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RISK FACTORS ASSOCIATED WITH ACHIEVING BODY MASS INDEX (BMI) BASED NORMAL NUTRITIONAL STATUS AMONG PERSONS LIVING WITH HIV (PLHIV) THAT UNDERWENT THE NUTRITION ASSESSMENT, COUNSELING AND SUPPORT (NACS) THRIVE STUDY IN THE COPPERBELT AND EASTERN PROVINCES OF ZAMBIA FROM 2012-2017

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ABSTRACT

RISK FACTORS ASSOCIATED WITH FAILURE TO ACHEIVE BODY MASS INDEX (BMI) BASED NORMAL NUTRITIONAL STATUS AMONG PERSONS LIVING WITH HIV (PLHIV) THAT UNDERWENT THE NUTRITION ASSESSMENT, COUNSELING AND SUPPORT (NACS) THRIVE STUDY IN THE COPPERBELT AND EASTERN PROVINCES OF ZAMBIA FROM 2012-2017

By Mushtaq Omar Dualeh

Background: The Republic of Zambia is home to one of the highest adult prevalence rates of HIV, currently at 12.4 percent. The Thrive project was implemented in 2012 to promote good nutrition and prevent malnutrition amongst PLHIV. The specific objectives of the Thrive project were: 1) to determine the level of nutritional knowledge, attitudes and practices (KAPs) among PLHIV; 2) understand the trends in BMI of NACS clients, and 3) define the levels of engagement, adherence and retention to care and treatment for PLHIV. There is a strong association of increased access to nutritional counseling and support with HIV treatment.
Methods: This is a secondary data analysis of the Thrive project. The study population (n=969) came from 16 selected health facilities in Copperbelt and Eastern Province, Zambia. Information on nutritional status was abstracted from medical and NACS records throughout the duration of the study, this included baseline and monthly measurements. A structured KAPs questionnaire was administered to PLHIV at the end of the study. The participants used for this analysis were individuals with at least two BMI measures, at baseline and at the third visit. The cohort was then stratified by those with abnormal BMI at baseline, high or low at baseline (n=322). A univariate analysis conducted on potential risk factors, determined variables included in the multivariate analysis. A stepwise logistic regression was used to determine significant findings.
Results: Among the analytic sample, at baseline 241 had low BMI (37.7%) and 81 had high BMI (12.6%). The majority of respondents (60.9%) were previously diagnosed as malnourished at a health facility and most respondents (71.4%) felt their nutrition status had improved over the course of the study. The majority (76.5%) with low BMI at baseline failed to achieve normal nutritional status by their third visit; similarly, the overwhelming majority, 91.4%, of those with high BMI at baseline failed to achieve normal nutritional status by their third visit.
Discussion: Our findings suggest that risk factors significantly associated with failure to reach normal nutritional standing differ between participants with low BMI at baseline and high BMI at baseline.

RISK FACTORS ASSOCIATED WITH ACHIEVING BODY MASS INDEX (BMI) BASED NORMAL NUTRITIONAL STATUS AMONG PERSONS LIVING WITH HIV (PLHIV) THAT UNDERWENT THE NUTRITION ASSESSMENT, COUNSELING AND SUPPORT (NACS) THRIVE STUDY IN THE COPPERBELT AND EASTERN PROVINCES OF ZAMBIA FROM 2012-2017

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LIST OF ACRONYMS

ANOVA	Analysis of Variance
ART	Antiretroviral Therapy
BMI	Body Mass Index
FANTA	Food and Nutrition Technical Assistance
HAART	Highly Active Antiretroviral Therapy
HIV	Human Immunodeficiency Virus
KAP	Knowledge, Attitudes, Practices
MOH	Ministry of Health
MCD	Ministry of Community Development
NACS	Nutrition Assessment, Counseling and Support
NGOs	Non-Governmental Organization
PEPFAR	U.S. President's Emergency Plan for AIDS Relief
PLHIV	People Living With HIV
RUTF	Ready to Use Therapeutic Food
SD	Standard Deviation
TB	Tuberculosis
TDRC	Tropical Diseases Research Centre
USAID	United States Agency for International Development
WHO	World Health Organization
WFP	World Food Programme

CHAPTER I: REVIEW OF LITERATURE

Public Health Burden of HIV/AIDS Worldwide

In 2017, an estimated 36.9 million people globally were living with HIV/AIDS: approximately 5,000 new infections occur each day and an estimated 1.8 million individuals became newly infected with HIV every year[1]. About 75 percent of people living with HIV (PLHIV) are aware of their status, while the remaining quarter (over 9 million individuals) remain in need of HIV services. Overall, trends in HIV infection have resulted in a reduction by 47% since its peak in 1996. Similarly, since 2010, new HIV infections among adults have declined by approximately 16% from 1.9 million to 1.6 million in 2017.

The majority of PLHIV reside in low- and middle-income nations, with 19.6 million PLHIV (53%) in eastern and southern Africa[1]. African nations carry a disproportionate burden of HIV, accounting for 70% of the global HIV burden[2]. The considerable decline in AIDS related deaths has largely been attributed to effectiveness of antiretroviral treatment (ART) which has allowed PLHIV to manage their condition and reduced the risk of continued HIV transmission. Despite rapid advancements in scientific understanding of HIV and increased adherence to ART globally, many PLHIV continue to lack access to prevention, care, and treatment. According to one study, a potential underlying element to consistent disparity is tied to the intersection between the HIV epidemic and food insecurity[3].

HIV Burden in Zambia

The Republic of Zambia is a landlocked country in south-central Africa, with a population of 16 million, of which almost half (46%) are under 14 years of age[4]. Zambia has experienced

rapid economic growth, graduating from a low income to a lower-middle income country in 2011[4]. However, poverty remains high in rural areas where the majority (60%) of the population resides. In 2016, the life expectancy for men and women was 60 and 64 years respectively, a significant increase from the 2012 average life expectancy for both sexes of 49.4 years[5]. This dramatic difference was partially due to the increased access to ART in the country; among those with access to ART, 89% are virally suppressed[6]. Rates of viral suppression are lower for younger PLHIV (15-24 years old), in 2016 U.S. President's Emergency Plan for AIDS Relief (PEPFAR) established that about 34% of young people on ART were virally suppressed.

Zambia has one of the highest adult prevalence rates of HIV in the world, affecting 12.4% of the entire population[1]. In 2017, Zambia had over 1 million PLHIV, approximately 41,000 new adult HIV infections and 16,000 AIDS related deaths, a 24% reduction in new infections since 2010[1]. HIV continues to exacerbate Zambia's TB epidemic, with the majority (83%) of PLHIV enrolled in care had active tuberculosis (TB)[5]. In Zambia, the HIV epidemic is driven by heterosexual sex: prevalence rates among young women are more than double that of young men[5].

Malnutrition

Malnutrition is defined as a deficiency, excess or imbalance in a person's intake of nutrients, affects people all over the world[7]. Body mass index (BMI), calculated as weight in kilograms (kg) divided by height in meters (m) squared (kg/m^2) is a metric commonly used to indicate malnutrition status. Malnutrition is defined by World Health Organization (WHO) as BMI less than $18.5kg/m^2$ (underweight; undernutrition) or higher than $24.9kg/m^2$ (overweight or obese; over nutrition)[8, 9]. Undernutrition incorporates stunting, wasting, underweight and

various other micronutrient deficiencies or insufficiencies. Over nutrition is when the intake of nutrients is oversupplied and exceeds the amount needed for normal development and metabolism[1], and persons who are overweight or obese have an increased risk for noncommunicable diseases such heart disease, stroke, cancer and diabetes.

Globally, 2 billion adults are overweight and 462 million are underweight[7]. An estimated 41 million children under-five are overweight or obese, while about 159 million are stunted and 50 million are wasting[7]. In fact, altogether, half of all under-five deaths are due to malnutrition[10].

In Zambia, malnutrition continues to remain a critical issue. In 2014, around 48% of the population were considered malnourished[11]. In 2017, 1.1 million (40%) of children under-five suffered from chronic malnutrition and 420,000 children (15%) suffered from acute malnutrition[6]. Limited access to health services, poverty and food insecurity pose major threats to the lives of children increasing incidence of undernutrition and high morbidity.

Malnutrition and HIV

HIV impacts nutritional status early in the infection. Most HIV-infected individuals present late for care and for treatment, and the majority of the patients are already affected by malnutrition[1].

Malnutrition prevalence among PLHIV

Most research on malnutrition prevalence among PLHIV is focused on children. One study found that the prevalence and risk factors of malnutrition among HIV-infected children aged 2-18 years old in Thailand was 43% and that malnutrition among HIV-infected children was largely associated with severity of disease and the use of Protease Inhibitor (PI)-based

highly active antiretroviral therapy (HAART), a second line drug regimen in Thailand related to advanced stage HIV[12]. The risk of malnutrition in HIV infection increases due to high pro-inflammatory cytokine activity which can result in stunting among children. When assessing undernutrition and factors associated with it among PLHIV and on ART, prevalence of undernutrition among adult patients on ART was 30%[13]. Thus, demonstrating the impact undernutrition has on ART outcomes reveals that undernutrition can amplify worsening effects of HIV. It is evident that routine nutritional assessment should be implemented at the time of ART initiation.

There is limited published research on the prevalence of malnutrition among PLHIV in Zambia, however prevalence of malnutrition among PLHIV has been studied in other countries. In Ethiopia, a prevalence was 23.6% (95% CI: 19.7%-27.4%) and food insecurity among PLHIV was 35% (95% CI: 31.1%-39%)[13,14]. A study conducted in China reported prevalence of malnutrition among PLHIV at 37.2% [15]. While a study in Iran described a prevalence of 42.2% and Tanzania study reported 18.4% of AIDS patients as underweight [16,17]. Factors associated with malnutrition in the Ethiopia study were unemployment, clinical stages, CD4 count, TB, duration on ART and food insecurity[14]. The interconnected nature of these factors shows a need to integrate programs to address related factors (e.g., undernutrition and food insecurity).

Reasons for malnutrition among PLHIV

Often, nutritionally insecure communities lack of proper infrastructure, access to health service coverage and have limited resources. These factors greatly contribute to malnutrition, which has been associated with unfavorable health outcomes including elevation of risk of infection in both HIV-infected and HIV uninfected persons[8]. The heightened risk of infection

associated with malnutrition is a particular concern among PLHIV and is compounded by the compromised immune status arising from HIV infection[8].

Three key factors that contribute to malnutrition in PLHIV are inadequate intake, malabsorption, and increased energy expenditure[18]. The main reason why individuals lose weight dramatically is due to loss of appetite which leads to reduced energy intake, leading to wasting in adults[18]. The etiology of weight loss and wasting is complex and multifaceted; malnutrition and severe weight loss are common in PLHIV and likely accelerate disease progression and reduce survival due to the impact of malnutrition on immunity[18].

Malnutrition accelerates HIV to AIDS (morbidity)

Malnutrition accelerates the progress of HIV to AIDS[9]. While HIV can exacerbate malnutrition through reduced food intake, poor nutrient absorption and increased energy needs, malnutrition can speed up the progression of the disease and deteriorate the immune system.

The immunology of malnutrition demonstrates that on its own malnutrition is the most common cause of immunodeficiency, as it stimulates dysfunction in the immune system thus promoting increased vulnerability to all infections[19]. When undernourished, cytokines diminish. Cytokines play an integral role in coordinating inflammatory response of the body to external and internal stimuli, they essential initiate defense against numerous pathogens. Malnutrition coupled with HIV form a vicious cycle depleting the immune system of the individual. This decimation of the immune system facilitates the progression of HIV to AIDS. Many deaths in AIDS are attributed to malnutrition and poor management of disease[19].

One study concluded that the recommended levels of nutrient intake levels for the general population is not sufficient for PLHIV[20]. Where an active non-PLHIV requires 2070 kcal/day including 57 grams/day of protein, a PLHIV requires 10 to 15 percent more energy and 50 to 100 percent more protein. Nutritionists and dieticians must guide PLHIV to prepare nutritious foods and to ensure access to the proper level of nutrients and supplements when needed.

Malnutrition and improved intake in PLHIV

Dietary studies in HIV have provided inconsistent results regarding the relationship between the HIV disease state and nutritional intake. A study that reviewed weight loss and wasting in the era of HAART from the Nutrition for Healthy Living (NFHL) cohort found that the intake of micronutrients was higher at decreased CD4+ T-lymphocyte (CD4+ cell) counts, and that many participants ingested amounts of micronutrients that were lower than recommended dietary intakes, even with sufficient median intake of micronutrients[18]. A quarter of women had inadequate dietary intake of vitamins A, C, E and B6. Evidence from a study on the effect of ready to use supplementary good among immunocompromised PLHIV in Africa initiating ART found that low CD4+ cell counts were poor indicators for supplementation, while other study results propose that low BMI itself is a satisfactory marker[21].

Moreover, the NFHL study demonstrated that inadequate dietary intake may be correlated with socioeconomic elements rather than clinical factors[19]. Dietary intake directly exposes the overlap between behavioral, economic and environmental influences, demonstrating the detrimental impact food insecurity has on the progression of disease among

PLHIV. Food accessibility and availability is critical to nutritional improvement of PLHIV with low BMI along with increased nutritional knowledge and practices.

A number of studies have reported connections between low BMI and the increased risk of early mortality among PLHIV initiated on ART in the sub-Saharan Africa region[19]. In PLHIV, lower BMI complicates management of HIV and weight loss has been associated with lower CD4+ cell counts and is an independent predictor of mortality[18, 22].

According to a prospective study of time of death after HAART initiation among HAART users in the Women's Interagency HIV study in the United States, being underweight prior to initiation of HAART among was linked to over double the rate of AIDS death[23]. Women with lower BMI were more likely to have markers of advanced HIV and by the end of study only 56% who were underweight were still alive compared to those who were normal weight (75%), overweight (78%) and obese (82%). Of the women who had non-AIDS related deaths, zero were underweight.

Interestingly, there is also an obesity paradox among PLHIV: higher BMI and fat mass among PLHIV has been associated with slower progression of disease[8,9, 24,23]. This was evident in the Women's Interagency HIV study, where the directionality of the hazard ratios implied higher BMI may have a protective association with non-AIDS death[23]. A 2016 study on the effect of BMI and fat mass on HIV disease progression in PLHIV in Botswana was among the first to demonstrate a longitudinal association between higher fat mass and lower risk of AIDS defining condition, and conclude that higher BMI and higher fat mass were associated with slower disease progression in HIV-infected adults[8]. An earlier study on the optimal BMI suggested an association between higher BMI and slower HIV disease progression before the

availability of ART. This observational cohort study assessed the relationship between pretreatment BMI and CD4+ from baseline to 12 months and found that 12-month immune reconstitution on ART was highest among overweight PLHIV[25].

Even so, PLHIV still benefit greatly from an active and nutritious lifestyle rather than intentional weight gain or loss. Individuals who gain too much weight in the first year of starting HIV treatment may have an increased risk of developing Type 2 diabetes and cardiovascular diseases later on in life[26]. The crucial elements include adherence to ART, nutritional status and food security[24].

Malnutrition and mortality in PLHIV

Although access to ART among PLHIV has increased, mortality remains high during early stages of treatment[27]. One study concluded that immunosuppression and undernutrition presented as low BMI are among the chief risk factors connected with high mortality[27]. The role of nutritional supplementation on HIV related outcomes have demonstrated modest beneficial effects. It is necessary to continue to encourage nutritional support, as it is essential in sustaining and prolonging the livelihoods of PLHIV in low resource settings.

