THE EFFECT OF FOOD INSECURITY ON CLINICAL PROGRESSION OF HIV/AIDS AND CD4 COUNT CHANGE AMONG HIV-INFECTED ADULTS RECEIVING ANTIRETROVIRAL THERAPY IN NORTH SHEWA HEALTH FACILITIES, OROMIA REGION, ETHIOPIA

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DISSERTATION FOR THE DEGREE OF DOCTOR OF PHILOSOPHY(PhD) IN PUBLIC HEALTH, ADDIS ABABA UNIVERSITY, ETHIOPIA

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ADDIS ABABA UNIVERSITY
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DEDICATION

This Dissertation is dedicated to all HIV-infected people in Ethiopia and worldwide who lost their lives and are currently suffering from HIV-related poor health conditions and life hardship due to lack of good care and treatment.

LIST OF ORIGINAL PAPERS

This dissertation is primarily based on the following five original papers which are listedhereunder.

I. **Boneya DJ**, Ahmed AA, Yalew AW. **The effect of gender on food insecurity among HIV-infected people receiving anti-retroviral therapy: A systematic review and meta-analysis**. PloS one. 2019 Jan 7;14(1): doi.org/10.1371/journal.pone.0209903

II. **Boneya DJ**, Ahmed AA and Yalew AW. **Food insecurity and its severity among adults receiving antiretroviral therapy in health facilities, northcentral Ethiopia: A multi-facility-based cross-sectional study.** Frontiers Public Health 2024 July 22, Volume 12:1380958. doi: 10.3389/fpubh.2024.1380958

III. **Boneya DJ**, Ahmed AA, Yalew AW and Gebremedhin S. **Fruits and vegetables dietary intake and its estimated consumption among adults receiving antiretroviral therapy in health facilities in Northcentral Ethiopia:** A multi-facility cross-sectional study. Frontiers in Nutrition, 2024 July 17, Volume 11:1380987. doi: 10.3389/fnut.2024.1380987.

IV. **Boneya DJ**, Ahmed AA, Yalew AW and Gebremedhin S. **The effect of food insecurity on clinical progression of HIV/AIDS among adults receiving antiretroviral therapy in public health facilities Northcentral Ethiopia**: Prospective cohort study (Manuscript under review)

V. **Boneya DJ**, Ahmed AA, Yalew AW and Gebremedhin S. **The effect of food insecurity on CD4 count change among adults receiving antiretroviral therapy in public health facilities Northcentral Ethiopia**: Prospective cohort study (Manuscript under review)

Acronyms and Abbreviations

AIC: Akaike information criterion

AIDS: Acquired Immunodeficiency Syndrome

AOR: Adjusted Odds Ratio

APR: Adjusted Prevalence Ratio

ARCH: Alcohol Research Collaboration on HIV/AIDS

ART: Antiretroviral Therapy

aRR: Adusted Risk Ratio

ARV: Antiretroviral

BIC: Bayesian information criterion

BMI: Body Mass Index

BRFSS: Behavioral Risk Factor Surveillance System

CAPIs: Computer Assisted Personal Interviews

CD4: Cluster of Differentiation 4

CI: Confidence interval

CPT: Cotrimoxazole Preventive Therapy

FANTA: Food and Nutrition Technical Assistance

FAO: Food and Agriculture Organization

FAVs: Fruits and Vegetables

HAART: Highly Active Antiretroviral therapy

HFIAS: Household Food Insecurity Access Scale

HIV: Human Immunodeficiency Virus

IQR: Interquartile Range

OIs: Opportunistic Infections

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

MCS: Mental Health Composite Score

MSM: Men Sex with Men

MUAC: Mid-Upper Arm Circumference

NCDs: None-Communicable Diseases

NSP: National Strategic Plan

PHCS: Physical Health Composite Score

PLHIV: People Living with HIV

PR: Prevalence Ration

RNA: Ribonucleic Acid

STATA: Statistics Data

TPT: Tuberculosis Preventive Therapy

UNAIDS: United Nations Programme on HIV/AIDS

USA: United States of America

WHO: World Health Organization

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Abstract

Background: Food security are critical for individuals, households, and communities affected by HIV. HIV and food insecurity are complexly linked and exacerbate the harmful impacts of each other. Food insecurity harms on the overall nutritional and health status of people infected by HIV. However, little is known about the effect of food insecurity on the clinical progression of HIV/AIDS and CD4 count change among adults receiving antiretroviral therapy in the Ethiopian context. The few studies conducted are cross- sectional, which do not show the temporal relationship and fail to identify the effects of food insecurity on the clinical progression of HIV/AIDS and CD4 count change among HIV-infected adults, and fail to serve as concrete evidence.

Objective: To assess the magnitude of food insecurity, magnitude of fruit and vegetable dietary intake, and examine the effect of food insecurity on clinical progression of HIV/AIDS and CD4 count change among adults on antiretroviral therapy in North Shewa Health Facilities.

Methods: A systematic review and meta-analysis were undertaken to address the study's first objective. A cross-sectional study was conducted for the Papers II and III objectives, and a prospective cohort study was conducted for Papers IV and V objectives. The sample sizes of 865, 574, and 442 were considered for Paper II and III, Paper IV, and Paper V, respectively. Simple random sampling was used to select 865 HIV-infected adults for paper II and III.The exposed groups were those who were food-insecure individuals, whereas the non-exposed groups were those who were food-secure HIV-infected adults. Simple random sampling was used to select both the exposed and non-exposed groups for Paper IV and Paper V, using a computer-generated random selection method based on a cross-sectional baseline assessment for food security status. We conducted an electronic, web-based search, using PubMed, CINAHL PopLine, MedNar, Embase, Cochrane Library, the JBI Library, the Web of Science, and Google Scholar to identifiy studies that reported the association between food insecurity and gender (Paper I). Baseline and food security status data were collected using a structured interviewer-administered questionnaire, and repeated measurements of HIV-infected adults for the effect of food insecurity on clinical progression of HIV/AIDs and CD4 count change. Food insecurity was measured using the Household Food Insecurity Access Scale (HFIAS) and reported across all papers, while fruit and vegetable dietary intake was measured through the frequency of consumption, using the Behavioral Risk Factor Surveillance System (BRFSS) assessment tools. The clinical progression of HIV-infected adults was measured by assessing viral load, with a viral load of 1,000 copies/mL or higher considered indicative of poor clinical progression. The primary data collected using the KoboToolbox digital data collection platform were exported to STATA 17 for cleaning and analysis (Paper II-V). A random effects model was used to estimate the pooled effect with a 95% confidence interval(CI) (Paper I). A log-binomial regression model was fitted to identify the association between food insecurity and independent variables (Paper II). A Poisson regression model with robust variance was fitted to identify associated factors with fruits and vegetables dietary intake (Paper III). A Generalized linear mixed effects model with logit links was fitted to assess the effect of food insecurity and other predictors on the clinical progression of HIV/AIDs and CD4 change (Paper IV-V).

Results: A total of 776 studies were identified, of which seventeen were included in the meta-analysis, comprising 5,827 HIV-infected adults receiving antiretroviral therapy (ART). The analysis revealed that gender had statistically significant effects on food insecurity. The pooled odds of developing food insecurity among female HIV-infected adults were 53% higher than among male HIV-infected adults (OR: 1.53, 95% CI: 1.29, 1.83).

In this study, 290(33.7%, 95% CI: 30.60, 36.91)) of HIV-infected adults studied experienced food insecurity during their treatment and follow-up, in which 152(52.41%, 95% CI: 46.64, 58.13) and 110 (37.93%, CI: 32.50, 43.68) of them were found to have severe and moderate forms of food insecurity, respectively. We found that younger age (age less than 35 years) (APR=2.27, 95% CI: 1.12, 4.60), being female (APR=1.87, 95% CI: 1.03, 3.39), lacking formal education (APR=10.79, 95% CI: 14.74, 24.58), having lower educational status (APR=5.99, 95% CI: 2.65, 13.54), being daily laborer (APR=6.90, 95% CI: 2.28, 20.85), having low monthly income (APR=1.89, 95% CI: 1.11, 3.22), advanced WHO clinical stage (APR=2.34, 95% CI: 1.08, 5.10), and receiving ART for less than 4 years (APR=2.28, 95% CI: 1.09, 4.74) were significantly associated with high proportion of food insecurity among HIV-infected adults.

The study indicated that 655 (76.34%; 95% CI: 73.38, 79.07) of HIV-infected adults reported consuming fruits and vegetables less than once per day, with 838 (97.67%, 95% CI: 96.41, 98.49) and 676 (78.79%, 95% CI: 75.92, 81.40) of HIV-infected adults reporting consuming fruits and vegetables less than once per day, respectively. The median (IQR) total fruits and vegetables intake was 271.3 (IQR: 92.5, 439.5) g/day, with the median (IQR) intake of fruits and vegetables being 248.1 (IQR: 100.0, 400.0) g/day and 273.78 (IQR: 82.44, 348.33) g/day, respectively.We found that being divorced (APR=1.57, 95% CI: 1.16, 2.12), daily laborer (APR=2.08, 95% CI: 1.36, 3.20), employed (APR=1.77, 95% CI: 1.10, 2.84), and merchants (APR=1.59, 95% CI: 1.03, 2.47), as well as having children as caregivers (APR=1.61, 95% CI: 1.02, 2.55), an advanced WHO clinical stage (APR=1.32, 95% CI: 1.32(1.03, 1.69), and receiving ART for more than 8 years' duration (APR=1.78, 95% CI: 1.18, 2.67) were found to be independent predictors of fruits and vegetables dietary intake among HIV-infected adults.

The study found that 106 (18.56%; 95% CI: 15.58–21.97), 119 (21.14%; 95% CI: 17.95–24.71), and 134 (23.84%; 95% CI: 20.49–27.55) HIV-infected adults reported poor clinical progression at the first, second, and third visits, respectively, with double the incidence among food-insecure HIV-infected individuals: 71 (25.00%), 80 (28.78%), and 91 (32.85%) of those showing clinical outcomes were food insecure at the first, second, and third visits, respectively. The overall incidence of poor clinical progression during the follow-up period was 21.17% (95% CI: 19.27%, 23.18%), with 28.84% of food-insecure HIV-infected adults and 13.65% of food-secure HIV-infected adults experiencing poor clinical progression. The type of psychosocial care/support received (aRR = 4.72, 95% CI: 1.10, 20.52), being food insecure (aRR = 5.44, 95% CI: 1.36, 21.76), being undernourished over time (aRR = 3.34, 95% CI: 1.21, 9.26), advanced WHO treatment stage (aRR = 6.43, 95% CI: 1.21, 34.41), and receiving ART for at least 4 years (aRR = 4.22, 95% CI: 1.11. 12.07) were found to be significant independent predictors of poor clinical progression.

The median CD4 counts at the first, second, and third visits were 433 cells/µl (IQR: 255-607), 482 cells/µl (IQR: 326-698), and 523 cells/µl (IQR: 356-687), respectively. A total of 105 (23.76%; 95% CI: 20.01–27.96), 78 (18.35%; 95% CI: 14.96–22.34), and 73 (17.26%; 95% CI: 13.94–21.17) of HIV-infected adults had low CD4 counts (<200 cells/mm³) at the first, second, and third

visits, respectively, showing an overall declining trend over the 9-months follow-up period. However, the incidence of low CD4 counts among food-insecure individuals remained higher than among food-secure HIV-infected: 59 (26.70%), 44 (20.37%), and 40 (19.14%) at the first, second, and third visits, respectively. The overall incidence of low CD4 counts during the follow-up period was 19.84% (95% CI: 17.76%, 22.11%), with 22.14% among food-insecure and 17.55% among food-secure HIV-infected adults. The gender of HIV-infected adults (aRR = 2.88, 95% CI: 1.14, 7.30), being food insecure (aRR = 2.56, 95% CI: 1.05, 6.26), being undernourished over time (aRR = 2.17, 95% CI: 1.03, 4.57), being anemic (aRR = 3.35, 95% CI: 1.37, 8.17), advanced WHO clinical stage (aRR = 4.11, 95% CI: 1.32, 12.84), and receiving ART for at least 4 years (aRR = 3.64, 95% CI: 1.25, 10.63) were found to be significant independent predictors of low CD4 count.

Conclusion: The systematic review and meta-analysis showed statistically significant effect of gender on food insecurity among HIV-infected adults receiving ART, in which odds of food insecurity was higher among female HIV-infected adults compared to male HIV-infected adults. This finding suggests the need to consider gender issues within food and nutrition interventions for HIV-infected adults, as well as culture- and context-specific gender-based policies to address gender-related vulnerability to food insecurity.

The magnitude of food insecurity among HIV-infected adults receiving ART was high with an extremely high magnitude of severe food insecurity. The finding suggests the need for culture- and context-specific nutritional interventions to address the gender dynamics of food insecurity, attention to the early stage of ART, and the integration of strategies to improve educational status and enhance income-generation activities of HIV-infected adults. This requires an emphasis on the link between food insecurity and HIV in Ethiopia's national food and nutrition policy.

The finding indicates a very low level of fruits and vegetables dietary intake among HIV-infected adults, falling below the minimum recommendation for the adult physically active population. Despite living in a surplus production area and producing these items, farmers are less likely to consume fruit and vegetable. The study emphasizes the importance of focusing on the early stage of ART treatment for patients and family therapy, including counseling and guidance on consuming healthy diets, such as fruits and vegetables, to enhance the role of children as caregivers for their families. Additionally, there is a need for comprehensive nutritional counseling to improve fruit and vegetable consumption, with a particular emphasis on educating individuals about portion size estimation for fruits and vegetables.

The study revealed that poor clinical progression was notably higher among food-insecure HIV-infected adults, with a persistent increase over time, underscoring the sustained, significant effect of food insecurity on HIV/AIDS progression. The types of care received, food security status, nutritional status over time, duration of ART, and advanced WHO treatment stage were identified as significant independent predictors of poor clinical progression. The study also found that the incidence of low CD4 count (<200 cells/mm^3) remained high, particularly among food-insecure HIV-infected adults, significantly higher incidence of low CD4 counts among food-insecure HIV-infected adults throughout the follow-up period. Gender, food security status, nutritional status, presence of anemia, WHO clinical stage, and duration of ART were identified as significant independent predictors of low CD4 count.

The findings suggest the need for targeted food security interventions to mitigate the effects of food insecurity on HIV/AIDs clinical and immunological progression. There should also be

culture- and context-specific food and nutrition interventions focusing on the gender dynamics of food insecurity and its health effects, including gender-related vulnerabilities.

Keywords: Food insecurity, HIV/AIDS, Fruits and vegetables, clinical progression, CD4 count, antiretroviral therapy, HIV-infected adults

1. Introduction

1.2. Background

Globally, human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS) continue to pose critical health problems at an alarming rate, particularly in developing countries [1]. In 2021, there were 1.5 million new HIV infections worldwide which is more than one million beyond the global targets [2, 3], with 38.4 million people living with HIV, of which 36.7 million HIV infections were among adults. There were 670,000 new HIV infections in Eastern and Southern Africa, with a total of 20.6 million people living with HIV [2]. The AIDS pandemic took a life every minute in 2021, with 650 000 AIDS-related deaths, despite effective HIV treatment and tools to prevent, detect and treat opportunistic infections [3, 4]. By the end of 2022, there were 1.3 million new HIV infections worldwide, with 39 million people living with HIV (PLHIVs), of which 37.5 million HIV infections were among adults [5]. Additionally, there were 500, 000 new HIV infections in Eastern and Southern Africa, with a total of 20.8 million people living with HIV [2, 6].

An estimated 4500 of the total were among adults aged 15 years and older, of whom about 43% are among women, about 37% are among young people (15–24 years) and about 22% are among young women (15–24 years) [7-10]. In Ethiopia, there were 7,194 new HIV infections with a total of 603,537 PLHIVs in 2023 [11, 12]. The estimated HIV prevalence (Aged 15–49) was 0.91% and the estimated AIDS deaths were 9,984 in 2023 [13, 14]. This requires a holistic and comprehensive approach in addition to the gains achieved through ART in areas where HIV prevalence is high like sub-Saharan Africa, including Ethiopia [8].

The goal to achieve an AIDS-free generation will require holistic and comprehensive approaches in addition to the gains achieved through ART that strategically target to the areas where there is potential for the most impact and populations where HIV prevalence is high like sub-Saharan Africa including Ethiopia [8]. One such strategy is the UNAIDS 2016–2021 strategy which calls for action to get on the fast track and reach people being left behind [9]. It is an urgent call to front-load investments and a call to reach the 90-90–90 (90% of people living with HIV know their status- 90% of people living with HIV who know their status are on treatment -90% of people on treatment are virally suppressed) treatment targets, to close the testing gap and to protect the health

of the 22 million people living with HIV who are still not accessing treatment, including in Ethiopia [9, 10].

Following the achievement of the 2016–2021 strategy's 90-90-90 treatment goal, UNAIDS developed a new set of ambitious targets that call for action to reach 95-95–95 (95% of all PLHIVs to know their HIV status, 95% of all people with diagnosed HIV infection to receive sustained ART, and 95% of all people receiving ART to have viral suppression by 2025 to close the testing gap and to protect the health of millions of PLHIVs, who are still not accessing treatment, including in Ethiopia [15, 16].

Ethiopia has made excellent progress towards achieving the 90-90–90 treatment goal of the 2016–2021 strategy, particularly the 2nd and 3rd 90s among adults, in which 79% of estimated PLHIVs who know their status, 90% were on ART and 91% were virally suppressed with marked regional variations in ART coverage [7]. The HIV/AIDS National Strategic Plan (NSP) for Ethiopia 2021-2025 indicates that the country is committed to achieving, the global new and ambitious 95-95-95 HIV prevention roadmap, with a particular focus on reaching 95% coverage of ART and viral suppression nationally, across all age groups [17].

Many of the countries hardest hit by HIV also suffer from other infectious diseases, food insecurity, and other serious problems [18]. In low-income countries, including Ethiopia chronic underlying poor nutritional status and its intersection with food insecurity, poverty, and co-infections have also a negative impact combating HIV infections and their progression to AIDS [19].

Food insecurity, defined as "the limited or uncertain availability of nutritionally adequate, safe foods or the inability to acquire personally acceptable foods in socially acceptable ways," is an important promoter of HIV transmission and disease progression [1], and the leading cause of morbidity and mortality [20]. It can have impact addressing the 95–95–95 NSP treatment targets that Ethiopia is committed to achieving, which is critical for treatment programs to establish community-centered strategies and systems. Despite the effort that has been made through different strategic interventions, studies in different parts of the world indicate a high prevalence of food insecurity among people living with HIV that can predict as well the clinical progress of the disease and its CD4 count change [21]. It was evidenced that the prevalence of food insecurity is high among PLHIV in both resource-rich settings where its prevalence ranges from 53.6% to

71% [22-24] and resource-poor settings like some countries of Africa [25-28] of which prevalence of food insecurity ranges from 49.1% to 84.6% and Ethiopia [29-38] with the range of high prevalence being between 35.2% and 92.82% respectively.

The 2021 Report of North Shewa Zone noted that there were about 5, 514 people living with HIV, and receiving ART in which 5, 266 were adults and 244 were children, with above 1% of HIV new infections rate [39]. The studies conducted in areas adjacent to the current study are (North Shewa Zone) on food insecurity among people living with HIV — each carried out in a single hospital — also showed a high prevalence of food insecurity among adults living with HIV and receiving ART [40-42]. This indicates that there is still a gap of context and culture-specific evidence on the effect of food insecurity on the clinical progression of HIV and CD4 count change among adults receiving ART.

1.2. Statement of problem

HIV infection exacerbates malnutrition by attacking the immune system and negatively impacting nutrient intake, absorption and the body's use of food, including healthy diets like fruits and vegetables. Like HIV/AIDS, poor nutritional status, including food insecurity, also compromises the immune function and increases susceptibility to severe illnesses and opportunistic infections (OIs). It hastens the clinical progression of HIV, decreases CD4 response outcome, and reduces survival [43-45].

Food insecurity is one of the leading causes of morbidity and mortality, highly linked to the HIV epidemic. It shapes individual actions and health outcomes through nutritional, mental health, and behavioral pathways [20].

HIV and food insecurity are complexly linked and exacerbate the harmful impacts of each other. Food insecurity has a negative impact on the overall nutritional and health status of those people infected by HIV [46, 47]. The report of clinical providers indicates that lack of adequate food intake with medication is one of the most common contributing factors for patients to discontinue ART [48, 49]. This indicates the need to integrate food and nutrition into the care and treatment plan to enhance treatment success and improve the quality of life for HIV-infected individuals. A well-balanced and healthy diet, including fruits and vegetables, can contribute to achieving a healthy weight, strengthen the immune system, prevent infection, and reduce hospital stays. It also

helps the body build and maintain muscle, enhances the effectiveness of medications, aids in managing medication side effects, improves overall quality of life, and better equips the body to fight against disease [50, 51].

A significant number of people living with HIV reside in countries with high levels of poverty and food insecurity, creating a substantial need for themselves and their families. Studies have noted that more than half of people living with HIV have been suffering from a high prevalence of food insecurity worldwide, [22-24, 52-54] and the problem is accentuated in resource-limited settings, including Africa [25-28, 55]. In Ethiopia, more than 60% of people living with HIV suffer from high prevalence of food insecurity that may exacerbate their health and treatment outcomes [29-36, 56].

In people living with HIV, food insecurity has economic, social, and health consequences that make it harder for them to cope with illness and maintain their health status. It is associated with incomplete HIV viral suppression [57], low CD4 cell counts [22], serves as a barrier to adherence to treatment [58], household instability, and lower household income [54], contributing to delayed ARV treatment initiation, incomplete adherence, and ARV treatment discontinuation [59] increase the incidence of opportunistic infections [60].

Evidence indicates that food-insecure HIV-infected individuals are at risk of poor physical health status, poor adherence, virologic failure, and other negative health outcomes [22, 61]. This could then lead to increased mortality among people living with HIV [62].

Often neglected, food security and nutrition are critical for individuals, households, and communities affected by HIV [63, 64]. Lack of food security and limited consumption of healthy diets may hasten the progression to AIDS-related illnesses, undermine adherence and response to ART, and exacerbate the socioeconomic impacts of the disease, i.e., AIDS [59, 60]. HIV infection itself undermines food security and nutrition by reducing work capacity and productivity, threatening household livelihoods. Addressing food security in all settings is vital to achieving the goal of universal access to HIV prevention, treatment, care, and support, to which all Member States of the United Nations, including Ethiopia, have committed themselves [65].

In many resource-constrained settings, people living with HIV have poor access to sufficient quantities of nutritious foods, which poses additional challenges to the success of ART. This can

lead to declining food security which in turn leads people to discontinue treatment [66, 67]. To achieve the full benefit of ART and meet the nutritional needs to cope with the disease, there is an apparent need to maintain an adequate amount of food and nutrient intake [36]. Nutritional support can be taken as an important factor for ART adherence as lack of food is reckoned to be one of the causes of non-adherence to ART program [68-70].

The combined effects of food insecurity and HIV place further strain on already limited household resources as affected family members struggle to meet household food needs. Food insecurity adversely affects health behavior, functional health status, and health outcomes of HIV. It has also been found to be associated with postponing needed medications and care, and increased emergency [71, 72]. Effects of food insecurity on health outcomes and utilization persist even after controlling for other measures of socioeconomic status [73]. If left unmanaged, food insecurity contributes to mortality among people living with HIV [74].

Food insecurity can have an impact on addressing the 95–95–95 global HIV treatment targets and NSP treatment targets that Ethiopia as well as the Oromia Regional State Government are committed to addressing in particular, the third 95 (95% of people on the treatment are virally suppressed), which is critical for treatment programs to establish community-centered strategies and systems. It can also have an impact on the CD4 count change as one of the immunological indicators. However, little is known about the effect of food insecurity on the clinical progression of HIV/AIDS and CD4 count change, and other predictors among HIV-infected adults receiving ART in the Ethiopian context.

The few studies conducted are cross-sectional, which fail to show the temporal relationship and did not demonstrate the effects of food insecurity and other independent predictors of clinical progression of HIV and CD4 count change among HIV-infected adults, and fail to serve as concrete evidence. Therefore, the main objective of this study was to assess the effect of food insecurity on the clinical progression of HIV/AIDS and CD4 count change among adults receiving ART in North Shewa Zone Health Facilities, Oromia region, Northcentral Ethiopia.

1.3. Rationale of the study

Food insecurity is an important predictor for the spread of HIV due to the negative effects of coping behaviors adopted for mitigation [75]. On the other hand, it compromises adherence to treatment, hasten poor HIV outcomes and immunological failure, and hasten AIDS-related mortality, even among those receiving ART [27, 76].

People living with HIV and receiving ART need a sufficient amount of food to maintain a healthy dietary intake, like fruits and vegetables, and cope with drug side effects. Food insecurity can pose significant challenges to the proper management of food and nutrition implications of ART [67].

Though few studies in Ethiopia indicate a high prevalence of food insecurity among PLHIV[30-36], there are no studies that have assessed the effect of food insecurity on clinical progression and CD4 count change and have addressed the extent to which possible negative HIV clinical and immunological outcomes associated with food insecurity, including in North Shewa Zone health facilities.

Further, the review of the national food and nutrition policy of Ethiopia indicates that due emphasis was not given to the link between food insecurity and HIV as well as the effect of food insecurity on disease progression and immunological status of PLHIV.

Hence, a proper understanding of the effect of food insecurity on the clinical progression of HIV and CD4 count change among PLHIV, as well as other independent predictors will pave the way to address the prevailing problems of HIV-related poor health outcomes and AIDS-related mortality in the local context, including in North Shewa Zone.

1.4. Significance of the study

This study aims to identify the effects of food insecurity on the clinical progression of HIV and CD4 count change among adults receiving ART in North Shewa Health facilities. The findings of the study will give substantial input for national and international organizations to integrate HIV and nutritional programs to increase the quality of life and life expectancy of HIV-infected people. It will provide important evidence to achieve good health and well-being (SDG 3) and indicate the way to minimize hunger (SD2) among HIV-infected people.

In providing input on the clinical and immunological progress of HIV, this study will help to address the 95–95–95 treatment targets that the country is committed to addressing through the establishment of community-centered strategies and intervention programs, such as engagement in income generation activities and home gardening.

In addition, it will also be a baseline to conduct further studies on the effects of nutrition intervention on clinical progression and CD4 count change among people living with HIV. An intervention project will be developed and implemented based on the findings of this study.

2. Literature Review

2.1. The link between HIV and Food insecurity

Acquired Immune Deficiency Syndrome is a disease caused by a retrovirus known as the Human Immunodeficiency Virus (HIV), which attacks and impairs the body's natural defense system against disease and infection. HIV is a slow-acting virus that may take years to produce illness in a person and an HIV-infected person's defense system is impaired, and other viruses, bacteria and parasites take advantage of this "opportunity" to further weaken the body and cause various illnesses [77].

Food insecurity is defined as "the limited or uncertain availability of nutritionally adequate, safe foods or the inability to acquire personally acceptable foods in socially acceptable ways". In implicit terms a food-insecure individual can have either insufficient quantity of food; limited dietary diversity; poor safety of food; feelings of hunger or anxiety regarding access to food; and procurement of food in socially unacceptable manners, including begging, relying on charity, scrounging, stealing, exchanging sex for food, and other illicit activities [78, 79].

In the past two decades, evidence has revealed a complex bi-directional relationship between food security and HIV. HIV triggers and exacerbates food insecurity by increasing medical expenditures, reducing work capacity, and threatening household livelihoods [72, 75]. In the same way, food insecurity fuels the further spread of HIV, when people are driven to adopt immediate survival strategies [72] and increases vulnerability to HIV infection by driving risky sexual behaviors, contributing to practices that increase mother-to-child transmission, and under-nutrition and micronutrient deficiencies that impair mucosal integrity and host defenses [20, 61].

The relationship between food insecurity and HIV is considered a syndemic or synergistic epidemic where epidemics coexist and perpetuate each other [79]. Although both have synergistic epidemics, in this study, we focus on the link that shows the effect of food insecurity on clinical outcome of HIV and immunological outcome, particularly CD4 count change.

In general, food insecurity is associated with a range of negative health outcomes among people living with HIV, such as increased HIV acquisition. Although there is a difference in the extent of

damage, it can affect HIV health outcomes and its prevention strategies in both resource-rich and resource-poor settings [20].

2.2. Magnitude of Food insecurity among HIV-infected adults

Global evidence indicates that approximately 2.4 billion people worldwide, including PLHIVs, lack access to adequate food, with 30% experiencing moderate or severe food insecurity. Furthermore, over 3.1 billion people were unable to afford a nutritious and healthy diet, with 78% of them residing in Africa in 2022 [80]. This situation is more exacerbated among HIV-infected adults, as a result of various contributing factors, including the infection process itself [80]. The review of current knowledge, gaps, and research priorities indicates a high prevalence of food insecurity among persons living with HIV and receiving antiretroviral therapy [78]. This review indicates that segments of the population affected with HIV experience high levels of food insecurity in the general population in both low- and high-resource settings [78].

The findings of studies conducted in different resource-rich settings present a high prevalence of food insecurity among HIV-infected adults. For instance, studies conducted in Brazil (66.5%) [24], San Francisco among homeless and marginalized HIV infected houses with incomplete RNA (51%) [73], among homeless HIV-infected adults (53.6%) [22], USA (54.5%) [76], Columbia (33%) [78], systematic review of food insecurity role on treatment adherence (71%) [23], British Columbia and Canada on the association of food insecurity and food procurement method (73%) [54], Atlanta among HIV-infected adults who drink alcohol (57%) [52], USA in Veterans affair Medical Center (24%) [81] and San Francisco among HIV-infected adults with depressive symptoms (55%) [82].

The magnitude of food insecurity among HIV-infected adults was also high in studies conducted in Mbarara of Uganda and St. Petersburg of Russia among HIV-infected adults who use alcohol (52%) [83], Russians among those who are not on ART (53%) [84], British Columbia and Canada among IV drug users and (71%) [62] and non-IV drug users (21%) [53], USA that assess food insecurity as a predictor of CD4 change (63%) [85]. In addition, the prevalence of food insecurity among HIV-infected adults in the study conducted in Honduras was 65% [86], India (49.1%) [87], and Rural Haiti 89% [88] respectively.

The findings of studies conducted in Africa present a consistently high prevalence of food insecurity among HIV-infected adults. For instance, the prevalence in studies conducted in rural Uganda (83%) [61], South Africa among students living with HIV (more than 60%) [55], Kenya (33.5%)[78], Democratic Republic of Congo (57%) [25], and Dakar (84.6%) [26], Uganda AIDS Rural Treatment Outcomes cohort (77.3%) [60], Rural Uganda (74.6%) [89], Uganda on social context (38%) [90] and food insecurity and ART adherence (78.5%) [27], Nigerian preliminary study (71.7%) [28], Namibia on food insecurity and ART adherence (93%) [91], Ugandan women receiving ART (76.4%) [92].

The findings of few cross-sectional studies conducted in Ethiopia show that the overall estimated magnitude of food insecurity is high which ranges with the lowest prevalence of 18.36% in a study conducted in Dembia, Gondar [93] to the highest prevalence of 87.4% in a study conducted in Fiche[40]. The prevalence of food insecurity in the study conducted in Arba Minch (19.54%) [94], Debre Markos Town (84.52%) [35], Hosanna (67.53%) [34], (68.48%) [33], West Shoa Zone (35.2%) [95], Tigray (40.43%) [96], two studies in Jimma (63.01%)[36], (85.92%) [30] and in two studies in Butajira (78.11%) [31], (79.02%) [32].

2.3. Factors Associated with food insecurity among HIV-infected adults

The findings of studies indicated that patients' educational status, gender, higher socio-economic class, occupation, benefit from food assistance, delaying drugs to prevent hunger; skipping drugs and exchanging sex for food were found to be contributing factors for higher food insecurity among HIV-infected adults, but the later stage of the diseases was found to be contributing factors for lower food insecurity level [28, 87]. In the same way, the findings of a study in Senegal indicate that patients missed clinic appointments and missed to take ART due to hunger [26].

Studies showed that the longer duration of ART [91], age of patients, lower income per capita, and lack of occupation but not gender of patients [24] were found to have a significant association with food insecurity. However, the finding of a study conducted in the Russia Alcohol Research cohort HIV/AIDS (ARCH) cohort didn't find a statistically significant association between food insecurity and longer time to ART initiation [84]. The findings of a qualitative review and synthesis indicate that economic instability, gender of the patient, in which women are at a greater risk and

HIV disclosure status were found to be contributing factors for higher levels of food insecurity [97].

The findings of few studies conducted in Ethiopia indicate that the lower economic status, lower educational status of HIV-infected adults, absence of food support, unemployment [34], being rural resident, low average monthly income and having inadequate household dietary diversity were significantly associated with food insecurity [32, 35, 36]. On the contrary, a study conducted in the Jimma Specialized Hospital did not find a statistically significant association between food insecurity and therapeutic food support [36].

The finding of another study conducted in southern Ethiopia indicated that being female, being rural a resident, lower monthly income, later WHO clinical stage of HIV, having presence of developing OIs, and poor adherence to treatment were found to be independent predictors of food insecurity [94].

From the review of literature under this section, it was understood that there were few studies conducted on food insecurity, its severity, and associated factors among HIV-infected adults in low-and middle-income countries, including Ethiopia. Even the few studies conducted in low-income countries, including Ethiopia, have presented controversial and inconclusive evidence.

2.4. Fruit and vegetable dietary intake and its estimated amount of consumption

Good nutrition should be integrated into care and treatment plans to enhance treatment success and improve the quality of life for HIV-infected individuals. A well-balanced diet can contribute to achieving a healthy weight, strengthen the immune system, prevent infection, and reduce hospital stays. It also helps the body build and keep muscle, allows medications to work better, and enables to handle the side effects of medications [50]. Good nutrition improves the overall quality of life by providing nutrients to the body's needs and keeps the immune system stronger so that one can better fight disease [51]. Fruits and vegetables are important components of a healthy diet and good nutrition. Their consumption could help prevent a variety of chronic communicable and non-communicable diseases, including HIV/AIDS [98].

HIV-infected adults have compromised immune systems, resulting in inflammation and increased risk of chronic diseases and infections that require balanced portions of fresh fruits and vegetables,

containing essential micro and macronutrients to address nutritional needs and reduce symptoms [50].

A healthy diet, including fruits and vegetables will have a serious impact not only on the quality of life of patients but also on the success of ART treatment [99]. The World Health Organization (WHO) recommends a daily intake of 400 grams of fruits and vegetables, equivalent to five portions, to mitigate the risk of chronic diseases. This intake is also beneficial for HIV-infected individuals, as it helps address micronutrient deficiencies, including antioxidants, like vitamins C, A, E, and selenium. Those nutrients contribute to metabolic regulation and bolster immune responses, potentially slowing the progression of HIV infection [100, 101].

Few studies conducted in high-income countries among the general population, including HIV-infected adults indicate that very low to low levels of fruits and vegetables dietary intake ranges from approximately 14% of the total population for fruits recommendations and 8% for vegetables in the USA [102]. In the same way, studies conducted in China and Canada indicate that 55.2% (labor force) and 40.7% (students), respectively, had insufficient fruit and vegetable dietary intake, with no significant urban-rural difference in the proportion of insufficient vegetable intake [103]. A study conducted in Portugal among HIV-infected adults also indicated the low frequency of fruit and vegetable consumption, in which 42.5% and 23.7% of participating individuals consumed fruit and vegetables less than once per day [104].

In Africa, studies indicate that only a low proportion of people consume and met the recommended amount. In that regard, a study conducted in Kenya indicates that 51.0% consumed fruits during the survey (previous day), with a mean intake of 189.6 (16.8%) g/day, of which only 16% of participants met WHO recommendations [105]. In the study conducted in Uganda among adults, it was indicated that only 12.2% of them consumed five or more servings of fruits and/or vegetables per day in a typical week [106].

2.5. Factors associated with Fruit and vegetable dietary intake

The evidence from a review of high-income countries indicates that gender, age, marital status, educational status, and income of participants were found as contributing factors for the low level of fruit and vegetable consumption [107]. For instance, a person who does not eat food, will not take antiretroviral medication. A person who does not take their medication consistently is less likely to benefit fully from treatment and will not be able to fully suppress the virus in their body

which will increase the likelihood of the patient developing illness and progressing more rapidly from HIV to AIDS [108].

In this regard, in the review of existing evidence, we did not find a single study conducted and documented among HIV-infected adults on fruit and vegetable dietary intake in Africa, including in Ethiopia. The review of national HIV and nutrition guidelines indicates that the guideline gives due emphasis on nutritional counseling, focusing on macronutrient and micronutrient deficiencierelated problems [109].

2.6. Effect of food insecurity on clinical progression in HIV-infected adults

Food insecurity poses an effect on the health outcome of HIV-infected adults directly or indirectly through the impact on their nutritional status, social and behavioral mechanisms that influence choices of coping mechanisms and behaviors [78]. Evidence shows that food insecurity can affect individual clinical and health outcomes through nutritional and behavioral pathways, which lead to HIV acquisition and disease progression [20].

The findings of studies conducted in San Francisco and resource-poor settings revealed that food insecurity has a range of negative health outcomes among people infected with HIV, such as incomplete viral load suppression, increased hospitalizations, higher odds of self-reported opportunistic infections and non-accidental mortality which can persist even after the effects of socioeconomic variables were controlled [20, 22, 60, 73]

2.6.1. Nutritional Pathway effects

In the nutritional pathway, food insecurity can lead to macronutrient and micronutrient deficiencies which can contributes to incomplete HIV viral load suppression, which in turn contribute to increased probability of other morbidities and AIDS-defining illness, and AIDS-related mortality among HIV-infected individuals [20].

A cohort study among Ugandan women with high median CD4 cell count found a strong association between food insufficiency and food insecurity and low sustained viral suppression [49].

A cross-sectional study in Fiche Hospital indicated that food insecurity was found to be significantly associated with depressive symptoms of HIV-infected adults, leading to poor health

and virological outcomes. The odds of depressive symptoms were almost fourfold among food-insecure HIV-infected adults [29].

The study conducted in San Francisco among Homeless HIV-infected adults recruited for the Research on Access to Care Cohort found an association between food insecurity, poor physical and mental health, and poor social functioning [22]. Food-insecure HIV-infected adults were found to have higher odds of poor physical health through poor nutritional status [22]. The finding of the study conducted in the Uganda AIDS Rural Treatment Outcomes cohort among HIV-infected adults also found a negative significant association between food insecurity and physical health-related quality of life over follow-up [60].

The finding of a cross-sectional study conducted in South Africa among HIV-infected students found that food-insecure students were more likely to consume inadequate amounts of micronutrients that are important for supporting the immune system [55].

The findings of different studies conducted in Atlanta, USA veteran cohort, San Francisco, and others among HIV-infected adults showed that undernutrition and food insecurity increased the odds of lower and incomplete viral load suppression [27, 52, 73, 76, 81]. Particularly in the study conducted in San Francisco, 37.2% of HIV-infected adults had unsuppressed viral loads [76].

Other studies conducted in Atlanta, Georgia and a systematic review found that food-insecure HIV-infected adults had 29% lower odds of achieving complete HIV viral suppression [52, 57]. Greater depression, stress, and emotional distress were found to be significant contributors to depression and hospitalization for psychiatric conditions [52].

The study conducted among veteran cohort of USA indicated that food-insecure veterans were more likely to have a lower median BMI compared to food-secure Veterans [81]. However, the finding indicated that neither antiretroviral medication adherence nor body mass index contributes to the association between food insecurity and unsuppressed HIV-1 RNA [81].

The cross-sectional British Colombia and Canadian study among HIV-infected adults found that food-insecure HIV-infected adults with hunger had a BMI of 22.6 kg/m2 compared to 23.1 kg/m2 among food insecure without hunger and 23.7 kg/m2 among food-secure [53]. A significant negative trend in HIV progression was found from food secure to food-insecure which could be seen as an increasing upper IQR range of the current viral load. The differences in HIV progression

were reflected by the lower median duration of any kind of therapy (24 months) among food-insecure HIV-infected adults with hunger, compared to 30 months for food-insecure without hunger and 34 months among food-secure [53].

The finding of a study conducted in Rural Haiti to assess the relation between food insecurity and clinical outcomes indicated that 86% of food-insecure HIV-infected adults had a BMI <18.5 kg/m2 [88]. BMI decreased significantly across levels of food insecurity, for median BMIs for low, moderate and severe among food-insecure HIV-infected adults were 23.2, 22.3 and 21.2 kg/m2 respectively [88]. A study conducted in Ethiopia also found that food insecurity increased the odds of malnutrition more than two times, which in turn increased the odds of poor clinical progression [33]. The study conducted among Russians who were not on ART found that there was no significant differences in HIV viral load between food-insecure and food-secure groups [84].

The finding of a study conducted in British Colombia indicated that through the effects of undernutrition and micronutrient deficiencies, food insecurity affects the clinical disease progression and can lead to death [62]. The death rate among food-insecure HIV-infected adults was almost two times than those who were food-secure HIV-infected adults, that is, 48.1% of food-insecure HIV-infected adults died over the study period [62]. The death among PLHIV with hunger was almost two times more than those without hunger, that is, 51.4% of HIV-infected adults with hunger died [62]. However, the study conducted in a Canadian setting on the relationship between hunger and plasma HIV RNA suppression showed that there was no significant association between hunger and lower likelihood of plasma HIV RNA suppression [110].

The study conducted in Atlanta, Georgia on the synergistic effect of food insecurity and drug use found a negative effect on adherence to ART among HIV-infected adults [111]. The disruptive effects of food insecurity and drug use on adherence to ART were more likely to be exaggerated with the presence of each other, which in turn, affects disease clinical progression [111].

2.6.2. Behavioral Pathway effects

The finding of a study conducted in Atlanta among HIV-infected adults who drink alcohol found that food-insecure HIV-infected adults missed ART for more months due to out of stock of medications and lack of transportation to the pharmacy; 48 % of food-insecure HIV-infected adults had run out of medications at least for one month, compared to 32 % of food-secure [52]. Those

HIV-infected adults who have experienced of food insecurity were more likely to be non-adherent to medication over the study period [52].

The longitudinal study conducted in San Francisco on Access to Care in the Homeless cohort found that 25.8% of HIV-infected adults were non-adherent to ART during follow-up [76]. Studies conducted in different settings showed that being food-insecure increased the odds of ART non-adherence and less adherence [27, 73, 76]. Higher adherence to ART was found to increase viral suppression, almost about six times [73]. ART adherence <90% was found to have over two times higher odds of incomplete viral suppression [27].

The finding of another study conducted in San Francisco did not show a significant difference in the effect of food insecurity on incomplete HIV RNA suppression between the low (<200 cells/μL) group and high (>=200 cells/μL) CD4 cell counts group [73].

Studies conducted in Uganda and Kenya identified food insecurity as an important barrier to accessing medical care and adherence to ART as well as health outcomes among HIV-infected adults. Food-insecure HIV-infected adults interrupt treatment and are non-adherent to ART through increased inappropriate appetite; and worsen the drug side effects; skipped doses and forget medication doses [59, 112].

The cross-sectional study conducted in the Democratic Republic of Congo found that 20.9% of HIV-infected adults were non-adherent to ART [25]. Food-insecure HIV-infected adults were two times more likely to be non-adherent to ART, compared to food-secure HIV-infected adults. The perceived harmfulness of ART, alcohol intake and skipping treatment doses increased the likelihood of non-adherence to ART, which in turn worsened the disease progression [25].

In the cross-sectional study conducted in Botswana and Swaziland food insufficiency was found to have a significant association with inconsistent condom use, with a non-primary partner, sex exchange, intergenerational sexual relationships, and lack of control in sexual relationships among women [113].

The study conducted in South African Townships found that food-insecure women HIV-infected adults had higher numbers of male sex partners and the relationships were fully mediated by women's alcohol use [114]. Food insecurity was negatively related to unprotected sex in men HIV-infected adults, but this relationship was not mediated by the alcohol use of men. The finding

indicated that food insecurity appears to be an important factor that poses an effect on the point of intervention for reducing HIV transmission and improving disease progression [114].

2.7. Effect of food insecurity on CD4 count change among HIV-infected adults

2.7.1. Nutritional Pathway Effect

The finding of a cross-sectional study conducted in San Francisco found that 85% of HIV-infected adults with low CD4 cell counts and low MCS and PHCS scores were food-insecure [22]. A longitudinal study conducted in the same place showed that 21.9% of HIV-infected adults had CD4þ cell counts less than 200 cells/ml and food insecurity increased the odds of low CD4þ cell counts of less than 200 cells/ml [76]. A cross-sectional study conducted in rural Uganda found that food insecurity increased by 47% greater odds of low CD4 cell count of which 69.9% of food-insecure HIV-infected adults had CD4<350, versus 61.3% of food-secure HIV-infected adults during follow-up [27]

The study conducted in Atlanta, Georgia showed that food insecurity was significantly associated with unsuppressed HIV, clinically low CD4 cell counts, greater HIV symptoms with multiple hospitalizations for HIV-related conditions [52]. The veterans' cohort study in the USA found that low BMI that results from food insecurity increased the likelihood of worse immunological outcomes (CD4 count <200 cells/μL) [81].

The finding of a study conducted in Russia's ARCH cohort found that there were no significant differences in CD4 cell count between groups with mild and moderate food insecure or severe food insecure versus food secure with the mean differences of -32.5 (95% CI -94.3, 29.3) and -45.5 (95% CI -124.1, 33.0) respectively [84].

The study conducted in two towns of Senegal found that 17.3% of HIV-infected adults missed clinic appointments due to hunger in Dakar and 23.1% of PLHIV did not take their ART due to hunger in Ziguinchor [26]. The finding indicated that severe food insecurity increases the likelihood of missing clinic appointments and not taking antiretroviral therapy, due to hunger which in turn causes malnutrition. This malnutrition was significantly associated with lower CD4 cell counts [26].

In the same study in Senegal 35% of malnourished HIV-infected adults and 17.0% of malnourished PLHIV failed to take their ART at least once a week for food insecure and food secure respectively

[26]. A significant negative trend of HIV progression was found in food secure compared to food insecure which could be seen as a decreasing upper IQR range of CD4 counts [53].

The finding of the study conducted in the USA indicated that food insecurity predicted negative changes in CD4 count over the follow-up period in which it predicted 99.5 cells/μL less change over the follow-up period among HIV-infected adults who faced at least one episode of food insecurity [85].

2.7.2. Behavioral Pathway Effect

The findings of the study conducted in Namibia revealed that severe household food insecurity increased the odds of poor ART adherence (MPR <80%) by almost four times, which in turn leads to lower CD4 counts [91].

The study conducted among sex workers in Swaziland indicated that women engaged in sex work due to their own hunger or their children's hunger continued to sell sex [115]. The finding of the study conducted in San Francisco indicated that food insecurity was found to have strong effects on risky sexual practices among MSM and female HIV-infected adults [116]. HIV-infected adults engaged in transactional sex for food or money to buy food, often during times of destitution, and it could lead to condom-less sex despite knowledge of and desire to use safe sexual practices which can lead to high HIV transmission and poor diseases clinical progression [116].

2.8. Independent predictors of clinical progression of HIV-infected adults

2.8.1. Socio-demographic and Economic predictors

The findings of studies conducted in different settings indicated, that increasing age[60, 81, 84], female gender, and being married were also all negatively associated with PHS [60, 113]. The study conducted among Russians who were not on ART found that food-insecure HIV-infected adults reported lower levels of social support than those who were food secure. However, income of participants did not show a significant association with viral suppression [84].

In the study conducted in Atlanta age, ethnicity and heavy drinking were found to be associated with adherence to ART [111]. An increase each year in age leads to a 2% increase in the odds of adherence and being heavy drinkers increased 32 % odds of optimal adherence. This indicated that increased odds of ART adherence have a significant effect on disease clinical progression [111].

The study conducted in British Colombia found that age and annual income were found to have effects on HIV disease progression[74].

2.8.2. Clinical predictors

In the pilot interventional trial in Honduras the provision of therapeutic food support was found to have effects in improving the suffering and physical health of PLHIV through improving food security [86]. An interventional study conducted in Kenya found that 49% of HIV-infected adults enrolled in intervention arm had a detectable HIV viral load, with 28% of HIV-infected adults enrolled in the control arm [117].

The finding of the study conducted in the Uganda AIDS Rural Treatment Outcomes cohort indicated that the duration of ART was found to have an impact on the disease clinical progression among HIV-infected adults by increasing the number of hospitalizations and missed clinic visits [60]. On the other hand, increased length of time on ART and increased CD4 cell counts were positively associated with physical health status. It was also found that severe food insecurity increased the odds of incident opportunistic infections almost by twofold [60].

2.9. Independent predictors of CD4 count change among HIV-infected adults

2.9.1. Socio-demographic and Economic predictors

The finding of a cross-sectional study conducted in the USA Veterans affair Medical Center found that age, marital status and employment status of the HIV-infected adults were significantly associated with higher odds of low CD4 count [81].

In the study conducted in British Colombia, 10-year increase in age leads to a 65% increase in the likelihood of lower plasma HIV RNA suppression. However, there was no significant association between monthly income and a lower likelihood of plasma HIV RNA suppression [110].

2.9.2. Clinical predictors

The finding of study conducted in Nambia found that the longer the duration of ART, the higher the odds of poor adherence (<80% MPR) to ART almost by 22% which leads to lower CD4 counts [91].

The study conducted in Malawi indicated that therapeutic food support had significant effects on nutrition and immunological response that differed according to the coping strategy index on admission, but not for MUAC, hemoglobin, and CD4 counts [118]. The study conducted in the

USA indicated that cumulative ART use predicted a positive change in CD4 count (41.3 cells greater change/additional year of ART) [85].

The finding of an interventional study conducted in Kenya among HIV-infected adults found that 21% and 33% of intervention and control site HIV-infected adults had WHO stage 3 or 4 disease respectively with median CD4 count being similar between arms (intervention: 446 cells/mm3 vs. control: 475 cells/ mm3) [117].

2.10. Summary of literature synthesis

In summary, the review of literature on the association between food insecurity and HIV, how food insecurity bears the effect on clinical progression and CD4 count change of HIV-infected adults, as well as other independent predictors of clinical progression and CD4 count change provides relatively consistent evidence. The review found consistently high prevalence of food insecurity among HIV-infected adults both in resource-rich and poor countries, including Ethiopia. The few studies conducted in Ethiopia also present a consistently high prevalence of food insecurity among HIV-infected adults. However, this review identified several limitations and gaps that justify the need for this particular study.

First, most of the available and identified studies were from developed or resources-rich countries, that did not consider the context of low-middle-income countries and very few of them were from low-middle-countries. Second, most of those studies that addressed some of the links between food insecurity and HIV clinical and immunological progression were cross-sectional, which do not show a temporal relationship and fails to identify the effect of food insecurity and other independent predictors on clinical progression and CD4 count change among HIV-infected adults.

Third, the design and analysis of most of the studies did not pay attention to potential confounders that can mask the presence and absence of apparent relationships.

Fourth, almost all of the reviewed studies did not address the independent socio-economic predictors of clinical progression and CD4 count change, such as educational status, religion, residence and number of children; and clinical predictors, such as WHO treatment stage of HIV and follow-up interval. Ultimately, the review indicated gaps in concrete, context, and culture-specific evidence for intervention in relation to the link between food insecurity and HIV, as well as, the way how food insecurity poses an effect on clinical progression and CD4 count change.

Finally, two systematic reviews and meta-analyses were conducted at the initial stage of this dissertation to identify gaps in the literature on the topic. Accordingly, the reviews identified gaps that require further investigation into the effect of food insecurity on the clinical progression of HIV/AIDS and CD4 count changes among HIV-infected adults, along with other potential confounders. One of the review papers was included as one of the objectives in this dissertation.

3. Conceptual Framework of the Study

This conceptual framework is adapted and constructed from a conceptual framework for understanding the links between food insecurity and HIV/AIDS. It incorporates the selected socio demographic and economic predictors, clinical predictors; both nutritional and behavioral pathways through which food insecurity affect clinical progression and CD4 count change [20, 78, 83].

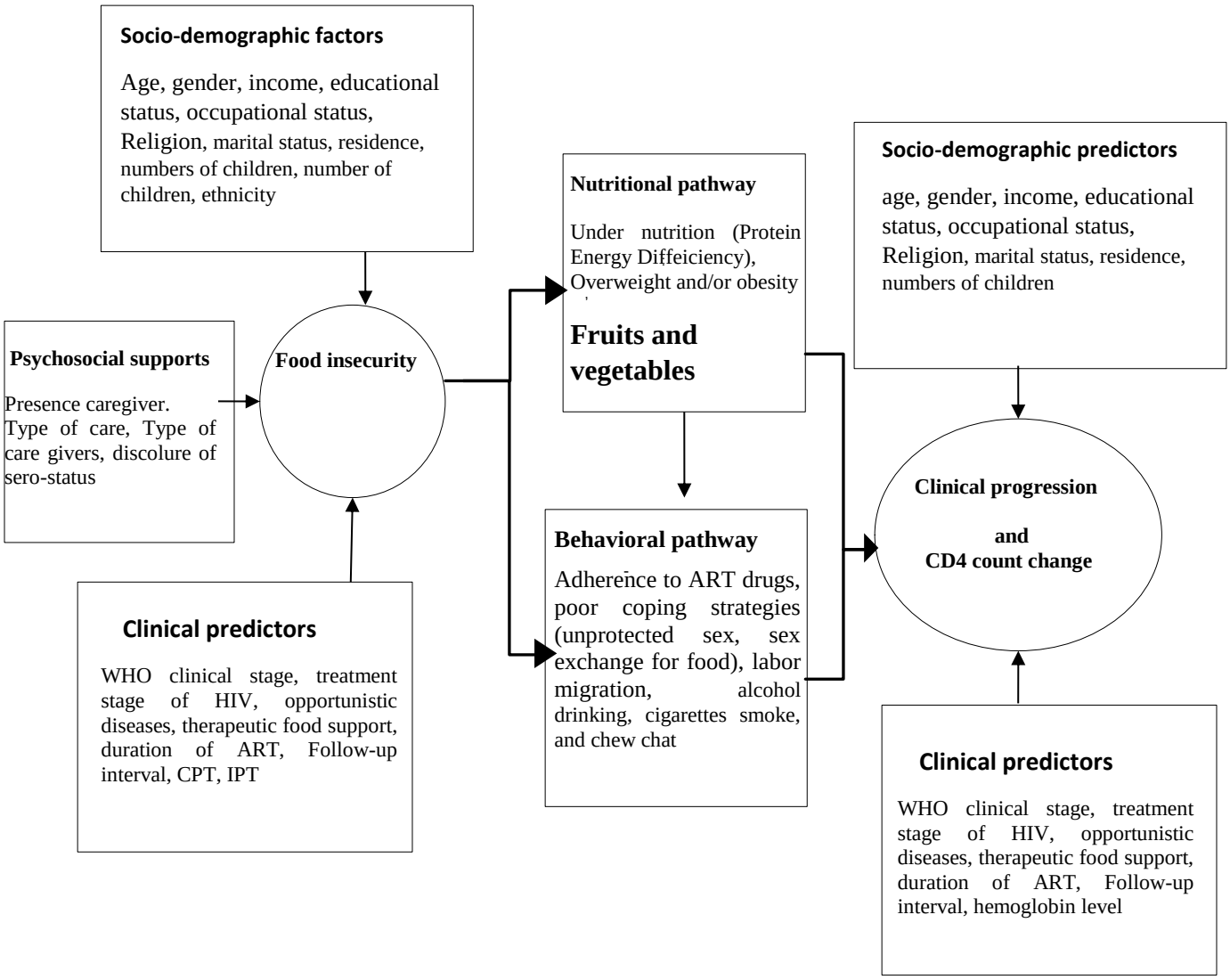


Figure 1. Conceptual framework for the study of effect of food insecurity on clinical progression of HIV/AIDS and CD4 count change, North Shewa, Ethiopia.

4. Research Hypothesis

- The effect of food insecurity is higher among female than male adults receiving ART in North Shewa Health Facilities
- The incidence of poor clinical progression is higher among food-insecure than food-secure adults receiving ART in North Shewa Health Facilities
- The incidence of low CD4 counts is higher among food-insecure than food-secure adults receiving ART in North Shewa Health Facilities
- The relationship between food insecurity and HIV clinical progression is moderated by other key predictors of clinical progression.
- The relationship between food insecurity and CD4 count change is moderated by other key predictors of clinical progression.

5. OBJECTIVES

5.1. General Objective

- To assess the magnitude with food insecurity, and fruit and vegetable dietary intake, and examine the effect of food insecurity on clinical progression of HIV/AIDS and CD4 count change among HIV-infected adults receiving antiretroviral therapy in North Shewa Health Facilities, Oromia Region, Ethiopia

5.2. Specific Objectives

- To estimate the pooled effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy.
- To assess the magnitude of food insecurity with its severity, and associated factors among adults receiving antiretroviral therapy in North Shewa Health Facilities
- To assess the magnitude of fruit and vegetable dietary intake, and associated factors among adults receiving antiretroviral therapy in North Shewa Health Facilities
- To determine the effect of food insecurity on clinical progression of HIV/AIDS among adults receiving antiretroviral therapy in North Shewa Health Facilities
- To determine the effect of food insecurity on CD4 count change among adults receiving antiretroviral therapy in North Shewa Health Facilities

6. MATERIALS AND METHODS

6.1. Study Area and Period

The study was conducted in North Shewa Zone Health Facilities, Oromia Regional State, Ethiopia. North Shewa is bordered on the south by Addis Ababa on the southwest by West Shewa, on the north by the Amhara Region, and on the southeast by East Shewa. According to the 2015 population projection, using 2007 Census, North Shewa Zone had a total of 1,431,305 (717,552 males and 713,753 females) population. North Shewa Zone consists of 16 districts (4 town administrations and 12 rural districts) [119]. The four town adminstrations include Ali Doro, Fiche, Gerba Guracha, and Sheno.The zone has five hospitals (one referral hospital and four primary hospitals), 64 health centers, and 275 health Posts. Eighteen health facilities (4 hospitals and 14 health centers) have ART clinics that have been providing ART services to people infected with HIV. The 2021 report of North Shewa Zone noted that there were 5, 514 people living with HIV receiving ART, with a new infection rate of 1% [39, 119]. A high caseload was observed six health centers, namely Shano, G/Tsion, M/Tur, Ijeere, Mandida and Hambiso, and in two hospitals, namely Fitche Hospital, Gundo Masqal Hospital, Kuyu Hospital, and Dara Hospital. This study was conducted from January 2022 to February 2023 in four hospitals and all six-health centers with a high caseload (Figure 2).

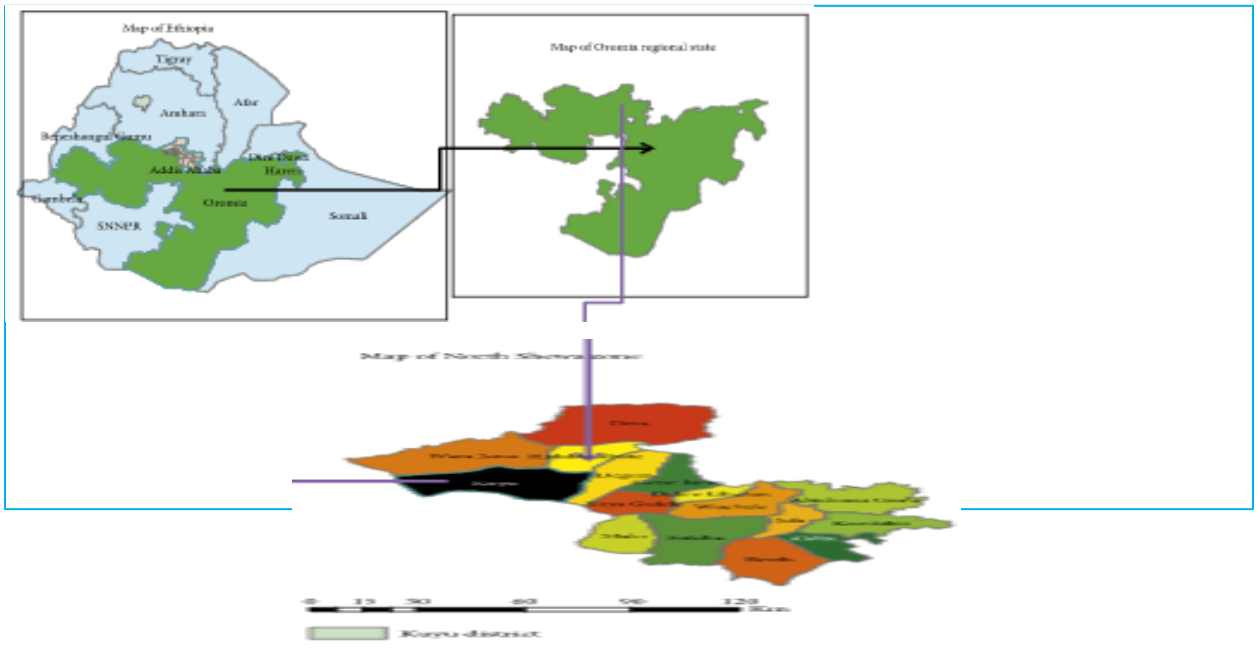


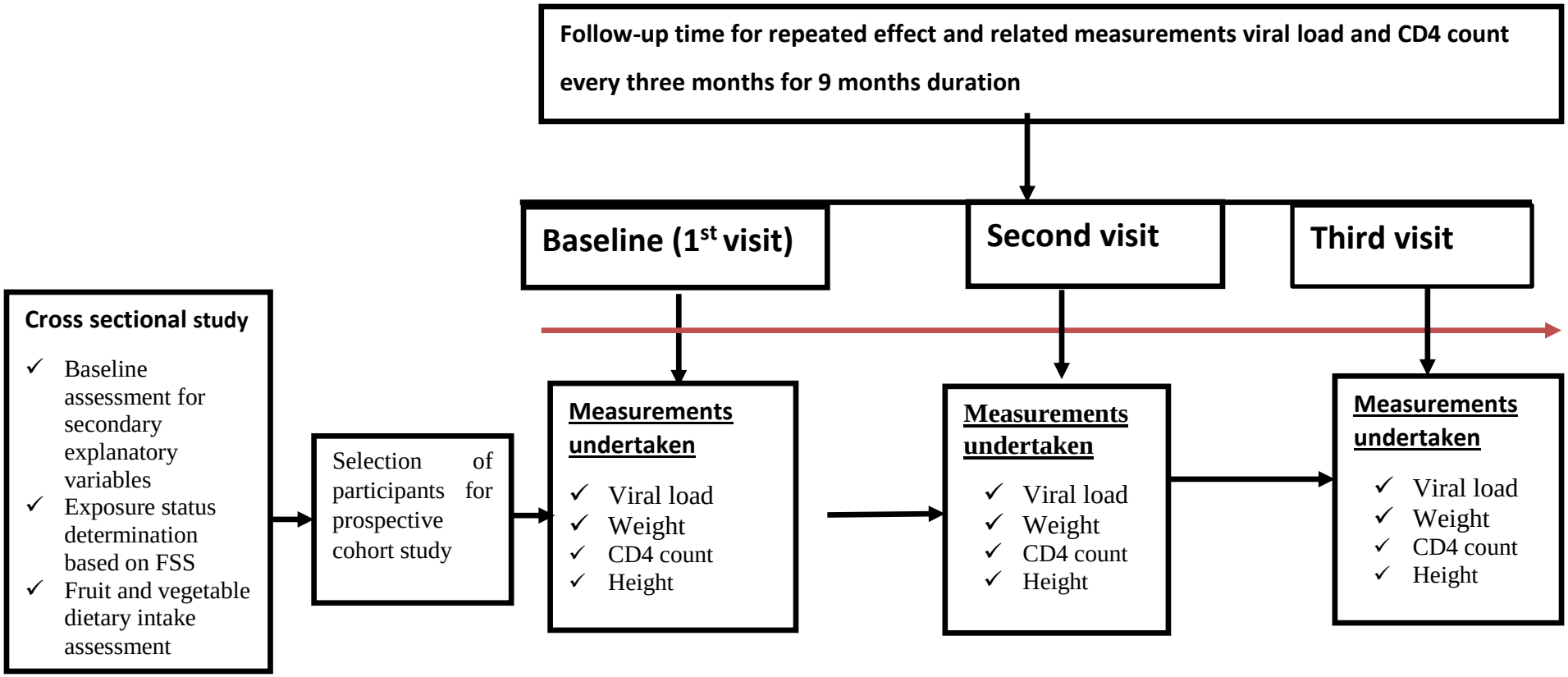
Figure 2: Map of study area that adapted from previous sources, Ethiopia, 2024.

Source: North Shewa Zone administration office and previous study [120].

6.2. Study Designs

A combination of different study designs were used based on the nature of the outcome variables assessed in this study. For Paper I, a systematic review and meta-analysis was used to estimate the pooled effects of gender on food insecurity among HIV-infected adults receiving ART. This helps to assess the pooled effect gender on food insecurity and identify the existing gaps in the literature as part of this thesis work. For Papers II and III, a cross-sectional study was employed to determine the magnitude of food insecurity and fruit and vegetable dietary intake, and also to identify their associated factors, using a quantitative data collection method. The study was also used to collect demographic baseline data and to assess food security status of PLHIV as an exposure variable of interest for the two subsequent papers.

For Papers IV and V, a prospective cohort study was conducted to examine the effect of food insecurity on clinical progression and CD4 count change, along with its potential confounders, using a quantitative data collection method. The study was carried out at all four hospitals and six health centers with high caseloads in the North Shewa Zone. It aimed to collect repeated measurements of HIV-infected adults to assess the effect of food insecurity on the clinical progression of HIV/AIDs and CD4 count changes (including CD4+ T-cell count, viral load, weight, and height). In addition to the baseline measurement, viral load, CD4 count, weight, and height measurements were undertaken using standard methods every three months for nine months, in accordance with the expected standard. This is illustrated in the diagram below, which shows the follow-up time and the link between outcome and explanatory variable measurements (Figure 3).



FSS- Food Security Status

Figure 3: Diagram for Prospective cohort study follow-up time and the link between outcome measurements and secondary explanatory variables, North Shewa Health Facilities, Northcentral Ethiopia from 2022-2024.

6.3. Population

6.3.1. Source Population

Adults infected with HIV and receiving ART with follow up for their treatment at North Shewa Health Facilities during the time of the study. All published and unpublished studies conducted worldwide among HIV-infected adults receiving ART, aged 18 years and older for the systematic review and meta-analysis.

6.3.2. Study Population

Systemaric review paper (paper I): All published and unpublished studies conducted worldwide among HIV-infected adults receiving ART whose ages were greater than 18 years by the time of February 30, 2018.

Paper II-V: All PLHIV receiving ART and being followed up at selected health facilities. The food security status of all HIV-infected adults receiving ART was assessed, using a food insecurity access score. The exposed group consisted of those who were food-insecure, while the non-exposed group comprised those who were food-secure, based on the food security status assessment. A baseline assessment was conducted on the HIV-infected adults receiving ART in the included hospitals and health centers to determine exposure status (food-secure and food-insecure).

6.3.4. Eligibility criteria

Inclusion criteria

Paper I: HIV-infected adults receiving ART whose ages were greater than 18 years, regardless of their gender, both community and institutional-based studies. All study types that were published in the form of journal articles, master's thesis and dissertation, that were written in English were included in the review. In addition, all studies conducted using cross-sectional, case-control, and cohort designs in all settings (community and institutional studies) were included.

Paper II-V: All HIV-infected adults receiving ART whose ages were greater than 18 years, regardless of their treatment regimen, and duration of follow-up, were included in the study.

Exclusion criteria

Paper I: We excluded studies conducted on the pediatric age group, studies with the methodological problems that was assessed using Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI), interventional studies, and review articles.

Paper II-V: Patients with other concomitant chronic diseases, such as heart disease, hypertension, diabetes mellitus and others that can suppress the immune system and deteriorate their nutritional status, pregnant women who started ART were excluded from this study. Those conditions were identified through the patient's record review.

6.4. Sample size determination

The required sample sizes for this study were calculated based on the specific objectives that were addressed as follows: -

6.4.1. Sample Size for Systematic review

We included all published and unpublished articles that fulfilled eligibility criteria and were conducted in the specified time.

6.4.2. Sample Size for Cross-Sectional Study

The sample size for the magnitude of food insecurity and its associated factors (Paper II) addressed by cross-sectional study was calculated, using the magnitude of food insecurity and the major exposure variables associated with food insecurity to ensure the adequacy of sample the paper as follows:

The sample size for the first specific objective of Paper II was calculated, using single population proportion formula, considering the following assumptions and parameters, a confidence level of 95%, a 4% margin of error, since the proportion was less than 50% and 35.2% proportion of food insecure HIV-infected adults from a study conducted in West Shewa Zone Health facilities [95].

$$n = \frac{Z(\alpha/2)^2 * P(1-p)}{d^2}$$

$$n = \frac{(1.96)^2 \times 0.352 \times 0.648}{(0.04)^2} = 547$$

n = 547+ 5% for non-response = **574**

Where:

n= sample size

p = Magnitude of food insecurity among HIV-infected taken from the previous study -0.352 (35.2%).

d= maximum allowable error (Margin of error) =0.04

z= value of the standard normal distribution (Z-statistic) at 95% confidence level (z=1.96)

The final sample size with 5% for non-response was **574** adult HIV-infected patients

The sample size for the second specific objective of Paper II that assessed the factors associated with food insecurity was calculated by two population proportion formula for the difference between two populations by considering major exposure variables of food insecurity after a review of different literature [121]. The required sample size for this objective was calculated by considering the following assumptions and parameters, a confidence level of 95%, a power of 80% and assuming a one-to-one allocation ratio of unexposed to exposed (1:1) for the following main exposure variables taken based on the current evidence from different literature (Table 2). Accordingly, the required sample size for this objective was calculated, using the STATCALC application of Epi-info version 7.0 statistical software [122] (Table 1).

$$n=\frac{(z\alpha/2\sqrt[2]{(1+\frac{1}{r})p(1-p)}+Z\beta\sqrt[2]{(p1\,(1-p1)+\frac{p2(1-p2)}{r}})2}{(p1-p2)2}$$

Table 1: Summary of sample for an objective that addresses factors associated with food insecurity in this study, 2024.

Factor	Proportion outcome among unexposed (%)	AOR/ PR	Confidence level	Power of test	Sample size (n)	Sample size with 5% non-response	Reference
Food support	**3.4**	**2.4**	**95%**	**80%**	**824**	**865**	[34]
Residence	42.9	2.3	95%	80%	204	214	[32]
Occupation	20.5	1.6	95%	80%	818	858	[24]
Household head being male	29.6	2.2	95%	80%	238	250	[24]

From the four calculated sample sizes, the largest was obtained as the optimum sample size for Paper II, which assess the magnitude of food insecurity and associated factors. Therefore, the final sample size for these two objectives in this study was **865.** This sample size was also used to

address Paper III, which assess the magnitude of fruit and vegetable dietary intake and its associated factors among adults receiving ART.

