact-sheet [Accessed 2022/22/03 2022].

VANCAMPFORT, D., STUBBS, B. & MUGISHA, J. 2018. Physical activity and HIV in sub-Saharan Africa: a systematic review of correlates and levels. *Afr Health Sci,* 18**,** 394-406.

WASSERSTEIN, R.L. AND LAZAR, N.A., 2016. The ASA statement on p-values: context, process, and purpose. The American Statistician, 70(2), pp.129-133.

WEBEL, A., HORVAT DAVEY, C., SCHEXNAYDER, J., CURRIE, J., AL BATTASHI, H., CHANG, J. & LONGENECKER, C. T. 2020. Impact of Perceived Cardiovascular Risk on Cardiovascular Disease Prevention Behaviors in People With and Without HIV Infection. *Journal of acquired immune deficiency syndromes (1999),* 83**,** 513-521.

WEBEL, A. R., SATTAR, A., FUNDERBURG, N. T., KINLEY, B., LONGENECKER, C. T., LABBATO, D., ALAM, S. K. & MCCOMSEY, G. A. 2017. Alcohol and dietary factors associate with gut integrity and inflammation in HIV-infected adults. *HIV Med,* 18**,** 402-411.

WEISER, S. D., YOUNG, S. L., COHEN, C. R., KUSHEL, M. B., TSAI, A. C., TIEN, P. C., HATCHER, A. M., FRONGILLO, E. A. & BANGSBERG, D. R. 2011. Conceptual framework for understanding the bidirectional links between food insecurity and HIV/AIDS. *American Journal of Clinical Nutrition,* 94**,** 1729S.

WEISS, J. J., SANCHEZ, L., HUBBARD, J., LO, J., GRINSPOON, S. K. & FITCH, K. V. 2019. Diet quality is low and differs by sex in people with HIV. *The Journal of nutrition,* 149**,** 78-87.

WORLD HEALTH ORGANIZATION. 2006. *Body mass index - BMI* [Online]. Available: https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi [Accessed 25/03/2022 2022].

WORLD HEALTH ORGANIZATION. 2008. *Guide to physical measurements. In part 3: training and practical guidelines* [Online]. Available: https://www.who.int/ncds/surveillance/steps/Part3_Section3.pdf [Accessed 25/03/2022 2022].

WRIGHT, L. & EPPS, J. B. 2014. Nutrition Risk and Complications in HIV/AIDS. *Topics in Clinical Nutrition,* 29**,** 288-293.

WROTTESLEY, S. V., MICKLESFIELD, L. K., HAMILL, M. M., GOLDBERG, G. R., PRENTICE, A., PETTIFOR, J. M., NORRIS, S. A. & FEELEY, A. B. 2014. Dietary intake and body composition in HIV-positive and-negative South African women. *Public health nutrition,* 17**,** 1603-1613.

YOUNG, J., JEGANATHAN, S., HOUTZAGER, L., DI GUILMI, A. & PURNOMO, J. 2009. A valid two-item food security questionnaire for screening HIV-1 infected patients in a clinical setting. *Public health nutrition,* 12**,** 2129-2132.

CHAPTER 5: ASSOCIATION BETWEEN HYPERTENSION, DIET QUALITY AND HEALTH VARIABLES AMONG PLWH IN CAPE TOWN

INTRODUCTION

The risk of CVD among PLWH is higher than among the uninfected population and is independent of the geographical region (Gutierrez et al., 2017). Several factors have been attributed to this increased CVD risk among PLWH including persistent immune activation and chronic inflammation due to HIV infection (Subramanian et al., 2012), and the use of HAART (Nduka et al., 2016). Other lifestyle factors which may exacerbate this association include alcohol use (Webel et al., 2017), smoking (Anne-Lise et al., 2015), central obesity, and diet.

Hypertension is an important modifiable risk factor for CVD, morbidity, and death globally (Mills et al., 2020). The global prevalence of hypertension has been predicted to rise above 1.6 billion people by 2025 (Mills et al., 2016), with a higher prevalence already being recorded in LMIC (Mills et al., 2020). The national prevalence of hypertension in South Africa was estimated at 30.4% by the National Health and Nutrition Examination Survey -1, with a distinct geographical variation (Shisana et al., 2014). The North West, Free State, and Northern Cape provinces had the highest, while Limpopo had the lowest prevalence (Kandala et al., 2013).

Hypertension has been identified as a leading risk factor for adverse outcomes among PLWH, especially in the era of the wide use of HAART (Peck et al., 2014). In their systematic review and meta-analysis of globally available studies published between 2011 and 2016, Xu et al. (2017) estimated the prevalence of hypertension among PLWH at 25.2%. This prevalence was higher among participants using ART (34.7%) than those who are ART-naïve (12.7%). A cross-sectional study was conducted between 2014 and 2015 in 17 randomly selected healthcare facilities in the Western Cape province providing ART to at least 325 PLWH monthly (Mutemwa et al., 2018). The prevalence of hypertension among the 827 adults recruited was 38.6% which is higher than the national estimate reported by Shisana et al. (2014).

The risk of CVD and mortality has been reported to be higher among PLWH with hypertension than those without hypertension or HIV-uninfected population with hypertension (Armah et al., 2014). This higher risk of CVD and higher prevalence of hypertension among PLWH require targeted efforts to mitigate adverse cardiovascular outcomes among PLWH.

Although the exact causes of primary hypertension have not been clearly understood and defined (Lenfant et al., 2003), some identified risk factors for hypertension among the general population may include age, family history, ethnicity, obesity, sedentary lifestyle, diet and alcohol intake (Basile and Bloch, 2015). These traditional risk factors for hypertension do not fully explain the increased risk seen among PLWH (Fahme et al., 2018). Some HIV-specific risk factors for hypertension include disease severity, duration of disease, and type of ART (Nguyen

et al., 2015). Others are immunodeficiency, immune activation, and inflammation (van Zoest et al., 2017). Most of the ART-related and virologic mechanisms that have been identified in the pathophysiology of hypertension among PLWH are associated with common pathways such as the renin-angiotensin-aldosterone system (Fahme et al., 2018).

Diet is related to most chronic or non-communicable diseases (Lim et al., 2012), and has been identified as a leading modifiable risk factor for morbidity and mortality (World Health Organization, 2015). We know that poor diet quality increases the risk of CVD (Reedy et al., 2014), and there have been reports of PLWH having a lower diet quality than the uninfected population (Weiss et al., 2019a). Given these two factors, close monitoring of dietary quality diet quality of PLWH should be central to clinical practice.

Sodium intake has been identified as a predictor of hypertension among PLWH (Magande et al., 2017). Similarly, PLWH with hypertension have a higher salt sensitivity than HIV-uninfected hypertensives. Higher salt sensitivity is also associated with hypertension and non-dipping blood pressure among PLWH and uninfected individuals in a cohort of adult Zambian population (Masenga et al., 2021). In 2016, the estimated salt intake in most countries around the world stood at about 9-12g per day which significantly exceeds the WHO recommendation of less than 5g per day (Rust and Ekmekcioglu, 2016). This high salt intake may be due to adding salt to dishes regularly (Magande et al., 2017), or habitual consumption of fast foods. Salt intake exceeded 6g per day among all ethnic groups in South Africa (Charlton et al., 2005), and the mandatory sodium legislation was followed by a reduction in this level (Charlton et al., 2021). However, this has not been reported specifically for PLWH. Therefore, it is important to assess the salt intake of PLWH in South Africa.

The Dietary Approaches to Stop Hypertension (DASH) diet has been found to reduce both systolic and diastolic blood pressure among HIV-uninfected adults with or without hypertension (Filippou et al., 2020). The DASH diet score was developed to assess adherence to the DASH diet recommendation (Fung et al., 2008). We have not identified any study evaluating the adherence of dietary intake of PLWH to the DASH diet recommendations, or its association with hypertension. To reduce the risk of CVD posed by the increasing prevalence of hypertension among PLWH, it is important to assess the dietary intake and its association with increased blood pressure in this population group.

This paper aims to describe the dietary intake of adults living with HIV on stable HAART attending a primary health facility in Cape Town. This paper will also explore the association that exists between increased blood pressure and diet quality and other health variables among PLWH.

METHODS

Study Design, Population, and Recruitment

This paper is based on a descriptive and cross-sectional study. The study population was all eligible adults with HIV that are stable on HAART, enrolled, and attending the adherence clubs at the Heideveld Community Health Clinic (CHC). To be classified as stable on HAART, participants must have been receiving HAART successfully for at least 1 year. This health care facility was selected because it has a well-established HIV adherence club structure and serves a diverse population of both locals and people from outside the community. Heideveld is in Athlone, a suburb in the Cape Town metropolitan area (Statssa, 2011). According to the 2011 census, 70% of adults are employed, but 58% of households have a monthly income of R3,200 or less. The study population is representative of the population that attends the CHC and not a reflection of the SA population and we interpreted the results accordingly.

The majority of the participants were recruited on the day they were scheduled to collect their medication or attend the facility for their annual blood sample collection. A trained fieldworker approached patients in the waiting area to provide an overview of the study and invite them to participate. An opportunistic sample of patients who showed their interest to learn more about the study procedures were attended to in a private room. They were informed about the study in more detail and asked to volunteer to participate. Patients were eligible to participate if they were HIV positive on stable HAART for at least 1 year, aged 18 years or older, and able to communicate in Afrikaans, English language, or isiXhosa. Participants were excluded if they were pregnant, are not physically or psychologically fit to answer questions, or did not give consent

The study of Muhammad et al. (2019) who investigated the associations of food insecurity and psychosocial measures with diet quality in adults aging with HIV was used to determine the sample size using G*Power (version 3.1.9.7). Muhammad et al. (2019) reported a diet quality score of 46.78±11.73 using the Alternate Healthy Index score that was initially designed by McCullough et al. (2002). This was used together with a 95% confidence level and a power of 90%.

The required sample size calculated was 234 participants. We recruited a total of 247 participants, and 1 participant was excluded during data cleaning due to extensive missing clinical data. Participants were recruited between December 2021 and January 2022.

Permission and Ethical considerations

Ethical approval was granted by the Human Research Ethics Committee of the Faculty of Health Sciences, University of Cape Town (Ref: 413/2021) (Appendix D). Approval was also obtained from the Western Cape Province Department of Health (Ref: WC_202110_011) (Appendix E). Participants' recruitment commenced only after ethical clearance was obtained and continued until the required sample size was reached. Participants signed an informed consent form before any assessment was conducted. There was a low probability of risk for participants in this study. It was emphasized that they could exit the study at any point without giving any reason. The Declaration of Helsinki (Goodyear et al., 2007), Good Clinical Practice, and the laws of South Africa were the guiding principles of this study.

Measures

An interviewer-administered questionnaire (Addendum1), developed for this study, as well as the patients' folder, were used to collect data for this study. Data was collected on socio-demographic variables, clinical information (blood pressure), and diet.

Socio-demographic assessments

Socio-demographic characteristics were obtained during an interview with the participants using the questionnaire. We obtained information on participants' highest level of education as seen in addendum 1 which was reclassified into "no high school" (below grade 8 in South Africa), "some high school" (between grade 8 to 11 in South Africa), and "high school completed" (grade 12). As a very small percentage of the participants had post-high school (tertiary) education, they were included in the "high school completed" category. Other variables include marital status (married or unmarried), employment status (employed or unemployed), social grant (yes or no), and pregnancy history. Date of birth and gender (male or female) were obtained from the folder.

Clinical measures

Blood pressure history for the past 5years (if available), from 2017 to 2021 was obtained from the medical folder. Hypertension was defined as systolic pressure from 140 mmHg, diastolic pressure from 90 mmHg, or being treated with antihypertensive medicines in the facility, others were classified as non-hypertensive. Blood pressure was classified according to the Hypertension guideline working group (2014).

Dietary Intake Assessment

The dietary intake of respondents over the past month was assessed using a quantified food frequency questionnaire (FFQ). The FFQ included 44 food items from different groups including grains/starch, dairy and drinks, fruits and vegetables, proteins/meat, and others. It was compiled by an expert panel of registered dietitians using existing FFQs that assessed the dietary intake of educators from low socio-economic areas in the Western Cape (Seme, 2013), HIV patients attending an outpatient clinic in Groote Schuur Hospital, Western Cape (unpublished data, Harbron J) and pregnant women from low socio-economic areas in Western Cape (unpublished data, PASS study). Cues were also taken from the FFQ proposed in the Dietary Assessment and Education Kit (DAEK) (Steyn and Senekal, 2004).

We employed the use of food cards which contained the photos of food items on the FFQ list to ensure easy identification of food consumed and accuracy by our respondents. Participants were asked to identify the food items they have consumed in the past month by selecting the food cards containing these food items. Items consumed were separated from food items never consumed or not during the past month by placing the former on one pile, and the latter on another pile.

The fieldworker obtained information from each respondent on the frequency of consumption and the portion size consumed for the food items in the "consumed" photo pile. The frequency of consumption was estimated as "Never", "1-3 times/month", "1-3 times/week", "4-6 times/week", or "Every day". Household utensils and measures, as well as food models, were used to assist participants to estimate portion sizes. Standard portion sizes were included for each item on the FFQ. Participants could indicate whether they consumed one, half, twice, or more than twice the portion for each item on the FFQ. The portion sizes consumed by participants were converted to the gram amount of the food item using the MRC food quantities manual. The daily gram amount of each line item consumed was calculated by multiplying the portion size with the selected frequency. The data was analyzed using the FoodFinder software which is linked to the latest MRC food quantities manual and South African Food composition tables. Participants with implausible energy intakes, defined as less than 3,000 kj/d (kilojoules/day) or more than 20,000 kj/d (Ambrosini et al., 2018) were excluded from further dietary analyses.