Food Insecurity

Food insecurity results in protein, energy and micronutrient deficiencies[28]. These deficiencies can impair the host defense mechanisms of the uninfected but has a greater impact on PLHIV[29]. A study of bidirectional links between food insecurity and HIV/AIDs reported a conceptual framework that centered nutritional, mental health and behavior as pathways through which food insecurity leads to HIV acquisition and progression of the disease[28].

The three main pathways in which food insecurity negatively impacts the lives of PLHIV: nutritional, behavioral and mental health[28]. With nutrition, food insecurity leads to general macronutrient and micronutrient deficiencies which contribute to immunologic decline and increased morbidity and mortality amongst PLHIV[28]. With mental health, food insecurity increases the likelihood of depression and drug use, which in turn contributes to HIV transmission and incomplete HIV viral load suppression[28]. With behavior, the inability to access food in socially acceptable ways, increases risky sexual behaviors, nonadherence to ART, missed clinic visits, migration for work, all of which have negative health outcomes. Food insecurity create environments that nurture HIV and allow it to progress[28].

Weight loss and wasting continue to be the most common AIDS-defining condition (ADCs) during the early stages of the HIV epidemic. Wasting has been defined as the unintentional weight loss of at least 10% body weight in the presence of diarrhea[18]. Today, there are numerous effective treatments of HIV-associated weight loss and wasting. It is achievable for PLHIV that are undernourished to return to normal BMI[18]. Interventions in weight loss amongst PLHIV, must be individualized and focused on the basis of weight loss for each patient in order to be effective[18]. Further recognition of the importance of nutritional considerations in the care of PLHIV in resource limited settings is imperative. Not meeting energy or macronutrient requirements results in wasting in adults[24].

An observational cohort study based in Lusaka, Zambia aimed to assess the relationships between appetite, dietary intake and treatment outcome twelve weeks after ART initiation among HIV infected adults with advanced malnutrition and immunosuppression[8]. It concluded that poor early ART outcomes were incredibly high in a cohort of HIV-infected adults with

advanced malnutrition and mortality was predicted by lower dietary intake[8]. As a result, the intervention trials to promote post-ART intake in the study population were recommend to benefit survival rates[8].

The Case for Concurrent ART and Nutritional Interventions for PLHIV

The expansion of quality nutritional services in sub-Saharan Africa is critical in reducing high mortality due to HIV. These services have a direct impact on ART adherence, retention to care and survival. A study conducted in sub-Saharan Africa aiming to quantify the availability of nutritional support services at HIV treatment and care sites found that the availability of nutritional support services, which included nutritional counseling, micronutrient supplementation, treatment for severe malnutrition and food rations, was high (90%)[30]. In 2003, the WHO recognized that need for greater research to determine the impact of ART in malnourished populations and if nutrition interventions, specifically targeting undernourished populations, provided concurrently with ART would have positive outcomes. Considerable progress has been made in developing evidence base on the importance of nutrition and concurrent ART in improving adherence and decreasing mortality[31] .

A randomized controlled study involving food insecure adults starting ART in Zambia found that individuals who received home-based World Food Programme (WFP) rations were 1.5 times more likely to achieve 95% ART adherence, compared with the control group[30]. Therefore, emphasizing the effectiveness of concurrent intake of ART and nutritious dietary intake results in decreased mortality. It is clear that concurrent nutritional supplementation and ART adherence can have a positive health impact and addresses challenges to HIV care in resource limited settings as they relate to malnutrition[32]. Ensuring food security is a

preventative measure, as it drives away adverse effects. A pilot study of food ration supplementation in Zambia proposed that food assistance is associated with better adherence to ART[33]. The analysis also illustrated that providing food to those who are food insecure is feasible and can improve adherence.

There is an association between undernutrition and increased risk of early mortality among PLHIV initiated on ART in sub-Saharan Africa region[32]. This finding suggest that nutritional supplements be taken concurrently with ART to promote weight gain, improve physical activity and improve immune response amongst PLHIV that present with weight loss at ART initiation[32].

Like ART, nutritional support is part of essential, critical care for PLHIV. A study of patients with BMI less than 17 kg/m^2 enrolled HIV/AIDS care programs in Uganda between March 2006 and August 2008 observed factors correlated with nutrition program failure and found that concurrent administration of ART with supplementary food increased chances of nutritional recovery in high risk patients and illustrated that nutritional support with ready to use therapeutic food (RUTF) may be more effective when provided at the early stages of malnutrition[34]. This was further underlined with a study that reported coexistent administration of ART and RUTF increases the opportunity of nutritional recovery in high-risk patients. More, adequate nutrition is imperative in treating malnourished HIV patients and continued development of strategies for management of severely malnourished PLHIV is critical[34].

Nutrition Programs for PLHIV in Zambia

The Government of Zambia has recognized the importance of nutrition in the provision of quality of care and support to PLHIV and has been actively engaged in its response to HIV and

malnutrition, yet progress is slow due to resistance in behavior change[1]. In response, the Government of Zambia conducted nutrition assessment, counseling, and support (NACS) as part of HIV care[35]. A federal contract dispatched in 2011 positions the pilot of NACS to Zambia in partnership with the United States Agency for International Development (USAID). NACS activity was funded by PEPFAR and designed to support the continued adoption, adaptation, and scale up of NACS as a standard of care within HIV programs in Zambia[35]. NACS interventions in Zambia meant a wide dissemination and use of NACS guidelines to complement materials on HIV prevention, treatment and support with the clear objective of improving the quality of life of PLHIV, furthering the capacity of nutritional services and facilitating the local production of specialized nutrient supplements[1,36].

Efforts taken by the Government of Zambia in order to alleviate malnutrition and improve nutrition are well documented. Throughout the last decade, Zambia has made a number of regional and global commitments in regard to nutrition and how it relates to HIV[6].

In 2010, Zambia joined a global movement named Scaling Up Nutrition (SUN), an international and multisectoral initiative aimed at improving nutrition. In 2012, Zambia pledged to reduce under-five mortality to 20 or fewer deaths per 1,000 live births by 2035 by decreasing leading preventable causes of child mortality, namely undernutrition. Zambia's vow to improve nutrition has also been outlined publicly in documents and frameworks like the National Food and Nutrition Strategic Plan and the National AIDS Strategic Framework, all with aims to reduce malnourishment in the population and increased agricultural development with sustainability in mind.

From 2013 to 2017, the Food and Nutrition Technical Assistance (FANTA) project collaborated with the Government of Zambia and other nutrition stakeholders in further integrating NACS into the health system at both the national and district level[37]. This partnership focused on scaling up NACS, training and supporting the community health volunteers in the Kitwe District in the Copperbelt Province of Zambia and developing training materials and resources that are readily accessible online for facility-based providers and community volunteers. This project provided technical support and training materials to USAID, governments and non-governmental organizations. These materials included modules for the NACS method to address malnutrition among PLHIV.

The Government of Zambia's duty to improving nutrition is also patent in the number of nutrition policies, strategies and initiatives in place, namely the National Health Strategic Plan of 2011 and the National Food and Nutrition Strategic Plan[6]. These are multisectoral strategies that help expand interventions related to nutrition in Zambia.

CHAPTER II: MANUSCRIPT

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Introduction

In 2017, nearly 40 million people globally were living with HIV/AIDS[1]. Worldwide, 21.7 million PLHIV (59%) had access to antiretroviral therapy (ART), an increase of 2.3 million since 2016[1].

In Zambia, there are about 59,000 new HIV infections and 21,000 AIDS-related deaths each year[1]. The most vulnerable populations impacted by HIV are women, children and young people, sex workers, men who have sex with men (MSM), migrants, prisoners, transgender people, and people who inject drugs (PWID)[5]. Zambia has made progress in reducing morbidity and mortality due to HIV/AIDS through the delivery of free comprehensive HIV prevention services and ART in all public health facilities. A national scale up of HIV testing services and increased access to HIV services in rural and urban areas has been ongoing in Zambia since 1998[38]. Life expectancy among PLHIV has improved, however, malnutrition remains a burden on the Zambian health care system and its battle with HIV as it accelerates the progression of HIV and deteriorates the immune system of the host[19]. Significant indicators of good health for PLHIV include good nutrition, proper adherence to ART and food security[19].

Thrive Overview

The Thrive project was implemented in Zambia in 2012 by PATH, in collaboration with USAID, the Zambia Ministry of Health (MOH) and the Zambia Ministry of Community Development (MCD)[36]. The specific objectives of the Thrive project were: 1) to determine the level of nutritional knowledge, attitudes and practices (KAPs) among PLHIV; 2) understand the trends in BMI of NACS clients, and 3) define the levels of engagement, adherence and retention to care and treatment for PLHIV[36].

Ultimately, the Thrive project aimed at promoting good nutrition, preventing malnutrition amongst PLHIV while also bolstering the Government of Zambia's capacity to lead NACS-related efforts and assist health facilities in integrating NACS services at the community and clinical level[36]. The Thrive project services were implemented in 16 health facilities in the Copperbelt and Eastern Provinces[36]. An evaluation of these services was conducted to assess NACS services based on program objectives 1 and 2 and concentrated on participants and the uptake of nutritional counseling services.

Methods

Study Population and Setting

The current evaluation is a secondary analysis of the Thrive project. The Thrive project was implemented from 2012 to 2017 in the Copperbelt and Eastern Provinces of Zambia and was funded by PATH in Zambia[36]. Throughout the period of study, the Thrive project worked on numerous program activities focused on promoting nutrition and preventing malnutrition among PLHIV including training over 1,000 nurses, pharmacists and nutritionists to provide integrated NACS with routine care and treatment for PLHIV, pregnant women and vulnerable children. In order to strengthen the overall functioning of the Zambian health system with regards to implementation of NACS services, the Thrive project also worked within various existing government health structures at national, provisional, district, and facility levels.

The Thrive project was designed to improve the nutritional status of participants within 3 months of the program. The entire Thrive project study population consist of individuals from 16 selected hospitals and health centers: eight centers in the Copperbelt Province and eight centers in the Eastern Province[36]. PATH partnered with the Tropical Diseases Research Centre (TDRC) in 2015 to conduct a review of the Thrive project. This analysis stems from data collected during that evaluation. For the evaluation, 53 adult PLHIV (aged 18 years or older) were randomly selected from the Thrive participants at each of the 16 health centers, with a 10% allowance for non-response, resulting in a total of 969 participants in the study.

Data Collection

This analysis is based on the 969 participants of the TDRC evaluation of the Thrive project. The data collected for the evaluation was gathered through a structured questionnaire,

the NACS Client Assessment. This mixed methods questionnaire included both a quantitative and qualitative component. Information was collected by 1) self-report of participants via face to face interview at the end of the study (e.g., sociodemographic characteristics, KAPS questions, NACS questions, etc.) and 2) nutritional registers and clinical records that collected the data throughout the study on a visit to visit basis (e.g., BMI, symptoms, type of counseling, ART adherence status, etc.).

The nutritional registers and clinical records collected the data throughout the study on a visit to visit basis. This data detailed anthropometric, clinical and functional status (visit dates, client status, weight in kilograms, height in meters, recorded BMI, mid-upper arm circumference, counseling type, ART status, symptoms experienced over last two weeks, severity of symptoms and functional status (e.g., working, ambulatory, bedridden)) from the nutritional registry and the clients' clinical record at four different time points, the first time point was baseline. As much data as possible was gathered for participants who have since died or were a lost to follow up at the time of the interview. The quantitative measures were used in this analysis to understand the trends in BMI of NACS clients.

A structured KAP questionnaire was administered to all participants at the end of the program. This questionnaire included recognition of the importance of eating a variety of nutritious foods, knowledge of the association between nutrition and health, practices related to avoidance of nutrient-deplete food sources, and practices of good hygiene and sanitation. There were a couple questions that inquired on life prior to the NACS program, namely “have you undergone any type of nutritional counseling?” and “have you ever been diagnosed as malnourished?” The nutritional KAPs questions were statements that participants were asked

to strongly agree, agree, disagree, strongly disagree or state 'do not know'. Examples of these statements are: a) It is important for PLHIV to be weighed regularly, b) It is important for PLHIV to eat a variety and more nutritious foods, c) It is important for PLHIV to drink plenty of boiled or treated water.

The questionnaire also collected sociodemographic (age, gender, residence, marital status, residence, and religion) and notably, tracked engagement, adherence and retention in the nutritional component of the program and ART. Engagement, adherence and retention to medication was defined as less than two doses missed over the past week or less than 2 days of total non-medication during the past 3 months. NACS data also included receipt of any type of nutritional counseling, topic of counseling, and level of participant satisfaction. Measurement of retention in the Thrive project included variables summarizing the number of missed visits, visit constancy, and gaps in care visitation. The qualitative measures were used in this analysis to understand the level of nutritional KAPs among this cohort of PLHIV and to better inform quantitative analysis.

The primary outcome measure for the present study was failure to achieve good nutritional status. Good nutritional status, or healthy weight is defined by the WHO as a BMI between 18.5kg/m^2 and 24.9kg/m^2 [8]. Information on nutritional status, measured by BMI, was assessed at baseline and during monthly visits for all Thrive participants throughout the duration of the study. Measures were recorded in medical and NACS register records and were abstracted into a database for the purpose of this evaluation.

Evaluation

All Thrive project participants in the TDRC were included in descriptive baseline analysis. The analysis aimed to determine factors associated with failure to achieve good nutritional status was restricted to the participants that were either undernourished or over nourished at the baseline assessment (i.e., persons not in good nutritional standing). Data on socio-demographic characteristics, NACS retention and adherence, retention and adherence to ART, nutrition KAPs were considered as factors in the analysis examining associations with the nutritional outcome defined as failure to achieve good nutrition after 3 of more months of the Thrive NACS Program.

Data Management and Coding

The dataset was compiled by the TDRC at the end as part of the Thrive project evaluation in 2017. The object of this analysis was to consider trends in BMI and determine the risk factors associated with achieving good nutritional status among the cohort. Data were cleaned via Microsoft Excel and SAS software package (version 9.4, Cary, NC). Data cleaning steps entailed deduplication, renaming variables, and checking for logical consistency via frequency tests by cross tabulating variables to determine inconsistencies. An exploratory analysis of the data step was performed to look for coding errors within the dataset and to decide which variables were crucial to the analysis and must contain values. Crucial variables included height and weight measurements in order to calculate BMI, visit dates, sociodemographic and NACS factors (e.g., previous nutritional counseling, previous malnutrition diagnoses). If participants were missing crucial variables, they were removed from

the analysis. A flowchart was developed to better visualize the screening process and final analytic sample (Figure 1).

Sociodemographic, clinical, NACS program factors

Age was grouped into traditional year bands (18-24, 25-34, 35-44, etc.). Other sociodemographic, clinical and NACS program factors were not altered.

Nutritional Status (BMI)

For data analysis, BMI measures were calculated using height and weight metrics and trichotomized as 'low', 'normal', high' BMI status as defined by WHO. Once trichotomized, further analysis was done with the analytic sample.

A continuous variable was created in order to determine if there was a change in BMI between the BMI measure at visit 3 and visit 1. This was useful in univariate analysis of potential risk factors and their associations with change in BMI.

A dichotomous variable was created to determine factors associated with failure to achieve good nutritional status among those with low BMI at baseline. If change in BMI was greater than or equal to 0, this would signify that participant had increased BMI by the third visit, and was counted as a success, otherwise it was a failure to achieve normal nutritional status. This process was repeated for those with high BMI at baseline. If change in BMI was less than or equal to 0 then this was a success among high BMI at baseline, while the opposite would be a failure.