6.4.3. Sample Size for Prospective Cohort Study

The sample size for Paper IV and V addressed using a prospective cohort study was calculated using a two-population proportion formula for the difference between two populations, considering major exposure variables that bring the difference between the two groups. Finally, the optimum sample size was taken from the list of the calculated samples. Accordingly, the required sample size for this objective was calculated using the STATCALC application of Epi-info version 7.0 statistical software [122] (Table 2).

$$n = \frac{\left(z\alpha/2\sqrt{(1+\frac{1}{r})p(1-p)} + Z\beta\sqrt{p1\,(1-p1)+\frac{p2(1-p2)}{r}}\right)2}{(p1-p2)2}$$

The required sample size for Paper IV was calculated considering the following assumptions and parameters: a confidence level of 95%, a power of 80%, and a ratio of unexposed (food secure PLHIV) to exposed (food insecure PLHIV). In this regard, taking an adjusted RR (Rate ratio) of 1.52 for severe food insecurity and a one-to-one allocation ratio of unexposed to exposed (1:1) is assumed. The percentage of outcome variable in the unexposed (poor clinical progression in food secure household, measured by viral load) was 27.5% [27]. The exposure variable was selected for the sample size calculation because recent evidence shows that food security status is the risk factor for the clinical progression of HIV/AIDS. Based on the above assumption, the total sample size is 374(187 for the unexposed group and 187 for the exposed group). To account intra-cluster correlation, the design effects of 1.5 was used, resulting in a final sample size of 561. After accounting for a 5% loss to follow-up, the sample size was adjusted to 590. However, we used a sample size of 574 (287 for the unexposed group and 287 for the exposed group) based on the availability of food-insecure (exposed group) HIV-infected adults who met the eligibility criteria. This adjustment was made to maintain the exposed-to-unexposed ratio, as we found only 287 food-insecure HIV-infected adults.

The required sample size for Papaer V was calculated considering the following assumptions and parameters: a confidence interval of 95%, a power of 80%, and a ratio of unexposed (food secure PLHIV) to exposed (food insecure PLHIV). In this regard, taking adjusted RR (RR ratio) of 2.08 for food security status and a one-to-one allocation ratio of unexposed to exposed (1:1) were assumed. The percentage of outcome variable in unexposed (low CD4 count in food secure households) was 32.3%. The exposure variable was selected for sample size calculation because recent evidence shows that food security status is the risk factor for CD4 count Change [22]. Based on the above assumption, the total sample size is 268 (134 for the unexposed group and 134 for the exposed group). To account for intra-cluster correlation, the design effects of 1.5 was used, resulting in a final sample size of 402. After accounting for a 5% loss to follow-up, the final sample size for this objective was 442 (221 from food-secure and 221 from food-insecure HIV-infected individuals) (Figure 4).

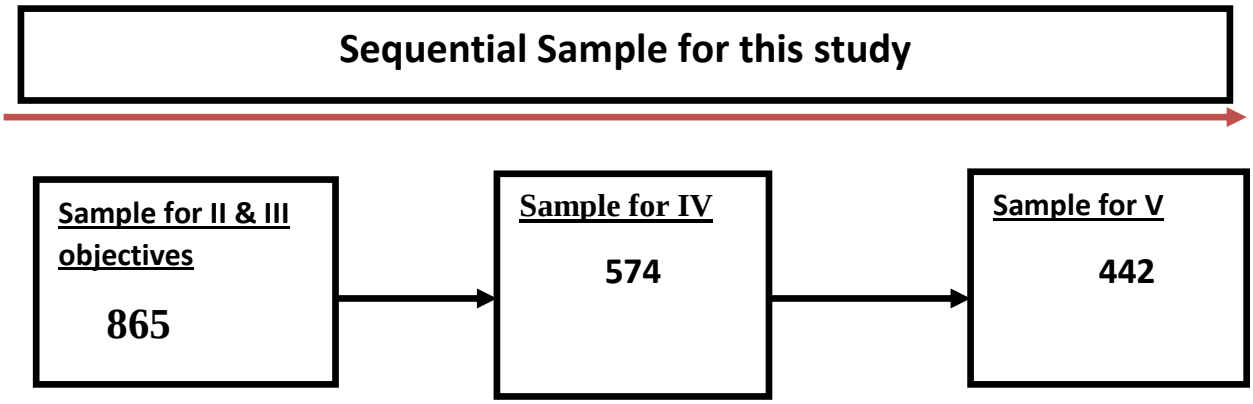


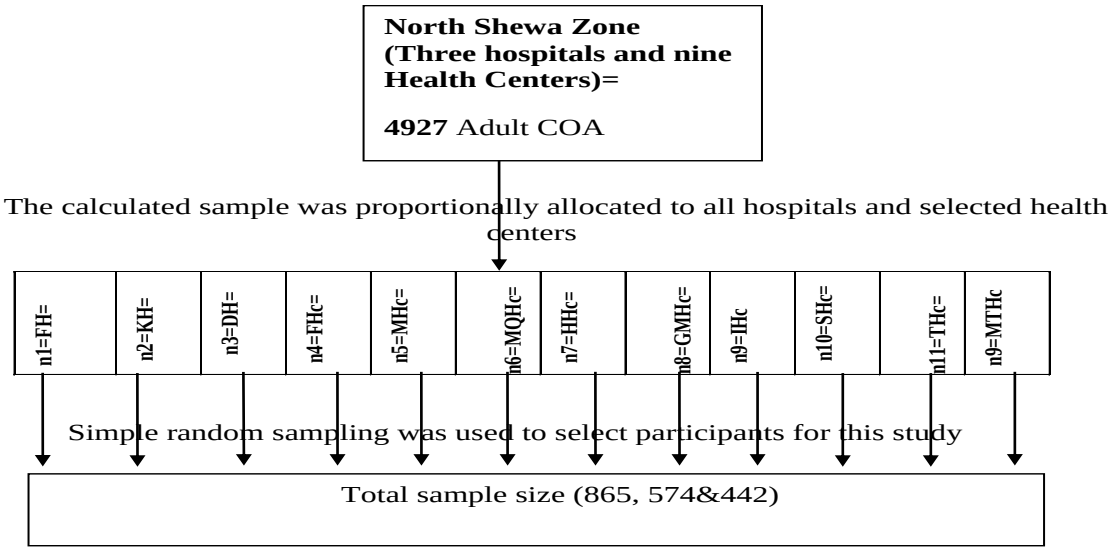
Figure 4: Diagram for Sequential Sample for the North Shewa Health Facilities, Northcentral Ethiopia

6.5. Sampling technique

Paper I: All study types that were written in the form of journal articles, master's theses and dissertations, that were written in English were included in the review. In addition, all studies conducted using cross-sectional, case-control and cohort designs were included.

Paper II-V: Hospitals and Health centers in North Shewa, that provide ART and care were identified. Four hospitals and six health centers that were providing the care were included in this study. The calculated sample for objectives II-IV was allocated proportionally to each hospital and health center, based on the size of patients. Simple random sampling was used to select participants from the partient registries. All HIV-infected adults receiving ART were assessed for food security status, using the Household Food Insecurity Access Scale (HFIAS) tool. The total number of

unexposed group (food-secure) and exposed groups (food-insecure) were identified based on the cross-sectional assessment from all four hospitals and six health centers. The calculated sample size was allocated to the hospitals and selected health centers proportionally, based on the number of both groups identified from each hospital and health center. For objective IV, simple random sampling was used to select 287 individuals for the unexposed group and 287 for the exposed group, using a computer-generated randomization method. For objective V, simple random sampling was used to select 221 individuals for the unexposed group and 221 individuals for the exposed group, using a computer-generated randomization method. Those individuals were then enrolled in the study for follow-up (Figure 5).



FH-Fiche Hospital, KH-Kuyu Hospital, DH-Dara Hospital, FHc-Fiche Health Center, MHc-Mandida Health Center, HHc- Hambiso Health center, MQHc - Gundo Masqal Health Center, GMHc - Miquawa Health Center and IHc – Ijeere Health Center, THc- G/Tsion Health Center, SHc- Shano Health Center, MTHc-Muka Turi Health Center

Figure 5: schematic presentation of sampling procedures on effect of food security study, North Shewa, Ethiopia, 2024.

6.7. Study Variables

Outcome variable

- Food security status (Paper I and II)
- Fruits and vegetable dietary intake (Paper III)
- Clinical disease progression (Paper IV)
- CD4 count change (Paper V)

Explanatory variables

Primary explanatory variable. The primary explanatory variable of this study was food insecurity which was assessed cross sectionally at baseline. Food insecurity was assessed at the household level using the Household Food Insecurity Access Scale (HFIAS) and reported at the individual level. The measurement of food insecurity was based on the conceptual framework for research in HIV/AIDS, emphasizing the nutritional and behavioral pathway, particularly on the domains of food insecurity, such as anxiety and uncertainty about the household food supply, insufficient quality (includes variety and preferences of the type of food), and insufficient food intake and its physical consequences [22, 25, 123].

Secondary explanatory variables: Those were variables that were assumed to be independent predictors of clinical progression and CD4 count change, and potential confounders of the effect of food insecurity on clinical progression and CD4 count change that were identified based on the clinical evidence and previous literature. Those included **socio-demographic predictors** (age, gender, income, educational status, occupational status, religion, marital status, residence, number of children, psychosocial supports (presence of caregiver, type of care, type of caregivers, discolure of serostatus)); **Clinical predictors** (Duration of ART treatment, WHO clinical stage, WHO treatment stage of HIV, opportunistic diseases, therapeutic food support, Follow-up interval, CPT provision, and IPT provision); **Nutritional predictors** (Undernutrition (Protein Energy Difficiency), Overweight and/or obesity); **Behavioral predictors** (Adherence to ART drugs, poor coping strategies (unprotected sex, labor migration)), cigarettes smoking, alcohol, and chat chewing.

6.8. Operational and Term Definitions

- **Food security**: when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life [124].
- **Effect:** Change in CD4+ T-cell count and important clinical marker measurement, like viral load as per standard (a viral load of 1000 copies/mL or higher and lower) either positively or negatively.

- **Change in CD4 count**: The difference between baseline CD4 and the most recent follow-up CD4 counts change intervals are in between 50 cells/mm3 and 100cells/mm3 in the period of six months [123].
- **Opportunistic diseases:** are categories of diseases that occur in immune-compromised hosts and are considered to be a complication of HIV infection resulting in either bacterial, viral, fungal, or protozoan microorganisms. For this study, patients were considered to have an opportunistic disease if they developed at least one such condition.
- **Adherence to ART:** Taking the right ARV medication, at the right dose, at the right time every day and exactly as prescribed for life long [123].
- **Health Facilities:** All hospitals and Health Centers (Fiche Health Center, Mandida Health Center, Hambiso Health center, Gundo Masqal Health Center, Miquawa Health Center and Ijere Health Center, G/Tsion Health Center, Shano Health Center, Muka Turi Health Center) in the North Shewa Zone that have been providing antiretroviral therapy.
- **Lost to Follow-Up:** To address loss to follow-up the cell phone numbers of each participant were registered at baseline. In this study, participants were considered as lost to follow-up if they were missed for more than or equal to 2 consecutive visits or if they were not contacted for at least equal to 6 months. The investigators took measures to locate patients and determine the status of those lost to follow-up.

6.9. Measurements

Food insecurity: It was assessed using the nine-item Household Food Insecurity Access Scale (HFIAS) developed and refined by the USAID Food and Nutrition Technical Assistance (FANTA) project [112, 125]. The HFIAS is a validated instrument and has been shown to distinguish food insecure from food secure households across different cultural contexts. It reflects the universal domains of the experience of food insecurity, including 1) anxiety and uncertainty about household food supply, 2) insufficient quality (including variety and preferences of types of food), and 3) insufficient food intake and its physical consequences. The results were dichotomized into food insecure and food secure [22, 25, 73].

Fruits and Vegetables dietary intake: The fruits and vegetables dietary intake in this study was assessed over the past 30 days through the frequency of consumption, using Behavioral Risk Factor Surveillance System (BRFSS) assessment tools. The frequency of consumption of two classes of fruits (whole fruits and 100% fruit juice, without sugar or other additives) and vegetables (such as

green leafy like cabbage and salads, cruciferous, marrow, starchy staples like potatoes, sweet potatoes, green peas, and others, carrots, and other vegetables) were assessed among HIV-infected adults in selected health facilities. We used ten categories to assess the frequency of FAVs consumption: never, <1 time per month, 1-3 times a month, once a week, 2-4 times a week, 5-6 times a week, once a day, 2-3 times a day, 4-5 times a day, and 6+ times a day [100, 126]. The median frequency of fruit and vegetable daily intake was initially calculated by converting weekly and monthly intake into daily intake. This was achieved by dividing the frequency of weekly or monthly reported intake, by 7 or 30, respectively. Subsequently, the frequencies of all fruit and vegetable variables were summed up to obtain the total frequency of fruit and vegetable intake. The median was then calculated using total daily fruit and vegetable frequency as a continuous variable [126]. Then, it was dichotomous, coded as 1 if the median frequency times per day was less than one time per day for low fruits and vegetable dietary intake, and 0 if the median frequency times per day was greater than or equal to one time per day for high fruit and vegetable [126]. In addition, the adequacy of fruit and vegetable was also assessed by considering the portion size of each selected fruit and vegetable. The portion sizes were then multiplied by the recommended grams to calculate the median grams based on the WHO/FAO recommendation. According to these recommendations, individuals should consume 400 or more grams of fruits and vegetables for overall health improvement, reducing the risk of certain NCDs, preventing chronic infections, contributing to metabolic regulation, and bolstering immune responses, potentially slowing the progression of HIV infection [100, 101].

Anemia: In this study, anemia was measured, using Hb concentration levels according to the WHO guidelines used at health facilities. The guidelines define anemia for males as an Hb concentration <13 g/dL (11.0–12.9 g/dL = mild; 8.0–10.9 g/dL = moderate, and <8.0 g/dL = severe), and for females as an Hb concentration <12.0 g/dL (11.0–11.9 g/dL = mild; 8.0–10.9 g/dL = moderate, and <8.0 g/dL = severe) [127, 128]. For consistency, this study used a minimum cutoff point of ≤12 g/dL to classify HIV-infected adults as anemic, encompassing the cutoff points for both males and females. Additionally, hemoglobin values were adjusted for altitude using WHO/CDC-recommended correction factors, based on the elevation of each study location. This ensured accurate assessment of anemia status [129, 130].

Adherence to ART drugs: The adherence to ART was assessed using percentages and calculated using the number of doses missed for the last month. The adherence to ART was categorized based on the recent national HIV/ART training guideline. Accordingly, an adherence percentage equal to or greater than 95% or ≤ 3 doses missed per month was considered as Good adherence to ART, 85-94% or 4-8 doses missed per month was considered as Fair adherence to ART, and less than 85% or ≥ 9 doses missed per month is considered as Poor adherence to ART [123]. It was computed as a continuous variable representing the percent of prescribed doses taken for each individual antiretroviral medication using the following formula [52].

$$\%\ \text{adherence} = \frac{(\text{quantity dispensed} + \text{previous pill count}) - (\text{quantity remaining})}{(\text{prescribed number of pills/day}) \times (\text{number of days between dispensing date and date of pill count})} \times 100$$

Nutritional status: Nutritional status was measured using BMI in this study as a reliable indicator of body fatness and was considered an alternative to direct measures of body fat. Participants were classified as undernourished if their BMI was < 18.5 kg/m², normal if their BMI was between 18.5 and 24.9 kg/m², and overnourished if their BMI was ≥ 25 kg/m². These classifications were based on the national HIV training guidelines and the World Health Organization's BMI classification scale [123, 131].

Clinical progression: The clinical progression of the participants, one of the outcome variables in this study, was measured by assessing the viral load, a key marker. An increasing viral load reflects the production of more viruses, leading to a rapid progression to AIDS, which was considered an indicator of poor clinical progression. Viral load indicates the activity of HIV infection and is a useful blood test to determine the amount of HIV in the blood. Over time, the viral load increases as more viruses are produced, resulting in rapid progression to AIDS. According to national guidelines, HIV viral load was measured at 6 months and 12 months after initiating ART [123]. For this study, HIV viral load measurements were undertaken using standard methods at every three months. A viral load of 1000 copies/mL or higher, measured in at least two consecutive measurements/tests taken 3 months apart, is considered as **poor clinical progression[123]**.

CD4 count Change: The difference between baseline CD4 counts and the most recent follow-up CD4 counts ranges between 50 cells/mm3 and 100 cells/mm3 over a period of six months. In this study, a change was considered low (low CD4 count change) if the CD4 count change increased within six-months interval is between 50 cells/mm3 and 100cells/mm3 [123]. Accordingly, the CD4 cell count is the most reliable marker for assessing disease progression, staging, and guiding treatment, with a count below 200 cells/mm³ considered an indicator of a low CD4 count. We classified the CD4 count as low (less than 200 cells/mm3), moderate (200-500 cells/mm3), and normal or high (greater than 500 cells/mm3) [132]. The low CD4 count change (below 200 cells/mm3) was considered as an immunological failure [123, 133].

6.10. Data collection tool

Paper I: Data were extracted using a standardized data extraction format. The data extraction spreadsheet included the primary author name, year of publication, country, study design, sample size, number of subject outcomes, response rate, number males with the outcome, number of females with the outcome, the total number of males and females in the study.

Paper II-V: A structured interviewer-administered questionnaire was developed to collect socio-demographic and HIV patient follow-up data. Questions were adapted from standard tools, such as the FANTA [112, 125] and BRFSS assessment tools, to collect data on food security status and dietary intake of fruits and vegetables [100, 126]. Questionnaire comprised of six parts, namely sociodemographic characteristics, psychosocial supports, clinical predictors and effects information, therapeutic food-related information, behavioral preditors and household food security status.

6.11. Data collection methods

Paper I: Before beginning our study, we checked for the presence of the existing systematic reviews and meta-analysis on our topic using the DARE database (http://www.library.UCSF.edu) and the Cochrane library, as well as JBI/SUMMARI website to avoid duplication and the availability of ongoing projects related to the current systematic review and meta-analysis. In addition, we searched for the two Trial Registries: ICTRP and Clinical Trials.gov. No previous systematic reviews or meta-analyses on the topic were found. We searched all relevant published studies in the following major databases; *PubMed, MEDLINE, Google Scholar, CINAHL, PopLine, MedNar, Embase, the Cochrane library, the JBI Library, the web of science, and African Journals*

Online. We also retrieved grey literature, using Google and Google Scholar searches. To identify and retrieve additional articles, we also reviewed reference lists of identified studies. Unpublished studies were retrieved from the official websites of international and local organizations and universities. The search for published studies was restricted by the age of the study participants (HIV-infected adults receiving ART whose age was greater than 18 years), but was not restricted by time or country.

The following search terms were used: food security status, food insecurity, the effect of gender, the effect of sex, adults living with HIV, patients living with HIV, individuals living with HIV, HIV-infected adults, HIV-infected individuals, and antiretroviral therapy separately and/or in combination.

We pre-defined search terms to allow a comprehensive search strategy that included the important studies. All fields within records and Medical Subject Headings (MeSH terms) were used to help expand the search in advanced PubMed search. The following search strategies were modified for the various databases, using the two important Boolean operators and search engines with initial keywords/search terms *1) ("Food security status" OR "food insecurity" AND "effect of sex" OR "effect of gender" AND "adult living with HIV" OR "Patients living with HIV" OR "individual living with HIV" AND "antiretroviral therapy"). 2) ("Food insecurity" OR "effect of sex" OR "effect of gender" AND "HIV-infected adults" OR "HIV-infected patients" OR "HIV-infected individual" OR "antiretroviral therapy" AND "Ethiopia").* The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline was followed during the systematic review [134]. Data were extracted by two independent reviewers, using a standardized data extraction format.

Paper II-V: Baseline data were collected, using a structured interviewer-administered questionnaire with closed-ended questions and repeated measurements of HIV patients for the effect of food insecurity on clinical progression of HIV/AIDs and CD4 count change. Food security status and dietary intake data for fruits and vegetables were collected using structured questions adapted from standard tools, such as FANTA [112, 125] and BRFSS assessment tools [100, 126]. Patient records were extracted to collect data of some variables, such as type of malignancy, IOs, Anemia, WHO staging and etc. We assessed nutritional status, using BMI, CD4 count, and viral load change quarterly for 9 months. Assessment for the viral load as a marker for clinical progression was conducted quarterly, using a standard measurement for 9 months. Weight,

height, viral load, and CD4 measurements were undertaken, using standard methods every three months by the same staff member for 9 months. Data were collected by nine BSc nurses with prior data collection experience, who were recruited and trained from local hospitals and health centers. The entire data collection process was supervised by two health officers with master's degrees in public health and prior experience in similar supervisory roles. They were also recruited and trained from those hospitals and health centers. Computer Assisted Personal Interviews (CAPIs) KoboToolbox digital data collection platform was used to collect data, using data collectors on a digital platform.

6.12. Data Quality control

Paper I: Retrieved studies were assessed for inclusion in the final review by reviewing their title, abstract and full text for their agreement with eligibility criteria. The Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) was used for critical appraisal of studies [135]. Disagreements between reviewers in the review process were discussed with review team members until consensus was reached. Discrepancies between two independent reviewers were resolved by involving a third reviewer. When access to full text articles was not available, document authors were contacted once. If no reply was received within a month, the documents were excluded from the study.

Paper II-V: In order to ensure the quality of collected primary data, the questionnaire was pretested on the 5% of sample at adjacent Hospital for feasibility, consistency, and completeness on the population with similar characteristics. Necessary modification was made based on the result of pretest before actual data collection. The content validation of the questionnaire with local experts was done before adapting the FANTA food insecurity access scale. Two days of training was given to data collectors and supervisors on the objectives of the study, methods of data collection including the use of CAPIs KoboToolbox, and how to maintain the confidentiality of information. They were familiarized with the tool of data collection. The measurement instruments were calibrated after every measurement. The collected data were checked for completeness and consistency.

6.13. Data Processing and Analysis

Data were exported from KoboToolbox to STATA 17 for analysis and modeling. Descriptive analysis was used to describe the characteristics of study participants for all five papers accordingly.

Paper I: We used reference management software (Endnote version X7.2) to combine database search results and to remove duplicate articles manually. A meta-analysis and synthesis was used to pool the effect of gender on food insecurity among HIV-infected adults receiving ART. The logarithm and standard error of the odds ratio (OR)for each original study were generated using the "generate" command in STATA. Cochrane's Q statistic (chi-square), I^2 and p-values were used to check for heterogeneity of the studies outcomes. The heterogeneity was considered as low, moderate or high when I^2 test statistics results were 25%, 50%, and 75% respectively [136]. Forest plots were also used to visualize the presence of heterogeneity. Because we found a high level of heterogeneity, we used a random effects model for analysis to estimate the Der Simonian and Laird's pooled effect. Furthermore, to identify the source of heterogeneity, meta-regression was conducted and statistically significant results were declared in the presence of heterogeneity. Publication bias was checked using a funnel plot of symmetry. Further, the statistical significance of publication bias was checked using the Egger and Begg tests [137-139]. A p-value less than 0.05 was used to declare the presence of publication bias. We performed a sensitivity analysis using a random effects model to assess the influence of a single study on the overall meta-analysis estimate.

Paper II: A log-binomial regression model was fitted to identify factors associated with food insecurity. All predictors associated with the outcome variable in bivariable analysis with a p-value of 0.20 or less were included in the Log-binomial regression model of multivariable analysis. The crude and adjusted Prevalence Ratios, together with their corresponding 95% confidence intervals, were computed. Multi-collinearity of explanatory variables was checked using the variance inflation factor, and the fitness of the model was checked. A P-value < 0.05 and a corresponding 95% CI were considered to declare a result as statistically significant.

Paper III: A Poisson regression model with robust variance was fitted to identify factors associated with fruits and vegetables consumption. All factors that were associated with the outcome variable in the bivariable analysis with a p-value of 0.20 or less were included in the multivariable Poisson regression model. The crude and adjusted prevalence ratio together with their corresponding 95% confidence intervals were computed. Multi-collinearity of explanatory variables was checked using the variance inflation factor, while the fitness of the model was checked, using information criteria such as AIC and BIC. A p-value of less than 0.05 and the

corresponding 95% confidence interval were considered statistically significant for declaring results.

Paper IV & V: The analysis of two papers used follow-up repeated measurements data over three consecutive follow-up periods covering 9 months. We used a generalized linear mixed-effects model, specifically mixed-effects logistic regression, by introducing random effects to account for clustering effects and the repeated nature of measurements. This approach was used to identify the independent predictors of the clinical progression of HIV/AIDS. Accordingly, a generalized linear mixed-effects model particularly mixed-effects logistic regression was fitted by introducing random-effects to address clustering effects to identify the association between food security and clinical progression of HIV/AIDs and CD4 count change. The assumptions of the generalized linear model (the independence of variables for equation) using variance-covariance structure of the random effects were checked before model fitting by running exploratory data analysis. Covariance Structures were selected based on the correlation structure of data.

All predictors that were associated with the outcome variable in bivariable analysis with a p-value of 0.20 or less were included in the multivariable mixed effects regression models. The crude and adjusted risk ratio (aRR) together with their corresponding 95% confidence level was computed. Multi-collinearity of explanatory variables was checked using variance inflation factor and the fitness of the model was checked using information criteria (AIC and BIC)**.** A P-value < 0.05 and corresponding 95% CI were considered to declare a result as statistically significant in this study in all cases.

6.14. Ethical Consideration

The study protocol was reviewed and approved by the Institutional Review Board of the College of Health Sciences, Addis Ababa University, with a protocol number of 104/19/SPH. The Oromia Regional Health Beauro, Zonal Health Department, respective hospitals and selected health centers were communicated and permission was obtained from respective hospitals and health centers before data collection. Focal persons at antiretroviral therapy clinics were also communicated before the data collection. Study participants were informed about the purpose of the study and verbal informed consent was obtained from each study participant to use their clinical information and collect primary data through interviews. In order to maintain the confidentiality of information throughout the study process, no names or any personal identifier information were used as part

of the reports or publication of this study. The interviews were consucted in the private room reserved for this purpose in collaboration with ART focal persons. All paper copies of information collected were kept in locked files and only the principal investigator had access to the information. The soft copy of data entered into computer were stored in encrypted files on password-protected computers. Participants were assured that the individual information gained through interview and measurements is strictly used for the purposes of the study. Participation in this study was voluntary and participants had full right not to participate or withdraw from the study. The potential risk to participation in this study was minimal.

6.15. Dissemination of Findings

The report of this research will be submitted to the School of Public Health of Addis Ababa University in the form of monograph and manuscripts. It will be presented and defended for evaluation at the presence of an examination committee for partial fulfillment of the Degree. The finding of this study will be presented to the Oromo Regional Health Bureau, Zonal Health Department and North Shewa Health Facilities. The study finding will be communicated to all stakeholders in the study area, policymakers and health program planners, and other concerned bodies. Papers will be prepared for publication on peer-reviewed journals. Presentation at different professional and academic conferences will be considered.

Table 2: Summary of the study objectives and methods for entire dissertation work effect of food insecurity on the clinical proression and CD4 count change among HIV-infected adults in Northcentral Ethiopia from 2022-2024.

Objective	**Design**	**Study population**	**Sample size**	**Sampling method**	**Data collection tool**	**Outcome variable**	**Data analysis (model used)**
The effect of gender on food insecurity among HIV-infected adults receiving ART	Systematic review and meta-analysis	HIV-infected adults receiving ART whose age was greater than 18 years). However, we excluded review paper, including systematic review and meta-analysis.	NA	NA	Review of existing literature	Food insecurity	Meta-analsyis and synthesis
Magnitude of food insecurity and its associated factors among adults receiving ART	Cross sectional	All HIV-infected adults who are on ART whose age is >18 years and have a current follow-up for their treatment.	**865**	Simple random sampling	Interviewer administered questionnaire	Food insecurity	Log-binomial regression
Fruit and vegetable dietary intake and its estimated amount consumption among adults receiving ART	Cross sectional	All HIV-infected adults who are on ART whose age is >18 years and have a current follow-up for their treatment.	865	Simple random sampling	Interviewer administered questionnaire	Fruit and vegetable dietary intake	Poisson regression model
Effect of food insecurity on clinical progression of HIV/AIDS among adults receiving ART	Prospective cohort	All HIV-infected adults who are on ART whose age is >18 years and have a current follow-up for their treatment.	**574**	Simple random sampling	Repeated Measurements	Clinical progression of HIV/AIDS	Generalized linear mixed model
Effect of food insecurity on CD4 count change among adults receiving ART	Prospective cohort	All HIV-infected adults who are on ART whose age is >18 years and have a current follow-up for their treatment.	**442**	Simple random sampling	Repeated Measurements	CD4 count change	Generalized linear mixed model

7. Results

7.1. The effect of gender on food insecurity among HIV-infected adults (Paper I)

7.1.1. Selection and identification of studies

We identified a total of 776 studies (775 published and one unpublished) that were conducted from 2009 to 2019. Of those, 135 duplicate studies were removed and 578 studies were excluded after reviewing of their titles and abstracts. The full text of the remaining 61 studies was assessed for eligibility and for whether they reported outcome of interest. Of those, 30 studies were excluded due to lack of outcome of interest, and 14 studies were excluded since they failed to meet the eligibility criteria. Of the remaining studies, 17 that scored-seven and above on the JBI quality appraisal eligibility criteria were included in the final Meta-analysis. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram was used to guide the selection process and present the systematic review overview (Figure 6).

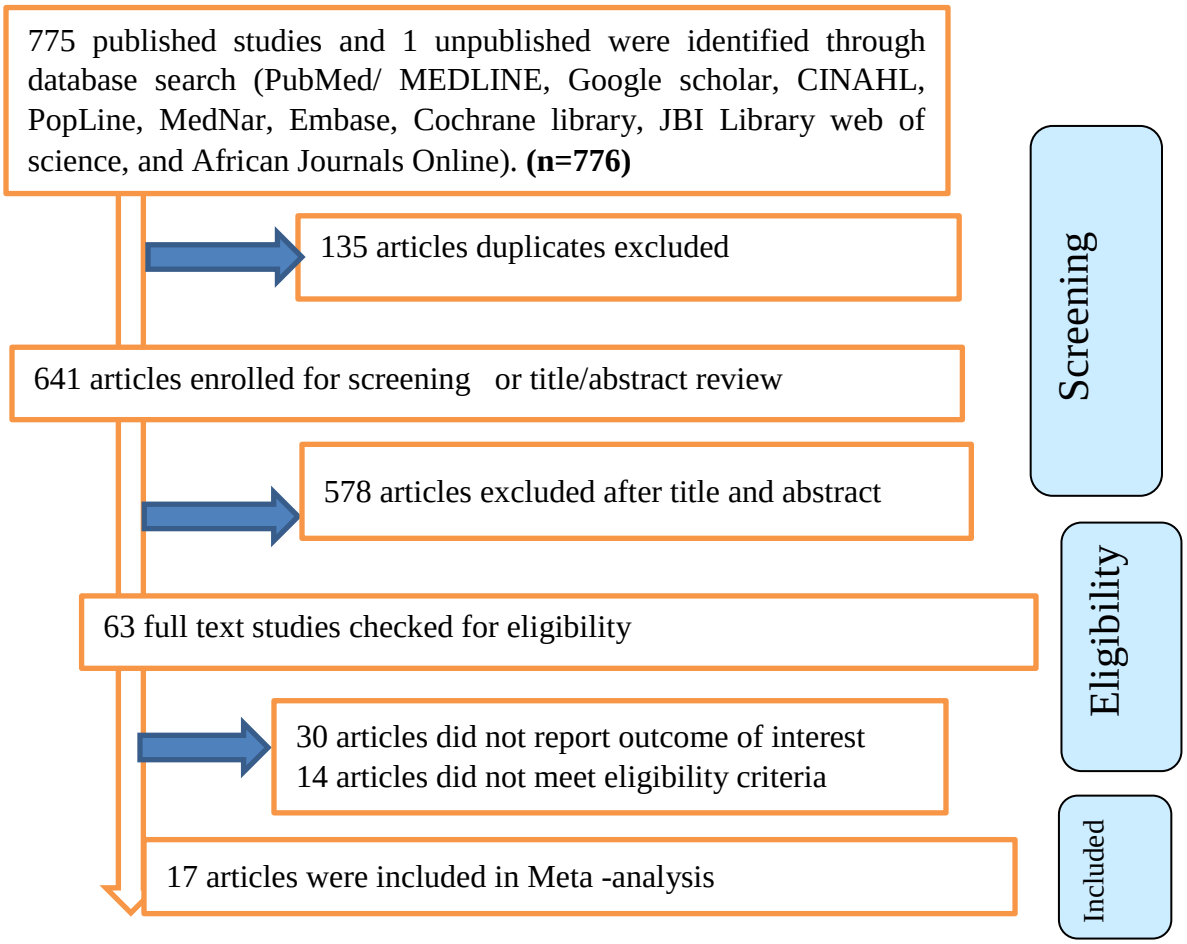


Figure 6: PRISMA flow diagram of included studies for the systematic review and meta-analysis of the effect of gender on food insecurity among HIV-infected people receiving ART from 2009-2019.

7.1.2. Characteristics of included studies

A total of 17 studies that assessed the association between food insecurity and gender among HIV infected adults receiving ART were included in this systematic review and meta-analysis, with a total sample of 5827 individuals living with HIV. Eleven of those studies were cross-sectional and six were prospective cohort (Table 3). The minimum and maximum sample size ranged from 104 in a study conducted in USA [73]and 796 in a study conducted in Brazil [24] . Of the total 17 included studies, four were conducted in Ethiopia [32, 34, 36, 94], five studies in the United States [22, 52, 73, 85, 140], two in Canada [54, 62], two in India [87, 141], Russia [84], Senegal [26], Uganda [89] and Brazil[24] each had one study. Six studies were conducted in low-income countries [26, 32, 34, 36, 89, 94], four studies in middle-income countries [24, 84, 87, 141] and seven studies in high-income countries [22, 52, 54, 62, 73, 85, 140] (Table 3).

The findings of individual studies varied and were inconclusive with the effects of gender found to be significant in some studies and in- significant in others. Of those studies that found significant effects of gender on food insecurity, the strongest positive association was found in the study conducted in Ethiopia [94], with an odds ratio of 4.30 (95% CI: 2.13, 8.68) and the weekest association was found in the study conducted in the United States [140], OR = 1.50 (1.01, 2,.23) (Table 3).

Table 3: Characteristics of studies included in the systematic review and meta-analysis on the effect of gender on food insecurity among HIV infected adults receiving antiretroviral therapy from 2009-2019.

Study No	Authors	Year	Country	Country income level	Study design	Sample size	Number of subject with outcome	Response rate	Number male with the outcome	Number female with the outcome	Total number of male	Total number of female	OR (95% CI)
1	M. Asnakew[34]	2015	Ethiopia	Low	Cross-sectional	385	260	97.72	88	172	136	249	1.22 (0.78, 1.97)
2	Gedle et al.[32]	2015	Ethiopia	Low	Cross-sectional	338	264	90	91	173	130	208	2.12 (1.26, 3.57)
3	Belijo ZN et al[94]	2017	Ethiopia	Low	Cross-sectional	394	77	100	10	67	134	260	4.30 (2.13, 8.68)
4	Tiyou et al[36]	2012	Ethiopia	Low	Cross-sectional	319	201	100	86	115	144	175	1.29 (0.82, 2.04)
5	Anema et al[62]	2013	Canada	High	Cohort	254	181	100	148	33	211	43	1.40 (0.65, 3.02)
6	Anema et al[54]	2016	Canada	High	Cross-sectional	262	192	100	140	52	191	71	1.00 (0.54, 1.84)
7	Benzekri et al[26]	2015	Senegal	Low	Cross-sectional	109	78	100	12	62	18	91	1.07 (0.36, 3.13)
8	Dasgupta et al[87]	2016	India	Middle	Cross-sectional	173	75	92	33	42	96	77	2.29 (1.24, 4.24)
9	Heylen et al[141]	2015	India	Middle	Cohort	367	58	100	38	20	239	128	0.98 (0.54, 1.77)
10	Idrisov, et al[84]	2017	Russia	Middle	Cohort	310	164	88.32	113	51	220	90	1.24 (0.76, 2.03)
11	Kalichman et al[52]	2013	USA	High	Cross-sectional	197	85	100	66	19	154	43	1.06 (0.53, 2.09)

12	McMahon et al[85]	2011	USA	High	Cohort	592	375	100	239	136	416	176	2.52 (1.68, 3.77)
13	Weiser D. et al[22]	2009	USA	High	Cohort	250	134	100	92	43	174	76	1.16 (0.68, 2.00)
14	Weiser D et al[73]	2009	USA	High	Cross-sectional	104	26	100	15	11	66	40	1.29 (0.52, 3.18)
15	Kalichman et al[140]	2014	USA	High	Cross-sectional	521	321	100	214	107	364	157	1.50 (1.01, 2,.23)
16	Mederios et al[24]	2017	Brazil	Middle	Cross-sectional	796	284	100	143	141	484	312	1.97 (1.46, 2.64)
17	Tsai et al[89]	2012	Uganda	Low	Cohort	456	340	100	93	247	132	324	1.35 (0.86, 2.12)

7.1.3. The effect of gender on food insecurity among HIV-infected adults

Our analysis of 17 included studies found significant heterogeneity across studies (I^2=45.5%, p <0.022) which suggested that the use of a fixed effect model might lead to unreliable estimates since those models assume that all heterogeneity can be explained by the covariates. This assumption may create excessive type I errors when there is residual, or unexplained, heterogeneity. To avoid that bias, we used random effects model to estimate the pooled effect of gender on food insecurity among HIV-infected adults in our 17 included studies, using an inverse variance method.

Using those methods, our meta-analysis found that gender of HIV-infected adults receiving ART had statistically significant effects on their food security status. The odds of developing food insecurity among female HIV-infected adults receiving ART were 53% higher than male HIV-infected adults (OR: 1.53, 95% CI: 1.29, 1.83) (Figure 7).

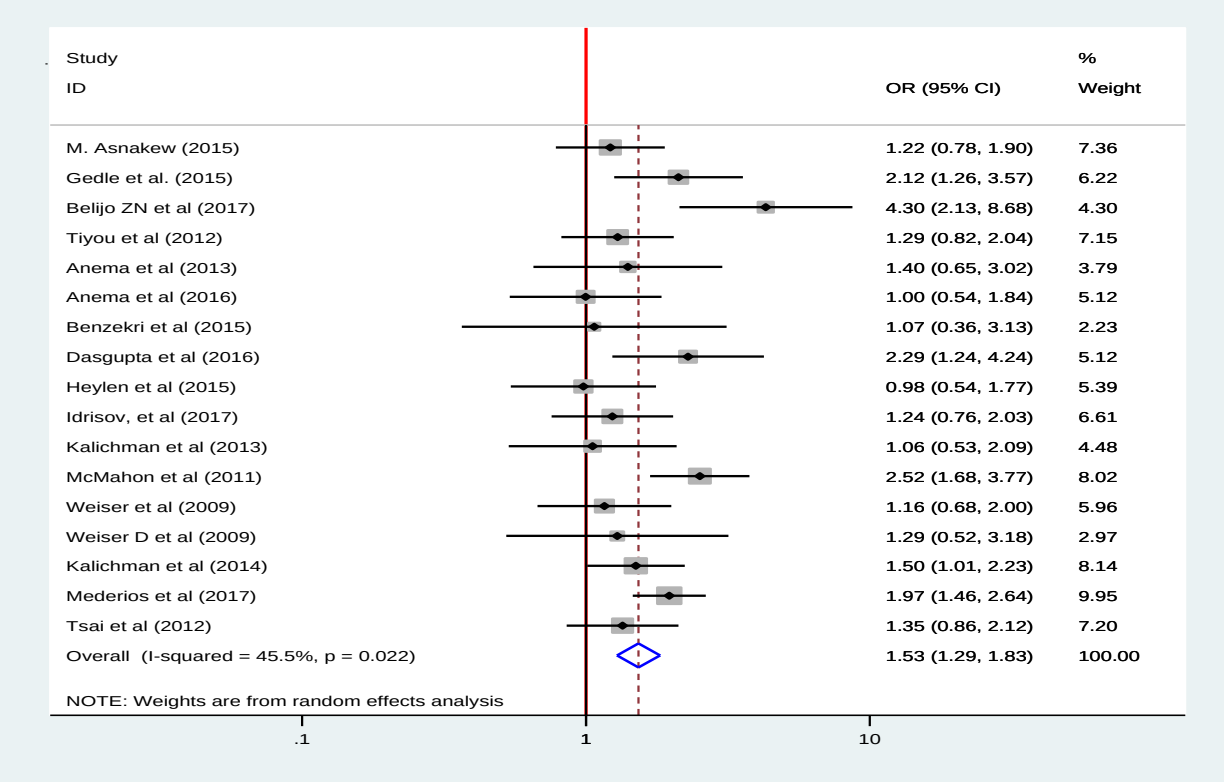


Figure 7. Forest plot of the pooled effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy from 2009-2019.

We further investigated the heterogeneity, using different statistical techniques to identify the source of heterogeneity. A meta-regression was performed, using publication year, sample size and country income level as covariates and by specifying the method for estimating the between-

study variance. None of the three variables were statistically significant for explaining the presence of heterogeneity (Table 4).

Table 4: Related factors with heterogeneity of the effects of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy, 2009-2019.

Variables	Coefficients	p-value
Publication Year	0.0284334	0.588
Sample size	0.0008173	0.588
Low income countries	0.0769214	0.751
Middle income countries	-0.1118692	0.731
High income countries	Reference	

The presence of publication bias was assessed using funnel plots and Egger and Begg statistical tests at 5% significant level. There was no statistical evidence of publication bias. The funnel plot was almost symmetrical, the Begg and Egger tests were not statistically significant with p-value = 0.484 and p-value = 0.321 respectively (Figure 8).

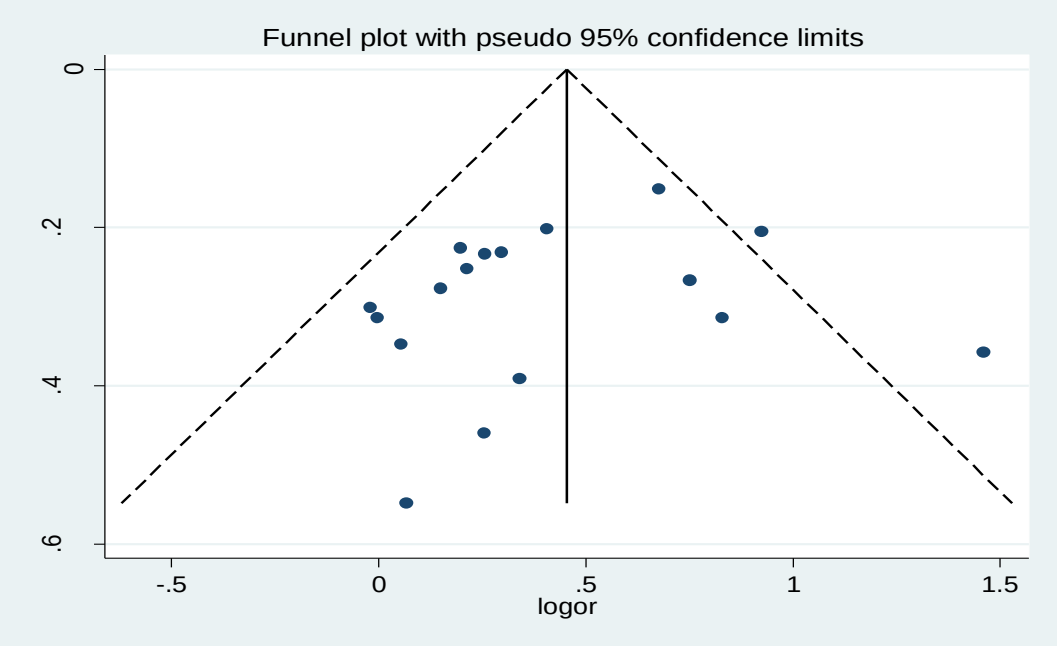


Figure 8:. Funnel plots for publication bias of effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy from 2009-2019.

To identify the effect of single study on overall meta-analysis estimate, we performed sensitivity analysis using a random effects model. The analysis found no strong evidence for influence of single study (Figure 9).

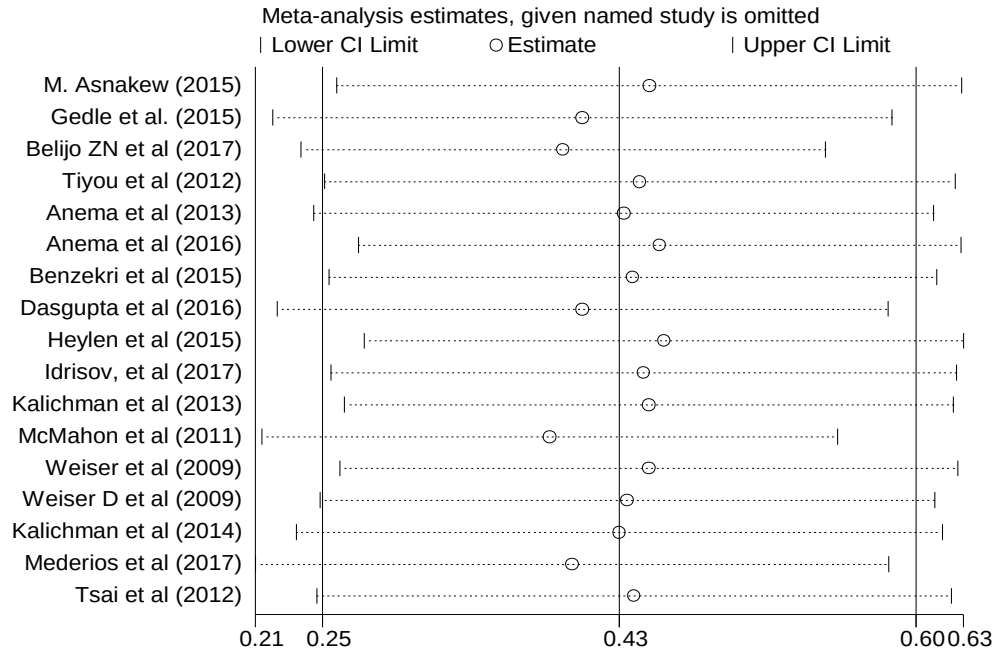


Figure 9. Sensitivity analysis for single study influence of effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy from 2009-2019.

7.1.4. Sub-group analysis by study design

We performed sub-group analysis by study design to minimize the potential random variations between studies by comparing the effect of gender on food insecurity of HIV-infected adults. Our sub-group analysis indicated almost consistent significant effect of gender on food insecurity among HIV-infected adults across the study designs. The analysis indicated that cohort studies had weaker associations than cross-sectional studies. The odds of developing food insecurity among female HIV-infected adults was 42% higher compared to male HIV-infected adults in cohort studies while the odds of developing food insecurity among female HIV-infected adults was 60% higher compared to male HIV-infected adults in cross sectional studies, with odds ratios of 1.42 (95% CI: 1.05, 1.92) and 1.60 (95% CI: 1.28, 2.00) respectively (Figure 10).

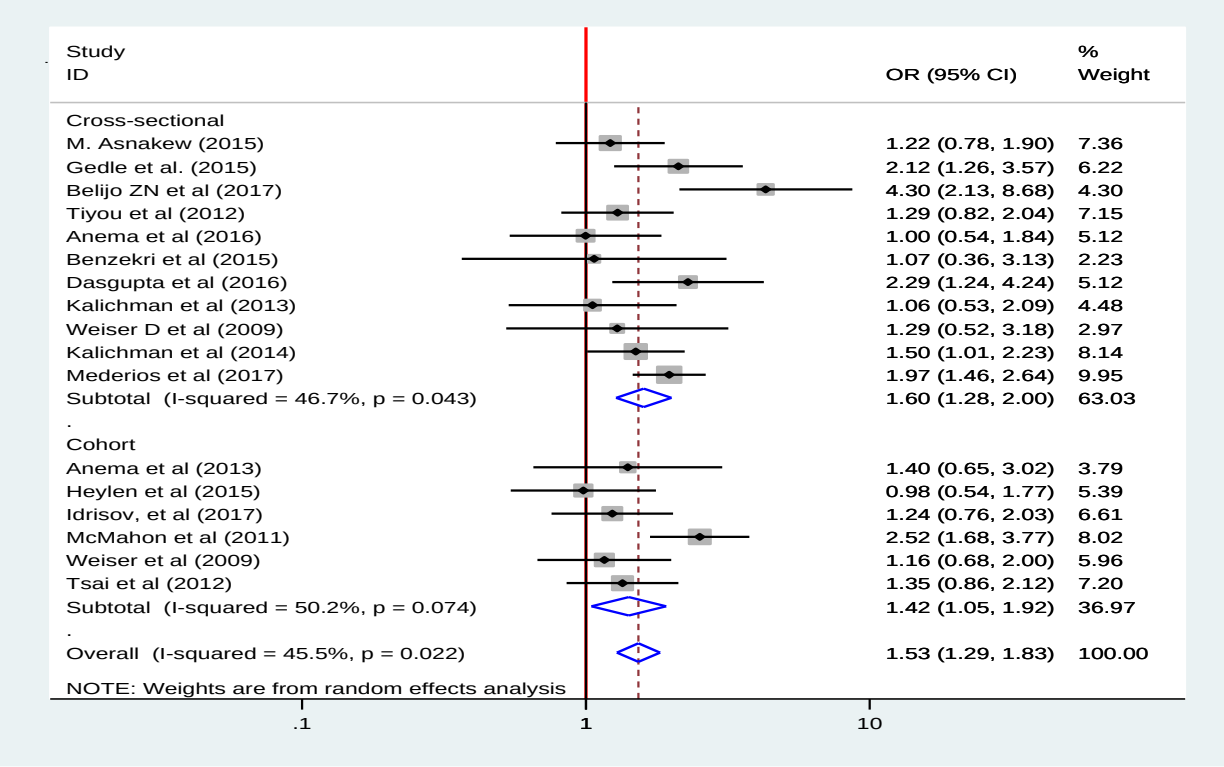


Figure 10. Sub-group analysis of effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy by study design from 2009-2019.

7.1.5. Sub-group analysis by country income level

In addition, we performed sub-group analysis by country income level to minimize the potential random variations between studies by comparing the effect of gender on food insecurity of HIV-infected adults. The analysis indicated that studies conducted in high-income countries found weaker associations than those in low and middle-income countries. The odds of developing food insecurity among female HIV-infected adults was 44% higher compared to male HIV-infected adults in the studies conducted in high-income countries, with an odds ratio of 1.44 (95% CI: 1.08, 1.90). While the odds of developing food insecurity among female HIV-infected adults was 64% and 57% higher compared to male HIV-infected adults in the studies conducted in low-and middle-income countries with odds ratios of 1.64 (95% CI: 1.15, 2.33) and 1.57 (95% CI: 1.09, 2.24) respectively (Figure 11).

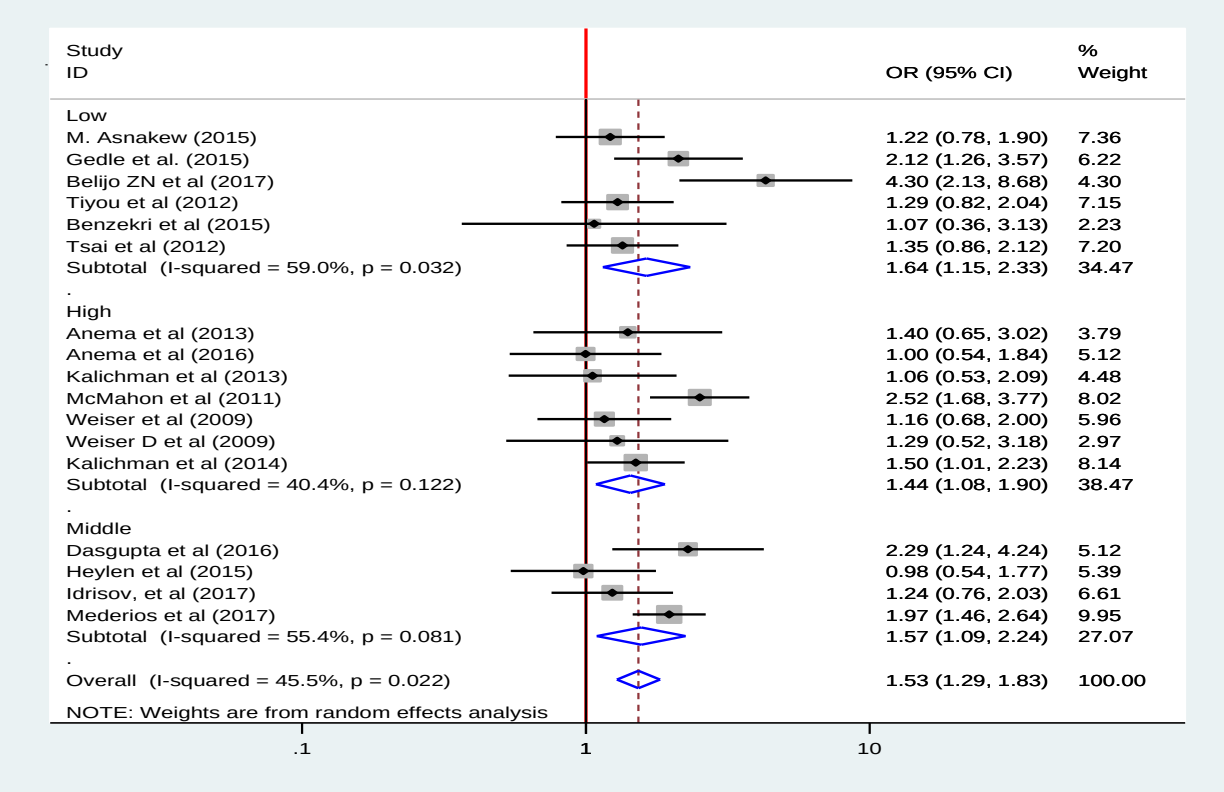


Figure 11. Sub-group analysis of effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy by country income level from 2009-2019.

7.2. Food insecurity and its severity among adults receiving ART (Paper II)

7.2.1. Socio-demographic characteristics

A total of 865 adult HIV-infected receiving ART were enrolled, of which 861 were willing and able to participate in this study with an overall response rate of 99.5%. The majority, 327(37.98%) of participants were in the age group of 35-44 years, and the mean age of enrolled participants was 38.66 (±9.86SD) years (Table 5). In terms of gender, 529 (61.44%) of them were females and 781(90.71%) were followers of Orthodox Christianity. The majority, 615(71.43%) of participants were from urban and 522(60.63%) were married. Six hundred forty-five (74.91%) were Oromo in ethnicity. Six hundred ninety-two (80.37%) reported that they had children, of which 507(73.27%) of them had less than four children with a median of 3.0 (IQR: 2, 4) (Table 5).

Table 5: Socio-demographic characteristics of HIV-infected adults receiving ART at health facilities in North Shewa Zone Northcentral Ethiopia, 2023 (n=861)

Variables	Frequency	Percent
Age of respondents		
<35 years	296	34.38
35-44 years	327	37.98
≥45 years	238	27.64
Average age in years	Mean	SD
Average (SD)	38.66	9.86
Gender of prticipants		
Male	332	38.56
Female	529	61.44
Residence		
Rural	246	28.57
Urban	615	71.43
Religion of participants		
Orthodox	781	90.71
Protestant	55	6.39
Others*	25	2.90
Marital Status		
Married	522	60.63
Single	96	11.15
Divorced	111	12.89
Widowed	132	15.33
Ethnicity of participants		
Oromo	645	74.91
Amhara	213	24.74
Gurage	3	0.35
Presence of children		
No	169	19.63
Yes	692	80.37
Number of children (n=692)		
≤3 children	507	73.27
4-9 children	185	26.73
Median number of children	Median	IQR
Median (IQR)	3	(2, 4)

*Catholic, musilim and wekefata

7.2.2. Socio-economic characteristics

The distribution of occupational status is almost consistent across each category. Accordingly, 198 (23.00%) and 193 (22.42%) HIV-infected adults were merchants and housewives, respectively. Three hundred eighty-one (33.10%) of HIV-infected adults had no formal education. Two hundred ninety-two (52.52%) of HIV-infected adults reported that they earned 2500 and above Ethiopian birr monthly income and with a median monthly income of 2500ETB (IQR: 1200, 4730) (Table 6)

Table 6: Socio-economic characteristics of HIV-infected adults receiving ART at health facilities in North Shewa Zone, Ethiopia, 2023 (n=861)

Variables	Frequency	Percent
Occupational Status		
Farmer	173	20.09
House wife	193	22.42
Daily laborer	148	17.19
Employed	149	17.31
Merchant/others	198	23.00
Educational status		
No formal education	381	33.10
Primary school	240	27.87
Secondary and above	240	27.87
Monthly income (n=556)		
<2500 ETB	264	47.48
≥2500 ETB	292	52.52
Median monthly income (ETB)	Median	IQR
Median (IQR)	2500	(1200, 4730)

7.2.3. Psychosocial support for HIV-infected adults

Of the total, most patients reported having some source of social support for informal caregiving. Accordingly, 417 (48.43%) of the HIV-infected adults reported that they received informal care from different caregivers, of which 273(65.47%) of them received economic support followed by psychological support (86, 20.62%) (Table 7). Hundred fifty-nine (38.13%) received care from their husband followed by wives (86, 20.62%). Four hundred forty (51.10%) of the HIV-infected adults had disclosed their HIV status. Husbands (148, 33.64%), wives (96, 21.82%), and children (92, 20.91%) were the common categories of people to whom studied HIV-infected adults disclosed their HIV serostatus (Table 7).

Table 7: Psychosocial support for HIV-infected adults receiving antiretroviral therapy at health facilities in North Shewa Zone, Northcentral Ethiopia, 2023 (n=861)

Variables	Frequency	Percent
Presence caregiver (n=861)		
No	444	51.57
Yes	417	48.43
Type of care received (n=417)		
Psychological support	86	20.62
Economic support	273	65.47
Physical support	24	5.76
Social support	34	8.15
Type of caregiver (n=417)		
Mother/ father	56	13.43
Wife	86	20.62
Husband	159	38.13
Children	81	19.42
Others	35	8.39
Disclose their Sero-status (n=861)		
No	421	48.90
Yes	440	51.10
To whom you disclose (n=421)		
Mother/ father	46	10.45
Wife	96	21.82
Husband	148	33.64
Children	92	20.91
Community supporter	27	6.14
Others	31	7.05

7.2.4. Clinical factors of HIV-infected adults

Of the total, only 43 (4.99%) reported they received therapeutic feeding in the courses of their treatment follow-up, of which 37(86.05%), 3(6.98%), and 3(6.98%) received plumpy nut, food prepared for treatment, and High protein diet (eggs), respectively. They received therapeutic feeding treatment for one to six months the duration. One hundred seventy-three (20.09%) of the patients reported having eating problem, of which the most common eating problem was loss of appetite (134, 77.46%) followed by Oral candidiasis (33, 19.08%). Only 4 (0.46%) of HIV-infected adults of the total sample reported malignancies, of 1 case of Kaposi's sarcoma, 2 cases of cervical cancer, and 1 case of unidentified malignancy. One hundred seventy-three (20.09%) of the patients developed opportunistic infections (OIs) during their care follow-up, of which the most common OIs were diarrheal disease (68, 39.31%) followed by tuberculosis (43, 24.86%). A significant proportion of studied participants reported that they developed anemia (212, 24.62%).

The majority, 624(72.47%) and 764(88.73%) of the HIV-infected adults at WHO clinical stage one and WHO treatment one, respectively. Six hundred ninety-six (80.84%) had been receiving ART and related care for more than 4 years, and with average amount of time that the studied HIV-infected adults received treatment was 9.2 years (±4.6SD). More than three-forth, 672 (78.05%) of studied adults reported that the follow-up interval time was 3 and above months (Table 8).

Table 8: Clinical factors of HIV-infected adults receiving ART at health facilities in North Shewa Zone, Northcentral Ethiopia, 2023 (n=861)

Variables	Frequency	Percent
Therapeutic food (n=861)		
No	818	95.01
Yes	43	4.99
Presence eating problems (n=861)		
No	688	79.91
Yes	173	20.09
Causes of Eating problem		
Loss of appetite	134	77.46
Oral candidiasis	33	19.08
Esophageal candidiasis	6	3.47
Opportunistic malignancy		
No	857	99.54
Yes	4	0.46
Presence of OIs (n=861)		
No	688	79.91
Yes	173	20.09
Type of OI disease		
Tuberculosis	43	24.86
Pneumonia	31	17.92
Diarrheal disase	68	39.31
Dispepsia	10	5.78
Others	21	12.14
Presence of anemia		
No	649	75.38
Yes	212	24.62
Duration of HIV infection		
<=5 years	192	22.30
>5years	669	77.70
Average duration of HIV infection in years	Mean	SD
Average (SD)	9.76	4.65
WHO clinical stage		
Stage one	624	72.47
Stage two	167	19.40
Stage three&four	70	8.13
WHO treatment stage		

Stage one	764	88.73
Stage two	84	9.76
Stage three&four	13	1.51
Duration of ART		
≤4 years	165	19.16
>4 years	696	80.84
Average duration of ART in years	Mean	SD
Average (SD)	9.20	4.56
Follow up interval		
Less than 3 months	189	21.95
3 and above months	672	78.05

7.2.5. Magnitude of Food insecurity among PLHIV

The food security status of PLHIV receiving ART was assessed using food insecurity access score and prevalence indicators in this particular study. Accordingly, 290(33.68%; 95% CI: (30.60, 36.91)) were food-insecure among adult HIV-infected patients receiving ART (Figure 12)

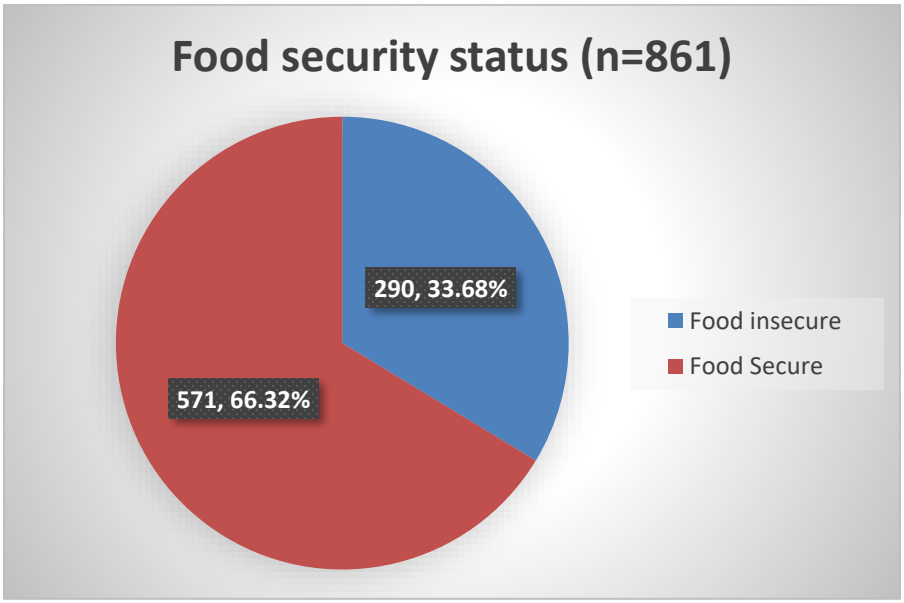


Figure 12: The household food security status of HIV-infected adults receiving ART at health facilities in North Shewa Zone, Northcentral Ethiopia, 2023

The majority, 152(52.41%, CI: 46.64, 58.13) of food-insecure HIV-infected adults were found to have a severe form of food insecurity followed by a moderate form of food insecurity, 110 (37.93%, CI: 32.50, 43.68) (Table 9)

Table 9: The level of household food insecurity among HIV-infected adults receiving ART at health facilities in North Shewa Zone, Nothcentral Ethiopia, 2023 (n=290)

Variables	Frequency	Percent with CI
Severity of food insecurity (n=290)		
Mild food-insecure	28	9.66(6.74, 13.64)
Moderaltely food-insecure	110	37.93(32.50, 43.68)
Severely food-insecure	152	52.41(46.64, 58.13)

7.2.6. Factors Associated with food insecurity among PLHIV

We used log-binomial regression to identify the association between food insecurity and independent variables as the use of classical logistic regression and its corresponding odds ratios will strongly overestimate the prevalence ratio in such a cross-sectional study with binary outcomes. It may not appropriately control the confounding effects. The prevalence ratio is also more interpretable and easier to communicate to non-specialists than the odds ratio.

Accordingly, in bi-variable analysis, eighteen variables namely, gender, age, marital status, occupational status, presence of children, number of children, monthly income, residence, educational status, type of caregivers, presence of opportunistic infections, types of opportunistic infections, duration HIV infection, duration of ART follow-up, ART follow-up interval, WHO clinical stage, and WHO treatment stage showed association with, a p-value of ≤ 0.20 and then selected as the candidate for multivariable analysis. Five of the seventeen variables, such as duration of HIV infection, presence of children, ART follow-up interval, type of caregivers, and types of opportunistic infections that showed collinearity with other related variables were reduced after collinearity check, using collinearity diagnostics, such as correlation matrix and variance inflation factor.

Thus, the multivariable log-binomial regression analysis was used by taking all the twelve variables into account simultaneously and seven of the most contributing factors were significantly and independently associated with food security status at a 5% level of significance.

The gender of HIV-infected adults was found to have a significant and independent predictor of food insecurity, of which the proportion of food insecurity was 1.9 times higher among females compared to males (APR=1.87, 95% CI: 1.03, 3.39) (Table 10). The proportion of food insecurity was higher among younger HIV-infected adults than the older, of the proportion of food insecurity was 2.3 times higher among those belonging to the age group less than 35years as compared with those belonging to the age group greater than 45 years (APR=2.27, 95% CI: 1.12, 4.60). The

educational status of the HIV-infected adults was found to have a strong significant association with food insecurity, of which the proportion of food insecurity was 11 and 6 times higher among HIV-infected adults who had no formal education and attended primary school, respectively compared to those who attended secondary and above education (APR=10.79, 95% CI: 4.74, 24.58) and (APR=5.99, 95% CI: 2.65, 13.54).

Concerning occupational status, the proportion of food insecurity was 6.9 times higher among daily laborer patients compared to farmer patients when the effect of other variables was kept constant (APR=6.90, 95% CI: 2.28, 20.85). The analysis found that a lower monthly income leads to a higher proportion of food insecurity among HIV-infected adults, of which the proportion of food insecurity was 1.9 times higher among HIV-infected adults who had a monthly income of less than 2500 Ethiopian birr compared to those who had monthly income greater than 2500 Ethiopian birr (APR=1.89, 95% CI: 1.11, 3.22).

Among clinical factors, the WHO clinical stage, and duration of antiretroviral treatment were strongly associated with the proportion of food insecurity among HIV-infected adults. The more advanced the WHO clinical stage with the higher proportion of food insecurity among adults studied, of which the proportion of food insecurity was 2.3 times higher among adults at WHO clinical stage two compared to WHO clinical stage one (APR=2.34, 95% CI: 1.08, 5.10). The proportion of food insecurity was 2.3 times higher among those receiving ART for less than 4 years' duration (APR=2.28, 95% CI: 1.09, 4.74). However, socio-economic support and food support/therapeutic food support were not significantly associated with the proportion of food insecurity in the final log-binomial multivariable regression (Table 10).

Table 10: Factors associated with food security status among HIV-infected adults receiveing ART at health facilities in Northcentral, Ethiopia, 2023. (n=861)

Variables	Food security status (No)		CPR with 95% CI	APR with 95% CI	P-value
	Food insecure	Food secure			
Sex					
Male	89	243	1.0	1.0	
Female	201	328	1.67 (1.24, 2.26)**	**1.87(1.03, 3.39)****	0.039
Age category					
<35 years	120	176	2.02(1.39, 2.94)**	**2.27(1.12, 4.60)****	0.023
35-44 years	110	217	1.50(1.04, 2.18)**	1.38(0.74, 2.60)	0.314
≥45 years	60	178	1.0	1.0	
Residence					
Rural	59	187	1.0	1.0	
Urban	231	384	1.91(1.36, 2.67)**	1.77(0 .82, 3.82)	0.148
Marital Status					
Married	145	377	1.0	1.0	
Single	31	65	1.24 (0.78, 1.98)	0.81(0.07, 9.13)	0.865
Divorced	57	54	2.74(1.81, 4.17)**	1.37(0.68, 2.78)	0.382
Widowed	57	75	1.98(1.33, 2.93)**	1.37(0.69, 2.75)	0.372
Educational status					
No formal education	172	209	4.99(3.29, 7.55)**	**10.79(4.74, 24.58)****	<0.001
Primary school	84	156	3.26(2.08, 5.11)**	**5.99(2.65, 13.54)****	<0.001
Secondary and above	34	206	1.0	1.0	
Occupational status					
Farmer	32	141	1.0	1.0	
House wife	64	129	2.19(1.34, 3.56)**	0.95(0.32, 2.80)	0.921
Daily laborer	106	141	11.12(6.58, 18.79)**	**6.90(2.28, 20.85)****	0.001
Employed	30	119	1.11(0.64, 1.93)	1.22(0.40, 3.74)	0.728
Merchant/others	58	140	1.83(1.12, 2.98)**	1.2(0.37, 2.83)	0.965
Monthly income(ETB)					
Less than 2500	144	120	3.74(2.61, 5.36)**	**1.89(1.11, 3.22)****	0.020
2500 and above	71	221	1.0	1.0	
WHO clinical stage					
Stage one	223	401	1.0	1.0	
Stage two	50	117	0.77(0.53, 1.11)*	**2.34(1.08 , 5.10)****	**0.032**
Stage three&four	17	53	0.58(0.33, 1.02)*	2.25(0.69, 7.33)	0.179
Duration of ART					
≤4 years	81	84	2.25(1.59, 3.17)**	**2.28(1.09, 4.74)****	0.028
>4 years	209	487	1.0	1.0	

7.3. Fruit and vegetable dietary intake and its estimated amount of consumption among adults (Paper III)

7.3.1. Socio-demographic and Socio-economic characteristics

A total 858 HIV-infected adults were enrolled and completed the interview. The majority, 552(64.34%) of participants belong to the age group less than and equal to 40 years with the mean age of enrolled participants being 38.64 (±9.85SD) years (Table 11). The majority, 527 (61.42%) were females and 614(71.56%) were from urban. The majority, 778 (90.68%) of participants were followers of Orthodox Christian and 519(60.49%) were married. Six-hundred forty-two (74.82%) were Oromo in ethnicity. One hundred ninety-eight (23.08%) of HIV-infected adults were merchants followed by housewives (191, 22.26%). Three hundred seventy-nine (44.17%) of HIV-infected adults had no formal education and 291(52.62%) of them responded as they earned 2500 and above ETB monthly income and with a median monthly income of 2500ETB (IQR: 1200, 4730) (Table 11)

Table 11: Socio-demographic and economic characteristics for fruits and vegetable dietary intake of HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2023 n=858)

Variables	Frequency	Percent
Age of respondents		
≤40 years	552	64.34
>40 years	306	35.66
Average age in years	Mean	SD
Average (SD)	38.64	9.85
Sex of prticipants		
Male	331	38.58
Female	527	61.42
Residence		
Rural	244	28.44
Urban	614	71.56
Religion of participants		
Orthodox	778	90.68
Protestant	55	6.41
Others*	25	2.91
Marital Status		
Married	519	60.49
Single	96	11.19
Divorced	111	12.94
Widowed	132	15.38
Ethnicity of participants		
Oromo	642	74.82
Amhara and gurage	216	25.18
Occupational Status		
Farmer	172	20.05
House wife	191	22.26

Daily laborer	148	17.25
Employed	149	17.37
Merchant/others	198	23.08
Educational status		
No formal education	379	44.17
Primary school	239	27.86
Secondary and above	240	27.97
Monthly income (n=553)		
<2500 ETB	262	47.38
≥2500 ETB	291	52.62
Median monthly income (ETB)	Median	IQR
Median (IQR)	2500	(1200, 4660)

*Catholic, musilim and wekefata

7.3.2. Socio-economic support for HIV-infected adult

With regard to socio-economic support, 415 (48.37%) of the HIV-infected adults received informal care from different caregivers, of which 271(65.30%) and 86 (20.72%) of HIV-infected adults received economic support and psychological support, respectively (Table 12). The majority, 245(72.29%) received care either from their husbands or wives and 438(51.05%) of the HIV-infected adults disclosed their HIV status, of which 244 (55.71%) of them disclosed their HIV serostatus to their husbands or wives (Table 12).