To assess diet quality, the Dietary Approaches to Stop Hypertension (DASH) diet score was calculated according to Fung et al. (2008). The scoring of (Fung et al., 2008) was adopted because it has been previously used to assess the risk of CVD. The DASH has been recommended as an effective way of controlling high blood pressure, and compliance with the

recommendation has been assessed using several methods (Chobanian et al., 2003, Kwan et al., 2013), some focused on feeding trial while some focused on dietary counselling. Fung et al, (2008) scoring method was selected because it was developed based on a large sample of a prospective cohort study. The DASH diet emphasizes intakes of high fruits and vegetables, moderate low-fat dairy products, low animal protein, and a substantial amount of plant protein from legumes and nuts (Appel et al., 1997).

The score developed by Fung et al. (2008) focused on 8 components including high intakes of fruits, vegetables, nuts and legumes, low-fat dairy products, and whole grains alongside low intakes of sodium, sweetened beverages, and red or processed meats. Intakes of each food component were presented in servings per day except for sodium which was presented in grams per day. Intake was categorized into quintiles, for the first 5 categories, high intake was desirable, thus participants with intakes in quintile 1 obtained 1 point while those in quintile 5 obtained 5 points. This scoring was reversed for the last 3 groups, where a low intake was desirable. This indicates that the highest obtainable score from each category is 5, giving a minimum and maximum total score of 8 and 40 respectively. Quintiles were calculated for female and male participants separately. A higher DASH score represents better diet quality and adherence to the DASH dietary guidelines

Dietary Habits

We included questions to elicit responses on the dietary habits of the participants. Discretionary salt intake was assessed by asking if participants added salt to their food while cooking (always, sometimes, never, or don't know), if they added salt to their food on the table or before eating (yes, or no), the quantity of table salt they usually add to their food, if they added aromat or any other similar spice to their food (yes, or no), and the quantity of aromat they usually add to their food.

Furthermore, we also asked the participants how many times on average in a month they visited some listed street or fast-food outlets. Participants could estimate how many times in a week or month they ate each fast food. They could also indicate if they rarely or never ate them. The responses obtained were converted to an average frequency per month. A total fast food score was then calculated from the average frequency per month by adding the frequency of consumption of all the individual fast food for each participant.

Table 5. 1 Scoring criteria for the DASH diet index (Fung et al., 2008).

Component	Serving Size	Foods	Scoring Criteria
Fruits	One serving is 1 medium piece of fruit or 0.5 cups of berries (1 cup = 236.59 g)	All fruits	Q1 = 1 point Q2 = 2 points Q3 = 3 points Q4 = 4 points Q5 = 5 points
Vegetables	One serving is 0.5 cups of vegetables or 1 cup of green leafy vegetables (1 cup = 236.59 g)	All vegetables except potatoes and legumes	
Nuts and legumes	One serving is 28.35 g of nuts or 1 tablespoon (15 mL) of peanut butter	Nuts and peanut butter, beans, peas, lentils	
Whole grains	One slice of whole-grain bread or ½ cup cooked whole-grain cereal	Brown rice, barley wheat, brown bread or rolls, whole grain cereals, bran	
Low-fat diary	One serving is 125 ml of low-fat milk	Skim milk	
Sodium	-	Sum of sodium contents of all foods in FFQ	**Reverse scoring:** Q1 = 5 points Q2 = 4 points Q3 = 3 points Q4 = 2 points Q5 = 1 point
Red and processed meat	One serving is 90 g of cooked meat.	Beef, pork, lamb, deli meats, organ meats, hot dogs, bacon, and other processed meats	
Sweetened beverages	One serving is 1 small glass (200 ml) of drink	Carbonated and non-carbonated sweetened beverages	

Other measures

HIV and ART duration were obtained from the medical folder, smoking status and physical activity were asked and recorded; waist circumference was measured. The methods for these variables were described in detail in chapter 4.

Statistical methods

Data was captured into a Microsoft Excel (version 2180) spreadsheet daily during data collection. Data were checked, cleaned, and analyzed using RStudio Version 1.2.5033. The distribution of numerical variables was explored for normality using box and whisker plots, and Shapiro-Wilk's test.

Numerical variables with parametric distribution were summarized using mean and standard deviation while those with a non-parametric distribution were summarized using the median and interquartile range. Categorical variables were summarized using count and proportions.

Participants were categorized into two groups using their most recent BP: non-hypertensive (non-HTN) and hypertensive (HTN). The hypertensive group also included those who were on anti-hypertensive medication but had normal B.P. Two-sample t-test was used to test for

differences in numerical variables with a parametric distribution between the two groups while Wilcoxon rank-sum test was used for numeric variables with a non-parametric distribution. Z-test for the difference in proportions was used to test differences in categorical variables between the two groups.

A multivariate logistic regression model was fitted to identify the odds of being hypertensive among the participants. All results with a p-value <0.05 were described as statistically significant.

RESULTS

We classified the participants into two groups; hypertensive (HTN) and non-hypertensive (non-HTN). Based on the defined protocol, the prevalence of hypertension among the participants was 50.0%. It is important to note that 57.7% of those with hypertension were being treated with medications. The two groups were merged for analysis.

Sociodemographic and Socioeconomic Information

The majority (69.9%) of participants were female and above 40 years old with a median age of 46 years (Table 5.2). A smaller proportion (15.9%) of the participants did not have high school education compared with those who had some high school education (41.5%) or those who completed high school (42.7%). More than half of the participants reported that they were unmarried (61.8%), unemployed (56.1%), and did not receive any form of social grant (62.6%). We recruited 172 female participants of which 94.2% reported to have been previously pregnant. A hundred (40.7%) participants were classified as obese while 68 (27.6%) were overweight and 31.7% were normal weight.

There were statistically significant differences in the median age, level of education, and being previously pregnant between those classified as hypertensive and those without hypertension. Participants with hypertension were on average 6 years older ($p<0.001$), and a higher proportion had previously been pregnant ($p=0.008$) compared with those without hypertension. The proportion of participants with no high school education was higher among the hypertensive group when compared with those without hypertension ($p=0.019$). There were no statistically significant differences between hypertensive participants and those without hypertension for sex ($p=0.781$), marital status ($p=0.793$), employment status ($p=0.607$), BMI category ($p=0.499$), and whether they were social grant recipients (Table 5.2).

Table 5. 2 Sociodemographic and Socioeconomic Information

	Total	***Non-HTN***	***HTN***	***P-value***
	(N=246)	***N (%) = 123 (50%)***	***N (%) = 123 (50%)***	
Age (years)				**<0.001**[1]
Median [IQR]	46.0 [39.0, 53.0]	43.0 [38.0, 49.0]	49.0 [42.5, 57.0]	
Sex [n (%)]				0.781[2]
Male	74 (30.1)	38 (30.9)	36 (29.3)	
Female	172 (69.9)	85 (69.1)	89 (70.7)	
Level of Education [n (%)]				**0.019**[2]
No High School	39 (15.9)	12 (9.8)	27 (22.0)	
Some high school	102 (41.5)	51 (41.5)	51 (41.5)	
High school completed	105 (42.7)	60 (48.8)	45 (36.6)	
Marital Status [n (%)]				0.793[2]
Unmarried	152 (61.8)	77 (62.6)	75 (61.0)	
Married	94 (38.2)	46 (37.4)	48 (39.0)	
Employment Status [n (%)]				0.607[2]
Employed	108 (43.9)	56 (45.5)	52 (42.3)	
Unemployed	138 (56.1)	67 (54.5)	71 (57.7)	
Social Grant [n (%)]				0.792[2]
Yes	92 (37.4)	47 (38.2)	45 (36.6)	
No	154 (62.6)	76 (61.8)	78 (63.4)	
Have you ever been pregnant? [n (%)] n=172				**0.008**[2]
Yes	162 (94.2)	76 (89.4)	86 (98.9)	
No	10 (5.8)	9 (10.6)	1 (1.1)	
BMI Category [n (%)]				0.499[2]
Normal	78 (31.7)	43 (35.0)	35 (28.5)	
Overweight	68 (27.6)	31 (25.2)	37 (30.1)	
Obese	100 (40.7)	49 (39.8)	51 (41.5)	

[1]: Wilcoxon's Rank Sum Test, [2]: Z-Test for Proportions, IQR = Interquartile Range

<u>Other Health-related Information</u>

Waist circumference has a significant association with hypertension status. PLWH who had hypertension had a higher median waist circumference compared with those without hypertension (p=0.042). There was no significant difference among those with or without hypertension for total physical activity score (p=0.838), HIV duration (p=0.147), ART duration (p=0.223), and smoking pack-year (0.607).

Table 5. 3 Other Health-related Information

	Total	***Non-HTN***	***HTN***	***P-value***
	(N=246)	***N (%) = 123 (50%)***	***N (%) = 123 (50%)***	
Waist circumference *(cm)*				**<0.042**[1]
Median [IQR]	94.1 [83.3, 105.6]	92.5 [82.5, 103.6]	95.8 [85.6, 107.6]	
Physical Activity Score				0.838[2]
Mean (SD)	7.9 (1.3)	7.9 (1.4)	7.9 (1.1)	
HIV Duration (years) n=237				0.147[1]
Median [IQR]	12.0 [8.0, 15.0]	12.0 [7.0, 15.0]	12.5 [9.0, 15.3]	
ART Duration (years) n=243				0.223[1]
Median [IQR]	10.0 [7.0, 13.0]	9.0 [7.0, 12.8]	10.0 [8.0, 13.0]	
Smoking pack-year) n=61				0.607[2]
Median [IQR]	6.0 [2.4, 14.5]	5.3 [1.7, 10.0]	7.7 [2.5, 15.0]	

[1]: Wilcoxon's Rank Sum Test, [2]: ANOVA, IQR = Interquartile Range

Diet quality

Table 5.4 below shows the median (IQR) intake of the different food components of the DASH diet score. The median (IQR) intake is presented for all the participants, as well as for those in the lowest quintile (Q1) and the highest quintile (Q5).

The median intake of fruits among the participants was 0.86 servings/day while for vegetables was 1.63 servings/day. The median intake of nuts and legumes was 0.43 servings/day, whole grains was 2.11 servings/day, and low-fat dairy was 0 servings/day. The median intake of sodium was 1.68 g/day, red and processed meat was 1.01 servings/day, and sugar-sweetened beverages were 1.01 servings/day.

The median intakes of these DASH components were compared between those with and without hypertension. Only the intake of Nuts and legumes was significantly different. Those with hypertension had a higher median (IQR) intake of nuts and legumes than those without hypertension [0.57 (0.14, 1.00) vs 0.29 (0.07, 0.61), p=0.003]. The intakes were also compared between male and female participants but there was no significant difference (data shown in Appendix C).

Table 5. 4 Median intakes of DASH Score components

Component[1]	*Total Median (IQR) Intake*	*Median (IQR) Intake – Lowest Quintile*	*Median (IQR) Intake – Highest Quintile*
Fruits (serving/day)	0.86 (0.29, 2.00)	0.25 (0.00, 0.29)	3.00 (3.00, 3.00)
Vegetables (serving/day)	1.63 (0.86, 2.57)	0.36 (0.07, 0.61)	4.03 (3.57, 5.00)
Nuts and legumes (serving/day)	0.43 (0.14, 0.86)	0.00 (0.00, 0.04)	1.93 (1.25, 2.29)
Whole grains (serving/day)	2.11 (0.57, 3.02)	0.07 (0.00, 0.29)	3.86 (3.36, 4.15)
Low-fat dairy (serving/day)	0 (0, 0)	0 (0, 0)	3 (3, 3)
Sodium (g/day)	1.69 (1.12, 2.31)	0.89 (0.69, 0.97)	2.93 (2.64, 3.15)
Red and processed meat (serving/day)	1.01 (0.34, 1.72)	0.11 (0.00, 0.21)	3.46 (2.73, 3.81)
Sweetened beverages (serving/day)	1.01 (0.50, 2.52)	0.19 (0.00, 0.25)	3.62 (3.02, 5.17)

IQR: Interquartile Range, [1]: See Table 5.1 for serving size

Table 5.5 shows the average score for each component of the DASH index, and the total DASH score for female, male, and all participants. The DASH score has a minimum and maximum score of 8 and 40 respectively. The total mean (SD) DASH score of the participants was 21.58 (4.5). Although the mean (SD) DASH Score of those without hypertension was 0.91 units higher than those with hypertension [22.10 (5.0) vs 21.19 (5.1), p=0.171], this difference was not statistically significant. The DASH score was divided into quintiles, the frequency of those with and without hypertension in each quintile was compared, and no significant difference was found (p=0.062). Similarly, systolic and diastolic blood pressure was compared between quintiles of the total DASH score. Although the highest quintile had the lowest systolic pressure (128.79 mmHg), and the third quintile had the highest (136.67mmHg), there was no statistically significant difference (p=0.126). Furthermore, the third quintile had the lowest diastolic pressure (77.07 mmHg), and the second quintile had the highest (78.6 mmHg), diastolic pressure was not significantly different between the groups (p=0.914). There was no significant difference in the DASH score between male and female participants.