Data Analysis

Descriptive statistics were conducted for all participants in a) the Thrive TDRC Evaluation sample and b) the risk factor analytic sample. Means along with their standard deviations (SD)

were computed to describe the distribution of continuous variables while the counts and percentage distributions were calculated to describe discrete variables. The analyses were achieved through use of SAS' FREQ, MEANS and UNIVARIATE procedures. In order to acquire p-values for characteristics, a PROC T-TEST was run on each continuous variable and a Chi-Square test for the categorical variables.

Several participants had missing BMI measures at differing time points. Thus, the analytic sample to determine factors related with failure to achieve good nutritional status (0/1) excluded all participants that did not have at least 2 BMI measures, were younger than 18 years old or who had extreme BMI observations (e.g., BMI measures over 200 or less than 12, as a result of incorrect weight or height measures). The final analytic sample therefore only included the participants that had measures for BMI at visit 1 (baseline) and visit 3 (since the program was designed to achieve good nutritional status in 3 months); this allowed us to have the highest sample size while maintaining a consistent exposure period (time period in the Thrive NACS Program).

Following an exploratory univariate analysis, PROC ANOVA was performed to analyze the association between change in BMI by initial BMI level.

The primary outcome of interest was failure to achieve normal nutritional status by month (visit) 3. This was restricted to participants that were either undernourished/low BMI or over nourished/high BMI. Odds ratio can be calculated in analyzing this cohort study, because we are under the assumption that the exposure odds ratio is equal to the disease odds ratio. Each characteristic (age, gender, religion, height, weight, BMI, education, residence, occupation, marital status, religion, previous nutritional counseling, and previous malnutrition

diagnosis) were first entered into a univariate logistic regression to evaluate crude associations with BMI at baseline. Odds ratios (OR) that were statistically significant ($p<0.05$) were entered into the multivariate model (Table 2). ORs with a p-value of 0.20 were also considered for the multivariate analysis and was ultimately based on plausibility. This is demonstrated in the stepwise selection model explained below.

Multivariate logistic regression was used as the primary method in determining the sociodemographic, KAPs or behavioral variables that were associated with failure to achieve normal nutritional status by visit three. Since the factors that may be associated with failing to achieve good nutritional status may be different in those that are undernourished versus those that are over nourished, the cohort was stratified between individuals with high BMI at baseline and low BMI at baseline. Therefore, two independent logistic models were created. The cohort that had good nutritional status at the baseline assessment was not included in the logistic models.

Collinearity was diagnosed when variables had condition indices higher than 30 and variation proportion greater than about 0.5. A stepwise logistic regression was used to eliminate variables that were not statistically significant in the full, adjusted model; 95% confidence intervals (CI) were calculated for the ORs. A significance level of 0.20 was required to allow a variable into the model (SLENTRY =0.20) and a significance level of 0.1 was required for a variable to stay in the model (SLSTAY=0.1). The Hosmer and Lemeshow goodness of fit test for the final selected model was used by specifying the LACKFIT option. The response variable option (EVENT= 0) corresponds to failure to reach good nutritional status.

Ethical Considerations

Written informed consent or parental assent for children under 18 years of age was obtained for all Thrive Program study participants prior to participation. The current study utilized secondary data and had no further contact with human subjects or individual records. The evaluation database was de-identified, meaning that it did not contain any personal identifying information. The current evaluation did not involve any further access to Thrive project participants or participant records. The analytic database for the current data analysis was stored on a password-protected computer. Documentation for permission to use the dataset for this thesis research was obtained from TDRC, PATH and USAID.

The Thrive Study protocol was reviewed and approved by the Zambia National Research Committee and the TDRC IRB. This secondary analysis was reviewed and approved by the Emory Rollins School of Public Health IRB and determined to be non-human subjects research.

Results

There were 969 individuals enrolled in the entire NACS study, while 639 individuals were in the analytic sample (Figure 1). The analytic sample was determined by including only participants that were 18 and older and had at least two BMI measures from baseline and the third visit, and was then further specified to explore factors associated with failure among individuals that were underweight (low BMI; n=241) or overweight (high BMI; (n=81) (excluding those with a normal BMI at baseline n=317), resulting in a final analytic sample of 322 individuals.

Table 1 describes basic demographic and behavioral characteristics including age, gender, weight, height, BMI, and adherence to antiretroviral therapy (ART) for both the full sample and the analytic sample.

Among the full sample, the majority of participants were middle-aged between 35 and 54 years old, there were 33% in the 35-44 age bracket and 26.3% in the 45-54 age bracket. This was also true in the analytic sample, where 32% were 35-44 years of age, and 27.4% were 45-55 years old. Younger participants aged 18-24 were underrepresented in this study with 7.2% among the full sample and 6.7% in the analytic sample. The elderly, those 65+ years of age, were also a minority in this sample, with 3.5% among the full sample and 3.9% in the analytic sample. This study was predominantly women with 66% in the full sample and 65% in the analytic sample. The average height was 1.56 meters (5 feet 1 inch) among the full sample and 1.58 meters (5 feet 2 inch) among the analytic sample, this was expected due to the higher proportion of women in the study. Forty-three percent attended at least primary school, and 8.3% had never been to school. Sixty-six percent of participants lived in urban environments

and 38.7% were self-employed; 30 percent were unemployed. Over half (55.6%, 57.4%) of participants were married; while a smaller (11%, 8.9%) contingent were single among the full sample and analytic sample, respectively.

Nutritional Knowledge, Attitudes, Practices

When asked if it is important for PLHIV to be weighed regularly, nearly all (98.8%) stated strongly agree or agree. Likewise, nearly all (99%) of the full NACS cohort (n=969) agreed on the importance for PLHIV to eat a variety and more nutritious foods. The majority (84.1%) strongly agreed of the importance of managing food and drug interactions through diet and most (88.3%) espoused the importance of being physically active as frequently as possible. Through this data, it is evident that the cohort is aware of the importance of monitoring diet, exercising and accessing nutritious and various foods.

In relation to questions on recent personal behavior, responses were slightly less harmonious. For instance, only 77% of respondents adhered to an appropriate food-drug time table in the previous 24 hours (at the time of questioning) and 50% utilized the recommended nutritional practice to manage symptoms when symptoms arose within the prior two weeks (at the time of questioning).

Malnutrition

The qualitative component of the evaluation also inquired on malnutrition. The majority of the respondents (60.9%) were previously diagnosed as malnourished at a health facility. Of those who have been previously diagnosed as malnourished, 33% believe they became malnourished because they were too sick to eat, and 10% stated it was due to not having food to eat at home. Most respondents (71.4%) felt their nutrition status had improved over the course of the study.

Body Mass Index

Malnutrition is defined by World Health Organization (WHO) as BMI less than 18.5kg/m^2 or higher than 24.9kg/m^2 at the time of presentation for care[8]. Figure 2 illustrates the body mass index categories used in the assessment of nutritional status of NACS participants, as defined by the WHO.

Table 2 illustrates the stratified by baseline BMI descriptive statistics. The majority of participants were women, 61.8% of those with low BMI at baseline and 92.6% of those with high BMI at baseline. Among both groups, most participants had at least a primary education, lived in urban areas and were married. About ninety-four percent of those at low BMI at baseline had previous nutritional counseling, while all (100%) of those with high BMI at baseline had previous nutritional counseling. Naturally, previous malnutrition diagnosis varied between groups, 74.7% of those at low BMI had received previous diagnosis while 34.6% of those at high BMI received that previous diagnosis.

Among the full sample at baseline, 269 (38.4%) had low BMI (<18.5 kg/m^2) indicating undernutrition, 88 (12.6%) had high BMI (>24.9 kg/m^2) indicating overnutrition and 343 had normal BMI (49%), with the remaining missing. Among the analytic sample at baseline, 241 (37.7%) had low BMI, 317 (49.6%) had normal BMI and 81 (12.6%) had high BMI, with the remaining missing. In short, just over half, 50.3% of participants had abnormal BMI at baseline (either low or high). The majority (76.5%) of PLHIV with low BMI at baseline failed to achieve normal nutritional status by their third visit; similarly, the overwhelming majority, 91.4%, of those with high BMI at baseline failed to achieve normal nutritional status by their third visit.

A boxplot generated via SAS' Output Delivery System (ODS) illustrates the association between change in BMI and baseline BMI (Figure 3). The distribution of the change in BMI illustrates that individuals with low baseline BMI on average had 0.45 increase in BMI by the third visit, while individuals at normal BMI at baseline on average had a 0 change in BMI (constant BMI) and individuals at high BMI at baseline on average had a decrease of 0.37 in BMI. The overall F test was significant (F=33.08, p= <.0001), indicating strong evidence that the median for baseline BMI at each BMI level and change in BMI were significantly different. Thus, useful in illustrating the apparent success of the Thrive study on the study population.

Univariate Analysis

A univariate analysis was conducted on potential risk factors associated with malnutrition at baseline and with failure to achieve normal nutritional standing to evaluate crude associations according to BMI at baseline (Table 3). Univariate analysis was stratified by baseline BMI and included an OR for all participants with abnormal BMI (both low and high at baseline). Univariate OR analyses operated on a significance threshold of 0.20. This significance level increased the number of variables that could be further investigated in multivariate analysis, to ensure that potential risk factors were not overlooked.

Multicollinearity

Through a multicollinearity analysis, we found no issues with multicollinearity in this data. Further, variance inflation factors demonstrated no correlation among the predictors.

Logistic Models

In order to look at factors associated with failure to achieve normal nutritional status, we stratified by BMI level at baseline and conducted a stratified multivariate analysis. Two

logistic models were created to determine the risk factors associated with failing to achieve normal nutritional status 1) among those with low baseline BMI and 2) among those with high baseline BMI. Both the low baseline BMI model and the high baseline BMI models included the following variables: education level, residence, religion, marital status, previous malnutrition diagnosis, previous nutritional counseling, gender and age.

Risk Factors Associated with Malnutrition at Baseline

We conducted a univariate analysis among those with malnutrition at baseline. Crude univariate ORs are shown in Table 3. We found that risk factors significantly associated with malnutrition at baseline included being a female participant (OR:1.38, 95% CI: 1.00, 1.92), tertiary education (OR: 0.42, 95% CI: 0.18, 0.98), peri-urban residence (OR: 1.79, 95% CI: 0.95, 3.39), previous nutritional counseling (OR: 2.16, 95% CI: 0.87, 5.38), and previous malnutrition diagnosis (OR:0.73, 95% CI: 0.53, 1.00). In order to further investigate, each of these factors were included in a multivariate analysis.

A stepwise selection was performed, 6 observations were deleted from the model due to missing values for the response or explanatory variables. The convergence criterion was satisfied and the overall model was not statistically significant. Model building was terminated within SAS due to the last effect entered being removed by the Wald statistic criterion, meaning that explanatory variables in the model were significant at an alpha level of 0.05. We increased the p-value threshold for this multivariate analysis to 0.10 and found one risk factor significantly associated with malnutrition at baseline, previous nutritional counseling (OR 2.2, 95% CI: 0.88, 5.51).

The odds of malnutrition at baseline were 2.2 times higher among those with previous nutritional counseling as compared to those who did not have previous nutritional counseling.

Risk Factors Associated with Failure

Low BMI at Baseline

We conducted a univariate analysis among those with low BMI at baseline. Crude univariate ORs are shown in Table 3. We found that peri-urban residence (OR: 0.60, 95% CI: 0.21, 1.70) and being married (OR: 1.83, 95% CI: 0.71, 4.68) were each associated with failure to achieve normal nutritional status among those with low BMI at baseline at a significance level of 0.20. The odds of failing to achieve normal nutritional standing were 1.6 times lower among participants who reside in a peri-urban setting as compared to participants who do not live in peri-urban settings. The odds of failing to achieve normal nutritional standing were 1.83 times higher for married participants when compared to single participants. Essentially, peri-urban residence had a protective effect on participants at low BMI, while being married increased odds of failure. In order to further investigate, both of these factors were included into our multivariate analysis.

A stepwise selection was performed, 2 observations were deleted from the model due to missing values for the response or explanatory variables. The convergence criterion was satisfied and the overall model was statistically significant. Previous diagnosis of malnutrition, peri-urban residence and previous nutritional counseling were found to be significantly associated with failing to reach normal nutritional status among those with low BMI at baseline.

The odds of failing to achieve normal nutritional standing were 3.4 times lower among a participant who had undergone any type of nutritional counseling previously compared to a

participant who had not undergone any type of nutritional counseling previously (OR: 0.29, 95% CI: 0.12, 0.72).

Additionally, residence proved to have protective effect on the lives of those living in urban or semi urban areas. The odds of failing to achieve normal nutritional standing were about 1.29 times lower among individuals who lived in urban residence as compared to those who lived in rural environments (OR: 0.77, 95% CI: 0.48, 1.22). Similarly, those living in peri-urban areas were 2.33 times less likely to fail as compared to those living in rural environments (OR: 0.43, 95% CI: 0.21, 0.87).

Previous malnutrition diagnosis had a negative impact on those with low BMI at baseline with the odds of failing to achieve normal nutritional standing 2.6 times higher among those with previous malnutrition diagnosis when compared to those without malnutrition diagnosis in the past (OR: 2.60, 95% CI: 1.71, 3.98)

High BMI at Baseline

We conducted univariate analysis among those with high BMI at baseline. All crude univariate ORs are shown in Table 3. Among those with high BMI at baseline, there two variables that did not have enough information for a crude OR calculation, religion and previous nutritional counseling. We found that junior secondary education (OR: 0.39, 95%, CI: (0.05, 2.89) senior secondary education (OR: 8.00, 95% CI: (1.00, 63.96), previous malnutrition diagnosis (OR: 2.22, 95% CI: (0.77, 6.41), and self-employment status (OR: 2.86, 95% CI: (0.53, 15.25) were each associated with failure to achieve normal nutritional status among those with high BMI at baseline. Among these four factors, only junior secondary education had a protective effect on participants, while senior secondary education, previous malnutrition

diagnosis and self-employment status increased odds of failing to achieve normal nutritional status. In order to further investigate, each of these factors were included into the multivariate analysis.

A stepwise selection was performed, 15 observations were deleted from the model due to missing values for the response or explanatory variables. The convergence criterion was satisfied and the overall model was statistically significant. The area under the receiver operating characteristic (ROC) curve was 0.71, indicating that the model is an acceptable fit.

The final overall model was statistically significant, where at least one beta was different from 0 and supports that previous malnutrition diagnosis and gender are significantly associated and have a protective effect among participants with high BMI at baseline.
The odds of failing to achieve normal nutritional standing among participants with previous malnutrition diagnosis were 2.6 times less than participants without previous malnutrition diagnosis (OR: 0.38, 95% CI: 0.22, 0.68). The odds of failure to reach normal nutritional standing among male participants were 5.8 times more likely when compared to female participants (OR: 5.80, 95% CI: 2.29, 14.93). At alpha level 0.05, we have evidence that previous nutritional counseling and gender are both significantly associated risk factors among those with high BMI at baseline.

Discussion

The objective of the Thrive project was to provide educational and nutritional support to promote returning to a normal nutritional status, as indicated by BMI. This secondary analysis' objective was to determine what risk factors were associated with failure to achieve normal nutritional status among the Thrive NACS cohort between the study period. Our analysis utilized components of the Thrive dataset to understand knowledge, attitudes and practices of participants and examined potential risk factors related to failing to achieve normal nutritional standing among participants. Failure was categorized as not meeting normal BMI within 3 months of a participants' start to the program. Participants were stratified by baseline BMI in the final analytic sample, with low BMI at baseline and high BMI at baseline as the groups of interest.