Table 12: Socio-economic support for fruits and vegetable dietary intake of HIV-infected adults receiving ART at health facilities in in Northcentral, Ethiopia, 2023 (n=858)

Variables	Frequency	Percent
Presence caregiver (n=858)		
No	443	51.63
Yes	415	48.37
Type of care received (n=415)		
Psychological support	86	20.72
Economic support	271	65.30
Social support and related	58	13.98
Type of caregiver (n=415)		
Mother/ father	55	13.25
Husband/Wive	245	72.29
Children	80	19.28
Others	35	8.43
Disclose their Sero-status (n=858)		
No	420	48.95
Yes	438	51.05
To whom you disclose (n=438)		
Mother/ father	45	10.27
Husband/Wive	244	55.71
Children	91	20.78
Others	58	13.24

7.3.4. Clinical and food-related characteristics of HIV-infected adults

The majority, 172(20.05%) of HIV-infected adults reported having eating problem during their treatment follow-up, in which the most common reasons given for having an eating problem were loss of appetite (133, 77.33%) followed by oral candidiasis (33, 19.19%) (Table 13). One hundred seventy-three (20.16%) developed opportunistic infections (OIs) and 43 (5.01%) reported receiving therapeutic feeding during the treatment follow-up. Two-hundred twelve (24.71%) of patients reported that they had anemia during their treatment follow-up. The majority of the participants had received ART for a long time, in which 534(62.24%) of them reported that they received ART for more than 8 years, and with the average amount of time that the studied HIV-infected adult's received treatment was 9.21 years (±4.54SD).

Six-hundred twenty-one (72.38%) and 761(88.69%) HIV-infected adults at WHO clinical stage one and WHO treatment one, respectively. A significant proportion of the HIV-infected adults reported as they experienced food insecurity (288, 33.57%). Eighty-four (9.76%) and 66(7.69%) of the HIV-infected adults have ever been forced to engage in unprotected sex and ever migrated from their previous place of residence to get their daily food, respectively (Table 13).

Table 13: Clinical and food related characterisitics for fruits and vegetable dietary intake of HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2023 (n=858)

Variables	Frequency	Percent
Presence eating problems (n=858)		
No	686	79.95
Yes	172	20.05
Causes of Eating problem(n=172)		
Loss of appetite	133	77.33
Oral candidiasis	33	19.19
Esophageal candidiasis	6	3.49
Presence of OIs (n=858)		
No	685	79.84
Yes	173	20.16
Therapeutic food (n=858)		
No	815	94.99
Yes	43	5.01
Presence of anemia (n=858)		
No	646	75.29
Yes	212	24.71
Duration of HIV infection(n=858)		
<5 years	157	18.30
5-10years	185	21.56
>10 years	516	60.14
Average duration of HIV infection (n=858)	Mean	SD
Average (SD)	9.76	4.64
WHO clinical stage (n=858)		
Stage one	621	72.38
Stage two and above	237	27.62
WHO treatment stage (n=858)		
Stage one	761	88.69
Stage two and above	97	11.31
Duration of ART (n=858)		
<4 years	138	16.08
4-8 years	186	21.68
>8 years	534	62.24
Average duration of ART in years	Mean	SD
Average (SD)	9.21	4.54
Unprotected sex for Daily food		
No	764	88.73
Yes	84	9.76
Ever migrated from for food		
No	792	92.31
Yes	66	7.69
Food security status		
Food secure	570	66.43
Food insecure	288	33.57

7.3.5. Fruits and vegetables dietary intake frequency

We assessed the frequency of consumption of two classes of fruits (whole fruits and 100% fruit juice without sugar or other additives) and vegetables (green leafy and salads, cruciferous, marrow, starchy staples, carrots, and other vegetables) among HIV-infected adults (Table 14). The study found a very low frequency of fruit and vegetable consumption among HIV-infected adults in relation to the recommended daily allowance. Accordingly, 205(23.89%) and 177(20.63%) of the HIV-infected adults consumed 100% fruit juice and whole fruit once per month, respectively. Two-hundred thirty-one (26.92%) and 160(18.65%) HIV-infected adults consumed green leafy vegetables and salad one time per month and 2-3 times per month, respectively. Three hundred thirty-one (38.58%) and 301(35.08%) of HIV-infected adults consumed cruciferous vegetables and starchy foods 2-3 times per month, respectively. Two hundred eighty-nine (33.68%), 220(25.64%), and 107(12.47%) reported that they consumed marrow vegetables, carrots, and other vegetables, respectively (Table 14).

Table 14: Fruits and vegetables intake frequency among HIV-infected adults receiving ART in Northcentral Ethiopia, 2023.

Type of fruit and vegetables	Frequency of intake in the past 30 days (No: %) (n=858)									
	Never	1 time per month	2–3 times per month	1–2 times per week	3–4 times per week	5–6 times per week	1 time per week	2–3 times per day	4–5 times per day	6 or more times per day
100% fruit juice	559(65.15)	205(23.89)	78(9.09)	9(1.05)	2(0.23)	2(0.23)	1(0.12)	1(0.12)	1(0.12)	0(0.00)
Whole fruits	597(69.58)	177(20.63)	72(8.39)	5(0.58)	1(0.12)	0(0.00)	1(0.12)	1(0.12)	4(0.47)	0(0.00)
Green leafy vegetables and salad	390 (45.45)	231(26.92)	160(18.65)	47(5.48)	16(1.86)	3(0.35)	7(0.82)	0(0.00)	4(0.47)	0(0.00)
Cruciferous vegetables	208(24.24)	197(22.96)	331(38.58)	60(6.99)	26(2.91)	2(0.23)	4(0.47)	0(0.00)	30(3.50)	1(0.12)
Marrow vegetables	377(43.94)	289(33.68)	158(18.41)	16(1.86)	5(0.58)	3(0.35)	4(0.47)	0(0.00)	5(0.58)	1(0.12)
Starchy foods	247(28.79)	181(21.10)	301(35.08)	57(6.64)	24(2.68)	5(0.58)	5(0.58)	4(0.47)	34(3.96)	1(0.12)
Carrots	269(31.35)	220(25.64)	212(24.71)	76(8.86)	36(4.20)	12(1.40)	8(0.93)	1(0.12)	23(2.68)	1(0.12)
Other vegetables	641(74.71)	107(12.47)	75(8.74)	18(2.10)	7(0.82)	2(0.23)	4(0.47)	0(0.00)	4(0.47)	0(0.00)
Any vegetables	221(25.76)	326(38.00)	192(22.38)	32(3.73)	32(3.73)	5(0.58)	9(1.05)	1(0.12)	39(4.55)	1(0.12)

7.3.6. Level of Fruit and vegetable dietary consumption among PLHIV

The level or magnitude of fruit and vegetable consumption was assessed, using the median frequency of fruit and vegetable daily intake after converting weekly and monthly intake into daily intake by dividing the frequency of weekly or monthly reported intake by 7 or 30, respectively. The frequencies of all fruit and all vegetable variables were summed to obtain the total frequency of fruit and vegetable intake and the median was calculated using the total daily fruit and vegetable frequency. Then, the median frequency times per day less than one time per day was considered as low fruit and vegetable dietary intake and greater than or equal to one time per day for high fruit and vegetable intake. Accordingly, 655 (76.34%; 95% CI: (73.38, 79.07)) HIV-infected adults reported that they were consuming fruit and vegetables less than once per day, while only 203 (23.66%; 95% CI: (20.93, 26.62)) of the HIV-infected adults reported that they were consuming fruit and vegetables greater than or equal to once per day (Figure 13).

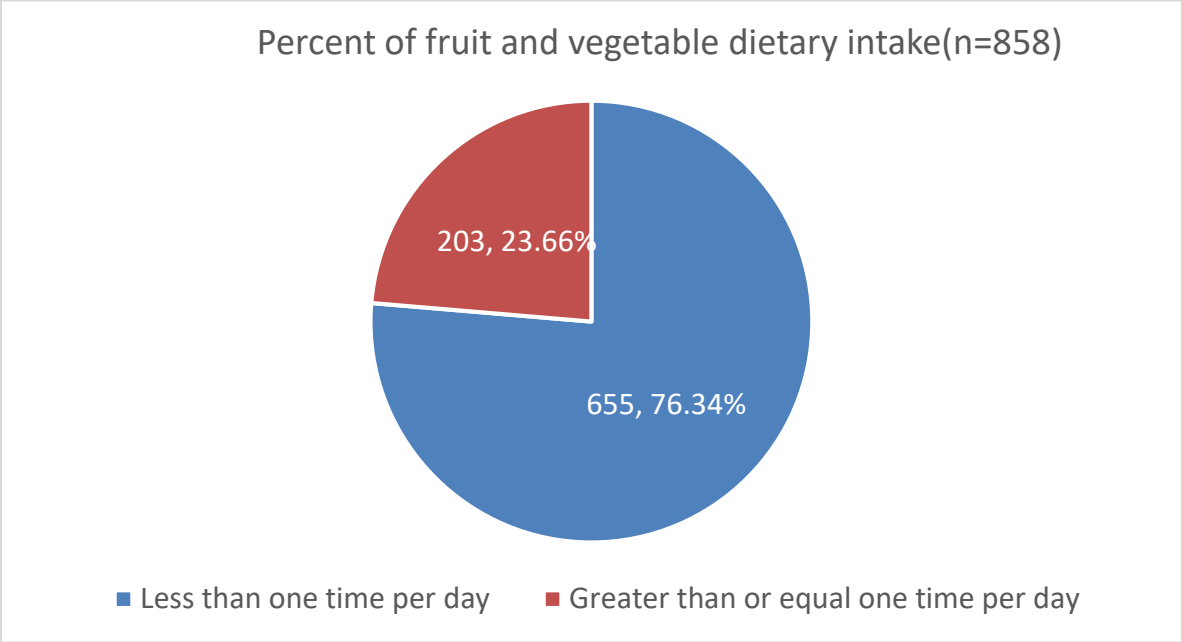


Figure 13: Fruit and vegetable dietary intake among HIV-infected adults receiving ART at health facilities in Northcentral Ethiopia, 2023

Specifically, 838(97.67%, 95% CI: 96.41, 98.49) and 676(78.79%, 95% CI: 75.92, 81.40) HIV-infected adults reported that they were consuming less than once per day fruit and vegetable, respectively, which was very low consumption (Figure 13).

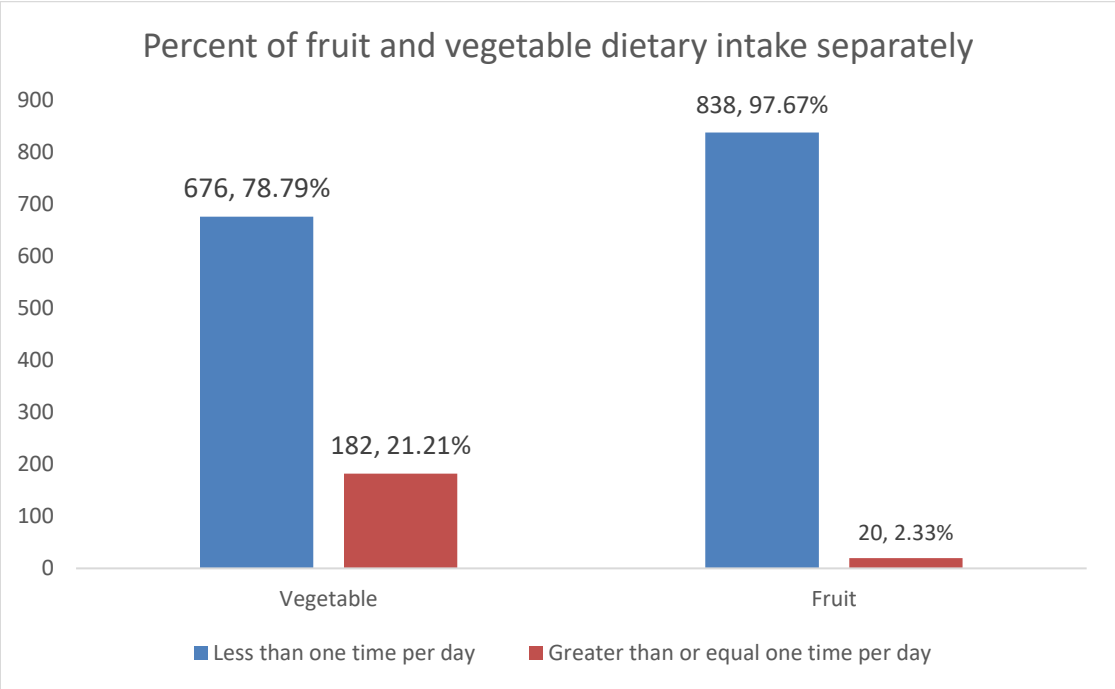


Figure 14: Fruit and vegetable dietary intake separately among HIV-infected adults receiving antiretroviral therapy at health facilities in Northcentral Ethiopia, 2023

7.3.7. Fruit and vegetable dietary consumption among PLHIV by food security status

The level of FAV dietary consumption was disaggregated by food security status as an exposure variable, and a nearly consistent proportion of FAV consumption was found in both the food insecure and food secure groups. Accordingly, 75.62% of food insecure and 77.78% of food secure individuals reported consuming fruits and vegetables less than once per day. The analysis did not find a significant difference in FAV dietary consumption between the two groups (Table 15).

Table 15: Fruit and vegetable dietary consumption by food security status among HIV-infected adults receiving antiretroviral therapy at health facilities in Northcentral Ethiopia, 2023

Variables	**Fruit and vegetable intake**		**Chi-square test and p-value**
	High No(%)	**Low No(%)**	
Food secure	139 (24.39)	431 (75.61)	chi2= 0.4959 and P-value= 0.481)
Food insecure	64 (22.22)	224 (77.78)	
Total	203 (23.66)	655 (76.34)	

7.3.8. Estimated amount of fruit and vegetable consumption

In this study, we tried to quantify the amount of fruit and vegetable, excluding fruit juices that they took in the 24-hour period day before the interview. In that regard, we found that there was no culture of portion size estimation even for those who reported that they consumed fruit and vegetable. The estimate was calculated based on the WHO/FAO recommendation that individuals should consume 400 or more grams of fruits and vegetables for their overall health improvement, certain NCDs risk reduction, and chronic infection prevention [142]. It was very difficult to generalize, since only 82 and 101 of the total sample responded for fruit and vegetable intake, respectively.

Accordingly, the median (IQR) total fruit and vegetable intake was 271.3 (IQR: 92.5, 439.5) g/day. The median (IQR) of the total fruit and vegetable consumption was 248.1 (IQR: 100.0, 400.0) g/day and 273.78 (IQR: 82.44, 348.33) g/day, respectively. The proportion of 400 g or more fruit and vegetable consumption was calculated only for 108 participants whose amount of consumption was quantified. Therefore, the proportion of HIV-infected adults who consumed 400g or more fruit and vegetables was 33(30.6%).

7.3.9. Factors Associated with fruit and vegetable dietary intake

We used Poisson regression analyses with robust variance to estimate the prevalence ratio that identifies the association between fruit and vegetable consumption, and independent variables that help to minimize the overestimation of the prevalence ratio in the cross-sectional study using classical logistic regression. The prevalence ratio was also more interpretable and easier to communicate to non-specialists than the odds ratio.

In bi-variable analysis, fourteen variables namely, educational status, marital status, occupational status, monthly income, categories of caregivers, types of care received, presence of opportunistic infections, presence of anemia, ever migrating from a permanent place of residence, people who disclose their serostatus, duration HIV infection, duration of ART follow-up, WHO clinical stage, and WHO treatment stage showed association with a p-value of ≤ 0.20 and then selected as the candidate for multivariable analysis. One of the fourteen variables such as duration of HIV infection showed collinearity with other related variables were reduced after the collinearity check, using the variance inflation factor.

Consequently, the multivariable Poisson regression analysis with robust variance fitted using all the thirteen variables simultaneously, and five of the most contributing factors were significantly

and independently associated with fruit and vegetable dietary intake at a 5% level of significance (Table 16).

The marital status of HIV-infected adults was significantly associated with fruit and vegetable intake, of which the proportion of fruit and vegetable dietary intake was 1.6 times higher among those divorced compared to married (APR=1.57, 95% CI: 1.16, 2.12) (Table 16).

The occupational status of HIV-infected adults was found to have a statistically significant association with fruit and vegetable dietary intake, of which the proportion of fruit and vegetable dietary intake was two times higher among daily laborers and employed HIV-infected adults compared to farmers, respectively (APR=2.08, 95% CI: 1.36, 3.20) and (APR=1.77, 95% CI: 1.10 2.84). In addition, the proportion of fruit and vegetable dietary intake was also 1.6 times higher among merchants compared to farmer's HIV-infected adults (APR=1.59, 95% CI: 1.03, 2.47) (Table 16).

The type of caregivers who have been providing care was found to have a statistically significant association with fruit and vegetable dietary intake, of which the proportion of fruit and vegetable dietary intake was 1.6 times higher among HIV-infected adults whose caregivers were their children compared to those whose caregivers were their mother/fathers (APR=1.61, 95% CI: 1.02, 2.55) (Table 16).

The WHO clinical stage and duration of antiretroviral treatment were found to be significant and independent predictors of fruit and vegetable dietary intake. Accordingly, the proportion of fruit and vegetable dietary intake at the advanced WHO clinical stage among HIV-infected adults was 1.3 times compared to the WHO clinical stage one (APR=1.32, 95% CI: 1.32(1.03, 1.69). In the same way, the proportion of fruit and vegetable dietary intake among HIV-infected adults was 1.8 times higher among those receiving ART for more than 8 years' duration (APR=1.78, 95% CI: 1.18, 2.67). However, the analysis did not indicate a significant association between food security status and socio-economic support in the final Poisson multivariable regression (Table 16).

Table 16: Factors associated with magnitude of fruit and vegetable dietary intake among HIV-infected adults receiveing ART at public health facilities in Northcentral, Ethiopia, 2023.

Variables	Fruit and vegetable intake (No)		CPR with 95% CI	APR with 95% CI	P-value
	High	Low			
Marital Status					
Married	123	396	1.0	1.0	
Single	36	60	0.82(0.70, 0.96) **	1.28(0.80, 2.07)	0.305
Divorced	16	95	1.12(1.03, 1.23) **	**1.57(1.16, 2.12) ** **	**0.003**
Widowed	28	104	1.03 (0.93, 1.14)	1.20 (0.88, 1.64)	0.239
Occupational status					
Farmer	42	130	1.0	1.0	
House wife	36	155	1.07 (0.96, 1.20) *	1.42 (0.89, 2.27)	0.139
Daily laborer	36	112	1.00 (0.88, 1.13)	**2.08(1.36, 3.20) ** **	**0.001**
Employed	41	108	0.96(0.84, 1.09)	**1.77(1.10 2.84) ** **	**0.018**
Merchant/others	48	150	1.00(0.89, 1.13)	**1.59(1.03, 2.47) ** **	**0.038**
Monthly income (ETB)					
Less than 2500	63	199	1.07(0.97, 1.18) *	1.02(0.83, 1.26)	0.853
2500 and above	84	207	1.0	1.0	
Type of care received					
Pychosocial support	48	96	1.0	1.0	
Economic support	74	197	1.09(0.95, 1.25) *	1.19(0.93, 1.54)	0.172
Care categories					
Mother/ father	23	32	1.0	1.0	
Husband/Wive	**74**	**171**	1.20(0.95, 1.52) *	1.14(0.76, 1.70)	0.535
Children	12	68	1.46(1.15, 1.86) **	**1.61(1.02, 2.55) ** **	**0.040**
Others	13	22	1.08(0.77, 1.52)	1.37(0.82, 2.29)	0.234
To whom you disclose					
Mother/ father	19	26	1.0	1.0	
Husband/Wive	61	183	1.30(1.00, 1.68) *	1.31(0.85, 2.00)	0.220
Children	22	69	1.31(1.00, 1.73) *	0.99(0.61, 1.61)	0.962
Others	31	27	0.81(0.56, 1.17)	0.76(0.41, 1.41)	0.383
Ever migrated for food					
No	181	611	1.0	1.0	
Yes	22	44	0.86(0.73, 1.03)	0.80(0.53, 1.21)	0.291
WHO clinical stage					
Stage one	162	459	1.0	1.0	
Stage two &above	41	196	1.12(1.04, 1.21) **	**1.32(1.03, 1.69) ** **	**0.028**
Duration of ART					
<4 years	62	76	1.0	1.0	0.028
4-8 years	55	131	1.28(1.07, 1.53) **	1.53(0.97, 2.40)	0.066
>8 years	86	448	1.52(1.30, 1.78) **	**1.78(1.18, 2.67) ** **	**0.006**

7.4. The effect of food insecurity on clinical progression of HIV/AIDS (Paper IV)

7.4.1. Socio-demographic and Socio-economic characteristics

A total of 574 HIV-infected adults, of which 287 were food-secure and 287 were food-insecure, were enrolled and followed for three consecutive follow-up intervals (quarters) to assess their clinical outcomes. Among them, 563 (98.08%) completed the follow-up, while 10 (1.74%) were lost to follow-up, and 1 (0.17%) died.

The majority, 359 (62.54%), were females, of which 196 (68.29%) were food insecure and 163 (56.79%) were food secure (Table 16). The distribution of participants' ages was almost consistent across each category. However, 207 (36.06%) of participants belong to the age group 35-44 years, with the mean age of enrolled participants being 38.59 (±9.83) years. Of these, 110 (38.33%) were food insecure and 97 (33.80%) were food secure. The sample was homogeneous in terms of religion, with 516 (89.90%) being followers of Orthodox Christian: 251 (87.46%) were food insecure, and 265 (92.33%) were food secure. Three hundred thirty (57.49%) were married, of which 144 (50.17%) were food insecure and 186 (64.81%) were food secure. Four hundred thirty-nine (76.48%) were Oromo in ethnicity. The majority, 411 (71.60%), were urban residents: 227 (79.09%) were food insecure, and 184 (64.11%) were food secure. More than three-fourths (79.79%) of participants reported having children: 222 (77.35%) were food insecure, and 236 (82.23%) were food secure. Of those who reported having children, 331 (72.27%) had less than four children, with 172 (77.48%) being food insecure and 159 (67.37%) being food secure.

The distribution of occupational status was homogeneous. However, the level of food insecurity was higher among daily laborers (104, 36.24%), followed by housewives (60, 20.91%) and merchants/traders (59, 20.56%). Two hundred eighty-two (49.13%) of HIV-infected adults had no formal education: 169 (58.89%) were food insecure, and 113 (39.37%) were food secure. One hundred ninety-four (51.32%) of HIV-infected adults reported having a monthly income of less than 2500 Ethiopian birr, of which 140 (66.04%) were food insecure. The food insecure group had a lower median monthly income (1500 ETB; IQR: 1000-3500) compared to the food secure group (Table 17).

Table 17: Baseline socio-demographic and economic characteristics for follow-up study on clinical progression of HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024 (n=574)

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Sex	Male	91 (31.71)	124 (43.21)	215 (37.46)
	Female	196 (68.29)	163 (56.79)	359 (62.54)
Age respondents	<35 years	118 (41.11)	88 (30.66)	206 (35.89)
	35-44 years	110(38.33)	97 (33.80)	207(36.06)
	≥45 years	59 (20.56)	102 (35.54)	161 (28.05)
The average age in years	Average (SD)	37.00(±8.80)	40.18(±10.54)	38.59(±9.83)
Religion of respodents	Orthodox	251 (87.46)	265(92.33)	516 (89.90)
	Protestant	23 (8.01)	17 (5.92)	40 (6.97)
	Others*	13 (4.53)	5 (1.74)	18 (3.14)
Marital status	Married	144 (50.17)	186 (64.81)	330 (57.49)
	Single	31 (10.80)	34 (11.85)	65 (11.32)
	Divorced	56 (19.51)	27 (9.41)	83 (14.46)
	Widowed	56 (19.51)	40 (13.94)	96 (16.72)
Ethnicity of participants	Oromo	210 (73.17)	229 (79.79)	439 (76.48)
	Amhara and gurage	77 (26.83)	58 (20.21)	135 (23.52)
Residence	Rural	60 (20.91)	103 (35.89)	163(28.40)
	Urban	227 (79.09)	184 (64.11)	411(71.60)
Presence of children	No	65 (22.65)	51 (17.77)	116 (20.21)
	Yes	222 (77.35)	236(82.23)	458 (79.79)
Number of children (n=458)	≤3 children	172 (77.48)	159 (67.37)	331 (72.27)
	4-9 children	50 (22.52)	77 (32.63)	127 (27.73)
Occupational Status	Farmer	34 (11.85)	80(27.87)	114 (19.86)
	House wife	60 (20.91)	56 (19.51)	116 (20.21)
	Daily laborer	104 (36.24)	23 (8.01)	127 (22.13)
	Employed	30 (10.45)	64 (22.30)	94 (16.38)
	Merchant/others	59 (20.56)	64 (22.30)	123 (21.43)
Educational status	No formal education	169 (58.89)	113 (39.37)	282 (49.13)
	Primary school	84(29.27)	78 (27.18)	162(28.22)
	Secondary and above	34 (11.85)	96 (33.45)	130 (22.65)
Monthly income (n=378)	<2500 ETB	140 (66.04)	54 (32.53)	194 (51.32)
	≥2500 ETB	72 (33.96)	112 (67.47)	184 (48.68)
Median monthly income (ETB)	Median (IQR)	1500(1000, 3500)	3500 (2000, 5294)	2050 (1000, 4500)

*Catholic, musilim and wekefata

7.4.2. Psychosocial support for HIV-infected adults

Concerning psychosocial support, 303 (52.79%) of the HIV-infected adults received care from different caregivers, of which 154 (53.66%) were food-insecure and 149 (51.92%) were food-secure (Table 18). Of those who received care from caregivers, 161 (61.62%) received economic

support, followed by psychological support (68, 25.09%). The sources of care for more than half of the participants, 167 (61.62%), were either their husbands or wives. Among these, 68 (51.13%) were food-insecure and 88 (63.77%) were food-secure. Two hundred ninety (50.52%) of the HIV-infected adults disclosed their HIV status, of which 154 (53.10%) disclosed their HIV serostatus to their husbands or wives. The proportion of participants who disclosed their HIV status was higher among the food-insecure group (147, 51.22%) compared to the food-secure group (143, 49.83%) (Table 18).

Table 18: Baseline Pyschosocial support for follow-up study on clinical progression of HIV-infected adults receiving ART at health facilities in in Northcentral, Ethiopia, 2024 (n=574)

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Presence caregiver	No	154 (53.66)	149 (51.92)	303 (52.79)
	Yes	133 (46.34)	138 (48.08)	271 (47.21)
Type of care received (n=271)	Psychological support	35 (26.32)	33 (23.91)	68 (25.09)
	Economic support	79(59.40)	88 (63.77)	167(61.62)
	Social support and related	19 (14.29)	17 (12.32)	36 (13.28)
Type of caregiver (n=271)	Mother/ father	28 (21.05)	12(8.70)	40 (14.76)
	Husband/Wive	68 (51.13)	88 (63.77)	156 (57.56)
	Children	25 (18.80)	29 (21.01)	54 (19.93)
	Others	12 (9.02)	9 (6.52)	21 (7.75)
Disclose their Sero-status	No	140 (48.78)	144 (50.17)	284 (49.48)
	Yes	147 (51.22)	143 (49.83)	290 (50.52)
To whom you disclose (n=290)	Mother/ father	21 (14.29)	11 (7.69)	32 (11.03)
	Husband/Wive	72 (48.98)	82 (57.34)	154 (53.10)
	Children	25 (17.01)	33 (23.08)	58 (20.00)
	Others	29 (19.73)	17 (11.89)	46 (15.86)

7.4.3. Clinical and food-related characteristics of HIV-infected adults

One hundred thirteen (19.69%) of HIV-infected adults reported having eating problems during their treatment follow-up, which is almost consistently distributed between the food-insecure (56, 19.51%) and food-secure (57, 19.86%) groups (Table 18). The most common reason reported for having an eating problem was loss of appetite (87, 76.99%): 46 (82.14%) in the food-insecure group and 41 (71.93%) in the food-secure group. One-third of HIV-infected adults (30.84%), reported having anemia during their treatment follow-up, which was higher in the food-insecure group (99, 34.49%) compared to the food-secure group (78, 27.18%) as defined by WHO's standard for anemia among HIV-infected individuals. One hundred nine (18.99%) developed opportunistic infections (OIs) while under care. The most common OIs were diarrheal diseases

(39.45%), followed by tuberculosis (24.77%). However, the proportion of tuberculosis (34.78%) among food-insecure individuals was higher compared to the proportion of other OIs. A small proportion (13, 4.53%) of participants reported receiving therapeutic feeding during the follow-up care, which was consistent across both food-insecure and food-secure groups (4.53% of food-insecure and 4.18% of food-secure).

Three hundred forty-seven (60.45%) of participants reported receiving ART for more than 8 years: 149 (51.92%) were food-insecure and 198 (68.99%) were food-secure. The average duration of ART among the HIV-infected adults was 9.03 years (±4.61 SD), with 8.26 years (±4.77 SD) for the food-insecure group and 9.80 years (±4.31 SD) for the food-secure group. The majority, 437(76.13%) reported having 3 and above months' follow-up interval, of which 201(70.03%) and 236(82.23%) were food-insecure and food-secure, respectively.

Almost three-fourths (72.13%) started ART at an early clinical stage: 218 (75.96%) of the food-insecure group and 196 (68.29%) of the food-secure group were at WHO clinical stage one. Similarly, 503 (87.63%) started ART at an early treatment stage: 250 (87.11%) of the food-insecure group and 253 (88.15%) of the food-secure group were at WHO treatment stage one.

A significant proportion, 179 (31.79%), of HIV-infected adults were not provided cotrimoxazole preventive therapy (CPT), with 77 (27.70%) being food-insecure and 102 (35.79%) being food-secure. Similarly, 78 (13.85%) of HIV-infected adults were not provided tuberculosis preventive therapy (TPT), which was almost consistent across the food-insecure (14.03%) and food-secure (13.68%) groups. This, in turn, contributed to the development of opportunistic infections (OIs), including tuberculosis, and hindered the clinical progression of HIV/AIDS. A small proportion (142, 24.74%) of the HIV-infected adults reported consuming fruits and vegetables at least once per day, as defined by WHO's standard for daily FAV consumption. This proportion was almost consistent across both food-insecure (62, 21.60%) and food-secure (80, 27.87%) groups (Table 19).

Table 19: Baseline clinical and nutritional characteristics for follow-up study on clinical progression of HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024 (n=574)

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Presence eating problems	No	231 (80.49)	230 (80.14)	461 (80.31)
	Yes	56 (19.51)	57 (19.86)	113 (19.69)
Causes of Eating problem(n=113)	Loss of appetite	46 (82.14)	41 (71.93)	87 (76.99)
	Oral candidiasis	9(16.07)	12 (21.05)	21(18.58)
	Esophageal candidiasis	1 (1.79)	4 (7.02)	5 (4.42)
Anemia	No	188 (65.51)	209 (72.82)	397 (69.16)
	Yes	99 (34.49)	78 (27.18)	177 (30.84)
Presence of OIs	No	241 (83.97)	224 (78.05)	465 (81.01)
	Yes	46 (16.03)	63 (21.95)	109 (18.99)
Type of OI disease (n=109)	Tuberculosis	16 (34.78)	11(17.46)	27 (24.77)
	Pneumonia	6 (13.04)	9 (14.29)	15 (13.76)
	Diarrheal disease	11 (23.91)	32 (50.79)	43 (39.45)
	Dispepsia	6 (13.04)	3 (4.76)	9 (8.26)
	Others	7 (15.22)	7 (12.70)	15 (13.76)
Therapeutic food	No	274 (95.47)	275 (95.82)	549 (95.64)
	Yes	13(4.53)	12 (4.18)	25(4.36)
Duration of HIV infection(n=858)	<5 years	73 (25.44)	40 (13.94)	113 (19.69)
	5-10years	74 (25.78)	55 (19.16)	129 (22.47)
	>10 years	140 (48.78)	192 (66.90)	332 (57.84)
The average duration of HIV infection in years	Mean (SD)	8.70 (±4.90)	10.40 (±4.39)	9.54 (±4.73)
WHO clinical stage	Stage one	218 (75.96)	196 (68.29)	414 (72.13)
	Stage two and above	196 (24.04)	91 (31.71)	160 (27.87)
WHO treatment stage	Stage one	250 (87.11)	253 (88.15)	503 (87.63)
	Stage two and above	37 (12.89)	34 (11.85)	71 (12.37)
Duration of ART	<4 years	66 (23.00)	33 (11.50)	99 (17.25)
	4-8 years	72 (25.09)	56 (19.51)	128 (22.30)
	>8 years	149 (51.92)	198 (68.99)	347 (60.45)
The average duration of ART in years	Average (SD)	8.26 (±4.77)	9.80 (±4.31)	9.03 (±4.61)
Follow up interval	Less than 3 months	86 (29.97)	51 (17.77)	137 (23.87)
	3 or above months	201 (70.03)	236 (82.23)	437 (76.13)
CPT provision status (n=563)	Provided	171 (61.51)	160 (56.14)	331 (58.79)
	ongoing	30 (10.79)	23 (8.07)	53 (9.41)
	Not provided	77 (27.70)	102 (35.79)	179 (31.79)
TPT provision status or IPT (n=563)	Complete	230 (82.73)	229 (80.35)	459 (81.53)
	Discontinue/interrupt	3 (1.08)	3 (1.05)	6 (1.07)
	ongoing	6 (2.16)	14 (4.91)	20 (3.55)
	Not given	39 (14.03)	39 (13.68)	78 (13.85)
Fruit and vegetable dietary intake	≥ One time per day	62 (21.60)	80(27.87)	142 (24.74)
	< One time per day	225 (78.40)	207 (72.13)	432 (75.26)

7.4.4. Behavioral Characteristics s of HIV-infected Adults

A total of twelve HIV-infected adults (2.09%) have ever been forced to engage in unprotected sex, of which 10 (3.48%) were food insecure (Table 19). Additionally, 52 (9.09%) of the HIV-infected adults have ever migrated from their previous place of residence to get their daily food, of which 45 (15.68%) were food insecure. One hundred eighty (31.36%) skipped doses of ART due to unmet restrictions such as food required with the drug, time schedule, and taking it on an empty stomach in the last 7 days: 96 (33.45%) were food insecure and 84 (29.27%) were food secure. The majority, 379 (66.03%) and 468 (81.53%), reported that they closely followed all specific schedules and special instructions in the past 7 days, respectively. Three hundred fifteen (54.88%) HIV-infected adults reported not missing doses in the last 7 days, of which 137 (47.74%) were food insecure and 178 (62.02%) were food secure. Three hundred fifty-nine (62.54%) of HIV-infected adults rated as having good adherence, which is consistent for both food-insecure (64.11%) and food-secure (60.98%) groups. A significant number of HIV-infected adults, 56 (9.95%), 283 (50.27%), and 33 (5.86%), reported that they had smoked cigarettes, drunk alcohol, and chewed khat, respectively (Table 20).

Table 20: Baseline Behavioral characteristics for follow-up study on clinical progression of HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Unprotected sex for Daily food	No	277 (96.52)	285 (99.30)	562 (97.91)
	Yes	10 (3.48)	2 (0.70)	12 (2.09)
Ever migrated from for food	No	242 (84.32)	280 (97.56)	522 (90.94)
	Yes	45 (15.68)	7 (2.44)	52 (9.06)
Skipped due to unmet restrictions in last 7 days	No	191 (66.55)	203 (70.73)	394 (68.64)
	Yes	96 (33.45)	84 (29.27)	180 (31.36)
Closely follow the schedule in past 7 days	Sometimes	14 (4.88)	9 (3.14)	23 (4.01)
	Most of the time	101 (35.19)	71 (24.74)	172 (29.97)
	All of the time	172 (59.93)	207 (72.13)	379 (66.03)
Follow special instruction	Sometimes	11 (3.83)	9 (3.14)	20 (3.48)
	Most of the time	36 (12.54)	50 (17.42)	86 (14.98)
	All of the time	240 (83.62)	228 (79.44)	468 (81.53)
Missing doses in the last 7 days	Missed	150 (52.26)	109 (37.98)	259 (45.12)
	Not missed	137 (47.74)	178 (62.02)	315 (54.88)
Level of adherence to ART	Good	184 (64.11)	175 (60.98)	359 (62.54)
	Fair	37 (12.89)	40 (13.94)	77 (13.41)
	Poor	66 (23.00)	72 (25.09)	138 (24.04)
Ever smoke cigarettes	No	259 (93.17)	248 (87.02)	507 (90.05)
	Yes	19 (6.83)	37 (12.98)	56 (9.95)
Ever drink alcohol	No	144 (51.80)	136 (47.72)	280 (49.73)
	Yes	134 (48.20)	149 (52.28)	283 (50.27)
Ever chew chat	No	268 (96.40)	262 (91.93)	530 (94.14)
	Yes	10 (3.60)	23 (8.07)	33 (5.86)

7.4.5. Incidence of nutritional status of HIV-infected adults

We assessed the nutritional status of HIV-infected adults at three visits over the follow-up duration. Accordingly, 98 (17.07%) of them developed undernutrition at the first visit, with 61 (21.25%) being food insecure and 37 (12.89%) being food secure (Table 20). At the second visit, 114 (20.14%) developed undernutrition, with 65(23.21%) being food insecure and 43 (17.13%) being food secure. At the third visit, 105 (18.65%) developed undernutrition, with 63 (22.66%) being food insecure and 42 (14.74%) being food secure (Table 21, Figure 15).

Table 21: Nutritional status of HIV-infected adults receiving ART at health facilities by food security status, Ethiopia, 2024 (n=574)

Food security status	Nutritional status (1st visit)			Nutritional status (2nd visit)			Nutritional status (3rd visit)		
	Under nutrition	Normal	Over Nutrition	Under nutrition	Normal	Over Nutrition	Under nutrition	Normal	Over Nutrition
	No (%)	No(%)	No(%)	No (%)	No(%)	No(%)	No (%)	No(%)	No(%)
Food insecure	61(21.25)	200(69.69)	26(9.06)	65(23.21	189(67.50)	26(9.29)	63(22.66)	192(69.06)	23(8.27)
Food secure	37(12.89)	209(72.82)	41(14.29)	43(17.13)	194(67.83)	43(15.03)	42(14.74)	204(71.58)	39(13.68)

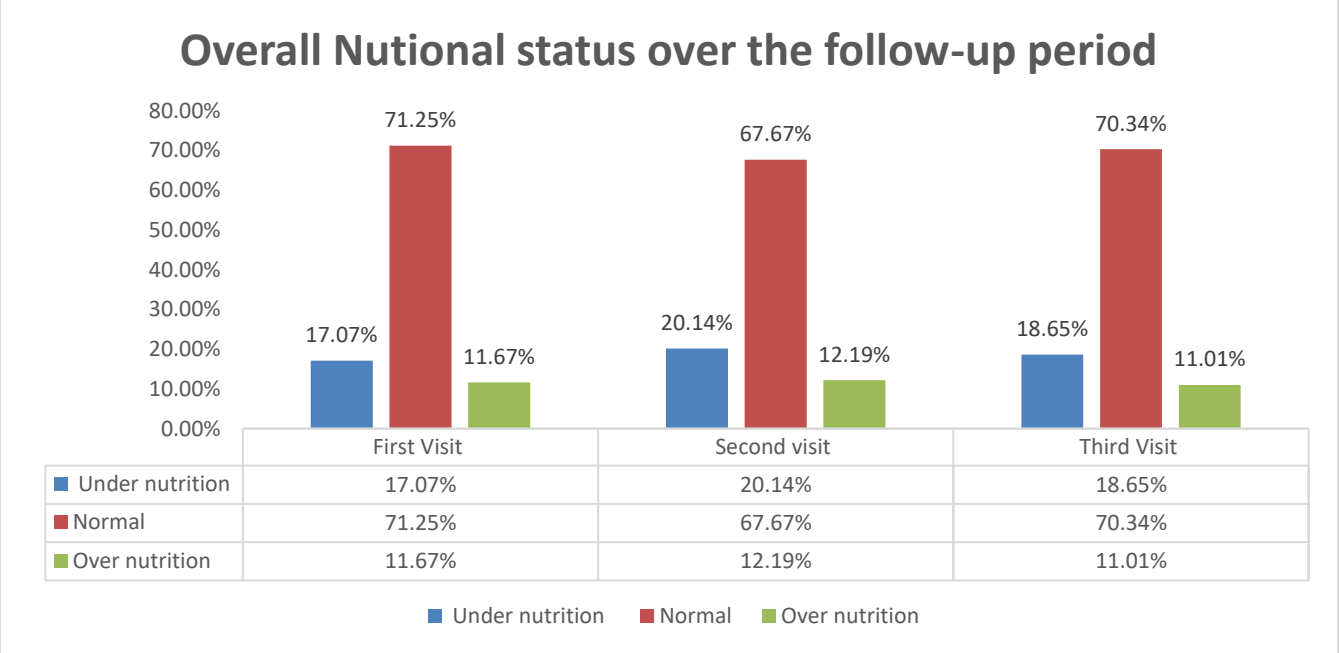


Figure 15: Overall nutritional status of HIV-infected adults receiving ART over the follow-up period at health facilities in Northcentral, Ethiopia, 2024

7.4.6. Incidence of Clinical outcome of HIV-infected adults

The clinical outcome of HIV-infected adults and its progression was assessed, using the viral load of the participants over three consecutive visits. Viral load indicates the activity of HIV infection

and is a useful blood test to determine how much HIV is present in the blood. Over time, the viral load increases as more viruses are produced, resulting in rapid progression to AIDS. A viral load of 1000 copies/mL or higher for at least two consecutive measurements taken three months apart is considered as indicator of poor clinical progression. During the follow-up period, we tracked a total of 574 individuals (287 food-secure and 287 food-insecure), with 1,722 observations. Accordingly, 106 (18.56%; 95% CI: 15.58–21.97), 119 (21.14%; 95% CI: 17.95–24.71), and 134 (23.84%; 95% CI: 20.49–27.55) HIV-infected adults had poor clinical progression at the first, second, and third visits, respectively (Table 21). The incidence of poor clinical progression was twice as high among food-insecure HIV-infected adults at each visit. Specifically, 71 (25.00%), 80 (28.78%), and 91 (32.85%) of those who showed poor clinical outcomes were food insecure at the first, second, and third visits, respectively. The overall incidence of poor clinical progression among observations during the follow-up period was found to be 21.17% (95% CI: 19.27%, 23.18%), with 28.84% among food-insecure HIV-infected adults and 13.65% among food-secure HIV-infected adults (Table 22).

Table 22: The incidence of clinical progression by food security among HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024 (n=574)

Food security status	**Clinical progression (1st visit)**		**Clinical progression (2nd visit)**		**Clinical progression (3rd visit)**	
	Poor	**Good**	**Poor**	**Good**	**Poor**	**Good**
	No (%)	**No(%)**	**No (%)**	**No(%)**	**No (%)**	**No(%)**
Food insecure	71 (25.00)	213 (75.00)	80 (28.78)	198 (71.22)	91 (32.85)	186 (67.15)
Food secure	35 (12.20)	252 (87.80)	39 (13.68)	248 (86.32)	43 (15.09)	242 (84.91)
Total	106 (18.56)	465 (81.44)	119 (21.14)	444 (78.86)	134 (23.84)	428 (76.16)

7.4.7. Predictors of clinical progression among adults receiving ART

In bi-variable generalized linear mixed-effects model, twenty variables, namely, sex/gender, age, educational status, occupational status, monthly income, categories of caregivers, types of care received, presence of anemia, people to whom they disclose their serostatus, duration of HIV infection, follow-up interval, duration of ART follow-up, presence of eating problems, nutritional status during follow-up, TPT provision status or IPT, missing doses in the last 7 days (indicating strict adherence to ART), WHO clinical stage, WHO treatment stage, and practice in following special instructions from health professionals, showed association with a p-value of ≤ 0.20 and were then selected as candidates for multivariable analysis. The duration of HIV infection and follow-up interval were highly correlated with the duration of ART follow-up. A professional decision was made to reduce the duration of HIV infection and follow-up interval in favor of the duration of ART follow-up.

Consequently, the multivariable generalized linear mixed-effects regression analysis with identity covariance structure was fitted using all eighteen variables simultaneously. Five of the most contributing factors, including food security status which was considered as the main exposure, were found to be significant independent predictors of clinical progression of HIV/AIDS at a 5% level of significance. As a single-variable random-effects specification in the identification equation, we selected a model with an identity covariance structure. This structure is set to identity by default, providing a simplified approach to handle random effects in our analysis. In addition, the model fitness or adequacy was assessed using information criteria and log-likelihood ratio test (LR chiasquare = 133.37, $p < 0.001$).

Correlation Structure	-2LL	LR TEST	AIC	BIC
Identity	-301.5612	133.37	655.1224	776.7266

Accordingly, the type of care received from different informal caregivers was found to be a significant independent predictor of poor clinical progression. The incidence of developing poor clinical progression among those receiving economic support was 5 times higher than those receiving psychological support (aRR = 4.72, 95% CI: 1.10, 20.52).

Food security status, considered the main exposure variable in this follow-up study, was found to be an independent predictor of poor clinical progression among HIV-infected adults after controlling for other potential confounders. The incidence of poor clinical progression was 5.4

times higher among food-insecure HIV-infected adults compared to food-secure HIV-infected adults (aRR=5.44, 95% CI: 1.36, 21.76).

The nutritional status of HIV-infected individuals was found to be an independent predictor of poor clinical progression. The incidence of poor clinical progression was 3.3 times higher among undernourished HIV-infected adults compared to those with normal nutritional status (aRR=3.34, 95% CI: 1.21, 9.26). The WHO treatment stage and duration of antiretroviral treatment were identified as independent predictors of poor clinical progression among HIV-infected adults. The incidence of poor clinical progression at the advanced WHO treatment stage among HIV-infected adults was 6.4 times higher than those with WHO treatment stage one (aRR=6.43, 95% CI: 1.21, 34.41). Similarly, the incidence of poor clinical progression among HIV-infected adults receiving ART for at least 4 years was 4.2 times higher than those receiving ART for more than 4 years (aRR=4.22, 95% CI: 1.11, 12.07).

However, the analysis did not indicate a significant association between fruits and vegetables dietary, HIV-seropositivity disclosure status, CPT provision status, and level of adherence in the final generalized linear mixed-effects multivariable regression model with a logit link function (Table 23).

Table 23: Predictors of clinical progression of HIV-infected adults receiveing ART at health facilities, Ethiopia, 2024. (n=574)

Variables	Response	cRR with 95% CI	aRR with 95% CI	aP-value
Sex	Male	1.0	1.0	
	Female	0.51(0.21, 1.21)*	0.51(0.12, 2.08)	0.347
Age respodents	<35 years	1.0	1.0	
	35-44 years	2.30 (0.75, 7.07)*	0.60 (0.15, 2.43)	0.474
	≥45 years	2.16 (0.70, 6.65)*	0.54(0.10, 2.80)	0.462
Educational status	No formal education	1.0	1.0	
	Primary school	0.88(0.33, 2.38)	0.74(0.18, 2.930)	0.662
	Secondary and above	0.44(0.14, 1.39)	0.46(0.08, 2.85)	0.405
Occupational status	Farmer	1.0	1.0	
	House wife	0.28 (0.07, 1.17)	0.22 (0.04, 1.34)	0.100
	Daily laborer	1.42 (0.41, 4.96)	0.10(0.02, 1.15)	0.073
	Employed	0.21(0.04, 1.01)	0.38(0.03 4.36)	0.436
	Merchant/others	1.07(0.30, 3.82)	0.70(0.09, 5.42)	0.734
Monthly income (ETB)	Less than 2500	3.90 (1.38, 11.04) **	0.82(0.16, 5.92)	0.735
	2500 and above	1.0	1.0	
Type of care received	Psychological support	1.	1.0	
	Economic support	4.81 (1.15, 20.06)**	**4.72(1.10, 20.52) ** **	**0.039****
	Social support and related	6.39 (0.94, 34. 55)*	3.04 (0.39, 24.00)	0.291
Care categories	Mother/ father	1.0	1.0	
	Husband/Wive	4.19 (0.68, 25.69) *	3.93 (0.57, 27.08)	0.164
	Children/others	5.50(0.77, 39.00) *	5.90 (0.64, 54.04)	0.117
To whom you disclose	Mother/ father	1.0	1.0	
	Husband/Wive	2.39(0.33, 17.27) *	1.52(0.16, 13.20)	0.823
	Children/others	10.58 (1.37, 81.85) **	5.92 (0.58, 52.73)	0.224
Presence of eating problems	No	1.0	1.0	
	Yes	2.71 (0.97, 7.52)	1.76(0.44, 7.08)	0.428
Food security status	Food secure	1.0	1.0	
	Food insecure	11.84 (4.36, 32.17) **	**5.44 (1.36, 21.76) ** **	**0.017****
Nutrional status	Under nutrition	3.33(1.57, 7.04)**	**3.34(1.21, 9.26) ** **	**0.020****
	Normal	1.0	1.0	
	Over nutrition	0.85 (0.26, 2.74)*	1.69(0.39, 7.30)	0.483
Presence of Anemia	No	1.0	1.0	
	Yes	7.72 (3.08, 19.38) **	2.14(0.57, 8.06)	0.261
WHO clinical stage	Stage one	1.0	1.0	
	Stage two &above	7.31 (2.90, 18.46) **	0.74(0.15, 4.53)	0.652
WHO treatment stage	Stage one	1.0	1.0	
	Stage two &above	18.49 (5.74, 59.54) **	**6.43(1.21, 34.41) ** **	**0.030****
Duration of ART	≤4 years	2.23(0.80, 6.25) *	**4.22(1.11. 12.07) ** **	**0.036****
	>4 years	1.0	1.0	
TPT provision status or IPT	Given	1.0	1.0	
	Not given/discontinue	4.14 (1.44, 11.77)**	0.74 (0.13, 4.23)	0.734
Missing doses in the last 7 days	Not missed	1.0	1.0	
	Missed	1.98 (0.84, 4.68)*	1.01(0.31, 3.34)	0.988

From the analysis, we found that the random effects capture the correlation in the repeated measurement data in this study. sd(b0i) =3.237 (95% CI: 2.565, 4.087) and sd("Σij) = 0.385.

Random-effects parameters	Estimate	Std. err.	[95% CI]	P-value
id: Identity: sd(_cons)	3.237	0.385	(2.565, 4.087)	<0.001

7.5. The effect of food insecurity on CD4 count change among adults (Paper V)

7.5.1. Socio-demographic and Socio-economic characteristics

A total of 442 HIV-infected adults, of which 221 were food-secure and 221 were food-insecure, were enrolled and followed for three consecutive follow-up intervals (quarters) to assess their immunological outcomes, using CD4 count changes. Among them, 435 (98.42%) completed the follow-up period, 6 (1.36%) were lost to follow-up, and 1 (0.23%) died. Two hundred seventy-one (61.31%) were females, of which 145 (65.61%) were food-insecure and 126 (57.01%) were food-secure (Table 23). Two hundred ninety-three (66.29%) of HIV-infected adults belong to the age group less than 40 years, with the mean age of enrolled participants being 38.99 (±9.53 SD) years: 166 (75.11%) were food-insecure and 127 (57.47%) were food-secure. Four hundred (90.50%) of the HIV-infected adults were followers of Orthodox Christianity, of which 195 (88.24%) were food-insecure and 205 (92.76%) were food-secure. Two hundred fifty (56.56%) were married, of which 114 (51.58%) were food-insecure and 136 (61.54%) were food-secure. Three hundred forty-two (77.38%) were of Oromo ethnicity, with a consistent distribution across both food-insecure and food-secure groups. The vast majority were from urban areas (80.09% of the food-insecure group and 64.71% of the food-secure group).

Three hundred forty-eight (78.73%) of HIV-infected individuals reported having children, of which 167 (75.57%) were food-insecure and 181 (81.90%) were food-secure. Of those who reported having children, 251 (72.13%) had less than four children, with 128 (76.65%) being food-insecure and 123 (67.96%) being food-secure. Ninety-seven (21.95%) were daily laborers, of which 78 (35.29%) were food-insecure. Two hundred eighteen (49.32%) of HIV-infected adults had no formal education: 127 (57.47%) were food-insecure and 91 (41.18%) were food-secure. One hundred forty-nine (51.92%) of HIV-infected adults reported having a monthly income of less than 2500 Ethiopian birr, of which 106 (64.63%) were food-insecure (Table 24).

Table 24: Baseline socio-demographic and economic characteristics for follow-up study on CD4 count change of HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024 (n=442)

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Sex	Male	76 (34.39)	95 (42.99)	171 (38.69)
	Female	145 (65.61)	126 (57.01)	271 (61.31)
Age of respondents	≤40 years	166 (75.11)	127 (57.47)	293 (66.29)
	>40 years	55 (24.89)	94 (42.53)	149 (33.71)
The average age in years	Average (SD)	36.37 (±8.28)	39.60 (±10.40)	38.99(±9.53)
Religion of respondents	Orthodox	195 (88.24)	205 (92.76)	400 (90.50)
	Protestant	17 (7.69)	12 (5.43)	29 (6.56)
	Others*	9 (4.07)	4 (1.81)	13 (2.94)
Marital status	Married	114 (51.58)	136 (61.54)	250 (56.56)
	Single	24 (10.86)	29 (13.12)	53 (11.99)
	Divorced	42 (19.00)	21 (9.50)	63 (14.25)
	Widowed	41 (18.55)	35 (15.84)	76 (17.19)
Ethnicity of participants	Oromo	165 (74.66)	177 (80.09)	342 (77.38)
	Amhara and gurage	56 (25.34)	44 (19.91)	100 (22.62)
Residence	Rural	44 (19.91)	78 (35.29)	122(27.60)
	Urban	177 (80.09)	143 (64.71)	320(72.40)
Presence of children	No	54 (24.43)	40 (18.10)	94 (21.27)
	Yes	167 (75.57)	181(81.90)	348 (78.73)
Number of children (n=348)	≤3 children	128 (76.65)	123 (67.96)	251 (72.13)
	4-9 children	39 (23.35)	58 (32.04)	97 (27.87)
Occupational Status	Farmer	26 (11.76)	59(26.70)	85 (19.23)
	House wife	45 (20.36)	42 (19.00)	87 (19.68)
	Daily laborer	78 (35.29)	19 (8.60)	97 (21.95)
	Employed	27 (12.22)	49 (22.17)	76 (17.19)
	Merchant/others	45 (20.36)	52(23.53)	97 (21.95)
Educational status	No formal education	127 (57.47)	91 (41.18)	218 (49.32)
	Primary school	64(28.96)	56 (25.34)	120(27.15)
	Secondary and above	30 (13.57)	74 (33.48)	104 (23.53)
Monthly income (n=287)	<2500 ETB	106 (64.63)	43 (34.96)	149 (51.92)
	≥2500 ETB	58 (35.37)	80 (65.04)	138 (48.08)

*Catholic, musilim and wekefata

7.5.1. Psychosocial support for HIV-infected adults

Two hundred thirty-nine (54.07%) of the HIV-infected adults received psychosocial support or care from different caregivers, which was consistent across the food insecure (54.75%) and food secure (53.39%) groups (Table 24). Of the support or care received, 127 (62.5%) received economic support, followed by psychological support (46, 22.66%). The majority, 112 (55.17%), received care from their husbands or wives, of which 49 (49.00%) were food insecure and 63

(61.17%) were food secure. Almost half (49.10%) of the HIV-infected adults had disclosed their HIV status, of which 114 (52.53%) disclosed their serostatus to their husbands or wives (Table 25).

Table 25:Baseline Pyschosocial support for follow-up study on CD4 count change HIV-infected adults receiving ART at health facilities in in Northcentral, Ethiopia, 2024

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Presence caregiver	No	121 (54.75)	118 (53.39)	239 (54.07)
	Yes	100 (45.25)	103(46.61)	203 (45.93)
Type of care received (n=203)	Psychological support	26 (26.00)	20 (19.42)	46 (22.66)
	Economic support	61(61.00)	66 (64.08)	127 (62.5)
	Social support and related	13 (13.00)	17 (16.50)	30 (14.78)
Type of caregiver (n=203)	Mother/ father	25 (25.00)	11(10.68)	36 (17.73)
	Husband/Wive	49 (49.00)	63 (61.17)	112 (55.17)
	Children	19(19.00)	22 (21.36)	41 (20.20)
	Others	7 (7.00)	7 (6.80)	14 (6.90)
Disclose their Sero-status	No	110 (49.77)	115 (52.04)	225 (50.90)
	Yes	111 (50.23)	106 (47.96)	217 (49.10)
To whom you disclose (n=290)	Mother/ father	17 (15.32)	10 (9.43)	27 (12.44)
	Husband/Wive	54(48.65)	60 (56.60)	114 (52.53)
	Children	20 (18.02)	23 (21.70)	43 (19.82)
	Others	20 (18.02)	13 (12.26)	33 (15.21)

7.5.3. Clinical and food-related characteristics of HIV-infected adults

A significant proportion, 83 (18.78%), of HIV-infected adults reported having eating problems during their care follow-up: 44 (19.91%) were food-insecure and 39 (17.65%) were food-secure (Table 25). Loss of appetite (63, 75.90%) was the main reason for the eating problem: 35 (79.55%) in the food-insecure group and 28 (71.79%) in the food-secure group. One hundred forty-three (32.35%) of HIV-infected adults reported having anemia during their care follow-up: 81 (36.65%) were food-insecure and 62 (28.05%) were food-secure, as defined by WHO's standard for anemia among HIV-infected adults. A total of 78 (17.65%) developed OIs during care follow-up, with the most common OIs being diarrheal diseases (43.59%), while the occurrence of tuberculosis (34.78%) was higher among food-insecure HIV-infected adults.

Only 13 (4.53%) of the total sample reported receiving therapeutic feeding, which was slightly higher among food-insecure HIV-infected adults (4.52%) than food-secure HIV-infected adults (3.62%). The majority, 267 (60.41%), of participants reported receiving ART for more than 8 years, with the average duration of ART being 8.96years (±4.60), 8.17 years (±4.62 SD) for the

food-insecure HIV-infected adults, and 9.76 years (±4.44 SD) for the food-secure. The majority, 317 (71.72%), of HIV-infected adults were at WHO clinical stage one, of which 163 (73.76%) were food-insecure and 154 (69.68%) were food-secure. Three hundred eighty-nine (88.01%) started ART at an early treatment stage, of which 191 (86.43%) were food-insecure and 198 (89.59%) were food-secure.

One hundred thirty-six (31.26%) and 62 (14.25%) of HIV-infected adults did not receive cotrimoxazole preventive therapy (CPT) and tuberculosis preventive therapy (TPT), respectively, which in turn increases the risk for OIs and worsens the clinical progression of HIV/AIDS. Nearly one-fourth (101, 22.85%) of the HIV-infected adults reported consuming fruits and vegetables at least once per day, as defined by WHO's standard for daily FAV consumption: 44 (19.91%) were food-insecure, and 57 (25.79%) were food-secure (Table 26).

Table 26: Baseline clinical and nutritional characterisitics for follow-up study CD4 count change of HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024 (n=442)

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Presence eating problems	No	177 (80.09)	182 (82.35)	359 (81.22)
	Yes	44 (19.91)	39 (17.65)	83 (18.78)
Causes of Eating problem(n=83)	Loss of appetite	35 (79.55)	28(71.79)	63 (75.90)
	Oral candidiasis	8(18.18)	8 (20.51)	16(19.28)
	Esophageal candidiasis	1 (2.27)	3 (7.69)	4 (4.82)
Anemia	No	140 (63.35)	159 (71.95)	299 (67.65)
	Yes	81 (36.65)	62 (28.05)	143 (32.35)
Presence of OIs	No	187 (84.62)	177 (80.09)	364 (82.35)
	Yes	34 (15.38)	44 19.91)	78 (17.65)
Type of OI disease (n=109)	Tuberculosis	11 (32.35)	7(15.91)	8 (10.26)
	Pneumonia	3 (8.82)	5 (11.36)	8 (10.26)
	Diarrheal disease	9 (26.47)	25 (56.82)	34 (43.59)
	Dispepsia	5 (14.71)	3 (6.82)	8 (10.26)
	Others	6 (17.65)	4 (9.09)	10 (12.82)
Therapeutic food	No	211 (95.48)	213 (96.38)	424 (95.93)
	Yes	10(4.52)	8 (3.62)	18(4.07)
Duration of HIV infection(n=858)	<5 years	54 (24.43)	33 (14.93)	87 (19.68)
	5-10years	59 (26.70)	41 (18.55)	100 (22.62)
	>10 years	108 (48.87)	147 (66.52)	255 (57.69)
The average duration of HIV infection in years	Mean (SD)	8.65 (±4.82)	10.41 (±4.51)	9.53 (±4.75)
WHO clinical stage	Stage one	163 (73.76)	154 (69.68)	317 (71.72)
	Stage two and above	58 (26.24)	67 (30.32)	125 (28.28)
WHO treatment stage	Stage one	191 (86.43)	198 (89.59)	389 (88.01)

	Stage two and above	30 (13.57)	23 (10.41)	53 (11.99)
Duration of ART	<4 years	49 (22.17)	28 (12.67)	77 (17.42)
	4-8 years	58 (26.24)	40 (18.10)	198 (22.17)
	>8 years	114 (51.58)	153 (69.23)	267 (60.41)
The average duration of ART in years	Average (SD)	8.17 (±4.62)	9.76 (±4.44)	8.96 (±4.60)
Follow up interval	Less than 3 months	73 (33.03)	39 (17.65)	112 (25.34)
	3 and above months	148 (66.97)	182 (82.35)	330 (74.66)
CPT provision status (n=435)	Provided	130 (60.47)	130 (59.09)	260 (59.77)
	ongoing	24 (11.16)	15 (6.82)	39 (8.97)
	Not provided	61 (28.37)	75 (34.09)	136 (31.26)
TPT provision status or IPT (n=435)	Complete	177 (82.33)	176 (80.00)	353 (81.15)
	Discontinue/interrupt	3 (1.40)	3 (1.36)	6 (1.38)
	ongoing	5 (2.33)	9 (4.09)	14 (3.22)
	Not given	30 (13.95)	32 (14.55)	62 (14.25)
Fruit and vegetable dietary intake	≥ One time per day	44 (19.91)	57 (25.79)	101 (22.85)
	< One time per day	177 (80.09)	164 (74.21)	341 (77.15)

7.5.4. Behavioral characteristics of HIV-infected Adults

Only 9 (2.04%) reported having ever been forced to engage in unprotected sex, of which 7 (3.17%) were food-insecure (Table 26). Forty-four (9.95%) of the HIV-infected adults reported ever migrating from their previous place of residence to get their daily food, of which 38 (17.19%) were food-insecure.

A significant proportion of HIV-infected adults, 136 (30.77%), skipped doses of ART in the last 7 days due to unmet restrictions such as needing food with the drug, time schedules, and taking it on an empty stomach: 74 (33.48%) were food-insecure and 62 (28.05%) were food-secure. Three hundred three (68.55%) and 373 (84.39%) reported that they closely followed all specific schedules and special instructions in the past 7 days, respectively, with consistent distribution among food-insecure and food-secure HIV-infected adults.

More than half (54.52%) of the HIV-infected adults reported strict adherence to ART by not missing doses in the last 7 days, including 108 (48.87%) who were food-insecure and 133 (60.18%) who were food-secure. The majority, 269 (60.86%) of HIV-infected adults, demonstrated good adherence to ART, with 143 (64.71%) being food-insecure and 116 (57.01%) being food-secure. A notable number of HIV-infected adults reported engaging in various behaviors: 49 (11.26%) had ever smoked cigarettes, 224 (51.49%) had drunk alcohol, and 26 (5.98%) had chewed khat (Table 27).

Table 27: Baseline bhavioral characteristics for follow-up CD4 count change of HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024 (n=574)

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Unprotected sex for Daily food	No	214 (96.83)	219 (99.10)	433 (97.96)
	Yes	7 (3.17)	2 (0.90)	9 (2.04)
Ever migrated from for food	No	118 (82.81)	215 (97.29)	398 (90.05)
	Yes	38 (17.19)	6 (2.71)	44 (9.95)
Skipped due to unmet restrictions in last 7 days	No	147 (66.52)	159 (71.95)	306 (69.23)
	Yes	74 (33.48)	62 (28.05)	136 (30.77)
Closely follow the schedule in past 7 days	Sometimes	10 (4.52)	5 (2.26)	15 (3.39)
	Most of the time	74 (33.48)	50 (22.62)	124 (28.05)
	All of the time	137 (61.99)	166 (75.11)	303 (68.55)
Follow special instruction	Sometimes	8 (3.62)	6 (2.71)	14 (3.17)
	Most of the time	23 (10.41)	32 (14.48)	55 (12.44)
	All of the time	190 (85.97)	183 (82.81)	373 (84.39)
Missing doses in the last 7 days	Missed	113 (51.13)	88 (39.82)	201 (45.48)
	Not missed	108 (48.87)	133 (60.18)	241 (54.52)
Level of adherence to ART	Good	143 (64.71)	116 (57.01)	269(60.86)
	Fair	29 (13.12)	34 (15.38)	63 (14.25)
	Poor	49 (22.17)	61 (27.60)	110 (24.89)
Ever smoke cigarettes	No	196 (91.16)	190 (86.36)	386 (88.74)
	Yes	19 (8.84)	30 (13.64)	49 (11.26)
Ever drink alcohol	No	107 (49.77)	104 (47.27)	211 (48.51)
	Yes	108 (50.23)	116 (52.73)	224 (51.49)
Ever chew chat	No	205 (95.35)	204 (92.73)	409 (94.02)
	Yes	10 (4.65)	16 (7.27)	26 (5.98)

7.5.5. Incidence of nutritional status of HIV-infected adults for CD4 count

We assessed the nutritional status of HIV-infected adults at three visits over the follow-up duration to identify its trend over the follow-up period and its effect on immunological progress or CD4 count change of HIV-infected adults. Accordingly, 82 (18.55%) of them developed undernutrition at the first visit, with 51 (23.08%) being food-insecure and 31 (14.03%) being food-secure (Table 27). At the second visit, 99 (22.71%) developed undernutrition, with 57(26.39%) being food-insecure and 42 (19.09%) being food-secure. At the third visit, 92 (21.15%) developed undernutrition, with 58 (26.98%) being food-insecure and 34 (15.45%) being food-secure (Table 28, Figure 16).

Table 28: Nutritional status for CD4 count change by food security status for HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024. (n=442)

Food security status	Nutritional status (1st visit)			Nutritional status (2nd visit)			Nutritional status (3rd visit)		
	Undernutrition	Normal	Over Nutrition	Undernutrition	Normal	Over Nutrition	Undernutrition	Normal	Over Nutrition
	No (%)	No(%)	No(%)	No (%)	No(%)	No(%)	No (%)	No(%)	No(%)
Food insecure	51(23.08)	153(69.23)	17(7.69)	57(26.39)	139(64.35)	20(9.26)	58(26.98)	142(66.05)	15 (6.98)
Food secure	31(14.03)	163(73.76)	2(12.22)	42(19.09)	145(65.91)	33(15.00)	34(15.45)	157(71.36)	29(13.18)

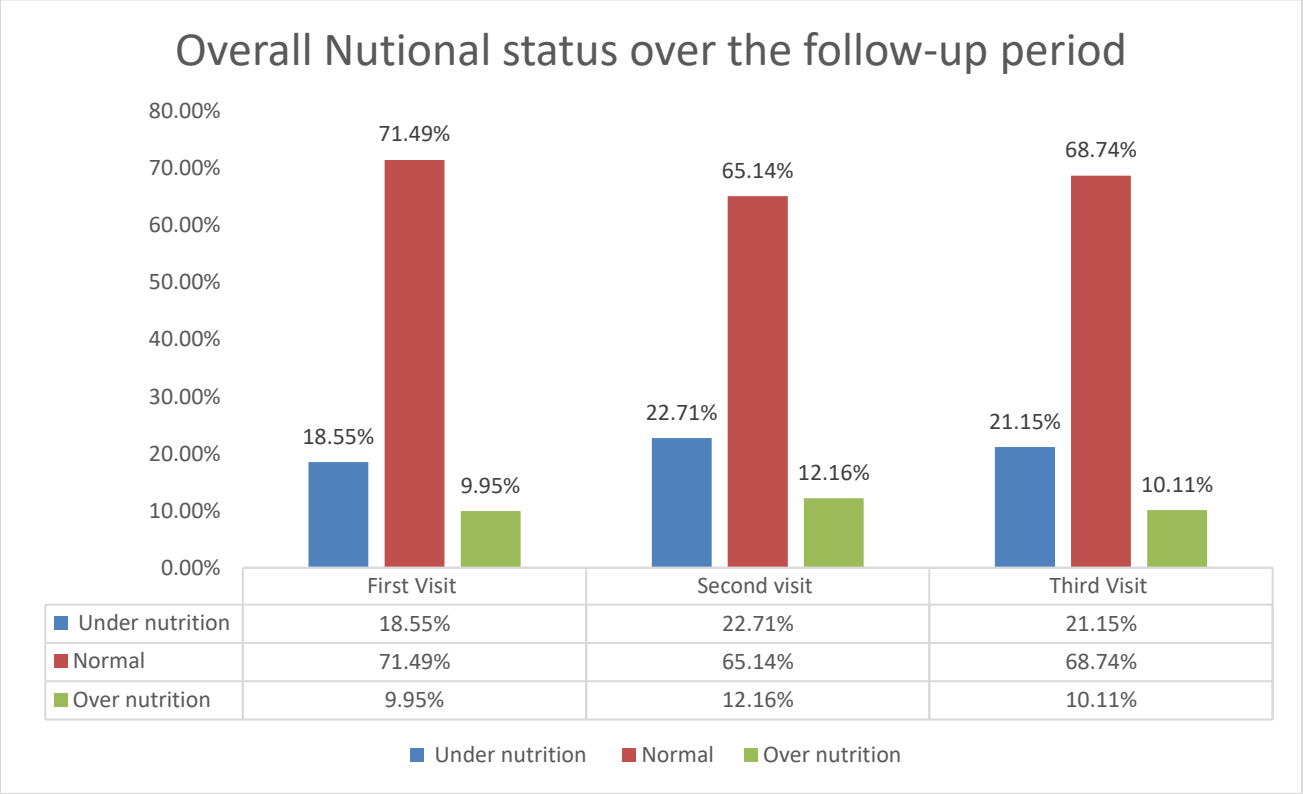


Figure 16: Overall nutritional status for CD4 count change of HIV-infected adults receiving ART over the follow-up period at health facilities in Northcentral, Ethiopia, 2024

7.5.6. Incidence of CD4 count change of HIV-infected adults

The CD4 count change of HIV-infected adults was assessed over three consecutive visits. The CD4 cell count is now considered the most reliable marker for assessing disease progression, staging the disease, and guiding treatment. A CD4 count falling below 200 cells/mm³ is one of the criteria used to diagnose AIDS. Accordingly, the median CD4 counts at the first, second, and third visits were 433 cells/µl (IQR: 255-607), 482 cells/µl (IQR: 326-698), and 523 cells/µl (IQR: 356-687), respectively (Table 29). There were 105 (23.76%; 95% CI: 20.01–27.96) HIV-infected adults, 78 (18.35%; 95% CI: 14.96–22.34) HIV-infected adults, and 73 (17.26%; 95% CI: 13.94–

21.17) HIV-infected adults with a CD4 count of <200 cells/mm³ at the first, second, and third visits, respectively. The proportion of HIV-infected adults with a CD4 count < 200 cells/mm³ declined from 23.76% to 17.26% over the 9-month follow-up period. This indicates a slight increase in the incidence of immunological recovery over the 9 months of follow-up. However, the incidence of a low CD4 count among food-insecure HIV-infected adults was still higher than that among food-secure HIV-infected adults at each visit. Specifically, 59 (26.70%), 44 (20.37%), and 40 (19.14%) of those with a low CD4 count were food-insecure at the first, second, and third visits, respectively. There was no significant change in immunological recovery from visit to visit in this group (Table 29).