Table 5. 5 DASH Score[1]

	All Participants		Female Participants		Male Participants	
Component	**Median (IQR) DASH Score**	**Mean (SD) DASH Score**	**Median (IQR) DASH Score**	**Mean (SD) DASH Score**	**Median (IQR) DASH Score**	**Mean (SD) DASH Score**
Fruits	**3.00 (1.00, 4.00)**	2.78 (1.41)	**3.00 (1.00, 4.00)**	2.81 (1.39)	**2.00 (1.00, 4.00)**	2.72 (1.45)
Vegetables	**3.00 (2.00, 4.00)**	2.98 (1.43)	**3.00 (2.00, 4.00)**	2.99 (1.43)	**3.00 (2.00, 4.00)**	2.96 (1.42)
Nuts and legumes	**3.00 (2.00, 4.00)**	2.96 (1.43)	**3.00 (2.00, 4.00)**	2.96 (1.43)	**3.00 (2.00, 4.00)**	2.96 (1.43)
Whole grains	**3.00 (2.00, 4.00)**	2.91 (1.45)	**3.00 (1.00, 4.00)**	2.90 (1.47)	**3.00 (2.00, 4.00)**	2.92 (1.41)
Low-fat dairy	**1.00 (1.00, 1.00)**	1.01 (0.24)	**1.00 (1.00, 1.00)**	1.02 (0.17)	**1.00 (1.00, 1.00)**	1.04 (0.36)
Sodium	**3.00 (2.00, 4.00)**	2.99 (1.42)	**3.00 (2.00, 4.00)**	3.00 (1.42)	**3.00 (2.00, 4.00)**	2.97 (1.43)
Red and processed meat	**3.00 (2.00, 4.00)**	2.99 (1.42)	**3.00 (2.00, 4.00)**	3.00 (1.42)	**3.00 (2.00, 4.00)**	2.96 (1.43)
Sweetened beverages	**3.00 (2.00, 4.00)**	2.95 (1.43)	**3.00 (2.00, 4.00)**	2.98 (1.41)	**3.00 (1.00, 4.00)**	2.89 (1.49)
TOTAL	22.00 (18.00, 25.00)	**21.58 (5.07)**	22.00 (18.00, 26.00)	**21.65 (5.03)**	22.00 (17.00, 26.00)	**21.41 (5.21)**

IQR: Interquartile Range, SD: Standard Deviation

[1]: Mean and median scores are reported here and in some other tables below because the otherwise appropriate measure (median) based on normality does not provide enough meaningful summary of the variables concerned

Consumption of Foods High in Salt Content

The majority (79.3%) of the participants added salt to their food while cooking, 11.8% sometimes add, while only 8.9% never add salt to their food (Table 5.6).

About 81.7% of the participants reported not adding salt to their food on the table, while the remaining 18.3% said they did. Among those who added salt to their food on the table, 73.3% estimated adding about ¼ teaspoon of salt to their food each day, while 26.7% estimated more than ¼ teaspoon. More than half (55.3%) of the participants added aromat or other similar spice to their food before eating, while 44.7% reported not doing so. Among those who added aromat or other similar spice to their food before eating, 48.5% estimated adding about ¼ teaspoon to their food each day, while 51.5% estimated more than ¼ teaspoon.

Table 5. 6 Consumption of Foods High in Salt Content

	Total	***Non-HTN***	***HTN***	***P-value***
	(N=246)	***N (%) = 123 (50%)***	***N (%) = 123 (50%)***	
Is salt added to your food while it is being cooked? [n (%)]				
Always	195 (79.3)	100 (81.3)	95 (77.2)	0.188[1]
Never	22 (8.9)	7 (5.7)	15 (12.2)	
Sometimes	29 (11.8)	16 (13.0)	13 (10.6)	
Do you add salt to your food before you eat it? [n (%)]				
No	201 (81.7)	100 (81.3)	101 (82.1)	0.869[1]
Yes	45 (18.3)	23 (18.7)	22 (17.9)	
How much salt do you add to your food each day? [n (%)] n=45				
¼ teaspoon	33 (73.3)	19 (82.6)	14 (63.6)	0.150[1]
> ¼ teaspoon	12 (26.7)	4 (17.4)	8 (36.4)	
Do you add Aromat or other similar spice to your food before you eat it? [n (%)]				
No	110 (44.7)	54 (43.9)	56 (45.5)	0.798[1]
Yes	136 (55.3)	69 (56.1)	67 (54.5)	
How much Aromat/other spice with Aromat do you add to your food each day? [n (%)] n=136				
¼ teaspoon	66 (48.5)	31 (44.9)	35 (52.2)	0.394[1]
> ¼ teaspoon	70 (51.5)	38 (55.1)	32 (47.8)	

[1]: Z-test

There was no statistically significant difference between the dietary habit of those with and without hypertension (Table 5.6).

Consumption of fast foods

The most consumed fast food among the participants was fried fish (and chips) takeaway with 67.5% while the least consumed was Chinese takeaway with 2.9%. While about 67.5% of the

participants reported frequent consumption, the median time of consumption for fried fish (and chips) takeaway was 2 times per month. Quarters from tuck shops had the highest median time of consumption (3 times per month), however, only 13.8% of the participants reported usual consumption (Table 5.7). In all, 88.2% of the participants reported frequent consumption of at least one fast food.

Table 5. 7 Consumption of Fast Foods

Fast Food	*Percentage of those who consumed n(%)*[1]	*Mean (SD) frequency of consumption / month*	*Median (IQR) frequency of consumption/month*
Fried fish (and chips) takeaway	166 (67.5)	3.7 (5.3)	2.0 (1, 4)
KFC	161 (65.5)	3.1 (4.6)	1.0 (1, 3)
Pizza	117 (47.6)	1.7 (1.1)	1.0 (1, 2)
Gatsby/ bunny chow	85 (34.6)	2.9 (4.8)	1.0 (1, 4)
Hamburger restaurants	75 (30.5)	2.2 (3.8)	1.0 (1, 2)
Others	48 (19.5)	2.4 (2.3)	1.5 (1, 2)
Spur	45 (18.3)	1.2 (0.6)	1.0 (1, 1)
Chicken Licken	42 (17.1)	2.2 (4.5)	1.0 (1, 1)
Nandos	39 (15.9)	1.4 (1.3)	1.0 (1, 1)
Quarters from tuck shop	34 (13.8)	5.7 (7.7)	3.0 (1, 7)
Mexican takeaway	10 (4.1)	2.0 (2.3)	1.0 (1, 1)
Chinese takeaway	7 (2.9)	2.3 (1.4)	2.0 (1, 4)
TOTAL	217 (88.2)	9.2 (11.6)	5.0 (2, 11)

[1]: Percentage of those who reported that they usually consumed each of the fast food recently.

The mean fast food score of those with and without hypertension (8.63 and 9.73 respectively) was not significantly different (p=0.456).

Predictors of Hypertension

A multivariate logistic regression model was constructed to identify the odds of being hypertensive among the participants. Variables that had a significant p-value from Tables 5.2 and 5.3 and the DASH score were added to this model. For the categorical independent variable "level of education", the "No high school" category was made the reference category.

As shown in Table 5.8, on average, a unit increase in DASH score is associated with 0.98 odds (95% CI: 0.92, 1.03) of being hypertensive. However, the relationship between DASH score and hypertension remained insignificant as it was in the univariate model. Although age, waist

circumference, and level of education had a significant association with being hypertensive in the univariate model, only age remained significant in the multivariate model. On average, a year increase in age is associated with 1.06 (95% CI: 1.02, 1.09) odds of being hypertensive, this association was statistically significant.

Table 5. 8 Predictors of Hypertension

Coefficients	***OR (95% CI)***	***p-value***
Age	1.06 (1.02 - 1.09)	**<0.001**
DASH score	0.98 (0.92 – 1.03)	0.906
Waist circumference	1.02 (1.00 – 1.04)	0.095
Level of Education		
• *Some high school*	0.69 (0.28 – 1.67)	0.422
• *High School completed*	0.61 (0.24 - 1.51)	0.289

OR = Odds Ratio, CI = Confidence Interval

DISCUSSION

The prevalence of hypertension in this study was 50.0%. This supports the idea that the global burden of hypertension is high among PLWH (van Zoest et al., 2017). This prevalence is higher than the prevalence (38.6%) reported by Mutemwa et al. (2018) in their cross-sectional study of PLWH in the Western Cape. Similarly, it is higher than the prevalence of 35.1% reported by Berry et al. (2017) in their South African population-wide study of hypertension among people aged 15 and above. This may be because we classified participants based on using anti-hypertensive medications or a single BP which may not be conventional, but may potentially identify undiagnosed participants. Additionaly the difference may also be because Berry et al. (2017) included participants from age 15 while we included adults aged 18 and above. This underscores the need to identify factors associated with being hypertensive among this population.

In their findings, Berry et al. (2017) reported that 91.1% of those with hypertension were either unscreened, undiagnosed, untreated, or uncontrolled. In our study, 42.0% of those classified as hypertensive among the participants were not on anti-hypertensive medications. The higher prevalence in the Berry study may be because they included participants who were unscreened – defind as never had their blood pressure measured. The difference in the prevalence reported by Mutemwa et al (2018) could be attributed to the difference in the methodologies used, for instance the Mutemwa study included larger sample size, used random sampling, and included 17 facilities. Hyle et al. (2019) reported that hypertension was prevalent among PLWH on ART in their South African study with less than half diagnosed, and fewer being treated. Focused attention should be given to chronic diseases within the primary healthcare system (Day et al., 2014), including among PLWH.

The median age of the participants was 46 years, and age had a significant association with being hypertensive. On average, people with hypertension were 6 years older than those without hypertension. This finding corroborates the findings of the SANHANES which showed that SBP and DBP increased with increasing age (Shisana et al., 2014). Similarly, Hyle et al. (2019) found that age was the only significant predictor of hypertension in their South African study among PLWH. The association between age and hypertension remained statistically significant in the multivariate analysis with results indicating a 6% increase in odds of being hypertensive for every one year increase in age. This suggests that the association between age and hypertension may not different with or without hypertension in South Africa.

Participants with hypertension were significantly less formally educated than those without hypertension (p=0.019). This corroborates the findings of Malaza et al. (2012) who reported that

educational attainment was significantly associated with hypertension in both univariate and multivariate analysis in their study of adults living with HIV. In our study, however, this association was not statistically significant after controlling for age and DASH score in the multivariate analysis. Cois and Ehrlich (2014) in their analysis of the South African National Income Dynamics study data also reported a similar association. Cois and Ehrlich (2014) reported that higher educational attainment was associated with lower blood pressure among women but higher blood pressure among men. Overall, our findings suggest that educational status as a measure of socioeconomic status may have an association with blood pressure.

Furthermore, among female participants, being previously pregnant was significantly associated with hypertension (p=0.008), with the hypertensive group having a higher proportion of those who had been previously pregnant. We could not trace any literature indicating an increased risk in women with a history of pregnancy. However, we suggest that this increased risk of hypertension may be related to a history of hypertension during previous pregnancies. Unfortunately, we do not have data to explore this association.

No other sociodemographic or socioeconomic characteristic of the participants had a significant association with being hypertensive or not. However, we believe that this may be affected by the peculiarity of our sample. For example, a national cross-sectional study showed that hypertension was significantly less likely among South African women than men (Peer et al., 2018). Higher blood pressure among men compared to women has also been reported among PLWH (Kent et al., 2017). On the other hand, our study shows no significant gender difference in the proportion of those who were hypertensive compared to those who were not. This may be due to the smaller proportion of males compared to females in our sample.

Having the largest foodservice market in sub-Saharan Africa and very competitive hospitality industry, South Africa's fast-food market size is projected to reach $4.9 billion by 2026 (Allied Market Research, 2019). A national survey by Steyn et al. (2011) showed that street food or fast food was consumed by a large proportion of the South African population. Fried fish (and chips) takeaway was the most commonly consumed fast food among the participants in our study and was consumed by over two-thirds of the sample. Similar findings were reported in an exploratory survey conducted in rural South Africa by Feeley et al. (2011). Feeley and colleagues reported that two-thirds of the participants consumed fried chips or vetkoek which is high in calories and fat.

There is a paucity of data on fast food consumption among PLWH. However, we found the study of Wrottesley et al. (2014) who reported that the consumption of fat, sugar and refined foods was common among their sample of HIV-infected and uninfected women in Soweto. Supporting

this, our findings show that at least a third of the participants consumed street or fast food including fried fish (and chips), KFC, pizza, and Gatsby at least once a month. This is an issue of public health concern due to the fat, sugar, and salt composition of these food items (Ronquest-Ross et al., 2015). Consumption of fast or street food may be affected by some sociodemographic factors including the possession of basic home appliances (Steyn et al., 2011). Nutrition education on cheap and healthy food choices is needed among PLWH attending primary healthcare facilities in South Africa.