Previous malnutrition diagnosis differed between groups, 74.7% of those at low BMI at baseline had received previous diagnosis as compared to 34.6% of those at high BMI at baseline. This difference is expected because those with low BMI have double the rates of mortality especially prior to ART initiation, meaning individuals with low BMI at baseline may have received urgent care previously, as compared to those with high BMI at baseline who could suffer from comorbidities not often associated with malnutrition due to increased BMI[23]. Additionally, those with low BMI in this analysis are defined as individuals less than 18.5kg/m^2. This can range from either moderately malnourished (16.0kg/m^2 to 18.4kg/m^2) to severely malnourished (<16.0kg/m^2). Thus, illuminating potential for participants suffering from chronic malnutrition.

About ninety-four percent of those at low BMI at baseline received previous nutritional counseling, and everyone with high BMI at baseline received previous nutritional counseling. Often, nutritionally insecure communities are a result of poor infrastructure, inadequate access to health service coverage and diminished resources. The high threshold in which these participants have previously utilized NACS services demonstrates a concerted effort by Copperbelt and Eastern province area health facilities.

Through univariate analysis, our findings suggest a number of risk factors associated with malnutrition at baseline among this cohort. Two factors had protective effects on participants, tertiary education and previous malnutrition diagnoses; two other factors increased odds of malnutrition at baseline, being a female participant and previous nutritional counseling.

Following multivariate analysis, only one risk factor was significantly associated with malnutrition at baseline, previous nutritional counseling (OR 2.2, 95% CI: 0.88, 5.51). The odds of malnutrition at baseline were 2.2 times higher among those with previous nutritional counseling as compared to those who did not have previous nutritional counseling. Conceivably, the high threshold reached of previous nutritional counseling among this sample could be cause for this. Additionally, improved access to previous nutritional counseling could highlight that these services are reaching targeted populations effectively and the continued participation in a NACS study demonstrate participant's utilization of HIV related services and/or recognition of nutrition's significance in improved health outcome.

Participants in this study overwhelmingly did not achieve normal nutritional standing within 3 months. The majority (76.5%) with low BMI at baseline failed to achieve normal nutritional status by their third visit; similarly, the overwhelming majority, 91.4%, of those with high BMI at baseline failed to achieve normal nutritional status by their third visit. Our analysis found significant associations related to failure to reach normal BMI in the low BMI at baseline and high BMI at baseline logistic models.

Those with low BMI at baseline with previous nutritional counseling were less likely to fail compared to those without previous nutritional counseling (OR: 0.29, 95% CI: 0.12, 0.72), while those who had previous malnutrition diagnosis were more likely to fail compared to those without previous malnutrition diagnosis (OR: 2.61, 95% CI: 1.71, 3.98). Additionally, living in urban areas and peri-urban areas had protective effects.

The odds of failing to achieve normal nutritional standing were 3.4 times lower among a participant who had undergone any type of nutritional counseling previously compared to a participant who had not undergone any type of nutritional counseling previously. This finding confirms the importance of nutritional counseling and support in HIV treatment, care and support. This also highlights the need for programs to continue efforts increasing food security and good nutritional intake. Incorporating nutritional counseling practices must be seriously considered in programmatic efforts as increased poverty and income vulnerability contribute to chronic malnutrition and mortality[39].

The odds of failing to reach normal nutritional standing were 2.6 times higher among those who were previously diagnosed with malnutrition when compared with those who were

not previously diagnosed. This finding may insinuate the critical impact of tertiary factors and how they lend themselves to harmfully impacting the health of PLHIV among this cohort. Nutritional counselling and support can delay disease progression and increase quality of life, however when chronic challenges persist it proves difficult for vulnerable populations such as those chronically malnourished to continue to adhere to strict nutritional regimens and successfully access supplementary foods. Socioeconomic factors may also be a bigger contributor than this study can identify, as those with previous malnutrition diagnoses may not have the consistent tools or resources to achieve normal nutritional standing.

Over seventy-six percent of participants with low BMI at baseline failed to achieve normal nutritional status by their third visit. Previous malnutrition diagnoses resulting in higher likelihoods of failure among this group suggest the need to actively supplement malnutrition diagnoses at health faculties with services fitted to participants needs. The protective effect of nutritional counseling suggests that NACS systems in place may be more supportive to clients.

Among participants with high BMI at baseline, previous malnutrition diagnosis (OR: 0.38, 95% CI: 0.22, 0.68) had a protective effect, while being a male participant resulted in higher odds of failure (OR: 5:84, 95% CI:2.29, 14.93).

The odds of failing to achieve normal nutritional standing were about 2.6 times lower among participants with previous malnutrition diagnosis compared to participants without previous malnutrition diagnosis (95% CI: 0.22, 0.68). This is interesting, as it is different from those with low BMI at baseline, where previous malnutrition diagnosis had a harmful effect. Perhaps, in this case, severity of malnutrition is an important consideration. A diagnosis of severe malnutrition is more enduring than milder or moderate malnutrition. This evaluation did

not question individuals on what level of malnutrition (mild, moderate, severe) the individual was previously diagnosed with. This information may be helpful in determining why previous diagnosis had a protective effect on high BMI at baseline but harmful effect on low BMI at baseline.

The odds of failing to reach normal nutritional standing are about 5.8 times higher for a male participants when compared to a female participants (95% CI: 2.29, 14.93). At alpha level 0.05, we have evidence that gender is significantly associated. This may be because women have better health seeking behaviors and are more proactive about seeking healthcare in general. Perhaps perceived severity of illness may also act as a motivating factor to seeking additional services to mitigate HIV[40]. Additionally, among individuals with high BMI at baseline, only 6 (7.4%) were male. Perhaps, more simply the significant difference stems from lack of gender diversity among those with high BMI at baseline.

Over ninety-one percent of participants with high BMI at baseline failed to achieve normal nutritional status by their third visit. Increased odds of failure among male participants among this group suggest the need to strengthen the integration of NACS service training to decrease gender disparity. Women are disproportionately impacted by HIV in Zambia, and this national context may play a bigger role than previously identified. Perhaps, NACS services are better suited to the needs of female participants.

There were a number of limitations to this study. The lack of data at time periods, participants lost to follow up and missing responses of critical variables presented a noteworthy gap in this research. Missing descriptive and explanatory variables presented challenges in analysis. At first glance of the data, nearly 75% of BMI measures were missing. This created

challenges in determining the trends in BMI for the NACS study over time. In order to overcome this, BMI was re-calculated through height and weight measurements acquired at each visit. Both linear regression and longitudinal analysis were conducted on the Thrive dataset, however this proved challenging.

The longitudinal analysis produced Figure 3, which illustrated incongruities within the data, namely participant's failure to visit health facilities on a monthly basis and did not properly demonstrate the depth of the dataset. A linear regression analysis proved challenging in determining the true effect of the study on participants, because failure to achieve normal nutritional status differed between those with low baseline BMI and high baseline BMI due to conflicting definitions of failure to achieve normal BMI by the third visit. Essentially, individuals at either level of BMI at baseline were failing bidirectionally, and thus could not easily determine trends in BMI.

Further limitation was the primary data collected used a cross-sectionally design approach, which excluded causal inferences regarding the collected data. Increasing trends in BMI may be due to contemporary factors that are beyond the scope of the Thrive project and consequently, this analysis. Another restriction in data analysis was the strong consideration of the retrospective KAPs data since it was self-reported and therefore subject to self-report bias, recall bias, and social desirability bias.

CHAPTER III: Conclusion and Recommendations

Sufficient nutrition is a necessary and critical component in the treatment, care and management of HIV and malnutrition[39]. The establishment of nutrition's importance in the provision of quality care has increased the quality of life among PLHIV. Our analysis illuminated risk factors associated with failure to achieving normal nutritional standing were dependent on baseline BMI. Overarching themes included the importance of consistent engagement with participants, tailored support dependent on baseline BMI or level of malnutrition, and integration of nutritional counseling services with health services.

Most HIV-infected individuals present late for care and for treatment, and the majority of PLHIV are already impacted by malnutrition[1]. High rates of malnutrition among PLHIV are evident among this cohort, where all included in the final analytic sample met WHO standards for malnutrition (either over- or undernourished based on BMI), see Figure 2. Among those with abnormal BMI, 60.9% were also previously diagnosed as malnourished at a health facility. Thirty-three percent of those who had previously been diagnosed as malnourished believed they became malnourished because they were too sick to eat, and 10% stated it was due to not having food to eat at home. This demonstrates the need for more amplified strategic efforts to combat the stability of malnutrition among this cohort. The lack of consistency attendance via monthly visits translates to inadequate nutritional counseling services throughout the study period.

In order to implement successful nutrition focused programs, it is crucial to consider outside factors that lend themselves to negative health outcomes. In this cohort, only 77% adhered to appropriate food-drug time table in the previous day (at the time of questioning)

and only half (50%) utilized nutritional practice to manage symptoms when they arose. Improvements could be made by implementing services fitted to the needs of malnourished participants. The Thrive NACS program could improve by implementing thresholds and specific NACS proficiencies to ensure that clients are gaining understanding and adequate counseling. It is necessary to understand the context in which participants are undergoing the study, and to standardize additional resources to ensure greater success for each participant, while supporting nutrition advocacy.

The implementation of these NACS services directly impact access to ART, retention to care, and survival. For next steps, we suggest that these services aim for holistic multisectoral approaches to bolster impact. The integration of these services in the broader Zambian health system can prove beneficial to PLHIV throughout the country when iteratively incorporated in the existing health system. Through the Thrive NACS study, progress has been made in developing evidence base on the importance of nutrition and counseling among PLHIV and increasing access to these HIV services and improving adherence to ART while decreasing rates of mortality[31]. Strengthening relationships between health facility NACS services with community level services creates sustainability.

In Zambia, NACS' aim to provide a nutrition standard of care for every individual and are determined to connect communities to clinical services[39]. Within our analytic sample, 71.4% of respondents felt their nutrition status had improved over the course of this particular study. Our findings demonstrate the effectiveness of the Thrive project in increasing attitudes and knowledge on NACS while also increasing awareness and access to HIV services available at local health facilities. These moves will continue to shift the perspective to more preventative

measures like early counseling and support for PLHIV to preserve adherence to ART, increased retention to care and increased awareness of nutritional management.

These trends are also clear in this cohort, where participants adhered to ART and demonstrated sufficient knowledge on the importance of nutrition. Ninety-nine percent of the participants of the Thrive NACS study agreed on the importance for PLHIV to eat a variety and more nutritious foods. The majority (84.1%) strongly agreed of the importance of managing food and drug interactions through diet and the bulk (88.3%) espoused the importance of being physically active as frequently as possible. Through this data, it is evident that the cohort is aware of the importance of monitoring diet, exercising and accessing nutritious and various foods.

Systems like NACS and more specifically the Thrive project, further establish connections and facilitate counseling to communities, however, more needs to be done to ensure the active engagement and participation of these services by PLHIV, especially among younger adult populations. It is vital to further embolden intersectional policies on nutrition and food accessibility; increase initiatives taken up by the Government of Zambia in addressing government collaboration and increased utilization of health and nutrition services.

Findings from this study can be useful to future programs and policies as it demonstrates positive strides of nutritional counseling on individuals regardless of baseline BMI. Although, the objective aim to achieve normal nutritional standing by the end of three months fell short, the Thrive NACS study still had a beneficial impact on the lives of those involved. This is illustrated in Figure 3 which demonstrates the beneficial change in BMI among participants' third visit and baseline stratified by their baseline BMI.

In conclusion, this study has highlighted the importance of nutritional counseling and previous malnutrition diagnoses among PLHIV. It has demonstrated that risk factors associated with failure to achieve normal nutritional standing differ depending on baseline BMI. It also illustrates the need to integrate additional resources to remedy divergent risk factors dependent on baseline BMI. From the public health perspective, it is necessary that NACS services continue its success in recruiting and counseling PLHIV not only in the Copperbelt and Eastern provinces, but throughout Zambia. The majority of participants with malnutrition failed to meet normal nutritional standing by the completion of the study period, emphasizing the importance of prolonging these services for malnourished individuals.

The Thrive project should consider investigating loss to follow up, determining what factors contributed to inconsistent monthly visits, implementing thresholds and NACS competencies to ensure a standardized nutritional counseling experience, and tailored treatment depending on baseline BMI. It is important that participants of NACS receive bespoke care and not a streamlined approach as this can result increased failure among those with malnutrition, as opposing baseline BMIs indicate conflicting risk factors associated with failure. Additionally, improving the method of data collection and management could increase the amount of viable data to run future analyses and develop better models to determine the effectiveness of NACS among PLHIV.

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TABLES AND FIGURES

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Table 1. Baseline Characteristics between Full Sample and the Full Analytic Sample of the NACS Study in Copperbelt and Eastern Province, Zambia 2012-2017

	Full Sample (n=969)	Full Analytic Sample (n=639)	P-value
Characteristic	*n (%)	*n (%)	
Age			<.0001
18-24	68 (7.17)	43 (6.73)	
25-34	179 (18.88)	117 (18.31)	
35-44	316 (33.33)	206 (32.24)	
45-54	249 (26.27)	175 (27.39)	
55-64	103 (10.86)	73 (11.42	
65+	33 (3.48)	25 (3.91)	
Missing	21	-	
Gender			<.0001
Male	324 (33.44)	217 (33.96)	
Female	643 (66.36)	421 (65.88)	
Anthropometric Data			
Height (kg)	1.56 ± 0.19 **	1.58 ± 0.17 **	
Weight (kg)	52.41 ± 28.23 **	52.63 ± 15.94 **	
Body Mass Index			<.0001
BMI (mean ±SD)	20.95 ± 12.15	20.24 ±4.4	
Low	269 (38.26)	241 (37.72)	
Normal	343 (48.79)	317 (49.61)	
High	91 (12.94)	81 (12.68)	
Missing	266	-	
Education			<.0001
Never been to school	80 (8.26)	53 (8.29)	
Primary	421 (43.45)	282 (44.13)	
Junior Secondary	267 (27.55)	171 (26.76)	
Senior Secondary	142 (14.65)	94 (14.71)	
Tertiary	59 (6.09)	39 (6.10)	
Residence			<.0001
Rural	254 (26.21)	163 (25.51)	
Urban	640 (66.05)	422 (66.04)	
Peri-urban	68 (7.02)	51 (7.98)	
Missing	7	3	
Occupation			<.0001
Formally employed	105 (10.84)	68 (10.64)	
Self-employed	375 (38.7)	252 (39.44)	
Unemployed	295 (30.44)	189 (29.58)	
Full-time housewife/husband	192 (19.81)	129 (20.19)	

Table 1 Cont'd. Baseline Characteristics between Full Sample and the final Analytic Samples of the NACS Study in Copperbelt and Eastern Province, Zambia 2012-2017

	Full Sample (n=969)	Full Analytic Sample (n=639)	P-Value
Characteristic	*n (%)	*n (%)	
Marital Status			<.0001
Single	113 (11.66)	57 (8.92)	
Married	539 (55.62)	367 (57.43)	
Divorced	90 (9.29)	56 (8.76)	
Separated	22 (2.27)	16 (2.50)	
Widow	174 (17.96)	123 (19.25)	
Widower	30 (3.1)	20 (3.13)	
Missing	1	-	
Religion			<.0001
Christianity	945 (97.52)	619 (96.87)	
Islam	10 (1.03)	8 (1.25)	
Other	8 (0.83)	7 (1.10)	
Missing	6	5	
Previous Nutritional Counseling			<.0001
Yes	928 (95.77)	615 (96.24)	
No	31 (3.20)	22 (3.44)	
Don't know	6 (0.62)	1 (0.16)	
Missing	4	1	
Previous Malnourished Diagnosis			<.0001
Yes	574 (59.24)	389 (60.88)	
No	390 (40.25)	250 (39.12)	

Note: *For categorical variables, reporting Frequency and Column Percentage. **For continuous variables, we report Mean ± Standard Deviation. In order to acquire p-values for characteristics, a PROC T-TEST was run on continuous variables and a Chi-Square test for categorical variables.