Table 29: The incidence of low CD4 count among HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024

Food security status	CD4 count change (1st visit)			CD4 count change (2nd visit)			CD4 count change (3rd visit)		
	< 200 cells/ mm3	200-500 cells/ mm3	>500 cells/ mm3	< 200 cells/ mm3	200-500 cells/ mm3	>500 cells/ mm3	< 200 cells/ mm3	200-500 cells/ mm3	>500 cells/ mm3
	No (%)	No(%)	No(%)	No (%)	No(%)	No(%)	No (%)	No(%)	No(%)
Food insecure	59(26.70)	75(33.94)	87(39.37)	44(20.37)	74(34.26)	98(45.37)	40(19.14)	60(28.71)	109(52.15)
Food secure	46(20.81)	88(39.82)	87(39.37)	34(16.27)	66(31.58)	109(52.15)	33(15.42)	60(28.04)	121(56.54)
Total	105(23.76)	163(36.88)	174(39.37)	78(18.35)	140(32.94)	207(48.71)	73(17.26)	120(28.37)	230(54.37)

The CD4 count also classified into more precise categories to make it more clear and smooth modelling process as low CD4 count (< 200 cells/ mm3) and high CD4 count (≥200 cells/ mm3). Accordingly, there were 105 (23.76%), 78 (18.35%), and 73 (17.26%) of HIV-infected adults who had a low CD4 count (<200 cells/mm³). In contrast, 337 (76.24%), 347 (81.65%), and 350 (82.74%) had a CD4 count greater than or equal to 200 cells/mm³, respectively (Table 30, Figure 17).

Table 30: The incidence of low CD4 count by food security status among HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024

Food security status	CD4 count (1st visit)		CD4 count (2nd visit)		CD4 count (3rd visit)	
	< 200 cells/ mm3	≥200 cells/ mm3	< 200 cells/ mm3	≥200 cells/ mm3	< 200 cells/ mm3	≥200 cells/ mm3
	No (%)	No(%)	No (%)	No(%)	No (%)	No(%)
Food insecure	59(26.70)	162(73.30)	44(20.37)	172(79.63)	40(19.14)	169(80.86)
Food secure	46(20.81)	175(79.19)	34(16.27)	175(83.73)	33(15.42)	181(84.58)

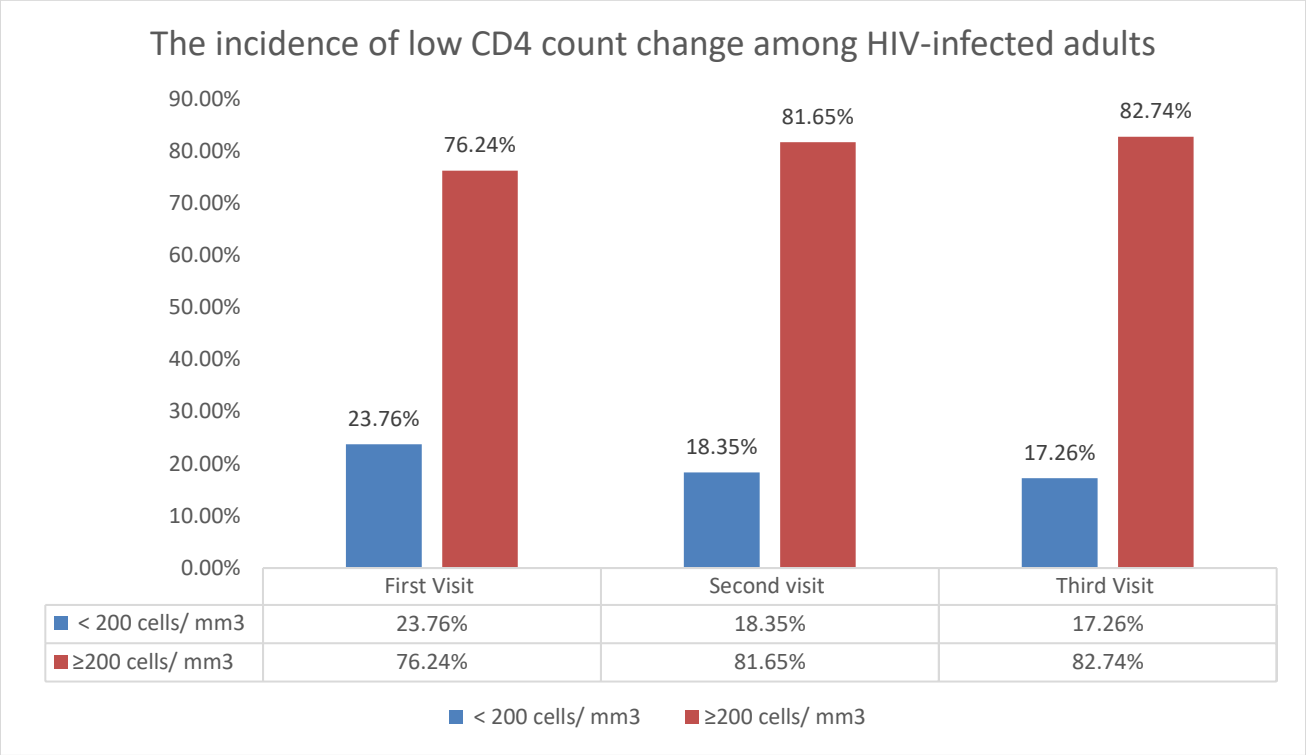


Figure 17: The incidence of CD4 count among HIV-infected adults receiving ART over the follow-up perion at health facilities in Northcentral, Ethiopia, 2024

Finally, during the follow-up period, we tracked a total of 442 individuals (221 food-secure and 221 food-insecure), with 1,326 observations. The overall incidence of low CD4 count change (< 200 cells/mm³) among observations during the follow-up period was found to be 19.84% (95% CI: 17.76%, 22.11%), with 22.14% among food-insecure HIV-infected adults and 17.55% among food-secure HIV-infected adults.

7.5.7. Predictors of CD4 count change among adults receiving ART

In the bi-variable generalized linear mixed-effects model, nineteen variables—specifically, sex/gender, age of the respondent, educational status, occupational status, residence, type of care received, presence of anemia, food security status, presence of eating problems, duration of HIV

infection, duration of ART follow-up, nutritional status during follow-up, TPT provision status or IPT, WHO clinical stage, WHO treatment stage, smoking history, alcohol consumption, fruit and vegetable dietary intake, and adherence to the treatment schedule—were associated with a p-value of ≤ 0.20 and were subsequently selected as candidates for multivariable analysis. The duration of HIV infection showed a high correlation with the duration of ART follow-up; chewing khat was strongly correlated with cigarette smoking and alcohol consumption; and following special instructions was strongly corrected with adherence to the treatment schedule. Professional judgment was applied to select the most appropriate variables for inclusion in the final models.

Consequently, a multivariable generalized linear mixed-effects regression analysis with an identity covariance structure was fitted using all eighteen variables simultaneously. Six of the most contributing factors identified as significant independent predictors of CD4 count change at a 5% significance level. For the random-effects specification in the identification equation, we selected a model with an identity covariance structure, which is the default setting, providing a straightforward approach to managing random effects in our analysis. The model's fit and adequacy were evaluated using information criteria and a log-likelihood ratio test (LR chi-square = 205.23, $p < 0.001$).

Correlation Structure	**-2LL**	**LR TEST**	**AIC**	**BIC**
Identity	-480.7115	205.23	1005.423	1118.824

Accordingly, the gender of HIV-infected adults receiving ART was found to be a significant independent predictor of low CD4 count change, with the incidence of developing a low CD4 count change among males being 2.8 times higher than that of females (aRR = 2.88, 95% CI: 1.14, 7.30).

Food security status was the primary predictor considered at the beginning of this follow-up study. The analysis of the current follow-up data indicated that the food security status of HIV-infected adults is an independent predictor of low CD4 count after controlling for other potential confounders. Being food insecure was found to independently increase the risk of low CD4 count. The incidence of low CD4 count was 2.6 times higher among food-insecure HIV-infected adults compared to food-secure HIV-infected adults (aRR=2.56, 95% CI: 1.05, 6.26).

Being undernourished was found to be an independent predictor of increased incidence of low CD4 count change among HIV-infected adults receiving ART. Specifically, the incidence of low

CD4 count change was 2 times higher among undernourished HIV-infected adults compared to those with normal nutritional status (aRR=2.17, 95% CI: 1.03, 4.57).

Being anemic was found to be an independent predictor of an increased risk of low CD4 count. Specifically, the incidence of low CD4 count was 3.4 times higher among HIV-infected adults with anemia compared to their counterparts during the follow-up period (aRR=3.35, 95% CI: 1.37, 8.17).

The WHO clinical stage and the duration of antiretroviral treatment were identified as significant independent predictors of CD4 count change in HIV-infected adults. The incidence of low CD4 count was 4 times higher at the advanced WHO clinical stage compared to the early stage (aRR=4.11, 95% CI: 1.32, 12.84). Likewise, the incidence of low CD4 count was 3.6 times higher in those receiving ART for 4 years or less compared to those on ART for more than 4 years (aRR=3.64, 95% CI: 1.25, 10.63).

However, the analysis did not reveal a significant association between fruit and vegetable consumption, TPT or IPT provision status, and adherence to ART in the final generalized linear mixed-effects multivariable regression model. (Table 31).

Table 31: Predictors of low CD4 count change HIV-infected adults receiveing ART at health facilities in Northcentral, Ethiopia, 2024.

Variables	Response	cRR with 95% CI	aRR with 95% CI	aP-value
Sex	Male	3.26 (1.41, 7.53)**	**2.88 (1.14, 7.30)****	**0.026****
	Female	1.0	1.0	
Age respodents	<35 years	1.0	1.0	
	35-44 years	2.042 (0.78, 5.36)*	2.01 (0.76, 5.34)	0.162
	≥45 years	2.04 (0.71, 5.86)*	2.14 (0.72, 6.40)	0.173
Educational status	No formal education	1.0	1.0	
	Primary school	0.78(0.30, 2.05)*	0.82 (0.29, 2.26)	0.694
	Secondary and above	0.50(0.17, 1.45)*	0.51 (0.14, 1.79)	0.292
Occupational status	Farmer	1.0	1.0	
	House wife	0.49 (0.14, 1.76)	0.56 (0.10, 3.15)	0.512
	Daily laborer	0.44 (0.12, 1.54)*	0.35(0.07, 1.91)	0.225
	Employed	0.40(0.10, 1.55)*	0.72 (1.12, 4.37)	0.720
	Merchant/others	0.60(0.17, 2.06)	0.66 (0.12, 3.62)	0.635
Residence	Rural	1.0	1.0	
	Urban	0.49(0.20, 1.20)*	1.57(0.39, 6.35)	0.528
Type of care received	Psychological support	1.	1.0	
	Economic support	4.33 (0.87, 21.44)*	2.21 (0.42, 12.64)	0.392
	Social support and related	6.00 (0.75, 48.01)*	2.34 (0.20, 19.17)	0.491
Presence of eating problems	No	1.0	1.0	
	Yes	2.42 (0.88, 6.67)	2.52 (0.56, 12.62)	0.247
Food security status	Food secure	1.0	1.0	
	Food insecure	1.90 (0.92, 4.33) *****	**2.56 (1.05, 6.26) ****	**0.039****
Nutrional status	Under nutrition	2.34 (1.13, 4.85)**	**2.17 (1.03, 4.57)****	**0.042****
	Normal	1.0	1.0	
	Over nutrition	0.61 (0.19, 2.04)	0.85(0.25, 2.88)	0.794
Presence of Anemia	No	1.0	1.0	
	Yes	4.37 (1.84, 10.39) **	**3.35 (1.37, 8.17)****	**0.008****
WHO clinical stage	Stage one	1.0	1.0	
	Stage two &above	3.78 (1.55, 9.20) **	**4.11 (1.32, 12.84)****	**0.015****
Duration of ART	≤4 years	4.36(1.64, 11.59)**	**3.64 (1.25. 10.63)****	**0.018****
	>4 years	1.0	1.0	
TPT provision status or IPT	Given	1.0	1.0	
	Not given/discontinue	3.79 (1.32, 10.92)**	1.48 (0.25, 8.87)	0.667
Ever drink alcohol	No	1.0	1.0	
	Yes	2.24 (0.98, 5.15)*	2.16(0.92, 5.05)	0.077
Fruit and vegetable intake	≥one time per day	1.0	1.0	
	< one time per day	0.50(0.19, 1.30)*	0.74(0.16, 3.43)	0.699

The analysis for this particular paper indicates that the random effects components of the model capture the correlation in the repeated measurements. sd(b0i) =3.050 (95% CI: 2.540, 3.662) and sd("Σij) = 0.285.

Random-effects parameters	Estimate	Std. err.	[95% CI]	P-value
id: Identity: sd(_cons)	3.050	0.285	(2.540, 3.662)	<0.001

8. Discussion

8.1. The effect of gender on food insecurity among HIV-infected adults (Paper I)

Our review and meta-analysis estimated the pooled effect of gender on food insecurity among HIV-infected adults receiving ART. The review and analysis demonstrated that the gender of HIV-infected adults has strong statistically significant effect on food insecurity. The odds of developing food insecurity among female HIV-infected adults receiving ART were higher than male HIV infected adults.

The significant effect of gender on food insecurity found in the current review and analysis is in line with the findings of a global gap analysis systematic review on food insecurity and HIV/AIDS in which significant inequity in the experience of food insecurity by gender was found, with females being most at risk in both resource-rich and resource-limited settings [78]. This finding is also consistent with the finding of a systematic review for formulating a conceptual framework for food insecurity and health, in which female HIV-infected adults were most affected by food insecurity [143]. As discussed above, these findings may be due to the fact that most females in the relationship have little power over household resource and food allocation, and that they serve as caregivers, which in turn, inhibits their ability to make further investments in their own skills and education, increasing their susceptibility to food insecurity.

The finding of the current review was also consistent with the evidence of a global policy review by the International Food Policy Research Institute, which indicated that gender inequity shapes power relations and risk [63]. The significant effect of gender on food insecurity in the current review is in line with the findings of narrative reviews and international food assistance program guidelines, in which food insecurity remains a challenge for women across diverse settings [58, 72].

Our analysis indicated a relatively consistent significant effect of gender on food insecurity among HIV-infected adults across study designs and country income levels. We found that cohort studies had weaker associations than cross-sectional studies due to the lack of temporal relationship assurance in cohort studies.

In addition, our analysis found that the weakest associations between food insecurity and gender occurred in the studies conducted in high-income countries and the strongest in low and middle-income settings. This most likely could be due to a relative lack of female social development

particularly a lack of education in low-and middle-income settings as well as lower female power in decision-making around resource allocation. This highlights a limited access to education and limited female empowerment in decision-making, in these settings. Addressing these issues may improve women's social development, enhance their decision-making power, and contribute to more equitable resource allocation.

8.2. Food insecurity and its severity among adults receiving ART (Paper II)

This study aimed to determine the magnitude of food insecurity and identify its associated factors among HIV-infected adults receiving ART. We found that a significant proportion (33.7%: (30.60, 36.91)) of the HIV-infected adults studied experienced food insecurity during their treatment and care follow-up. Gender, early age, occupational status, educational status, monthly income, WHO clinical stage, and duration of ART, were significantly and independently associated with food insecurity.

The magnitude of food insecurity in this study is in line with the study conducted in West Shoa Zone (35.2%) [95] and in Kenya (33.5%) [78]. However, the finding is lower than the finding of some recent studies in Ethiopia, particularly studies conducted in Benishangul Gumuz (76%) [144], Hospitals in western Ethiopia (68.8%) [41], Debre Markos Town (84.52%) [35], Hosanna (67.53%) [34], (68.48%) [33], Tigray (40.43%) [96], two studies in Jimma (63.01%) [36], (85.92%) [30], Kembata Tembaro (57.3%) [145] and in two studies in Butajira (78.11%) [31], (79.02%) [32]. The difference may be due to the time gap, in which the majority of previous studies were conducted almost 10 years, and the large sample size and multiple study settings that are considered in the current study.

The magnitude of food insecurity in this study was also lower than in some previous studies in African countries. For instance, South Africa among PLHIV (60%) [55], Democratic Republic of Congo (57%) [25], and Dakar (84.6%) [26], Rural Uganda (74.6%) [89] and (38%) [90]. The long duration since these studies were conducted, the socio-economic characteristics of the population, and the cultural context of the study areas are considered to be possible explanations for the difference in the level of food insecurity.

The magnitude of food insecurity in the current study is higher than the finding of the study conducted in Dembia Gondar (18.36%) [93] and Arba Minch (19.54%) [94]. The possible explanation may be the smaller sample in the previous study and the timing of the study.

We find that 52.4%(46.6, 58.1) of HIV-infected adults experienced a severe form of food insecurity, which is extremely higher than the finding of studies in Western Ethiopia (16.35%) [41], Kembata Tambaro Zone (17.4%) [145], two studies in Butajira (42.0%) [31] and (41.7%) [32], and Brazil (17.6%) [24]. This needs critical attention in care and support during ART follow-up as only 4.99% of the participants reported that they received food and related care and support including nutritional counseling. However, the magnitude of severe food insecurity the finding from Nambia (67%) is higher than the finding of the current study [91]. This finding highlights the urgent need for improved care and support during ART follow-up, including increased access to food assistance and nutritional counseling to ensure better health outcomes. We find the strong and significant association between the gender of HIV-infected adults and food insecurity, in which the proportion of food insecurity was 2 times higher among females. This finding is unsurprising and in line with those recent studies on the topic. For instance, a systematic review that was published by the same authors at the early stage of this study [56], a study conducted in Arba Minch [94], and the Dominican Republic [97]. However, it needs special attention in a country like Ethiopia, in which women are more disadvantaged both socially and economically which can aggravate their food insecurity situation.

Our study found that age and magnitude of food insecurity were significantly associated, in which the proportion of food insecurity was higher in the early age group as compared to the older age group. Surprisingly, we find mixed evidence regarding age as a contributing factor for food insecurity among HIV-infected adults. For instance, the younger age of patients was associated with an increased proportion of food insecurity in the study conducted in Brazil and other high resource setting [24, 54], and African countries [146], and while an increased proportion of food insecurity was found among older age adults in the United States [147] and some studies indicated a lack of significant association between patients' age with food insecurity. This indicates the need for further study on the association between the age of HIV-infected adults and food insecurity.

This study found a significant and independent association monthly income of HIV-infected adults and food insecurity that stipulated the lower the monthly income the higher the proportion of food insecurity among HIV-infected adults. This finding was fairly established and in line with the findings of previous studies conducted in Western Ethiopia [41], Hosana Town [34], Kambata Tembaro zone [145], Arba Minch [94], Butajira [32], and rural Zambian Hospitals [148].

We found a strong significant association between the proportion of food insecurity and the educational status of HIV-infected adults, in which the proportion of food insecurity was higher among HIV-infected adults who had no formal education and attended primary school. The finding is in line with other previous studies that no education and lower level of education were found to be strongly associated with food insecurity in Western Ethiopia [41], Hosanna Town [34], Brazil [24], Jimma Zone [36], and Nigeria [28].

In the current study, the lack of permanent employment was found to have a significantly strong association with the proportion of food insecurity higher among daily laborer patients. It may be the result of a lack of permanent employment that will affect earning capacity of the HIV-infected adults which will also in turn leads to an increased proportion of food insecurity. The finding is supported by the finding of the previous studies that unemployment was found to have a significant association with food insecurity in Hosanna Town [34], Nigeria [28], and Brazil [24].

Concerning clinical factors, we find a significant and independent association between the WHO clinical stage and the duration of antiretroviral treatment among HIV-infected adults. The proportion of food insecurity among patients with advanced the WHO clinical stage and receiving ART for less than 4 year's duration was found to be high. This may be due to worsening disease situations and deteriorated health status at the advanced clinical stage of HIV with delayed ART initiation. The significant association of food insecurity with advanced clinical stage is supported with previous studies conducted in different areas and settings, for example, in Ethiopia [33, 38, 42, 94, 145]. In the same way, significant association with ART is also supported by the findings of studies conducted in Africa including Ethiopia [54] and Namibia [91], in which the shorter duration of ART and the high proportion of food insecurity among HIV-infected adults.

However, we found a lack of significant association between food security and socio-economic status and food support in the final log-binomial multivariable regression while the absence of food support was found to be strongly associated with food insecurity in South Wollo [42], Kembata Tembaro and Hossana Town [33, 145] and Dominican Republic [97]. The lack of significant association between therapeutic feeding supports in the current study may be due to the fact that very insignificant proportion of HIV-infected adult received food by prescription.

8.3. Fruit and vegetable dietary intake and its estimated amount consumption among adults (Paper III)

This study aimed to determine the magnitude of fruit and vegetable dietary intake and identify its associated factors among HIV-infected adults receiving ART in health facilities of Northcentral Ethiopia. Accordingly, the current study found that more than three-fourths (76.34%: (73.38, 79.07)) of the HIV-infected adults who participated in the study reported as they consumed fruit and vegetable with less than one median frequency per day. This indicated the very low fruit and vegetable dietary intake in the studied population with critically low fruit dietary intake, in which 97.67% (96.41, 98.49) of them reported as the consumed fruit less than one median frequency per day. The study finds a very low frequency of fruit and vegetable consumption among HIV-infected adults in northcentral Ethiopia. The proportion of HIV-infected adults who consumed fruit and vegetable less than once a day was seriously higher than the finding of the study conducted in Nampula Central Hospital (42.5% and 23.7%) [149], and study conducted among students in OYO STATE of Nigeria (63%) [150]. However, the finding is lower than the finding of the study conducted among adults in South Africa, in which only 0.6% of adults reported they had consumed an adequate amount of fruits and vegetables daily [151]. The finding is higher than the finding from Five Southeast Asian Countries among the general population of adolescents, in which 28% reported consuming fruits less than once per day and 13.8% indicated consuming vegetables less than once per day [152].

The frequency of fruit and vegetable consumption across all nine categories was low, 23.89% and 20.63% of the HIV-infected adults consumed 100% fruit juice and whole fruit once per month, respectively. Despite the productivity of the study area, only 26.92% and 18.65% of HIV-infected adults consumed green leafy vegetables and salad one time per month and 2-3 times per month, respectively. This finding is still very much lower than the finding of the study conducted in Nampula Central Hospital among a similar population, in which the highest frequency of consumption were mango, papaya, and bananas among fruits (48.75% of women and 40% of men) [149].

The overall median amount of the fruit and vegetable dietary intake in this study was was 271.3 g/day, of which the median amount of fruit and vegetable consumption was 248.1 g/day and 273.8g/day, respectively. This finding is lower than the WHO/FAO recommendation that individuals should consume 400 or more grams of fruits and vegetables for their overall health

improvement and chronic infections prevention [142]. The finding is in line with the finding of the studies in Thailand, in which the amounts of fruit and vegetables consumed by study participants were very much lower than the daily recommended amount [153, 154]. The difference may be the small sample of the current study and study settings. In addition, the difference may be due to the difference in the study population in which WHO recommendation is for general health population, while the current study is conducted among HIV-inefected adults. The finding of the study also much lower than the finding of study conducted among HIV-Infected pregnant women in Kenya, in which the overll mean quantity of fruits and vegetables consumed was 301.2g/day [155].

Marital status, occupational status, caregiver's category, WHO clinical stage, and duration of ART, were found to be statistically significant contributing factors for this low level of fruit and vegetable dietary intake. The current study found that the marital status of the HIV-infected adults was significantly associated with fruit and vegetable dietary intake, in which, the proportion of fruit and vegetable was two times higher among divorced as compared with those who are still in marriage. Surprisingly, we find varied evidence about marital status of HIV-infected adults as a contributing factor for fruit and vegetable dietary intake. For instance, the finding is in line with the finding of the systematic review of fruit and vegetable consumption among European elders, in which most of the socio-demographic and socioeconomic characteristics including marital status showed statistically significant association with FAV [107]. However, the direction of association is varied from study to study like the studies conducted in the France and Thialand [154, 156] and Switzerland [157] indicated that being a single status and separate living status was associated with high vegetable consumption. The disparity may be due to differences in the study population, in which both studies were conducted among elders, and the long duration of the previous study. In another hand, the difference may be the difference in the study settings and the age of participants, in which the previous studies were conducted in high-income countries and advanced age groups.

The finding of this study showed that the consumption of producers of the fruit and vegetable was extremely low, in which the proportion of recommended frequency of the consumption is higher among daily laborers, employers, and mechants as compared to farmers who are the producers of those fruit and vegetables. This is supported by the global health and metric analysis finding, in which fruit and vegetable availability has consistently been insufficient to supply recommended consumption levels [158]. The finding of this study is in line with the finding of study conducted

among adults in South Africa, in which proportion of consuming 2–3 daily servings of vegetables and two of fruits was higher among employed adults than unemployed adults including farmers [151].

The type of caregivers who have been providing care was found to have a statistically significant association with fruit and vegetable dietary intake, of which the proportion of fruit and vegetable dietary intake was higher among HIV-infected adults whose caregivers are their children as compared to those whose caregivers are their mother/fathers. The role of informal caregivers is critical for the success of ART and related care including nutritional intervention especially children as caregivers for their families will play a critical role as they may care for their family more than other categories of caregivers such as mothers/fathers.

The current study finds an independent and statistically significant association between increased fruit and vegetable dietary intake, and the advanced WHO clinical stage and longer duration of ART among HIV-infected adults. The proportion of fruit and vegetable dietary intake among HIV-infected adults with advanced the WHO clinical stage and receiving ART for more than 8 year's duration was found to be high. This may be due to the change in their awareness of nutrient-dense foods consumption, including fruit and vegetable through patient education and nutritional counseling during the long-duration treatment follow-up. The longer duration of the treatment follow-up and better awareness about disease progress and related precaution as they had several contacts with help professionals. As this study is among the very few studies conducted in Africa following the study conducted among HIV-infected pregnant women and the first study in Ethiopia among HIV-infected adults, we did not find the literature to compare the findings related to clinical factors and fruit and vegetable dietary intake.

However, the current study did not indicate a statistically significant difference in fruit and vegetable consumption among food-secure and food-insecure HIV-infected adults. A similar finding was observed for psychosocial support in the final Poisson multivariable regression while the presence of food insecurity was more likely to report decreasing any type of fruit and vegetable consumption during the COVID-19 pandemic in high-income countries [159]. Other finding indicated that the fruit and vegetable intake was higher among food-secure households than food insecure, in which the probability of having low fruit and vegetable intake increased among food-insecure individuals [160].

8.4. The effect of food insecurity on clinical progression of HIV/AIDS (Paper IV)

The current multicenter prospective cohort study aimed to examine the effect of food insecurity on the clinical progression of HIV/AIDS among adults receiving ART and to identify its independent predictors among HIV-infected adults receiving ART in health facilities of Northcentral Ethiopia. Accordingly, the study found that the overall incidence of poor clinical progression during the follow-up period was 21.17% (95% CI: 19.27, 23.18), with the incidence being more than twice as high among food-insecure individuals (28.84%) compared to food-secure individuals (13.65%). This finding is surprisingly higher than the findings from the African Cohort Study (9%) [161], the Treat Asia HIV Observational Database (3 per 100 person-years) [162], and studies conducted in Ethiopia (12.22% and 10.24%) [163, 164]. However, the two studies conducted in Ethiopia were retrospective follow-up and cross-sectional studies, which may not be directly comparable to the current study, which was a prospective cohort study.

We observed an increasing trend in the incidence of poor clinical progression over the follow-up period, with rates of 18.56%, 21.14%, and 23.84% at the first, second, and third visits, respectively. The increased trend of food insecurity on the clinical progression of HIV/AIDS persisted throughout the follow-up, with the incidence of poor clinical progression among food-insecure HIV-infected adults being twice as high as that of food-secure HIV-infected adults: 25.00%, 28.78%, and 32.85% at the first, second, and third visits, respectively. Despite the lack of studies directly assessing the effect of food insecurity through prospective follow-up, existing evidence indicates that food insecurity is associated with a range of negative health outcomes among HIV-infected adults, including clinical progression. It can affect HIV health outcomes and prevention strategies in both resource-rich and resource-poor settings [20]. This may be due to the persistent lack of various forms of support, including therapeutic food support, which only 4.4% of participants in the current study reported receiving therapeutic food support, as well as the ongoing insecurity in the study area for more than five years. These factors have contributed to the higher severity of food insecurity, leading to poor clinical progression.

The findings of this study also indicated a significantly higher risk of poor clinical progression among food-insecure HIV-infected adults, with more than a fivefold increased risk compared to food-secure HIV-infected adults. The findings are unsurprisingly supported by evidence from a study conducted in San Francisco and other resource-poor settings, which indicates that food insecurity negatively impacts clinical and health outcomes [78] among HIV-infected adults, such

as incomplete viral load suppression, increased hospitalizations, and disease progression [20, 22, 60, 73], in which 37.2% of HIV-infected adults had unsuppressed viral loads in San Francisco study [76]. The findings of this study are also supported by a study conducted in Atlanta, Georgia, where food insecurity was significantly associated with unsuppressed HIV and multiple hospitalizations for HIV-related conditions [52].

Despite the variation in the setting in which the current study was conducted, the finding is in line with the finding of a study conducted in New York State, where an increase in the severity of food insecurity was found to increase the incidence of unsuppressed viral load, an indicator of poor clinical progression [165]. The findings are supported by a study conducted in Ethiopia, where an increased incidence of poor clinical progression was found among food-insecure HIV-infected adults [33].

Surprissingly, the finding is not supported the study conducted among Russians who were not on ART that there was no significant differences in HIV viral load between food insecure and food secure groups [84]. The lack of significant differences in the Russian study may be due to the absence of treatment, which worsened the clinical progression in both groups, or other underlying factors specific to this context.

The types of care received from informal caregivers, nutritional status during follow-up, duration of ART follow-up, and WHO treatment stage were found to be significant independent predictors of poor clinical progression. The type of informal care provided by different sources or caregivers was identified as a significant independent predictor of poor clinical progression. Specifically, individuals receiving economic support experienced a higher rate of poor clinical progression compared to those who received psychological support. This could be due to the fact that economic support alone may not be as effective in improving clinical outcomes if it does not address the psychological and emotional needs of individuals. Psychological support has a more direct and substantial effects on clinical progression by addressing the mental and emotional aspects of individuals living with HIV. While economic support addresses immediate material needs, psychological support plays a crucial role in overall disease management and clinical outcomes, suggesting the integration of both types of support.

The incidence of poor clinical progression among undernourished HIV-infected adults was higher than among those with normal nutritional status. This finding is unsurprising and consistent with

studies from Sub-Saharan Africa, where the increased risk of morbidity and mortality is significantly associated with undernutrition-related immune system dysfunction and increased susceptibility to opportunistic infections [166]. Similarly, a study conducted in Ethiopia presented findings that support the current study, showing that food insecurity more than doubled the risk of malnutrition, which, in turn, increased the odds of poor clinical progression [33].

The study finds the increased incidence of poor clinical progression among HIV-infected adults at advanced WHO treatment stage. This finding is not surprising, as individuals at advanced treatment stages are more likely to experience rapid and severe clinical progression due to a compromised immune system. This results in a higher risk of poor clinical outcomes, such as deteriorating health, increased hospitalizations, and a higher mortality rate, and can also lead to significant declines in health and quality of life. This finding is supported by a cohort study among HIV-infected individuals in Guinea-Bissau, which found that advanced WHO stages at entry were significantly associated with poorer clinical progression [167]. However, we did not find more previous studies that measure the effect of entry WHO treatment stages as a predictor variable for clinical progression.

The duration of ART follow-up was found to be a significant independent predictor of HIV clinical progression after controlling for the other potential confounders. A shorter duration of ART follow-up (4 years or less) was associated with an increased incidence of poor clinical progression among HIV-infected adults receiving ART. This could be due to the adverse side effects of the medication, which may be more pronounced early in the treatment, coupled with a lack of comprehensive psychosocial support during these initial stages, leading to challenges in managing the condition effectively.

The findings of previous studies do not support the current study's findings. For example, in Uganda, the longer duration of follow-up was associated with an increased incidence of poor clinical progression among HIV-infected adults, due to a higher number of hospitalizations and missed clinic visits [60]. Similarly, a longer duration of follow-up was linked to an increased incidence of poor clinical progression due to decreased adherence to ART in China [168], and in a multicenter randomized strategy trial [169].

However, the analysis did not indicate a significant association between HIV-seropositivity disclosure status and the level of adherence in the final generalized linear mixed-effects

multivariable regression model. While improved ART adherence had a significant effect on disease clinical progression in a study conducted in Atlanta, Georgia [111], the disclosure of HIV status was found to have significant effects on HIV clinical progression through reductions in adherence to clinic visits and patient representation in a study conducted in Eastern Uganda [170].

8.5. The effect of food insecurity on CD4 count change among adults (Paper V)

The current multicenter prospective cohort study aimed to investigate the effect of food insecurity on CD4 count changes in HIV-infected adults receiving ART, along with other independent predictors of CD4 count changes in health facilities in Northcentral Ethiopia. Accordingly, the median CD4 counts at the first, second, and third visits were 433 cells/µl (IQR: 255-607), 482 cells/µl (IQR: 326-698), and 523 cells/µl (IQR: 356-687), respectively.

This finding is consistent with the findings of the collaborative analysis of cohorts from low-income countries (sub-Saharan Africa, Latin America, and Asia), where the median CD4 cell count increased over the follow-up period from 114 cells/µL at ART initiation to 395 cells/µL (IQR 240-592) at the fifth year of follow-up [171]. The findings from the TREAT Asia HIV Observational data analysis and the retrospective analysis in northern Ethiopia also indicated that the median CD4 count continued to increase even when the concurrent HIV viral load was detectable over the follow-up period [172-174]. However, the median increase in CD4 count in the current study appears higher than that in previous studies. This may be attributed to the longer duration of follow-up, the larger sample size with broader area coverage, and the socio-economic variations of the previous studies from the current one.

The study found that the overall incidence of low CD4 count (<200 cells/mm^3) over the follow-up period was 19.84% (95% CI: 17.76–22.11), with a higher incidence among food-insecure HIV-infected adults (22.14%) compared to food-secure HIV-infected adults (17.55%). This finding is in line with the findings of the studies conducted in the different part of the world. For instance, the longitudinal study and retrospective anlasyis conducted in San Francisco (21.9%) [76] and Bhutan (20%) [175], in which patients had CD4 counts below 200 cells/mm^3.

The study indicates a decline in the incidence of low CD4 count (a CD4 count <200 cells/mm^3) from 23.76% to 17.26% during the follow-up period, suggesting a slight increase in the incidence of immunological recovery over the 9 months of follow-up. This could be due the effectiveness of ART in promoting immune recovery, consistent adherence to treatment, and improved patient

management, leading to enhanced immune function over time. This finding is consistent with the findings of a retrospective analysis in Ethiopia, where the incidence of CD4+ cell count <200 cells/mm³ declined from 28.3% to 15.0% over the follow-up period [174].

However, the incidence of low CD4 count among food-insecure individuals was consistently higher than among food-secure individuals: 26.70%, 20.37%, and 19.14% of HIV-infected adults with a low CD4 count (<200 cells/mm³) were food-insecure at the first, second, and third visits, respectively. This suggests that food insecurity may have a persistent effect on immune function over time, potentially due to inadequate nutritional intake, which can impair immune response and contribute to lower CD4 counts in food-insecure individuals. This finding is consistent with the findings of prospective cohort studies conducted in the Boston and Providence area [85] and British Colombia [53], where the incidence of low CD4 count was persistently higher among food-insecure individuals across repeated measurements. The study reflected negative changes in CD4 count over the follow-up period, predicting a decrease of 99.5 cells/μL in CD4 count over that time [85].

The current follow-up study underscores that food insecurity was found to be an independent predictor of low CD4 count after controlling for other potential confounders, in which the risk of low CD4 count was more than twofold higher among food-insecure HIV-infected adults compared to their food-secure counterparts. This finding is supported by studies conducted in San Francisco [76] and Atlanta, Georgia [52], which showed that food insecurity increased the incidence of low CD4 cell counts (<200 cells/mm³) and worsened immunological outcomes. The finding also supported by the finding of study in British Columbia, Canada, in which the significant decreasing trend of CD4 count was found in food-insecure HIV-infected adults [53].

However, the finding of a study conducted in a cohort of U.S. veterans [81] and Russia ARCH cohort [84] were inconsistent with the current study, as there was no significant difference in low CD4 counts between food-insecure and food-secure individuals. This discrepancy may be due to variations in the study populations, including differences in socioeconomic status, access to healthcare, and adherence to ART. These factors could influence the impact of food insecurity on immune function and CD4 counts, leading to divergent outcomes across different settings.

The gender of participants, nutritional status, presence of anemia, WHO clinical stage, and the duration of ART were found to be significant independent predictors of low CD4 count. The

finding indicated the gender of HIV-infected adults receiving ART was found to be a significant independent predictor of low CD4 count change, in which higher incidence of developing low CD4 count change found among male than females. This finding is unsurprising and is supported by the descriptive results of this study, which indicated that more than half of the participants reported consuming alcohol (51.49%), a behavior common among males in Ethiopia. Evidence suggests that people with HIV who regularly drink alcohol tend to have a compromised immune system, with a lower overall CD4 count. This finding is consistent with the findings of studies conducted in Ethiopia [174] and Bhutan [175] where a larger number of males showed a low CD4 count (<200 cells/μL) compared to females, as well as a study in Brazil and in low-income countries [171, 176], which found that immune recovery was significantly higher among females than males.

The finding indicated that poor nutritional status independently predicted an increased incidence of low CD4 count among HIV-infected adults on ART, with undernourished individuals found to have twice the incidence of low CD4 count compared to those with normal nutritional status. Unsurprisingly, this finding was supported by a longitudinal studies conducted in Senegal, which found that poor nutritional status significantly predicted poor immunologic recovery [26, 177]. This may be due to the persistent lack of various forms of support, including therapeutic food support, with only a few participants (4%) in the current study reporting they received such support. This lack likely contributed to undernutrition, leading to low CD4 counts. This was supported by a study in Malawi, which found that therapeutic food support had significant effects on nutrition and immunological response [118].

However, surprisingly, this finding is inconsistent with a cohort study in Indonesia, which found no significant association between changes in nutritional status and changes in CD4 cell count after 6, 12, and 18 months of treatment [178]. This discrepancy could be due to differences in the study populations, including baseline nutritional status, healthcare access and quality, dietary practices, and the availability and quality of nutritional support programs, all of which may have influenced the outcomes differently.

This study found that anemia independently predicted a threefold increased risk of low CD4 count among HIV-infected adults during the follow-up period. This may be due to anemia's impact on immune function, exacerbating the effects of HIV on CD4 counts. This finding is consistent with

a study conducted in Nepal [179], which found that the presence of anemia was significantly associated with immunological status.

The study found that WHO clinical stage had a significant independent effect on CD4 count change, with the incidence of low CD4 count being four times higher at the advanced WHO clinical stage compared to the early stage. This is likely because advanced WHO clinical stages are associated with more severe disease progression, which can lead to greater immune system compromise and lower CD4 counts. Surprisingly, we found inconsistent findings in a study conducted in Uganda, where more than half of the subjects with CD4 counts (≥200 cells/μL) were at an advanced WHO clinical stage [180], and in a retrospective analysis in Ethiopia [181], where most patients presenting with severe immunosuppression (CD4 count <200 cells/μL) were classified in early WHO clinical stages. This discrepancy could be due to an imbalance in the number of study participants in the Uganda study, where the majority were in the advanced disease stage, variations in the populations studied, the long time elapsed since the study was conducted, and the retrospective nature of the study in Ethiopia, where confounders were not adequately addressed.

The finding revealed that the duration of ART independently influenced changes in low CD4 count among HIV-infected adults. The incidence of low CD4 count was four times higher in those receiving ART for 4 years or less compared to those on ART for more than 4 years. This may be due to longer ART duration allowing more time for immune system recovery and better management of the disease, leading to improved CD4 counts. This study's finding surprisingly not supported by a studies in Namibia [91] and Ethiopia [182], which found that a longer duration of ART was associated with a higher risk of poor adherence, leading to lower CD4 counts.

The analysis did not reveal a significant association between low CD4 count and fruit and vegetable consumption in the final multivariable generalized linear mixed-effects model, whereas consuming fruits and vegetables was identified as an important predictor of immune recovery in a study conducted in the Southwest region of Cameroon [183]. This difference may be due to variations in the types and quantities of fruits and vegetables consumed and differences in overall diet quality, which could influence immune recovery.

9. VALIDITY AND GENERALIZABILITY OF THE STUDY

The validity of any study depends on the study design, data collection instruments, and appropriate methods for handling random and systematic errors. Therefore, this dissertation has employed various techniques to enhance internal and external validity at the design, data collection, and analysis stages. Multiple study designs were used to address the research questions from different perspectives, including a systematic review and meta-analysis, a multi-facility-based cross-sectional study, and a multi-facility-based prospective cohort study. Additionally, we tried to control the effects of bias, chance, and confounding factors at all stages.

We developed an extensive search strategy to include relevant studies on the topic and set eligibility criteria that were appropriate for selecting suitable articles and documents, including PICO. The use of the JBI-MAStARI for critical appraisal of identified paper for review helped ensure the external validity of the study [135]. Additionally, more than one independent reviewer was involved in the review process to minimize the risk of bias in the selection and quality assessment of each article or document. A rigorous meta-analysis, including a detailed publication bias assessment, was conducted to ensure the overall quality of the study, thereby strengthening both the internal and external validity of the paper.

A fairly large and representative sample size was estimated for primary data based papers, considering the necessary assumptions, including statistical power, to ensure the representativeness of the sample and, consequently, the external validity of the papers. Sample sizes were calculated for all specific objectives within these papers to identify the largest sample size needed for representativeness across all objectives. As a result, the largest sample sizes were used for each paper to increase the precision and power of the study. Appropriate statistical significance tests at the 5% significance level and 95% confidence intervals for each measure of association (odds and risk ratios) were applied to minimize the role of chance in the estimation and decision-making processes. Additionally, the use of probability sampling, which ensures an equal chance for all members of the study population to be selected, helped minimize selection bias from the chosen health facilities. The high institutional coverage was ensured with proportionate rural and urban representation. We included eighteen health facilities providing ART services, covering all 16 districts of the North Shewa zone in the Oromia region, in this dissertation.

The primary data collection for this dissertation was based on a prospective cohort study, where the effect of selection bias is minimal; however, it may still occur due to losses to follow-up. Notably, the cumulative loss to follow-up rate across all four papers in this dissertation was 3.1%, which is significantly lower than the estimated loss to follow-up/non-response rate of 5% used in the sample size calculation for all the objectives of the papers.

The use of standard data collection instruments such as the FANTA tool for food security [112, 125], BRFSS assessment tools for fruit and vegetable dietary intake [100, 126], and the KOBO Toolbox online data collection platform, along with the recruitment of qualified and experienced professional data collectors and supervisors, training for data collectors and supervisors, pretesting of tools for content validation, supervision and follow-up, and proper data management, minimized measurement bias.

All relevant potential confounders were identified and considered from the existing literature before developing a conceptual framework at the design stage and selecting of candidate variables for multivariable regressions to minimize confounding effects during the analysis. Measures for controlling confounding effects, such as multivariable analysis with backward elimination variable selection methods, were applied in all regression models used in this dissertation. The use of regression models appropriates for each study design and data type, such as log-binomial regression, Poisson regression models with robust variance estimates, and generalized linear mixed-effects models with a logit link function, improved the estimation of effect measures and addressed related conditions, thereby ensuring the validity of the findings.

Therefore, the findings of this dissertation can be reasonably generalized to the HIV-infected population living in the North Shewa zone, the region, and the country in settings with similar conditions. However, some findings of this study, particularly those based on primary data, are less likely to be replicated in settings with different sociocultural, socioeconomic, and other related characteristics—especially in more developed contexts where living standards, including food and nutrition security and healthy diet practices, have improved.

10. Strengths and limitations of the study

10.1. Strengths of the study

The following are the strengths of the dissertation: First, the use of comprehensive search strategies across various databases in the systematic review and meta-analysis helped include both published and unpublished studies. The use of an internationally agreed-upon and validated critical appraisal tool/checklist (JBI-MAStARI), along with the involvement of multiple assessors in the quality assessment and the application of a random effects model, ensured the validity of the findings by addressing risks of bias in the assessment and selection, as well as potential variability across studies in the analysis.

Second, the current dissertation utilized multiple study designs and included nearly all hospitals and high-caseload health centers in the North Shewa Zone, encompassing diverse levels of service delivery helped to generate comprehensive evidence for policy and program implications. Third, it is the first study conducted based on a multicenter prospective cohort study to assess the effect of food insecurity on the clinical progression of HIV/AIDS and CD4 count changes among HIV-infected adults receiving ART in Ethiopia in general, and in the North Shewa Zone of the Oromia Region in particular. This also helped to test temporal relationships and assume less recall bias. Fourth, this study is also the first study conducted in Ethiopia to assess and measure the fruits and vegetables dietary intake and its estimated consumptions among HIV-infected adults, providing valuable insights to design nutritional counseling strategies for this population sub-group.

Fifth, the dissertation utilized a large sample size to ensure the precision and power of the study in relation to the total number of HIV-infected adults receiving ART. This could improve the representativeness of the sample, ensure the external validity of the findings, and highlight the importance of the finding at the national level for designing specific interventions and strategies to address food and nutrition problems among HIV-infected adults. Sixth, the use of standardized tools (FANTA tool and BRFSS assessment tools), along with their content validation adapted to the local context, ensure the validity and reliability of the data in assessing and measuring food security status and fruit and vegetable dietary intake with its estimated consumption.

Seventh, though food insecurity often arises from chronic diseases and related situations (intermediate and chronic FI), such as prolonged poverty, lack of assets, and inadequate access to productive or financial resources, it is long-term, persistent, and predictable, following a sequence

of known events. We considered a follow-up period of less than one year (nine months) to minimize the effect due to its transient nature.

Eightth, the use of the KoboToolbox digital data collection platform, which allows the investigator to monitor and approve the data collected on a daily basis, along with training for data collectors and supervisors, supervision and follow-up, and proper data management, ensured the credibility of the evidence generated through this study. Ninth, the study considered potential temporal and cultural variations in dietary patterns for FAV assessment, including the effects of religious fasting and feast periods. This enhances the reliability of the dietary intake estimates. A structured and contextually adapted BRFSS tool was employed to capture usual intake while accounting for seasonal and religious variations.Last, advanced statistical models appropriate for each study design and data type, such as log-binomial regression, Poisson regression models with robust variance estimates, and generalized linear mixed-effects models with a logit link function, were used to ensure accurate estimation of effect measures and to address data-related effects for each paper in identifying independent predictors.

10.2. Limitations of the study

The study has some situational and methodological limitations. First, restricting the systematic review and meta-analysis to studies published in English, limited the number of studies included in the analysis. Second, the use of a cross-sectional study design for the first two papers may limit the ability to identify causal relationships between dependent and independent variables in both papers due to lack of a temporal relationship.

Third, there is a possibility of recall bias, particularly in the assessment of food security status and fruit and vegetable dietary intake, as participants were asked about their experiences over the past 30 days for both issues. Fourth, since both food security status and fruit and vegetable intake were assessed through participants' self-reports, there is a possibility that some participants may have misreported, potentially leading to an overestimation or underestimation of the magnitude of food insecurity and fruit and vegetable dietary intake.

Fifth, there is a possibility of social desirability bias due to the sensitivity of issues under study and the limited cultural openness in our society to discuss such sensitive topics frankly. Sixth, the lack of adjustment for day-of-the-week effects in fruit and vegetable (FAV) consumption may

obscure variations across different days and could have led to underestimation of usual FAV intake.

Last, there are limited previous studies on fruit and vegetable dietary intake among HIV-infected populations, as well as prospective cohort studies on the effect of food insecurity on the clinical progression of HIV/AIDS and CD4 count changes, making comparisons with these findings challenging.

11. Conclusions

The systematic review and meta-analysis indicated a consistent and statistically significant association between gender and food insecurity among HIV-infected adults receiving ART, being female showing a significant positive association with the development of food insecurity across various settings. This association was strongest in low- and middle-income countries, where the odds of developing food insecurity among HIV-infected females living in the low and middle income countries was higher compared to those living in high-income countries.

The study found a high magnitude of food insecurity among HIV-infected adults receiving ART, with an extremely high magnitude of the severe form of food insecurity. Although there has been a slight improvement in food insecurity levels among PLHIV over the past few years, it remains to be a critical public health problem in our society, even in areas with surplus crop production. The gender of HIV-infected adults, younger age, occupational status, educational status, monthly income, WHO clinical stage, and duration of ART were all significantly and independently associated with a high prevalence of food insecurity among HIV-infected adults.

Our finding indicates that a very high proportion of HIV-infected adults consumed fruits and vegetables less than once per day, a dietary intake considered very low and far below the minimum recommendations for health, which will reduce protection against opportunistic infections and non-communicable diseases of all types. Despite living in a surplus production area, farmers were less likely to consume fruits and vegetables. The marital status, occupational status, type of caregivers, WHO clinical stage, and duration of ART were found to be significant and independent predictors of fruit and vegetable dietary intake of HIV-infected adults.

In this study, poor clinical progression was notably higher among food-insecure individuals, with more than double the incidence compared to food-secure HIV-infected adults. The trend of poor clinical progression increased over time, and the effect of food insecurity on HIV/AIDS

progression remained significant throughout the follow-up period. The types of psychosocial care received from informal caregivers, food security status, nutritional status during follow-up, duration of ART, and WHO treatment stage were found to be significant independent predictors for poor clinical progression.

The study found that while the median CD4 count increased over time, the incidence of low CD4 count (<200 cells/mm³) remained high, particularly among food-insecure individuals, compared to food-secure individuals. Although there was a decline in incidence of low CD4 count over 9 months, indicating slight immunological recovery, food-insecure individuals consistently experienced a higher incidence of low CD4 counts. The gender of participants, food security status, nutritional status, presence of anemia, WHO clinical stage, and duration of ART were found to be significant independent predictors of low CD4 count.

12. Recommendations

Based on the findings of the study the following recommendations are forwarded:

FMOH, RHB, ZHD, and health facilities

- Policymakers, planners, program managers, and healthcare providers should give due attention to food insecurity in HIV care and treatment.
- Efforts should be made to strengthen food and nutrition intervention programs, such as "food by prescription," in a culture- and context-specific manner, which in turn would lead to better ART adherence, especially during the early initiation of care and treatment.
- Attention should be given to early ART treatment and the advanced clinical stages of patients through patient education and nutritional counseling tailored to improve food security and promote healthy dietary practices, including increased consumption of FAVs.
- Policymakers, planners, program managers, and healthcare providers should give due attention to FAVs consumption to make it part of treatment and care for HIV-infected people.
- There is a need for comprehensive, context-specific nutritional counseling to improve FAV consumption. This should include a focus on portion size estimation to help estimate the recommended daily allowance and enhance the culture of portion size estimation.
- As caregivers play a significant role in the care and treatment of HIV-infected adults, it is important to recognize the critical role of children as caregivers. Incorporating family therapy

can help enhance the role of children in supporting their family's care, including promoting FAV consumption.

- Developing and implementing targeted food security interventions for HIV-infected individuals, focusing on improving access to nutritious food to mitigate the effect of food insecurity on clinical and immunological progressions
- Integrate comprehensive nutritional support and counseling into HIV treatment programs, and ensure that individuals receive appropriate dietary guidance and support to improve their nutritional status and overall health.
- Increase efforts to monitor and support individuals with shorter durations of treatment to ensure optimal clinical outcomes and reduce the risk of poor progression and low CD4 counts.
- Implement targeted nutritional interventions and support programs for food-insecure individuals to address the higher incidence of low CD4 counts.
- Utilize an integrated approach that combines nutritional support, medical care, and social support to improve overall health outcomes for HIV-infected individuals.

FMOE, MoWSA, REB, ZED, and WEO

- As lack of formal education and lower education levels are associated with higher food insecurity, that suggests the need for integrated strategies to improve educational status and food and nutrition awareness among HIV-infected individuals and the community at large.
- The findings suggest the need for critical attention to HIV-infected women, who are disadvantaged both socially and economically, in the design and implementation of HIV prevention and control programs that address food insecurity.
- Food and nutrition interventions designing and healthcare planning should be culture- and context-specific to address the gender dynamics of food insecurity and reduce its health effects on HIV-infected adults.

FMOA, RAB, ZAD, and WAO

- There should be an emphasis on initiating context- and culture-specific urban agriculture, including promoting home garden food production and consumption in urban settings to ensure the availability and diversity of nutrient-dense foods.
- The findings also suggest the need for income-generating activities such as diversified home gardening and agro-pastoral activities.
- There should be efforts to create permanent employment opportunities to enhance earning capacity and improve access to food items.

Researchers and academic institutions:

- Conduct qualitative research to explore the effects of diverse cultural practices, including food consumption and food taboos, on food security status, as well as a longitudinal study to assess the role of nutritional counseling on the food security status of HIV-infected adults.
- Conduct further and focused investigation of FAV dietary intake using both quantitative and qualitative study to address the nutritional need of this high-risk population sugments.
- Conduct further research to understand the long-term effects of food insecurity and nutritional status on HIV progression and changes in CD4 count.

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Annex I: List of paper drived from this thesis (Published and Under review)

PLOS ONE

RESEARCH ARTICLE

The effect of gender on food insecurity among HIV-infected people receiving anti-retroviral therapy: A systematic review and meta-analysis

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Abbreviations: AIDS, Acquired Immunodeficiency Syndrome; HFIAS, Household Food Insecurity Access Scale; HIV, Human immune virus; WHO, World Health Organization.

Abstract

Background

HIV-infected adults receiving anti-retroviral therapy have a high prevalence of food insecurity in both high- and low-income settings., Women bear an inequitable burden of food insecurity due to lack of control over resources and over household food allocation decision-making. The few studies conducted on the association between food insecurity and gender among HIV-infected adults have inconclusive findings. Therefore, the objective of this systematic review and meta-analysis was to estimate the pooled effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy.

Method

We conducted an electronic, web-based search using PubMed, CINAHL, PopLine, MedNar, Embase, Cochrane library, the JBI Library, the Web of Science and Google Scholar. We included studies which reported the association between food insecurity and gender among HIV-infected adults receiving antiretroviral therapy whose age was greater than 18 years. The analysis was conducted using STATA 14 software. A random effects model was used to estimate the pooled effect a 95% confidence interval(CI). Forest plots were used to visualize the presence of heterogeneity. Funnel plots and Egger's and Begg's tests were used to check for publication bias.

Results

A total of 776 studies were identified of which seventeen studies were included in the meta-analysis, with a total of 5827 HIV infected adults receiving antiretroviral therapy. We found that the gender of HIV-infected adults receiving anti-retroviral therapy had statistically significant effects on food insecurity. The pooled odds of developing food insecurity among female HIV infected adults receiving anti-retroviral therapy was 53% higher than male HIV infected adults (OR: 1.53, 95% CI: 1.29, 1.83). Our analysis indicate the findings of studies

conducted in the high-income countries showed weakest associations between gender and food insecurity than those conducted in low- and middle-income countries.

Conclusion

Our systematic review and meta-analysis showed statistically significant effect of gender on food insecurity among HIV-infected adults receiving anti-retroviral therapy in which odds of food insecurity was higher among female HIV infected adults compared to male HIV-infected adults. These findings suggest that the need to include within food and nutrition interventions for HIV-infected adults receiving antiretroviral treatment, culture- and context-specific gender-based policies to address the sex/gender related vulnerability to food insecurity.

Background

Human immunodeficiency virus (HIV) infection and the acquired immunodeficiency syndrome (AIDS) remain a critical global health crisis[1]. Globally in 2016, there were 36.7 million people living with HIV of which 48.5% (17.8 million) were women of reproductive age (15–49years)[2]. Of the 4,500 daily new HIV infections among adults aged 15 years and older, 43% are among women and 22% are among young women (15–24years)[2].

HIV-infection and food insecurity are closely associated in both low- and high-income settings. For example, food insecurity defined as having uncertain or limited availability of nutritionally adequate or safe food or the inability to procure food in socially acceptable ways has been identified as the critical contributing factor for poor health outcome among adults living with HIV[3–6]. In addition to harming immunological and clinical outcomes in HIV-infected individuals, food insecurity has also been shown to increase the risk of HIV exposure and infection [7].

Studies show a consistently high prevalence of food insecurity among HIV-infected individuals receiving antiretroviral therapy, with HIV-infected women bear an inequitable burden of food insecurity in both high- and low-income settings [8–15].

Females are biologically, socioeconomically, and socio-culturally at higher risk of HIV infection than males. Gender inequity shape power relations and access to health education, and reduces the power of women to negotiate or practice safer sexual behavior which greatly increases their risk of HIV-infection in many settings [7]. Particularly, females in relationships are often more food-insecure than male partners, as a result of unequal power over economic resources and household food allocation decision-making. In addition, females often serve as caregivers and are therefore constrained in their ability to make further investments in their own skills and education, increasing their susceptibility to food insecurity[16].

Despite the fact females have increased vulnerability to food insecurity, studies conducted on the association between food insecurity and gender among HIV-infected adults receiving antiretroviral therapy across the world (low, middle and high-income countries), have presented controversial and inconclusive evidences. For instance, some studies have found significantly positive effect of gender on food insecurity [13, 14, 17–20], while others failed to demonstrate the effect [3, 9–11, 15, 21–26].

Estimating the pooled effect of gender on food insecurity among HIV-infected adults and identify the reasons for this discrepancy in findings is important for addressing food security-related problems and for implementing focused interventions to address food security in this population. Therefore, the main objective of the current systematic review and meta-analysis

is to estimate the pooled effect of gender on food insecurity among HIV—infected adult patients receiving antiretroviral therapy. Our research question is: "Does gender of HIV-infected adults receiving ant-retroviral therapy determine their food security status?".

The findings of this analysis will be helpful to policy makers and program planners in the design of appropriate interventions to improve the problems related to the association between food insecurity and gender among HIV infected adults receiving anti-retroviral therapy. The findings would also be useful for clinicians and future researchers in related fields.

Methods

Search strategy

This systemic review and meta-analysis was conducted to estimate the effects of gender on food insecurity among HIV-infected adults, receiving antiretroviral therapy. Before beginning our study, we checked for the presence of the existing systematic reviews and meta-analysis on our topic using the DARE database (http://www.library.UCSF.edu) and the Cochrane library to avoid duplication. We also checked the availability of ongoing projects related to the current systematic review and meta-analysis. In addition, we searched the two Trial Registries: ICTRP and Clinical Trials.gov (searched 30 February, 2018). No previous systematic reviews or meta-analyses on the topic were found.

We searched all relevant published studies in the following major databases; *PubMed, MEDLINE, Google Scholar, CINAHL, PopLine, MedNar, Embase, the Cochrane library, the JBI Library, the web of science, and African Journals Online*. We also retrieved grey literature using Google and Google Scholar searches. To identify and retrieve additional articles, we also reviewed reference lists of identified studies. Unpublished studies were retrieved from the official websites of international and local organizations and universities.

The search for published studies was restricted by the age of the study participants (HIV-infected adults receiving antiretroviral therapy whose age was greater than 18 years), but was not restricted by time or country. All published and unpublished articles written by the time of our search in February 30, 2018 were included in the systematic review and meta-analysis.

The following search terms were used: food security status, food insecurity, effect of gender, effect of gender, adults living with HIV, patients living with HIV, individuals living with HIV, HIV-infected adults, HIV-infected individuals and antiretroviral therapy separately and/or in combination.

We pre-defined search terms to allow a comprehensive search strategy that included all the important studies. All fields within records and Medical Subject Headings (MeSH terms) were used to help expand the search in advanced PubMed search. The following search strategies were modified for the various databases using the two important Boolean operators and search engines with initial keywords/search terms *1) ("Food security status" OR "food insecurity" AND "effect of sex" OR "effect of gender" AND "adult living with HIV" OR "Patients living with HIV" OR "individual living with HIV" AND "antiretroviral therapy"). 2) ("Food insecurity" OR "effect of sex" OR "effect of gender" AND "HIV infected adults" OR "HIV-infected patients" OR "HIV-infected individual" OR "antiretroviral therapy" AND "Ethiopia")*. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline was followed during the systematic review (S1 Table) [27].

Study selection and eligibility criteria

The review included articles that were conducted on the association between food insecurity and gender among HIV-infected people, receiving antiretroviral therapy globally. Participants were HIV-infected adults on antiretroviral therapy whose age was greater than 18 years,

regardless of their gender. This review considered both community and institution based studies. The outcomes considered were food insecurity and its association with gender or the effect of gender on food insecurity as measured using the Household Food Insecurity Access Scale (HFIAS)[28, 29]. All study types that were published in the form of journal articles, master's thesis and dissertation, that were written in English were included in the review. In addition, all studies conducted using cross sectional, case-control and cohort designs were included. We excluded studies conducted on the pediatric age group, studies with the methodological problems, interventional studies, and review articles. Retrieved studies were assessed for inclusion in the final review by reviewing their title, abstract and full-text for their agreement with our eligibility criteria.

Quality assessment and data extraction

We used reference management software (Endnote version X7.2) to combine database search results and to remove duplicate articles manually. The Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) was used for critical appraisal of studies (S2 Table) [30]. Data were extracted by two independent reviewers using a standardized data extraction format. The data extraction spreadsheet included primary author name, year of publication, country, study design, sample size, number of the subject outcome, response rate, number male with the outcome, number of females with the outcome, the total number of males and females in the study (S1 Dataset). Disagreement between reviewers in the review process were discussed with review team members until consensus was reached. Discrepancies between two independent reviewers were resolved by involving third reviewer. When access to full-text articles were not available, document authors were contacted once. If no reply was received within a month, the documents were excluded from the study.

Data analysis and synthesis

The extracted data were categorized and sorted by quality scores and entered into the computer using command window of STATA v.14. Analysis of the data were done using STATA v.14 statistical software. The logarithm and standard error of the odds ratio (OR)for each original study were generated using "generate" command in STATA. Cochrane's Q statistic (chi-square), I^2 and p-values were used to check for heterogeneity of the studies' outcomes. The heterogeneity was considered as low, moderate or high when I^2 test statistics results were 25%, 50%, and 75% respectively [31]. Forest plots were also used to visualize the presence of heterogeneity. Because we found high level of heterogeneity, we used a random effects model for analysis to estimate the Der Simonian and Laird's pooled effect. Furthermore, to identify source of heterogeneity, meta regression was conducted and statistically significant results were declared in the presence of heterogeneity. Publication bias was checked using funnel plot of symmetry. Further, the statistical significance of publication bias was checked using Egger and Begg tests [32–34]. A p-value less than 0.05 was used to declare the presence of publication bias. We performed sensitivity analysis using a random effects model to assess the influence of a single study on the overall meta-analysis estimate.

Results

Selection and identification of studies

We identified a total of 776 studies (775 published and one unpublished study) that were conducted from 2009 to 2017. Of those identified, 135 duplicate studies were removed and 578 studies were excluded after reviewing of their titles and abstracts. The full text of remaining the 61

studies were assessed for eligibility and for whether they report outcome of interest. Of these, 30 studies were excluded due to lack of outcome of interest and 14 studies were excluded because they failed to meet the eligibility criteria. Of the remaining studies, the 17 that scored- seven and above on the JBI quality appraisal eligibility criteria were included in the final Meta-analysis. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram was used to guide selection process and present the systematic review overview (Fig 1).

Characteristics of included studies

A total of 17 studies that assessed the association between food insecurity and gender among HIV infected adults receiving anti-retroviral therapy were included in this systematic review and meta-analysis, with a total sample of 5827 individuals living with HIV. Eleven of these studies were cross sectional and six were prospective cohort. The range of minimum and maximum sample size ranged from104 in a study conducted in USA[3]and 796 in a study conducted in Brazil [13].

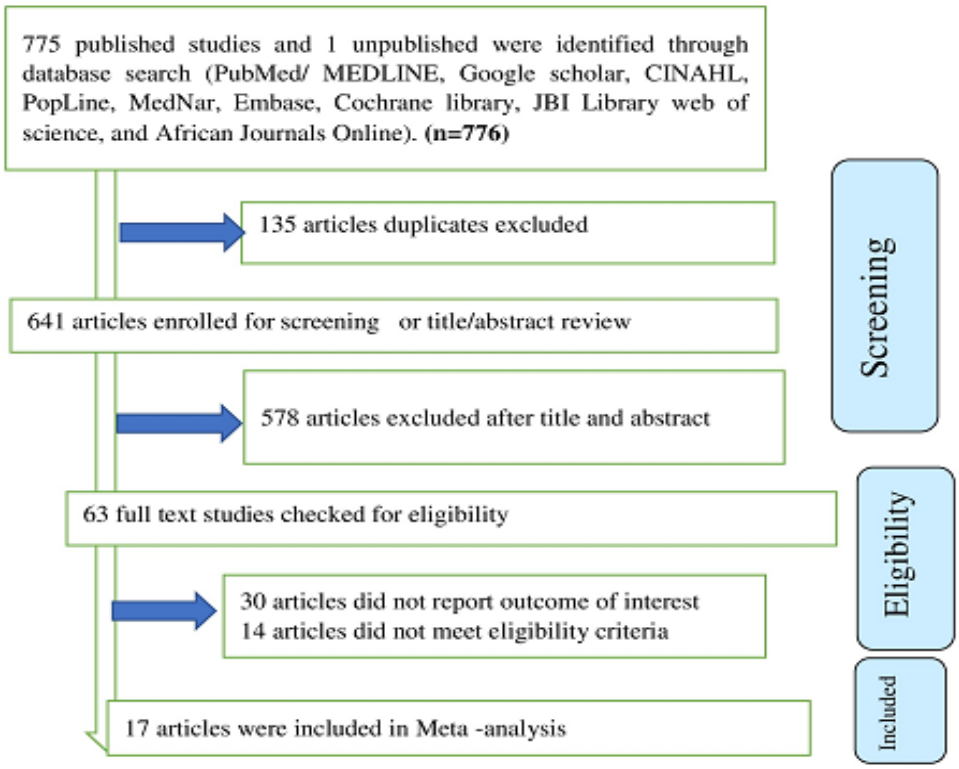

Fig 1. PRISMA flow diagram of included studies in the systematic review and meta-analysis of the effect of gender on food insecurity among HIV-infected people receiving antiretroviral therapy from 2009–2017.

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Table 1. Characteristics of studies included in the systematic review and meta-analysis on the effect of gender on food insecurity among HIV infected people receiving antiretroviral therapy from 2009–2017.

Study No	Authors	Year	Country	Country income level	Study design	Sample size	Number of subject with outcome	Response rate	Number male with the outcome	Number female with the outcome	Total number of male	Total number of female	OR (95% CI)
1	M. Asnakew [21]	2015	Ethiopia	Low	Cross-sectional	385	260	97.72	88	172	136	249	1.22 (0.78, 1.97)
2	Gedle et al. [17]	2015	Ethiopia	Low	Cross-sectional	338	264	90	91	173	130	208	2.12 (1.26, 3.57)
3	Belijo ZN et al[14]	2017	Ethiopia	Low	Cross-sectional	394	77	100	10	67	134	260	4.30 (2.13, 8.68)
4	Tiyou et al [22]	2012	Ethiopia	Low	Cross-sectional	319	201	100	86	115	144	175	1.29 (0.82, 2.04)
5	Anema et al [9]	2013	Canada	High	Cohort	254	181	100	148	33	211	43	1.40 (0.65, 3.02)
6	Anema et al [10]	2016	Canada	High	Cross-sectional	262	192	100	140	52	191	71	1.00 (0.54, 1.84)
7	Benzekri et al[11]	2015	Senegal	Low	Cross-sectional	109	78	100	12	62	18	91	1.07 (0.36, 3.13)
8	Dasgupta et al[18]	2016	India	Middle	Cross-sectional	173	75	92	33	42	96	77	2.29 (1.24, 4.24)
9	Heylen et al [23]	2015	India	Middle	Cohort	367	58	100	38	20	239	128	0.98 (0.54, 1.77)
10	Idrisov, et al [24]	2017	Russia	Middle	Cohort	310	164	88.32	113	51	220	90	1.24 (0.76, 2.03)
11	Kalichman et al[25]	2013	USA	High	Cross-sectional	197	85	100	66	19	154	43	1.06 (0.53, 2.09)
12	McMahon et al[19]	2011	USA	High	Cohort	592	375	100	239	136	416	176	2.52 (1.68, 3.77)
13	Weiser D. et al[15]	2009	USA	High	Cohort	250	134	100	92	43	174	76	1.16 (0.68, 2.00)
14	Weiser D et al[3]	2009	USA	High	Cross-sectional	104	26	100	15	11	66	40	1.29 (0.52, 3.18)
15	Kalichman et al[20]	2014	USA	High	Cross-sectional	521	321	100	214	107	364	157	1.50 (1.01, 2,.23)
16	Mederios et al[13]	2017	Brazil	Middle	Cross-sectional	796	284	100	143	141	484	312	1.97 (1.46, 2.64)
17	Tsai et al[26]	2012	Uganda	Low	Cohort	456	340	100	93	247	132	324	1.35 (0.86, 2.12)

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Of the total 17 included studies, four were conducted in Ethiopia[14, 17, 21, 22], five studies in the United States [3, 15, 19, 20, 25], two in Canada[9, 10], two in India[18, 23], Russia[24], Senegal[11], Uganda[26] and Brazil[13] each had one study. Six studies were conducted in low-income countries[11, 14, 17, 21, 22, 26], four studies in middle-income countries[13, 18, 23, 24] and seven studies in high-income countries[3, 9, 10, 15, 19, 20, 25].