Discretionary salt consumption was commonly reported among the participants of a study by (Charlton et al., 2021) with 79.3% always cooking with salt. Furthermore, 55.3% reported adding aromat or other similar spices to their food. Aromat is a flavour enhancer containing monosodium glutamate (Charlton et al., 2008), thus may potentially increase the sodium content of food. The median sodium intake per day among the participants was 1.70g, this complies with the WHO recommendation of less than 2g per day (WHO, 2020). This may be a reflection of the reduction in salt intake followed by national regulation (Charlton et al., 2021). As legislation is being enforced to reduce the sodium content of processed food, PLWH, and the general population should be educated on hidden and discretionary sources of sodium in the diet. However, the measure of sodium intake using the quantified FFQ with nutritional databases was not triangulated with other measure of sodium intake, this may be the reason for this result. We recommened cautious interpretation and the use of other objective measure of sodium intake in further studies. Furthermore, the participants consumed on average 1 serving of sweetened beverages, and red and processed meat daily. There are no studies reporting intakes of these dietary components among PLWH in South Africa. Due to the role of diet in the management of chronic diseases, more research is needed to inform possible nutrition interventions among PLWH in South Africa.

Adherence to the DASH diet encouraging a high intake of fruits, vegetables, and a moderate intake of low-fat dairy is associated with low CVD risk (Appel et al., 1997). The median servings of fruits and vegetables consumed by the participants per day were 0.86 and 1.63 respectively. This falls short of the WHO recommendation of at least five portions of fruits and vegetables per day (WHO, 2020). The low intake of fruits and vegetables has been reported in a national cross-sectional study by Labadarios et al. (2011), and among PLWH in Cape Town by Hyle et al. (2021). However, studies reporting fruit and vegetable intake among PLWH are limited across South Africa. Low intakes of fruits and vegetables contribute significantly to the global burden of diseases especially CVD and cancers (Lock et al., 2005). Therefore, it is important to engage in further research to assess current levels of intake across the nation.

The mean (SD) DASH score of the participants was 21.58 (5.1). DASH diet score has not been reported among PLWH in South Africa, similarly, we could not identify any study among the uninfected population reporting DASH diet score. None of the DASH score components nor the total DASH score was significantly different by gender. This is contrary to the report of (Weiss et al., 2019b) who found a significantly lower HEI score among female PLWH than males in the US. However, this may be because of the higher percentage of females in the current study. Weiss et al. (2019b) recruited similar proportions of female and male participants. We propose further research recruiting equal proportions of females and males to be conducted to explore this possible difference in the diet quality.

Although the DASH score of participants without hypertension was higher, the difference was not statistically significant from the score of participants with hypertension both in the univariate and multivariate analysis. Similarly, systolic and diastolic blood pressure was not significantly different between quintiles of DASH. This non-significant relationship of DASH score with hypertension and blood pressure is contrary to the findings of Fung et al. (2008) who reported a significant association between adherence to DASH recommendations and a lower risk of Coronary Heart Disease (CHD) among women enrolled in the Nurses' Health Study in the US.

However, among PLWH, Policarpo et al. (2017) and Turcinov and Begovac (2011) reported that adherence to the Mediterranean diet recommendation was not associated with lipodystrophy and dichotomized CHD risk scores respectively. Although these studies, like the current one, were cross-sectional and Turcinov and Begovac (2011) had a relatively small sample size which may all introduce bias, the findings agree and may suggest that the increased risk of CVD among PLWH is not related to diet quality. It is important to note, however, that the measure of risk of CVD or CVD used in all the studies are not the same. While Policarpo et al. (2017) assessed lipodystrophy, Turcinov and Begovac (2011) assessed CHD risk scores, and we assessed hypertension. This makes the studies very heterogenous, we highly recommend cautious generalization. As this is the first South African study assessing the diet quality of PLWH with a predefined index, we suggest further studies across South Africa to provide more evidence. We conclude that the diet quality of hypertensive and non-hypertensive participants in our study was not significantly different.

STRENGTHS AND LIMITATION

It is also the first to assess dietary adequacy using a diet quality index in South Africa. This will lay a foundation for further research and form a basis for nutrition intervention among PLWH. Another strength of this study is the inclusion of all eligible non-pregnant adults with no maximum age limit.

A major limitation of this study is the use of a single blood pressure value to categorize participants into groups, in addition to those who are on anti-hypertensive medication. However, since Berry et al. (2017) reported that several people with hypertension are undiagnosed in South Africa, this might have enabled us to identify participants who may be potentially hypertensive but not yet diagnosed by the clinic. This was reported to the physician daily to ensure proper follow up. Recruiting participants from one clinic and having no uninfected control limits the extent to which the findings of this study may be generalized. It is therefore important that the finding of this study be confirmed in further case-control or intervention studies. The use of self-reported dietary data is subject to recall bias and may affect accuracy of findings. Furthermore, the measure of sodium intake using the quantified FFQ with nutritional databases as mentioned earlier could be a another limitation of the study. Finally, another limitation that require cautious interpretation of our finding is the likelihood of false positive with multiple variable testing (Groenwold et al., 2021). This along with the fact that statistical significance does not imply clinical significance (Wasserstein and Lazar, 2016) should be borne in mind while using the finding of this study.

CONCLUSION

In conclusion, the findings of this study confirm that the burden of hypertension among PLWH is high and a fifth of our sample had untreated hypertension. Blood pressure was significantly associated with age, level of education, and previous pregnancy. Discretionary salt intake was commonly reported among the participants, specifically cooking with salt and adding aromat to their food. However, median sodium intake was within WHO recommendations. We recommend that other means of assessing sodium levels, such as urinary sodium concentration, should be adopted with the dietary assessment to confirm whether there may be inconsistencies with the use of nutritional databases.

The majority of the participants used full-cream milk and cooked it with sunflower or other similar oil. The most commonly consumed fast foods were fried fish (and chips), KFC, pizza, and gatsby; and they were consumed on average at least once a month. Intakes of fruits and vegetables fell short of recommendation, and an average daily intake of 1 serving of sweetened beverages, and red and processed meat were reported among the participants.

The diet quality of participants in this study had medium adherence to the DASH regulation and was not significantly different by the presence or absence of hypertension. Further research specifically reporting nutrient intakes of PLWH in South Africa is needed especially because this was not fully explored in the current study. We also suggest the adoption of diet quality indices for the assessment of diet adequacy among PLWH in further studies in South Africa. This will

provide evidence and form a basis for nutritional intervention which will consequently yield great public health benefits.

REFERENCES

ALLIED MARKET RESEARCH. 2019. *South Africa Fast Food Market Outlook-2026* [Online]. Available: https://www.alliedmarketresearch.com/south-africa-fast-food-market#:~:text=The%20South%20Africa%20fast%20food,and%20highly%20competitive%20hospitality%20industry. [Accessed 11/05/2022 2022].

AMBROSINI, G. L., HURWORTH, M., GIGLIA, R., TRAPP, G. & STRAUSS, P. 2018. Feasibility of a commercial smartphone application for dietary assessment in epidemiological research and comparison with 24-h dietary recalls. *Nutrition journal,* 17**,** 1-10.

ANNE-LISE, P., CHANG, C.-C. H., SO-ARMAH, K. A., BUTT, A. A., LEAF, D. A., BUDOFF, M., RIMLAND, D., BEDIMO, R., GOETZ, M. B. & RODRIGUEZ-BARRADAS, M. C. 2015. Human immunodeficiency virus infection, cardiovascular risk factor profile and risk for acute myocardial infarction. *Journal of acquired immune deficiency syndromes (1999),* 68**,** 209.

APPEL, L. J., MOORE, T. B., OBARZANEK, E., VOLLMER, W. M., SVETKEY, L. P., SACKS, F. M., BRAY, G. A., VOGT, T. M., CUTLER, J. A., WINDHAUSER, M. M., LIN, P.-H., KARANJA, N., SIMONS-MORTON, D., MCCULLOUGH, M., SWAIN, J., STEELE, P., EVANS, M. A., MILLER, E. R. & HARSHA, D. W. 1997. A Clinical Trial of the Effects of Dietary Patterns on Blood Pressure. 336.

ARMAH, K., CHANG, C., BAKER, J., RAMACHANDRAN, V., BUDOFF, M., CRANE, H., GIBERT, C., GOETZ, M., LEAF, D. & MCGINNIS, K. 2014. Veterans Aging Cohort Study (VACS) Project Team. Prehypertension, hypertension, and the risk of acute myocardial infarction in HIV-infected and-uninfected veterans. *Clin Infect Dis,* 58**,** 121-9.

BASILE, J. & BLOCH, M. J. 2015. Overview of hypertension in adults. *UpToDate, Waltham, MA*.

BERRY, K. M., PARKER, W.-A., MCHIZA, Z. J., SEWPAUL, R., LABADARIOS, D., ROSEN, S. & STOKES, A. 2017. Quantifying unmet need for hypertension care in South Africa through a care cascade: evidence from the SANHANES, 2011-2012. *BMJ global health,* 2**,** e000348.

CHARLTON, K. E., CORSO, B., WARE, L., SCHUTTE, A. E., WEPENER, L., MINICUCI, N., NAIDOO, N. & KOWAL, P. 2021. Effect of South Africa's interim mandatory salt reduction programme on urinary sodium excretion and blood pressure. *Prev Med Rep,* 23**,** 101469.

CHARLTON, K. E., STEYN, K., LEVITT, N. S., PEER, N., JONATHAN, D., GOGELA, T., ROSSOUW, K., GWEBUSHE, N. & LOMBARD, C. J. 2008. A food-based dietary strategy lowers blood pressure in a low socio-economic setting: a randomised study in South Africa. *Public health nutrition,* 11**,** 1397-1406.

CHARLTON, K. E., STEYN, K., LEVITT, N. S., ZULU, J. V., JONATHAN, D., VELDMAN, F. J. & NEL, J. H. 2005. Diet and blood pressure in South Africa: Intake of foods containing sodium, potassium, calcium, and magnesium in three ethnic groups. *Nutrition,* 21**,** 39-50.

CHOBANIAN, A. V., BAKRIS, G. L., BLACK, H. R., CUSHMAN, W. C., GREEN, L. A., IZZO JR, J. L., JONES, D. W., MATERSON, B. J., OPARIL, S. & WRIGHT JR, J. T. 2003. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. *Jama,* 289**,** 2560-2571.

COIS, A. & EHRLICH, R. 2014. Analysing the socioeconomic determinants of hypertension in South Africa: a structural equation modelling approach. *BMC Public Health,* 14**,** 1-11.

DAY, C., GROENEWALD, P., LAUBSCHER, R., VAN SCHAIK, N. & BRADSHAW, D. 2014. Monitoring of non-communicable diseases such as hypertension in South Africa: Challenges for the post-2015 global development agenda. *South African medical journal,* 104**,** 680-687.

FAHME, S. A., BLOOMFIELD, G. S. & PECK, R. 2018. Hypertension in HIV-infected adults: novel pathophysiologic mechanisms. *Hypertension,* 72**,** 44-55.

FEELEY, A. B. B., KAHN, K., TWINE, R. & NORRIS, S. 2011. Exploratory survey of informal vendor-sold fast food in rural South Africa. *South African Journal of Clinical Nutrition,* 24**,** 199-201.

FILIPPOU, C. D., TSIOUFIS, C. P., THOMOPOULOS, C. G., MIHAS, C. C., DIMITRIADIS, K. S., SOTIROPOULOU, L. I., CHRYSOCHOOU, C. A., NIHOYANNOPOULOS, P. I. & TOUSOULIS, D. M. 2020. Dietary Approaches to Stop Hypertension (DASH) Diet and Blood Pressure Reduction in Adults with and without Hypertension: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Adv Nutr,* 11**,** 1150-1160.

FUNG, T., CHIUVE, S., MCCULLOUGH, M., REXRODE, K., LOGROSCINO, G. & HU, F. 2008. Adherence to a DASH-Style diet and risk of coronary heart disease and stroke in women. *Archives Of Internal Medicine,* 168**,** 713-720.

GROENWOLD, R. H. H., GOEMAN, J. J., CESSIE, S. L., AND DEKKERS, O. M. (2021). Multiple testing: when is many too much?. *European Journal of Endocrinology* 184, 3, E11-E14, available from: < https://doi.org/10.1530/EJE-20-1375> [Accessed 21 October 2022]

GOODYEAR, M. D., KRLEZA-JERIC, K. & LEMMENS, T. 2007. The declaration of Helsinki. British Medical Journal Publishing Group.

GUTIERREZ, J., ALBUQUERQUE, A. L. A. & FALZON, L. 2017. HIV infection as vascular risk: a systematic review of the literature and meta-analysis. *PloS one,* 12**,** e0176686.

HYLE, E. P., BEKKER, L. G., MARTEY, E. B., HUANG, M., XU, A., PARKER, R. A., WALENSKY, R. P. & MIDDELKOOP, K. 2019. Cardiovascular risk factors among ART-experienced people with HIV in South Africa. *J Int AIDS Soc,* 22**,** e25274.

HYLE, E. P., MARTEY, E. B., BEKKER, L. G., XU, A., PARKER, R. A., WALENSKY, R. P. & MIDDELKOOP, K. 2021. Diet, physical activity, and obesity among ART-experienced people with HIV in South Africa. *AIDS Care***,** 1-7.

HYPERTENSION GUIDELINE WORKING GROUP 2014. South African hypertension practice guideline 2014 [correction appears in Cardiovasc J Afr 2015; 26: 90.]. *Cardiovasc J Afr,* 25**,** 288-94.

KANDALA, N.-B., TIGBE, W., MANDA, S. O. & STRANGES, S. 2013. Geographic variation of hypertension in sub-saharan Africa: a case study of South Africa. *American journal of hypertension,* 26**,** 382-391.