Table 2. Final Analytic Sample by Baseline BMI status, Zambia 2012-2017

	Low BMI at Baseline n=241	High BMI at baseline n=81	P-Value
Characteristic	**N (%)**	**N (%)**	
Age			<.0001
18-24	16 (6.6)	4 (4.9)	
25-34	50 (20.7)	9 (11.1)	
35-44	80 (33.2)	35 (43.2)	
45-54	58 (24.1)	22 (27.2)	
55-64	26 (10.8)	10 (12.4)	
65+	11 (4.6)	1 (1.2)	
Gender			<.0001
Male	92 (38.2)	6 (7.4)	
Female	149 (61.8)	75 (92.6)	
Education			<.0001
Never been to school	25 (10.4)	8 (9.9)	
Primary	104 (43.2)	32 (39.5)	
Junior Secondary	58 (24.1)	26 (32.1)	
Senior Secondary	42 (17.4)	11 (13.6)	
Tertiary	12 (4.9)	4 (4.9)	
Residence			0.4485
Rural	50 (20.6)	19 (23.5)	
Urban	163 (67.6)	59 (72.8)	
Peri-urban	26 (10.8)	3 (3.7)	
Missing	2 (0.8)		
Occupation			0.6411
Formally employed	25 (10.4)	11 (13.6)	
Self-employed	89 (36.9)	36 (44.4)	
Unemployed	88 (36.5)	11 (13.6)	
Full-time housewife/husband	39 (16.2)	23 (28.4)	
Marital Status			0.2005
Single	25 (10.4)	4 (4.9)	
Married	130 (53.9)	46 (56.8)	
Divorced	26 (10.8)	5 (6.2)	
Separated	6 (2.5)	0 (0)	
Widow	45 (18.7)	24 (29.6)	
Widower	9 (3.7)	2 (2.4)	
Religion			0.1009
Christianity	235 (97.5)	78 (96.3)	
Islam	3 (1.2)	1 (1.2)	
Other	2 (0.8)	0 (0)	
Missing	1	2 (2.5)	

Table 2 Cont'd Stratified Analytic Sample by Baseline BMI status, Zambia 2012-2017

	Low BMI at Baseline n=241	High BMI at baseline n=81	P-Value
Characteristic	**N (%)**	**N (%)**	
Previous Nutritional Counseling			0.0212
Yes	225 (93.7)	81 (100)	
No	15 (6.3)	0 (0)	
Previous Malnourished Diagnosis			<.0001
Yes	180 (74.7)	28 (34.6)	
No	61 (25.3)	53 (65.4)	

Note: In order to acquire p-values for characteristics, a PROC T-TEST was run on continuous variables and a Chi-Square test for categorical variables.

Table 3. Univariate Odds Ratios of potential risk factors (n=322), Zambia 2012-2017

	Low BMI at Baseline n=241	High BMI at baseline n=81	Both Groups n= 322
Characteristic	**cOR (95%)**	**cOR (95%)**	**cOR (95%)**
Gender			
Male	—[a]	—[a]	—[a]
Female	1.23 (0.72, 2.1)	2.50 (0.28, 22.56)	1.4 (1.00, 1.92)**
Education			
Never been to school	—[a]	—[a]	—[a]
Primary	1.02 (0.42, 2.50)	1.80 (0.31, 10.39)	0.56 (0.31, 1.03)
Junior Secondary	0.73 (0.28, 1.93)	0.39 (0.05, 2.89)**	0.58 (0.31, 1.10)
Senior Secondary	1.0 (0.37, 2.80)	8.00 (1.00, 63.96)**	0.78 (0.39, 1.56)
Tertiary	2.0 (0.43, 9.22)	1.0 (0.063, 15.98)	0.42 (0.18, 0.98)**
Residence			
Rural	—[a]	—[a]	—[a]
Urban	1.03 (0.54, 1.97)	1.55 (0.49, 4.89)	1.51 (1.05, 2.18)
Peri-urban	0.60 (0.21, 1.70) **	—[1]	1.79 (0.95, 3.39)**
Occupation			
Formally employed	—[a]	—[a]	—[a]
Self-employed	1.44 (0.55, 3.82)	2.86 (0.53, 15.25)**	0.87 (0.51, 1.50)
Unemployed	1.62 (0.61, 4.28)	1.00 (0.12, 8.73)	0.98 (0.56, 1.70)
Full-time housewife/husband	2.20 (0.75, 6.47)	2.40 (0.42, 13.89)	0.82 (0.46, 1.48)
Marital Status			
Single	—[a]	—[a]	—[a]
Married	1.83 (0.71, 4.68)**	0.44 (0.06, 3.43)	0.89 (0.51, 1.55)
Divorced	0.95 (0.28, 3.24)	0.67 (0.05, 9.47)	1.20 (0.57, 2.51)
Separated	1.28 (0.19, 8.67)	—[1]	0.58 (0.186, 1.81)
Widow	1.71 (0.59, 4.93)	0.50 (0.06, 4.23)	1.23 (0.66, 2.32)
Widower	1.29 (0.25, 6.61)	—[1]	1.18 (0.42, 3.30)
Religion			
Christianity	—[a]	—[a]	—[a]
Islam	0.85 (0.08, 9.52)	—[1]	0.98 (0.24, 3.94)
Other	—[1]	—[1]	0.39 (0.07, 2.03)
Prev* Nutritional Counseling			
Yes	—[a]	—[a]	—[a]
No	0.59 (0.18, 1.91)	—[1]	2.16 (0.87, 5.38)**
Prev* Malnutrition Diagnosis			
Yes	—[a]	—[a]	—[a]
No	1.31 (0.73, 2.40)	2.22 (0.77, 6.41)**	0.73 (0.53, 1.00)**

Note: [a] Reference, *Previous, [1] Not enough information for OR calculation **significant at 0.20 level

Table 4. Multivariate Odds Ratios (n=322), Zambia 2012-2017

	Low BMI n=241	High BMI n=81	Analytic Sample** n=639
Characteristic	**aOR (95%)**	**aOR (95%)**	**aOR (95%)**
Gender			
Male	—[a]	5.84 (2.29, 14.93) [5]	
Female		—[a]	
Previous Malnutrition Diagnosis			
Yes	—[a]	—[a]	
No	2.61 (1.71, 3.98) [1]	0.38 (0.22, 0.68) [6]	
Previous Nutritional Counseling			
Yes	—[a]		—[a]
No	0.29 (0.12, 0.72) [2]		2.2 (0.88, 5.51)[7]
Residence			
Rural	—[a]		—[a]
Urban	0.77 (0.48, 1.22) [3]		1.51 (1.05, 2.18) [8]
Peri-Urban	0.43 (0.21, 0.87) [4]		1.82 (0.95, 3.47) [9]

Note: ****These multivariate ORs demonstrate risk factors associated with malnutrition at baseline among the full analytic sample.**

[1]p-value <.0001 **[5]p-value 0.0002** **[9]p-value 0.1963**
[2]p-value 0.0074 **[6]p-value 0.0011**
[3]p-value 0.4623 **[7]p-value 0.0927**
[4]p-value 0.0271 **[8]p-value 0.5514**

THE GOAL: Identify the risk factors associated with achieving good nutritional status among cohort of PLHIV in Zambia.

TIMELINE: The Zambia Thrive NACS study was ongoing for the period of 2012-2017.

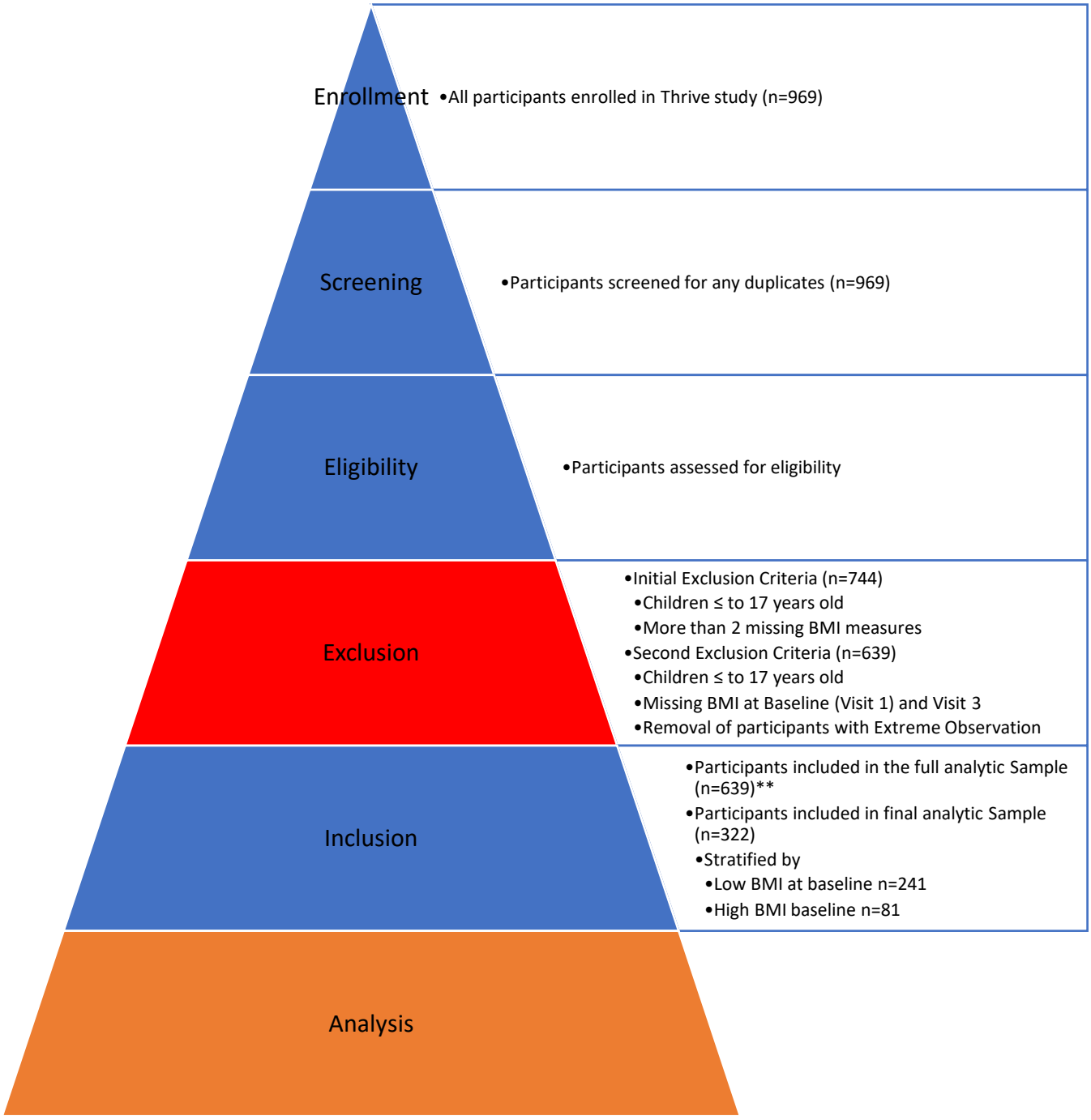

Figure 1. Flow Diagram

This flowchart shows the study enrollment and screening process, along with the inclusion and exclusion criteria. The final number of participants in the analytic sample was 322, the individuals with abnormal BMI from the full analytic sample.

Note: **Individuals in the full analytic sample with normal baseline BMI were not considered in the final analytic sample, which was stratified between the abnormal baseline BMI groups, low and high.

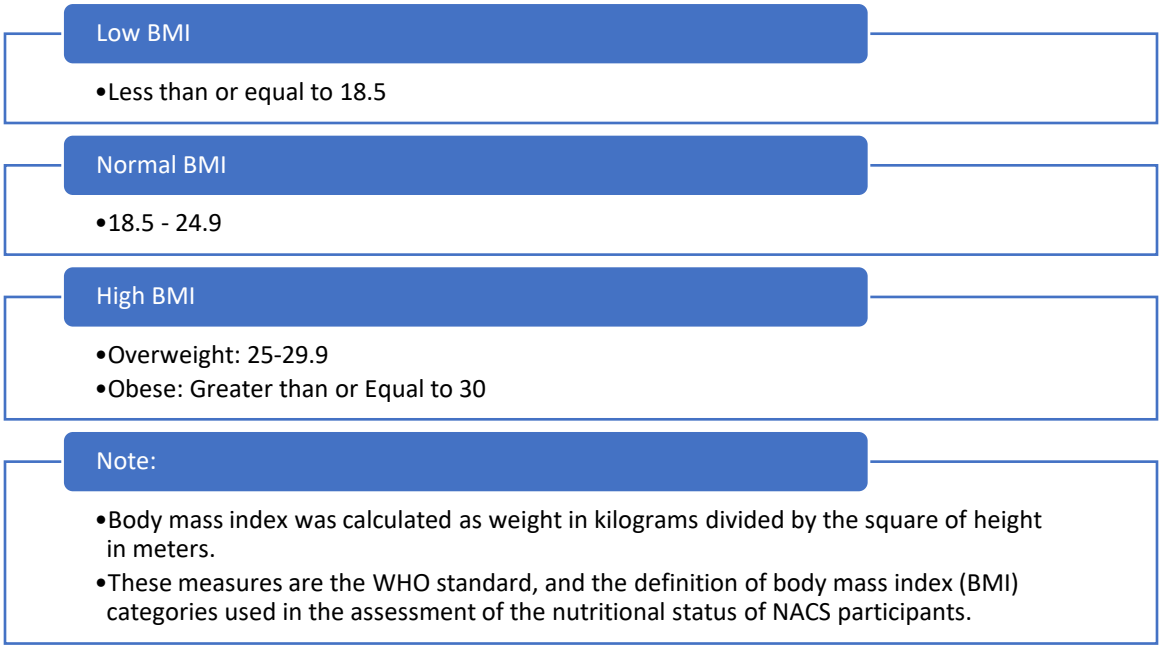

Figure 2. BMI Categorized by WHO Definition.
Definitions of body mass index (BMI) categories used in the assessment of the nutritional status of NACS participants.