The findings of individual studies were varied and inconclusive with the effects of gender/sex found to be significant in some studies and in- significant other. Of those studies that found significant effects of gender on food insecurity, the strongest positive association was found in the study conducted in Ethiopia[14], with an odds ratio of 4.30 (95% CI: 2.13, 8.68) and the smallest association was found in the study conducted in the United States [20], OR = 1.50 (1.01, 2,.23) (Table 1).

The effect of gender on food insecurity among HIV-infected adults receiving anti-retroviral therapy

Our analysis of 17 included studies found significant heterogeneity across studies (I^2 = 45.5%, p <0.022) which suggested that the use of a fixed effect model might lead to unreliable estimates because those model assume that all heterogeneity can be explained by the covariates.

This assumption may create excessive type I errors when there is residual, or unexplained, heterogeneity. To avoid this bias, we used random effects model to estimate the pooled effect of gender on food insecurity among HIV-infected adults in our 17 included studies using an inverse variance method.

Using these methods, our meta-analysis found that gender of HIV-infected adults receiving anti-retroviral therapy had statistically significant effects on their food security status. The odds of developing food insecurity among female HIV-infected adults receiving anti-retroviral therapy were 53% higher than male HIV-infected adults (OR: 1.53, 95% CI: 1.29, 1.83) (Fig 2).

We further investigated the heterogeneity using different statistical techniques to identify the source of heterogeneity. A meta-regression was performed using publication year, sample size and country income level as covariates and by specifying the method for estimating the

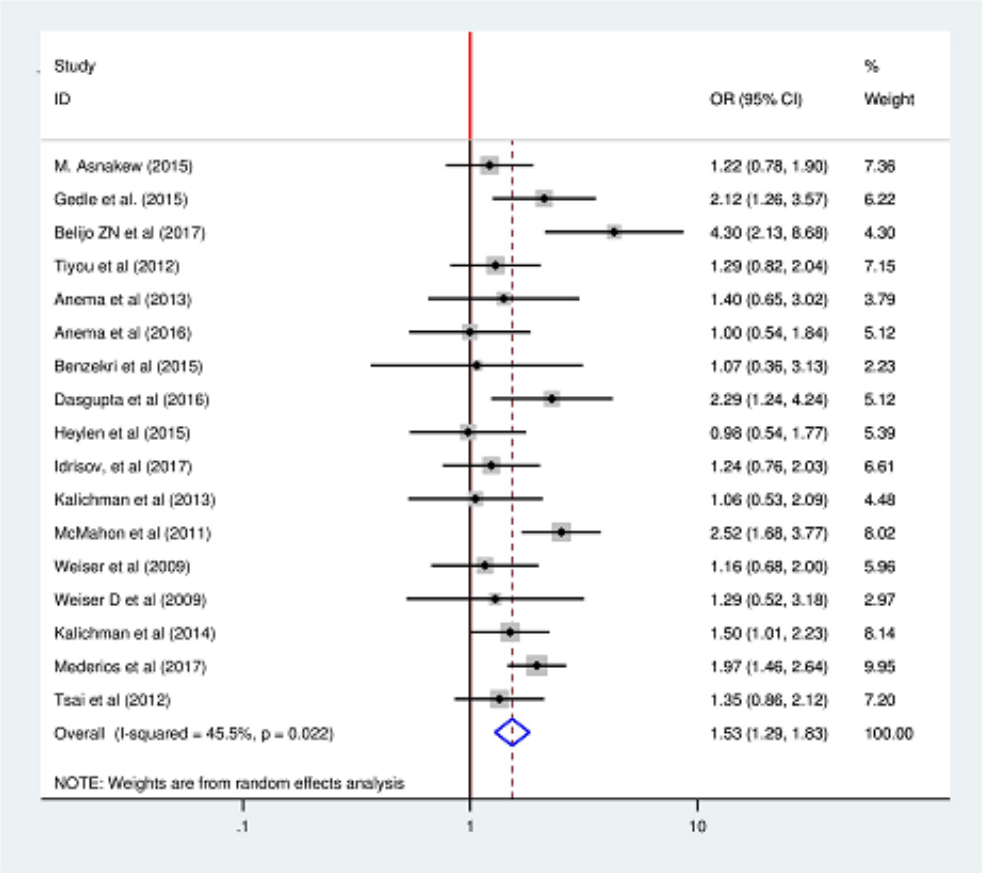

Fig 2. Forest plot of the pooled effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy from 2009–2017.

https://doi.org/10.1371/journal.pone.0209903.g002

Table 2. Related factors with heterogeneity of the effects of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy, 2009–2017.

Variables	Coefficients	p-value
Publication Year	0.0284334	0.588
Sample size	0.0008173	0.588
Low income countries	0.0769214	0.751
Middle income countries	-0.1118692	0.731
High income countries	Reference	

https://doi.org/10.1371/journal.pone.0209903.t002

between-study variance. None of the three variables were statistically significant for explaining the presence of heterogeneity (Table 2).

The presence of publication bias was assessed using funnel plots and Egger and Begg statistical tests at 5% significant level. There was no statistical evidence of publication bias. The funnel plot was almost symmetry, the Begg and Egger tests were not statistically significant with p-value = 0.484 and p-value = 0.321 respectively (Fig 3).

To identify the effect of single study on overall meta-analysis estimate, we performed sensitivity analysis using a random effects model. The analysis found no strong evidence for influence of single study (Fig 4).

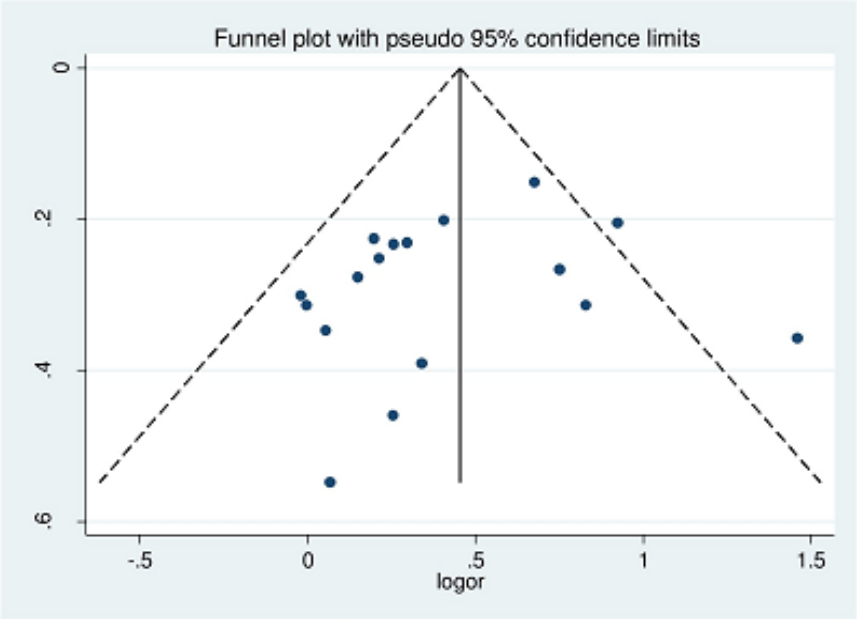

Fig 3. Funnel plots for publication bias of effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy from 2009–2017.

https://doi.org/10.1371/journal.pone.0209903.g003

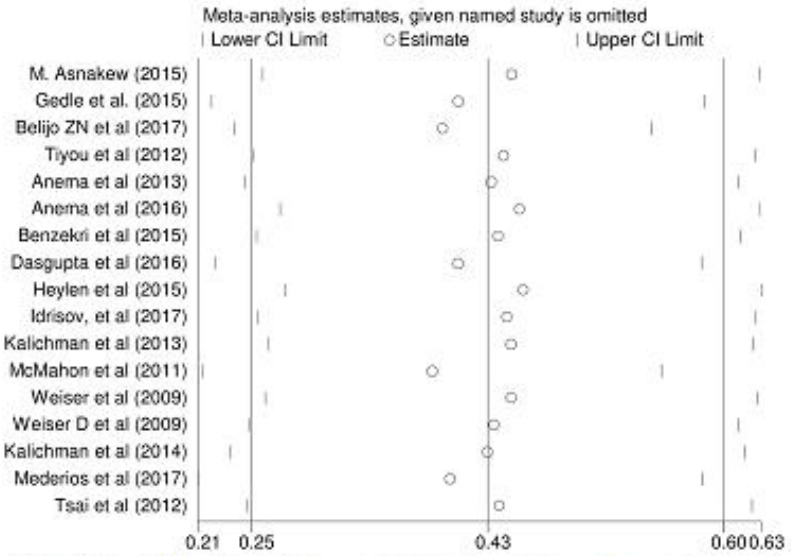

Fig 4. Sensitivity analysis for single study influence of effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy from 2009–2017.

https://doi.org/10.1371/journal.pone.0209903.g004

Sub-group analysis by study design

We performed sub-group analysis by study design to minimize the potential random variations between studies by comparing the effect of gender on food insecurity of HIV-infected adults. Our sub-group analysis indicated almost consistent significant effect of gender on food insecurity among HIV-infected adults across the study designs. The analysis indicated that cohort studies had weaker associations than cross-sectional studies. The odds of developing food insecurity among female HIV-infected adults was 42% higher compared to male HIV-infected adults in cohort studies while the odds of developing food insecurity among female HIV-infected adults was 60% higher compared to male HIV-infected adults in cross sectional studies, with odds ratios of 1.42 (95% CI: 1.05, 1.92) and 1.60 (95% CI: 1.28, 2.00) respectively (Fig 5).

Sub-group analysis by country income level

In addition, we performed sub-group analysis by country income level to minimize the potential random variations between studies by comparing the effect of gender on food insecurity HIV-infected adults. The analysis indicated that studies conducted in high-income countries found weaker associations than those in low and middle-income countries. The odds of developing food insecurity among female HIV-infected adults was 44% higher compared to male HIV-infected adults in the studies conducted in high-income countries, with an odds ratio of 1.44 (95% CI: 1.08, 1.90). While the odds of developing food insecurity among female HIV-infected adults was 64% and 57% higher compared to male HIV-infected adults in the studies conducted in low-and middle-income countries with odds ratios of 1.64 (95% CI: 1.15, 2.33) and 1.57 (95% CI: 1.09, 2.24) respectively (Fig 6).

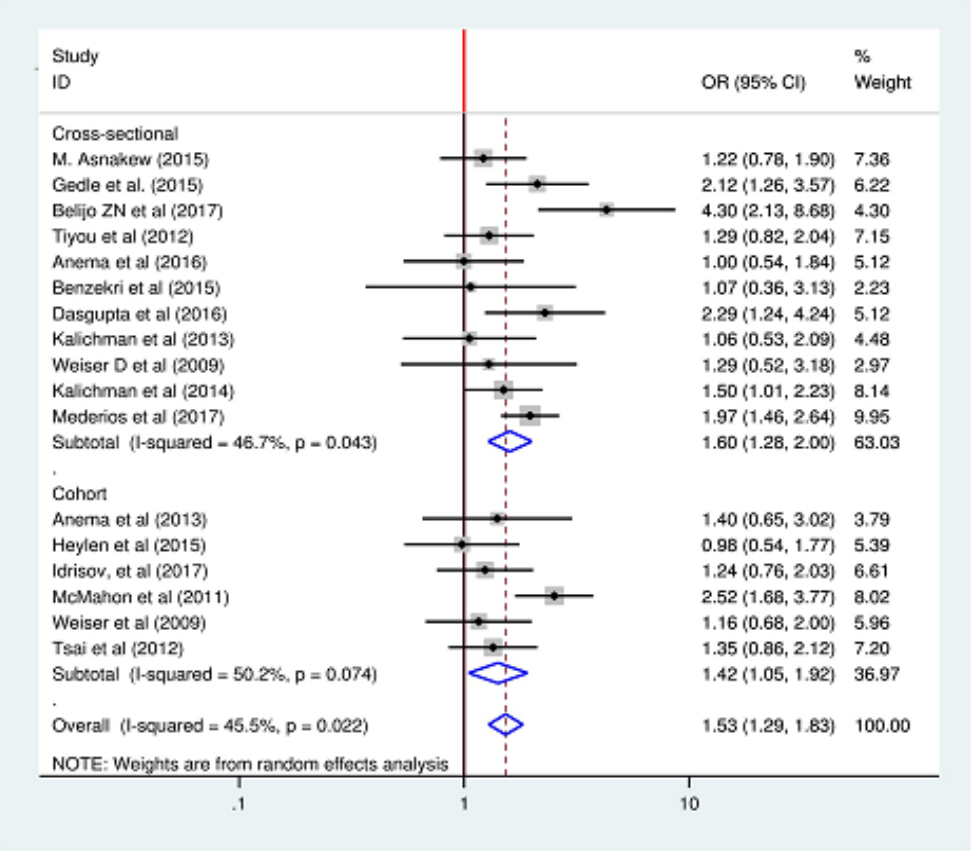

Fig 5. Sub-group analysis of effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy by study design from 2009–2017.

https://doi.org/10.1371/journal.pone.0209903.g005

Discussion

Our review and meta-analysis estimated the pooled effect of gender on food insecurity among HIV-infected adults receiving anti-retroviral therapy. The review and analysis demonstrated that the gender of HIV-infected adults has strong statistically significant effect on food insecurity. The odds of developing food insecurity among female HIV-infected adults receiving anti-retroviral therapy were higher than male HIV infected adults.

The significant effect of gender on food insecurity found in the current systematic review and analysis is in line with the findings of a global gap analysis systematic review on food insecurity and HIV/AIDS in which significant inequity in the experience of food insecurity by gender was found, with females being most at risk in both resource-rich and resource-limited settings[35]. This finding also consistent with the finding of a systematic review for

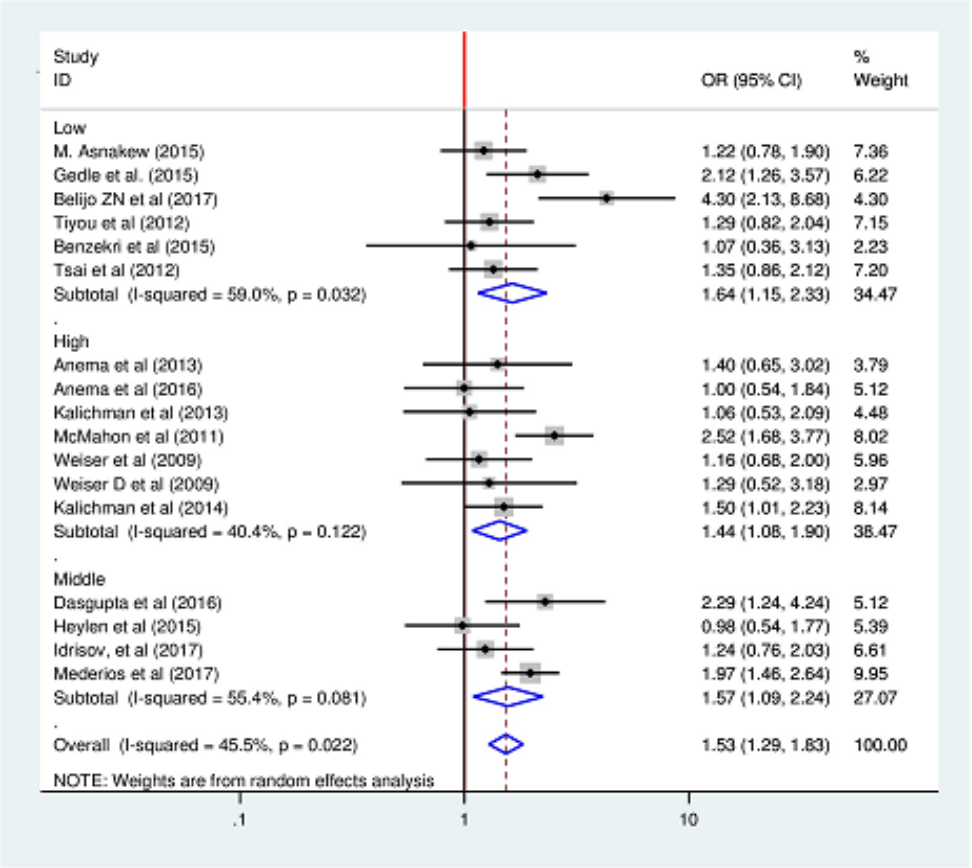

Fig 6. Sub-group analysis of effect of gender on food insecurity among HIV-infected adults receiving antiretroviral therapy by country income level from 2009–2017.

https://doi.org/10.1371/journal.pone.0209903.g006

formulating a conceptual framework for food insecurity and health in which female HIV-infected adults were most affected by food insecurity. [16]. As discussed above, these findings may be due to the fact that most females in the relationship have little power over household resource and food allocation, and that they serve as caregivers. which in turn, inhibits in their ability to make further investments in their own skills and education, increasing their susceptibility to food insecurity.

The finding of current systematic review was also consistent with the evidence of global policy review by the International Food Policy Research Institute which indicated gender inequity shapes power relations and risk[7]. The significant effect of gender on food insecurity in the current review is in line with the finding of narrative reviews and international food assistance program guidelines in which food insecurity remains a challenge for women across diverse settings[36, 37].

Our analysis indicated a relatively consistent significant effect of gender on food insecurity among HIV-infected adults across study designs and country income level. We found that cohort studies had weaker associations than cross-sectional studies due to the lack of temporal relationship assurance in cohort studies.

In addition, our analysis found that the weakest associations between food insecurity and gender occurred in the studies conducted in high-income countries and the strongest in low and middle income country settings. This most likely due to a relative lack female social development particularly a lack of education in low-and middle-income settings as well as lower female power in decision-making around resource allocation.

We used comprehensive search strategies in our review systematic review and meta-analysis. We searched both published and unpublished studies through different database searches. We used random effects model to address the issues of potential variability across studies. More than one assessor was used in the quality assessment and appraisal process using JBI--MAStARI. Nevertheless, the restriction of studies published in English language limited the number of studies included in meta-analysis.

Conclusion

The systematic review and meta-analysis indicated a consistent, and statistically significant effect of gender on food insecurity among HIV-infected adults receiving anti-retroviral therapy. Being female was found to have a positive significant effect on the development of food insecurity across a range of settings; however, the association was strongest for low- and middle-income countries. The review found strong significant positive effect on the development of food insecurity among female HIV infected adults living in the low and middle income countries compared to female HIV infected adults living in high income countries. These findings suggest that policy makers, planners, and program managers in these settings should pay attention to gender dynamics in the design and implementation of HIV prevention and control program that address food insecurity. Food, nutrition and HIV intervention programs should be culture and context specific, to address the sex/gender related vulnerability to food insecurity of HIV-infected adults.

Supporting information

S1 Table. PRISMA 2009 checklist.
(DOC)

S2 Table. Critical appraisal BI-MAStARI instrument.
(DOCX)

S1 Dataset. Gender effect dataset.
(DTA)

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Methodology: Dube Jara Boneya.

Software: Dube Jara Boneya.

Supervision: Ahmed Ali Ahmed, Alemayehu Worku Yalew.

Validation: Ahmed Ali Ahmed, Alemayehu Worku Yalew.

Visualization: Ahmed Ali Ahmed, Alemayehu Worku Yalew.

Writing – original draft: Dube Jara Boneya.

Writing – review & editing: Dube Jara Boneya, Ahmed Ali Ahmed, Alemayehu Worku Yalew.

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Food insecurity and its severity among adults receiving antiretroviral therapy in health facilities, northcentral Ethiopia: a multi-facility-based cross-sectional study

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Background: Food insecurity plays a crucial role in predicting the spread of HIV due to the adverse effects of coping mechanisms adopted to mitigate it. However, there is a scarcity of context-specific evidence regarding food insecurity among HIV-infected adults. Therefore, this study aimed to assess the context-specific magnitude of food insecurity and associated factors among adults receiving antiretroviral therapy (ART) in health facilities in the North Shewa Zone, Ethiopia, ultimately contributing to the achievement of the 95–95-95 HIV treatment target in the local context.

Methods: A multi-facility cross-sectional study was conducted among 865 HIV-infected adults receiving ART and being followed up for their treatment. We included health facilities that provide ART, including four hospitals and six health centers. A log-binomial regression model was fitted to identify the association between food insecurity and independent variables. Adjusted prevalence ratios (APRs) with a 95% confidence interval were computed to measure the strength of the association.

Results: In this study, 290 (33.7, 95% CI: 30.60, 36.91) of the HIV-infected adults studied had food insecurity during their treatment and follow-up, of which 152 (52.41, 95% CI: 46.64, 58.13) and 110 (37.93%, CI: 32.50, 43.68) of them were found to have severe and moderate forms of food insecurity, respectively. We found that being younger (APR = 2.27, 95% CI: 1.12, 4.60), being female (APR = 1.87, 95% CI: 1.03, 3.39), lacking formal education (APR = 10.79, 95% CI: 14.74, 24.58), having lower educational status (APR = 5.99, 95% CI: 2.65, 13.54), being a daily laborer (APR = 6.90, 95% CI: 2.28, 20.85), having low monthly income (APR = 1.89, 95% CI: 1.11, 3.22), advanced WHO clinical stage (APR = 2.34, 95% CI: 1.08, 5.10), and receiving ART for less than 4 years (AOR = 2.28, 95% CI: 1.09, 4.74) were significantly associated with a high proportion of food insecurity among HIV-infected adults.

Conclusion: The magnitude of food insecurity among HIV-infected adults receiving ART was high, with an extremely high magnitude of severe food insecurity. The finding suggests the need for culture- and context-specific nutritional interventions to address the gender dynamics of food insecurity, attention to the early stage of ART, and the integration of strategies to improve educational status and enhance income-generation activities of HIV-infected

adults. This requires an emphasis on the link between food insecurity and HIV in Ethiopia's national food and nutrition policy.

KEYWORDS
Food insecurity, HIV/AIDS, clinical progression, antiretroviral therapy, adults

Introduction

Globally, human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS) continue to pose critical health problems at an alarming rate, particularly in developing countries (1). By the end of 2022, there were 1.3 million new HIV infections worldwide, with 39 million people living with HIV (PLHIV), of which 37.5 million HIV infections were among adults (2). Additionally, there were 500, 000 new HIV infections in Eastern and Southern Africa, with a total of 20.8 million PLHIV (3, 4).

In Ethiopia, there were 7,194 new HIV infections, for a total of 603,537 PLHIV in 2023 (5, 6). The estimated HIV prevalence (aged 15–49) was 0.91%, and the estimated AIDS deaths were 9,984 in 2023 (7, 8). This requires a holistic and comprehensive approach in addition to the gains achieved through antiretroviral therapy (ART) in areas where HIV prevalence is high, such as sub-Saharan Africa, including Ethiopia (9).

As one of the strategic approaches, UNAIDS developed a new set of ambitious targets that call for action to reach 95–95-95: 95% of all PLHIV to know their HIV status, 95% of all people with diagnosed HIV infection to receive sustained ART, and 95% of all people receiving ART to have viral suppression by 2025. This aims to close the testing gap and protect the health of millions of PLHIV who are still not accessing treatment, including in Ethiopia (10, 11).

Ethiopia has made excellent progress toward achieving the 90–90-90 treatment goal of the 2016–2021 strategy, particularly the second and third 90s among adults, in which 79% of estimated PLHIV who know their status were on ART, 90% were on ART and 91% were virally suppressed, with marked regional variations in ART coverage (12). The HIV/AIDS National Strategic Plan (NSP) for Ethiopia 2021–2025 indicates that the country is committed to achieving the global new and ambitious 95–95-95 HIV prevention roadmap, with a particular focus on reaching 95% coverage of ART and viral suppression nationally, across all age groups (13).

Food insecurity, defined as "the limited or uncertain availability of nutritionally adequate, safe foods or the inability to acquire personally acceptable foods in socially acceptable ways," is an important promoter of HIV transmission and disease progression (1) and the leading cause of morbidity and mortality (14). It can have an impact on addressing the 95–95-95 NSP treatment targets that Ethiopia is committed to achieving, which is critical for treatment programs to establish community-centered strategies and systems. Despite this fact, global evidence indicates that approximately 2.4 billion people worldwide, including PLHIV, lack access to adequate food, with 30% experiencing moderate or severe food insecurity. Furthermore, over 3.1 billion people were unable to afford a nutritious and healthy diet, with 78% of them residing in Africa in 2022. This situation is more exacerbated among PLHIV as a result of various contributing factors, including the infection process itself (15). In this regard, studies have noted that the prevalence of food insecurity is high among PLHIV in both resource-rich settings, where its prevalence ranges from 53.6 to 71% (16–18), and resource-poor settings, such as countries of Africa (19–22), where the prevalence of food insecurity ranges from 49.1 to 84.6%. In Ethiopia (23–32), the prevalence ranges from 35.2 to 92.82%.

Studies have indicated that educational status, gender, occupation, food assistance, delaying and skipping drugs, longer duration of ART, missing clinical appointments, and exchanging sex for food are contributing factors for higher food insecurity among PLHIV (18, 20, 22, 33–35).

In Ethiopia, studies indicated that the economic status, educational status of PLHIV, absence of food support, unemployment, residence, WHO clinical stage, poor adherence to treatment, and inadequate household dietary diversity were found as contributing factors for food insecurity, while these studies suggested further investigation on the direction of effect about sample variation (26, 28–30, 36). PLHIV and receiving ART need a sufficient amount of food to maintain a healthy dietary intake and cope with drug side effects. Food insecurity can pose significant challenges to the proper management of food and nutrition implications of ART (37). Furthermore, the review of the National Food and Nutrition Policy of Ethiopia indicates that due emphasis was not given to the link between food insecurity and HIV (38).

It is apparent that few studies were conducted on food insecurity and its associated factors among HIV-infected adults in low- and middle-income countries, including Ethiopia. Very little evidence has been documented online for researchers and policymakers. Therefore, the main objective of this study was to assess the magnitude of food insecurity and its severity and to identify factors associated with food insecurity, among adults receiving ART in health facilities, in Northcentral Ethiopia.

Materials and methods

Study design, setting, and period

A multi-facility cross-sectional study was conducted as part of a multi-center prospective follow-up study in health facilities in North Shewa Zone, Oromia, Ethiopia. The Zone has 16 districts (4 town administrations and 12 rural districts) with an estimated total population of 1,431,305 (717,552 male individuals and 713,753 female individuals) (39). The Zone has 5 hospitals (1 referral hospital and 4 primary hospitals) and 64 health centers. The study was conducted in 10 health facilities (4 hospitals and 6 health centers) that have been providing ART services to HIV-infected people with established ART clinics between January 2021 and April 2022.

Population and eligibility criteria

Adults infected with HIV and receiving ART who had follow-up for their treatment in North Shewa Public Health Facilities were considered the source population. All PLHIV who were receiving ART and had follow-up for their treatment in selected health facilities were the study population. All PLHIV who were receiving ART and whose ages were greater than 18 years, regardless of their treatment regimen and duration of follow-up, were included in the study. Patients with other concomitant chronic diseases, such as heart disease, hypertension, diabetes mellitus, and others that can suppress the immune system and deteriorate their nutritional status, including pregnant women who started ART, were excluded.

Sample size determination and sampling procedure

The current study is part of a multi-center prospective follow-up study that aimed to assess the effect of food insecurity on the clinical progression of HIV/AIDS and CD4 count change among adults receiving ART in North Shewa Zone Health Facilities. The required sample size was calculated using two population proportion formulas for the difference between the two populations, considering major exposure variables of food insecurity after reviewing different literature. Therefore, the required sample size was calculated using STATCALC application of Epi-info version 7.0 statistical software (40), considering a confidence level of 95%, power of 80%, an adjusted prevalence ratio (PR) of 2.4 for food support, a one-to-one allocation ratio of unexposed to exposed (1:1), a percentage of the outcome variable in unexposed (food insecure household receiving food support) of 3.4% (28), and 5% non-response rate. The final sample size was determined to be 865 using the two-population proportion formula below (41).

$$n = \frac{\left(\frac{z\alpha}{2}\sqrt{\left(1+\frac{1}{r}\right)p(1-p)} + Z\beta\sqrt{p1(1-p1)+\frac{p2(1-p2)}{r}}\right)^2}{(p1-p2)^2} = 824.$$

After adding in a 5% non-response rate, the sample size remained at 865.

Hospitals and health centers in North Shewa that provided ART and care were identified. All hospitals and six health centers that provided care were included in the study. The calculated sample was proportionally allocated to each hospital and health center based on the size of the patient population. Finally, the data were collected from the participants selected, using simple random sampling from the registration of patients through the computer random generation method.

Study variables and measurement

The dependent variable was food security status, which was assessed cross-sectionally at baseline using a nine-item Household Food Insecurity Access Scale (HFIAS) developed and refined by the USAID Food and Nutrition Technical Assistance (FANTA) project (42, 43) and reported at the individual level. Considering the observation independence assumption, care was taken to not include more than one individual from the same household. The HFIAS is a validated instrument and has been shown to distinguish food insecure households from food secure households across different cultural contexts, considering the three dimensions of food security, such as (1) anxiety and uncertainty about household food supply, (2) insufficient quality (including variety and preferences of types of food), and (3) insufficient food intake and its physical consequences. The results were dichotomized into food insecurity and food security (16, 19, 44). Sociodemographic characteristics (age, gender, income, educational status, occupational status, religion, marital status, residence, number of children, and psychosocial supports) and clinical factors (duration of ART treatment, WHO clinical stage, WHO treatment stage of HIV, opportunistic diseases, therapeutic food support, and follow-up interval) were treated as independent variables in this study.

Data collection tools and methods

A structured interviewer-administered questionnaire was developed to collect sociodemographic and HIV patient follow-up data. The questionnaire consisted of six parts, namely sociodemographic characteristics, psychosocial supports, clinical predictors and effects information, therapeutic food-related information, and household food security status. Food security data were collected, using a structured interviewer-administered questionnaire. Patient records were extracted to collect data on some variables, such as type of malignancy, IOs, anemia, and WHO staging. The questionnaire was pretested on 5% of the sample at Chancho Hospital for feasibility, consistency, and completeness in the population with similar characteristics. The necessary modification was made based on the result of the pretest before actual data collection. The content validation of the questionnaire with local experts was performed before adapting the FANTA food insecurity access scale. Experienced and qualified nurses, health officer data collectors, and supervisors were recruited and trained from those hospitals and health centers. Two days of training were given to data collectors and supervisors on the objectives of the study, methods of data collection, including the use of computer-assisted personal interviews (CAPIs) using KoboToolbox, and how to maintain the confidentiality of information. The CAPIs KoboToolbox digital data collection platform was used to collect data using data collectors on a digital platform. The measurement instruments were calibrated after every measurement. The collected data were checked for completeness and consistency.

Data management and analysis

The data collected using the KoboToolbox digital data collection platform were exported to STATA 17 for cleaning and analysis, including modeling. Descriptive analysis was used to characterize

the study variables. A log-binomial regression model was fitted to identify factors associated with food insecurity. All predictors associated with the outcome variable in bivariable analysis with a *p*-value of 0.20 or less were included in the log-binomial regression model of multivariable analysis. The crude and APRs, considered relative risk, together with their corresponding 95% confidence intervals, were computed. Multi-collinearity of explanatory variables was checked using the variance inflation factor, and the fitness of the model was checked. A *p*-value of <0.05 and corresponding 95% CI were considered to declare a result as statistically significant.

Ethical consideration

The study protocol was reviewed and approved by the Institutional Review Board of the College of Health Sciences, Addis Ababa University, with a protocol number of 104/19/SPH. Permission for data collection was obtained from respective health facilities before data collection, and focal persons at ART clinics were informed. Study participants were informed about the purpose of the study and verbal informed consent was obtained from each study participant. The confidentiality of collected information was maintained by locking it in a file cabinet, accessible only by principal investigators. Participation in this study was voluntary, and participants had full right not to participate or withdraw from the study. The soft copy of data entered into a computer was stored in encrypted files on password-protected computers.

Results

Sociodemographic characteristics

A total of 865 adults who were HIV-infected and receiving antiretroviral therapy were enrolled, of those, 861 were willing and able to participate in this study, resulting in an overall response rate of 99.5%. The majority, 327(37.98%) of the participants were within the age group 35–44 years, and the mean age of the enrolled participants was 38.66 (±9.86SD) years. In terms of gender, 529 (61.44%) of them were women, and 781(90.71%) were Orthodox Christians. The majority of 615 (71.43%) participants were from urban areas. Six hundred forty-two (74.82%) were Oromo in ethnicity, and 522 (60.63%) were married. Six hundred ninety-two (80.37%) reported that they had children, of whom 507(73.27%) had less than 4 children, with a median of 3.0 (IQR: 2, 4; Table 1).

TABLE 1 Sociodemographic characteristics of HIV-infected adults receiving antiretroviral therapy at health facilities in North Shewa Zone, Ethiopia, 2023 (*n* = 861).

Variables	Frequency	Percent
Age of respondents		
<35 years	296	34.38
35–44 years	327	37.98
≥45 years	238	27.64
Mean(±SD) 38.66(±9.86)		
Gender of participants		
Male	332	38.56
Female	529	61.44
Religion of participants		
Orthodox	781	90.71
Protestant	55	6.39
Others*	25	2.90
Residence		
Rural	246	28.57
Urban	615	71.43
Marital Status		
Married	522	60.63
Single	96	11.15
Divorced	111	12.89
Widowed	132	15.33
Ethnicity of participants		
Oromo	645	74.91
Amhara	213	24.74
Gurage	3	0.35
Having children		
No	169	19.63
Yes	692	80.37
Number of children (*n* = 692)		
≤3 children	507	73.27
4–9 children	185	26.73
Median number of children	Median	IQR
Median (IQR)	3	(2, 4)

*Catholic, Muslim and Wakefata.

Socio-economic characteristics

The distribution of occupational status is almost consistent across each category. Accordingly, 198 (23.00%) and 193 (22.42%) HIV-infected adults were merchants and housewives, respectively. Three hundred eighty-one (44.25%) of HIV-infected adults had no formal education. Two hundred ninety-two (52.52%) of HIV-infected adults reported earning a monthly income of 2,500 and above Ethiopian birr, with a median monthly income of 2500ETB (IQR: 1200, 4,730; Table 2).

Psychosocial support for HIV-infected adults

Of the total, most patients reported having some source of social support for informal caregiving. Accordingly, 417 (48.43%) of the HIV-infected adults reported that they received informal care from

TABLE 2 Socio-economic characteristics of HIV-infected adults receiving antiretroviral therapy at health facilities in North Shewa Zone, Ethiopia, 2023 ($n = 861$).

Variables	Frequency	Percent
Occupational Status		
Farmer	173	20.09
Housewife	193	22.42
Daily laboorer	148	17.19
Employed	149	17.31
Merchant/others	198	23.00
Educational status		
No formal education	381	44.25
Primary school	240	27.87
Secondary and above	240	27.87
Monthly income ($n = 556$)		
<2,500 ETB	264	47.48
≥2,500 ETB	292	52.52
Median monthly income (ETB)	Median	IQR
Median (IQR)	2,500	(1,200, 4,730)

different caregivers. Of those, 273(65.47%) received economic support, followed by psychological support (86, 20.62%). Hundred fifty-nine (38.13%) received care from their husbands, followed by wives (86, 20.62%). Four hundred forty (51.10%) of the HIV-infected adults had disclosed their HIV status. Husbands (148, 33.64%), wives (96, 21.82%), and children (92, 20.91%) were the common categories of people to whom studied HIV-infected adults disclosed their HIV serostatus (Table 3).

Clinical factors of HIV-infected adult

Only 43 (4.99%) reported they received therapeutic feeding in the courses of their treatment follow-up; of those, 37(86.05%), 3(6.98%), and 3(6.98%) received plumpy nut, food prepared for treatment, and high protein diet (eggs), respectively. They received therapeutic feeding treatment for 1 to 6 months. Hundred seventy-three (20.9%) of the patients developed eating problems; of those, 134 (77.46%) reported that they developed a loss of appetite. Only four (0.46%) of HIV-infected adults in the total sample reported malignancies, with one case of Kaposi's sarcoma, two cases of cervical cancer, and one case of unidentified malignancy. One hundred seventy-three (20.09%) of the patients developed opportunistic infections (OIs) during their care follow-up, with the most common OIs being diarrheal disease (68, 39.31%), followed by tuberculosis (43, 24.86%). A significant proportion of studied participants reported that they developed anemia (212, 24.62%).

Six hundred ninety-six (80.84%) had been receiving ART and related care for more than 4 years, and the average amount of time that the studied HIV-infected adults received treatment was 9.2 years (±4.6SD). More than three-fourths, 672 (78.05%) of studied adults reported that the follow-up interval time was 3 and above months. The majority, 624(72.47%) and 764(88.73%) of the HIV-infected adults were at WHO clinical stage one and WHO treatment one, respectively (Table 4).

The magnitude of food insecurity among PLHIV

The food security status of PLHIV receiving ART was assessed using food insecurity access score and prevalence indicators in this particular study. We used food insecurity indicators, specifically the Household Food Insecurity Access Scale (HFIAS) score and its prevalence indicator, to assess and report the status and severity of food insecurity. This involved utilizing nine items of HFIAS, along with questions regarding the frequency of occurrence. The prevalence indicators enabled us to assess and report the severity of food insecurity occurrence, categorizing households into four levels: food secure, mildly, moderately, and severely food insecure. Accordingly, 290 [33.68%; 95% CI: (30.60, 36.91)] were food insecure among adult HIV-infected patients receiving ART (Figure 1). Among those who were food insecure, 152 (52.41%, CI: 46.64, 58.13) of food insecure HIV-infected adults were found to have a severe form of food insecurity, followed by a moderate form of food insecurity, 110 (37.93%, CI: 32.50, 43.68; Table 5).

Factors associated with food insecurity among PLHIV

We used log-binomial regression to identify the association between food insecurity and independent variables, a robust method of analysis for cross-sectional studies with binary outcomes, aiming to minimize the overestimation of the prevalence ratio. The prevalence ratio is also more interpretable and easier to communicate to non-specialists than the odds ratio.

Accordingly, in bivariable analysis, 17 variables—gender, age, marital status, occupational status, presence of children, number of children, monthly income, residence, educational status, type of caregivers, presence of OIs, types of OIs, duration HIV infection, duration of ART follow-up, ART follow-up interval, WHO clinical stage, and WHO treatment stage—showed association with a p-value of ≤0.2 and were selected as candidates for multivariable analysis. Five of the 17 variables, such as duration of HIV infection, presence of children, ART follow-up interval, type of caregivers, and types of OIs that showed collinearity with other related variables, were reduced after collinearity check using collinearity diagnostics such as correlation matrix and variance inflation factor.

Thus, the multivariable log-binomial regression analysis was performed, taking all variables into account simultaneously, and seven of the most contributing factors were significantly and independently associated with food security status at a 5% level of significance.

The gender of HIV-infected adults was found to have a significant and independent predictor of food insecurity, of which the proportion of food insecurity was 1.9 times higher among female subjects than male subjects [adjusted prevalence ratio (APR) = 1.87, 95% CI: 1.03, 3.39]. Food insecurity was higher among younger HIV-infected adults than older adults; the proportion of food insecurity was 2.3 times higher among those belonging to the age group less than 35 years than those belonging to the age group greater than 45 years (APR = 2.27, 95% CI: 1.12, 4.60). The educational status of the HIV-infected adults was found to have a strong significant association with food insecurity, of which the proportion of food insecurity was 11 and 6 times higher among HIV-infected adults who had no formal education and

TABLE 3 Psychosocial support for HIV-infected adults receiving antiretroviral therapy at health facilities in North Shewa Zone, Ethiopia, 2023.

Variables	Frequency	Percent
Presence caregiver (*n* = 861)		
No	444	51.57
Yes	417	48.43
Type of care received (*n* = 417)		
Psychological support	86	20.62
Economic support	273	65.47
Physical support	24	5.76
Social support	34	8.15
Type of caregiver (*n* = 417)		
Mother/ father	56	13.43
Wife	86	20.62
Husband	159	38.13
Children	81	19.42
Others	35	8.39
Disclose their Sero-status (*n* = 861)		
No	421	48.90
Yes	440	51.10
To whom you disclose (*n* = 421)		
Mother/father	46	10.45
Wife	96	21.82
Husband	148	33.64
Children	92	20.91
Community supporter	27	6.14
Others	31	7.05

TABLE 4 Clinical factors of HIV-infected adults receiving antiretroviral therapy at health facilities in North Shewa Zone, Ethiopia, 2023.

Variables	Frequency	Percent
Therapeutic food (*n* = 861)		
No	818	95.01
Yes	43	4.99
Presence of eating problems (*n* = 861)		
No	688	79.91
Yes	173	20.09
Causes of Eating problem		
Loss of appetite	134	77.46
Oral candidiasis	33	19.08
Esophageal candidiasis	6	3.47
Opportunistic malignancy		
No	857	99.54
Yes	4	0.46
Presence of OIs (*n* = 861)		
No	688	79.91
Yes	173	20.09
Type of OI disease		
Tuberculosis	43	24.86
Pneumonia	31	17.92
Diarrheal disease	68	39.31
Dyspepsia	10	5.78
Others	21	12.14
Presence of anemia		
No	649	75.38
Yes	212	24.62
Duration of HIV infection		
<=5years	192	22.30
>5years	669	77.70
Average duration of HIV infection in years	Mean	SD
Average (SD)	9.76	4.65
WHO clinical stage		
Stage one	624	72.47
Stage two	167	19.40
Stages three and four	70	8.13
WHO treatment stage		
Stage one	764	88.73
Stage two	84	9.76
Stages three and four	13	1.51
Duration of ART		
≤4 years	165	19.16
>4years	696	80.84
Average duration of ART in years	Mean	SD
Average (SD)	9.20	4.56
Follow up interval		
Less than 3 months	189	21.95
3 and above months	672	78.05

attended primary school, respectively, than those who attended secondary and above education (APR = 10.79, 95% CI: 14.74, 24.58) and (APR = 5.99, 95% CI: 2.65, 13.54).

Concerning occupational status, the proportion of food insecurity was 6.9 times higher among daily laborer patients than farmer patients when the effect of other variables was kept constant (APR = 6.90, 95% CI: 2.28, 20.85). The analysis found that lower monthly income leads to a higher proportion of food insecurity, among HIV-infected adults, of which the proportion of food insecurity was 1.9 times higher among HIV-infected adults who had monthly income less than 2,500 Ethiopian Birr than those who had monthly income greater than 2,500 Ethiopian Birr (APR = 1.89, 95% CI: 1.11, 3.22).

Among clinical factors, the WHO clinical stage and duration of antiretroviral treatment were strongly associated with a higher proportion of food insecurity among HIV-infected adults. The more advanced the WHO clinical stage, the higher proportion of food insecurity among adults was noted. Specifically, the proportion of food insecurity was 2.3 times higher among adults at WHO clinical stage two than the WHO clinical stage one (APR = 2.34, 95% CI: 1.08, 5.10). The proportion of food insecurity was 2.3 times higher among those receiving ART for less than 4-year duration (APR = 2.28, 95% CI: 1.09, 4.74). However, socio-economic support and food support/therapeutic food support were not significantly associated with the proportion of

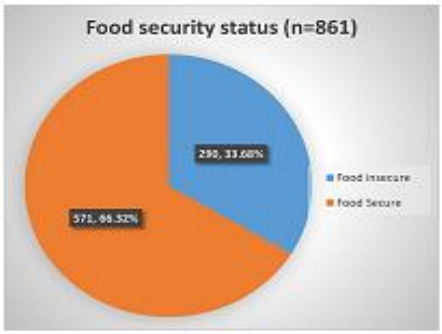

FIGURE 1
Household food security status of HIV-infected adult receiving antiretroviral therapy at health facilities in North Shewa Zone, Ethiopia, 2023.

food insecurity in the final log-binomial multivariable regression (Table 6).

Discussion

This study aimed to determine the magnitude of food insecurity, its severity, and its associated factors among HIV-infected adults receiving ART. We found that one-third [33.7%: (30.60, 36.91)] of the HIV-infected adults living in the household have food insecurity. Gender, early age, occupational status, educational status, monthly income, WHO clinical stage, and duration of ART were significantly and independently associated with food insecurity.

The magnitude of food insecurity in this study is in line with the study conducted in the West Shoa Zone (35.2%) (31) and in Kenya (33.5%) (45). However, the finding is lower than the finding of studies in Ethiopia, particularly studies conducted in Benishangul Gumuz (76%) (46), hospitals in western Ethiopia (68.8%) (47), Debre Markos Town (84.52%) (29), Hosanna (67.53%) (28), (68.48%) (27), Tigray (40.43%) (48), studies in Jimma (63.01%) (30), (85.92%) (24), Kembata Tembaro (57.3%) (49), and studies in Butajira (78.11%) (25), (79.02%) (26). The difference may be attributed to several factors, including the time gap between previous studies and the current one, as well as the larger sample size included compared to previous studies. As a multi-center study, the inclusion of multiple study sites ensured the representativeness of the area, which could have contributed to the variation in the findings. The magnitude of food insecurity in this study was also lower than in some previous studies in African countries. For instance, among PLHIV, rates were reported as 60% in South Africa (50), 57% in the Democratic Republic of Congo (19), 84.6% in Dakar (20), and 74.6% (51) and 38% (52) in two studies in rural Uganda. The long duration since the previous studies were conducted, the socio-economic characteristics of the population, and the cultural context of the study areas are considered to be possible explanations for the difference in the level of food insecurity.

The magnitude of food insecurity in the current study is higher than the findings of the studies conducted in Dembia Gondar (18.36%) (53) and Arba Minch (19.54%) (36). The possible explanation may be the smaller sample in the previous studies and the timing of the studies.

We find that 52.4% (46.6, 58.1) of HIV-infected adults from households living with food insecurity were found to have a severe form of food insecurity, which is higher than the findings of studies in Western Ethiopia (16.35%) (47), Kembata Tembaro Zone (17.4%) (49), and two studies in Butajira (42.0%) (25) and (41.7%) (26). This highlights the need for critical care and support attention during ART follow-up, as only 5% of the participants reported that they received food support, including nutritional counseling.

We found a strong and significant association between the gender of HIV-infected adults and food insecurity, in which the proportion of food insecurity was two times higher among female subjects. This finding is not surprising and is in line with those recent studies on the topic. For instance, a systematic review published early in this study by the principal author of Onyenakie et al. (54), a study conducted in Arba Minch (36), and another study conducted in the Dominican Republic (35) (have reported similar findings). However, it requires special attention in a country like Ethiopia, where women often face greater social and economic disadvantages, potentially aggravating their food insecurity situations.

Our study found that age and magnitude of food insecurity were significantly associated, with the proportion of food insecurity being higher in the younger age group compared to the older age group. Surprisingly, we found mixed evidence regarding age as a contributing factor to food insecurity among HIV-infected adults. For instance, the younger age of patients was associated with an increased proportion of food insecurity in the study conducted in Brazil and other high-resource settings (18, 56) as well African countries (55), while an increased proportion of food insecurity was found among older adults in the United States (56), and some studies indicated a lack of significant association between patients' age and food insecurity. This indicates the need for further study on the association between the age of HIV-infected adults and food insecurity.

This study found a significant and independent association between the monthly income of HIV-infected adults and food insecurity, which stipulated that the lower the monthly income, the higher the proportion of food insecurity among HIV-infected adults. This finding was fairly established and in line with findings of previous studies conducted in Western Ethiopia (47), Hosana Town (28), Kembata Tembaro Zone (49), Arba Minch (36), Butajira (26), and rural Zambian hospitals (57).

We found a strong and significant association between the proportion of food insecurity and the educational status of HIV-infected adults, in which the proportion of food insecurity was higher among HIV-infected adults who had no formal education and attended primary school. The finding is in line with other previous studies that have found no education and lower levels of education to be strongly associated with food insecurity in Western Ethiopia (47), Hosanna Town (28), Brazil (18), Jimma Zone (30), and Nigeria (22).

In the current study, the lack of permanent employment was found to have a significantly strong association with the proportion of food insecurity being higher among patients who were daily laborers. It may be the result of a lack of permanent employment, which can affect the earning capacity of HIV-infected adults and, consequently, increase the proportion of food insecurity. The finding is supported

by the finding of the previous studies that unemployment was found to have a significant association with food insecurity in Hosanna Town (28), Nigeria (22), and Brazil (18).

Concerning clinical factors, we found a significant and independent association between the WHO clinical stage and the duration of antiretroviral treatment among HIV-infected adults. The proportion of food insecurity among patients with advanced WHO clinical stage and receiving ART for less than 4-year duration was found to be high. This may be due to worsening disease situations and deteriorated health status at the advanced clinical stage of HIV with delayed ART initiation. The significant association of food insecurity with advanced clinical stages is supported by previous studies conducted in different areas and settings, for example, in Ethiopia (27, 32, 36, 49, 58). In the same way, a significant association with the duration of ART is also supported by the findings of studies conducted in Africa, including Ethiopia (59) and Namibia (34), in which the shorter duration of ART and the high proportion of food insecurity among HIV-infected adults have been demonstrated. This will imply that longer ART duration, greater than 4 years, may be associated with lower food insecurity, possibly due to improved health status and coping capacity among HIV-infected adults receiving ART. However, it is not sufficient to establish a cause-and-effect relationship using a cross-sectional survey alone without evidence from a follow-up study.

TABLE 5 Level of household food insecurity among HIV-infected adults receiving antiretroviral therapy at health facilities in North Shewa Zone, Ethiopia, 2023.

Variables	Frequency	Percent with CI
Severity of food insecurity ($n = 290$)		
Mild food insecure	28	9.66(6.74, 13.64)
Moderately food insecure	110	37.93 (32.50, 43.68)
Severely insecure	152	52.41(46.64, 58.13)

TABLE 6 Factors associated with food security status among HIV-infected adults receiving antiretroviral therapy at health facilities in North Shewa Zone, Ethiopia, 2023.

Variables	Food security status (No)		CPR with 95% CI	APR with 95% CI	*p*-value
	Food insecure	Food secure			
Gender					
Male	89	243	1.0	1.0	
Female	201	328	1.67 (1.24, 2.26)**	1.87(1.03, 3.39)**	0.039
Age category					
<35 years	120	176	2.02(1.39, 2.94)**	2.27(1.12, 4.60)**	0.023
35–44 years	110	217	1.50(1.04, 2.18)**	1.38(0.74, 2.60)	0.314
≥45 years	60	178	1.0	1.0	
Educational status					
No formal education	172	209	4.99(3.29, 7.55)**	10.79(4.74, 24.58)**	<0.001
Primary school	84	156	3.26(2.08, 5.11)**	5.99(2.65, 13.54)**	<0.001
Secondary and above	34	206	1.0	1.0	
Occupational status					
Farmer	32	141	1.0	1.0	
Housewife	64	129	2.19(1.34, 3.56)**	0.95(0.32, 2.80)	0.921
Daily laborer	106	141	11.12(6.58, 18.79)**	6.90(2.28, 20.85)**	0.001
Employed	30	119	1.11(0.64, 1.93)	1.22(0.40, 3.74)	0.728
Merchant/others	58	140	1.83(1.12, 2.98)**	1.2(0.37, 2.83)	0.965
Monthly income(ETB)					
Less than 2,500	144	120	3.74(2.61, 5.36)**	1.89(1.11, 3.22)**	0.020
2,500 and above	71	221	1.0	1.0	
WHO clinical stage					
Stage one	223	401	1.0	1.0	
Stage two	50	117	0.77(0.53, 1.11)*	2.34(1.08, 5.10)**	0.032
Stages three and four	17	53	0.58(0.33, 1.02)*	2.25(0.69, 7.33)	0.179
Duration of ART					
≤4 years	81	84	2.25(1.59, 3.17)**	2.28(1.09, 4.74)**	0.028
>4 years	209	487	1.0	1.0	

*Mean factors that show association with FAVs at *p*-value less than 0.25 (rule of thumb). **Mean factors that show statistically significant association with FAVs at *p*-value less than 0.05. Bold values indicates those factors that showed statistically significant association with food insecurity.

However, we found a lack of significant association between food security and socio-economic status and food support in the final log-binomial multivariable regression, while the absence of support was found to be strongly associated with food insecurity in South Wollo (58), Kembata Tembaro and Hosanna Town (27, 49), and the Dominican Republic (35). The lack of a significant association between therapeutic feeding supports in the current study may be due to the fact that a very small proportion of HIV-infected adults received food by prescription.

Limitations of the study

The current study assessed the food security status of HIV-infected adults by including all health facilities with established ART clinics with diverse service delivery levels and using a large sample size to determine the number of HIV-infected adults receiving ART. The KoboToolbox digital data collection platform allows the investigator to follow and approve the collected data daily, train data collectors and supervisors, and use a log-binomial model suitable for estimating prevalence ratios. This ensures the credibility of the evidence generated in this study. However, the current study has some situational and methodological limitations. The first is the use of a cross-sectional study design, in which data were collected at a point in time for both independent and dependent variables for this specific objective. This temporal relationship may limit the ability to identify causal and effect relations between food insecurity and independent variables. The second is the possibility of recall bias, particularly in food security status assessments, as they were asked about their experience over the last 30 days. Third, given the scope of the current study, the relationship between food insecurity and loss of follow-up among HIV-infected individuals was not explored. Further comparative research is required to analyze food insecurity differences between those lost to follow-up and those not lost and their impact on loss to follow-up. Fourth, there is a possibility of social desirability bias due to the sensitivity of the issues under study and the limited cultural tendency in our societies to discuss such sensitive issues frankly.

Conclusion

The findings of this study indicate that the magnitude of food insecurity among HIV-infected adults receiving ART was high, with extremely severe forms of food insecurity. This is also indicated as its magnitude is still a critical public health problem in the society living in areas with surplus crop production. The gender of HIV-infected adults, being younger, occupational status, educational status, monthly income, WHO clinical stage, and duration of ART were significantly and independently associated with a high proportion of food insecurity among HIV-infected adults. The findings suggest the importance of education for HIV-infected people, attention to the early stage of ART, and advanced clinical stages of patients in the form of patient education and nutritional counseling for patients with advanced clinical stages of the disease. The nutritional intervention should be culture- and context-specific to address the gender dynamicity of food insecurity among HIV-infected adults. The findings also suggest the need for emphasis on the link between food insecurity and HIV in Ethiopia's National Food and Nutrition Policy.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study involving humans were approved by the Institutional Review Board of the College of Health Sciences, Addis Ababa University, with a protocol number of 104/19/SPH. The study were conducted in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants in accordance with the national legislation and the institutional requirements. The participants provided their verbal informed consent to participate in this study.

Author contributions

DB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Visualization, Writing – original draft, Writing – review & editing. AA: Conceptualization, Data curation, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – review & editing. AY: Conceptualization, Data curation, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Fruits and vegetables dietary intake and its estimated consumption among adults receiving antiretroviral therapy in health facilities in Northcentral Ethiopia: a multi-facility cross-sectional study

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Background: Despite the significant role of fruit and vegetables (FAVs) in preventing a variety of chronic diseases and their potential to bolster immune responses and slow the progression of HIV infection to AIDS, there is a lack of studies on the dietary intake of FAVs among HIV-infected adults in Africa, including Ethiopia. Hence, this study aimed to investigate the magnitude of FAV intake and estimated consumption among HIV-infected adults receiving antiretroviral therapy (ART) in northcentral Ethiopia.

Methods: A multifacility cross-sectional study was conducted on the FAV intake among 865 HIV-infected adults receiving ART. A Poisson regression model with robust variance was used to identify factors associated with FAVs dietary intake.

Results: The study indicated that 655 (76.34%; 95% CI: 73.38, 79.07) HIV-infected adults reported consuming FAVs less than once per day, with 838 (97.67%, 95% CI: 96.41, 98.49) and 676 (78.79%, 95% CI: 75.92, 81.40) HIV-infected adults reporting consuming fruits and vegetables less than once per day, respectively. The median (IQR) total FAV intake was 271.3 (IQR: 92.5, 439.5) g/day, with the median (IQR) intake of fruits being 248.1 (IQR: 100.0, 400.0) g/day and vegetables being 273.78 (IQR: 82.44, 348.33) g/day, respectively. We found that being divorced (APR = 1.57, 95% CI: 1.16, 2.12), employed as a daily laborer (APR = 2.08, 95% CI: 1.36, 3.20), being employed (APR = 1.77, 95% CI: 1.10, 2.84), merchants (APR = 1.59, 95% CI: 1.03, 2.47), having children as caregivers (APR = 1.61, 95% CI: 1.02, 2.55), an advanced WHO clinical stage (APR = 1.32, 95% CI: 1.32(1.03, 1.69), and receiving ART for more than 8 years (APR = 1.78, 95% CI: 1.18, 2.67) were found to be independent predictors of FAV dietary intake among HIV-infected adults. From the findings, we understood that farmers were less likely to consume FAVs compared to employed individuals, daily laborers, and merchants.

Conclusion: The finding indicated a very low level of FAV dietary intake among HIV-infected adults receiving ART, falling well-below the minimum recommendation for physically active adults. Despite living in areas with surplus production and producing these items, farmers are less likely to consume FAV. The study emphasizes the importance of focusing on the early stage of ART treatment for patients and family therapy, including counseling and guidance on consuming healthy diets such as FAVs, to enhance the role of children as caregivers for their families. Additionally, there is a need for comprehensive

nutritional counseling to improve FAV consumption, with a particular emphasis on educating individuals about portion size estimation for the consumption of FAVs.

KEYWORDS

fruit, vegetable, HIV/AIDS, dietary intake, antiretroviral therapy, adults

Introduction

In 2022, approximately 1.3 million new HIV infections were recorded globally, exceeding the global targets by over one million (1–3). Despite the availability of effective HIV treatments and tools for preventing, detecting, and treating opportunistic infections, the AIDS pandemic claimed a life every minute, resulting in 500,000 AIDS-related deaths in 2022 (2–5).

Good nutrition should be integrated into the care and treatment plan to enhance treatment success and improve the quality of life among HIV-infected individuals. A well-balanced diet can contribute to achieving a healthy weight gain, strengthening the immune system, preventing infection, and reducing hospital stays. It also helps the body build and maintain muscle mass, enhances the effectiveness of medications, aids in managing the side effects of medication, and improves the overall quality of life (6, 7). Fruits and vegetables (FAVs) are important components of a healthy diet and good nutrition. The consumption of FAVs could help prevent a variety of chronic communicable and non-communicable diseases, including HIV/AIDS (8).

HIV-infected patients have compromised immune systems, leading to inflammation and an increased risk of chronic diseases and infections. They require balanced portions of fresh FAVs containing essential micro and macronutrients to address their nutritional needs and reduce symptoms (6).

Few studies conducted in high-income countries among the general population, including HIV-infected adults, indicate very low to low levels of fruit and vegetable dietary intake. In the USA, only approximately 14% of the total population meets the recommended fruit intake levels and 8% for vegetables (9). Similarly, studies conducted in China and Canada report insufficient fruit and vegetable intake, with 55.2% of the labor force and 40.7% of students falling short of recommended levels, showing no significant differences between urban and rural populations in the proportion of insufficient vegetable intake (10). A study conducted in Portugal among HIV-infected adults also indicated the low frequency of fruit and vegetable consumption, in which 42.5 and 23.7% of participating individuals consumed FAVs less than once per day (11). In Africa, studies indicate that only a small proportion of people consume and meet the recommended amount. In that line, a study conducted in Kenya indicates that 51.0% of the people consumed fruits during the survey (the previous day), with a mean intake of 189.6 (16.8) g/day, of which only 16% of the participants met WHO recommendations (12). In the study conducted in Uganda among adults, it was indicated that only 12.2% of them consumed five or more servings of fruits and/or vegetables per day in a typical week (13). The evidence from a review of high-income countries indicated that the sex, age, marital status, educational status, and income of participants were found to be contributing factors to the low level of fruit and vegetable consumption (14).

A healthy diet, including FAVs, will have a significant impact not only on the quality of life of patients but also on the success of ART treatment (15). The World Health Organization (WHO) recommends a daily intake of 400 g of FAVs, equivalent to five portions, to mitigate the risk of chronic diseases. This intake is also beneficial for HIV-positive individuals, as it helps address micronutrient deficiencies, including antioxidants such as vitamins C, A, E, and selenium. These nutrients contribute to metabolic regulation and bolster immune responses, potentially slowing the progression of HIV infection (16, 17).

In this regard, in the review of existing evidence, we did not find a single study investigating fruit and vegetable dietary intake among HIV-infected adults in Africa, including Ethiopia. Furthermore, the review of national HIV and nutrition guidelines revealed that while there is a significant focus on nutritional counseling for macronutrient and micronutrient deficiency-related problems (18), there is no explicit mention of the benefits of a healthy diet, which is assumed to contribute to improvements in the immune system function and enhanced quality of life among HIV-infected individuals. Therefore, the main objective of this study is to assess the magnitude of fruit and vegetable dietary intake, estimate the amount consumed, and identify factors associated with these dietary habits among adults receiving ART in health facilities in northcentral Ethiopia.

Materials and methods

Study design, settings, and period

This study employed a multi-center facility cross-sectional study in health facilities located in North Shewa Zone, northcentral, Oromia, Ethiopia. The zone consists of 16 districts, including four town administrations and 12 rural districts (19). It is noteworthy that the zone comprises one referral hospital and four primary hospitals, along with 64 health centers and 275 health posts. Among these facilities, 18 health facilities (four hospitals and 14 health centers) were identified as having ART clinics to provide ART services to HIV-infected people. We conducted this study in ten health facilities, comprising four hospitals and six health centers, which were providing ART services to HIV-infected individuals with high caseloads and established ART clinics. The study was conducted from January 2021 to April 2022.

Study population and participants

All people living with HIV (PLHIV) receiving ART in the six health centers and four hospitals, aged 18 years and older, regardless of their treatment regimen and duration of follow-up, were eligible for inclusion. However, patients with other concomitant chronic diseases, such as heart disease, hypertension, and diabetes mellitus, and those that could suppress the immune system and deteriorate nutritional status, as well as pregnant women who received ART, were excluded from this study to ensure data quality. This condition impairs their health and affects their access to sufficient FAVs. It could also exacerbate the existing suppression of the immune system caused by the presence of HIV.

Sample size determination and sampling procedures

The sample for the current study was determined using the double-population proportion formula in EpiInfo version 7 for sample size calculation (20), focusing on the factors associated with fruit and vegetable (FAV) dietary intake as the outcome of interest. Based on a literature review, the sample size was determined by the differences in FAV dietary intake between the two populations, considering food support as a major exposure variable. Furthermore, it was noted that the proportion of HIV-infected adult patients with FAV intake without food support was 3.4%, with an adjusted odds ratio for the association between FAV intake and food support was 2.4 (21). With these figures, this study used a one-to-one (1:1) allocation ratio of unexposed to exposed, a 5% level of significance (two-sided), and a power of 80%. To account for potential non-responses, an additional 5% was added to the sample size, resulting in a total sample size of 865. Four hospitals and six health centers that provided care were included in this study after identifying all hospitals and health centers that provided ART in North Shewa, Oromia. A list of all eligible HIV-infected adults receiving ART in clinics was obtained from the patient registration book. The calculated sample was allocated proportionally to each included health facility based on the size of patient populations. Then, simple random sampling was used to select participants from the patient registration book using the SPSS (version 25) select cases menu.

Study variables and measurement

The dependent variable for the study was FAV dietary intake in the last 30 days, assessed through the frequency of consumption using Behavioral Risk Factor Surveillance System (BRFSS) assessment tools. The frequency of consumption of two classes of fruits (whole fruits and 100% fruit juice, without sugar or other additives) and vegetables (such as green leafy vegetables, like cabbage and salads; cruciferous; marrow; starchy staples like potatoes, sweet potatoes, green peas, and others; carrots; and other vegetables) was assessed among HIV-infected adults in selected health facilities. We used 10 categories to assess the frequency of FAV consumption: never, <1 time per month, 1–3 times a month, once a week, 2–4 times a week, 5–6 times a week, once a day, 2–3 times a day, 4–5 times a day, and 6+ times a day (16, 22). The median frequency of FAV daily intake was initially calculated by converting weekly and monthly intake into daily intake. This was achieved by dividing the frequency of weekly or monthly reported intake by 7 or 30, respectively. Subsequently, the frequencies of all FAV variables were summed up to obtain the total frequency of FV intake. The median was then calculated using the total daily FAV frequency as a continuous variable (22). Then, it was dichotomous, coded as 1 if the median frequency was less than one time per day for low FAV dietary intake and 0 if the median frequency was greater than or equal to one time per day for high fruit and vegetable intake (22). In addition, the adequacy of FAV was also assessed by considering the portion size of each selected FAV. The portion sizes were then multiplied by the recommended grams to calculate the median grams based on the WHO/FAO recommendation. According to these recommendations, individuals should consume 400 or more grams of FAVs for overall health improvement, reducing the risk of certain NCDs and preventing chronic infections (17). This dietary practice contributes to metabolic regulation and bolsters immune responses, potentially slowing the progression of HIV infection due to the content of vitamins and minerals such as vitamins C, A, E, and selenium, which possess antioxidant effects (16, 17).

We considered two independent variable categories. The first category included sociodemographic and socioeconomic characteristics (age, gender, income, educational status, occupational status, ethnicity, religion, marital status, residence, and psychosocial support). The second category included nutrition, treatment, and clinical characteristics (the duration of ART treatment, WHO clinical stage, WHO treatment stage of HIV, opportunistic infections, therapeutic food support, follow-up interval, and food security status).

Data collection tools and methods

A structured interviewer-administered questionnaire was developed to collect sociodemographic, socioeconomic, and clinical characteristics of HIV-infected adults. Additionally, we used the standard Behavioral Risk Factor Surveillance System (BRFSS) tool to assess the frequency and intake of FAV among HIV-infected adults. Patient records were extracted to collect data on some variables, such as the type of malignancy, IOs, anemia, and WHO staging. The data collection process was supervised by the principal investigator and two field supervisors. Nine health professionals (nurses and health officers) who were not working in ART clinics were recruited and trained for 2 days before being deployed for data collection. The questionnaire was pretested on 5% of the sample at Chancho Hospital to ensure its validity and reliability, which included content validation of the standard Behavioral Risk Factor Surveillance System (BRFSS) tool with local experts before adapting it for data collection. The necessary amendment was made based on the findings of the pretest before actual data collection.

Data management and analysis

Data were exported from KoboToolbox to STATA 17 for analysis and modeling. A descriptive analysis was used to describe the characteristics of the study participants. A Poisson regression model with robust variance was fitted to identify factors associated with fruit and vegetable consumption. All factors that were associated with the outcome variable in the bivariable analysis with a *p*-value of 0.20 or less were included in the multivariable Poisson regression model. The crude and adjusted prevalence ratios, together with their corresponding 95% confidence intervals, were computed. The multicollinearity of explanatory variables was checked using the variance inflation factor, while the fitness of the model was checked using information criteria such as AIC and BIC. A *p*-value of <0.05 and the corresponding 95% confidence interval were considered statistically significant.

Ethical consideration

Ethical clearance for the study was obtained from the Institutional Review Board of the College of Health Sciences, Addis Ababa University, under registration number 104/19/SPH. Data collection commenced only after obtaining permission from the participating hospitals and health centers. All focal personnel at the ART clinics of the respective health facilities were duly informed about the study protocols. The participants provided their written informed consent before participating in the study, after being fully briefed on its purpose. The confidentiality of the collected data was maintained by not revealing personal identifiers and locking the data in the file cabinet. Participation in this study was voluntary, with participants having the full right to opt out, or withdraw at any point from the study. This study did not cause harm to the participants except for minor discomfort during the interview process. There were no direct benefits for the participants in participating in this study. The soft copy of data entered into the computer was stored in encrypted files on password-protected computers.

Results

Sociodemographic and socioeconomic characteristics

A total of 858 HIV-infected adults were enrolled and completed the interview. A total of 552 (64.34%) participants belonged to the age group ≤ 40 years, with the mean age of the enrolled participants was 38.64 (±9.85 SD) years. Additionally, 527 participants (61.42%) were women, and 614 participants (71.56%) were from urban areas. A total of 778 (90.68%) participants were followers of Orthodox Christianity, and 519 participants (60.49%) were married. A total of 642 (74.82%) participants belonged to Oromo in ethnicity. A total of 198 (23.08%) HIV-infected adults were merchants, followed by housewives (191, 22.26%). A total of 379 (44.17%) HIV-infected adults had no formal education, and 291 (52.62%) participants responded that they earned a monthly income of 2,500 and above ETB and had a median monthly income of 2500ETB (IQR: 1,200, 4,730) (Table 1).

TABLE 1 Sociodemographic and economic characteristics of HIV-infected adults receiving antiretroviral therapy at health facilities in northcentral, Ethiopia, 2023.

Variables	Frequency	Percent
Age of respondents		
≤40 years	552	64.34
>40 years	306	35.66
Mean (±)	38.64 (±9.85)	
Sex of participants		
Male	331	38.58
Female	527	61.42
Residence		
Rural	244	28.44
Urban	614	71.56
Religion of participants		
Orthodox	778	90.68
Protestant	55	6.41
Others*	25	2.91
Marital status		
Married	519	60.49
Single	96	11.19
Divorced	111	12.94
Widowed	132	15.38
Ethnicity of participants		
Oromo	642	74.82
Amhara and Gurage	216	25.18
Occupational status		
Farmer	172	20.05
Housewife	191	22.26
Daily laborer	148	17.25
Employed	149	17.37
Merchant/others	198	23.08
Educational status		
No formal education	379	44.17
Primary school	239	27.86
Secondary and above	240	27.97
Monthly income (*n* = 553)		
<2,500 ETB	262	47.38
≥2,500 ETB	291	52.62
Median monthly income (ETB)	**Median**	**IQR**
Median (IQR)	2,500	(1,200, 4,660)

*Catholic, Muslim, and Wakefata.

TABLE 2 Socioeconomic support for HIV-infected adults receiving antiretroviral therapy at health facilities in northcentral, Ethiopia, 2023.

Variables	Frequency	Percent
Presence caregiver (n = 858)		
No	443	51.63
Yes	415	48.37
Type of care received (n = 415)		
Psychological support	86	20.72
Economic support	271	65.30
Social support and related	58	13.98
Type of caregiver (n = 415)		
Mother/father	55	13.25
Husband/wife	245	72.29
Children	80	19.28
Others	35	8.43
Disclose their sero-status (n = 858)		
No	420	48.95
Yes	438	51.05
To whom you disclose (n = 438)		
Mother/father	45	10.27
Husband/wife	244	55.71
Children	91	20.78
Others	58	13.24

Socioeconomic support for HIV-infected adults

Regarding socioeconomic support, 415 (48.37%) HIV-infected adults received informal care from different caregivers; of which, 271 (65.30%) and 86 (20.72%) HIV-infected adults received economic support and psychological support, respectively. The majority, 245 (72.29%), received care either from their husbands or wives, and 438 (51.05%) HIV-infected adults had disclosed their HIV status, with 244 participants (55.71%) disclosing their HIV serostatus to their husbands or wives (Table 2).