KENT, S. T., SCHWARTZ, J. E., SHIMBO, D., OVERTON, E. T., BURKHOLDER, G. A., OPARIL, S., MUGAVERO, M. J. & MUNTNER, P. 2017. Race and sex differences in ambulatory blood pressure measures among HIV+ adults. *Journal of the American Society of Hypertension,* 11**,** 420-427.e3.

KWAN, M. W.-M., WONG, M. C.-S., WANG, H. H.-X., LIU, K. Q.-L., LEE, C. L.-S., YAN, B. P.-Y., YU, C.-M. & GRIFFITHS, S. M. 2013. Compliance with the Dietary Approaches to Stop Hypertension (DASH) diet: a systematic review. *Plos one,* 8**,** e78412.

LABADARIOS, D., STEYN, N. P. & NEL, J. 2011. How diverse is the diet of adult South Africans? *Nutr J,* 10**,** 33.

LENFANT, C., CHOBANIAN, A. V., JONES, D. W. & ROCCELLA, E. J. 2003. Seventh report of the Joint National Committee on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) resetting the hypertension sails. Am Heart Assoc.

LIM, S. S., VOS, T., FLAXMAN, A. D., DANAEI, G., SHIBUYA, K., ADAIR-ROHANI, H., ALMAZROA, M. A., AMANN, M., ANDERSON, H. R. & ANDREWS, K. G. 2012. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The lancet,* 380**,** 2224-2260.

LOCK, K., POMERLEAU, J., CAUSER, L., ALTMANN, D. R. & MCKEE, M. 2005. The global burden of disease attributable to low consumption of fruit and vegetables: implications for the global strategy on diet. *Bulletin of the World health Organization,* 83**,** 100-108.

MAGANDE, P. N., CHIRUNDU, D., GOMBE, N. T., MUNGATI, M. & TSHIMANGA, M. 2017. Determinants of uncontrolled hypertension among clients on anti-retroviral therapy in Kadoma City, Zimbabwe, 2016. *Clin Hypertens,* 23**,** 14.

MALAZA, A., MOSSONG, J., BÄRNIGHAUSEN, T. & NEWELL, M.-L. 2012. Hypertension and obesity in adults living in a high HIV prevalence rural area in South Africa.

MASENGA, S. K., KIRABO, A., HAMOOYA, B. M., NZALA, S., KWENDA, G., HEIMBURGER, D. C., MUTALE, W., KOETHE, J. R., PILIC, L. & MUNSAKA, S. M. 2021. HIV-positive demonstrate more salt sensitivity and nocturnal non-dipping blood pressure than HIV-negative individuals. *Clin Hypertens,* 27**,** 2.

MCCULLOUGH, M. L., FESKANICH, D., STAMPFER, M. J., GIOVANNUCCI, E. L., RIMM, E. B., HU, F. B., SPIEGELMAN, D., HUNTER, D. J., COLDITZ, G. A. & WILLETT, W. C. 2002. Diet quality and major chronic disease risk in men and women: moving toward improved dietary guidance. *The American journal of clinical nutrition,* 76**,** 1261-1271.

MILLS, K. T., BUNDY, J. D., KELLY, T. N., REED, J. E., KEARNEY, P. M., REYNOLDS, K., CHEN, J. & HE, J. 2016. Global Disparities of Hypertension Prevalence and Control: A Systematic Analysis of Population-Based Studies From 90 Countries. *Circulation,* 134**,** 441-50.

MILLS, K. T., STEFANESCU, A. & HE, J. 2020. The global epidemiology of hypertension. *Nature Reviews Nephrology,* 16**,** 223-237.

MUHAMMAD, J., FERNANDEZ, J., CLAY, O., SAAG, M., OVERTON, E. & WILLIG, A. 2019. Associations of food insecurity and psychosocial measures with diet quality in adults aging with HIV. *AIDS care,* 31**,** 554-562.

MUTEMWA, M., PEER, N., DE VILLIERS, A., MUKASA, B., MATSHA, T. E., MILLS, E. J. & KENGNE, A. P. 2018. Prevalence, detection, treatment, and control of hypertension in human

immunodeficiency virus (HIV)-infected patients attending HIV clinics in the Western Cape Province, South Africa. *Medicine,* 97**,** e12121.

NDUKA, C., STRANGES, S., SARKI, A., KIMANI, P. & UTHMAN, O. 2016. Evidence of increased blood pressure and hypertension risk among people living with HIV on antiretroviral therapy: a systematic review with meta-analysis. *Journal of human hypertension,* 30**,** 355-362.

NGUYEN, K. A., PEER, N., MILLS, E. J. & KENGNE, A. P. 2015. Burden, determinants, and pharmacological management of hypertension in HIV-positive patients and populations: a systematic narrative review. *AIDS Rev,* 17**,** 83-95.

PECK, R. N., SHEDAFA, R., KALLUVYA, S., DOWNS, J. A., TODD, J., SUTHANTHIRAN, M., FITZGERALD, D. W. & KATARAIHYA, J. B. 2014. Hypertension, kidney disease, HIV and antiretroviral therapy among Tanzanian adults: a cross-sectional study. *BMC medicine,* 12**,** 1-11.

PEER, N., BALAKRISHNA, Y., DE VILLIERS, A. & NAIDOO, P. 2018. Differential associations of cardio-metabolic diseases by population group, gender and adiposity in South Africa. *PLoS One,* 13**,** e0202899.

POLICARPO, S., RODRIGUES, T., MOREIRA, A. C. & VALADAS, E. 2017. Adherence to Mediterranean diet in HIV infected patients: Relation with nutritional status and cardiovascular risk. *Clin Nutr ESPEN,* 18**,** 31-36.

REEDY, J., KREBS-SMITH, S. M., MILLER, P. E., LIESE, A. D., KAHLE, L. L., PARK, Y. & SUBAR, A. F. 2014. Higher diet quality is associated with decreased risk of all-cause, cardiovascular disease, and cancer mortality among older adults. *The Journal of nutrition,* 144**,** 881-889.

RONQUEST-ROSS, L.-C., VINK, N. & SIGGE, G. O. 2015. Food consumption changes in South Africa since 1994. *South African Journal of Science,* 111**,** 01-12.

RUST, P. & EKMEKCIOGLU, C. 2016. Impact of salt intake on the pathogenesis and treatment of hypertension. *Hypertension: from basic research to clinical practice***,** 61-84.

SEME, Z. B. 2013. *Formative assessment of teachers of grade four to six learners to advise the development of the teacher focus of a multi-component primary school-based intervention programme for the prevention of non-communicable diseases.* University of Cape Town.

SHISANA, O., LABADARIOS, D., REHLE, T., SIMBAYI, L., ZUMA, K., DHANSAY, A., REDDY, P., PARKER, W., HOOSAIN, E. & NAIDOO, P. 2014. The South African National Health and Nutrition Examination Survey, 2012: SANHANES-1: the health and nutritional status of the nation.

STATSSA. 2011. *Heideveld* [Online]. Available: https://census2011.adrianfrith.com/place/199029022 [Accessed 24/10/2022].

STEYN, N. P., LABADARIOS, D. & NEL, J. H. 2011. Factors which influence the consumption of street foods and fast foods in South Africa-a national survey. *Nutrition Journal,* 10**,** 104.

STEYN, N. P. & SENEKAL, M. 2004. *A guide for the use of the dietary assessment and education kit (DAEK)*, Medical Research Council.

SUBRAMANIAN, S., TAWAKOL, A., BURDO, T. H., ABBARA, S., WEI, J., VIJAYAKUMAR, J., CORSINI, E., ABDELBAKY, A., ZANNI, M. V. & HOFFMANN, U. 2012. Arterial inflammation in patients with HIV. *Jama,* 308**,** 379-386.

TURCINOV, D. & BEGOVAC, J. 2011. Predicted coronary heart disease risk in croatian HIV infected patients treated with combination antiretroviral therapy. *Coll Antropol,* 35**,** 115-21.

VAN ZOEST, R. A., VAN DEN BORN, B.-J. H. & REISS, P. 2017. Hypertension in people living with HIV. *Current Opinion in HIV and AIDS,* 12**,** 513-522.

WASSERSTEIN, R.L. AND LAZAR, N.A., 2016. The ASA statement on p-values: context, process, and purpose. The American Statistician, 70(2), pp.129-133.

WEBEL, A. R., SATTAR, A., FUNDERBURG, N. T., KINLEY, B., LONGENECKER, C. T., LABBATO, D., ALAM, S. K. & MCCOMSEY, G. A. 2017. Alcohol and dietary factors associate with gut integrity and inflammation in HIV-infected adults. *HIV Med,* 18**,** 402-411.

WEISS, J. J., SANCHEZ, L., HUBBARD, J., LO, J., GRINSPOON, S. K. & FITCH, K. V. 2019a. Diet Quality Is Low and Differs by Sex in People with HIV. *J Nutr,* 149**,** 78-87.

WEISS, J. J., SANCHEZ, L., HUBBARD, J., LO, J., GRINSPOON, S. K. & FITCH, K. V. 2019b. Diet quality is low and differs by sex in people with HIV. *The Journal of nutrition,* 149**,** 78-87.

WHO. 2020. *Healthy Diet* [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/healthy-diet#:~:text=At%20least%20400%20g%20(i.e.,cassava%20and%20other%20starchy%20roots. [Accessed 12/05/2022 2022].

WORLD HEALTH ORGANIZATION 2015. *Global status report on noncommunicable diseases 2014*, World Health Organization.

WROTTESLEY, S. V., MICKLESFIELD, L. K., HAMILL, M. M., GOLDBERG, G. R., PRENTICE, A., PETTIFOR, J. M., NORRIS, S. A. & FEELEY, A. B. 2014. Dietary intake and body composition in HIV-positive and -negative South African women. *Public Health Nutrition,* 17**,** 1603-1613.

XU, Y., CHEN, X. & WANG, K. 2017. Global prevalence of hypertension among people living with HIV: a systematic review and meta-analysis. *Journal of the American Society of Hypertension,* 11**,** 530-540.

CHAPTER 6: OVERVIEW, FINAL CONCLUSIONS AND RECOMMENDATIONS

OVERVIEW OF FINDINGS

A growing population of PLWH are being diagnosed with non-communicable diseases (NCDs). Shah et al. (2018) reported that PLWH have twice the risk of developing a CVD when compared to the uninfected population. CVD is an important cause of non-AIDS-related mortality among PLWH, and its prevalence may increase as PLWH continue to age (McGettrick et al., 2020). Findings from other studies have also suggested the increased risk of CVD among PLWH (Anne-Lise et al., 2015, Freiberg et al., 2013), including in South Africa (Hyle et al., 2019, Mashinya et al., 2015). Hyle et al. (2019) indicated that 23.0% of their sample had hypertension, while Mashinya et al. (2015) reported a prevalence of 48.3% and 33.2% for low HDL-C and hypercholesterolemia respectively among their South African cohort.

Factors that may are associated with the increased risk of CVD among PLWH have been identified including the use of HAART (Nsagha et al., 2015), and systemic inflammation (Duprez et al., 2012). Other non-HIV-specific factors associated with CVD among PLWH include male gender and aging. Bailin et al. (2020) suggested that diet and sedentary lifestyle which may contribute to excess adiposity may also increase the risk of CVD among PLWH.

The relationship between higher diet quality and a lower risk of CVD has been reported among PLWH (Muhammad et al., 2019) in the US, and the uninfected population (Xu et al., 2020). Furthermore, dietary interventions have reduced the risk of CVD among PLWH (Estruch et al., 2018, Lazzaretti et al., 2012, Stradling et al., 2012). However, studies reporting dietary intake among PLWH in South Africa are not recent and were conducted among ART-naïve participants (Hattingh et al., 2014, Hattingh et al., 2006, Wrottesley et al., 2014). Nonetheless, Wrottesley et al. (2014) reported that the diet of women in their study was obesogenic. The diet was high in refined carbohydrates, added sugar, and processed foods, and low in fruits, vegetables, and fish (Wrottesley et al., 2014). This prompted us to investigate the nutritional and health status of adults living with HIV stable on HAART attending the Heideveld CHC in Cape Town.

This study assessed the nutritional and health status of PLWH and investigated the association that may exist between this and the risks of CVD. We collected anthropometric data such as height and weight and compile indices such as BMI and WHR. Biochemical data were obtained from the medical folder. Dietary intake was assessed using a quantified FFQ, and diet quality indices including the aHEI and DASH scores were calculated from the FFQ data. Other parameters measured included food security status, smoking and alcohol intake, self-esteem, weight goals and perception, and the preferred weight management interventions of respondents.

The prevalence of obesity was 40.7% while 27.6% were overweight. Most of the participants in this study were middle-aged women with a median age of 46 years. The majority were unmarried, unemployed, did not receive any form of social grant, and only about half had completed high school education. The median duration of infection was 12 years, and the participants had been on ART for a median time of 10 years with the majority previously on the ARV regimen TEE and currently on TLD. The majority (94.7%) of participants had suppressed viral load (<50 copies/ml), while 66.5% (155) of these had a viral load Lower than Detectable Limits (LDL). About a third of the participants had comorbidities with hypertension being the most prevalent comorbidity reported, followed by dyslipidemia and diabetes. Other comorbidities reported were CVD, renal problems, and cancer. Using the most recent blood pressure, 37.4% of the participants had high blood pressure. Hypertension had a significant positive association with age. Median SBP and DBP were 133 mmHg and 77 mmHg respectively.