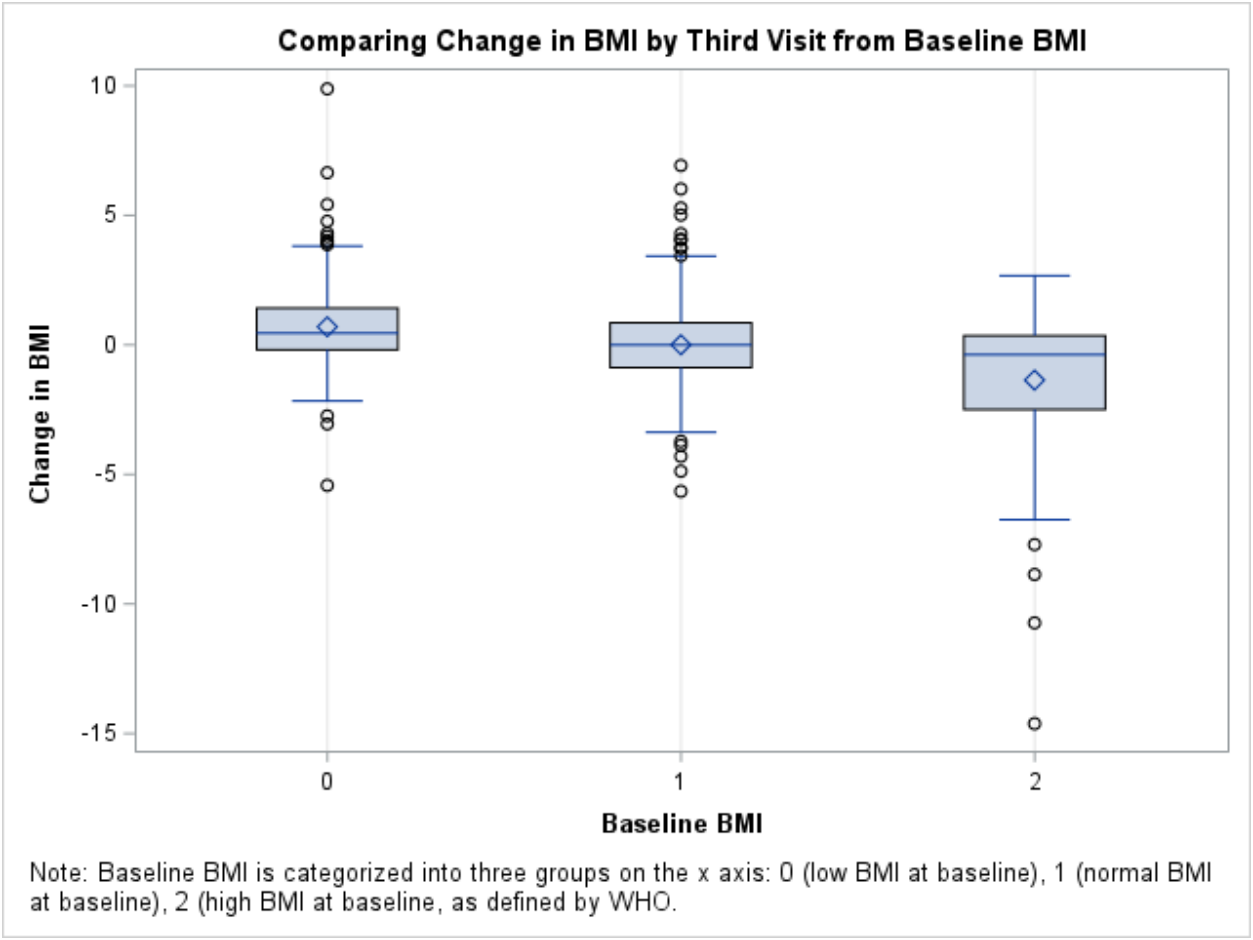

Figure 3. Box-plots Comparing Change in BMI between two time points (Baseline and Visit 3)
This figure illustrates the association between change in BMI and baseline BMI, showing the distribution of change in BMI by baseline.

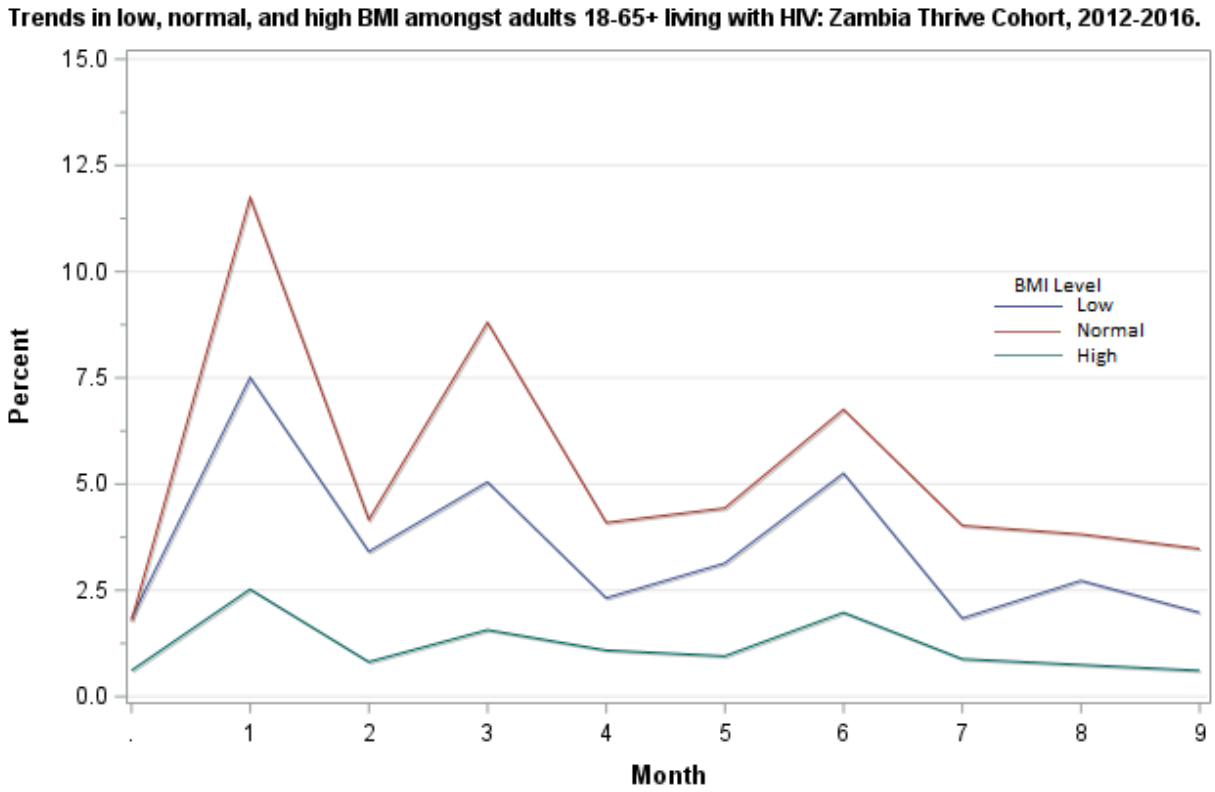

Figure 4. Trends among mean Baseline BMI over time

This figure demonstrates the percent mean BMI over time among each baseline BMI strata.