Clinical and food-related characteristics of HIV-infected adults

A total of 172 (20.05%) HIV-infected adults reported having eating problems during their treatment follow-up, the most common reasons being the loss of appetite (133, 77.33%), followed by oral candidiasis (33, 19.19%). Moreover, 173 participants (20.16%) developed opportunistic infections (OIs), and 43 participants (5.01%) reported receiving therapeutic feeding during the treatment follow-up. In total, 212 (24.71%) patients reported being anemic during their treatment follow-up. A total of 621 (72.38%) and 761 (88.69%) HIV-infected adults were at the WHO

TABLE 3 Clinical and food-related characterisitics of HIV-infected adults receiving antiretroviral therapy at health facilities in northcentral, Ethiopia, 2023.

Variables	Frequency	Percent
Presence of eating problems (n = 858)		
No	686	79.95
Yes	172	20.05
Causes of eating problems (n = 172)		
Loss of appetite	133	77.33
Oral candidiasis	33	19.19
Esophageal candidiasis	6	3.49
Presence of OIs (n = 858)		
No	685	79.84
Yes	173	20.16
Therapeutic food (n = 858)		
No	815	94.99
Yes	43	5.01
Presence of anemia (n = 858)		
No	646	75.29
Yes	212	24.71
Duration of HIV infection (n = 858)		
<5 years	157	18.30
5–10 years	185	21.56
>10 years	516	60.14
The average duration of HIV infection in years (n = 858)	Mean	SD
Average (SD)	9.76	4.64
WHO clinical stage (n = 858)		
Stage one	621	72.38
Stage two and above	237	27.62
WHO treatment stage (n = 858)		
Stage one	761	88.69
Stage two and above	97	11.31
Duration of ART (n = 858)		
<4 years	138	16.08
4–8 years	186	21.68
>8 years	534	62.24
The average duration of ART in years	Mean	SD
Average (SD)	9.21	4.54
Unprotected sex for daily food		
No	764	88.73
Yes	84	9.76

(Continued)

TABLE 3 (Continued)

The average duration of ART in years	Mean	SD
Ever migrated from home for food		
No	792	92.31
Yes	66	7.69
Food security status		
Food secure	570	66.43
Food insecure	288	33.57

clinical stage one and WHO treatment stage one, respectively, while 534 (62.24%) participants reported that they received ART for more than 8 years, and the average amount of time that the studied HIV-infected adults received treatment was 9.21 years (±4.54 SD), which is considered a longer ART duration.

A total of 84 (9.76%) and 66 (7.69%) HIV-infected adults claimed to have been forced to engage in unprotected sex and had migrated from their previous place of residence to obtain daily food, respectively. A significant proportion of the HIV-infected adults reported experiencing food insecurity (288, 33.57%) (Table 3).

Fruits and vegetable dietary intake frequency

We assessed the frequency of consumption of two classes of fruits (whole fruits and 100% fruit juice without sugar or other additives) and vegetables (green leafy and salads, cruciferous, marrow, starchy staples, carrots, and other vegetables) among HIV-infected adults. We found a very low frequency of FAV consumption among HIV-infected adults in relation to the recommended daily allowance. Only 205 (23.89%) and 177 (20.63%) of the HIV-infected adults consumed 100% fruit juice and whole fruit once per month, respectively. A total of 231 (26.92%) and 160 (18.65%) HIV-infected adults consumed green leafy vegetables and salad one time per month and 2–3 times per month, respectively. In total, 331 (38.58%) and 301 (35.08%) HIV-infected adults consumed cruciferous vegetables and starchy foods 2–3 times per month, respectively. Moreover, 289 (33.68%), 220 (25.64%), and 107 (12.47%) HIV-infected adults reported consuming marrow vegetables, carrots, and other vegetables, respectively (Table 4).

The level of fruit and vegetable dietary consumption among PLHIV

In the study, more than three-quarters, i.e., 655 [76.34%; 95% CI: (73.38, 79.07)] HIV-infected adults reported consuming FAVs less than once per day,

TABLE 4 FAVs intake frequency among HIV-infected adults in northcentral Ethiopia, 2023.

Type of FAVs	Frequency of intake in the past 30 days (No: %) ($n = 858$)								
	Never	1 time per month	2–3 times per month	1–2 times per week	3–4 times per week	5–6 times per week	1 time per week	2–3 times per day	4–5 times per day	6 or more times per day
100% fruit juice	599 (65.15)	205 (23.89)	78 (9.09)	9 (1.05)	2 (0.23)	2 (0.23)	1 (0.12)	1 (0.12)	1 (0.12)	0 (0.00)
Whole fruits	597 (69.58)	177 (20.63)	72 (8.39)	5 (0.58)	1 (0.12)	0 (0.00)	1 (0.12)	1 (0.12)	4 (0.47)	0 (0.00)
Green leafy vegetables and salad	390 (45.45)	231 (26.92)	160 (18.65)	47 (5.48)	16 (1.86)	3 (0.35)	7 (0.82)	0 (0.00)	4 (0.47)	0 (0.00)
Cruciferous vegetables	208 (24.24)	197 (22.96)	331 (38.58)	60 (6.99)	26 (2.91)	2 (0.23)	4 (0.47)	0 (0.00)	30 (3.50)	1 (0.12)
Marrow vegetables	377 (43.94)	289 (33.68)	158 (18.41)	16 (1.86)	5 (0.58)	3 (0.35)	4 (0.47)	0 (0.00)	5 (0.58)	1 (0.12)
Starchy foods	247 (28.79)	181 (21.10)	301 (35.08)	57 (6.64)	24 (2.80)	5 (0.58)	5 (0.58)	4 (0.47)	34 (3.96)	1 (0.12)
Carrots	269 (31.35)	220 (25.64)	212 (24.71)	76 (8.86)	36 (4.20)	12 (1.40)	8 (0.93)	1 (0.12)	23 (2.68)	1 (0.12)
Other vegetables	641 (74.71)	107 (12.47)	75 (8.74)	18 (2.10)	7 (0.82)	2 (0.23)	4 (0.47)	0 (0.00)	4 (0.47)	0 (0.00)
Any vegetables	221 (25.76)	326 (38.00)	192 (22.38)	32 (3.73)	32 (3.73)	5 (0.58)	9 (1.05)	1 (0.12)	39 (4.55)	1 (0.12)

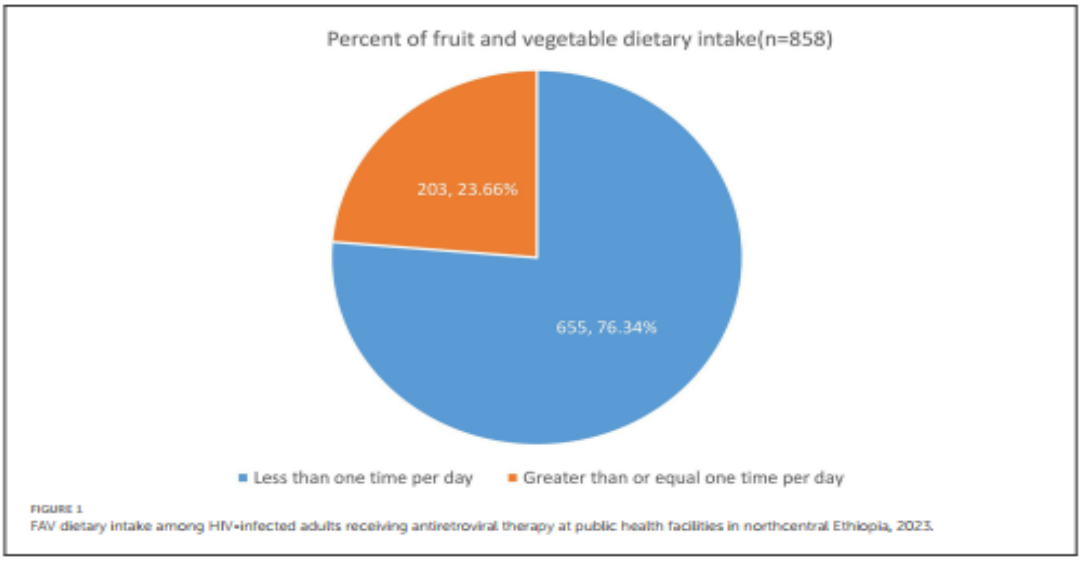

FIGURE 1
FAV dietary intake among HIV-infected adults receiving antiretroviral therapy at public health facilities in northcentral Ethiopia, 2023.

while only 203 [23.66%; 95% CI: (20.93, 26.62)] HIV-infected adults reported consuming FAVs once per day or more (Figure 1).

We also calculated the consumption of FAVs separately to compare their intake. Accordingly, 838 (97.67%, 95% CI: 96.41, 98.49) and 676 (78.79%, 95% CI: 75.92, 81.40) HIV-infected adults reported consuming fruits and vegetables less than once per day, respectively, indicating very low consumption of both fruits and vegetables (Figure 2).

Estimated amount of fruit and vegetable consumption

In this study, we found that there was no culture of portion size estimation, including for those who reported consuming FAVs. It was very difficult to generalize since only 82 and 101 of the total sample responded to the consumption of fruits and vegetables, respectively.

Accordingly, the median (IQR) total FAV intake was 271.3 (IQR: 92.5, 439.5) g/day. The median (IQR) of the total fruit and vegetable consumption was 248.1 (IQR: 100.0, 400.0) g/day and 273.78 (IQR: 82.44, 348.33) g/day, respectively. The proportion of participants consuming 400 g or more of FAVs was calculated based only on the 108 participants whose amount of consumption was quantified. Therefore, the proportion of HIV-infected adults who consumed 400 g or more of FAV was 33 (30.6%) (Table 5).

Factors associated with fruit and vegetable dietary intake

In the bi-variable Poisson regression analysis, 14 variables, namely educational status, marital status, occupational status, monthly income, categories of caregivers, the types of care received, the presence of opportunistic infections, the presence of anemia, ever migrated from a permanent place of residence, people to whom they disclose their serostatus, duration of HIV infection, duration of ART follow-up, the WHO clinical stage, and the WHO treatment stage, showed association with a p-value of $\leq$0.20 and were selected as the candidates for multivariable analysis. Out of the 14 variables, the duration of HIV infection showed collinearity with other related variables but was reduced after the collinearity check using the variance inflation factor.

Consequently, the multivariable Poisson regression analysis with robust variance fitted all 13 variables simultaneously. Five of the most contributing factors were significantly and independently associated with FAV dietary intake at a 5% level of significance.

The marital status of the HIV-infected adults was significantly associated with FAV consumption, with the proportion of FAV dietary intake being 1.6 times higher among those divorced compared to those married (APR = 1.57, 95% CI: 1.16, 2.12) (Table 6).

The occupational status of patients was found to have a statistically significant association with FAV dietary intake. The proportion of FAV dietary intake was two times higher among daily laborers and employed patients (APR = 2.08, 95% CI: 1.36, 3.20) compared to patients who are farmers (APR = 1.77, 95% CI: 1.10, 2.84). Additionally, the proportion of FAV dietary intake was also 1.6 times higher among merchants compared to patients who are farmers (APR = 1.59, 95% CI: 1.03, 2.47) (Table 6).

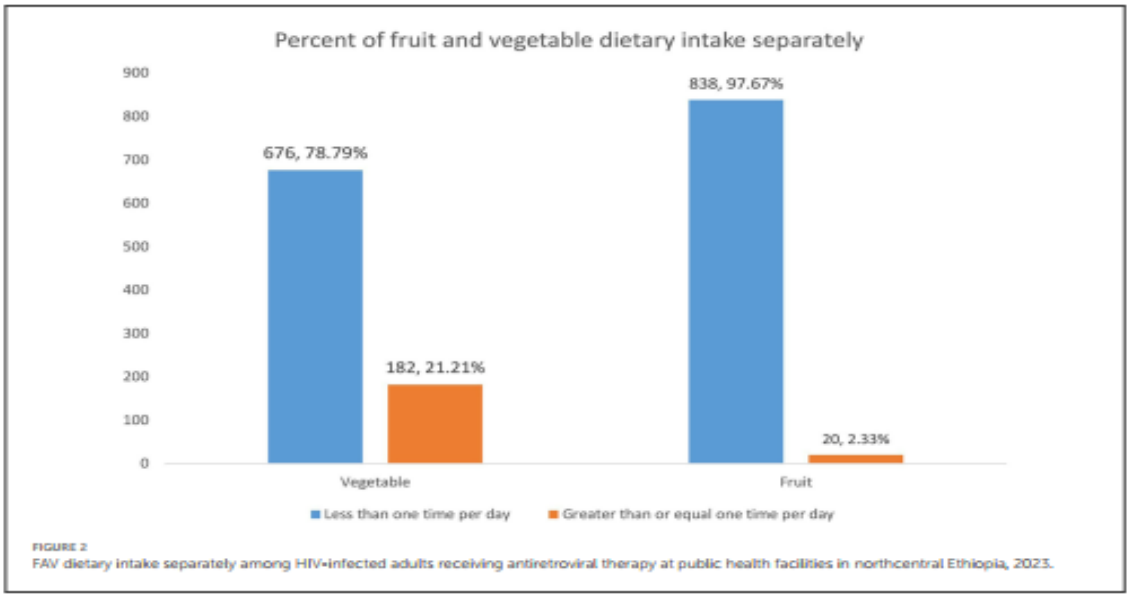

FIGURE 2
FAV dietary intake separately among HIV-infected adults receiving antiretroviral therapy at public health facilities in northcentral Ethiopia, 2023.

TABLE 5 The median fruit and vegetable intake among HIV-infected adults receiving antiretroviral therapy at health facilities in North Shewa Zone, Ethiopia, 2023.

Variables	Median	IQR
Overall median (IQR) FAV intake (*n* = 108)	271.30 g/day	(92.5, 439.5)
Median (IQR) fruit intake (*n* = 82)	248.10 g/day	(100.0, 400.0)
Median (IQR) vegetable intake (*n* = 101)	273.78 g/day	(82.44, 348.33)

The type of caregiver providing care was found to have a statistically significant association with FAV dietary intake. The proportion of FAV dietary intake was 1.6 times higher among HIV-infected adults whose caregivers are their children compared to those whose caregivers are their mothers/fathers (APR = 1.61, 95% CI: 1.02, 2.55) (Table 6).

The WHO clinical stage and the duration of antiretroviral treatment were found to be significant and independent predictors of FAV dietary intake. Specifically, HIV-infected adults at an advanced WHO clinical stage reported a 1.3 times higher FAV dietary intake compared to those at the WHO clinical stage one [APR = 1.32, 95% CI: 1.32 (1.03, 1.69)]. Similarly, the proportion of FAV dietary intake among HIV-infected adults was 1.8 times higher among those receiving ART for more than 8 years (APR = 1.78, 95% CI: 1.18, 2.67). However, the analysis did not indicate a significant association between food security status and socioeconomic support in the final Poisson multivariable regression analysis (Table 6).

Discussion

This study aimed to determine the magnitude of FAV dietary intake, its estimated amount, and the factors associated with it among HIV-infected adults receiving ART in health facilities in northcentral Ethiopia. Accordingly, the study found that more than three-fourths [76.34%: (73.38, 79.07)] of the HIV-infected adults who participated in the study reported consuming FAV less than once per day, based on the median frequency time. This indicated very low FAV dietary intake in the studied population, particularly low fruit dietary intake. Specifically, 97.67% (96.41, 98.49) of them reported consuming fruit less than once per day, based on the median frequency. The study found a very low frequency of fruit and vegetable (FAV) consumption among HIV-infected adults in northcentral Ethiopia, which is much lower than the consumption of FAVs in the general population of Ethiopia. Approximately 15% of households reported consuming FAVs once or more per day (23, 24). The proportion of HIV-infected adults consuming FAV less than once per day in this study was higher than the findings of the study conducted in Portugal among HIV-infected individuals (42.5 and 23.7%, respectively) (16), and 63% of students of tertiary institutions from OYO State, Nigeria reported FAV intake of less than once per day (25). However, the finding is lower than that of the study conducted among adults in South Africa, where only 0.6% of adults with chronic diseases reported consuming FAV daily (26). Furthermore, the finding is higher than the findings from Five Southeast Asian Countries among the general adolescent population, where 28% reported consuming fruits less than once per day and 13.8% indicated consuming vegetables less than once per day (27).

TABLE 6 Factors associated with the magnitude of fruit and vegetable dietary intake among HIV-infected adults receiving ART at health facilities in northcentral, Ethiopia, 2023.

Variables	Fruit and vegetable intake (No)		CPR with a 95% CI	APR with a 95% CI	*P*-value
	High	Low			
Marital status					
Married	123	396	1.0	1.0	
Single	36	60	0.82 (0.70, 0.96)**	1.28 (0.80, 2.07)	0.305
Divorced	16	95	1.12 (1.03, 1.23)**	1.57 (1.16, 2.12)**	0.003
Widowed	28	104	1.03 (0.93, 1.14)	1.20 (0.88, 1.64)	0.239
Occupational status					
Farmer	42	130	1.0	1.0	
Housewife	36	155	1.07 (0.96, 1.20)*	1.42 (0.89, 2.27)	0.139
Daily laborer	36	112	1.00 (0.88, 1.13)	2.08 (1.36, 3.20)**	0.001
Employed	41	108	0.96 (0.84, 1.09)	1.77 (1.10 2.84)**	0.018
Merchant/others	48	150	1.00 (0.89, 1.13)	1.59 (1.03, 2.47)**	0.038
Type of care received					
Psychosocial support	48	96	1.0	1.0	
Economic support	74	197	1.09 (0.95, 1.25)*	1.19 (0.93, 1.54)	0.172
Care categories					
Mother/father	23	32	1.0	1.0	
Husband/wife	74	171	1.20 (0.95, 1.52)*	1.14 (0.76, 1.70)	0.535
Children	12	68	1.46 (1.15, 1.86)**	1.61 (1.02, 2.55)**	0.040
Others	13	22	1.08 (0.77, 1.52)	1.37 (0.82, 2.29)	0.234
Ever migrated for food					
No	181	611	1.0	1.0	
Yes	22	44	0.86 (0.73, 1.03)	0.80(0.53, 1.21)	0.291
WHO clinical stage					
Stage one	162	459	1.0	1.0	
Stage two & above	41	196	1.12 (1.04, 1.21)**	1.32 (1.03, 1.69)**	0.028
Duration of ART					
<4 years	62	76	1.0	1.0	0.028
4–8 years	55	131	1.28 (1.07, 1.53)**	1.53 (0.97, 2.40)	0.066
>8 years	86	448	1.52 (1.30, 1.78)**	1.78 (1.18, 2.67)**	0.006

Bold values indicates those factors that showed statistically significant association with FAVs dietary intake. *Mean factors that show association with FAVs at *p*-value < 0.25 (rule of thumb). **Mean factors that show statistically significant association with FAVs at *p*-value < 0.05.

The frequency of FAV consumption across all nine categories was low; only 23.89 and 20.63% of the HIV-infected adults consumed 100% fruit juice and whole fruit once per month, respectively. Despite the productivity of the study area, only 26.92 and 18.65% of the HIV-infected adults consumed green leafy vegetables and salad one time per month and 2–3 times per month, respectively. This finding shows that this prevalence is still lower than the prevalence found from the results of the study conducted in Portugal among a similar population, in which the highest frequency of consumption was mango, papaya, and bananas among fruits (48.75% of women and 40% of men) (16).

The study revealed that the overall median FAV intake was 271.3 g/day; of which, the median amount of fruit and vegetable intake was 248.1 and 273.8 g/day, respectively. This level of consumption was below the WHO/FAO recommendation that individuals should consume at least 400 or more grams of FAVs for their overall health improvement and chronic infection prevention (28). This finding was also lower than similar studies conducted in Kenya (12). Moreover, the results were in line with findings from studies in Thailand, in which the amounts of FAVs consumed by study participants were lower than the daily recommended amount (29, 30). The difference in FAV intake may be due to differences in the study settings and population. The WHO recommendation applies to the general population, including those with HIV, whereas our study specifically focused on HIV-infected individuals. Additionally, the study in Thailand

was conducted in a middle-income country, whereas our study was conducted in a low-income country. These intake levels were also lower than those found in a study among HIV-infected pregnant women (12), suggesting that different subgroups within the HIV-infected population may have varying nutritional profiles and needs.

Marital status, occupational status, caregiver's category, the WHO clinical stage, and the duration of ART were found to be statistically significant factors for this low level of FAV dietary intake. The current study found that the marital status of HIV-infected adults was significantly associated with FAV dietary intake, with the proportion of FAV being higher among divorced people compared to those who were married. Surprisingly, we found varied evidence about the marital status of HIV-infected adults as a contributing factor for FAV dietary intake. For instance, the findings of the studies in France, Thailand, and Switzerland indicated that being single and having separate living statuses were associated with high vegetable consumption (30–32). The disparity may be due to differences in the study population and settings. The studies mentioned above were conducted in high-income countries, and the duration of the previous study was longer. Despite the variation in settings, the current finding is consistent with those from the UK, where marital transition played a significant role in fruit and vegetable consumption. Those who remained married showed significant declines in fruit quantity, fruit variety, vegetable quantity, and vegetable variety compared to those who were separated, divorced, or remained single.

The findings of this study showed that the FAV dietary intake among farmers who are producers was extremely low compared to daily laborers, employers, and merchants. This is supported by the global health and metric analysis finding, in which FAV availability has consistently been insufficient to supply recommended consumption levels (33). Additionally, similar patterns were observed in South Africa, where FAV consumption was higher among employed adults (26).

The type of caregivers who have been providing care was found to have a statistically significant association with FAV dietary intake, with caregivers who were children of HIV-infected adults and who showed higher FAV intake. This indicated that children, as caregivers for their families, will play a critical role, potentially more so than other categories of caregivers. They will also play a critical role in providing advise on various topics, including the consumption of healthy diets such as FAVs. This study's findings are consistent with those of a study conducted in peri-urban Dar es Salaam, Tanzania, where the knowledge of family members about the importance of nutritious food for HIV treatment and their support were found to play a critical role in the consumption of a healthy diet (34).

The study revealed an independent and statistically significant association between increased FAV dietary intake and advanced WHO clinical stages, as well as longer durations of antiretroviral treatment among HIV-infected adults. It was observed that the prevalence of FAV dietary intake among HIV-infected adults at an advanced WHO clinical stage and those receiving ART for more than 8 years was notably high. This correlation may be attributed to the cumulative effects of patient education and nutritional counseling provided during treatment follow-up. Patients with longer treatment follow-up durations are likely to have greater awareness of disease progression and necessary precautions due to their frequent interactions with health professionals. This study is among the very few conducted in Africa and the first to specifically explore these variables among HIV-infected adults in Ethiopia. Currently, there is a lack of comparative literature regarding the relationship between clinical factors and FAV dietary intake in this population.

We assessed the FAV dietary intake among HIV-infected adults receiving ART in health facilities in northcentral Ethiopia, using a large sample size that ensures the external validity of our findings. This pioneering study within Ethiopia among HIV-infected adults plays a crucial role in shaping nutritional counseling strategies targeted at this group. The use of the BRFSS assessment tools and the KoboToolbox digital data collection platform helps to ensure data quality. In addition, the use of a Poisson regression with a robust variance that suits prevalence ratio estimation improves the validity of the evidence generated in this particular study.

However, this study does have methodological limitations. First, since FAV consumption was assessed through participants' self-reports, there is a potential for overestimation or underestimation of actual FAV dietary intake. Second, the cross-sectional design of the study limits our ability to establish temporal relationships between outcomes and independent variables. Third, the assessment of FAV experiences of HIV-infected adults over the last 30 days is subject to recall bias, which may affect the accuracy of the reported data.

Conclusion

The finding indicates that a very high proportion of HIV-infected adults consumed FAVs less than one time per day, which could be considered as a very low FAV dietary intake. The FAV consumption among HIV-infected adults is far below the minimum recommendation for health, which will decrease the protection against opportunistic infections and non-communicable diseases of all types. Despite their production and living in the surplus production of the area, farmers are less likely to consume FAVs. The marital status, occupational status, type of caregivers, WHO clinical stage, and duration of ART of the HIV-infected adults were found to be significant and independent contributing factors for the FAV dietary intake of HIV-infected adults.

Given these findings, there is a critical need for comprehensive, context- and culture-specific nutritional counseling to improve FAV consumption, especially among farmers. These interventions should focus on educating about portion sizes to ensure adequate daily nutrient intake. Additionally, it is essential to integrate nutritional support into the early stages of ART and throughout the treatment process. Family therapy, including counseling on healthy eating habits and the role of children as caregivers, can further support dietary improvements. We also suggest further and focused investigation of FAV dietary intake, using both quantitative and qualitative

studies to address the nutritional needs of these high-risk population segments.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study involving human participants was reviewed and approved by the study's protocol from Addis Ababa University, College of Health Sciences Institutional Review Board (IRB). Participants were informed that they could withdraw at any time and/or refrain from responding to questions. The study participants provided their written informed consent to participate in this study.

Author contributions

DB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AA: Conceptualization, Data curation, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing. AY: Conceptualization, Data curation, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing. SG: Conceptualization, Data curation, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Paper IV: The effect of food insecurity on clinical progression of HIV/AIDS among adults receiving antiretroviral therapy in Health Facilities Northcentral Ethiopia: A multi-facility Prospective cohort study

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Abstract

Objectives: The objective this study is to examine the effect of food insecurity on clinical progression of HIV/AIDS and other independent predictors among HIV-infected adults on antiretroviral therapy in North Shewa Health Facilities, Northcentral Ethiopia.

Methods:

Design: A multi-facility prospective cohort study was conducted.

Settings and Participants: HIV-infected adults receiving antiretroviral therapy (ART) and currently in follow-up (n=574), including 287 food-insecure and 287 food-secure individuals.

Main outcomes and Measurements: The clinical progression of HIV-infected adults was measured by assessing viral load every three months over a 9-month. A viral load of 1,000 copies/mL or higher was considered poor clinical progression. A generalized linear mixed-effects model was fitted to identify the effect of food insecurity and other independent predictors on clinical progression.

Results: The study found that 18.56% (95% CI: 15.58–21.97), 21.14% (95% CI: 17.95–24.71), and 23.84% (95% CI: 20.49–27.55) HIV-infected adults had poor clinical progression at the first, second, and third visits, respectively. The overall incidence of poor clinical progression during the follow-up was 21.17% (95% CI: 19.27%, 23.18%), with double the incidence among food-insecure individuals. Type of care received (aRR = 4.72, 95% CI: 1.10, 20.52), being food-insecure (aRR = 5.44, 95% CI: 1.36, 21.76), being undernourished (aRR = 3.34, 95% CI: 1.21, 9.26), advanced WHO treatment stage (aRR = 6.43, 95% CI: 1.21, 34.41), and receiving ART for at least 4 years (aRR = 4.22, 95% CI: 1.11, 12.07) were found to be significant independent predictors of poor clinical progression.

Conclusion: The study found that poor clinical progression was notably higher among food-insecure individuals, with a persistent increase over time, underscoring the sustained and significant effect of food insecurity. The findings suggest the need to integrate nutritional support, social support, medical care, and counseling into HIV treatment to mitigate the effects of food insecurity.

Keywords: Food insecurity, HIV/AIDS, clinical progression, antiretroviral therapy, HIV-infected adults

What is already known on this topic

- Scientific evidence shows a complex syndemic relationship between HIV and food insecurity, where both conditions worsen each other's effects, requiring further investigation. However, there is a lack of context- and culture-specific evidence on the effect food insecurity on HIV progression in among HIV-infected adults receiving ART.

What this study adds

- Generated culture- and context-specific evidence on the effect of food insecurity on the clinical progression of HIV, which can help to design interventions such as improving access to nutritious food and enhancing nutritional counseling for HIV-infected adults.

How this study might affect research, practice or policy

- The integration of nutritional support, social support, medical care, research, and nutritional counseling into HIV treatment is essential to mitigate the effects of food insecurity and other potential predictors on clinical progression.

Introduction

Despite global efforts, HIV remains a critical public health problem, with 39.9 million people living with HIV by the end of 2023, 65% of whom are in the WHO African Region, including Ethiopia [1]. Of these, 38.6 million were adults (>15 years old), and 53% were women and girls [2]. This includes 1.3 million newly infected individuals, with an estimated 630,000 people died from HIV-related causes [1, 3]. In Ethiopia, there were an estimated 580,000 adults aged 15 and over living with HIV by the end of 2023, with about 63.8% being women and girls [4, 5] that requires a holistic and comprehensive intervention approach [6].

In this regard, UNAIDS has developed a new set of ambitious targets, known as the 95-95-95 treatment goals. By the end of 2025, the aim is for 95% of all people living with HIV to be diagnosed, 95% of those diagnosed to be receiving lifesaving antiretroviral treatment, and 95% of those on treatment to achieve a suppressed viral load. As of 2023, globally, about 86% knew their status, 77% were accessing treatment, and 72% were virally suppressed [2]. In Ethiopia, about 75% were virally suppressed, which is below the target [4].

Food insecurity is one of the leading causes of morbidity and mortality, closely linked to the HIV epidemic, and can contribute to unsuppressed viral loads among HIV-infected adults [7]. In Ethiopia, more than 60% of HIV-infected adults experience high levels of food insecurity, which may exacerbate their health and treatment outcomes [8-11]. This associated with incomplete HIV viral suppression [12], household instability and lower household income [13], delayed ARV treatment initiation, incomplete adherence, and ARV treatment discontinuation [14].

Lack of food security and limited access to healthy diets, along with other independent factors such as age, gender, marital status [15, 16], alcohol consumption, and annual income [17] may accelerate the progression to AIDS-related illnesses [14, 16]. However, the effect of food insecurity on health outcomes will persist, even when accounting for socioeconomic status. Addressing food security is essential for achieving global HIV prevention, treatment, care, and support, a commitment made by all United Nations Member States, including Ethiopia [18].

However, little is known about the effect of food insecurity on the clinical progression of HIV/AIDS and their predictors among adult clients receiving ART in the Ethiopian context. This highlights a gap in context- and culture-specific evidence on the effects of food insecurity on the clinical progression of HIV among adults receiving ART. The few studies conducted were cross-sectional, failing to show temporal relationships or demonstrate the effects of food insecurity and other independent predictors on the clinical progression among HIV-infected adults. Therefore, the objective of this study was to examine the effect of food insecurity on clinical progression of HIV/AIDS among adults receiving ART in North Shewa Zone Health Facilities, Oromia Region, Northcentral Ethiopia.

Materials and Methods

Study design and settings

A multi-center prospective cohort study was conducted as part of follow-up study in Health Facilities in North Shewa *Zone*, Northcentral, Ethiopia. Adminstratively, the *Zone* is divided into 12 rual and 4 town administrations districts, with five hospitals (one referral hospital and four primary hospitals), 64 health centers, and 275 health Posts [19]. The study was conducted from January 2022 to February 2023 in ten health facilities (four hospitals and six health centers with high caseloads) that have been providing ART services to people living with HIV.

Population and Errollment criteria

The study population consisted of HIV-infected adults receiving ART and had follow-up treatment at the selected health facilities. The exposure status was determined based on food security status, assessed using the Food Insecurity Access Score at baseline. Accordingly, the exposed group consisted of those who were food insecure, while the non-exposed group comprised those who were food secure. All HIV-infected adults receiving ART who were older than 18 years, regardless of their treatment regimen or duration of follow-up, were enrolled in the cohort study. Patients with other chronic diseases, such as heart disease, hypertension, diabetes mellitus, or other

conditions that could suppress the immune system and deteriorate their nutritional status, as well as pregnant women who had recently started ART, were excluded.

Sample size determination and sampling procedures

The sample size for the current prospective cohort study was calculated using the STATCALC application of Epi-info version 7.0 statistical software [20]. The required sample size was calculated using a two-population proportion formula with the following assumptions: a 95% confidence level, 80% power, a 1:1 ratio of unexposed (food-secure PLHIV) to exposed (food-insecure PLHIV), an adjusted rate ratio (RR) of 1.52 for severe food insecurity, and a 27.5% incidence of poor clinical progression in food-secure individuals [21], and a design effect of 1.5 for intra-cluster correlation and accounting for a 5% loss to follow-up, the final adjusted sample size was 574 (287 food secure and 287 food insecure individuals). A baseline assessment was conducted for 865 HIV-infected adults to determine their food security status using using the Household Food Insecurity Access Scale (HFIAS), the main exposure variable in this cohort study. Food-secure and food-insecure individuals were identified across four hospitals and six health centers following baseline assessment. The sample of participants was selected through simple random sampling using a computer-generated randomization method and then enrolled in the study for follow-up.

Study Variables and Measurement

The outcome variable was the clinical progression of HIV/AIDS, measured by assessing the viral load, which indicates the activity of HIV infection and is a useful test to determine the amount of HIV in the blood. Over time, an increase in viral load reflects more virus production, leading to rapid progression to AIDS. According to national guidelines, HIV viral load is measured at 6 and 12 months after initiating ART [22]. In this study, HIV viral load measurements were conducted using standard methods every three months for nine months. A viral load of 1000 copies/mL or higher in at least two consecutive measurements taken three months apart was considered indicative of poor clinical progression [22]. Socio-demographic predictors (age, gender, income, educational status, occupational status, religion, marital status, residence, number of children, psychosocial supports (presence of caregiver, type of care, type of caregivers, disclosure of sero-status)); clinical predictors (duration of ART treatment, WHO clinical stage, WHO treatment stage of HIV, opportunistic diseases, therapeutic food support, follow-up interval, CPT provision, and IPT provision); nutritional predictors (undernutrition (Protein Energy Diffieciencies), overweight and/or obesity); food security status; and behavioral predictors (adherence to ART drugs, poor coping strategies (unprotected sex, labor migration), cigarette smoking, alcohol use, and khat chewing) were considered independent variables and potential confounders.

Data collection tools and methods

Socio-demographic, clinical, nutritional, and behavioral predictors, household food security status and fruit and vegetable dietary intake data were collected using structured interviewer-administered questionnaire. Patient records were reviewed using a data extraction checklist for variables such as type of malignancy, opportunistic infections (OIs), anemia, WHO staging, and others. We also assessed weight and height to determine nutritional status using BMI and measured viral load quarterly for 9 months. Nine data collectors and two supervisors with previous experience and a health background (nurses and health officers) collected both baseline and follow-up data using the KoboToolbox digital data collection platform. The questionnaire was pretested on 5% of the sample at an adjacent hospital to evaluate feasibility and consistency with a population of similar characteristics. Necessary modifications were made based on the results of

the pretest before actual data collection. Data collectors and supervisors received two days of training on the study objectives, data collection methods and tools, and how to maintain confidentiality of information. The measurement instruments were calibrated after every measurement.

Data management and Analysis

After exporting data from KoboToolbox to STATA 17, descriptive analysis was conducted to compare the characteristics of the cohort based on food security status. The overall incidence of nutritional status and clinical progression of HIV/AIDS was calculated, along with the incidence over three consecutive visits from follow-up repeated measurements collected quarterly over 9 months. A generalized linear mixed-effects model, specifically mixed-effects logistic regression, was fitted by introducing random effects to account for clustering effects and to identify the association between food security and clinical progression of HIV/AIDS. The assumptions of the generalized linear model, using the variance-covariance structure of the random effects, were checked through exploratory data analysis before fitting the model. Covariance structures were selected based on the correlation structure of the data. All predictors associated with the outcome variable in the bivariable analysis with a p-value of 0.20 or less were included in the multivariable mixed-effects regression models. The crude and adjusted risk ratios (aRR), along with their corresponding 95% confidence intervals (CI), were computed. Multicollinearity of explanatory variables was assessed using the variance inflation factor, and model fitness was evaluated using information criteria (AIC and BIC). A p-value < 0.05 and the corresponding 95% CI were considered to indicate statistical significance.

Results

Socio-demographic and Socio-economic characteristics

A total of 574 HIV-infected adults, consisting of 287 food-secure and 287 food-insecure individuals, were enrolled and followed for three consecutive follow-up intervals (quarters). Of these, 563 (98.08%) completed the follow-up period, while 10 (1.74%) were lost to follow-up, and 1 (0.17%) died. The majority, 359 (62.54%), were females, of which 196 (68.29%) were food insecure and 163 (56.79%) were food secure. The distribution of participants' ages was almost consistent across each category. However, 207 (36.06%) of participants belong to the age group 35-44 years, with the mean age of enrolled participants being 38.59 (±9.83) years. Five hundred sixteen (89.90%) were followers of Orthodox Christianity: 251 (87.46%) were food-insecure, and 265 (92.33%) were food-secure. Three hundred thirty (57.49%) were married, of which 144 (50.17%) were food-insecure and 186 (64.81%) were food-secure. The majority, 411 (71.60%), were urban residents: 227 (79.09%) were food-insecure, and 184 (64.11%) were food-secure. Four hundred fifth-eight (79.79%) of participants reported having children: 222 (77.35%) were food-insecure, and 236 (82.23%) were food-secure. Of those who reported having children, 331 (72.27%) had less than four children, with 172 (77.48%) being food-insecure and 159 (67.37%) being food-secure.

The level of food insecurity was higher among daily laborers (104, 36.24%), followed by housewives (60, 20.91%) and merchants/traders (59, 20.56%). Two hundred eighty-two (49.13%) of HIV-infected adults had no formal education: 169 (58.89%) were food-insecure, and 113 (39.37%) were food-secure. One hundred ninety-four (51.32%) of HIV-infected adults reported having a monthly income of less than 2500 Ethiopian birr, of which 140 (66.04%) were food-insecure (Table 1).

Table 1: Baseline socio-demographic and economic characteristics of HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Sex	Male	91 (31.71)	124 (43.21)	215 (37.46)
	Female	196 (68.29)	163 (56.79)	359 (62.54)
Age respondents	<35 years	118 (41.11)	88 (30.66)	206 (35.89)
	35-44 years	110(38.33)	97 (33.80)	207(36.06)
	≥45 years	59 (20.56)	102 (35.54)	161 (28.05)
The average age in years	Average (SD)	37.00(±8.80)	40.18(±10.54)	38.59(±9.83)
Religion of respondents	Orthodox	251 (87.46)	265(92.33)	516 (89.90)
	Protestant	23 (8.01)	17 (5.92)	40 (6.97)
	Others*	13 (4.53)	5 (1.74)	18 (3.14)
Marital status	Married	144 (50.17)	186 (64.81)	330 (57.49)
	Single	31 (10.80)	34 (11.85)	65 (11.32)
	Divorced	56 (19.51)	27 (9.41)	83 (14.46)
	Widowed	56 (19.51)	40 (13.94)	96 (16.72)
Residence	Rural	60 (20.91)	103 (35.89)	163(28.40)
	Urban	227 (79.09)	184 (64.11)	411(71.60)
Presence of children	No	65 (22.65)	51 (17.77)	116 (20.21)
	Yes	222 (77.35)	236(82.23)	458 (79.79)
Number of children (n=458)	≤3 children	172 (77.48)	159 (67.37)	331 (72.27)
	4-9 children	50 (22.52)	77 (32.63)	127 (27.73)
Occupational Status	Farmer	34 (11.85)	80(27.87)	114 (19.86)
	House wife	60 (20.91)	56 (19.51)	116 (20.21)
	Daily laborer	104 (36.24)	23 (8.01)	127 (22.13)
	Employed	30 (10.45)	64 (22.30)	94 (16.38)
	Merchant/others	59 (20.56)	64 (22.30)	123 (21.43)
Educational status	No formal education	169 (58.89)	113 (39.37)	282 (49.13)
	Primary school	84(29.27)	78 (27.18)	162(28.22)
	Secondary and above	34 (11.85)	96 (33.45)	130 (22.65)
Monthly income (n=378)	<2500 ETB	140 (66.04)	54 (32.53)	194 (51.32)
	≥2500 ETB	72 (33.96)	112 (67.47)	184 (48.68)

*Catholic, musilim and wekefata

Psychosocial support for HIV-infected adults

Concerning psychosocial support, 303 (52.79%) of the HIV-infected adults received care from different caregivers, of which 154 (53.66%) were food-insecure and 149 (51.92%) were food-secure. Of those who received care from caregivers, 161 (61.62%) received economic support, followed by psychological support (68, 25.09%). Among these, 68 (51.13%) were food-insecure and 88 (63.77%) were food-secure. Two hundred ninety (50.52%) of the HIV-infected adults had disclosed their HIV status, of which 154 (53.10%) disclosed their HIV serostatus to their husbands or wives. The proportion of participants who disclosed their HIV status was higher among the food-insecure group (147, 51.22%) than the food-secure group (143, 49.83%) (Table 2).

Table 2: Baseline psyschosocial support of HIV-infected adults receiving ART at health facilities, Ethiopia, 2024

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Presence caregiver	No	154 (53.66)	149 (51.92)	303 (52.79)
	Yes	133 (46.34)	138 (48.08)	271 (47.21)
Type of care received (n=271)	Psychological support	35 (26.32)	33 (23.91)	68 (25.09)
	Economic support	79(59.40)	88 (63.77)	167(61.62)
	Social support and related	19 (14.29)	17 (12.32)	36 (13.28)
Type of caregiver (n=271)	Mother/ father	28 (21.05)	12(8.70)	40 (14.76)
	Husband/Wive	68 (51.13)	88 (63.77)	156 (57.56)
	Children	25 (18.80)	29 (21.01)	54 (19.93)
	Others	12 (9.02)	9 (6.52)	21 (7.75)
Disclose their Sero-status	No	140 (48.78)	144 (50.17)	284 (49.48)
	Yes	147 (51.22)	143 (49.83)	290 (50.52)
To whom you disclose (n=290)	Mother/ father	21 (14.29)	11 (7.69)	32 (11.03)
	Husband/Wive	72 (48.98)	82 (57.34)	154 (53.10)
	Children	25 (17.01)	33 (23.08)	58 (20.00)
	Others	29 (19.73)	17 (11.89)	46 (15.86)

Clinical and food related characterisitics of HIV-infected adults

One hundred thirteen (19.69%) of HIV-infected adults reported having eating problems, with most common reason reported for having an eating problem was loss of appetite (87, 76.99%). One-third of HIV-infected adults (30.84%) reported having anemia, which higher in the food-insecure group (99, 34.49%) compared to the food-secure group (78, 27.18%) as defined by WHO's standard for anemia among HIV-infected individuals. One hundred nine (18.99%) developed opportunistic infections (OIs) while under care, with the most common OIs were diarrheal diseases (39.45%). A small proportion (13, 4.53%) of participants reported receiving therapeutic feeding, with 4.53% of food-insecure and 4.18% of food-secure individuals.

Three hundred forty-seven (60.45%) of participants reported receiving ART for more than 8 years: 149 (51.92%) were food insecure and 198 (68.99%) were food secure. The average duration of ART among the HIV-infected adults was 9.03 years (±4.61 SD), with 8.26 years (±4.77 SD) for the food-insecure group and 9.80 years (±4.31 SD) for the food-secure group. The majority, 414 (72.13%) started ART at an early clinical stage: 218 (75.96%) of the food-insecure group and 196 (68.29%) of the food-secure group were at WHO clinical stage one. Similarly, 503 (87.63%) started ART at an early treatment stage: 250 (87.11%) of the food -nsecure group and 253 (88.15%) of the food-secure group were at WHO treatment stage one. One hundred seventy-nine (31.79%), of HIV-infected adults were not provided cotrimoxazole preventive therapy (CPT) and 78 (13.85%) of HIV-infected adults were not provided tuberculosis preventive therapy (TPT). A small proportion (142, 24.74%) of the HIV-infected adults reported consuming FVs at least once per day, as defined by WHO's standard for daily FAV consumption (Table 3).

Table 3: Baseline clinical and nutritional characteristics of HIV-infected adults receiving ART at health facilities, Ethiopia, 2024

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Presence eating problems	No	231 (80.49)	230 (80.14)	461 (80.31)
	Yes	56 (19.51)	57 (19.86)	113 (19.69)
Causes of Eating problem(n=113)	Loss of appetite	46 (82.14)	41 (71.93)	87 (76.99)
	Oral candidiasis	9(16.07)	12 (21.05)	21(18.58)
	Esophageal candidiasis	1 (1.79)	4 (7.02)	5 (4.42)
Anemia	No	188 (65.51)	209 (72.82)	397 (69.16)
	Yes	99 (34.49)	78 (27.18)	177 (30.84)
Presence of OIs	No	241 (83.97)	224 (78.05)	465 (81.01)
	Yes	46 (16.03)	63 (21.95)	109 (18.99)
Type of OI disease (n=109)	Tuberculosis	16 (34.78)	11(17.46)	27 (24.77)
	Pneumonia	6 (13.04)	9 (14.29)	15 (13.76)
	Diarrheal disease	11 (23.91)	32 (50.79)	43 (39.45)
	Dispepsia	6 (13.04)	3 (4.76)	9 (8.26)
	Others	7 (15.22)	7 (12.70)	15 (13.76)
Therapeutic food	No	274 (95.47)	275 (95.82)	549 (95.64)
	Yes	13(4.53)	12 (4.18)	25(4.36)
WHO clinical stage	Stage one	218 (75.96)	196 (68.29)	414 (72.13)
	Stage two and above	196 (24.04)	91 (31.71)	160 (27.87)
WHO treatment stage	Stage one	250 (87.11)	253 (88.15)	503 (87.63)
	Stage two and above	37 (12.89)	34 (11.85)	71 (12.37)
Duration of ART	<4 years	66 (23.00)	33 (11.50)	99 (17.25)
	4-8 years	72 (25.09)	56 (19.51)	128 (22.30)
	>8 years	149 (51.92)	198 (68.99)	347 (60.45)
Average duration of ART in years	Average (SD)	8.26 (±4.77)	9.80 (±4.31)	9.03 (±4.61)
CPT provision status (n=563)	Provided	171 (61.51)	160 (56.14)	331 (58.79)
	Ongoing	30 (10.79)	23 (8.07)	53 (9.41)
	Not provided	77 (27.70)	102 (35.79)	179 (31.79)
TPT provision status or IPT (n=563)	Complete	230 (82.73)	229 (80.35)	459 (81.53)
	Discontinue/interrupt	3 (1.08)	3 (1.05)	6 (1.07)
	Ongoing	6 (2.16)	14 (4.91)	20 (3.55)
	Not given	39 (14.03)	39 (13.68)	78 (13.85)
Fruit and vegetable dietary intake	≥ One time per day	62 (21.60)	80(27.87)	142 (24.74)
	< One time per day	225 (78.40)	207 (72.13)	432 (75.26)

Behavioral characteristics of HIV-infected Adults

A total of twelve HIV-infected adults (2.09%) have ever been forced to engage in unprotected sex, of which 10 (3.48%) were food-insecure. Additionally, 52 (9.09%) of the particpants have ever migrated from their previous place of residence to get their daily food, of which 45 (15.68%) were food-insecure. One hundered eighty (31.36%) skipped doses of ART due to unmet restrictions such as food required with the drug, time schedule, and taking it on an empty stomach in the last 7 days: 96 (33.45%) were food-insecure and 84 (29.27%) were food-secure. Three hundred fifteen (54.88%) participants reported not missing doses in the last 7 days, of which 137 (47.74%) were

food insecure and 178 (62.02%) were food-secure. Three hundred fifty-nine (62.54%) of participats rated as having good adherence. A significant number of participants, 56 (9.95%), 283 (50.27%), and 33 (5.86%), reported that they have ever smoked cigarettes, drunk alcohol, and chewed khat, respectively (Table 4).

Table 4: Baseline behavioral characterisitics of HIV-infected adults receiving ART at health facilities, Ethiopia, 2024

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Unprotected sex for Daily food	No	277 (96.52)	285 (99.30)	562 (97.91)
	Yes	10 (3.48)	2 (0.70)	12 (2.09)
Ever migrated from for food	No	242 (84.32)	280 (97.56)	522 (90.94)
	Yes	45 (15.68)	7 (2.44)	52 (9.06)
Skipped due to unmet restrictions in last 7 days	No	191 (66.55)	203 (70.73)	394 (68.64)
	Yes	96 (33.45)	84 (29.27)	180 (31.36)
Missing doses in the last 7 days	Missed	150 (52.26)	109 (37.98)	259 (45.12)
	Not missed	137 (47.74)	178 (62.02)	315 (54.88)
Level of adherence to ART	Good	184 (64.11)	175 (60.98)	359 (62.54)
	Fair	37 (12.89)	40 (13.94)	77 (13.41)
	Poor	66 (23.00)	72 (25.09)	138 (24.04)
Ever smoke cigarettes	No	259 (93.17)	248 (87.02)	507 (90.05)
	Yes	19 (6.83)	37 (12.98)	56 (9.95)
Ever drink alcohol	No	144 (51.80)	136 (47.72)	280 (49.73)
	Yes	134 (48.20)	149 (52.28)	283 (50.27)
Ever chew chat	No	268 (96.40)	262 (91.93)	530 (94.14)
	Yes	10 (3.60)	23 (8.07)	33 (5.86)

Incidence nutritional status of HIV-infected adults

We assessed the nutritional status of HIV-infected adults at three visits over the follow-up duration. Accordingly, 98 (17.07%) of them developed undernutrition at the first visit, with 61 (21.25%) being food-insecure and 37 (12.89%) being food secure. At the second visit, 114 (20.14%) developed undernutrition, with 65(23.21%) being food-insecure and 43 (17.13%) being food-secure. At the third visit, 105 (18.65%) developed undernutrition, with 63 (22.66%) being food-insecure and 42 (14.74%) being food-secure (Figure 1).

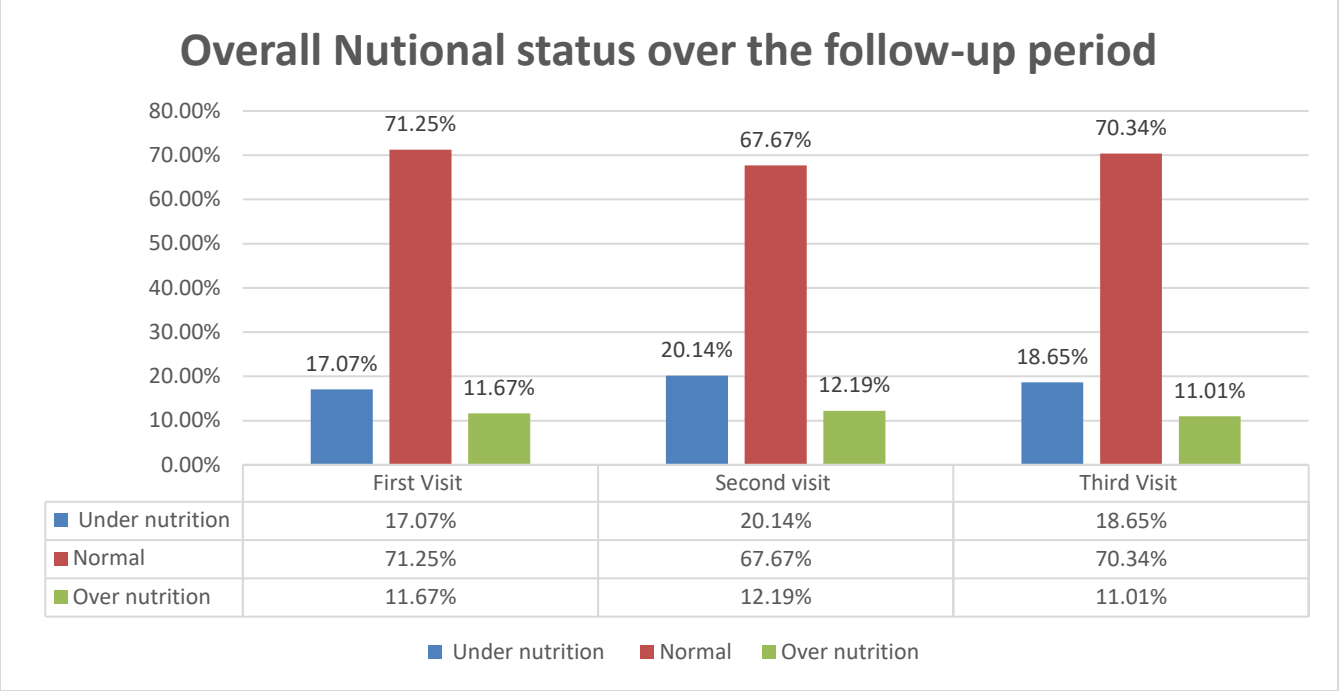

Figure 1: Overall nutritional status of HIV-infected adults receiving ART over the follow-up period at health facilities in Northcentral, Ethiopia, 2024

Incidence of Clinical outcome of HIV-infected adults

The clinical outcomes and progression of HIV in adults were assessed by measuring the viral load of participants over three consecutive visits. A total of 574 individuals were followed, resulting in 1,722 observations. Accordingly, 106 (18.56%; 95% CI: 15.58–21.97), 119 (21.14%; 95% CI: 17.95–24.71), and 134 (23.84%; 95% CI: 20.49–27.55) HIV-infected adults had poor clinical progression at the first, second, and third visits, respectively. The incidence of poor clinical progression was twice as high among food-insecure HIV-infected adults at each visit. Specifically, 71 (25.00%), 80 (28.78%), and 91 (32.85%) of those who showed poor clinical outcomes were food insecure at the first, second, and third visits, respectively. The overall incidence of poor clinical progression among observations during the follow-up period was found to be 21.17% (95% CI: 19.27%, 23.18%), with 28.84% among food-insecure individuals and 13.65% among food-secure individuals (Table 5).

Table 5: The incidence of clinical progression among HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024

Food security status	Clinical progression (1st visit)		Clinical progression (2nd visit)		Clinical progression (3rd visit)	
	Poor	Good	Poor	Good	Poor	Good
	No (%)	No(%)	No (%)	No(%)	No (%)	No(%)
Food-insecure	71 (25.00)	213 (75.00)	80 (28.78)	198 (71.22)	91 (32.85)	186 (67.15)
Food-secure	35 (12.20)	252 (87.80)	39 (13.68)	248 (86.32)	43 (15.09)	242 (84.91)
Total	106 (18.56)	465 (81.44)	119 (21.14)	444 (78.86)	134 (23.84)	428 (76.16)

Predictors of clinical progression among adults receiving ART

In bi-variable analysis, twenty variables, namely, sex/gender, age, educational status, occupational status, monthly income, categories of caregivers, types of care received, presence of anemia, people to whom they disclose their serostatus, duration of HIV infection, follow-up interval, duration of ART follow-up, presence of eating problems, nutritional status during follow-up, TPT provision status or IPT, missing doses in the last 7 days (indicating strict adherence to ART), WHO clinical stage, WHO treatment stage, and practice in following special instructions from health professionals, showed association with a p-value of ≤ 0.20 and were then selected as candidates for multivariable analysis.The duration of HIV infection and follow-up interval were highly correlated with the duration of ART follow-up reduced after the collinearity check using generalized variance inflation factor.

Consequently, the multivariable generalized linear mixed-effects regression analysis with identity covariance structure was fitted using all eighteen variables simultaneously. Five of the most contributing predictors, including food security status which was considered as the main exposure, were found to be significant independent predictors of clinical progression of HIV/AIDS at a 5% level of significance. We selected a model with an identity covariance structure, as it provides a simplified approach to handling random effects in the analysis. In addition, the model fitness or adequacy was assessed using information criteria and log-likelihood ratio test (LR chiasquare = 133.37, $p < 0.001$).

From the analysis, we found that the random effects capture the correlation in the repeated measurement data in this study. sd(b0i) =3.237 (95% CI: 2.565, 4.087) and sd("Σij) = 0.385, with p-value less than 0.001.

Accordingly, the type of care received from different informal caregivers was found to be a significant independent predictor of poor clinical progression. The incidence of developing poor clinical progression among those receiving economic support was 5 times higher than those receiving psychological support (aRR = 4.72, 95% CI: 1.11, 20.52). Food security status was found to be an independent predictor of poor clinical progression among HIV-infected adults after controlling for other potential confounders. The incidence of poor clinical progression was 5.4 times higher among food-insecure HIV-infected adults compared to food-secure HIV-infected adults (aRR=5.44, 95% CI: 1.36, 21.76).

The nutritional status of HIV-infected individuals was found to be an independent predictor of poor clinical progression. The incidence of poor clinical progression was 3.3 times higher among undernourished HIV-infected adults compared to those with normal nutritional status (aRR=3.34, 95% CI: 1.21, 9.26). The WHO treatment stage and duration of antiretroviral treatment were identified as independent predictors of poor clinical progression among HIV-infected adults. The incidence of poor clinical progression at the advanced WHO treatment stage among HIV-infected adults was 6.4 times higher than those with WHO treatment stage one (aRR=6.43, 95% CI: 1.26, 34.41). Similarly, the incidence of poor clinical progression among HIV-infected adults receiving ART for at least 4 years was 4.4 times higher than those receiving ART for more than 4 years (aRR=4.22, 95% CI: 1.11, 12.07).

However, the analysis did not indicate a significant association between fruits and vegetables dietary, HIV-seropositivity disclosure status, CPT provision status, and level of adherence in the final generalized linear mixed-effects multivariable regression model. This is due to the fact that some of these variables had severely skewed observations in certain categories and a lack of significant differences in observations between categories (Table 6).

Table 6: Predictors of clinical progression of HIV-infected adults receiveing ART at health facilities in Northcentral, Ethiopia, 2024.

Variables	Response	cRR with 95% CI	aAR with 95% CI	aP-value
Type of care received	Psychological support	1.	1.0	
	Economic support	4.81 (1.15, 20.06)**	**4.72(1.10, 20.52) ** **	**0.039****
	Social support and related	6.39 (0.94, 34. 55)*	3.04 (0.39, 24.00)	0.291
Food security status	Food-secure	1.0	1.0	
	Food-insecure	11.84 (4.36, 32.17) **	**5.44 (1.36, 21.76) ** **	**0.017****
Nutrional status	Undernutrition	3.33(1.57, 7.04)**	**3.34(1.21, 9.26) ** **	**0.020****
	Normal	1.0	1.0	
	Over nutrition	0.85 (0.26, 2.74)*	1.69(0.39, 7.30)	0.483
WHO treatment stage	Stage one	1.0	1.0	
	Stage two &above	18.49 (5.74, 59.54) **	**6.43(1.21, 34.41) ** **	**0.030****
Duration of ART	≤4 years	2.23(0.80, 6.25) *	**4.22(1.11. 12.07) ** **	**0.036****
	>4 years	1.0	1.0	

Discussion

The current multicenter prospective cohort study aimed to examine the effect of food insecurity on the clinical progression of HIV/AIDS among adults receiving ART, along with other independent predictors among HIV-infected adults receiving ART in health facilities of Northcentral Ethiopia. Accordingly, the study found that the overall incidence of poor clinical progression during the follow-up period was 21.17% (95% CI: 19.27, 23.18), with the incidence being more than twice as high among food-insecure HIV-infected adults. This finding is surprisingly higher than the findings from the African Cohort Study (9%) [23], the Treat Asia HIV Observational Database (3 per 100 person-years) [24], and studies conducted in Ethiopia (12.22% and 10.24%) [25, 26]. However, the two studies conducted in Ethiopia were retrospective follow-up and cross-sectional studies, in contrast to the current prospective cohort study, and they did not assess the effect of food insecurity.

We observed an increasing trend in the incidence of poor clinical progression over the follow-up period, with rates of 18.56%, 21.14%, and 23.84% at the first, second, and third visits, respectively. The effect of food insecurity on the clinical progression of HIV/AIDS persisted throughout the follow-up, with the incidence of poor clinical progression among food-insecure individuals being twice as high as that of food-secure individuals. Despite the lack of studies directly assessing the effect of food insecurity through prospective follow-up, existing evidence indicates that food insecurity is associated with a range of negative health outcomes among HIV-infected adults, including clinical progression [7]. This may be due to the persistent lack of various forms of support, including therapeutic food assistance, as only 4.4% of participants in the current study reported receiving such support. This lack of assistance likely contributed to the higher severity of food insecurity, leading to poor clinical progression.

The findings of this study also indicated a significantly higher risk of poor clinical progression among food-insecure HIV-infected adults, with more than a fivefold increased risk compared to food-secure HIV-infected adults. The findings are unsurprisingly supported by evidence from a study conducted in San Francisco and other resource-poor settings, which indicates that food insecurity negatively impacts clinical and health outcomes [27] among HIV-infected adults [7, 16, 28].

Despite the variation in the setting, the finding of the study is in line with of a study conducted in New York State, where an increase in the severity of food insecurity was found to increase the incidence of poor clinical progression [29]. The findings are supported by a study conducted in Ethiopia, where an increased incidence of poor clinical progression was found among food-insecure HIV-infected adults [30].

Surprissingly, the finding is not supported the study conducted among Russians who were not on ART that there was no significant differences in HIV viral load between food insecure and food secure groups [31]. The lack of significant differences in the Russian study may be due to the absence of treatment, which worsened the clinical progression in both groups, or other underlying factors specific to the context.

The types of care received from informal caregivers, nutritional status during follow-up, duration of ART follow-up, and WHO treatment stage were found to be significant independent predictors of poor clinical progression. The type of informal care provided by different caregivers was identified as a significant independent predictor of poor clinical progression. Specifically, individuals receiving economic support experienced a higher rate of poor clinical progression compared to those who received psychological support. This could be due to the fact that economic support alone may not be as effective in improving clinical outcomes if it does not address the psychological and emotional needs of individuals. Psychological support has a more direct and substantial effect on clinical progression by addressing the mental and emotional aspects of HIV-infected adults than economic support.

The incidence of poor clinical progression among undernourished HIV-infected adults was higher than among those with normal nutritional status. This finding is unsurprising and consistent with studies from Sub-Saharan Africa, where the increased risk of morbidity and mortality is significantly associated with undernutrition-related immune system dysfunction and increased susceptibility to OIs [32].

The study finds the increased incidence of poor clinical progression among HIV-infected adults at advanced WHO treatment stage. This finding is not surprising, as individuals at advanced treatment stages are more likely to experience rapid and severe clinical progression due to a compromised immune system. This results in a higher risk of poor clinical outcomes and can also lead to significant declines in health and quality of life. This finding is supported by a cohort study among HIV-infected individuals in Guinea-Bissau, which found that advanced WHO stages at entry were significantly associated with poorer clinical progression [33].

The duration of ART follow-up was found to be a significant independent predictor of HIV clinical progression. A shorter duration of ART follow-up was associated with an increased incidence of poor clinical progression among HIV-infected adults receiving ART. This could be due to the pronounced adverse side effects of the medication in the early treatment stage, combined with a lack of comprehensive psychosocial support during these initial stages, leading to challenges in managing the condition effectively.

The findings of previous studies do not support the current study's findings. For example, in Uganda, the longer duration of follow-up was associated with an increased incidence of poor clinical progression among HIV-infected adults [16]. Similarly, a longer duration of follow-up was linked to an increased incidence of poor clinical progression in China [34], and in a multicenter randomized strategy trial [35].

However, the analysis did not indicate a significant association between HIV-seropositivity disclosure status and the level of adherence in the final generalized linear mixed-effects multivariable regression model. While improved ART adherence had a significant effect on disease clinical progression in a study conducted in Atlanta, Georgia [36], the disclosure of HIV status was found to have significant effects on HIV clinical progression through reductions in adherence to clinic visits and patient representation in a study conducted in Eastern Uganda [37].

The wider institutional coverage used in this study helped to ensure the external validity of the findings. This study is the first in Ethiopia to use a prospective cohort design among HIV-infected adults to assess the effect of food insecurity on the clinical progression of HIV/AIDS, which helps minimize selection bias and confounding. Additionally, the use of advanced statistical models, specifically generalized linear mixed-effects regression models, improved the estimation of effect measures, thereby enhancing the validity of the findings. However, the current study has some situational and methodological limitations. First, there is a possibility of recall bias, particularly in the assessment of food security status and FAV dietary intake, as participants were asked to recall their experiences over the past 30 days. Second, since both food security status and FAV dietary intake were assessed through self-reports, there is a possibility that some participants may have misreported their experiences, potentially leading to an overestimation or underestimation of food insecurity and fruit and vegetable intake.

Conclusions

In this study, poor clinical progression was notably higher among food-insecure individuals, with more than double the incidence compared to food-secure individuals. The trend of poor clinical progression increased over time, and the effect of food insecurity on HIV/AIDS progression remained significant throughout the follow-up period. The types of care received from informal caregivers, food security status, nutritional status during follow-up, duration of ART, and WHO treatment stage were found to be significant independent predictors of poor clinical progression. The findings suggest that critical attention should be given to food insecurity in HIV care and treatment, with an emphasis on early ART initiation and advanced clinical stages through patient education and nutritional counseling. Additionally, enhancing access to nutritious food, combined with nutritional support, medical care, and social support, can help mitigate the effects of food insecurity and improve overall health outcomes HIV-infected adults. The findings also suggest the need for further studies to understand the long-term effects of food insecurity and nutritional status on HIV progression.

Ethics approval and informed consent

Ethical approved was obtained from the Institutional Review Board of the College of Health Sciences, Addis Ababa University, with a protocol number of 104/19/SPH. Permission was obtained from the Zonal Health Department, as well as from the respective hospitals and health centers, before the commencement of data collection. Study participants were informed about the purpose of the study, and verbal informed consent was obtained from each participant. We maintained confidentiality by avoiding personal identifiers, locking paper records, and encrypting digital files accessible only to the principal investigator. Participation in this study was voluntary, and participants had the full right to choose not to participate or to withdraw from the study at any time. The potential risks associated with participation in this study were minimal.

Data availability

Data will be available up on request

Funding
Addis Ababa University, School of Public Health partially funded this study, specifically for data collection. There were no other external organizations that funded this research. Therefore, the University has no conflicts of interest related to this study.

Competing interests
There is no competing interest of this research

Authors' Contributions
DJ conceived the study, developed the study protocol, participated in data collection and analysis, prepared the initial drafts of the manuscript, and revised subsequent drafts. AA and AY assisted with revising the initial draft and finalizing the manuscript data analysis. SG contributed to the design of data collection tools and the development and revision of the manuscript. DJ prepared the final draft of the manuscript. All authors read and approved the final manuscript.

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Paper V: The effect of food insecurity on CD4 Count Change among HIV-infected adults receiving antiretroviral therapy in North Shewa Health Facilities, Oromia Region, Northcentral Ethiopia: A multi-facility Prospective cohort study

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Abstract

Background: Food insecurity with HIV accelerates CD4 count decline and immunological failure, even with treatment. The sustained high prevalence of food insecurity among HIV-infected individuals suggests the need for context-specific evidence in countries like Ethiopia. Therefore, the objective of this study is to assess the effect of food insecurity on CD4 count changes among adults receiving ART in North Shewa health facilities.

Methods: We conducted a prospective cohort study with 442 participants (221 in the food insecure and 221 in the food secure groups). A generalized linear mixed-effects regression model was fitted to assess the impact of food insecurity and other predictors on changes in CD4 count.

Results: The findings indicate that 105 (23.76%; 95% CI: 20.01–27.96), 78 (18.35%; 95% CI: 14.96–22.34), and 73 (17.26%; 95% CI: 13.94–21.17) HIV-infected adults had low CD4 counts (<200 cells/mm³) at the first, second, and third visits, respectively, showing an overall declining trend over the 9 months. However, the incidence of low CD4 counts among food-insecure HIV-infected adults remained higher. The overall incidence of low CD4 counts during the follow-up period was 19.84% (95% CI: 17.76%, 22.11%), with 22.14% among food-insecure and 17.55% among food-secure HIV-infected adults. The gender of HIV-infected adults (aRR = 2.88, 95% CI: 1.14, 7.30), being food-insecure (aRR = 2.56, 95% CI: 1.05, 6.26), being undernourished (aRR = 2.17, 95% CI: 1.03, 4.57), being anemic (aRR = 3.35, 95% CI: 1.37, 8.17), advanced WHO clinical stage (aRR = 4.11, 95% CI: 1.32, 12.84), and receiving ART for at least 4 years (aRR = 3.64, 95% CI: 1.25, 10.63) were found to be significant independent predictors of low CD4 count.

Conclusion: The study found that the incidence of low CD4 count remained high, particularly among food-insecure HIV-infected adults, who consistently experienced a higher incidence of low CD4 counts throughout the follow-up period. The findings suggest targeted, culturally and context-specific food security interventions, with attention to advanced and early clinical stages of treatment, addressing gender dynamics to mitigate food insecurity's effects on CD4 count changes.

Keywords: Food insecurity, HIV/AIDS, low CD4 count, HIV-infected adults, North Shewa

Introduction

Human immunodeficiency virus (HIV) infection remains a significant health challenge, progressing at an alarming rate. It impairs the body's ability to combat infections by decreasing CD4 cell counts and attacking the immune cells crucial for responding to infectious agents globally, including in Ethiopia [1, 2]. In this regard, by the end of 2023, 38.6 million out of 39.9 million people living with HIV were adults, with the majority residing in Africa. Among them, 5.4 million people were unaware of their HIV status in 2023, including in Ethiopia [3]. Africa accounts for more than 35% of the new HIV infections, with 450,000 of the 1.3 million people who became newly infected with HIV in 2023, including Ethiopia, with 7,194 new HIV infections [3-6].

HIV damages CD4 cells, impairing the immune system and increasing susceptibility to opportunistic infections such as tuberculosis, fungal infections, severe bacterial infections, and some cancers [3], by targeting and destroying CD4 T lymphocytes in the peripheral blood [7]. The co-existence of food insecurity and malnutrition with HIV infection exacerbates immune system impairment and accelerates CD4 count decline, leading to immunological failure even among HIV-infected individuals receiving treatment[8, 9].

Food insecurity, which refers to the limited or uncertain access to nutritionally adequate and safe foods, or the inability to obtain acceptable foods through socially acceptable means, significantly contributes to the spread of HIV and the progression of the disease [1], is a leading cause of illness and mortality [10]. It compromises immune function, increases susceptibility to severe illnesses and opportunistic infections (OIs), decreases CD4 response, reduces survival, and accelerates immunological failure, even among those receiving ART [9, 11, 12].

Despite of effort that has been made through different strategic interventions, studies indicate high prevalence of food insecurity among HIV-infected individuals that can predict CD4 count change immunological progress of the diseases through its effect on CD4 count change [13]. It was evidenced that the high prevalence of food insecurity both resource-rich and poor settings 71% and 84.6%, respectively [14-18]. Studies in resource-rich countries have highlighted that food insecurity increases the odds of having low CD4+ cell counts (less than 200 cells/μL)[11]. It is significantly associated with clinically low CD4 cell counts, more severe HIV symptoms, and multiple hospitalizations for HIV-related conditions [19]. Food insecurity also increases the likelihood of worse immunological outcomes [20, 21].