Obesity prevalence was significantly higher among females, those who had completed high school education, and women who had been previously pregnant. Central obesity was prevalent, with more than half of the participants at a high risk of metabolic complications based on their waist circumference and WHR. BMI category had a statistically significant positive relationship with waist circumference, WHR, and SBP.

The majority of the participants were happy with their current weight, about half thought their weight was normal, and there was a trend of underestimating their actual body weight. Participants in the overweight BMI category had the highest proportion of those who were satisfied with their present weight, while the obese category had the highest proportion of those who would like to lose weight. A half acknowledged that their weight had increased compared to the previous year, and the majority had never tried to lose nor gain weight. The majority indicated their interest in a nutrition intervention program and more than half of these preferred a group program. The interest of the participants in an intervention program opens a window of opportunity to be explored for stemming the tide of CVDs among PLWH.

Food insecurity was reported by 89.0% of the participants. About half did not engage in sports and exercise, as well as engaged in sedentary activities. Physical activity score had a significant negative association with BMI. Obese participants were more likely to engage in sedentary activities. The majority had high self-esteem scores. More than half had never smoked, and about a third were previous smokers. Obese participants were less likely to be previous or current smokers. Among the 21.5% who were current smokers, the mean smoking duration was 270 months, the median number of cigarettes smoked on a typical day was 7 sticks, and the

median smoking pack-year was 6. Alcohol consumption in the previous 12 months was reported among 36.2% of the participants.

The majority of the participants always cooked with salt and added aromat to their food. The most consumed fast food was fried fish (and chips), it was consumed on average two times a month by 67.5% of the participants. Other commonly consumed fast foods were KFC and pizza. Consumption of fruits and vegetables falls short of recommendation. Furthermore, habitual consumption of SSB and processed meat on average of 1 serving/day was reported among the participants. The consumption of these high-calorie foods coupled with the low consumption of fruits and vegetables in this population raises public health concerns and requires prompt and decisive actions.

Diet quality was assessed using the aHEI and DASH scores. The mean aHEI of the participants was below average score. The diet quality scores were not significantly associated with the presence or absence of comorbidity. This may suggest a non-significant association between diet and the risk of CVD among PLWH and this confirms the null hypothesis stated in the chapter one. However, more nutrition-focused research among PLWH is needed in South Africa to give more evidence to this finding.

PLWH with hypertension were older, less likely to have completed high school education, more likely to have been previously pregnant, and had higher waist circumference than those without hypertension. No associations were found for other variables including sex, BMI, diet quality, and patterns.

It is important to bear in mind the following limitations while interpreting the findings of this research:

- Biochemical data were obtained from the medical folder. These tests were conducted by the National Health Laboratory Services (NHLS) in the public section, and although this may indicate validity, the data may not reflect the current state of the participants
- The use of BMI alone with all its inherent limitations for grouping participants makes it important to apply the implications of this study with caution.
- The sample may not be representative of PLWH in the South African diverse population since we recruited participants from one clinic.
- Participants were not compared with uninfected control.
- The use of a single blood pressure reading to diagnose hypertension is not conventional.
- Incomplete biochemical data including creatinine and total cholesterol might have reduced the power of the study to detect associations and differences.

- The use of self-reported data especially for smoking, alcohol intake, physical activity, and dietary assessments may not be reliable. This is subject to recall bias, or participants intentionally providing false information to align with social norms.

FINAL CONCLUSIONS

The nutritional and health assessment of the participants indicated that, the prevalence of obesity and hypertension was high among the participants, and hypertension was the most prevalent comorbidity reported. The participants were mostly middle-aged females, they were on long-term ART and most of them had an undetectable viral load.

The dietary habits and consumption of participants did not conform to recommendations. This is evidenced by lower consumption of fruits and vegetables and higher consumption of SSBs, processed meat, and fast foods. Furthermore, diet quality of PLWH in this study was not significantly associated with hypertension and BMI category. Physical activity score was low, a few participated in physical activity while more engaged in sedentary behaviours.

The majority were satisfied with their weight and had a high self-esteem score. Nevertheless, about half of the participants acknowledged that their weight had increased over the past year without a deliberate intention to do so. Furthermore, the majority were interested in a group intervention program targeting health and wellness. People who were obese were more likely to be females, had completed secondary education, and had previously been pregnant. They were also less likely to be physically active during leisure, smokers, and satisfied with their weight. Hypertension was more likely among the older participants.

RECOMMENDATION

PLWH that are currently treated in the public sector at Heideveld clinic attend the clinic for routine medical checks and monitoring, as well as the collection of their ARVs. Those who may require dietary counseling are referred to a registered dietitian as determined by the doctor.

Based on the findings of this study, we make the following recommendations:

- We recommend that group nutrition education programs targeting weight management, physical activity, dietary intake, and smoking cessation be incorporated into routine HIV care at the PHC level.
- The dietary component of this nutrition education should focus on adequate intake of fruits and vegetables, lower intake of SSBs, and red and processed meat.

- We further recommend that an enabling environment that facilitates adequate PA should be made equitably available both in rural and urban areas.
- Due to the population of women of childbearing age in our sample, we recommend continued awareness of the importance of PMTCT.
- Regular screening for comorbidities especially hypertension among PLWH will reduce the possibility of undiagnosed cases.
- Higher educational attainment should be encouraged among PLWH. In addition, more employment opportunities should be made available to them. This may go a long way to reduce the level of food insecurity among PLWH.
- More nutrition-focused research among PLWH in SA should be encouraged. We recommend multi-level research covering multiple facilities and provinces for easy comparison.
- It is necessary to monitor the renal function of PLWH, therefore, we recommend that further studies should assess the glomerular filtration rate to assess this.

REFERENCES

ANNE-LISE, P., CHANG, C.-C. H., SO-ARMAH, K. A., BUTT, A. A., LEAF, D. A., BUDOFF, M., RIMLAND, D., BEDIMO, R., GOETZ, M. B. & RODRIGUEZ-BARRADAS, M. C. 2015. Human immunodeficiency virus infection, cardiovascular risk factor profile and risk for acute myocardial infarction. *Journal of acquired immune deficiency syndromes (1999),* 68**,** 209.

BAILIN, S. S., GABRIEL, C. L., WANJALLA, C. N. & KOETHE, J. R. 2020. Obesity and weight gain in persons with HIV. *Current HIV/AIDS Reports,* 17**,** 138-150.

DUPREZ, D. A., NEUHAUS, J., KULLER, L. H., TRACY, R., BELLOSO, W., DE WIT, S., DRUMMOND, F., LANE, H. C., LEDERGERBER, B. & LUNDGREN, J. 2012. Inflammation, coagulation and cardiovascular disease in HIV-infected individuals.

ESTRUCH, R., ROS, E., SALAS-SALVADÓ, J., COVAS, M.-I., CORELLA, D., ARÓS, F., GÓMEZ-GRACIA, E., RUIZ-GUTIÉRREZ, V., FIOL, M., LAPETRA, J., LAMUELA-RAVENTOS, R. M., SERRA-MAJEM, L., PINTÓ, X., BASORA, J., MUÑOZ, M. A., SORLÍ, J. V., MARTÍNEZ, J. A., FITÓ, M., GEA, A., HERNÁN, M. A. & MARTÍNEZ-GONZÁLEZ, M. A. 2018. Primary Prevention of Cardiovascular Disease with a Mediterranean Diet Supplemented with Extra-Virgin Olive Oil or Nuts. *The New England journal of medicine,* 378**,** e34.

FREIBERG, M. S., CHANG, C.-C. H., KULLER, L. H., SKANDERSON, M., LOWY, E., KRAEMER, K. L., BUTT, A. A., GOETZ, M. B., LEAF, D. & OURSLER, K. A. 2013. HIV infection and the risk of acute myocardial infarction. *JAMA internal medicine,* 173**,** 614-622.

HATTINGH, Z., LE ROUX, M., NEL, M. & WALSH, C. 2014. Assessment of the physical activity, body mass index and energy intake of HIV-uninfected and HIV-infected women in Mangaung, Free State province. *South African Family Practice,* 56**,** 196-200.

HATTINGH, Z., WALSH, C. M., VELDMAN, F. J. & BESTER, C. J. 2006. Macronutrient intake of HIV-seropositive women in Mangaung, South Africa. *Nutrition Research,* 26**,** 53-58.

HYLE, E. P., BEKKER, L. G., MARTEY, E. B., HUANG, M., XU, A., PARKER, R. A., WALENSKY, R. P. & MIDDELKOOP, K. 2019. Cardiovascular risk factors among ART-experienced people with HIV in South Africa. *J Int AIDS Soc,* 22**,** e25274.

LAZZARETTI, R. K., KUHMMER, R., SPRINZ, E., POLANCZYK, C. A. & RIBEIRO, J. P. 2012. Dietary intervention prevents dyslipidemia associated with highly active antiretroviral therapy in human immunodeficiency virus type 1-infected individuals: a randomized trial. *Journal of the American College of Cardiology,* 59**,** 979-988.

MASHINYA, F., ALBERTS, M. & COLEBUNDERS, R. 2015. Assessment of cardiovascular risk factors in people with HIV infection treated with ART in rural South Africa: a cross sectional study. *AIDS research and therapy,* 12**,** 1-10.

MCGETTRICK, P., MALLON, P. W. G. & SABIN, C. A. 2020. Cardiovascular disease in HIV patients: recent advances in predicting and managing risk. *Expert Review of Anti-infective Therapy,* 18**,** 677-688.

MUHAMMAD, J., FERNANDEZ, J., CLAY, O., SAAG, M., OVERTON, E. & WILLIG, A. 2019. Associations of food insecurity and psychosocial measures with diet quality in adults aging with HIV. *AIDS care,* 31**,** 554-562.

NSAGHA, D. S., ASSOB, J. C. N., NJUNDA, A. L., TANUE, E. A., KIBU, O. D., AYIMA, C. W. & NGOWE, M. N. 2015. Risk factors of cardiovascular diseases in HIV/AIDS patients on HAART. *The open AIDS journal,* 9**,** 51.

SHAH, A. S., STELZLE, D., LEE, K. K., BECK, E. J., ALAM, S., CLIFFORD, S., LONGENECKER, C. T., STRACHAN, F., BAGCHI, S. & WHITELEY, W. 2018. Global burden of atherosclerotic cardiovascular disease in people living with HIV: systematic review and meta-analysis. *Circulation,* 138**,** 1100-1112.

STRADLING, C., CHEN, Y. F., RUSSELL, T., CONNOCK, M., THOMAS, G. N. & TAHERI, S. 2012. The effects of dietary intervention on HIV dyslipidaemia: A systematic review and meta-analysis. *PLoS ONE,* 7.

WROTTESLEY, S. V., MICKLESFIELD, L. K., HAMILL, M. M., GOLDBERG, G. R., PRENTICE, A., PETTIFOR, J. M., NORRIS, S. A. & FEELEY, A. B. 2014. Dietary intake and body composition in HIV-positive and-negative South African women. *Public health nutrition,* 17**,** 1603-1613.

XU, Z., STEFFEN, L. M., SELVIN, E. & REBHOLZ, C. M. 2020. Diet quality, change in diet quality and risk of incident CVD and diabetes. *Public Health Nutrition,* 23**,** 329-338.

APPENDIX A – PARTICIPANTS' INFORMATION SHEET AND CONSENT FORM

Research on the Nutritional and Health Status of HIV+ Adults on Stable HAART Attending a Healthcare Facility in Cape Town, South Africa (2021)

Investigators: Janetta Harbron, Alastair Duncan, Tasneem Adams, Iyanuoluwa Oyetunji

Division of Physiological Sciences, Department of Human Biology, Faculty of Health Sciences, University of Cape Town (UCT)

Dear Study Participant,

You are invited to take part in a research study. We know that people living with HIV may have a risk of developing heart diseases and high sugar levels. We want to find out why this may be happening. We will ask questions about your physical activity levels, food you eat, and about your general health. The information will help us to propose recommendations to prevent the development of heart diseases and other long-term illnesses.

You may take part in this study if you attend this adherence club and have been taking medication for 1 year or more. You may not take part if you are currently below 18years, or currently pregnant. There will be about 250 participants in this study.

What will be expected of you?

If you agree to take part, we would like to:

- Measure how tall you are and how much you weigh.
- Measure your waist circumference, hip circumference and upper arm circumference using a tape measure.
- Ask you some questions and fill in a questionnaire about your usual pattern of consumption of certain foods, smoking, physical activity and how you feel about your health status.
- Obtain certain information from your medical file including your date of birth, age, height, weight at previous visits to this adherence club, medication history, as well as results of blood tests previously done in this clinic including your blood sugar, blood lipids, blood pressure, viral load and CD4 count history (if available).

This will be done by our research staff and will take about 45 minutes of your time.

Are there any benefits or risks for you if you take part in this study?

We want you to know that it is safe to take part in this study. After this study, we will give you a copy of the healthy eating pamphlet from the department of health, ***and a cash gift of R50.00.*** The information you give us will help us to understand your usual food intake pattern and how this and other factors affect your health status. It will also help us to develop possible

future treatment or intervention programs. A report of our findings from your assessment will be provided to the clinic staff for further follow-up if required.

How will your confidentiality be protected?

All information we get from this study will be coded and will be stored in a computer database that can only be assessed by the researchers with an assurance of confidentiality. Results published from this survey will not include any names.