APPENDIX A: SAS Code

```
************************************
***********MUSHTAQ DUALEH***********
*******MASTER OF PUBLIC HEALTH*******
***********GLOBAL HEALTH***********
************THESIS 2019************
************************************;

*IMPORTING DATASET;
proc import datafile = 'H:/Thesis/NACSDATA3.csv'
 out = thesis
 dbms = csv
 replace;
run;
run;


proc contents data=thesis;
run;

*Cleaning Thesis;
data work.thesis1;
      set work.thesis;

if weight1 gt 800 then weight1=.;
if weight2 gt 800 then weight2=.;
if weight3 gt 800 then weight3=.;
if weight4 gt 800 then weight4=.;

if height1 ge 3 then height1=.;
if height2 ge 3 then height2=.;
if height3 ge 3 then height3=.;
if height4 ge 3 then height4=.;

ARTvisit=0;
if art1=. then ARTvisit =ARTvisit+1;
if art2=. then ARTvisit =ARTvisit+1;
if art3=. then ARTvisit =ARTvisit+1;
if art4=. then ARTvisit =ARTvisit+1;


if height=88 then height=.;
if weight=88 then weight=.;

run;


data work.thesis2; *CATEGORIZING BMI INTO THREE GROUPS: LOW BMI (0), NORMAL
BMI (1), HIGH BMI (2);
      set work.thesis1;

if weight1=. | height1=. then calcbmi1=.; *this eliminates the missing
weights and heights so that they are not calculated;
```

```
else calcbmi1=  (weight1) / (height1**2); *formula to calculate the bmi;
if weight2=. | height2=. then calcbmi2=.;
else calcbmi2 = (weight2) / (height2**2);
if weight3=. | height3=. then calcbmi3=.;
else calcbmi3 = (weight3) / (height3**2);
if weight4=. | height4=. then calcbmi4=.;
else calcbmi4 = (weight4) / (height4**2);

if calcbmi1 le 1 | calcbmi1 ge 88 then bmiv1=.;
if calcbmi1 gt 1 & calcbmi1 lt 18.5 then bmiv1=0;                  *LOW BMI
(ABNORMAL);
if calcbmi1 ge 18.5 & calcbmi1 le 24.9 then bmiv1=1; *NORMAL BMI;
if calcbmi1 gt 24.9 & calcbmi1 lt 88 then bmiv1=2;                 *HIGH BMI
(ABNORMAL);

if calcbmi2 le 1 | calcbmi2 ge 88 then bmiv2=.;
if calcbmi2 gt 1 & calcbmi2 lt 18.5 then bmiv2=0;                  *LOW BMI
(ABNORMAL);
if calcbmi2 ge 18.5 & calcbmi2 le 24.9 then bmiv2=1; *NORMAL BMI;
if calcbmi2 gt 24.9 & calcbmi2 lt 88 then bmiv2=2;                 *HIGH BMI
(ABNORMAL);

if calcbmi3 le 1 | calcbmi3 ge 88 then bmiv3=.;              *bmi;
if calcbmi3 gt 1 & calcbmi3 lt 18.5 then bmiv3=0;                  *LOW BMI
(ABNORMAL);
if calcbmi3 ge 18.5 & calcbmi3 le 24.9 then bmiv3=1; *NORMAL BMI;
if calcbmi3 gt 24.9 & calcbmi3 lt 88 then bmiv3=2;                 *HIGH BMI
(ABNORMAL);

if calcbmi4 le 1 | calcbmi4 ge 88 then bmiv4=.;
if  calcbmi4 gt 1 & calcbmi4 lt 18.5 then bmiv4=0;                 *LOW BMI
(ABNORMAL);
if  calcbmi4 ge 18.5 & calcbmi4 le 24.9 then bmiv4=1; *NORMAL BMI;
if calcbmi4 gt 24.9 & calcbmi4 lt 88 then bmiv4=2;                 *HIGH BMI
(ABNORMAL);

if age ge 18 & age le 24 then age_="18-24";
if age ge 25 & age le 34 then age_="25-34";
if age ge 35 & age le 44 then age_="35-44";
if age ge 45 & age le 54 then age_="45-54";
if age ge 55 & age le 64 then age_="55-64";
if age ge 65 then age_="65+";

BMIvisit=0;
if bmiv1=. then BMIvisit =BMIvisit+1;
if bmiv2=. then BMIvisit =BMIvisit+1;
if bmiv3=. then BMIvisit =BMIvisit+1;
if bmiv4=. then BMIvisit =BMIvisit+1;

IF CALCBMI1=. THEN BMI1MISS=1;
ELSE BMI1MISS=0;

IF CALCBMI2=. THEN BMI2MISS=1;
ELSE BMI2MISS=0;

IF CALCBMI3=. THEN BMI3MISS=1;
ELSE BMI3MISS=0;
```

```
IF CALCBMI4=. THEN BMI4MISS=1;
ELSE BMI4MISS=0;

run;

*In order to determine the best sample size for final analytic sample. This
informs on BMI measures missing, once determined it will simplify process for
modeling;
proc freq data=thesis2;
tables BMI1MISS*BMI2MISS*BMI3MISS*BMI4MISS/list missing;
run;
proc contents data=thesis2;
run;

*Baseline Characteristics for Table 1, Full Sample;
proc means data=thesis1;
var height1 weight1;
run;

proc freq data=thesis2;
table  bmiv1 bmiv2 bmiv3 bmiv4;
run;

proc print data=thesis2 (obs=10);
var calcbmi1 calcbmi2 calcbmi3 calcbmi4;
run;

proc freq data=thesis2;
table kaps1 kaps2 kaps3 kaps4 kaps5 kaps6 kaps7 kaps8 kaps9 kaps10 kaps11
kaps12 kaps13 kaps14;
run;

proc freq data=thesis2;
table nutcoun satisnutcou lastnutcou nutcouaccess heps hepsnowhy hepsexpect ;
run;

proc freq data=thesis2;
table eiacp2 eiacp3 eiacp4 eiacp5 eiacp6 eiacp7 eiacp8 eiacp9;
run;

proc freq data=thesis2;
table hivmed1 hivmed3 hivmed4 hivmed5 hivmed6 hivmed7;
run;

 *INITIAL INCLUSION CRITERIA;
data thesis3;
      set thesis2;
if age ge 18 & bmivisit le 2; *including only adults in the study *including
only those with less than 2 missing BMI measures;
run;

proc freq data=thesis3;
table  bmiv1 bmiv2 bmiv3 bmiv4;
run;

proc freq data=thesis3;
```

```
table hivmed1 hivmed3 hivmed4 hivmed5 hivmed6 hivmed7;
run;
proc freq data=thesis3;
table bmiv bmiv1 bmiv2 bmiv3 bmiv4;
run;

proc freq data=thesis3;
table kaps1 kaps2 kaps3 kaps4 kaps5 kaps6 kaps7 kaps8 kaps9 kaps10 kaps11
kaps12 kaps13 kaps14;
run;

proc freq data=thesis3;
table nutcoun satisnutcou lastnutcou nutcouaccess heps hepsnowhy hepsexpect ;
run;

proc freq data=thesis3;
table eiacp2 eiacp3 eiacp4 eiacp5 eiacp6 eiacp7 eiacp8 eiacp9;
run;
*INTRODUCING SECOND INCLUSION CRITERIA);
data thesis4;
      set thesis3;
if age ge 18 & bmivisit le 2 & calcbmi1 ne .; *including only adults in the
study *including only those with less than 2 missing BMI measures;
if questid in (45397, 45112, 45909, 45408, 45419, 45663, 45403) then delete ;
*these individuals had extreme values;
run;

proc freq data=thesis4;
table  bmiv1 bmiv2 bmiv3 bmiv4;
run;

proc freq data=thesis4;
table hivmed1 hivmed3 hivmed4 hivmed5 hivmed6 hivmed7;
run;
proc freq data=thesis4;
table bmiv bmiv1 bmiv2 bmiv3 bmiv4;
run;

proc freq data=thesis4;
table kaps1 kaps2 kaps3 kaps4 kaps5 kaps6 kaps7 kaps8 kaps9 kaps10 kaps11
kaps12 kaps13 kaps14;
run;

proc freq data=thesis4;
table nutcoun satisnutcou lastnutcou nutcouaccess heps hepsnowhy hepsexpect ;
run;

proc freq data=thesis4;
table eiacp2 eiacp3 eiacp4 eiacp5 eiacp6 eiacp7 eiacp8 eiacp9;
run;
*INTRODUCES NEW VARIABLE THAT CREATES DAYS BETWEEN VISIT VARIABLES AND THEN
DIFFERENITATING MONTHS ACCORDING TO DAYS SINCE BASELINE.;

data thesis5;
      set thesis4;

*Determines the amount of days between the two visits);
```

```
visit1_2days=intck('day', visit1, visit2);  *Visit 1 and Visit 2;
visit1_3days=intck('day', visit1, visit3);      *Visit 1 and Visit 3;
visit1_4days=intck('day', visit1, visit4);      *Visit 1 and Visit 4;


*Creating new month variable associated with number of days between two
visits;

if visit1 ne . then visitba=0;

*Setting month 1 to occur between 20 and 50 days;
if visit1_2days ge 20 & visit1_2days le 50 then visitb1="1"; *If number of
days between baseline and month 1 is 20-40 then month1visit is truly month 1;
if visit1_3days ge 20 & visit1_3days le 50 then visitb1="1"; *If number of
days between baseline and month 2 is 20-40 then month1visit is actually visit
1;
if visit1_4days ge 20 & visit1_4days le 50 then visitb1="1"; *If number of
days between baseline and month 3 is 20-40 then month1visit is actually visit
1;

*Setting month 2 to occur between 51 and 81 days after baseline ( ge 51 & le
81);

if visit1_2days ge 51 & visit1_2days le 81 then visitb2="2"; *If number of
days between baseline and month 1 is 51-75 then month2visit is actually visit
2;
if visit1_3days ge 51 & visit1_3days le 81 then visitb2="2"; *If number of
days between baseline and month 2 is 51-75 then month2visit is actually visit
2;
if visit1_4days ge 51 & visit1_4days le 81 then visitb2="2"; *If number of
days between baseline and month 3 is 51-75 then month2visit is actually visit
2;

*Setting month 3 to occur between 82 and 112 days after baseline ( ge 76 & le
100);

if visit1_2days ge 82 & visit1_2days le 112 then visitb3="3"; *If number of
days between baseline and month 1 is 76-95 then month is actually month 3;
if visit1_3days ge 82 & visit1_3days le 112 then visitb3="3"; *If number of
days between baseline and month 2 is 76-95 then month is actually month 3;
if visit1_4days ge 82 & visit1_4days le 112 then visitb3="3"; *If number of
days between baseline and month 3 is 76-95 then month is actually month 3;

if visit1_2days ge 113 & visit1_2days le 143 then visitb4="4"; *If number of
days between baseline and month 1 is 113-143 then month is actually month 4;
if visit1_3days ge 113 & visit1_3days le 143 then visitb4="4"; *If number of
days between baseline and month 2 is 113-143 then month is actually month 4;
if visit1_4days ge 113 & visit1_4days le 143 then visitb4="4"; *If number of
days between baseline and month 3 is 113-143 then month is actually month 4;

if visit1_2days ge 144 & visit1_2days le 174 then visitb5="5"; *If number of
days between baseline and month 1 is 144-174 then month is actually month 5;
if visit1_3days ge 144 & visit1_3days le 174 then visitb5="5"; *If number of
days between baseline and month 2 is 144-174 then month is actually month 5;
if visit1_4days ge 144 & visit1_4days le 174 then visitb5="5"; *If number of
days between baseline and month 3 is 144-174 then month is actually month 5;
```

```
if visit1_2days ge 175 & visit1_2days le 205 then visitb6="6"; *If number of
days between baseline and month 1 is 175-205 then month is actually month 6;
if visit1_3days ge 175 & visit1_3days le 205 then visitb6="6"; *If number of
days between baseline and month 2 is 175-205 then month is actually month 6;
if visit1_4days ge 175 & visit1_4days le 205 then visitb6="6"; *If number of
days between baseline and month 3 is 175-205 then month is actually month 6;

if visit1_2days ge 206 & visit1_2days le 236 then visitb7="7"; *If number of
days between baseline and month 1 is 206-236 then month is actually month 7;
if visit1_3days ge 206 & visit1_3days le 236 then visitb7="7"; *If number of
days between baseline and month 2 is 206-236 then month is actually month 7;
if visit1_4days ge 206 & visit1_4days le 236 then visitb7="7"; *If number of
days between baseline and month 3 is 206-236 then month is actually month 7;

if visit1_2days ge 237 & visit1_2days le 267 then visitb8="8"; *If number of
days between baseline and month 1 is 237-267 then month is actually month 8;
if visit1_3days ge 237 & visit1_3days le 267 then visitb8="8"; *If number of
days between baseline and month 2 is 237-267 then month is actually month 8;
if visit1_4days ge 237 & visit1_4days le 267 then visitb8="8"; *If number of
days between baseline and month 3 is 237-267 then month is actually month 8;

if visit1_2days ge 268 & visit1_2days le 298 then visitb9="9"; *If number of
days between baseline and month 1 is 268-298 then month is actually month 9;
if visit1_3days ge 268 & visit1_3days le 298 then visitb9="9"; *If number of
days between baseline and month 2 is 268-298 then month is actually month 9;
if visit1_4days ge 268 & visit1_4days le 298 then visitb9="9"; *If number of
days between baseline and month 3 is 268-298 then month is actually month 9;

if visit1_2days ge 299 & visit1_2days le 329 then visitb10="10"; *If number
of days between baseline and month 1 is 299-329 then month is actually month
10;
if visit1_3days ge 299 & visit1_3days le 329 then visitb10="10"; *If number
of days between baseline and month 2 is 299-329 then month is actually month
10;
if visit1_4days ge 299 & visit1_4days le 329 then visitb10="10"; *If number
of days between baseline and month 3 is 299-329 then month is actually month
10;

if visit1_2days ge 330 & visit1_2days le 360 then visitb11="11"; *If number
of days between baseline and month 1 is 330-360 then month is actually month
11;
if visit1_3days ge 330 & visit1_3days le 360 then visitb11="11"; *If number
of days between baseline and month 2 is 330-360 then month is actually month
11;
if visit1_4days ge 330 & visit1_4days le 360 then visitb11="11"; *If number
of days between baseline and month 3 is 330-360 then month is actually month
11;


if visit1_2days ge 361 & visit1_2days le 391 then visitb12="12"; *If number
of days between baseline and month 1 is 361-391 then month is actually month
12;
if visit1_3days ge 361 & visit1_3days le 391 then visitb12="12"; *If number
of days between baseline and month 2 is 361-391 then month is actually month
12;
```

```
if visit1_4days ge 361 & visit1_4days le 391 then visitb12="12"; *If number
of days between baseline and month 3 is 361-391 then month is actually month
12;

*missing;
if visit1_2days =. then visitb1=.;
if visit1_3days =. then visitb1=.;
if visit1_4days =. then visitb1=.;
if visit1_2days =. then visitb2=.;
if visit1_3days =. then visitb2=.;
if visit1_4days =. then visitb2=.;
if visit1_2days =. then visitb3=.;
if visit1_3days =. then visitb3=.;
if visit1_4days =. then visitb3=.;
if visit1_2days =. then visitb4=.;
if visit1_3days =. then visitb4=.;
if visit1_4days =. then visitb4=.;
if visit1_2days =. then visitb5=.;
if visit1_3days =. then visitb5=.;
if visit1_4days =. then visitb5=.;
if visit1_2days =. then visitb6=.;
if visit1_2days =. then visitb6=.;
if visit1_3days =. then visitb6=.;
if visit1_2days =. then visitb7=.;
if visit1_3days =. then visitb7=.;
if visit1_4days =. then visitb7=.;
if visit1_2days =. then visitb8=.;
if visit1_3days =. then visitb8=.;
if visit1_4days =. then visitb8=.;
if visit1_2days =. then visitb9=.;
if visit1_3days =. then visitb9=.;
if visit1_4days =. then visitb9=.;
if visit1_2days =. then visitb10=.;
if visit1_3days =. then visitb10=.;
if visit1_4days =. then visitb10=.;
if visit1_2days =. then visitb11=.;
if visit1_3days =. then visitb11=.;
if visit1_4days =. then visitb11=.;
if visit1_2days =. then visitb12=.;
if visit1_3days =. then visitb12=.;
if visit1_4days =. then visitb12=.;

run;

proc print data=thesis5 (obs=20);
var questid visit1_2days visit1_3days visit1_4days visit1 visit2 visit3
visit4;
run;

proc freq data=work.thesis5;
table  visit1_2days visit1_3days visit1_4days visitb1 visitb2 visitb3;
run;

proc sort data=work.thesis5;
by age_ ;
run;
```

```
proc freq data=work.thesis5;
table bmiv1 bmiv2 bmiv3 bmiv4 bmiv;
by age_;
run;

proc print data=work.thesis5;
var bmiv;
by age_;
run;
proc print data=work.thesis5 (obs=20);
var visitb1 visitb2 visitb3 visitb4 visitb5 visitb6 visitb7 visitb8 visitb9
visitb10 visitb11 visitb12;
run;

proc freq data=work.thesis5;
table visitb1 visitb2 visitb3 visitb4 visitb5 visitb6 visitb7 visitb8 visitb9
visitb10 visitb11 visitb12;
run;

*To accurately place BMI with the right time componens;
data work.thesis6;
      set work.thesis5;

bmiba=calcbmi1;

if visit1_2days ge 20 & visit1_2days le 50 then bmib1=calcbmi2;
if visit1_3days ge 20 & visit1_3days le 50 then bmib1=calcbmi3;
if visit1_4days ge 20 & visit1_4days le 50 then bmib1=calcbmi4;

if visit1_2days ge 51 & visit1_2days le 81 then bmib2=calcbmi2;
if visit1_3days ge 51 & visit1_3days le 81 then bmib2=calcbmi3;
if visit1_4days ge 51 & visit1_4days le 81 then bmib2=calcbmi4;

if visit1_2days ge 82 & visit1_2days le 112 then bmib3=calcbmi2;
if visit1_3days ge 82 & visit1_3days le 112 then bmib3=calcbmi3;
if visit1_4days ge 82 & visit1_4days le 112 then bmib3=calcbmi4;

if visit1_2days ge 113 & visit1_2days le 143 then bmib4=calcbmi2;
if visit1_3days ge 113 & visit1_3days le 143 then bmib4=calcbmi3;
if visit1_4days ge 113 & visit1_4days le 143 then bmib4=calcbmi4;

if visit1_2days ge 144 & visit1_2days le 174 then bmib5=calcbmi2;
if visit1_3days ge 144 & visit1_3days le 174 then bmib5=calcbmi3;
if visit1_4days ge 144 & visit1_4days le 174 then bmib5=calcbmi4;

if visit1_2days ge 175 & visit1_2days le 205 then bmib6=calcbmi2;
if visit1_3days ge 175 & visit1_3days le 205 then bmib6=calcbmi3;
if visit1_4days ge 175 & visit1_4days le 205 then bmib6=calcbmi4;

if visit1_2days ge 206 & visit1_2days le 236 then bmib7=calcbmi2;
if visit1_3days ge 206 & visit1_3days le 236 then bmib7=calcbmi3;
if visit1_4days ge 206 & visit1_4days le 236 then bmib7=calcbmi4;

if visit1_2days ge 237 & visit1_2days le 267 then bmib8=calcbmi2;
if visit1_3days ge 237 & visit1_3days le 267 then bmib8=calcbmi3;
if visit1_4days ge 237 & visit1_4days le 267 then bmib8=calcbmi4;
```

```
if visit1_2days ge 268 & visit1_2days le 298 then bmib9=calcbmi2;
if visit1_3days ge 268 & visit1_3days le 298 then bmib9=calcbmi3;
if visit1_4days ge 268 & visit1_4days le 298 then bmib9=calcbmi4;

if visit1_2days ge 299 & visit1_2days le 329 then bmib10=calcbmi2;
if visit1_3days ge 299 & visit1_3days le 329 then bmib10=calcbmi3;
if visit1_4days ge 299 & visit1_4days le 329 then bmib10=calcbmi4;

if visit1_2days ge 330 & visit1_2days le 360 then bmib11=calcbmi2;
if visit1_3days ge 330 & visit1_3days le 360 then bmib11=calcbmi3;
if visit1_4days ge 330 & visit1_4days le 360 then bmib11=calcbmi4;