However, little is known about the effect of food insecurity on CD4 count changes and other predictors among HIV-infected adults receiving ART in resource-limited countries, including Ethiopia. Existing cross-sectional studies do not fully address these effects. A comprehensive understanding of how food insecurity and other predictors affect CD4 count changes is crucial for tackling poor health outcomes. Therefore, the main objective of this study is to assess the effect of food insecurity on CD4 count change among adults receiving ART in North Shewa Health Facilities

Materials and Methods

Study design, settings, and population

We employed a multi-center prospective cohort study across health facilities in the North Shewa Zone of Northcentral Ethiopia. The zone comprises 16 districts (12 rural and 4 urban) [22]. According to the 2022 zonal report, the zone has five hospitals, 64 health centers, and 275 health posts, with 5,514 HIV-infected adults receiving ART [22, 23]. The current follow-up study was conducted from January 2022 to February 2023 at four hospitals and six health centers with high caseloads, all of which provide ART servicesAll HIV-infected adults receiving ART and had follow-up treatment, who were older than 18 years, regardless of their treatment regimen or duration of follow-up, were enrolled in the cohort study at the selected health facilities. Food security status was assessed at baseline using the Food Insecurity Access Score to determine exposure status, with food insecure HIV-infected adults at baseline considered as the exposed group and food secure HIV-infected considered as the unexposed group. We excluded individuals with other chronic diseases, such as heart disease, hypertension, diabetes mellitus, or conditions that could suppress the immune system and deteriorate nutritional status, as well as pregnant women who had recently started ART.

Sample size determination and sampling procedures

The required sample size for this study was calculated using two population proportion formulas to determine the difference between the two groups, considering major predictors of CD4 count change based on existing literature. The calculation was performed using the STATCALC application of Epi Info version 7.0 statistical software [24]. Accordingly, with a 95% confidence level, 80% power, a 1:1 ratio of unexposed to exposed individuals, an adjusted rate ratio (RR) of

2.08 for low CD4 count change among food secure individuals, and an incidence of low CD4 count of 32.3% in food secure HIV-infected adults [25], the required sample size was calculated as 402 using the two-population proportion formula [26].

$$n = \frac{(z\alpha/2\sqrt{(1+\frac{1}{r})p(1-p)} + Z\beta\sqrt{(p1(1-p1) + \frac{p2(1-p2)}{r})}2}{(p1-p2)2} = 402$$

Considering a 5% non-response rate for loss to follow-up and a 1.5 design effect for intra-cluster correlation, the final sample size was 442 (221 from food-secure and 221 from food-insecure HIV-infected adults). Four hospitals and four health centers providing ART were identified through communication with the Zonal Department and ART focal points at the health facilities, along with the number of HIV-infected adults receiving ART from patient registries. The calculated sample was proportionally allocated to the health facilities based on the number of HIV-infected adults identified in the baseline assessment for exposure status (food security status). Finally, the allocated sample of participants was selected using a computer-generated random number method for simple random sampling and then enrolled in the study for follow-up.

Study Variables and Measurement

The outcome variable was the change in CD4 count, measured as the difference between baseline CD4 counts and the most recent follow-up CD4 counts, as it is the most reliable marker for assessing disease progression, staging, and guiding treatment. This change ranged between 50 cells/mm³ and 100 cells/mm³ over a period of six months [27]. Accordingly, we classified the CD4 count as low (less than 200 cells/mm3), moderate (200-500 cells/mm3), and normal or high (greater than 500 cells/mm3) [28]. The low CD4 count change (below 200 cells/mm3) was considered as immunological failure that was considered in the final analysis [27, 29]. Food insecurity, the primary predictor, was assessed at baseline using the Household Food Insecurity Access Scale (HFIAS). This scale evaluates dimensions such as anxiety and uncertainty about the household food supply, insufficient food quality (including variety and preferences), and insufficient food intake and its physical consequences [27, 30]. Socio-demographic predictors (age, gender, income, educational status, occupational status, religion, marital status, residence, number of children, psychosocial support including the presence and type of caregiver, type of care, and disclosure of serostatus), clinical predictors (duration of ART treatment, WHO clinical stage, WHO treatment stage of HIV, opportunistic diseases, therapeutic food support, follow-up interval, CPT, and IPT), nutritional status, and behavioral predictors (adherence to ART drugs, poor coping strategies, cigarette smoking, alcohol use, and khat chewing) were considered as independent variables.

Data collection tools and methods

Socio-demographic information, psychosocial support, clinical predictors, therapeutic food-related information, and behavioral predictors were collected using a structured interviewer-administered questionnaire at baseline. Food security status and fruit and vegetable dietary intake data were also collected at baseline using the nine-item Household Food Insecurity Access Scale (HFIAS) and the Behavioral Risk Factor Surveillance System (BRFSS) tools, respectively. Data extraction checklist was used collected data on type of malignancy, opportunistic infections (OIs), anemia, WHO staging, and others. Nutritional status data (weight and height) and CD4 count data were collected quarterly for 9 months. Experienced professionals (nurses and health officers) who were not providing services in the ART clinic collected both baseline and follow-up measurements

using the KoboToolbox digital data collection platform. Two days of training were provided to data collectors and supervisors by the principal investigator on the study objectives, data collection methods and tools, including the use of Computer Assisted Personal Interviews (CAPIs) with KoboToolbox, and how to maintain confidentiality of information. The questionnaire was pretested on 5% of the sample at Chancho Hospital to ensure the consistency and completeness of the data. Necessary modifications were made based on the results of the pretest before the actual data collection. Content validation of both the FANTA and BRFSS tools was conducted with local subject-related experts before adapting the tools for final data collection. The CAPIs with the KoboToolbox digital data collection platform was used to collect data. Measurement instruments were calibrated after each measurement. The collected data were checked for completeness and consistency.

Data management and Analysis

The collected data were cleaded, coded, and exposed to STATA 17 version for further processing and analysis. Descriptive statistics was used to describe and compare the characteristics of study participans based on the study varaibles. The incidence low CD4 count, along with the incidence of undernutrition over the follw up period was calculated based on repeated measurements collected quarterly over 9 months. A generalized linear mixed-effects model with logit link function was fitted to account for clustering effects and to identify the association between food security and CD4 count change. Variance-covariance structure of the random effects was used to check model assumption conducting exploratory data analysis before fitting the model. All predictors associated with the outcome variable in the bivariable analysis with a p-value of 0.20 or less were included in the multivariable mixed-effects regression models. Crude and adjusted risk ratios (aRR), along with their corresponding 95% confidence intervals (CI), were calculated. Multicollinearity of explanatory variables was assessed using the variance inflation factor, and model fit was evaluated using information criteria (AIC and BIC). Statistical significance was indicated by a p-value < 0.05 and the corresponding 95% CI.

Results

Socio-demographic and Socio-economic characteristics

A total of 442 HIV-infected adults, of which 221 were food-secure and 221 were food-insecure, were enrolled and followed for three consecutive quarters to assess their CD4 count cange. Among them, 435 (98.42%) completed the follow-up period, 6 (1.36%) were lost to follow-up, and 1 (0.23%) died. Two hundred seventy-one (61.31%) were females, of which 145 (65.61%) were food-insecure and 126 (57.01%) were food-secure. Two hundred ninety-three (66.29%) of HIV-infected adults belong to the age group less than 40 years, with the mean age of enrolled participants being 38.99 (±9.53 SD) years: 166 (75.11%) were food-insecure and 127 (57.47%) were food-secure. Four hundred (90.50%) of the HIV-infected adults were followers of Orthodox Christian, of which 195 (88.24%) were food-insecure and 205 (92.76%) were food-secure. Two hundred fifty (56.56%) were married, of which 114 (51.58%) were food-insecure and 136 (61.54%) were food-secure. The vast majority were from urban areas (80.09% of the food-insecure group and 64.71% of the food-secure group).

Three hundred forty-eight (78.73%) of HIV-infected individuals reported having children, of which 167 (75.57%) were food-insecure and 181 (81.90%) were food-secure. Of those who reported having children, 251 (72.13%) had less than four children, with 128 (76.65%) being food-insecure and 123 (67.96%) being food-secure. Ninety-seven (21.95%) were daily laborers, of

which 78 (35.29%) were food-insecure. Two hundred eighteen (49.32%) of HIV-infected adults had no formal education: 127 (57.47%) were food-insecure and 91 (41.18%) were food-secure. One hundred forty-nine (51.92%) of HIV-infected adults reported having a monthly income of less than 2500 Ethiopian birr, of which 106 (64.63%) were food-insecure (Table 1).

Table 1: Baseline socio-demographic and economic characteristics of HIV-infected adults receiving ART at health facilities, Ethiopia, 2024

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Sex	Male	76 (34.39)	95 (42.99)	171 (38.69)
	Female	145 (65.61)	126 (57.01)	271 (61.31)
Age respondents	≤40 years	166 (75.11)	127 (57.47)	293 (66.29)
	>40 years	55 (24.89)	94 (42.53)	149 (33.71)
The average age in years	Average (SD)	36.37 (±8.28)	39.60 (±10.40)	38.99(±9.53)
Religion of respondents	Orthodox	195 (88.24)	205 (92.76)	400 (90.50)
	Protestant	17 (7.69)	12 (5.43)	29 (6.56)
	Others*	9 (4.07)	4 (1.81)	13 (2.94)
Marital status	Married	114 (51.58)	136 (61.54)	250 (56.56)
	Single	24 (10.86)	29 (13.12)	53 (11.99)
	Divorced	42 (19.00)	21 (9.50)	63 (14.25)
	Widowed	41 (18.55)	35 (15.84)	76 (17.19)
Residence	Rural	44 (19.91)	78 (35.29)	122(27.60)
	Urban	177 (80.09)	143 (64.71)	320(72.40)
Presence of children	No	54 (24.43)	40 (18.10)	94 (21.27)
	Yes	167 (75.57)	181(81.90)	348 (78.73)
Number of children (n=348)	≤3 children	128 (76.65)	123 (67.96)	251 (72.13)
	4-9 children	39 (23.35)	58 (32.04)	97 (27.87)
Occupational Status	Farmer	26 (11.76)	59(26.70)	85 (19.23)
	House wife	45 (20.36)	42 (19.00)	87 (19.68)
	Daily laborer	78 (35.29)	19 (8.60)	97 (21.95)
	Employed	27 (12.22)	49 (22.17)	76 (17.19)
	Merchant/others	45 (20.36)	52(23.53)	97 (21.95)
Educational status	No formal education	127 (57.47)	91 (41.18)	218 (49.32)
	Primary school	64(28.96)	56 (25.34)	120(27.15)
	Secondary and above	30 (13.57)	74 (33.48)	104 (23.53)
Monthly income (n=287)	<2500 ETB	106 (64.63)	43 (34.96)	149 (51.92)
	≥2500 ETB	58 (35.37)	80 (65.04)	138 (48.08)

*Catholic, musilim and wekefata

Psychosocial support for HIV-infected adults

Two hundred thirty-nine (54.07%) of the HIV-infected adults received psychosocial support or care from different caregivers, which was consistent across both groups. Of the support or care received, 127 (62.5%) received economic support, followed by psychological support (46, 22.66%). The majority, 112 (55.17%), received care from their husbands or wives, of which 49 (49.00%) were food-insecure and 63 (61.17%) were food-secure. Almost half (49.10%) of the

participants had disclosed their HIV status, of which 114 (52.53%) disclosed their serostatus to their husbands or wives (Table 2).

Table 2: Baseline pyschosocial support for HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Presence caregiver	No	121 (54.75)	118 (53.39)	239 (54.07)
	Yes	100 (45.25)	103(46.61)	203 (45.93)
Type of care received (n=203)	Psychological support	26 (26.00)	20 (19.42)	46 (22.66)
	Economic support	61(61.00)	66 (64.08)	127 (62.5)
	Social support and related	13 (13.00)	17 (16.50)	30 (14.78)
Type of caregiver (n=203)	Mother/ father	25 (25.00)	11(10.68)	36 (17.73)
	Husband/Wive	49 (49.00)	63 (61.17)	112 (55.17)
	Children	19(19.00)	22 (21.36)	41 (20.20)
	Others	7 (7.00)	7 (6.80)	14 (6.90)
Disclose their Sero-status	No	110 (49.77)	115 (52.04)	225 (50.90)
	Yes	111 (50.23)	106 (47.96)	217 (49.10)
To whom you disclose (n=290)	Mother/ father	17 (15.32)	10 (9.43)	27 (12.44)
	Husband/Wive	54(48.65)	60 (56.60)	114 (52.53)
	Children	20 (18.02)	23 (21.70)	43 (19.82)
	Others	20 (18.02)	13 (12.26)	33 (15.21)

Clinical and food-related characteristics of HIV-infected adults

A significant proportion, 83 (18.78%), of HIV-infected adults reported having eating problems during their care follow-up: 44 (19.91%) were food-insecure and 39 (17.65%) were food-secure. Loss of appetite (63, 75.90%) was the main reason for the eating problem. One hundred forty-three (32.35%) of HIV-infected adults reported having anemia during their care follow-up: 81 (36.65%) were food-insecure and 62 (28.05%) were food-secure, as defined by WHO's standard for anemia among HIV-infected individuals. A total of 78 (17.65%) developed OIs during care follow-up, with the most common OIs being diarrheal diseases (43.59%), while the occurrence of tuberculosis (34.78%) was higher among food-insecure HIV-infected adults.

Only 13 (4.53%) of the total sample reported receiving therapeutic feeding. The majority, 267 (60.41%), of participants reported receiving ART for more than 8 years, with the average duration of ART being 8.96years (±4.60), 8.17 years (±4.62 SD) for the food insecure HIV-infected adults, and 9.76 years (±4.44 SD) for the food-secure HIV-infected adults. The majority, 317 (71.72%), of HIV-infected adults were at WHO clinical stage one, of which 163 (73.76%) were food-insecure and 154 (69.68%) were food-secure. Three hundred eighty-nine (88.01%) started ART at an early treatment stage, of which 191 (86.43%) were food-insecure and 198 (89.59%) were food-secure.

One hundred thirty-six (31.26%) and 62 (14.25%) of HIV-infected adults did not receive cotrimoxazole preventive therapy (CPT) and tuberculosis preventive therapy (TPT), respectively. Nearly one-fourth (101, 22.85%) of the HIV-infected adults reported consuming fruits and vegetables at least once per day, as defined by WHO's standard for daily FAV consumption (Table 3).

Table 3: Baseline clinical and nutritional characteristics of HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Presence eating problems	No	177 (80.09)	182 (82.35)	359 (81.22)
	Yes	44 (19.91)	39 (17.65)	83 (18.78)
Causes of eating problem(n=83)	Loss of appetite	35 (79.55)	28(71.79)	63 (75.90)
	Oral candidiasis	8(18.18)	8 (20.51)	16(19.28)
	Esophageal candidiasis	1 (2.27)	3 (7.69)	4 (4.82)
Anemia	No	140 (63.35)	159 (71.95)	299 (67.65)
	Yes	81 (36.65)	62 (28.05)	143 (32.35)
Presence of OIs	No	187 (84.62)	177 (80.09)	364 (82.35)
	Yes	34 (15.38)	44 19.91)	78 (17.65)
Type of OI disease (n=109)	Tuberculosis	11 (32.35)	7(15.91)	8 (10.26)
	Pneumonia	3 (8.82)	5 (11.36)	8 (10.26)
	Diarrheal disease	9 (26.47)	25 (56.82)	34 (43.59)
	Dispepsia	5 (14.71)	3 (6.82)	8 (10.26)
	Others	6 (17.65)	4 (9.09)	10 (12.82)
Therapeutic food	No	211 (95.48)	213 (96.38)	424 (95.93)
	Yes	10(4.52)	8 (3.62)	18(4.07)
WHO clinical stage	Stage one	163 (73.76)	154 (69.68)	317 (71.72)
	Stage two and above	58 (26.24)	67 (30.32)	125 (28.28)
WHO treatment stage	Stage one	191 (86.43)	198 (89.59)	389 (88.01)
	Stage two and above	30 (13.57)	23 (10.41)	53 (11.99)
Duration of ART	<4 years	49 (22.17)	28 (12.67)	77 (17.42)
	4-8 years	58 (26.24)	40 (18.10)	198 (22.17)
	>8 years	114 (51.58)	153 (69.23)	267 (60.41)
Average duration of ART in years	Average (SD)	8.17 (±4.62)	9.76 (±4.44)	8.96 (±4.60)
CPT provision status (n=435)	Provided	130 (60.47)	130 (59.09)	260 (59.77)
	Ongoing	24 (11.16)	15 (6.82)	39 (8.97)
	Not provided	61 (28.37)	75 (34.09)	136 (31.26)
TPT provision status or IPT (n=435)	Complete	177 (82.33)	176 (80.00)	353 (81.15)
	Discontinue/interrupt	3 (1.40)	3 (1.36)	6 (1.38)
	Ongoing	5 (2.33)	9 (4.09)	14 (3.22)
	Not given	30 (13.95)	32 (14.55)	62 (14.25)
Fruit and vegetable dietary intake	≥ One time per day	44 (19.91)	57 (25.79)	101 (22.85)
	< One time per day	177 (80.09)	164 (74.21)	341 (77.15)

Behavioral characteristics of HIV-infected Adults

Only 9 (2.04%) reported having ever been forced to engage in unprotected sex. Forty-four (9.95%) of the HIV-infected adults reported ever migrating from their previous place of residence to get their daily food, of which 38 (17.19%) were food-insecure. One hundred thrity-six (30.77%), skipped doses of ART in the last 7 days due to unmet restrictions such as needing food with the drug, time schedules, and taking it on an empty stomach: 74 (33.48%) were food-insecure and 62 (28.05%) were food-secure. More than half (54.52%) of the HIV-infected adults reported strict

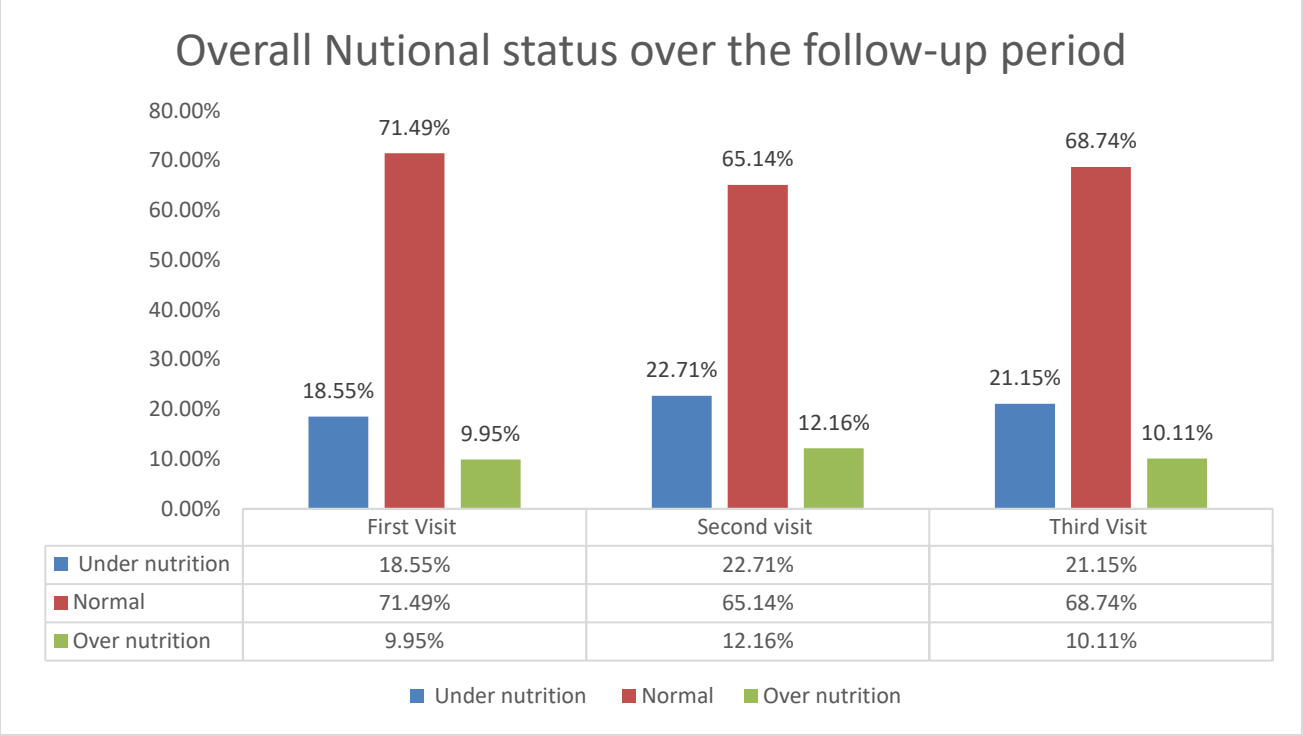
adherence to ART by not missing doses in the last 7 days, including 108 (48.87%) who were food-insecure and 133 (60.18%) who were food-secure. The majority, 269 (60.86%) of HIV-infected adults, demonstrated good adherence to ART, with 143 (64.71%) being food-insecure and 116 (57.01%) being food-secure. A notable number of HIV-infected adults reported engaging in various behaviors: 49 (11.26%) had ever smoked cigarettes, 224 (51.49%) had drunk alcohol, and 26 (5.98%) had chewed khat (Table 4).

Table 432: Baselin behavioral characteristics of HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024

Variables	Response	Food security status		
		Food-Insecure No (%)	Food-secure No (%)	Total No (%)
Unprotected sex for Daily food	No	214 (96.83)	219 (99.10)	433 (97.96)
	Yes	7 (3.17)	2 (0.90)	9 (2.04)
Ever migrated from for food	No	118 (82.81)	215 (97.29)	398 (90.05)
	Yes	38 (17.19)	6 (2.71)	44 (9.95)
Skipped due to unmet restrictions in last 7 days	No	147 (66.52)	159 (71.95)	306 (69.23)
	Yes	74 (33.48)	62 (28.05)	136 (30.77)
Missing doses in the last 7 days	Missed	113 (51.13)	88 (39.82)	201 (45.48)
	Not missed	108 (48.87)	133 (60.18)	241 (54.52)
Level of adherence to ART	Good	143 (64.71)	116 (57.01)	269(60.86)
	Fair	29 (13.12)	34 (15.38)	63 (14.25)
	Poor	49 (22.17)	61 (27.60)	110 (24.89)
Ever smoke cigarettes	No	196 (91.16)	190 (86.36)	386 (88.74)
	Yes	19 (8.84)	30 (13.64)	49 (11.26)
Ever drink alcohol	No	107 (49.77)	104 (47.27)	211 (48.51)
	Yes	108 (50.23)	116 (52.73)	224 (51.49)
Ever chew chat	No	205 (95.35)	204 (92.73)	409 (94.02)
	Yes	10 (4.65)	16 (7.27)	26 (5.98)

Incidence of nutritional status of HIV-infected adults for CD4 count

We assessed the nutritional status of HIV-infected adults at three visits over the follow-up duration to identify its trend over follow-up period and its effect on CD4 count change of HIV-infected adults. Accordingly, 82 (18.55%) of them developed undernutrition at the first visit, with 51 (23.08%) being food-insecure and 31 (14.03%) being food-secure. At the second visit, 99 (22.71%) developed undernutrition, with 57(26.39%) being food-insecure and 42 (19.09%) being food secure. At the third visit, 92 (21.15%) developed undernutrition, with 58 (26.98%) being food-insecure and 34 (15.45%) being food-secure (Figure 1).



	First Visit	Second visit	Third Visit
Under nutrition	18.55%	22.71%	21.15%
Normal	71.49%	65.14%	68.74%
Over nutrition	9.95%	12.16%	10.11%

Figure 1: Overall nutritional status of HIV-infected adults receiving ART over the follow-up period at health facilities in Northcentral, Ethiopia, 2024

Incidence of CD4 count change of HIV-infected adults

A total of 442 individuals (221 food-secure and 221 food-insecure) were followed, resulting in 1,326 observations used to assess CD4 count changes over three consecutive visits. Accordingly, the median CD4 counts at the first, second, and third visits were 433 cells/µl (IQR: 255-607), 482 cells/µl (IQR: 326-698), and 523 cells/µl (IQR: 356-687), respectively. One hundred five (23.76%; 95% CI: 20.01–27.96) HIV-infected adults, 78 (18.35%; 95% CI: 14.96–22.34) HIV-infected adults, and 73 (17.26%; 95% CI: 13.94–21.17) HIV-infected adults were with a CD4 count of <200 cells/mm³ at the first, second, and third visits, respectively. The proportion of HIV-infected adults with a CD4 count < 200 cells/mm³ declined from 23.76% to 17.26% over the 9-month follow-up period. This indicates a slight increase in the incidence of immunological recovery over the 9 months of follow-up. However, the incidence of a low CD4 count among food-insecure HIV-infected adults was still higher than among food-secure HIV-infected adults at each visit. Specifically, 59 (26.70%), 44 (20.37%), and 40 (19.14%) of those with a low CD4 count were food-insecure at the first, second, and third visits, respectively. There was no significant change in immunological recovery from visit to visit in this group. In contrast, 337 (76.24%), 347 (81.65%), and 350 (82.74%) had a CD4 count greater than or equal to 200 cells/mm³, respectively (Table 5, Figure 2).

Table 5: The incidence of low CD4 count change among HIV-infected adults receiving ART at health facilities in Northcentral, Ethiopia, 2024

Food security status	CD4 count change (1st visit)		CD4 count change (2nd visit)		CD4 count change (3rd visit)	
	< 200 cells/ mm3	≥200 cells/ mm3	< 200 cells/ mm3	≥200 cells/ mm3	< 200 cells/ mm3	≥200 cells/ mm3
	No (%)	No(%)	No (%)	No(%)	No (%)	No(%)
Food-insecure	59(26.70)	162(73.30)	44(20.37)	172(79.63)	40(19.14)	169(80.86)
Food-secure	46(20.81)	175(79.19)	34(16.27)	175(83.73)	33(15.42)	181(84.58)

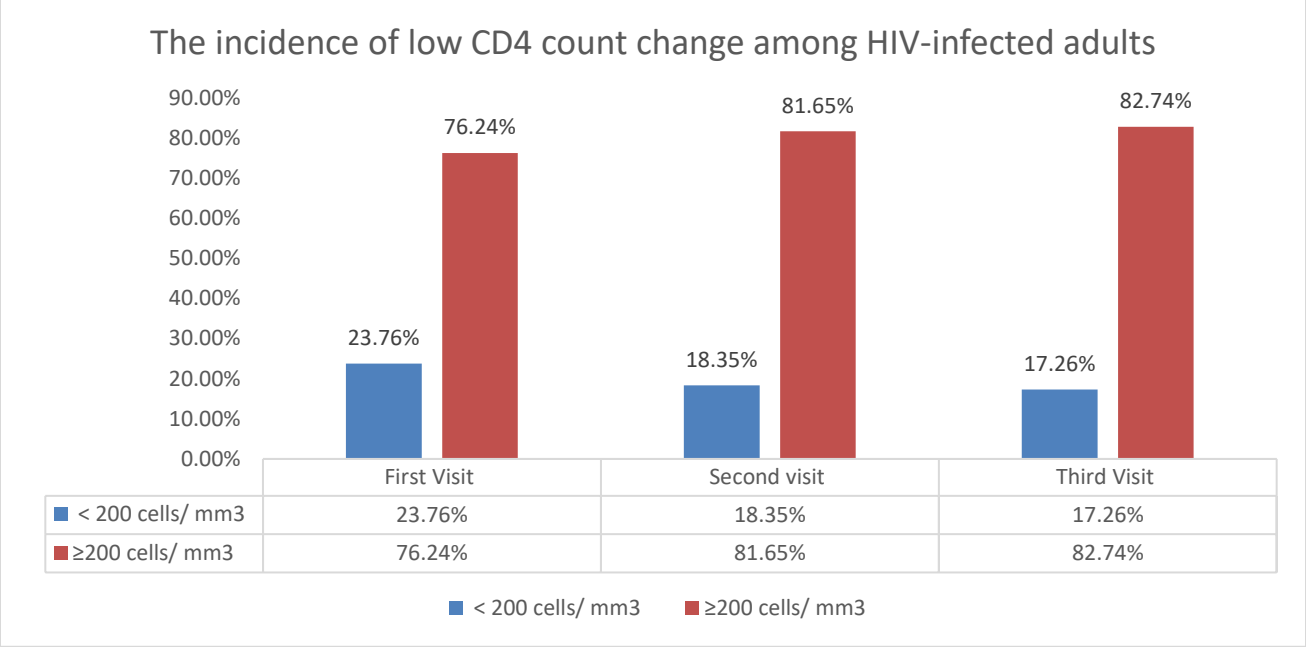


Figure 2: The incidence of CD4 count change among HIV-infected adults receiving ART over the follow-up perion at health facilities in Northcentral, Ethiopia, 2024

The overall incidence of low CD4 count change (< 200 cells/mm³) among observations during the follow-up period was found to be 19.84% (95% CI: 17.76%, 22.11%), with 22.14% among food-insecure HIV-infected and 17.55% among food-secure HIV-infected adults.

Predictors of CD4 count change among adults receiving ART

In the bi-variable generalized linear mixed-effects model, nineteen variables—specifically, sex/gender, age of the respondent, educational status, occupational status, residence, type of care received, presence of anemia, presence of eating problems, duration of HIV infection, duration of ART follow-up, nutritional status during follow-up, TPT provision status or IPT, WHO clinical stage, WHO treatment stage, smoking history, alcohol consumption, fruit and vegetable dietary intake, and adherence to the treatment schedule—were associated with a p-value of ≤ 0.20 and were subsequently selected as candidates for multivariable analysis. The duration of ART follow-up, chewing khat, and following special instructions were reduced after the collinearity check using generalized variance inflation factor.

Consequently, a multivariable generalized linear mixed-effects regression analysis with an identity covariance structure was fitted using all eighteen variables simultaneously. Six of the most contributing factors identified as significant independent predictors of CD4 count change at a 5% significance level. We selected a model with an identity covariance structure, as it provides a simplified approach to handling random effects in the analysis. The model's fit and adequacy were evaluated using information criteria and a log-likelihood ratio test (LR chi-square = 205.23, $p < 0.001$). The analysis for this particular paper indicates that the random effects components of the model capture the correlation in the repeated measurements. sd(b0i) =3.050 (95% CI: 2.540, 3.662) and sd("Σij) = 0.285, with p-value less than 0.001.

Accordingly, the gender of HIV-infected adults receiving ART was found to be a significant independent predictor of low CD4 count change, with the incidence of developing a low CD4 count change among males being 2.9 times higher than that of females (aRR = 2.88, 95% CI: 1.14, 7.30).

The food security status of HIV-infected adults is an independent predictor of low CD4 count after controlling for other potential confounders. Being food insecure was found to independently increase the risk of having a low CD4 count. The incidence of low CD4 count was 2.6 times higher among food-insecure HIV-infected adults compared to food-secure HIV-infected adults (aRR=2.56, 95% CI: 1.05, 6.26).

Being undernourished was found to be an independent predictor of increased incidence of low CD4 count change among HIV-infected adults receiving ART. Specifically, the incidence of low CD4 count change was 2 times higher among undernourished HIV-infected adults compared to those with normal nutritional status (aRR=2.17, 95% CI: 1.03, 4.57).

Being anemic was found to be an independent predictor of an increased risk of low CD4 count. Specifically, the incidence of low CD4 count was 3.3 times higher among HIV-infected adults with anemia compared to their counterparts during the follow-up period (aRR=3.35, 95% CI: 1.37, 8.17).

The WHO clinical stage and the duration of antiretroviral treatment were identified as significant independent predictors of CD4 count change in HIV-infected adults. The incidence of low CD4 count was 4 times higher at the advanced WHO clinical stage compared to the early stage (aRR=4.11, 95% CI: 1.32, 12.84). Likewise, the incidence of low CD4 count was 3.6 times higher in those receiving ART for 4 years or less compared to those on ART for more than 4 years (aRR=3.64, 95% CI: 1.25, 10.63).

However, the analysis did not reveal a significant association between fruit and vegetable consumption, TPT or IPT provision status, and adherence to ART in the final generalized linear mixed-effects multivariable regression model. This is attributed to some variables having severely skewed observations in specific categories and a lack of significant differences between categories (Table 6).

Table 6: Independent predictors of low CD4 count change HIV-infected adults receiveing ART at health facilities in Northcentral, Ethiopia, 2024.

Variables	Response	cRR with 95% CI	aAR with 95% CI	aP-value
Sex	Male	3.26 (1.41, 7.53)**	**2.88 (1.14, 7.30)****	**0.026****
	Female	1.0	1.0	
Food security status	Food secure	1.0	1.0	
	Food insecure	1.90 (0.92, 4.33) *	**2.56 (1.05, 6.26) ****	**0.039****
Nutrional status	Under nutrition	2.34 (1.13, 4.85)**	**2.17 (1.03, 4.57)****	**0.042****
	Normal	1.0	1.0	
	Over nutrition	0.61 (0.19, 2.04)	0.85(0.25, 2.88)	0.794
Presence of Anemia	No	1.0	1.0	
	Yes	4.37 (1.84, 10.39) **	**3.35 (1.37, 8.17)****	**0.008****
WHO clinical stage	Stage one	1.0	1.0	
	Stage two &above	3.78 (1.55, 9.20) **	**4.11 (1.32, 12.84)****	**0.015****
Duration of ART	≤4 years	4.36(1.64, 11.59)**	**3.64 (1.25. 10.63)****	**0.018****
	>4 years	1.0	1.0	

Discussion

The current multicenter prospective cohort study aimed to investigate the effect of food insecurity on CD4 count changes in HIV-infected adults receiving ART, along with other independent predictors of CD4 count changes in health facilities in Northcentral Ethiopia. Accordingly, the median CD4 counts at the first, second, and third visits were 433 cells/µl (IQR: 255-607), 482 cells/µl (IQR: 326-698), and 523 cells/µl (IQR: 356-687), respectively.

This finding is consistent with the findings of the collaborative analysis of cohorts from low-income countries (sub-Saharan Africa, Latin America, and Asia), where the median CD4 cell count increased over the follow-up period from 114 cells/µL at ART initiation to 395 cells/µL (IQR 240-592) at the fifth year of follow-up [31]. The findings from the TREAT Asia HIV Observational data analysis and the retrospective analysis in northern Ethiopia also indicated that the median CD4 count continued to increase even when the concurrent HIV viral load was detectable over the follow-up period [32-34].

The study found that the overall incidence of low CD4 count (<200 cells/mm³) over the follow-up period was 19.84% (95% CI: 17.76–22.11), with a higher incidence among food-insecure HIV-infected adults (22.14%) compared to food-secure HIV-infected adults (17.55%). This finding is in line with the findings of the studies conducted in the different part of the world. For instance, the longitudinal study and retrospective anlasyis conducted in San Francisco (21.9%) [11] and Bhutan (20%) [35], in which patients had CD4 counts below 200 cells/mm³.

The study indicates a decline in the incidence of low CD4 count (a CD4 count <200 cells/mm³) from 23.76% to 17.26% during the follow-up period, suggesting a slight increase in the incidence of immunological recovery over the 9 months of follow-up. This could be due the effectiveness of ART in promoting immune recovery, consistent adherence to treatment, and improved patient management, leading to enhanced immune function over time. This finding is consistent with the findings of a retrospective analysis in Ethiopia, where the incidence of CD4+ cell count <200 cells/mm³ declined from 28.3% to 15.0% over the follow-up period [34].
However, the incidence of low CD4 count among food-insecure individuals was consistently higher than among food-secure individuals: 26.70%, 20.37%, and 19.14% of HIV-infected adults with a low CD4 count (<200 cells/mm³) were food-insecure at the first, second, and third visits,

respectively. This suggests that food insecurity may have a persistent effect on immune function over time, potentially due to inadequate nutritional intake, which can impair immune response and contribute to lower CD4 counts in food-insecure individuals. This finding is consistent with the findings of prospective cohort studies conducted in the Boston and Providence area [36] and British Colombia [20], where the incidence of low CD4 count was persistently higher among food-insecure individuals across repeated measurements. The study reflected negative changes in CD4 count over the follow-up period, predicting a decrease of 99.5 cells/μL in CD4 count over that time [36].

The current follow-up study underscores that food insecurity was found to be an independent predictor of low CD4 count after controlling for other potential confounders, in which the risk of low CD4 count was more than twofold higher among food-insecure HIV-infected adults compared to their food-secure counterparts. The finding on the effect of food insecurity is supported by studies conducted in San Francisco [11] and Atlanta, Georgia [19], which showed that food insecurity increased the incidence of low CD4 cell counts (<200 cells/mm³). The finding also supported by the finding of study in British Columbia, Canada, in which the significant decreasing trend of CD4 count was found in food-insecure HIV-infected adults [20].

However, the finding of a study conducted in a cohort of U.S. veterans [21] and Russia ARCH cohort [37] were inconsistent with the current study, as there was no significant difference in low CD4 counts between food-insecure and food-secure HIV-infected adults. This discrepancy may be due to variations in the study populations, including differences in socioeconomic status, access to healthcare, and adherence to ART. These factors could influence the impact of food insecurity on immune function and CD4 counts, leading to divergent outcomes across different settings.

The gender of participants, nutritional status, presence of anemia, WHO clinical stage, and the duration were found to be significant independent predictors of low CD4 count. The finding indicated the gender of HIV-infected adults receiving ART was found to be a significant independent predictor of low CD4 count change, in higher incidence of developing low CD4 count change found among male that females. This finding is unsurprising and is supported by the descriptive results of this study, which indicated that more than half of the participants reported consuming alcohol (51.49%), a behavior common among males in Ethiopia. Evidence suggests that people with HIV who regularly drink alcohol tend to have a compromised immune system, with a lower overall CD4 count. This finding is consistent with the findings of studies conducted in Ethiopia [34] and Bhutan [35] where a larger number of males showed a low CD4 count (<200 cells/μL) compared to females, as well as a study in Brazil and in low-income countries [31, 38], which found that immune recovery was significantly higher among females than males.

The finding indicated that poor nutritional status independently predicted an increased incidence of low CD4 count among HIV-infected adults on ART, with undernourished individuals found to have twice the incidence of low CD4 count compared to those with normal nutritional status. Unsurprisingly, this finding was supported by a longitudinal studies conducted in Senegal, which found that poor nutritional status significantly predicted poor immunologic recovery [17, 39]. This may be due to the persistent lack of various forms of support, including therapeutic food support, with only a few participants (4%) in the current study reporting they received such support. This lack likely contributed to undernutrition, leading to low CD4 counts. This was supported by a study in Malawi, which found that therapeutic food support had significant effects on nutrition and immunological response [40].

However, surprisingly, this finding is inconsistent with a cohort study in Indonesia, which there was no significant association between changes in nutritional status and changes in CD4 cell count after 6, 12, and 18 months of treatment [41]. This discrepancy could be due to differences in the study populations, including baseline nutritional status, healthcare access and quality, dietary practices, and the availability and quality of nutritional support programs, all of which may have influenced the outcomes differently.

This study found that anemia independently predicted a threefold increased risk of low CD4 count among HIV-infected adults during the follow-up period. This may be due to anemia's impact on immune function, exacerbating the effects of HIV on CD4 counts. This finding is consistent with a study conducted in Nepal [42], which found that the presence of anemia was significantly associated with immunological status.

The study found that the WHO clinical stage had a significant independent effect on CD4 count change, with the incidence of low CD4 count being four times higher at the advanced WHO clinical stage compared to the early stage. Surprisingly, we found inconsistent findings in a study conducted in Uganda, where more than half of the subjects with CD4 counts (≥200 cells/μL) were at an advanced WHO clinical stage [43], and in a retrospective analysis in Ethiopia [44], where most patients presenting with severe immunosuppression were classified in early WHO clinical stages. This discrepancy could be due to an imbalance in the number of study participants in the Uganda study, where the majority were in the advanced disease stage, variations in the populations studied, the long time elapsed since the study was conducted, and the retrospective nature of the study in Ethiopia, where confounders were not adequately addressed.

The finding revealed that the duration of antiretroviral treatment independently influenced changes in low CD4 count among HIV-infected adults. The incidence of low CD4 count was four times higher in those receiving ART for 4 years or less compared to those on ART for more than 4 years. This may be due to longer ART duration allowing more time for immune system recovery and better management of the disease, leading to improved CD4 counts. This study's finding surprisingly not supported by studies in Namibia [45] and Ethiopia [46], which found that a longer duration of ART was associated with a higher risk of poor adherence, leading to lower CD4 counts.

The analysis did not reveal a significant association between low CD4 count and fruit and vegetable consumption in the final multivariable generalized linear mixed-effects model, whereas consuming fruits and vegetables was identified as an important predictor of immune recovery in a study conducted in the Southwest region of Cameroon [47]. This difference may be due to variations in the types and quantities of fruits and vegetables consumed and differences in overall diet quality, which could influence immune recovery.

We assessed the effect of food insecurity on CD4 count change among HIV-infected adults receiving ART in Northcentral Ethiopia. With a large sample size across multiple health facilities with diverse levels of service delivery, this approach ensures the external validity of the findings and provides comprehensive evidence for policy and program implications. This is the first multicenter prospective cohort study in Ethiopia to assess the effect of food insecurity on CD4 count change among HIV-infected adults receiving ART. It allows for the testing of temporal relationships and assumes less recall bias. The use of generalized linear mixed-effects regression models improved the estimation of effect measures, thereby enhancing the accuracy and validity of the findings. However, we assessed food security status and FAVs dietary intake by asking participants about their experiences over the past 30 days, which may be subject to recall bias.

Additionally, self-reported responses increased the possibility that some participants may have misreported their data, potentially leading to an overestimation or underestimation of their estimates.

Conclusions

The study found that while the median CD4 count increased over time, the incidence of low CD4 count (<200 cells/mm³) remained high, particularly among food-insecure HIV-infected adults Although there was a decline in incidence of low CD4 count over 9 months, indicating slight immunological recovery, food-insecure HIV-infected adults consistently experienced a higher incidence of low CD4 counts. The gender of participants, food security status, nutritional status, presence of anemia, WHO clinical stage, and duration of ART were found to be significant independent predictors of low CD4 count. The findings suggest the need for targeted and comprehensive food and nutrition intervention programs, including nutritional counseling tailored to improve food security and nutritional status among HIV-infected adults. It is also important to monitor and support individuals with shorter durations of treatment. Food and nutrition interventions should be designed to be culture- and context-specific to address the gender dynamics of food insecurity and mitigate its health effects on HIV-infected adults.

Data Sharing Statement

The original dataset used in this study are available from the corresponding author upon reasonable request.

Ethics Approval and Informed Consent

Ethical approved was obtained from the Institutional Review Board of the College of Health Sciences, Addis Ababa University, with a protocol number of 104/19/SPH. We collected data after communicating and obtaining permission from health facilities, focal persons at ART clinics and all responsible bodies. Participants were informed about the purpose of the study, and verbal informed consent was obtained from each individual. Confidentiality was ensured by not collecting names or any personal identifiers. All paper records were stored in locked files, and electronic data were kept in encrypted files on password-protected computers, accessible only to the principal investigator. Participation in the study was voluntary, and individuals had the right to choose not to participate or to withdraw at any time. The potential risks associated with participation were minimal.

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Authors' Contributions

All authors contributed to the conception of the topic, data analysis, drafting, and revising of the article. They agreed on the journal to which the article will be submitted, provided final approval of the version to be published, and accepted responsibility for all aspects of the work. Specifically, DJ conceived the study, drafted the study protocol, participated in data collection and management, drafted the initial manuscript, and revised subsequent drafts. AA and AY assisted with revising the initial draft and finalizing the manuscript and data analysis. SG contributed to the design of

data collection tools and the development and revision of the manuscript. DJ prepared the final draft of the manuscript. All authors read and approved the final manuscript.

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Disclosure
The authors report no conflicts of interest in this research.

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Annex II: Information sheet and informed consent

Addis Ababa University

College of Health Sciences

School of Public Health

The Effect of Food Insecurity on Clinical Progression of HIV/AIDS and CD4 Count Change among Adults Receiving ART in North Shewa health facilities, Ethiopia: A multicenter Prospective Cohort Study

Principal Investigator: Dube Jara (MPHE, PhD Student)

Sponsored by _____

1. Information sheet and informed consent

1.1. Information sheet

Study title: The Effect of Food Insecurity on Clinical Progression of HIV/AIDS and CD4 Count Change among Adults Receiving ART in North Shewa health facilities.

Principal Investigators: Dube Jara (MPHE, PhD student)

Supervisors: Prof. Ahmed Ali Ahmed (PhD) and Prof. Alemayehu Worku Yalew (PhD)

Coordinating office: Addis Ababa University, School of Public Health

Introduction: HIV and food insecurity have complicated link, in which one exacerbate the harmful effects of each other. Food insecurity has a negative effect on the overall nutritional and health status of people infected by HIV. The few studies conducted were fail to identify the effects of food insecurity on clinical progression of AIDS and CD4 count change among adults living with HIV. This questionnaire is prepared to collect information on effect of food insecurity on clinical progression of HIV/AIDS and CD4 count change among adults receiving ART in North Shewa health facilities. This questionnaire also helps to assess the socio-demographic characteristic, psychosocial support.

Purpose: The main objective of this study is to assess the effect of food insecurity on clinical progression of HIV/AIDS and CD4 count change among adults receiving ART who are already on follow up in the North Shewa zone Health Facilities. The information you provide is very helpful to us to get more understanding of the problem to develop strategy on how to alleviate the problem.

Procedures and Participation: There was a maximum of 30 minutes' interview to collect general information. Patient records will be extract to collect data of some variables such as type of

malignancy, IOs, Anemia, WHO staging and etc. Follow-up was made for selected participants to collect repeated follow-up data every six months for one year. Your honest answers to these questions and your continuous interest to participate in the study will help us to better understand the effect of food insecurity on clinical progression of HIV/AIDS and CD4 count change and related factors to address the problem. You may be called some time for the purpose of study during the follow up. Therefore, we would greatly appreciate your full participation in the study.

Confidentiality: In order to ensure confidentiality no names or any personal identifier information was used as part of the reports or publication of this study. All information collected was kept in locked files and only the principal investigator had access to the information. Again, we would like to assure you that the individual information gained through asking you and measurements is strictly used for the purposes of the study.

Benefits and Risks: By participating in this study and answering the questions, you will not receive any direct benefit except acknowledgment. However, the information helped us to understand effect of food insecurity on clinical progression of HIV/AIDS and CD4 count change among adults receiving ART, in order to appropriately inform future interventions.

Inducement, incentive and compensation: the participation in the process of this study does not have any form of inducement, coercion and does not bring and risks that incur compensation.

Findings Dissemination: Principal investigator is responsible and fully accountable for dissemination of findings to all stakeholders in the study area, policymakers and health program planners, and other concerned bodies. Effort was made to publish the paper on peer-reviewed journals, and to present at different professional and academic conferences.

Freedom to Withdraw: Please note that participation in this study is voluntary; you may refuse to participate. You may also at any stage withdraw from the study if you wish to do so. This would not have any effect at all on your treatment and any other benefits you get from the hospital and nobody will enforce you to explain the reason of withdrawal.

Person to Contact: You have right to ask information that is not clear about the study before and during the process of study. You can contact the Principal investigator and his supervisors. Moreover, this study ethically reviewed and approved by Addis Ababa University College of Health Sciences IRB. For further information and question for clarity, you may contact the following people.

Addis Ababa University College of Health Sciences IRB secretary office Tel. 0118961396, Email: chs.irb@aau.edu.et

Principal Investigator name and address: Dube Jara (telephone address +251913910575).

Supervisor name and address: School of Public Health, College of Health Sciences Addis Ababa University, Mobile:

1.2. Informed Consent Form

Study title: "The effect of Food Insecurity on Clinical Progression of HIV/AIDS and CD4 Count Change among Adults Receiving ART in North Shewa health facilities"

I have been well aware of that this study undertaking is a postgraduate degree partial fulfillment dissertation, which is fully supported and coordinated by AAU College of Health of Sciences, School of Public Health, and the designate principal investigator is **Dube Jara**. I have been fully informed in the language I understand about these study objectives that are to understand the effect of food insecurity on clinical progression and CD4 count change adults receiving ART in North Shewa health facilities.

I have been informed that all the information I shall provide to the interviewer will be kept confidential. I also knew that I have the right to withhold information, skip questions to answer or to withdraw from the study any time I have acquainted nobody will impose me to explain the reason of withdrawal. It is also enlightening, there would have no effect at all in my health benefit or other administrative effect that I get from the hospital. I have assured that the right to ask information that is not clear about the study before and/or during the process and to contact

Addis Ababa University College of Health Sciences IRB secretary office Tel. 0118961396, Email: chs.irb@aau.edu.et
Principal Investigator name and address: Dube Jara (telephone address +251913910575).
Supervisor name and address: Mobile:
I have read this form, or it has been read to me in the language I comprehend and understood the condition stated above, therefore, I am willing and confirm my participation by signing the consent.

Agreed to participate in the study?

Confirm their participants by Yes/No in the electornic form Yes/No _____ date _____

Signature of the interviewer Name _____ Signature _____ date _____

Supervisors/Researcher remark and signature _____ Name _____ Signature _____ date _____

Annex III: English version Questionnaire

The effect of Food Insecurity on Clinical Progression of HIV/AIDS and CD4 Count Change, among adults receiving ART in North Shewa Health Facilities, Ethiopia

Code number of the cards_____

Investigator's name _____ Signature_____ Date of data collection_____

Data collector's name_____ Signature_____ Date_____

Part I: Socio demographic characteristics			
Code .no	**Variables**	**Category** (encircle the chosen number)	**Skip to Q**
101	Age (in full years)	_____	
102	Sex	1.Male 2.Female	
103	Religion	1.Orthodox 2.Muslim 3.Protestant 4.Catholic 5.Others(Specify)_____	
104	Marital status	1.married 2.single 3.divorced 4.widowed 5. separated	
105	Ethnicity	1. Oromo 2. Amhara 3. Agew 4. Tigre 5. Others_____	
106	Occupational status	1.farmer 2. House wife 3.daily laborer 4.private employee 5.government employee 6.NGOs 7. Merchant 8. other _____	
107	Monthly income	_____	
107.1 Household wealth Data 107.1.1. House hold Agricultural land ownership			

	Type of land	Area by self/rent/		Type of land	Area by self/rent/
107.1.1.1	Self-land(taxed)		107.1.1.5	Land shared for others	
107.1.1.2	Land Rent from others		107.1.1.6	Family(relative) land	
107.1.1.3	Land Rent for others		107.1.1.7	other	
107.1.1.4	Land Shared from others				
	Total land ownership by Hectare_____				

107.1.2 If your livelihood is by farming, would you tell total annual and type of crop cultivated last year, please?

	Major Crops	Total Crop by kuntal	Current Price in birr	Total price in birr
107.1.2.1				
107.1.2.2				
107.1.2.3				
107.1.2.4				
107.1.2.5				
	Household annual crop cultivated from major crops in birr_____			

107.1.3 Does your last year annual crop cultivated cover your household food consumption?

1. Yes 0. No

107.1.4 If your answer is No, how can you cover the remaining food consumption? _____.

107.1.5 other additional income gaining ways

	Type of additional income gaining ways	Total crop(kuntal)	Total price in birr
107.1.5.1	Selling animal products(better, egg-----)		
107.1.5.2	Hand worker (wood worker, tailor …)		
107.1.5.3	Selling plant products(Equaliptus, Gasho..)		
107.1.5.4	others)_____		
107.1.5.5	Total Annual Household income gaining ways(in birr)		

107.1.6. Total Household livestock

	type of animal	number		type of animal	Number
107.1.6.1	Oxen		107.1.6.7	hoarse	
107.1.6.2	Cow		107.1.6.8	sheep	
107.1.6.3	Donkeys		107.1.6.9	gout	
107.1.6.4	Calves		107.1.6.10	hen	
107.1.6.5	Heifer		107.1.6.11	others_____	
107.1.6.6	Mule				
107.1.7. Household livestock wealth					

TLU=tropical livestock unit and 250kg live ruminant = 1 TLU

	Type of animal	TLU	Total price (Birr)		Type of live animal	TLU	
107.1.7.1	Oxen	1		107.1.7.7	Horse	1.1	
107.1.7.2	Cow	0.9		107.1.7.8	Mule	1	
107.1.7.3	Donkeys	0.7		107.1.7.9	Sheep	0.1	
107.1.7.4	Calves	0.25		107.1.7.10	Goats	0.1	
107.1.7.5	Heifer	0.75		107.1.7.11	hens	0.13	

107.1.7.6	Household total annual income from livestock selling in Birr		
107.1.8 Total annual income of the household from selling Household livestock ____(in birr) 107.1.9 Total income of the family 1. Annual_____ (in birr) 2.monthly _____(in birr) Source: storck et.al 1991			
108	Residence	1.Rural 2.Urban 3. Semi urban	
109	Educational Status	1. Can't read and write 2. Can read and write 3. Primary school 4. Secondary school 5. Tertiary	
110	Presence of children	1.Yes 2.No ⇒	Q201
111	Number of children	_____	
	Part II: Psychosocial supports		
201	Is there care giver?	1.Yes 2.No ⇒	Q204
202	What are the types of care you get?	1. psychological support 2. Economic support 3. physical support 4. social support	
203	Who are the care givers?	1.Mother/ father 2.Religious father 3.Wife 4.Husband 5.Children 6.Others _____	
204	For whom do you want to disclose about your HIV sero-status?	1.Mother/ father 2.Religious father 3.Wife 4.Husband 5.Children 6.Community supporter 7.Others_____	
Part III: Clinical predictors and effect information section			
301	Current Weight (kg)	_____ (kg)	
302	Current Height (cm)	_____(cm)	
303	Baseline Body Mass Index?	_____(kg/m^2)	
304	Baseline CD4 count	_____($cells/mm^3$)	
305	Baseline Viral load	_____(Copies/mL)	
306	Baseline Hemoglobin level in mg/dl	_____(mg/dl)	
307	Have you faced eating problems?	1.Yes	

		2.No ⟹	Q309
308	What are causes of eating problems?	1.Loss of appetite 2.Oral candidiasis 3.Esophageal candidiasis 4.Others	
309	Presence of opportunistic malignancy	1.Yes 2.No ⟹	Q311
310	Type of opportunistic malignancy	1.Kaposi's sarcoma 2.Cervical cancer 3.Others	
311	Presence of opportunistic disease	1.Yes 2.No	
312	Type of opportunistic disease	1.Tuberculosis 2.Pneumonia 3. Diarrheal disease 4.Meningitis 5.Dyspepsia 6.Others_____	
313	Duration of HIV infection from period of diagnosis	_____(weeks)	
314	Presence of anemia	1.Yes 2.No	
315	WHO clinical stage of the disease	1.Stage one 2.Stage two 3.Stage three 4.Stage four	
316	Who treatment stage of the disease	1. Treatment stage one 2. Treatment stage two 3. Treatment stage three 4. Treatment stage four	
317	Total duration of ART treatment follow up (follow up time)	_____	
318	Follow up interval	_____	
319	History of Cotrimoxazole preventive therapy(CPT) provision status	1. Provided 2. On going 3. Not provided	
320	Tuberculosis Preventive Therapy(TPT) provision status or IPT	1. Complete 2. Discontinue/interrupt 3. On going 4. Not given	
	Part IV: Therapeutic food related information		
401	Do you take any therapeutic food during the course of ART treatment?	1. yes 2. no	

402	If yes, can you mention them?	_____	
403	When did you start the therapeutic food	_____	
404	For how during did you take it?	_____	
	Part V: Behavioral predictors		
501	**Patient interview:** What are the number of doses skipped due to unmet restrictions, i.e. like food required with drug, time schedule, with empty stomach . . . etc	Number of doses skipped: Today, _____ Yesterday, _____ In the past three days, _____ In the past seven days,_____	
502	How closely did you follow specific schedule in the past 7 days?	1. Never 2. Sometimes 3. About half of the time 4. Most of the time 5. All of the time.	
503	How often did you follow special instruction?	1. Never 2. Sometimes 3. About half of the time 4. Most of the time 5. All of the time.	
504	For patients who brought their pills, Count pills remaining in the pill bottle & calculate the difference between actual & expected number of pills remaining.	Number of pills remaining _____ Number of pills dispensed last time _____ Expected number of pills remaining _____	
505	Have you ever smoke cigarettes?	1. No 2. yes	
506	Have you ever drink alcohol?	1. No 2. yes	
507	Have you ever chew chat?	1. No 2. yes	
508	Have you ever been forced to engage in the unprotected sex to get your daily food?	1. No 2. Yes	
509	Have you ever migrated from your previous place of residence to search for food?	1. Yes 2. No	
	Part VI: Household Food Insecurity Access Scale (FIAS) Generic Questions		

601	In the past four weeks, did you worry that you and your household member would not have enough food?	0. No ⟹ 1. yes	Q603
602	If yes to 601, how many times?	1. Rarely (once or twice in the past four weeks) 2. Sometimes (three to ten times in the past four weeks) 3. Often(more than ten times in the past four weeks)	
603	In the past four weeks, were you and any household member not able to eat the kinds of food you preferred because of lack of resource?	0. No ⟹ 1. yes	Q605
604	If yes to 603, how many times?	1. Rarely (once or twice in the past four weeks) 2. Sometimes (three to ten times in the past four weeks) 3. Often(more than ten times in the past four weeks)	
605	In the past four weeks, did you and any household member have to eat a limited variety of foods due to lack of resources?	0. No ⟹ 1. Yes	Q607
606	if yes to Q605 How many times?	1. Rarely (once or twice in the past four weeks) 2. Sometimes (three to ten times in the past four weeks) 3. Often(more than ten times in the past four weeks)	
607	In the past four weeks, did you and any household member have to eat some foods that you really did not want to eat because of lack of resources to obtain other types of food?	0. No ⟹ 1. yes	Q609
608	If yes to Q607, how many times?	1. Rarely (once or twice in the past four weeks) 2. Sometimes (3-10 times in the past four weeks) 3. Often(more than ten times in the past four weeks)	
609	In the past four weeks, did you and any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0. No ⟹ 1. yes	Q611
610	If yes to Q609, how many times?	1. Rarely (once or twice in the past four weeks) 2. Sometimes (3-10 times in the past four weeks) 3. Often (more than ten times in the past four weeks)	

611	In the past four weeks, did you and any household member have to eat fewer meals in a day because there was not enough food?	0. No ⟹ 1. yes	Q613
612	If yes to Q611, how many times?	1. Rarely (once or twice in the past four weeks) 2. Sometimes (3-10 times in the past four weeks) 3. Often(more than ten times in the past four weeks)	
613	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	0. No ⟹ 1. Yes	Q615
614	If yes to Q613, how many times?	1. Rarely (once or twice in the past four weeks) 2. Sometimes (three to ten times in the past four weeks) 3. Often (more than ten times in the past four weeks)	
615	In the past four weeks, did you and any household member go to sleep at night hungry because there was no enough food?	0. No ⟹ 1. yes	Q617
616	If yes to Q515, how many times?	1. Rarely (once or twice in the past four weeks) 2. Sometimes (three to ten times in the past four weeks) 3. Often(more than ten times in the past four weeks)	
617	In the past four weeks, did you and any household member go a whole day and night without eating anything because there was not enough food?	0. No ⟹ 1. Yes	Q701
618	If yes to Q617, how many times?	1. Rarely (once or twice in the past four weeks) 2. Sometimes (three to ten times in the past four weeks) 3. Often(more than ten times in the past four weeks)	

Part VII: Behavioural Risk Factor Surveillance System (BRFSS) fruit and vegetable dietary intake for HIV-infected adult			
701	Now think about the foods you ate or drank during the past month, that is, the past 30 days, including meals and snacks.	Never……..(01) 1 times per month……..(02) 2–3 times per month……..(03) 1–2 times per week……..(04) 3–4 times per week……..(05)	

	How often did you eat the following fruits and vegetables in the past 30 days? You can tell me times per day, per week or per month.	5–6 times per week……..(06) 1 times per week……..(07) 2–3 times per day……..(08) 4–5 times per day……..(09) 6 or more times per day……..(10)	
701A	In the past one month, how often did you drink 100% fruit juice such as orange, mango, papaya, avocado, strawberry juices? Do not include fruit-flavoured drinks or fruit juices you added sugar to.	|___| times	
701B	In the past one month, how often did you eat fruits such as banana, orange, mango, papaya, avocado, pineapple, strawberry, including fresh or dried fruits? Do not count fruit juice.	|___| times	
701C	In the past one month, how often did you eat any fruit or drink 100% fruit juice? Do not include fruit-flavoured drinks or fruit juices you added sugar to.	|___| times	
701D	In the past one month, how often did you eat green leafy vegetables or lettuce salad with or without other vegetables?	|___| times	
701E	In the past one month, how often did you eat cruciferous vegetables like cabbage, cauliflower, broccoli with or without other vegetables?	|___| times	
701F	In the past one month, how often did you eat marrow vegetables like Pumpkin, cucumber and zucchini with or without other vegetables?	|___| times	
701G	In the past one month, how often did you eat potatoes, sweet potatoes, yams, casava boiled, baked, fried, mashed or as part of other dishes?	|___| times	
701H	In the past one month, how often did you eat carrots?	|___| times	
701I	In the past one month, Excluding the aforementioned vegetables, how often did you eat other vegetables?	|___| times	
701J	In the past one month, how often did you eat any vegetable?	|___| times	
INTAKE OF FRUITS, VEGETABLES AND SWEETS IN THE PREVIOUS 24 HOURS			
702	Can you please quantify the fruits (excluding fruit juices) you took yesterday in the 24-hour period (from yesterday sunrise to today's sunrise)? *Data collector: if the consumed portion size cannot be estimated enter 99*		
702A	Orange/mandarin (1 fruit)	_____	
702B	Banana (1 fruit)	_____	
702C	Mango (1 fruit)	_____	
702D	Papaya (1 fruit)	_____	
702E	Pineapple (1 slice)	_____	
702F	Apple (1 fruit)	_____	
702G	Grape fruit (1 fruit)	_____	

702H	Avocado (1 fruit)	_____
702I	Strawberry (1 fruit)	_____
702J	Dates (1 fruit)	_____
702K	Lemon/lime (1 fruit)	_____
702L	Watermelon (1 slice)	_____
702M	Other fruit (specify the type and amount consumed)	_____
703	Can you please quantify the vegetables you took yesterday in the 24-hour period (from yesterday sunrise to today's sunrise)? *Data collector: if the consumed portion size cannot be estimated enter 99*	
703A	Potato (1 vegetable)	_____
703B	beetroot (1 vegetable)	_____
703C	Tomato (1 vegetable)	_____
703D	Carrot (1 vegetable)	_____
703E	Sweet potato (1 vegetable)	_____
703F	Green leafy vegetables including salads (1 coffee cup)	_____
703G	Cruciferous: cabbage, cauliflower, broccoli (1 coffee cup)	_____
703H	Pumpkin, zucchini (1 slice)	_____
703I	Cucumber (1 vegetable)	_____
703J	Other vegetable (specify the type and amount consumed)	_____

	Part VIII: Follow up Information format			
S.No	**Variables**	**First visit (Baseline)**	**Second visit**	**Third visit**
801	Weight (kg)			
802	Height (cm)			
803	BMI (kg/m^2)	Will be calculated	Will be calculated	Will be calculated
804	CD4 (cells/mm^3)			
805	Viral load (copies/mL)			

Thank You!!!

Miiltoo IV. Guca deggartuu ragaafi waliigaltee Afaan Oromoon

Yunivarsiitii Finfinnee

Kolleejjii Fayya

Mana Barumsaa Fayyaa Hawaasaa

Dhaabbillee fayyaa Kaaba Shawaa gara Kaaba guddu-galeessa Itiyyophiyaatti arggamanitti adeemsi dhukkubaa fayyadamoonni qoricha HIV/AIDS ii agarsiisaniifi dhiibbaan hanqina nyaataa isaanii hanga CD4 irratti qabuu fi sababawwan gurgguddoo dhiibbaalee kanniinii ta'an mata-duree jedhu irratti qo'annaadhaaf guca horddoffii fi aaf-gaaffii bal'inaan dhi'aate.

Dursaan qo'annaa kanaa,

Duubee Jaarraa (Dig. 2^{ffaa}, barataa dig.3^{ffaa})

1. Guca deggartuu ragaafi waliigaltee: Afaan Oromoon.

1.1.Deggartuu ragaafi waliigaltee Afaan Oromoon

Mata-duree qo'annichaa: Dhiibbaan hanqinin ga'umsa soorataa adeemsa dhukkubaa fayyadamoonni qoricha HIV/AIDS ii agarsiisaniifi hanga CD4 irratti qabuu fi sababawwan gurgguddoo dhiibbaalee kanniinii ta'an. Qorannichi, dhaabbillee fayyaa Kaaba Shawaa Kaaba guddu-galeessa Itiyyophiyaatti arggamanititti.

Qo'ataa dursaan: Duubee Jaarraa (Dig. 2^{ffaa}, barataa dig.3^{ffaa})

Gorssitoota qo'annichaa: Profee. Ahimad Ali Ahimad (dig. 3^{ffaa}) fi Profee. Alamaayyoo Warquu Yaalaw (dig.$3^{ffaa)}$

Waajjira miilttoo: Yunivarsiitii Finfinneetti Mana Barumsaa Fayyaa Hawaasaa

Seensa: Walitti dhufeenni dhukkuba HIV fi hanqinni ga'umsa soorataa baayyee wal-xaxaa wanna ta'eef dhibbaan isa tokkoo isa kan biraa irratti abaasa. Keechattiyyuu, ga'umsi sooraataa haala waliigala fayyaa fi akkaataa nyaataa namoota dhukkuba HIV dhaan qabaman irratti dhiibbaa badaa akka fidu qo'annowwan asiin dura taasiifaman hinagarsiisu. Yaa ta'uyyuu malee, akkaataan walitti dhufeenya lamaan isaanii jidduu jiru irratti qo'annowwan gaggeeffaman xiqqaa ta'u isaa irra darbeeyyuu haala hanqina soorata ga'aa fudhatuu fi dhiibbaan hanqinin ga'umsa adeemsa dhukkuba HIV fi dhiibbaa jijjiirama hangi CD4 ifatti waan hin ilaaliniif akka madda odeeffannoo guutuutitti fayyadamuun Nama dhiba. Aaf-gaaffiin Kun, adeemsa dhukkubaa fayyadamoota qoricha HIV fi dhiibbaan hanqinin ga'umsa soorataa adeemsa dhukkubaa fayyadamoonni qoricha HIV/AIDS ii agarsiisaniifi hanga CD4 irratti qabuufi sababawwan gurgguddoo dhiibbaa kanniinii. Mata-duree jedhu irratti qo'atuu ta'a. Aaf-gaaffiin bal'inaan dhi'aate Kun haalawwan uummataafi hawaassummaa, haalawwan xin-samuufi hawaassummaa, rokkoolee keessoo namootaa, rakkoolee kunuunsa hawaasaa fi naannoo akkasumas dhiibbaan ga'umsi nyaataa qabuu fi sababawwan gurgguddoo kanniinii qo'atuuf dhi'aatee dha.

Kaayyoo qo'annichaa: kaayyoon gooroon qo'annaa kanaa dhaabbilee fayyaa Kaaba shawaa keechatti argamanitti haala dhiibbaan hanqinin ga'umsa soorataa adeemsa dhukkubaa fayyadamoonni qoricha HIV/AIDS ii agarsiisaniifi hanga CD4 irratti qabuu fi sababawwan gurgguddoo dhiibbaawwan kanniinii xiinxalanii hubachuu dha. Ragaan isin qo'annaa kanaaf jecha kennitan kaayyoo qo'annichaa galmmaan ga'uu fi rakkoosaa gadi-fageenyaan hubachuun rakkinichi hundeedhaa akka furamu gochuu keechatti ga'ee olaanaa gumaacha.

Adeemsa qo'annichaa fi hirmmaannaasaa: walumaa galatti ragaa qo'annaa kanaa walitti qabuuf turmaata yeroo daqiiqa 30 fudhata. Dabalees, ragaaleen dhiibbaa hanqina ga'umsa soorataafi horddoffiin wallaanamtoota HIV baatii jahaa, jahaan waggaa tokkoof walitti qabama. Ragaan isin walitti fuufiinsaan qajeelummaan kennitan kaayyoo qo'annichaa galmaan ga'anii fala rakkichaaf kaa'uu keechatti ga'ee ol-aanaa qaba. Itti dabalees, gaaffiiwwan dhi'aataniif deebiiwwan isin amanamummaafi haqummaan kennitan dhiibbaan hanqinin ga'umsa soorataa adeemsa dhukkubaa fayyadamoonni qoricha HIV/AIDS ii agarsiisaniifi hanga CD4 irratti qabuu fi sababawwan gurgguddoo dhiibbaalee kanniinii baruufi qo'annicha galmaan ga'uuf wanna nu fayyaduuf hirmmaannaan keechan murteessaa dha. Ragaan kallattiidhaan hirmmaattoota irraa argamuu hindandeenye galmmee horddoffii yaalamtootaa irraa walitti qabama. Kanaafuu, hirmmaannaa keechan hinjajjabeessina.

Hiccitii ragaa: Hiccitii raga keechanii eeguuf jecha ragaan eenyummaa dhuunfaa Kan ibsu kamiyyuu adeemsa gabasaafi maxxansa irratti hojiirra hinoolu. Ragaaleen isin irraa fuudhataman hundinuu sanduuqa qorataa dursaa keessatti qollofamee eegama. Dabalees, ragaan isin irraa argganne kaayyoo qo'annaa kanaaf qofa Kan oolu ta'uusaa isinii mirkanneessina.

Faayidaafi sodaa: qo'annaa kanatti hirmmaattanii deebiiwwan deebisuu keechaniin faaydaan kallattiidhaan arggattan galata malee hoomtuu hinjiru. Sodaan isin irra ga'us gonkumaa hinjiru. Yaa ta'uyyuu malee, ragaan isin kennitan rakkinicha gadi-fageenyaan hubachuudhaan gara fuula duraatti rakkoo kana furuuf kallattii wallaansaa barbaachisaa kaa'uuf isiniifi namoota biroof faayidaa guddaa qaba. Itti dabaluudhaanis, qo'annaa kana irratti hirmmaachuu keechaniif dhiibbaan qaamaa, kan hawaasuummaa, kan xinsamuufi balaan dinagdee isin irra ga'u kamiyyuu hinjiru.

Qo'annicha irratti hirmmaachisuuf jecha faayidaan dhiibbaa uumuufi beenyaa kennuu: Qo'annaa kana irratti hirmmaachisuuf jecha **faayidaadhaanifi** dhiibbaan godhamu gonkumaa hinjiru. Akkasumas, hirmmaachuu keechaniif **beenyaan kennamu tokkollee** hinjiru. Qo'annichi hirmmaattota irratti dhiibbaa fidu wanna hinqabneef qo'annicha irratti akka hirmaataniif dhiibbaan godhamus beenyaan kennamus hinjiraatu

Tamsaasa bu'aa qo'annichaa: qo'atichi arggannoo/bu'aa qo'annichaa wal-tajjii adda addaa irratti qaamolee dhimmisaa ilaallatuuf dhi'eessuuf **itti-gaafatamummaa** fi dirqama qaba. Kana irra darbees, bu'aan qo'annichaa maxxansiitoota idil-addunyaa bebbeekamoo ta'an irratti maxxansiisuun itti-fayyadamoota biraan ga'uuf carraaqqiin hintaasifama.