Other important ethical considerations:

- This study was approved by the Faculty of Health Sciences, Human Research Ethics Committee of UCT (Reference number: 413-2021)
- The research will be done to international standards.
- Participation in this study is by your own free choice.
- You may withdraw from the study at any time without stating a reason. It will not count against you in any way and will not affect your current or future treatment in this adherence club or any other place.
- If any concerns arise from the non-routine assessment that will be done as part of the research, it will be brought to the attention of the clinic staff for further follow up.

Contact Information

If you have any questions or concerns regarding the ethics of this study or your rights as a research participant, you may contact the UCT Human Research Ethics Committee on 021 406 6338.

For any other questions regarding this study, please feel free to contact the following people: Dr. Janetta Harbron on 021 406 6769 (supervisor); or Iyanuoluwa Oyetunji on 0792407222.

Informed Consent form

Research on the Nutritional and Health Status of HIV+ Adults on Stable HAART Attending a Healthcare Facility in Cape Town, South Africa (HREC Ref nr 413-2021)

Investigators: Janetta Harbron, Alastair Duncan, Tasneem Adams, Iyanuoluwa Oyetunji

Declaration by participant:

By signing below, I..... (Write in your name and surname) voluntarily agree to take part in this research study. I confirm that the exact procedures and nature of the study detailed in the Information sheet have been explained to me. I have had the opportunity to ask questions about it and my questions have been answered to my satisfaction. The decision to take part in this study is my own. I understand that I am free to withdraw from the study at any time without giving a reason.

..... Your signature

..... Date

Declaration by investigator:

I declare that I did not force the participant to take part in this study and that I will do no harm to the participant. I have fully informed the person above of the study procedures. I will ensure that their personal information is kept confidential and that their privacy will be protected.

..... Investigator name (print)

..... Investigator signature

..... Date

APPENDIX B – QUESTIONNAIRE

Section A – From File

Interviewer:		**Participant name (1):**	
		(2):	**Code (3):**

A	**SOCIODEMOGRAPHIC INFORMATION**	
1	Date of Birth	4.
2	Gender? 1. Male 2. Female	5.

B	**BIOCHEMICAL DATA**									
	Dates									
	Blood Glucose									
	Total Chol									
	CD4 count									
	Viral load									
	Creatinine									

C	**MEDICAL DATA**		
Weight History	**Dates**	**Blood Pressure History**	**Dates**

	Co-morbidities	**Yes**	**Date of Diagnosis**
	1. Diabetes/ insulin resistance		
	2. CVD		
	3. Hypertension		
	4. Dyslipidemia		
	5. Lipodystrophy		
	Is participant on Medical nutrition therapy for any of these or other co-morbidities? If yes, specify which condition(s):		
	Year participant tested positive for HIV:		
	Date started on ART:		
	HIV stage:		

	Current ART (circle correct medication)	
	<u>PIs</u>	**<u>NRTIs</u>**
	Lopinavir	Tenofovir
	Atazanavir	Abacavir
	Ritonavir	Lamivudine
	Darunavir	Zidovudine
	<u>NNRTIs</u>	Emtricitabine
	Efavirenz	**<u>Integrase Inhibitors</u>**
	Nevirapine	Raltegravir
		Dolutegravir
	Other medication:	

	ART history	

Section B: From Participant

A	ANTHROPOMETRIC MEASUREMENTS:				
	Measures	1	2	3	Average
1	Height (cm)				
2	Weight (kg)				
3	MUAC (cm) Right arm				
4	Waist (cm)				
5	Hip (cm)				
6	Hand grip strength (kg) ***Use the hand free from surgery, arthritis or pain for the past 3 months***				

B	SOCIODEMOGRAPHIC INFORMATION:		
1.	What is your highest level of education attained?	No formal education Primary school Some high school High school completed After school qualification Diploma, Certificate Degree Post-graduate Other: (specify)…….	
2.	Marital status	Single Married Divorced Widowed Living with partner Other: (specify)…….	
3.	How would you describe your present employment status? (underline correct option)	Employed: Full time/ Part time Unemployed Student Retired Other: (specify)…….	
4.	Do you receive a social grant	Yes No	
5.	Have you ever been pregnant?	Yes; Nr of pregnancies…. Nr of live births….. No	
C	**SMOKING**		
1.	Have you ever smoked cigarettes (tobacco)? (circle the correct answer)	Yes, daily……...1 Yes, less than daily……. 2 Yes, but not now…….. 3 No, not at all……. 4	

2.	Do you currently smoke cigarettes (Tobacco)	Yes, daily…….. 1 Yes, less than daily……. 2 No, not at all……. 3	
3.	For how long have you been smoking cigarettes (tobacco) regularly? If less than one month, enter “00” for years and months	Number of years:……. Number of months:……..	
4.	On average, how many manufactured cigarettes do you smoke each day/week (not number of packs)	Per day:……. Per months:……	
D	**ALCOHOL INTAKE**		

A single tot of spirits (whisky, gin, vodka) (e.g. 25ml at 43%)

A small glass of liqueur or aperitif (e.g. 25ml at 30%)

1 can of ordinary beer (e.g. 340ml at 5%)

1 glass of wine (e.g. 120ml at 12%)

Carton of ordinary commercial sorghum beer (e.g. 500ml at 3%)

1.	How often do you have a drink containing alcohol in the past 12 months?	Never…….. 0 Monthly or less……. 1 2-4 times a month…… 2 2-3 times a week……. 3 4 or more times a week…….. 4	
2.	How many drinks containing alcohol do you have on a typical day when you are drinking?	1 or 2……. 0 3 or 4……. 1 5 or 6……. 2 7, 8 or 9……. 3 10 or more…….. 4	
3.	How often do you have (for men) five or more and (for women) four or more drinks on one occasion?	Never…….. 0 Less than monthly…… 1 Monthly…….. 2 Weekly…… 3 Daily or almost daily…….. 4	
E	**WEIGHT MANAGEMENT**		
1	How happy are you with your present weight?	Happy…… 1 Somewhat happy..…… 2 Unhappy……. 3 Other (specify)…….. 4	
2	Do you think you are……?	Underweight……. 1 Normal weight…..…… 2 Overweight..…… 3 Other (specify)…….. 4	
3	Would you like to weigh…….?	More……..…… 1 Less……...…… 2 The same weight as you are now……3 Other (specify)…….. 4	

4	Compared with last year do you weigh…….?	More……..…… 1 Less……..…… 2 Same weight (kg)…… 3 Don't know…..…….. 4	
5	Have you ever tried to lose weight?	Yes……..1 No…….2	
9	During the past 12 months have you tried to lose weight?	Yes……..1 No…….2	
10	During the past 12 months have you tried to gain weight?	Yes……..1 No…….2	
11	Would you be interested to take part in a program about a healthy lifestyle and how to best manage weight if it was available here at the clinic?	Yes……1 No……..2	
12	What type of program would you prefer	Group sessions……..1 Individual sessions ……..2	
13	What type of cell phone do you have access to?	I do not have access to a cell phone……...1 Cell phone with no internet feature……..2 Internet-enabled cell phone……..3	
14	If you have access to a cell phone, how much access do you have?	Restricted access……...1 Full access……..2	
15	Would you like to receive messages on how to manage your weight, eat healthy foods and do exercise via your cell phone?	Yes……1 No……..2	
F.	**FOOD INTAKE**		
1.	Which meals do you skip almost on a daily basis?	Breakfast……..1 Lunch……2 Evening meal…….. 3 None of these……..4	
2.	Is salt added to your food while it is being cooked?	Always……..1 Sometimes……2 Never……3 Don't know…….. 4	
3.	Do you add salt to your food before you eat it?	YES……...1 NO…… 0	

4.	If yes, how much salt do you add to your food each day?	¼ teaspoon……..1 ½ teaspoon……..2 ¾ teaspoon……..3 1 teaspoon……...4 Other specify:……. 5				
5.	Do you add Aromat or other similar to your food before you eat it?	YES……...1 NO……..0				
6.	If yes, how much Aromat/other spice with Aromat do you add to your food each day?	¼ teaspoon……..1 ½ teaspoon……..2 ¾ teaspoon……..3 1 teaspoon……...4 Other specify:……. 5				
7.	In an average month how often do you eat at the following places?		Frequency of visits (select 1)			
			Times/week	Times/month	Rarely/never	
		Nandos				
		Spur				
		Macdonalds/Burger King/Steers/ Wimpy				
		KFC				
		Chicken Licken				
		Pizza e.g. Debonaire's Romans etc.				
		Fried fish (and Chips) takeaway				
		Chinese takeaway				
		Mexican takeaway				
		Gatsby/ bunny chow				
		Other restaurants/takeaways				
		Quarters from tuck shop				

Food intake over the past month

I will now ask you some questions about your usual intake of some foods and drinks over the **PAST MONTH**.

Please look through these food cards and divide them into 2 piles:

- 1 pile is for foods you ate in the past month and
- the other pile for foods you never eat or did not eat in the past month.

Give the participant a while to go through the cards, while you look for information in file.

We will now look at the food cards in the pile "ate in the past month", please tell me:

1. HOW OFTEN do you usually eat/drink the item on the food card? Please select one of these options (show A4 laminated options) – mark one block with a cross (X) to indicate frequency
2. HOW MUCH EACH TIME (PORTION SIZE): The standard portion for this item is ……..; do you usually eat this amount, or ½ this amount, or twice this amount or more than 2 times this amount? – mark one block with (X)

	HOW OFTEN					HOW MUCH EACH TIME (PORTION SIZE)				
	Never	1-3 times/ month	1-3 times/ week	4-6 times/ week	Every day	Portion size	1 times portion	½ the portion	2 times portion	>2 times portion
GRAINS/STARCH										
1. Oats porridge						½ cup				
2. Maize meal porridge, crumbly or soft, other cooked cereal						½ cup				
3. Cereals, like Weet-Bix, Corn flakes, Pronutro, All Bran flakes, Coco Pops, Rice Krispies						½ cup				
4. Sugar or honey on cereal/porridge						1 tsp				
5. Pasta or spaghetti, white rice, including in akni, biryani, or salad						½ cup				
6. Brown rice, wild rice, samp (stampmielies), barley, pearled wheat (stampkoring)						½ cup				
7. Beans, lentils, split peas, toppers, including in curry, biryani, stews or soups						½ cup				
8. **Whole wheat or Brown** bread or rolls						1 slice				
9. White bread, burger or hot dog buns, rolls.						1 slice				
DAIRY & DRINKS										
10. Cheese, cheese in sandwiches, sauces & dishes						1 slice 30g matchbox				
11. Milk: glass, on cereal, in coffee, tea						125ml				
12. Dairy and fruit juice mix like Tropika, Fiesta.						1 small glass 200ml				
13. Fruit juice, such as Ceres or Liqui-Fruit.						1 small glass 200ml				
14. Soft drinks like Coke, Cream soda, Sparletta, iced tea, Red Bull, Eleven-in-One. *DO NOT include diet drinks.*						1 small glass 200ml				

	HOW OFTEN					HOW MUCH EACH TIME (PORTION SIZE)				
	Never	1-3 times/ month	1-3 times/ week	4-6 times/ week	Every day	Portion size	1 times portion	½ the portion	2 times portion	>2 times portion
15. Cordials (regular): Oros, Drink O-pop, Hall's, Nectar, Frutal, Dalys, Wild-island.						1 small glass 200ml				
FRUIT										
16. Any kind of fruit, fresh including berries						1 medium fruit ½ cup fruit salad				
VEGETABLES										
17. Green salad and any vegetables you put in salad						1 cup raw				
18. Roasted or fried potatoes or chips						1 potato 1 cup				
19. Potatoes, boiled, mashed, or in potato salad or stews (not fried)						½ cup or ½ potato				
20. Dark green vegetables: broccoli, spinach, including in mixed dishes						½ cup cooked				
21. Yellow vegetables: pumpkin, butternut, carrots, sweet potato, mealies/corn on cob, sweetcorn, including in mixed dishes						½ cup cooked				
22. ALL other vegetables: mixed vegetables, gem squash, cabbage, cauliflower, onion, green beans, green pepper, peas, including in mixed dishes						½ cup 1 mealie				
23. Sugar or syrup added to vegetables						1 tsp				
PROTEINS/MEATs										
24. Eggs: fried, boiled, scrambled, omelettes.						1 egg				
25. Polony, Vienna Russian sausage, sliced ham, (corned) bully beef						1 slice				
26. Pies, sausage rolls, samosas, vetkoek						2 small				
27. Mince meat, patty, meat balls, bobotie, boerewors, meat in lasagne or bolognaise						60-90g 2-3 matchboxes				
28. Roast, steaks or chops like beef, lamb, mutton						90g 3 matchboxes				
29. Neck/knuckle meat (beef, lamb,mutton) or organ meats (liver, tripe) in mixed dishes, like bredie, potjiekos, curry, biryani, akni						90g 3 matchboxes				
30. Chicken fried, snitzel, patties, strips						90g piece				
31. Chicken roast or pieces or in bredie, stews/curries						90g piece				
32. Chicken feet, organ meat						2-3 feet 1 cup dish				
33. Fish or fish cakes						Medium piece 90g 2 fish cakes				

	HOW OFTEN					HOW MUCH EACH TIME (PORTION SIZE)				
	Never	1-3 times/ month	1-3 times/ week	4-6 times/ week	Every day	Portion size	1 times portion	½ the portion	2 times portion	>2 times portion
OTHER										
34. Crisps/snack chips like Simba, Lays, Fritos, NikNaks, Ghost Pops						Small packet 30g – 40g				
35. Crackers, like cream crackers, saltycrax, Marie biscuits or other snack crackers						3-4 small crackers				
36. Peanuts, peanut butter, other nuts or seeds						2 Tbsp				
37. Frozen yogurt, ice cream, custard, pudding						½ cup				
38. Doughnuts, cake, cookies, shortbread, koeksister, sweet or cream pastry, cupcakes, milk tart.						1 or small piece				
39. Sweets, any type, or chocolates						3 sweets 2 small choc				
40. Jam, marmalade, syrup, honey.						1 tsp				
41. Salad dressing, mayonnaise						1 Tbsp				
42. Margarine or butter on bread or vegetables						1 Tbsp				
43. Instant soups, 2-min noodles						1 packet				
44. Sugar in coffee/tea/other hot drinks						2 tsp				

	FREQUENCY								
	Rarely	1-2/ week	3-4/ week	5-6/ week	1/ day	1 ½/ day	2/ day	3/ day	4+/ day
45. How often did you use fat or oil for cooking?									