if visit1_2days ge 361 & visit1_2days le 391 then bmib12=calcbmi2;
if visit1_3days ge 361 & visit1_3days le 391 then bmib12=calcbmi3;
if visit1_4days ge 361 & visit1_4days le 391 then bmib12=calcbmi4;

run;

data thesis7;
      set thesis6;
bmicatba=bmiv1;
if visit1_2days ge 20 & visit1_2days le 50 then bmicat1=bmiv2;
if visit1_3days ge 20 & visit1_3days le 50 then bmicat1=bmiv3;
if visit1_4days ge 20 & visit1_4days le 50 then bmicat1=bmiv4;

if visit1_2days ge 51 & visit1_2days le 81 then bmicat2=bmiv2;
if visit1_3days ge 51 & visit1_3days le 81 then bmicat2=bmiv3;
if visit1_4days ge 51 & visit1_4days le 81 then bmicat2=bmiv4;

if visit1_2days ge 82 & visit1_2days le 112 then bmicat3=bmiv2;
if visit1_3days ge 82 & visit1_3days le 112 then bmicat3=bmiv3;
if visit1_4days ge 82 & visit1_4days le 112 then bmicat3=bmiv4;

if visit1_2days ge 113 & visit1_2days le 143 then bmicat4=bmiv2;
if visit1_3days ge 113 & visit1_3days le 143 then bmicat4=bmiv3;
if visit1_4days ge 113 & visit1_4days le 143 then bmicat4=bmiv4;

if visit1_2days ge 144 & visit1_2days le 174 then bmicat5=bmiv2;
if visit1_3days ge 144 & visit1_3days le 174 then bmicat5=bmiv3;
if visit1_4days ge 144 & visit1_4days le 174 then bmicat5=bmiv4;

if visit1_2days ge 175 & visit1_2days le 205 then bmicat6=bmiv2;
if visit1_3days ge 175 & visit1_3days le 205 then bmicat6=bmiv3;
if visit1_4days ge 175 & visit1_4days le 205 then bmicat6=bmiv4;

if visit1_2days ge 206 & visit1_2days le 236 then bmicat7=bmiv2;
if visit1_3days ge 206 & visit1_3days le 236 then bmicat7=bmiv3;
if visit1_4days ge 206 & visit1_4days le 236 then bmicat7=bmiv4;

if visit1_2days ge 237 & visit1_2days le 267 then bmicat8=bmiv2;
if visit1_3days ge 237 & visit1_3days le 267 then bmicat8=bmiv3;
if visit1_4days ge 237 & visit1_4days le 267 then bmicat8=bmiv4;

if visit1_2days ge 268 & visit1_2days le 298 then bmicat9=bmiv2;
if visit1_3days ge 268 & visit1_3days le 298 then bmicat9=bmiv3;
if visit1_4days ge 268 & visit1_4days le 298 then bmicat9=bmiv4;
```

```
if visit1_2days ge 299 & visit1_2days le 329 then bmicat10=bmiv2;
if visit1_3days ge 299 & visit1_3days le 329 then bmicat10=bmiv3;
if visit1_4days ge 299 & visit1_4days le 329 then bmicat10=bmiv4;

if visit1_2days ge 330 & visit1_2days le 360 then bmicat11=bmiv2;
if visit1_3days ge 330 & visit1_3days le 360 then bmicat11=bmiv3;
if visit1_4days ge 330 & visit1_4days le 360 then bmicat11=bmiv4;

if visit1_2days ge 361 & visit1_2days le 391 then bmicat12=bmiv2;
if visit1_3days ge 361 & visit1_3days le 391 then bmicat12=bmiv3;
if visit1_4days ge 361 & visit1_4days le 391 then bmicat12=bmiv4;


run;

data thesis8;
set THESIS7;

*Creating change in BMI variable, continuous, it is normally distributed;
changebmi= calcbmi3-calcbmi1;

if bmiv1=0 then lowbmi=0;

*Dichotomizing change in BMI;
IF CHANGEBMI<0 THEN BMIST=0; *decrease in BMI;
ELSE IF CHANGEBMI>0 THEN BMIST=1; *increase in BMI;


run;

title 'Extreme BMI Observations';   *determined what variables to exclude
from analytic sample;
ods select ExtremeObs;
proc univariate data=thesis8;
   var changebmi;
   id questid;
run;
proc print data=thesis8;
where questid in (45397, 45112, 45909, 45408, 45916, 45343, 45753, 45419,
45663, 45403);
run;
proc freq data=thesis8;
table bmist;
run;

proc freq data=thesis8;
tables bmiv1 bmiv3;
run;

*Exploring Change in BMI variable;
proc univariate data=thesis8 plots;
var changebmi;
run;

proc univariate data=thesis8; *0.453242, increase;
var changebmi;
where bmiv1=0;
```

```
run;
proc univariate data=thesis8;  *0 constant, no change;
var changebmi;
where bmiv1=1;
run;
proc univariate data=thesis8; *-0.376761 change;
var changebmi;
where bmiv1=2;
run;

ods graphics on;
title 'Change in BMI amongst BMI levels';
proc anova data=thesis8;
class bmiv1;
model changebmi = bmiv1;
ods output BoxPlot=changeinbmi;
run;
ods graphics off;

** Boxplot Change in BMI from baseline BMI code;
proc template;
define statgraph sgdesign;
dynamic _CHANGEBMI _BMIV1A;
begingraph;
   entrytitle halign=center 'Comparing Change in BMI by Third Visit from
Baseline BMI';
   entryfootnote halign=left 'Note: Baseline BMI is categorized into three
groups on the x axis: 0 (low BMI at baseline), 1 (normal BMI at baseline), 2
(high BMI at baseline, as defined by WHO.';
   layout lattice / rowdatarange=data columndatarange=data rowgutter=10
columngutter=10;
      layout overlay / xaxisopts=( type=discrete display=(LINE TICKVALUES
LABEL TICKS ) griddisplay=on label=('Baseline BMI') labelattrs=(style=NORMAL
weight=BOLD ) discreteopts=( tickvaluelist=("0" "1" "2") tickdisplaylist=("0"
"1" "2") tickvaluefitpolicy=splitrotate tickvaluerotation=vertical))
yaxisopts=( label=('Change in BMI ') labelattrs=(style=NORMAL weight=BOLD ));
         boxplot x=_BMIV1A y=_CHANGEBMI / name='box' legendlabel='Change in
BMI' boxwidth=0.4 groupdisplay=Cluster;
      endlayout;
   endlayout;
endgraph;
end;
run;

proc sgrender data=WORK.THESIS8 template=sgdesign;
dynamic _CHANGEBMI="CHANGEBMI" _BMIV1A="BMIV1";
run;



*Baseline Characteristics for Analytic Sample, Table 2;
*Low BMI Baseline;
proc freq data=thesis9;
table age_ gender educ residence occu marstat religion mal1 nutcoun;
where bmiv1=0;
run;
*High BMI Baseline;
```

```
proc freq data=thesis9;
table age_ gender educ residence occu marstat religion mal1 nutcoun;
where bmiv1=2;
run;

*CREATING LOW BASELINE BMI VARIABLE FOR LOGISTIC MODEL;

data thesis9;
set thesis8;

if changebmi ge 0 & bmiv1=0 then low_reach =1; *success;
else low_reach=0; *fail;

if nutcoun = 98 | nutcoun=3 then nutcoun=.;
if residence = 98 then residence=.;
if ART1 = 98  then ART1=.;
if gender = 98  then gender=.;
if religion = 98 then religion =.;
run;

*CREATING HIGH BASELINE BMI VARIABLE FOR LOGISTIC MODEL;
data thesis10;
set thesis9;

if changebmi le 0 & bmiv1=2 then high_reach =1; *success;
else high_reach=0; *fail;

run;

*CREATING BASELINE BMI VARIABLE FOR EASIER CLASSIFICATION;
data thesis11;
set thesis10;

if bmiv1=0 or bmiv1=2 then baselinebmi=0; *abnormal;
else baselinebmi=1; *normal;

run;

PROC FREQ DATA=THESIS11;
TABLES HIGH_REACH LOW_REACH BASELINEBMI;
RUN;


*UNIVARIATE ODDS RATIOS AND CI'S FOR TABLE 3;
*LOW BMI;
proc logistic data=thesis11; *p - .45;
      where bmiv1=0;
      class gender (ref="1");
      model low_reach (event = "0") =gender;
run;

proc logistic data=thesis11;
      where bmiv1=0;
      class educ (ref="1");
      model low_reach (event = "0") =educ;
run;
proc logistic data=thesis11;
```

```
      where bmiv1=0;
      class residence (ref="1");
      model low_reach (event = "0") =residence;
run;
proc logistic data=thesis11;
      where bmiv1=0;
      class occu (ref="1");
      model low_reach (event = "0") =occu;
run;
proc logistic data=thesis11;
      where bmiv1=0;
      class marstat (ref="1");
      model low_reach (event = "0") =marstat;
run;
proc logistic data=thesis11;
      where bmiv1=0;
      class religion (ref="1");
      model low_reach (event = "0") =religion;
run;
proc logistic data=thesis11;
      where bmiv1=0;
      class nutcoun (ref="1");
      model low_reach (event = "0") =nutcoun;
run;
proc logistic data=thesis11;
      where bmiv1=0;
      class mal1 (ref="1");
      model low_reach (event = "0") =mal1;
run;
*UNIVARIATE ODDS RATIOS AND CI'S FOR TABLE 3;
*HIGH BMI;
proc logistic data=thesis11;
      where bmiv1=2;
      class gender (ref="1");
      model high_reach (event = "0") =gender;
run;

proc logistic data=thesis11;
      where bmiv1=2;
      class educ (ref="1");
      model high_reach (event = "0") =educ;
run;
proc logistic data=thesis11;
      where bmiv1=2;
      class residence (ref="1");
      model high_reach (event = "0") =residence;
run;
proc logistic data=thesis11;
      where bmiv1=2;
      class occu (ref="1");
      model high_reach (event = "0") =occu;
run;
proc logistic data=thesis11;
      where bmiv1=2;
      class marstat (ref="1");
      model high_reach (event = "0") =marstat;
run;
```

```
proc logistic data=thesis11;
      where bmiv1=2;
      class religion (ref="1");
      model high_reach (event = "0") =religion;
run;
proc logistic data=thesis11;
      where bmiv1=2;
      class nutcoun (ref="1");
      model high_reach (event = "0") =nutcoun;
run;
proc logistic data=thesis11;
      where bmiv1=2;
      class mal1 (ref="1");
      model high_reach (event = "0") =mal1;
run;

*UNIVARIATE ODDS RATIOS AND CI'S FOR TABLE 3;
*BASELINE BMI REFERENCE IS ABNORMAL, SO THIS IS LOOKING AT RISK FACTORS
ASSOCIATED WITH ACHEIVING ABNORMAL BMI;

proc logistic data=thesis11;
      class gender (ref="1");
      model baselinebmi (event = "0") =gender;
run;
proc logistic data=thesis11;
      class educ (ref="1");
      model baselinebmi (event = "0") =educ;
run;
proc logistic data=thesis11;
      class residence (ref="1");
      model baselinebmi (event = "0") =residence;
run;
proc logistic data=thesis11;
      class occu (ref="1");
      model baselinebmi (event = "0") =occu;
run;
proc logistic data=thesis11;
      class marstat (ref="1");
      model baselinebmi (event = "0") =marstat;
run;
proc logistic data=thesis11;
      class religion (ref="1");
      model baselinebmi (event = "0") =religion;
run;
proc logistic data=thesis11;
      class nutcoun (ref="1");
      model baselinebmi (event = "0") =nutcoun;
run;
proc logistic data=thesis11;
      class mal1 (ref="1");
      model baselinebmi (event = "0") =mal1;
run;

proc ttest data=thesis11;
class baselinebmi;
var  residence occu gender educ;
run;
```

```
proc logistic data = thesis11;
class  RESIDENCE(REF="1") educ(REF="1") nutcoun(REF="1")  gender(REF="1");
model baselinebmi (event="0") = RESIDENCE educ nutcoun
gender/SELECTION=STEPWISE SLENTRY=.20 SLSTAY=.10;  *BELOW .1 SIGNIFI TO STAY,
HAD TO BE .05 TO ENTER;
run;
*MULTIVARIATE ODDS RATIO TABLE 4;

*HIGH BASELINE BMI;
proc logistic data = thesis10;
class  religion(REF="1") RESIDENCE(REF="1") AGE_(REF="18-24")educ(REF="1")
nutcoun(REF="1") marstat(REF="1") art1(REF="1") mal1(REF="1")
gender(REF="1");
model high_reach (event="0") = religion RESIDENCE AGE_ educ nutcoun marstat
art1 mal1 gender/SELECTION=STEPWISE SLENTRY=.20 SLSTAY=.05;  *BELOW .1
SIGNIFI TO STAY, HAD TO BE .05 TO ENTER;
run;
ods graphics on;
proc logistic data = thesis10 PLOTS(ONLY)=ROC; *, the area under the ROC
curve is 0.7114, which indicates an average fit;
class   mal1(REF="1")  gender(REF="2") ;
model high_reach (event="0") =  mal1  gender ;
run;

*LOW BMI AT BASELINE LOGISTIC MODEL;
proc reg data=thesis11;
model low_reach= religion educ nutcoun marstat art1 mal1 gender / tol vif
collin;
run;

proc logistic data = thesis11;
class  educ (REF="1") RESIDENCE (REF="1")religion(REF="1") nutcoun(REF="1")
marstat(REF="1") art1(REF="1") mal1(REF="1") gender(REF="1") AGE_(REF="18-
24");
model low_reach (event="0") = religion RESIDENCE AGE_ educ nutcoun marstat
art1 mal1 gender/SELECTION=STEPWISE SLENTRY=.20 SLSTAY=.05; *BELOW .05
SIGNIFI TO STAY, HAD TO BE .20 TO ENTER;
run;
ods graphics on;
proc logistic data = thesiS11 PLOTS(ONLY)=ROC; *the area under the ROC curve
is 0.6453, which indicates an ok fit;
class  RESIDENCE (REF="1") nutcoun (REF="1") mal1 (REF="1");
model low_reach (event="0") = RESIDENCE nutcoun  mal1 ;
run;

**********************************
T-test Table 1
;

*P-Value for Categorical Variable;
proc freq data=thesis2;
tables age_ gender /chisq;
run;
proc freq data=thesis11;
tables age_ gender /chisq;
run;
```

```
proc ttest data=thesis2;
var gender religion residence occu educ marstat nutcoun mal1 bmiv1;
run;
proc ttest data=thesis11;
var gender religion residence occu educ marstat nutcoun mal1 bmiv1;
run;
**********************************
T-test Table 3
;
proc freq data=thesis9;
tables age_ gender /chisq;
run;

title "P-values for Continuous Variables";
proc ttest data=thesis9;
var gender religion residence occu educ marstat nutcoun art1 mal1;
run;
proc ttest data=thesis9;
var gender religion residence occu educ marstat nutcoun art1 mal1;
run;

proc sort data=thesis9;
by age_;
run;
proc ttest data=thesis9;
var bmiv1;
by age_;
run;
proc means data=thesis2;
var calcbmi1;
run;
proc means data=thesis8;
var calcbmi1;
run;

proc ttest data=thesis11;
var age_;
run;
```

```
*******************************
************CODE FOR THE LONGITUDINAL FIGURE 5;
```

```
*******************************;

data thesis12;
      set thesis8;
month=visitba; bmi=bmiba; bmicat=bmicatba; output;
month=visitb1; bmi=bmib1; bmicat=bmicat1; output;
month=visitb2; bmi=bmib2; bmicat=bmicat2; output;
month=visitb3; bmi=bmib3; bmicat=bmicat3; output;
month=visitb4; bmi=bmib4; bmicat=bmicat4; output;
month=visitb5; bmi=bmib5; bmicat=bmicat5; output;
month=visitb6; bmi=bmib6; bmicat=bmicat6; output;
month=visitb7; bmi=bmib7; bmicat=bmicat7; output;
month=visitb8; bmi=bmib8; bmicat=bmicat8; output;
month=visitb9; bmi=bmib9; bmicat=bmicat9; output;
month=visitb10; bmi=bmib10; bmicat=bmicat10; output;
month=visitb11; bmi=bmib11; bmicat=bmicat11; output;
month=visitb12; bmi=bmib12; bmicat=bmicat12; output;

if bmi ne . & month ne .;

keep month bmi bmicat bmistat age_ questid gender;

run;



proc print data=thesis9 (obs=100);
where bmi ne . & bmistat=1;
run;

proc freq data=work.thesis9  (obs=100);
table bmi bmicat ;
run;

ods trace on;
proc means data=thesis9;  *Need to get bmi mean at each month in order to get
appropriate figure;
class month;
var bmi;
where bmistat=1;
ods output summary=means;
run;
ods trace off;

proc print data=means;
run;

data means2;
      set means;
left=bmi_mean - bmi_stddev;
right=bmi_mean + bmi_stddev;

run;

proc print data=means2;
run;
```

```
proc sgplot data=means2;  *BMI MEAN BY MONTH;
scatter x=month y=bmi_mean;
series x=month y=bmi_mean;
run;


proc sort data=thesis8;
by age_;
run;
ods trace on;
proc tabulate data=thesis8;  *Need to get bmi mean at each month in order to
get appropriate figure;
class month ;
var bmi;
table month all, bmicat, bmi*(n pctn);
ods output table=percent;
run;
ods trace off;

proc print data=percent;
run;

proc sgplot data=percent;  *BMI PERCENT BY MONTH;
scatter x=month y=bmi_PctN_00_bmi / group=bmicat;
series x=month y=bmi_PctN_00_bmi / group=bmicat;
run;

proc print data=thesis8 (obs=50);
where bmi ne .;
run;

*Percent BMIcat by Month;
proc template;
define statgraph Graph;
dynamic _MONTH _BMI_PCTN_00_BMI _BMICAT;
begingraph / dataskin=crisp;
   entryfootnote halign=left 'NOTE: Using the age groups 18-24, 25-34, 35-44,
45-54, 55-64, and 65+. Low is defined as a body mass index (BMI) less than
18.5; normal BMI is defined as greater than or equal to 18.5 but less than or
equal to 24.9; high BMI is defined as greater than 24.9 but less than 88.
Source: ' / textattrs=(size=10 );
   layout lattice / rowdatarange=data columndatarange=data rowgutter=10
columngutter=10;
      layout overlay / xaxisopts=( label=('Month') labelattrs=(style=NORMAL
weight=BOLD ) discreteopts=( tickvaluefitpolicy=splitrotate)) yaxisopts=(
reverse=false griddisplay=on label=('Percent') labelattrs=(style=NORMAL
weight=BOLD ) linearopts=( viewmax=15.0 minorticks=true));
         seriesplot x=_MONTH y=_BMI_PCTN_00_BMI / group=_BMICAT name='series'
connectorder=xaxis;
          entry halign=left 'Trends in low, normal, and high BMI amongst
adults 18-65+ living with HIV: Zambia Thrive Cohort, 2012-2016. ' /
valign=top location=outside textattrs=(style=normal weight=bold );
      endlayout;
   endlayout;
endgraph;
end;
run;
```

```
proc sgrender data=WORK.PERCENT template=Graph;
dynamic _MONTH="MONTH" _BMI_PCTN_00_BMI="'BMI_PCTN_00_BMI'n"
_BMICAT="BMICAT";
run;


*Mean BMIcat by month;

proc template;
define statgraph Graph2;
dynamic _MONTH _BMI_MEAN _BMICAT;
begingraph;
   layout lattice / rowdatarange=data columndatarange=data rowgutter=10
columngutter=10;
      layout overlay / xaxisopts=( display=(TICKS TICKVALUES LINE LABEL )
label=('Month') labelattrs=(style=NORMAL weight=BOLD ) discreteopts=(
tickvaluefitpolicy=splitrotate)) yaxisopts=( offsetmin=0.0 display=(TICKS
TICKVALUES LINE LABEL ) label=('Mean BMI') labelattrs=(style=NORMAL
weight=BOLD ));
         seriesplot x=_MONTH y=_BMI_MEAN / group=_BMICAT name='series'
clusterwidth=0.5 connectorder=xaxis grouporder=data;
         entry halign=center 'Mean Trends in low, normal and high BMI among
adults 18-80: Zambia Thrive Cohort 2012-2016' / valign=top location=outside
textattrs=(size=10 style=normal weight=bold );
      endlayout;
   endlayout;
endgraph;
end;
run;

proc sgrender data=WORK.MEANS2 template=Graph2;
dynamic _MONTH="MONTH" _BMI_MEAN="'BMI_MEAN'n" _BMICAT="BMICAT";
run;
```