46. What type of milk or powdered milk did you usually drink? MARK ONE.	Full-cream milk	Soy milk
	Low- fat 2% milk	Don't know
	Nonfat or skim milk	I don't drink milk or soy milk
47. What kind of cereal did you usually eat? Choose the 2 that you eat most often.	Weet-Bix, Nutrific, All Bran, Puffed wheat, Muesli, plain Oats, Maltabella, Right Start Fibre plus	
	O-tees, Oatso easy, Instant oats, Jungle b-fast, Nestle Cheerios or Milo, Funkydz strawberry or frosted crunches, Right Start Oat Flakes	
	Other sweet cereals, like Frosted Flakes, Special K, Frosties, Coco Pops, Right Start Bran flakes or Raisin Bran flakes	
	Pronutro, whole wheat and whole wheat flavours	
	Pronutro, traditional maize and flavours; FutureLife	
	Any other like Corn Flakes, Rice Krispies, Rice Crunchies, Kreemymeel	
48. What kind of fat or oil did you usually use in cooking? MARK ONLY 1 or 2.	None	Sunflower oil, "fish oil" or other oil
	Hard margarine, Marvelo or butter	Beef or mutton tallow
	Soft tub margarine	Chicken fat
	Canola oil, olive oil	Don't know, don't cook

G	FOOD SECURITY:		
Please tell me whether the following statements were OFTEN, SOMETIMES or NEVER true for you or other members of your household in the last *12 months*			
1.	The food you/your household members bought just did not last, and you didn't have money to get more	Never true……..1 Sometimes true……..2 Often true……3	
2.	You/your household members couldn't afford to eat balanced meals	Never true……..1 Sometimes true……..2 Often true……3	

H	PHYSICAL ACTIVITY (BAECKE QUESTIONNAIRE)		
1.	Work Index		
	Question	Response	Points
1	What is your main occupation? *(1) low activity including clerical work, driving, shop keeping, teaching, studying, housework, medical practice, and occupations requiring a university education; (2) middle activity including factory work, plumbing, carpentry, and farming; (3) high activity includes dock work, construction work, and professional sport*	Low activity	1
		Moderate activity	3
		High activity	5
2	At work I sit	Never	1
		Seldom	2
		Sometimes	3
		Often	4
		Always	5
3	At work I stand	Never	1
		Seldom	2
		Sometimes	3
		Often	4
		Always	5
4	At work I walk	Never	1
		Seldom	2
		Sometimes	3
		Often	4
		Always	5
5	At work I lift heavy loads	Never	1
		Seldom	2
		Sometimes	3
		Often	4
		Always	5
6	After working I am tired	Very often	5
		Often	4
		Sometimes	3
		Seldom	2
		Never	1
7	At work I sweat	Very often	5
		Often	4
		Sometimes	3
		Seldom	2
		Never	1

8	In comparison of others of my own age I think my work is physically	Much heavier	5
		Heavier	4
		As heavy	3
		Lighter	2
		Much lighter	1
	Sport Index		
	Question	Response	Points
9	Do you engage in sports or exercise?	Yes (proceed)	
		No (go to question 10)	
9a	**Data on Most Frequently Played Sport**	**Findings**	**Value**
	What sport do you play/practice most frequently? (1) low level (billiards sailing bowling golf etc) with an average energy expenditure of 0.76 MK/h; (2) middle level (badminton cycling dancing swimming tennis) with an average energy expenditure of 1.26 MJ/h; (3) high level (boxing basketball soccor rugby rowing) with an average energy expenditure of 1.76 MJ/h	Low intensity	0.76
		Medium intensity	1.26
		High intensity	1.76
	How many hours do you play in a week?	< 1 hour	0.5
		1-2 hours	1.5
		2-3 hours	2.5
		3-4 hours	3.5
		> 4 hours	4.5
	How many months do you play in a year?	< 1 month	0.04
		1-3 months	0.17
		4-6 months	0.42
		7-9 months	0.67
		> 9 months	0.92
9b	**Data on Second Most Frequently Played Sport**	**Findings**	**Value**
	What is your second most frequently played sport? (1) low level (billiards sailing bowling golf etc) with an average energy expenditure of 0.76 MK/h; (2) middle level (badminton cycling dancing swimming tennis) with an average energy expenditure of 1.26 MJ/h; (3) high level (boxing basketball football rugby rowing) with an average energy expenditure of 1.76 MJ/h	Low intensity	0.76
		Medium intensity	1.26
		High intensity	1.76
	How many hours do you play in a week?	< 1 hour	0.5
		1-2 hours	1.5
		2-3 hours	2.5
		3-4 hours	3.5
		> 4 hours	4.5
	How many months do you play in a year?	< 1 month	0.04
		1-3 months	0.17
		4-6 months	0.42
		7-9 months	0.67
		> 9 months	0.92
	Question	Response	Points
10	In comparison with others of my own age I think my physical activity during leisure time is	Much more	5
		More	4
		The same	3
		Less	2
		Much less	1

11	During my leisure time I sweat	Very often	5
		Often	4
		Sometimes	3
		Seldom	2
		Never	1
12	During leisure time I engage in sporting activity or exercise	Never	1
		Seldom	2
		Sometimes	3
		Often	4
		Very often	5
2.	Leisure Index		
	Question	Response	Points
13	During leisure time I watch television, I use my computer (not for work) or phone (screen time)	Never	1
		Seldom	2
		Sometimes	3
		Often	4
		Very often	5
14	During leisure time I walk	Never	1
		Seldom	2
		Sometimes	3
		Often	4
		Very often	5
15	During leisure time I cycle	Never	1
		Seldom	2
		Sometimes	3
		Often	4
		Very often	5
16	How many minutes do you walk and/or cycle per day to and from work, school and shopping?	< 5 minutes	1
		5-15 minutes	2
		15-30 minutes	3
		30-45 minutes	4
		> 45 minutes	5

Rosenberg Self-Esteem Scale (RSE)

Instructions

- ❑ I am going to read 10 statements, you must please tell me if you strongly agree, agree, disagree or strongly disagree with each statements
- ❑ When I read the statements think about your present and recent feelings, not those you had in the past.

	Strongly Agree	Agree	Disagree	Strongly Disagree
1. I feel that I am a person of worth, at least on an equal plane with others.				
2. I feel that I have a number of good qualities.				
3. All in all, I am inclined to feel that I am a failure.				
4. I am able to do things as well as most other people.				
5. I feel I do not have much to be proud of.				
6. I take a positive attitude toward myself.				
7. On the whole, I am satisfied with myself.				
8. I wish I could have more respect for myself.				
9. I certainly feel useless at times.				
10. At times I think I am no good at all.				

APPENDIX C – DASH Score Components for Male and Female Participants

Male Participants

Component[1]	***Total Median (IQR) Intake***	***Median (IQR) Intake – Lowest Quintile***	***Median (IQR) Intake – Highest Quintile***
Fruits (serving/day)	0.57 (0.29, 1.43)	0.25 (0.05, 0.29)	3.00 (3.00, 3.00)
Vegetables (serving/day)	1.35 (0.86, 2.54)	0.29 (0.02, 0.64)	4.00 (3.57, 4.14)
Nuts and legumes (serving/day)	0.50 (0.14, 1.00)	0.00 (0.00, 0.04)	2.14 (1.93, 2.21)
Whole grains (serving/day)	2.86 (0.79, 3.14)	0.00 (0.00, 0.25)	4.04 (3.75, 4.36)
Low-fat dairy (serving/day)	0 (0, 0)	0 (0, 0)	3 (3, 3)
Sodium (g/day)	1.87 (1.23, 2.31)	1.00 (0.89, 1.04)	3.09 (2.94, 3.15)
Red and processed meat (serving/day)	1.00 (0.36, 1.59)	0.06 (0.00, 0.23)	3.21 (2.49, 3.68)
Sweetened beverages (serving/day)	0.95 (0.25, 2.58)	0.06 (0.00, 0.25)	4.41 (3.37, 5.29)

IQR: Interquartile Range, [1]: See Table 5.1 for serving size

Female Participants

Component[1]	***Total Median (IQR) Intake***	***Median (IQR) Intake – Lowest Quintile***	***Median (IQR) Intake – Highest Quintile***
Fruits (serving/day)	1.00 (0.29, 2.00)	0.21 (0.00, 0.29)	3.00 (2.57, 3.00)
Vegetables (serving/day)	1.71 (0.86, 2.64)	0.36 (0.11, 0.60)	4.29 (3.57, 5.29)
Nuts and legumes (serving/day)	0.39 (0.14, 0.79)	0.00 (0.00, 0.04)	1.57 (1.07, 2.29)
Whole grains (serving/day)	2.00 (0.57, 3.00)	0.07 (0.00, 0.43)	3.57 (3.29, 4.00)
Low-fat dairy (serving/day)	0 (0, 0)	0 (0, 0)	2 (2, 2)
Sodium (g/day)	1.64 (1.10, 2.29)	0.80 (0.63, 0.93)	2.97 (2.55, 3.13)
Red and processed meat (serving/day)	1.00 (0.34, 1.76)	0.11 (0.00, 0.21)	3.38 (2.74, 3.81)
Sweetened beverages (serving/day)	1.13 (0.50, 2.39)	0.22 (0.00, 0.25)	3.46 (2.90, 4.57)

IQR: Interquartile Range, [1]: See Table 5.1 for serving size

APPENDIX D – Ethics Approval Letter (UCT)

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room GS0- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-enquiries@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

30 September 2021

HREC REF: 413/2021

DrJ Harbron
Department of Human Biology
Room 3.09, Anatomy Building-FHS
Email: Janette.harbron@uct.ac.za
Student: Oytiya001@myuct.ac.za

Dear Dr Harbron

PROJECT TITLE: NUTRITIONAL AND HEALTH STATUS OF HIV+ ADULTS ON STABLE HAART ATTENDING A PRIMARY HEALTH CARE FACILITY IN CAPE TOWN (MMED DEGREE - MR IYANUOLUWA OYETUNJI)

Thank you for your response letter, addressing the issues raised by the Faculty of Health Sciences Human Research Ethics Committee (HREC).

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, dated 17 March 2020: 06 July 2020 & 01 July 2021.

Approval is granted for one year until the 30 September 2022.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the student: Mr Iyanuoluwa Oyetunji will also be involved in this study.

Please quote the HREC REF 413/2021 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON FACULTY OF HEALTH SCIENCES HUMAN S COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
NHREC-registration number: REC-210208-007

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

HREC/REF 413/2021sa

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Health.Research@westerncape.gov.za
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5th Floor, Norton Rose House,, 8 Riebeek Street, Cape Town, 8001
www.capegateway.gov.za)

Western Cape Government
Health

REFERENCE: WC_202110_011
ENQUIRIES: Dr Sabela Petros

University of Cape Town
Anzio Road
Observatory
Cape Town
7925

For attention: Dr Janetta Harbron, Mr Iyanuoluwa Oyetunji

Re: NUTRITIONAL AND HEALTH STATUS OF HIV+ ADULTS ON STABLE HAART ATTENDING A PRIMARY HEALTH CARE FACILITY IN CAPE TOWN

Thank you for submitting your proposal to undertake the above -mentioned study. We are pleased to inform you that the department has granted you approval for your research.
Please contact the following people to assist you with any further enquiries in accessing the following sites:

Heideveld CDC	**Sr Gercia Human**	**021 638 1690**

Kindly ensure that the following are adhered to:

1. Arrangements can be made with managers, providing that normal activities at requested facilities are not interruptedand the constraints caused by the Covid19 epidemic above are respected and adhered to.
2. Researchers, in accessing provincial health facilities, are expressing consent to provide the department with an electronic copy of the final feedback (**Annexure 9**) within six months of completion of research. This can be submitted to the provincial Research Co -ordinator (Health.Research@westerncape.gov.za).
3. In the event where the research project goes beyond the *estimated completion* date which was submitted, researchers are expected to complete and submit a progress report (**Annexure 8**) to the provincial Research Co-ordinator (Health.Research@westerncape.gov.za).
4. The reference number above should be quoted in all future correspondence.

Yours sincerely

DR M MOODLEY
DIRECTOR: HEALTH INTELLIGENCE
DATE: 15/11/2021
CC