Mirga hirmmaataa: Kan ani isinii mirkkaneessuu barbaadu yoo jiraate, hirmmaannaan qo'annaa kanaa gutumaa guutuutti kan fedhii irratti hundaa'ee dha. Adeemsa aaf-gaafii kanaa keessatti wanni isinitti hintolle yoo jiraate gidduuttis ta'e walumaa galatti hirmmaannaa keechan addaan kutuu akka danddeessan isiniin mirkkaneessa. Hirmmaannaa qo'annichaa addaan kutuu keessaniin eenyullee akka isin hindirqisiisnee fi tajaajila buufaticha fayyaa fi hospitaalicha irraa arggattan irratt dhiibbaa akka hinqabaane isiniin mirkaneessa.

Itti-gaafatamaa aantee: qo'annichi odoo hinjalqabaminis ta'e erga jalqabamee adeemsa qo'annichaa irratti wanni ifa hinta'in yoo jiraate odeeffannoo gaafachuuf mirga guutuu qabdu. Qo'annicha ilaalchisee gaafii qabddan kamiyyuu dursaa qo'annichaa, dursaa gorsaa qo'annichaa fi Yunivarsiitii Finfinnee kollejjii saayinsii Fayyaa koreewwan qo'annaa kanaaf dhaabbatan dubbisuu hindandeessu.

Odeeffannoo dabalataaf:

Yunivarsiitii Finfinnee kollejjii saayinsii Fayyaa qo'annicha ilaalchisee lakk. Bil. 0118961396, E-meelii: chs.irb@aau.edu.et

Dursaa qo'ataa: Obbo Duubee Jaarraa Lakk.Mob.+251913910575

Gorsaa dursaa qo'annichaa: Profee. Ahimad Ali Ahimad (dig. 3^{ffaa}) Lakk.Mob +251911684399

1.2. Guca walii-galtee hiika Afaan Oromootiin

Mata-duree qo'annichaa: Dhiibbaan hanqinin ga'umsa soorataa adeemsa dhukkubaa fayyadamoonni qoricha HIV/AIDS ii agarsiisaniifi hanga CD4 irratti qabuu fi sababawwan gurgguddoo dhiibbaalee kanniinii ta'an qo'achuu dha. Qo'aannichis, dhaabbillee fayyaa Shawaa Kaaba guddu-galeessa Itiyyophiyaatti arggamanititti gaggeeffama.

Ani qo'annaan kanaan digirii sadafaa guttachuuf hennaan ta'u gutumaa gutuutitti deggersa Yunivarsiitii Finfinnee Mana baruumsaa Fayyaatiin hawaasaatiin akka ta'e fi dura-bu'aan qo'annichaas Obbo Duubee Jaarraa ta'uu isaanii hubadheen jira. Kaayyoon qo'annaa kanaas dhaabbilee fayyaa kaaba shawaa keechatti argamanitti haala dhiibbaan hanqinin ga'umsa soorataa adeemsa dhukkubaa fayyadamoonni qoricha HIV/AIDS ii agarsiisaniifi hanga CD4 irratti qabu hubachuuf akka gaggeeffamu afaan naa galuun naaf ibsamee hubadheen jira. Qaama ragaa guuruu kanaaf ragaan kennamu kamiyyuu hiccitiin isaa akka eeggamu hubadheen jira. Akkasumas, qo'annaa kana irratti hirmmaachuudhaan rakkoon akka nama irra hingeenye hubadheen jira.

Ani kanan armaan gaditti mallatteesse kaayyoo qo'annaa kanaa hubadhee hennaa ta'u akkasumas yoon ani yaada kiyya jijjiire mirga addaan kutuu akkan qabu baree qo'annicha irratti hirmmaachuu kiyya nanmirkkaneessa. Qo'annicha ilaalchisee odeeffannoon barbaachisaan hundi anaaf kennamee jira. Akkasumas, yeroon barbaadetti hirmmaannaa qo'annichaa yoon addaan kute rakkoon qaamaa alaa irraa yookaan dhaabbilee fayyaa deggarsa irraa arggachaa jiru irraa dhiibbaan kamiyyuu akka na hinquunnamne anaaf mirkaneeffameejira. Waa'ee qo'annichaa odeeffannoo oggaan arggachuu fedhutti akkan arggachuu danda'u anaaf mirkanaa'eetu jira.

Yunivarsiitii Finfinnee kollejjii saayinsii Fayyaa qo'annicha ilaalchisee lakk. Bil. 0118961396, E-meelii: chs.irb@aau.edu.et

Dursaa qo'ataa: Obbo Duubee Jaarraa Lakk.Mob.+251913910575

Gorsaa dursaa qo'annichaa: Profee. Ahimad Ali Ahimad (dig. 3ffaa) Lakk.Mob +251911684399

Odeeffannoo armaan olitti gadi-fageenyaan ibsaman hubatanii qo'annaa kana irratti hirmmaachuuf fedhii qabdu?

Eyyeen ☐

Hirmmaataa eeyyee/lakkii jedhe murteessuu isaani karaa foormii electronikistiin mirkaaneessi

Eeyyee/lakkii_____Guyyaa_____

(Aaf-gaafiicha itti fufaa)

Miti ☐ (Aaf-gaafiicha addaan kutaa)

Mallattoo ragaa sassaabaa

Maqaa_____Mallattoo_____Guyyaa_____

Yaadaa fi Mallattoo to'ataa/ qo'ataa

Yaada_____ Mallattoo_____

Maqaa_____Mallattoo_____Guyyaa_____

Miiltoo V. Aaf-gaafii hikaa Afaan Oromootiin

Hulaagaa qulqullina ragaa eegsisuuf qophaa'e
Lakk. Koodii kaardii_____

Maqaa qo'atichaa_____Mallattoo_____Guyyaa itti ragaan sassaabame_____

Maqaa sassaabaa ragaa_____mallattoo_____ Guyyaa itti ragaan sassaabame_____

Kutaa I. Odeeffannoo sirna-uummataafi haala hawaasummaa			
Lakk. Koodii	Gaaffilee	Ramaddii	Ibsa
101	Umrii (waggaa guutuun)	___	
102	Saala	1. Dhiira 2. Dhalaa	
103	Amantaa	1. Ortodoksii 2. Isilaama 3. Pirotestaantii 4. Kaatolikii 5. Kanbiroo_____	
104	Haala gaa'elaa (fuudhaafi heerumaa)	1. kan fuudhe 2. kan hinfuune 3. kan hike/tte 4. kan irraa du'e/duute 5. addaan ba'anii kan jiraatan	
105	Sabummaa	1. Oromoo 2. Amaaraa 3. Aga'uu 4. Tigiree 5. kan biraa(ibsaa)	
106	Haala hojjaa	1. Qotee bulaa 2. Haadha warraa 3.Hojjataa guyyaa 4. Hoj.dhaabb. dhuunfaa 5. Hoj. Mootummaa 6. Hoj. miti-mootummaa 7. Daldaalaa(Naggaadee) 8. Kan biraa(ibsaa)	
107	Galiin ji'aan arggattan hagam ta'a?	_____	

107.1.Odeeffannoo haala dinagdee

107.1.1.Qabiyyee lafa qonnaa maatiisaa bifa addaddaatiin

	Gosa qabiyyee lafaa	Bali'ina isaa ximmaadiin		Gosa qabiyyee lafaa	Bali'ina isaa ximmaadiin
107.1.1.1	Kan ofiisaa (kan itti gabbaru)		107.1.1.5	Lafa inni nama biraaf qoode	
107.1.1.2	Kan nama biraa irraa kiraa fudhate		107.1.1.6	Lafa maatiisaa (firasaa)	
107.1.1.3	Lafa inni nama biraatti kiraa kennate		107.1.1.7	Kan biraan yoo jiraate yaa ibsamu	
107.1.1.4	Lafa inni nama biraa irraa qooddate				
	Qabiyyee lafa waliigalaa heektaaraan				

107.2 Jireenyi keessan qonnarratti kan hundaa'ee yoo ta'e oomisha keessan waggaa darbbee gosa midhaaniitiin naaf ibsuu dandeessuu?

	Gosoota omiishaalee gurguddoo	Oomisha waliigalaa kuntaalaan	Gatii yeroo sanaa	Gatii waliigalaa qarshiidhaan
107.2.1				
107.2.2				
107.2.3				
107.2.4				
107.2.5				
	Galii waggaa waliigalaa maatichaa gosa oomishaalee gurgguddoo irraa argamu qarshiidhaan			

107.3. Oomishin midhaanii waggaa darbee fedhii nyaata waggaa maatii keessanii quubsee jiraa?

1. Eyyeen 0. Miti

107.4 Deebiin keessan yoo hinquubsine ta'e, isa hafe akkamittiin hufisuu danddeessan?_____

107.5 Madda galiiwwan dabalataa biroo

	Gosoota madda galiiwwanii dabalataa	Oomisha waliigalaa safartuu naannootiin	Gatii waliigalaa qarshiidhaan
107.5.1	Bu'aa beeyladaa gurgurtaa irraa (dhadha,qillee,kkf)		
107.5.2	Hojjii-harkaan (muka soofuu, kafana hodhuu)		
107.5.3	Bu'aa biqilootaa gurgurtaa irraa (baar-zaafii, geeshoo, kkf.)		
107.5.4	Kan biraan yoo jiraate(ibsaa)_____		
107.5.5	Galiin waliigalaa maatiin kun waggaattii madda galii dabalataa irraa arggatu qarshiidhaan		

107.6 Hanga qabeenya beeyladaa maatii kanaa

	Gosa beeyladaa	lakkobsa		Gosa beeyladaa	Lakkobsa waliigalaa
107.6.1	Sangaa/oota		107.6.7	farad	
107.6.2	sa'a		107.6.8	Hoolaa	
107.6.3	Harree		107.6.9	ra'ee	
107.6.4	Jibicha		107.6.10	hindaaqqoo	
107.6.5	Raada		107.6.11	kanbiraa	
107.6.6	gaangee				

107.7 Galiin waliigalaa maatiin kun wagggaatti qabeenya beeyladaa irraa arggatu

	Gosa beeyladaa	TLU	Gatii waliigalaa(qar.)		Gosa beeyladaa	TLU
107.7.1	Sangaa	1		107.7.7	farad	1.1
107.7.2	Sa'a	0.9		107.7.8	gaangee	1

	107.7.3	Harree	0.7		107.7.9	hoolaa	0.1
	107.7.4	Jibicha	0.25		107.7.10	ra'ee	0.1
	107.7.5	Raada	0.75		107.7.11	hindaaqqoo	0.13
					107.7.12	Kan biro-------	
	107.7.6	Qarshiin waliigalaa maatiin kun waggaatti gurgurtaa beeyladoota addaaddaa irraa argatu					
	107.1.8 Galiin waliigalaa maatiin kun waggaattigurgurtaa beeyladaa irraa argate, Qarshii_____.						
	107.1.9. Waliigala galii maatii kana _____.						
108	Bakka jireenyaa	1. Baadiyya 2. Magaalaa 3. Magaala baadiyyaa					
109	Sad.barmootaa	1. Dubbisuu fibarreessuu hin danda'an 2. Dubbisuu fi barreessuu ni danda'u 3. Barmoota Sad. 1ffaa 4. Barmoota Sad. 2ffaa 5. Barmoota Sad. 3ffaa					
110	Daa'ima qabduu?	1. Eyyeen 2. Lakkii ⟹				Gaaf. lakk.201	
111	Daa'imman meeqa qabdu?	_____					
Kutaa II. Deggarsa Hawaasummaa fi Xinsamuu kan ilaallatu							
201	Maatii isin kunuunsu (gargaaru) qabduu?	1. Eyyee 2. Lakkii ⟹				Gaaf. lakk .205	
202	Kunuunsa maal maalfaa arggattu?	1. kan xinsamuu 2. kan dinagdee 3. kan qaamaa 4. kan hawaasummaa					

203	Maatiin kunuunsa isiiniif godhu eenyu?	1. Ayyoo/abbaa 2. Ayyoo/abbaa amantaa/ kirissinnaa 3. Haadha manaa 4. Abbaa manaa 5. Daa'imman 6. Kan biro_____	
204	Vaayirasiin HIV dhiiga keechan keecha akka jiru eenyutti himuu barbaaddu?	1. Ayyoo/Abbaa 2. Abbaa/ayyoo amantaa/kiristtinnaa 3. Haadha manaa 4. Abbaa manaa 5. Ijoollee 6. Hawaasa deggersa godhan 7. Kan biro(ibsaa)----------	
	Kutaa III. Dhiibbaa hanqina nyaataa fi dhiibbaa kanniiniff ---------		
301	Ulfaatiina amma abu/qabdu?	Kilo-Gm _____	
302	Dheerinni amma qabu/qabdu?	(SM) _____	
303	Guddinni amma inni/ishiin qabu/qabdu ?	(kg/m2)_____	
304	Hanga CD4 inni/ishiin duraan qabu/ddu?	(cells/mm3) _____	
305	Dhiibbaan vaayirasii inni/ishiin duraan qabu/ddu?	(copies/mL) _____	
306	Hanga hemoglobiinii mg/dl dhaan	_____	
307	Oggaa nyaata nyaattan rakkoon akkaataa nyaataan isin mudate jira?	1.Eyyeen 2.Lakkii ⟹	Gaaf. Lakk.309
308	Rakkoon adeemsa nyaataan isin quunname maal ture?	1. Fedhiin nyaataa hirrachuu 2. Fangasii afaanii 3. Fangasii qoonqoo 4. Kan biro_____	
309	Dhibewwan kaansarii HIV n wal-qabatanii dhufan qabduu?	1. Eyyeen 2. Lakkii ⟹	Gaaf. Lakk.311
310	HIV n wal-qabatanii kan dhufan gosoonni kansarii kamifaa qabdu?	1. Kaapis sarkoomaa 2. Kansarii balbala gameessaa	

		3. Kanbiroo (ibsaa) _____	
311	Dhibeewwan HIV n wal-qabatanii dhufan qabduu?	1. Eyyen 2. Lakkii ⟹	Gaaf. Lakk.313
312	Dhibee gosa kami qabdu?	1. Dhibee TB 2. Dhibee sombaa 3. Dhibee garaa kaasaa 4. Dhibee manjjalloo (morma jallisu) 5. Dhibee garaachaa 6. Kan biro_____	
313	Dhibeen HIV erga isin irratti argamee hammam ta'e jira?	_____	
314	Rakkoon hirrina dhiigaa isin mudatee jiraa?	1. Eyyeen 2. Lakkii	
315	Akkaataa Dhaabbata Fayya Addunyaattii HIV sad. meeqaffaa irratti arggamtu	1. Sad. 1 2. Sad. 2 3. Sad. 3 4. Sad. 4	
316	Akkaataa Dhaabbata Fayya Addunyaattii wallaansa HIV sad. Meeqaffaa irratti arggamtu?	1. Sad. wallaansa 1ffaa 2. Sad. wallaansa 2ffaa 3. Sad. wallaansa 3ffaa 4. Sad. wallaansa 4ffaa	
317	Hordoffii qoricha HIV yeroo ammamiif fudhattan?(yeroo horddoffii)	_____	
318	Yeroo meeqa, meeqaan deddebitanii fudhattu?	_____	
319	Seenaa haala kenniisaa yaala ittisaa Cotrimoxazole(CPT)	1. Kan kenname 2. Adeemsa irra 3. Hin kennamne	
320	Haala kenniinsa Yaala Ittisa Dhukkuba Tiruu(TPT)	1. Kan kenname 2. addaan kutuu/adda kutuu 3. Adeemsa iraa 4. Hin kennamne	

Kutaa IV. Nyaata bifa qorichaan qophaa'e haala ittiin sooratan ilaalchisee gaafilee raga guuruuf qophaa'an

401	Qoricha HIV oggaa fayyadamtan nyaata bifa qorichaan qophaa'e fudhattanii beektuu?	1. Eyyeen 2. Lakkii	

402	Deebiin keechan eyyen yoo ta'e, gosa nyaata kanaa naa maal fa'i?	_____	
403	Nyaata bifa qorichaan qophaa'e fudhachuu yoomii kaastanii jalqabddan?	_____	
404	Yeroo hagamiitiif fayyadamtan?	_____	
	Kutaa V. Gaafannoo haala sababawwan sirna-amalaan walqabatan		
501	Murtoo qoricha fayyadamuu fi dhukkubsatoota qoricha odoo hinfudhatiin hafan addaan baasanii hubachuu. **Aaf-gaafii dhukkubsatootaa**: sababawwan fedhiiwwan addaddaa (hanqina nyaataa, hanqina yeroo, kkf.) yeroo hagamiif qorichasaanii akkaataa ajajameen odoo hinfudhatiin haftan?	Qoricha ajajame akkaataa ajajameen odoo hinfudhatiin kan hafan Harra---------- Kaleecha---------- Guyyoota sadan darbaniif---------- Guyyoota turban darbaniif---------	
502	Guyyoota turban darbanitti yeroo dhaabbaataa itti tokkoo tokkoo qorichaa fudhattan akkamitti horddoftu?	1. Gonkumaa hinhordofu 2. Yeroo tokko tokkoo 3. Harka shantama ol 4. Yeroo baayyee nanhordofa 5. Gutumaa gututitti nanhordofa	
503	Qajjeelfama addaa fayyadama qorichaa Ogeessa fayyaatiin isiniif kenname akkamitti hordoftu?	1. Gonkumaa hinhordofu 2. Yeroo tokko tokkoo 3. Harka shantama ol 4. Yeroo baayyee nanhordofa 5. Gutumaa gututitti nanhordofa	
504	Dhukkubsatichi qoricha inni baatiitti fudhate baruudhaa akkasumas, baatii tokko keechatti meeqa akka fudhatee baruudhaaf kiniinii harkasaa jiru lakkaa'uu	1. Ammaa harkasaa irraa meeqatu hafe---------- 2. Kiniiniin baatiif kennameef---------- 3. Amma harkasaa irratti hafe jedhamee kan tilmaamamu----------	
505	Sigaaraa xuuxxanii ni beektu?	1. Eyyeen 2. Lakkii	
506	Alkoolii/dhugaatii dhugdanii ni beektu?	1. Eyyeen 2. Lakkii	

507	Caatii/jimaa qaamtani ni beektu?	1. Eyyeen 2. Lakkii	
508	Ga'umsa nyaataa guyyuu mirkaneeffachuuf jecha ykn nyaata harraa-boruu arggachuuf wal-quunnamtii saalaa of-eeggannaa hinqabne raawwachuuf yeroon itti dirqisiifamtan jira laataa?	1. Eyyeen 2. Lakkii	
509	Ga'umsa nyaataa keessan mirkaneeffachuuf ykn nyaata arggachuuf jecha bakka duraan jiraataa turtan irraa gara biraatti deemtanii beektuu?	1. Eyyeen 2. Lakkii	
Kutaa VI. Gaafannoo ga'umsa nyaataa maatii madaaluu ilaallatu			
601	Torbanoota afuran darbanitti isinii fi miseensoonni maatiin keechanii wanna nyaannu dhabna jettanii yaaddoftanii beektuu?	1. Eyyeen 0. Lakkii ⟹	Gaaf.lakk.603
602	Deebii gaafii lakk. 601 eyyeen yoo jettan, yeroo hagamiif?	1. Yeroo baayyee xiqqaadhaaf (torban 4,4 n al- takka/al-lama) 2. Yeroo takka takka (turban 4, 4 n al-3 hanga al-10) 3. Yeroo baayyee dhaaf(turban 4, 4 n al-10)	
603	Torbanoota afuran darbanitti isinii fi miseensonni maatii keechanii nyaata nyaachuuf barbaaddan sababa dhi'eessii midhaanii arggachuu dhabuun odoo hinnyaatiin yeroon itti haftan jiraa?	1. Eyyeen 2. Lakkii ⟹	Gaaf.lakk.605
604	Deebii gaafii lakk. 603 eyyeen yoo jettan, yeroo hagamiif ?	0. Yeroo baayyee xiqqaadhaaf (torban4, 4 n al-takka/lama) 1. Yeroo takka takka(turban 4, 4 n al-3 hanga al-10) 2. Yeroo baayyee dhaaf (turban 4, 4 n al-10)	
605	Torbanoota afuran darbanitti isinii fi maatiwwaan keechan nyaata madaalame nyaachuuf feetanii sababa dhi'eessii midhaanii arggachuu dhabuun gossoonni	1. Eyyeen 0. Lakkii ⟹	Gaaf.lakk.607

	nyaata keechanii yeroonni itti hirrate jiraa?		
606	Deebii gaafii lakk. 605 eyyeen yoo jettan, yeroo hagamiif?	1. Yeroo baayyee xiqqaadhaaf (torban4, 4 n al-takka/lama) 2. Yeroo takka takka(turban 4, 4 n al-3 hanga al-10) 3. Yeroo baayyee dhaaf (turban 4, 4 n al-10)	
607	Torbanoota afuran darbanitti isiniis ta'e miseensonni maatii keechanii asiin dura kan nyaataa turttan sababa hanqina dhi'eessii midhaaniitiin gosoota nyaataa soorachuu hinfeene soorachuuf haalli isin dirqqamtan jiraa?	1. Eyyen 0. Lakkii ⟹	Gaaf.lakk.609
608	Deebii gaafii lakk. 607 eyyeen yoo jettan, yeroo hagamiif ?	1. Yeroo baayyee xiqqaadhaaf (torban4, 4 n al-takka/lama) 2. Yeroo takka takka(turban 4, 4 n al-3 hanga al-10) 3. Yeroo baayyee dhaaf(turban 4, 4 n al-10)	
609	Torbanoota afuran darbanitti isinii fi miseensi maatiii keechanii hanga nyaata fudhachuu barbaaddanii sababa hanqina dhi'eessii midhaaniitiin hangi nyaataa keechan hirratee jiraa?	1. Eyyen 0. Lakkii ⟹	Gaaf.lakk.611
610	Deebii gaafii lakk. 609 eyyeen yoo jettan, yeroo hagamiif?	1. Yeroo baayyee xiqqaadhaaf (torban4, 4 n al-takka/lama) 2. Yeroo takka takka(turban 4, 4 n al-3 hanga al-10) 3. Yeroo baayyee dhaaf (turban 4, 4 n al-10)	
611	Torbanoota afuran darbanitti isinii fi miseensi maatiii keechanii sababa hanqina dhi'eessii soorataa guyyaatti hanga yeroo nyaataa keechan hirristtanii jirtuu?	1. Eyyen 0. Lakkii ⟹	Gaaf.lakk.613
612	Deebii gaafii lakk. 611 eyyeen yoo jettan, yeroo hagamiif?	1. Yeroo baayyee xiqqaadhaaf (torban4, 4 n al-takka/lama) 2. Yeroo takka takka(turban 4, 4 n al-3 hanga al-10) 3. Yeroo baayyee dhaaf (turban 4, 4 n al-10)	

613	Torbanoota afuran darbanitti nyaatni mana keechanitti nyaattan sababa harka-qallinaatiin haalli isin guutumaa guutuutitti odoo hinsooratiin haftan jiraa?	1. Eyyen 0. Lakkii ⟹	Gaaf.lakk.615
614	Deebii gaafii lakk. 613 eyyeen yoo jettan, yeroo hagamiif ?	1. Yeroo baayyee xiqqaadhaaf (torban4, 4 n al-takka/lama) 2. Yeroo takka takka(turban 4, 4 n al-3 hanga al-10) 3. Yeroo baayyee dhaaf (turban 4, 4 n al-10)	
615	Torbanoota afuran darbanitti nyaatni mana keechanitti nyaattan dhi'eessiin midhaanii ga'aan wanna hinturreef maatii keechan keechaa odoo irbaata (iraatii) hinnyaatiin bule jiraa?	1.Eyyen 0. Lakkii ⟹	Gaaf.lakk.617
616	Deebii gaafii lakk. 615 eyyeen yoo jettan, yeroo hagamiif?	1. Yeroo baayyee xiqqaadhaaf (torban4, 4 n al-takka/lama) 2. Yeroo takka takka(turban 4, 4 n al-3 hanga al-10) 3. Yeroo baayyee dhaaf (turban 4, 4 n al-10)	
617	Torbanoota afuran darbanitti nyaatni mana keechanitti nyaattan dhi'eessii ga'aan sababa hinturreef maatii keechan keessaa wanna takka odoo hinsooratiin hagabuu isaa oolee kan bule jiraa?	1. Eyyen 0. Lakkii ⟹	Gaaf.lakk.701
618	Deebii gaafii lakk. 617 eyyeen yoo jettan, yeroo hagamiif?	1. Yeroo baayyee xiqqaadhaaf (torban4, 4 n al-takka/lama) 2. Yeroo takka takka(turban 4, 4 n al-3 hanga al-10) 3. Yeroo baayyee dhaaf (turban 4, 4 n al-10)	

Afaan Oromootiin

701	Me waa'yee haala nyaataa dhugaatii kee ji'a darbee yaadadhu. Jechuunis, guyyoota 30 mman darban keessatti, nyataa, ciree, kkf dabalatee.	Gonkumaa……..(01) jiatti si'a tokko……..(02) Ji'atti si'a 2 hang 3 tti……..(03)	

	Kuduraalee fi fuduraalee armaan gadii yoom, yoomfaa nyaatte guyyoota 30 mman darban keessatti? Guyyaatti si'a meeqa akka nyaattu, torbanitti ykn immoo ji'atti jettanii natti himuu dandeessu.	Torbanitti si'a 1 hanga 2 tti……..(04) Torbanitti si'a 3 hanga 4 tti……..(05) Torbanitti si'a 5 hanga 6 tti……..(06) Torbanitti si'a 1……..(07) Guyyaatti si'a 2 hanga 3 tti……..(08) Guyyaatti si'a 4 hanga 5 tti Guyyaatti si'a 6 fi isaan ol ……..(10)		
701A	Ji'a darbe keessatti, juusii kuduraalee (100%) akka burtukaanii, maangoo, paappayyaa, abukaadoo, goraa faa si'a meeqa dhugde? Dhugaatiiwwan dhandhama kuduraalee ykn kuduraalee juusii shukkaara itti dabaluun fayyadamte itti hinlakkaa'in.		Si'a |____|	
701B	Ji'a tokko darbe keessatti, kuduraalee akka muuzii, burtukaanii, maangoo, paappayyaa, abukaadoo, anaanaasii, goraa, juusiwwan ho'aa fi goggogaa dabalatee, si'a meeqa dhugde?Juusii tokko tokkoon hinlakkaa'iin.		Si'a |____|	
701C	Ji'a tokko darbe keessatti, kuduraa gosa kamiiniyyuu haa ta'uu, juusii kuduraa 1oo% si'a meeqa nyaatte, yookaan dhugde? Dhugaatiiwwan dhandhama kuduraalee ykn kuduraalee juusii shukkaara itti dabaluun fayyadamte itti hinlakkaa'in.		Si'a |____|	
701D	Ji'a tokko darbe keessatti, fuduraalee baalawoo magariisaa yookaan salaaxaa, qoosxaa faa si'a meeqa nyaatte? Qophaa isaanii ta'u yookaan fuduraalee biroon makamees ta'u.		Si'a |___|	
701E	Ji'a tokko darbe keessatti, fuduraalee waan akka raafuu, **koliflaahorii**, **brokoolii** faa si'a meeqa nyaatte? Qophaa isaaniis ta'u yookaan fuduraalee biroon makamees ta'u.		Si'a |____|	
701F	Ji'a tokko darbe keessatti, fuduraalee (marrow vegetables) kanneen akka buqqee, **kukumber**, **zukiiinii** si'a meeqa nyaatte? Qophaa isaanii yookaan fuduraalee biroon makamees ta'u.		Si'a |____|	
701G	Ji'a tokko darbe keessatti, nyaatawwan akka dinichaa, hanbaalbee/mixaaxisaa/, yaamsii, kasaavaa danfe, tolchame, sukkuumame yookaan nyaata bifa biraan hojjetame, si'a meeqa nyaatte?.		Si'a |____|	
701H	Ji'a tokko darbe keessatti, kaarotii si'a meeqa nyaatte?		S'a |____|	
701I	Ji'a tokko darbe keessatti, fuduraalee armaan olitti tarreeffamaniin alatti, fuduraalee biroo si'a meeqa nyaatte?		Si'a|____|	
701J	Ji'a tokko darbe keessatti, fuduraa kamiyyuu si'a meeqa nyaatte?		Si'a |____|	

kutaa VI: Haala soorata kuduraalee, fuduraalee fi nyaata mi'aa'woo sa'atii 24 keessatti		
702	Baayyina nyaata kuduraalee nyaattee (juusii kuduraan alatti), kaleessa ganamaa kaaftee hanga harra ganamaatti, saa'a 24 keessatti jechuudhaa, natti himuu dandeessaa? *Raga sassaabaa: yoo hanga sooratame tilmaamuun hindanda'amne, lakk. 99 galch*.	
702A	Burtukaanii/mandariinii (firiidhaan)	_____
702B	Muuzii (firiidhaan)	_____
702C	Maangoo (firiidhaan)	_____
702D	Paappayyaa (firiidhaan)	_____
702E	Anaanaasii (firiidhaan)	_____
702F	Appilii (firiidhaan)	_____
702G	Ija wayinii (firiidhaan)	_____
702H	Abukaadoo (firiidhaan)	_____
702I	Goraa (firiidhaan)	_____
702J	Tamirii (firiidhaan)	_____
702K	Loomii /laayimii (firiidhaan)	_____
702L	Hababii (muraadhaan)	_____
702M	Kuduraalee biroon yoo jiraate, (gosa isaa fi hanga sooratte ibsi)	_____
703	Baayyina nyaata fuduraalee nyaattee kaleessa ganamaa kaaftee hanga harra ganamaatti, saa'a 24 keessatti jechuudhaa, natti himuu dandeessaa? *Raga sassaabaa: yoo hanga sooratame tilmaamuun hindanda'amne, lakk. 99 galchi.*	
703A	Dinicha (baayyina firiidhaan)	_____
703B	Hundee diimaa (baayyina firiidhaan)	_____
703C	Timaatimii (baayyina firiidhaan)	_____
703D	Kaarotii (baayyina firiidhaan)	_____
703E	Mixaaxisa/hinbaalbee (baayyina firiidhaan)	_____
703F	Fuduraalee baalawoo,salaaxaa dabalatee (sinii bunaatiin)	_____
703G	Gosawwan raafuu: raafuu, kooliifilaahorii, birookoolii (sinii bunaatiin)	_____
703H	Buqqee, Zukiiniii (muraadhaan)	_____
703I	**kiyaara** (1 vegetable)	_____
703J	Fuduraalee biroon yoo jiraate, (gosa isaa fi hanga nyaatame ibsi)	_____

	Kutaa VI. Guca iitiin ragaan hordoffii guuramu			
Lakk.	Gosa raga	Dawwii 1^{ffaa}	Dawwii2^{ffaa}	Dawwii3^{ffaa}
801	Ulfaatina(K/g)			
802	Dheerina(cm)			
803	Hanga madaalli namaa(K/g)			
804	Hanga CD4(cells/mm3)			
805	Dhiibbaa vaayirasii (copies/mL)			

Galatoomaa!

አባሪ VI. የአማርኛ ትርጉም የስምምነት አጋዥ መረጃና የስምምነት ቅፅ

አዲስ አበባ ዩኒቨርሲቲ
ጤና ሳይንስ ኮሌጅ
የህብረተሰብ ጤና ትምህርት ቤት

በሰሜን ሸዋ ያሉ የጤና ተቋማት በሰሜን ማዕከላዊ ኢትዮጵያ አካባቢ የኤችአይቪ መድሃኒት ተጠቃሚዎች የህመም ሂደትና የሲዲፎር መጠን ላይ የምግብ ዋስትና ያለውን ተፅዕኖ እና ለተፅዕኖ ዋና ዋና ምክንያቶች በሚል ርዕስ ላይ ለማጥናት ተዘጋጅቶ የቀረበ ዝርዝር የክትትልና ማረጋገጫ መጠይቅ።

የዚህ ጥናት ዋና ተመራማሪ፤

ዱቤ ጃራ (2ኛ ዲግሪ፤ የ3ኛ ዲግር ተማሪ)

1. የአማርኛ ትርጉም የስምምነት አጋዥ መረጃና የስምምነት ቅፅ

1.1. የአማርኛ ትርጉም የስምምነት አጋዥ መረጃ

የጥናቱ ርዕስ: የኤችአይቪ መድሃኒት ተጠቃሚዎች የህመም ሂደትና የሲዲፎር መጠን ላይ የምግብ ዋስትና ጉድለት ተፅዕኖ እና ለተፅዕኖ ዋና ዋና ምክንያቶች ጥናት ሰሜን ሸዋ ያሉ የጤና ተቋማት በሰሜን ማዕከላዊ ኢትዮጵያ::

ዋና ተመራማሪ፡ ዱቤ ጃራ (2ኛ ዲግሪ, የ3ኛ ዲግሪ ተማሪ)
የጥናቱ አማካሪዎች፡ ፕ/ር አህመድ አሊ አህመድ (3ኛ ዲግሪ) እና ፕ/ር አለማየሁ ወርቁ ያለው (3ኛ ዲግሪ)

ማስተባበሪያ ቢሮ፡ አዲስ አበባ ዩኒቨርሲቲ የህብረተሰብ ጤና ትምህርት ቤት
መግቢያ፡ ኤችአይቪ እና ምግብ ዋስትና ጉድለት ያላቸው ግንኙነት በጣም የተወሳሰበ በመሆኑ በዚህ ግንኙነታቸው አንዱ የለላውን ጎጂ ተፅዕኖ ያባብሳሉ። በተለይም የምግብ ዋስትና በኤችአይቪ ቫይረስ የተያዙ ሰዎች አጠቃላይ የጤናና አመጋገብ ሁኔታቸው ላይ አሉታዊ ተፅዕኖ እንደሚያመጣ ጥናቶች ያመለክታሉ። ነገር ግን በሁሌቱ ግንኙነቶች ዙሪያ የተጠኑ ጥኖቶች በቁጥር ጥቅት ከመሆናቸውም ባሻገር የምግብ ዋስትና ጉድላት በኤችአይቪ ህመም ሂደትና የሲዲፎር መጠን ለውጥ ያለውን ተፅዕኖ በጉልህ ባለመለየቱ እንደአጥጋብ መረጃ ምንጭ ለመጠቀም ያስቸግራል። ይህ መጠይቅ የኤችአይቪ መድሃኒት ተጠቃሚዎች የህመም ሂደትና የሲዲፎር መጠን ለውጥ ላይ የምግብ ዋስትና ያለውን ተፅዕኖ እና ለተፅዕኖ ዋና ዋና ምክንያቶች በሚል ርዕስ ላይ ለማጥናት ነዉ። ይህ ዝርዝር መጠይቅ የስነ-ህዝብና ማህበራዊ ጉዳዮችን፣ የስነ-ልቦናና ማህበራዊ ጉዳዮችን፣ ውስጣዊ የሰው ችግሮችን፣ ማህበራዊና አካባቢያዊ ክብካቤ ችግሮችንና፣ የምግብ ዋስትና ያለውን ተፅዕኖ እና ለተፅዕኖ ዋና ዋና ምክንያቶች ለማጥናት የተዘጋጀ ነው።

ጥናቱ አላማ: የዚህ ጥናት ዋና አላማ ሰሜን ሸዋ ያሉ የጤና ተቋማት ክትትል ላይ ያሉ የኤችአይቪ መድሃኒት ተጠቃሚዎች የህመም ሂደትና የሲዲፎር መጠን ለውጥ ላይ በምግብ ዋስትና ጉድለት የሚመጣ ተፅዕኖ እና ለተፅዕኖ ዋና ዋና ምክንያቶች መፈተሽና ማወቅ ነው። ለዚህ ጥናት የሚሰጡት መረጃ የጥናቱ አላማ ለማሳካትና የችግሩን ጥልቀት በመረዳት ችግሩ የሚቀረፍበት ዘዴዎችን ለማመላከት ከፍተኛ ሚና ይኖረዋል።

የጥናቱ ሂደት እና ተሳታፊነት: የዚህ ጥናት ጠቅላላ መረጃ ለመሰብሰብ በአማካይ 30 ደቂቃዎችን ይወስዳል። ከዚህ በተጨማሪ የምግብ ዋስትና ጉድለት ተፅዕኖና ተያያዥ የክትትል መረጃዎች ለአንድ አመት በየስድስት ወሩ ይሰበሰባል፡ ፡ በጥናቱ በተከታታይ በመሳተፍ በቅንነት የሚሰጡት መረጃ የጥናቱ አላማ ለማሳካት እና ለችግሩ መፍትሄ ለማምጣት ከፍተኛ ሚና ይኖረዋል። ከዚህም በተጨማሪ ለጥያቄዎች የሚሰጡ እውነተኛ እና ተአማኒ መልሶች የኤችአይቪ መድሃኒት ተጠቃሚዎች የህመም ሂደትና የሲዲፎር መጠን ላይ በምግብ ዋስትና ጉድለት የሚመጣ ተፅዕኖ እና ለተፅዕኖ ዋና ዋና ምክንያቶች ለማወቅና ጥናቱን ዉጤታማ ለማድረግ ስለሚረዳን የእርሰዎ ተሳትፎ ወሳኝ ነው።

ከተሳታፊዎች በቀጥታ የማይገኙ መረጃዎች ከክትትል መዝገብ ይሰበሰባሉ። ስለሆነም ሙሉ ተሳትፈዎትን እናበረታታለን።

የመረጃ ሚስጥራዊነት: የመረጃ ሚስጥራዊነትን ለመጠበቂ ሲባል ምንም አይነት ግለሰባዊ ማንነትን የሚገልፅ መረጃ በሪፖርትና በህትመት ሂደት ጥቅም ላይ አይውልም። ሁሉም ከእርስዎ የተሰበሰቡ መረጃዎች በዋና ተመራማሪ በቁልፍ የተቆለፈው ሳጥን ውስጥ ይጠበቃል። በተጨማሪ የተሰጡን መረጃ የጥናቱን አላማ ብቻ የሚውል መሆኑን እናረጋግጣለን።

ጥቅምና ስጋት: በዚህ ጥናት በመሳተፈዎና ጥያቄዎችን በመመለሰዎት ከምስጋና ውጭ የሚያገኙት ምንም ቀጥተኛ ጥቅም አይኖርም። የሚደርስበዎትም ስጋት አይኖርም። ሆኖም ግን የሚሰጡት መረጃ የችግሩን ጥልቀት በማወቅ ለወደፊት ችግሩ የሚቀረፍበት ተገቢ የህክምና አቅጣጫዎችን ለማመላከት ለእርስዎና ሌሎች ሰዎች ከፍተኛ ጥቅም ይኖረዋል። በተጨማሪ በዚህ ጥናት በመሳተፍዎ ምንም አይነት አካላዊ፣ ማህበራዊ፣ ስነ-ልቦናዊ እና ኢኮኖሚያዊ ጉዳትና ተፅዕኖ የለውም።

በጥናቱ እንዲሳተፉ በጥቅም የማገፋፋት እና ካሳ መስጠት: በጥናቱ እንዲሳተፉ ለማድረግ ማኦኛውም በጥቅም የማገፋፋት አይኖርም እንዲሁም በመሳተፍዎ ምንም አይነት ካሳ አይሰጥም። ጥናቱ በተሳታፊዎች የሚያሳድርው ተጽእኖ ስለሌለ፣ በጥናቱ እዲሳተፉ በማለት ምንም የሚገፋፉበት ወይም የሚሰጠው ካሳ አይኖርም።

የጥናቱ ግኝት ስርጭት፡ ተማራማሪው የጥናቱ ግኝት/ውጤት በተለያዩ መድረኮች ጉዳዩ ለሚመለከታቸው አካላት የማሰራጨት ታላፊነትና ግዴታ አለበት። ከዛም በዘለለ ውጤቱን በአለም አቀፍ ታዋቂ በሆኑት ህትመቶች በማሳተም ለተጠቃሚዎች ለማድረስ ጥረት ይደረጋል።

የተሳታፍ መብት: የሚያረጋግጥለዎት ነገር ቢኖር የዚህ ጥናት ተሳትፎ ሙሉ በሙሉ በፍቃደኝነት ላይ የተመሠረተ ነው። በከፍልም ሆነ በሙሉ የቃለመጠይቅ ሂደት ያልተመቸዎት ነገር ካለ በመሀል ማቋረጥ እንደሚችሉ አረጋግጥለዎታለሁ። ጥናቱን በመሀል በማቋረጥዎ ማንም የማያስገድድና ከሆስፒታሉ የሚያገኙትን የህክምና ድጋፍ ላይ ተፅዕኖ የማያመጣ መሆኑን አረጋግጥላችሃለሁ።

የቅርብ ተጠሪ፡ ጥናቱ ከመጀመሩ በፍትም ሆነ ጥናቱ ከተጀመረ በኃላ በጥናቱ ሂደት ግልጽ ያልሆኑበትን መረጃ የመጠየቅ ሙሉ መብት አለ። ስለጥናቱ የሚኖርዎት ማንኛውም ጥያቄ የጥናቱን ዋና ተመራማሪ፣ የጥናቱ ዋና አማካሪ እና በአዲስ አበባ ዩንቨርስቲበ ሳይንስ ኮሌጅ ጥናቱ የሚመለከት የኮሚቴ ተወካዮችን ማነጋገር ይችላሉ። ለበለጠ መረጃ፡-

አዲስ አበባ ዩንቨርስቲ የጤና ሳይንስ ኮሌጅ ጥናቱ የሚመለከት ኮሚቴ ስልክ- 0118961396, Email: chs.irb@aau.edu.et

ዋና ተመራማሪ: አቶ ዱቤ ጃራ በሞባይል በስልክ ቁጥር +251913910575

የጥናቱ ዋና አማካሪ፡ ፕ/ር አህመድ አሊ አህመድ (3ኛ ዲግሪ) በስልክ ቁጥር +251911684399

1.2. የአማርኛ ትርጉም የስምምነት ወል ቅፅ

የጥናቱ ርዕስ: የኤችአይቪ መድሃኒት ተጠቃሚዎች የህመም ሂደትና የሲዲፎር መጠን ላይ የምግብ ዋስትና ጉድለት ተፅዕኖ እና ለተፅዕኖ ዋና ዋና ምክንያቶች ጥናት በሰሜን ሸዋ ያሉ የጤና ተቋማት በሰሜን ማዕከላዊ ኢትዮጵያ::

እኔ ይህ ጥናት ለ3ኛ ዲግሪ መሟያነት እንደሚካሄድና ሙሉ በሙሉ አዲስ አበባ ዩኒቨርሲቲ የህብረተሰብ ጤና ትምህርትቤት የሚደገፍ እና በዋና ተመራማሪ አቶ ዱቤ ጃራ አስተባባሪነት የሚካሄድ መሆኑ ተገንዝበዋለሁ። የዚህ

ጥናት አላማ ለማለት ሰሜን ሸዋ ያሉ የጤና ተቋማት የኤችአይቪ መድሃኒት ተጠቃሚዎች የህመም ሂደትና የሲዲፎር መጠን ላይ የምግብ ዋስትና ጉድለት ተፅዕኖ ለመረዳት እንደሚካሄድ በሚገባኝ ቋንቋ ተገልፆልኝ ተረድቸዋለሁ። ለመረጃ ሰብሳቢ የሚሰጣቸው ማንኛውም መረጃ ሚስጥራዊነቱ የተጠበቀ መሆኑን ተረድቻለሁ። እንዲሁም በጥናቱ በመሳተፌ ጉዳት እንደለለ ተገንዝባለሁ።

እኔ ከዚህ በታች የፈረምኩት የዚህን ጥናት አላማ በመገንዘብ እንዲሁም ሀሳቤን ከቀየርኩ የመውጣት መብት እንዳለኝ በማወቅ በጥናት ለመሳተፍ መስማማቴን አረጋግጣለሁ። ስለጥናቱ አስፈላጊው መረጃ፡ ተሰጥቶኛል:: እንዲሁም በፈለኩት ጊዜ ካለቅጣትና ካለምንም ውጫዊ ተፅዕኖ ወይም ከጤና ተቋማት የሚያገኘው የህክምና ድጋፍ ላይ ተፅዕኖ ጥናቱን ማቋረጥ እንደምችል ተረጋግጦልኛል። ስለጥናቱ ማግኘት የፈለኩትን መረጃ በፈለኩት ጊዜ ማግኘት እንዲችልም ተረጋግጦልኛል።
አዲስ አበባ ዩንቨርስቲ የጤና ሳይንስ ኮሌጅ ጥናቱ የሚመለከት ኮሚቴ ስልክ- 0118961396, Email: chs.irb@aau.edu.et
ዋና ተመራማሪ: አቶ ዱቤ ጃራ በሞባይል በስልክ ቁጥር +251913910575
የጥናቱ ዋና አማካሪ፡ ፕ/ር አህመድ አሊ አህመድ (3ኛ ዲግሪ) በስልክ ቁጥር +251911684399

ከዚህ በላይ የተገለፁት ዝርዝር መረጃዎች በመረዳት በዚህ ጥናት ለመሳተፍ ፍቃደኛ ነዎት?

አዎ ☐

የተሳታፍ ፍቃደኛ መሆናቸውን አዎ/አይደለም በማለት በኤለክትሮንክስ ቅጽ አረጋገጥ አዎ/አይደለም_____ ቀን _____ (ቃለመጠይቁን ቀጥሉ)

አይደለም ☐ (ቃለመጠይቁን አቁርጡ)

የመረጃ ሰብሳቢው ፌርማ ስም _____ ፌርማ _____ ቀን _____

የተቆጣጣሪ/የተመራማሪ ሀሳብና ፌርማ ስም _____ ፌርማ_____ ቀን _____

አባሪ VII: የአማርኛ ትርጉም ቃለመጠይቅ

የመረጃ ጥራትን ለመጠበቅ የተዘጋጀ የመመዘኛ መስፈርት።

የካርድ ኮድ ቁጥር----------

የተመራማሪው ስም----------ፊርማ----------መረጃ የተሰበሰበበት ቀን----------

የመረጃ ሰብሳቢው ስም----------ፊርማ----------መረጃ የተሰበሰበበት ቀን----------

ክፍል አንድ፡-የስነ-ህዝብና ማህበራዊ ሁኔታዎች መረጃ			
ኮድ ቁጥር	ጥያቄዎች	መደብ	መግለጫ
101	እድሜ (በሙሉ ዓመት)	_____	
102	ፆታ	1. ወንድ 2. ሴት	
103	ሀይማኖት	1. ኦርቶዶክስ 2. ሙስሊም 3. ፕሮቴስታንት 4. ካቶሊክ 5. 5. ሌላ----------	
104	የጋብቻ ሁኔታ	1. ያገባ 2. ያላገባ 3. የተፋታ/ች 4. የሞተበት/ባት 5. ተለያይተው የሚኖሩ	
105	ብሔር	1. ኦሮሞ 2. አማራ 3. አገው 4. ትግሬ 5. ሌላ (ግለፁ)----------	
106	የሥራ ሁኔታ	1. ገበሬ 2. የቤት እመቤት 3. የቀን ሠራተኛ 4. የግል ተቀጣሪ 5. የመንግስት ሠራተኛ 6. የመንግስታዊ ያለሆነ ተቋም ሠራተኛ 7. ነጋዴ	

		8. ሌላ(ግለፁ)----------	
107	የወር ገቢዎት ምን ያህል ነው?	_____	

107.**1** የምጣኔ ሀብት መረጃዎች

107.1.1 የቤተሰቡ የዕርሻ መሬት ይዞታ በተለያየ ስሪት

	የመሬት ስሪት አይነት	ስፋት በጥማድ		የመሬት ስሪት አይነት	ስፋት በጥማድ
107.1.1.1	የራሱ (የሚገብርበት)		107.1.1.5	ለሌላ ያጋራው መሬት	
107.1.1.2	ከሌላ የተከራየው መሬት		107.1.1.6	የቤተሰብ (የዘመድ) መሬት	
107.1.1.3	ለሌላ ያከራው መሬት		107.1.1.7	ሌላ ካለ ይገለፅ	
107.1.1.4	ከሌላ የተጋራው መሬት				
	ጠቅላላ የመሬት ይዞታ በሔክታር				

107.2 መተዳደሪያዎ እርሻ ከሆነ የአምና አጠቃላይ ምርትዎን በሰብል አይነት ቢገልፁልን?

	ዋና ዋና የምረት ሰብሎች	ጠቅላላ ምርት በኩንታል	የወቅቱዋጋ	ጠቅላላ ዋጋ በብር
107.2.1				
107.2.2				
107.2.3				
107.2.4				
107.2.5				
	የቤተሰቡ አመታዊ አጠቃላይ ገቢ ከዋና ዋና ምርቶች በብር			

107.3 የአምና የሰብል ምርትዎ የቤተሰቡን አመታዊ ምግብ ፍጆታ ሸፍኖልዎታል? 1. አዎን 0. የለም

107.4 መልስዎ አልሸፈነልኝም ከሆነ ቀሪውን ፍጆታ እንዴት ሊሸፍኑት ቻሉ _____

107.5 ሌሎች ተጨማሪ የገቢ ማስገኛ መንገዶች

	ተጨማ ሪየገቢ ማስገኛው አይነት	ጠቅላላ ምርት በአካባቢው መለኪያ	ጠቅላላ ዋጋ በብር
107.5.1	የእንስሳት ተዋፅዖ በመሸጥ (ቅቤ፣ እንቁላል…)		
107.5.2	የእጅ ሙያ (አናፂ፣ልብስስፌት…)		
107.5.3	የእፅዋት ተዋፅዖ በመሸጥ(ባህርዛፍ፣ጌሾ…)		
107.5.4	ሌላ ካለይ ገለፅ)_____		
107.5.5	የቤተሰቡ አመታዊ አጠቃላይ ገቢ ከተጨማሪ የገቢ ማስገኛ መንገዶች በብር		

107.6 የቤተሰቡ የእንስሳት ሐብት መጠን

	የእንስሳውአይነት	ቁጥር		የእንስሳውአይነት	ጠቀላ ላቁጥር
107.6.1	በሬ(ዎች)			107.7.7ፈረስ	
107.6.2	ላም			107.7.8 በግ	
107.6.3	አህያ			107.7.9 ፍየል	

107.6.4	ወይፈን			107.7.10 ዶሮ		
107.6.5	ጊደር			107.7.11 ሌላ_____		
107.6.6	በቅሎ					

107.7 የቤተሰብ ጠቅላላ አመታዊ ገቢ ከእንስሳት ሃብት

	የቤት እንስሳ አይነት	TLU	ጠቅላላ ዋጋ (ብር)		የቤት እንስሳ አይነት	TLU	
107.7.1	በሬ	1		107.7.7	ፈረስ	1.1	
107.7.2	ላም	0.9		107.7.8	በቅሎ	1	
107.7.3	አህያ	0.7		107.7.9	በግ	0.1	
107.7.4	ወይፈን	0.25		107.7.10	ፍየል	0.1	
107.7.5	ጊደር	0.75		107.7.11	ደሮ	0.13	
				107.7.12	ሌላ----------		
107.7.6	የቤተሰቡ ጠቅላላ አመታዊ ገቢ የቤት እንስሳ አይነት ሽያጭ በብር						

111.8 ቤተሰቡበ አመቱ ውስጥ ከእንስሳት ሽያጭ ያገኘው ጠቅላላ ገቢ = _____(በብር)

111.9 የቤተሰቡ አጠቃላይ ገቢ፡-

108	የመኖሪያ ቦታ	1. ገጠር 2. ከተማ 3. ከፊል ከተማ	
109	የትምህርት ደረጃ	1. መፃፍና ማንበብ የማይችሉ 2. መፃፍና ማንበብ የሚችሉ 3. የመጀመሪያ ደረጃ ትምህርት 4. የሁለተኛ ደረጃ ትምህርት 5. ሶስተኛ ደረጃ	
110	ልጅ አለዎት?	1. አለ 2. የለም ⟹	ጥ.ቁ 201
111	ስንት ልጆች አለዎት?	----------	

ክፍል ሁለት፡-ስነ-ልቦናዊና ማህበራዊ ድጋፍን የተመለከተ			
201	እንክብካቤ የሚሰጥዎት ረዳት በቴሰብ አለዎት?	1. አለ 2. የለም ⟹	ጥ.ቁ 205
202	የሚያገኙት የእንክብካቤ አይነቶች ምንድናቸው?	1. ስነ-ልቦናዊ ድጋፍ 2. ኢኮኖሚካዊ ድጋፍ 3. አካላዊ ድጋፍ 4. ማህበራዊ ድጋፍ	
203	እንክብካቤ የሚሰጥዎት ረዳት በቴሰብ ማን ነው?	1. እናት/አባት 2. የሃይማኖት አባት 3. ምስት 4. ባል 5. ልጆች 6. ሌላ----------	
204	የኤች.አ.ቪ ቫይረስ በደመዎት ውስጥ እንደሚገኝ ለማን ማሳወቅ/መናገር ይፈልጋሉ?	1. እናት/አባት 2. የሃይማኖት አባት 3. ምስት 4. ባል 5. ልጆች 6. የማህበረሰብ ድጋፍ ሰጭዎች 7. ሌላ(ግፁ)----------	
ክፍል ሶስት፡-የምግብ ዋስትና ተፅዕኖ እና ለተፅዕኖ ህክምናዊ ዋና ዋና ምክንያቶች ለመለየት የተዘጋጀ መዝርዝር			
301	አሁን ያለው/ላት የክብደት መጠን?	(ክ/ግ)	
302	አሁን ያለው/ላት የቁመት መጠን?	(cm)	
303	አሁን ያለው/ላት መጠነ ግዝፈት?	(kg/m2)	
304	መጀመሪያ ላይ ያለው/ላት የሲዲፎር መጠን	(cells/mm3)	
305	መጀመሪያ ላይ ያለው/ላት የቫይረስ ጫና	(copies/mL)	
306	የሄሞግሎብን መጠን በ mg/dl		
307	ምግብ ሲበሉ/ሲወስዱ/ ያጋጠመዎት የአመጋገብ ችግር አለ?	1. አለ 2. የለም ⟹	ጥ.ቁ 309
308	ለአጋጠመዎት የአመጋገብ ችግር ምክንያቱ ምን ነበር?	1. ፍላጎት መቀነስ 2. የአፍ ውስጥ ፈንገስ 3. የጉረሮ ውስጥ ፈንገስ	

		4. 4. ሌላ----------	
309	ኤችይቪን ተከትለው የሚመጡ የካንሰር በሽታዎች አለዎት?	1. አለ 2. የለም ⟹	ጥ.ቁ 311
310	ኤችይቪን ተከትለው የሚመጡ ያለዎት የካንሰር በሽታ ምን አይነት?	1. ካፖሲስ ሳርኮማ 2. የማህፀን በር ካንሰር 3. ሌላ(ግለፁ)----------	
311	ኤችይቪን ተከትለው የሚመጡ በሽታዎች አለዎት?	1. አለ 2. የለም ⟹	ጥ.ቁ 313
312	ምን አይነት በሽታ አለዎት?	1. የቲቢ በሽታ 2. የሳምባ ምች 3. የተቅማጥ በሽታ 4. የማጅራት ገትር በሽታ 5. የጨጋራ ችግር 6. ሌላ----------	
313	የኤችይቪ በሽታ ከተገኘበዎት ምን ያህል ጊዜ ሆኗል?	----------	
314	የደም ማነስ ችግር ገጥሞታል/ማታል	1. አዎ 2. የለም	
315	በአለም ጤና ደርጅት መሰረት ስንተኛ የኤችይቪ በሽታ ደረጃ ላይ ናቸው	1. ደረጃ አንድ 2. ደረጃ ሁለት 3. ደረጃ ሶስት 4. ደረጃ አራት	
316	በአለም ጤና ደርጅት መሰረት ስንተኛ የኤችይቪ በሽታ ህክምና ደረጃ ላይ ናቸው	1. ህክምና ደረጃ አንድ 2. ህክምና ደረጃ ሁለት 3. ህክምና ደረጃ ሶስት 4. ህክምና ደረጃ አራት	
317	የኤችይቪ መድሃኒት ህክምና ክትትል ምንያህል ጊዜ ወሰዱ?(የክትትሉ ጊዜ)	----------	
318	በየስንት ጊዜ ክትትል አለዎት	----------	
319	የCotrimoxazole የመከላከያ ህክምና አሰጣጥ ሁኔታ ታሪክ	1. የተሰጠ 2. በመህደት ላይ 3, አልተሰጠም።	
320	የሳንባ ነቀርሳ መከላከያ ሕክምና (ቲፒቲ) አሰጣጥ ሁኔታ	1.ተጠናቀቀ 2. የተቋረጠ 3. በህድት ላይ 4. አልተሰጠም	

ክፍል አራት፡ በመድሃኒት መልክ የተዘጋጀ ምግብ አዎሳሰድን የተመለከተ መረጃ ለመሰብሰብ የተዘጋጀ መዘርዝር			
401	ኤች.አይ.ቪ መድሃኒት ሲጠቀሙ በመድሃኒት መልክ የተዘጋጀ ምግብ ወስደው ያውቃሉ?	1. አዎ 2. የለም	
402	መልስዎት አዎ ከሆነ የወሰዱትን ምግቦች ሊዘረዝሩት ይችላሉ?	----------	
403	በመድሃኒት መልክ የተዘጋጀ ምግብ መወስድ መቸነው የጀመሩት?	----------	
404	ለምን ያህል ጊዜ ነው የወሰዱት?	----------	
	ክፍል አምስት፡- ስነ-ባህራዊ ምክንያቶችን በተመለከተ የተዘጋጀ መጠይቅ		
501	የመድሐኒት ቁርኝት እና መድሐኒታቸዉን ሳይዎስዱ የሚቀሩ በሽተኞችን ያልዎሰዱበትን ጊዜ ብዛት ማጣራት፡ ፡ **የበሽተኞች የቃል ጥያቄ:** በተለያዩ ያልተሳኩ ፍላጎቶች (የምግብ እጥረት፣ በጊዜ እጥረት፣ ወዘተ) ምክንያት ለምን ያህል ጊዜ መድሐኒታቸዉን በትዕዛዝ መሰረት ሳይወስዱ ቀርቷል?	መድሐኒት በትዕዛዝ መሰረት ያልዎሰዱበት ጊዜ ዛሬ -------- ትናንትና ------- ለአለፍት ሥስት ቀናት---------- ለአለፍት ሰባት ቀናት ----------	
502	በአለፉት ሰባት ቀናት እያንዳንዱ መድሐኒት የሚወስዱበት የጊዜ ሰላዳ ክትትል እንዴት ይከታተሉታል?	1. በጭራሽ አልከታተልም 2. አንዳንድ ጊዜ 3. ከግማሽ ጊዜ በላይ 4. አብዛኛውን ጊዜ እከታተላለሁ 5. ሙሉ በሙሉ እከታተላለሁ	
503	በጤና ባለሙያ የተሰጠዎት ልዩ የመድሐኒት አወሳሰድ መመሪያ እንዴት ይከተሉታል?	1. በጭራሽ አልከተልም 2. አንዳንድ ጊዜ 3. ከግማሽ ጊዜ በላይ 4. አብዛኛውን ጊዜ ይከተላለሁ 5. ሙሉ በሙሉ እከተላለሁ	
504	በሽተኛዉ በወር የወሰደዉን መድሐኒት በማዎቅና በወር ዉስጥ ስንት እንደዎሰደ በመቆጠር በእጁ ያለዉን ማዎቅ (ክኒን በመቁጠር)	አሁን በእጁ ላይ ስንት ክኒኖች ቀሩ---------- ለወር የተሰጡ ክኒኖች ---------- አሁን በእጅ ይቀራል ተብሎ የሚገመት ክኒኖች ----------	
505	ሲጋራ አጨሶ ያውቃለሉ?	1. አዎ 2. አይለም	

506	መጠጥ ጠጥቶ ያውቃሉ?	1. አዎ 2. አይለም	
507	ጫት ቅሞ ያውቃሉ?	1. አዎ 2. አይደለም	
508	የዕለት ተዕለት የምግብ ዋስትናዎትን ለማረጋገጥ ወይም ዕላታዊ ምግብ ለማግኘት ጤናማ ያልሆነ የግብረ ስጋ ግንኙነት ለማድረግ የተገደዱበት ወቅት ነበረ ወይ?	1. አዎ 2. አይደለም	
509	የምግብ ዋስትናዎትን ለማረጋገጥ ወይም ምግብን ለማግኘት ስሉ ቀድሞ ከሚኖሩበት አከባቢ ወደ ሌላ አከባቢ ተሰዶ ያውቃሉ?	1. አዎ 2. አይደለም	
ክፍል ስድስት፡ የቤተሰብ አባላት የምግብ ዋስትና ምዘና መጠይቆች			
601	ባለፉት አራት ሳምንታት እርስዎና የቤተሰብዎ አባላት የሚመገቡት ያጣሉ ብለው ሰግተው ያውቃሉ?	1. አዎ 0. አይ ⟶	ጥያቄ ቁጥር 603
602	ለጥያቄ 601 አዎ ካሉ፣ ምን ያህል ጊዜ?	1. በጣም በጥቂቱ (አንድ-ሁለትጊዜ/በ 4 ሳምንት) 2. አንዳንዴ (3 to 10 ጊዜ/በ 4 ሳምንት) 3. ብዙ ጊዜ (›10 ጊዜ/በ 4 ሳምንት)	
603	ባለፉት አራት ሳምንታት እርሰዎና የቤተሰብዎ አባላት ሊመግቡ የፈለጉትን ምግብ የምግብ ግብዓት ማጣት ምክንያት ሳይመግቡ የቀሩበት ጊዜ አለ?	1. አዎ 0. አይ ⟶	ጥያቄ ቁጥር 605
604	ለጥያቄ 603 አዎ ካሉ፣ ምን ያህል ጊዜ?	1. በጣም በጥቂቱ (አንድ-ሁለትጊዜ/በ 4 ሳምንት) 2. አንዳንዴ (3 to 10 ጊዜ/በ 4 ሳምንት) 3. ብዙ ጊዜ (›10 ጊዜ/በ 4 ሳምንት))	
605	ባለፉት አራት ሳምንታት እርሰዎና የቤተሰብዎ አባላት ሊመግቡ የፈለጉትን የምግብ ስብጥሮች የምግብ ግብዓት ማጣት ምክንያት አይነታቸውን የቀነሱበትጊዜ አለ?	1. አዎ 0. አይ ⟶	ጥያቄ ቁጥር 607
606	ለጥያቄ 605 አዎ ካሉ፣ምን ያህል ጊዜ?	1. በጣም በጥቂቱ (አንድ-ሁለትጊዜ/በ 4 ሳምንት) 2. አንዳንዴ (3 to 10 ጊዜ/በ 4 ሳምንት) 3. ብዙ ጊዜ (›10 ጊዜ/በ 4 ሳምንት)	
607	ባለፉት አራት ሳምንታት እርሶም ሆኑ የቤተሰብዎ አባላት በፊት ሊመገቡት የማይፈልጉትን የምግብ አይነቶች	1. አዎ 0. አይ ⟶	ጥያቄ ቁጥር 609

	የምግብ ግብዓት ማጣት ምክንያት እንድመገቡ የተገደዱበት አጋጣሚ አለ?		
608	ለጥያቄ 507 አዎ ካሉ፣ ምን ያህል ጊዜ?	1. በጣም በጥቂቱ (አንድ-ሁለትጊዜ/በ 4 ሳምንት) 2. አንዳንዴ (3 to 10 ጊዜ/በ 4 ሳምንት) 3. ብዙ ጊዜ (›10 ጊዜ/በ 4 ሳምንት)	
609	ባለፉት አራት ሳምንታት እርሰዎና የቤተሰብዎ አባላት የሚመገቡትን የምግብ መጠን በቂ የምግብ ግብዓት ባለመኖሩ ምክንያት የቀነሱበትጊዜ አለ?	1. አዎ 0. አይ	ጥያቄ ቁጥር 611
610	ለጥያቄ 509 አዎ ካሉ፣ ምን ያህል ጊዜ?	1. በጣም በጥቂቱ (አንድ-ሁለትጊዜ/በ 4 ሳምንት) 2. አንዳንዴ (3 to 10 ጊዜ/በ 4 ሳምንት) 3. ብዙ ጊዜ (›10 ጊዜ/በ 4 ሳምንት)	
611	ባለፉት አራት ሳምንታት እርሰዎና የቤተሰብዎ አባላት በቀን ውስጥ የሚመገቡትን የምግብ ጊዚያት በቂ ምግብ ባለመኖሩ ምክንያት የቀነሱበትጊዜ አለ?	1. አዎ 0. አይ	ጥያቄ ቁጥር 613
612	ለጥያቄ 611 አዎ ካሉ፣ ምን ያህል ጊዜ?	1. በጣም በጥቂቱ (አንድ-ሁለትጊዜ/በ 4 ሳምንት) 2. አንዳንዴ (3 to 10 ጊዜ/በ 4 ሳምንት) 3. ብዙ ጊዜ (›10 ጊዜ/በ 4 ሳምንት)	
613	ባለፉት አራት ሳምንታት በቤትዎ ውስጥ የሚመገቡት ምግብ በአቅም ማጣት ምክንያት ሙሉ በሙሉ ያልተመገቡበት ጊዜ አለ?	1. አዎ 0. አይ	ጥያቄ ቁጥር 615
614	ለጥያቄ 513 አዎ ካሉ፣ ምን ያህል ጊዜ?	1. በጣም በጥቂቱ (አንድ-ሁለትጊዜ/በ 4 ሳምንት) 2. አንዳንዴ (3 to 10 ጊዜ/በ 4 ሳምንት) 3. ብዙ ጊዜ (›10 ጊዜ/በ 4 ሳምንት)	
615	ባለፉት አራት ሳምንታት በቤትዎ ውስጥ የሚመገቡት ምግብ በቂ የምግብ ግብዓት ባለመኖሩ ምክንያት ራት ሳይመገቡ የተኙ የቤተሰብ አባል አለ?	1. አዎ 0. አይ	ጥያቄ ቁጥር 617
616	ለጥያቄ 615 አዎ ካሉ፣ ምን ያህል ጊዜ?	1. በጣም በጥቂቱ (አንድ-ሁለትጊዜ/በ 4 ሳምንት) 2. አንዳንዴ (3 to 10 ጊዜ/በ 4 ሳምንት) 3. ብዙ ጊዜ (›10 ጊዜ/በ 4 ሳምንት)	

617	ባለፉት አራት ሳምንታት በቤትዎ ውስጥ የሚመገቡት ምግብ በቂ ምብግ ባለመኖሩ ምክንያት ምንም ሳይመገቡ ቀኑን ውሎ ለሊቱ ያደረ የቤተሰብ አባል አለ?	1. አዎ 0. አይ ⟶	ጥያቄ ቁጥር 701
618	ለጥያቄ 517 አዎ ካሉ ፣ ምን ያህል ጊዜ?	1. በጣም በጥቂቱ (አንድ-ሁለትጊዜ/በ 4 ሳምንት 2. አንዳንዴ (3 to 10 ጊዜ/በ 4 ሳምንት) 3. ብዙ ጊዜ (›10 ጊዜ/በ 4 ሳምንት)	

Amharic version

701	አሁን በባለፈው 30 ቀናት የተመገቡዋቸውን ምግቦችና መጠጦች፣ የመቆያ ምግቦችን ጨምሮ ያስብ። በምን ያህል ድግግሞሽ የሚከተሉትን አትክልትና ፍራፈሬዎች በባለፈው አንድ ወር ተመገቡ? ድግግሞሹን በቀን፣ በሳምንት፣ ወይም በወር አስበው ሊነግሩኝ ይችላሉ።	በጭራሽ……..(01) በወር አንዴ……..(02) በወር ከ2–3 ጊዜ……..(03) በወር ከ1–2 ጊዜ……..(04) በሳምንት ከ3–4 ጊዜ……..(05) በሳምንት ከ5–6 ጊዜ……..(06) በቀን 1 ጊዜ……..(07) በቀን ከ2–3 ጊዜ……..(08) በቀን ከ4–5 ጊዜ……..(09) በቀን 6 ጊዜ ወይም ከዚያ በላይ……..(10)	
701ሀ	በባለፈው 30 ቀናት በምን ያህል ድግግሞሽ 100% የፍራፍሬ ጭማቂ፤ እንደ ብረቱካን፣ ማንጎ፣ ፓፓያ፣ አቮካዶ፣ እንጆር ጭማቂ ያሉ ጠጡ? ይህ ስኳር የተጨመረበትን የፍራፍሬ ጭማቂ ወይም በፍራፍሬ ጣእም የተዘጋጁ መጠጦችን አይጨምርም።	|___| ጊዜ	
701ለ	በባለፈው 30 ቀናት የፍራፍሬ ጭማቂን ሳይጨምር በምን ያህል ድግግሞሽ ፍራፍሬዎችን፤ እንደ ሙዝ፣ ብርቱካን፣ ማንጎ፣ ፓፓያ፣ አቮካዶ፣ አናናስ፣ እንጆሪ ያሉ፤ ተመገቡ? ይህ የደረቀ ወይም ያልደረቀ ፍራፍሬ ይጨምራል።	|___| ጊዜ	
701ሐ	በባለፈው 30 ቀናት በምን ያህል ድግግሞሽ ፍራፍሬ ወይም 100% የፍራፍሬ ጭማቂ ተመገቡ ወይም ጠጡ? ጠጡ? ይህ ስኳር የተጨመረበትን የፍራፍሬ ጭማቂ ወይም በፍራፍሬ ጣእም የተዘጋጁ መጠጦችን አይጨምርም።	|___| ጊዜ	
701መ	በባለፈው 30 ቀናት በምን ያህል ድግግሞሽ አረንጓዴ ቅጠላ ቅጠሎች ወይም ሰላጣ (ይህ ከሌሎች አትክልቶች ጋር ለብቻ ወይም በጋራ የቀረበን ጨምሮ) ተመገቡ?	|___| ጊዜ	

701ሠ	በባለፈው 30 ቀናት በምን ያህል ድግግሞሽ እንደ ጥቅል ጎመን፣ በሮኮሊ፣ አበባ ጎመን ያሉ አትክልቶችን ተመገቡ?	|___| ጊዜ	
701ረ	በባለፈው 30 ቀናት በምን ያህል ድግግሞሽ እንደ ዝኩኒ፣ ዱባ፣ ኪያር ያሉ አትክልቶችን ተመገቡ?	|___| ጊዜ	
701ሰ	በባለፈው 30 ቀናት በምን ያህል ድግግሞሽ እንደ ድንች፣ ስኪር ድንች፣ ያም፣ ካሳቫ የመሳሰሉ አትክልቶችል የተቀቀል፣ የተጠበሰ፣ ወይም ልሞ የተፍጨን ጨምሮ ተመገቡ?	|___| ጊዜ	
701ሸ	በባለፈው 30 ቀናት በምን ያህል ድግግሞሽ ካሮት ተመገቡ?	|___| ጊዜ	
701ቀ	በባለፈው 30 ቀናት በምን ያህል ድግግሞሽ ሌሎች አትክልቶችን ተመገቡ?	|___| ጊዜ	
701በ	በባለፈው 30 ቀናት በምን ያህል ድግግሞሽ አትክልቶች በጠቅላላው ተመገቡ?	|___| ጊዜ	

ክፍል 6፡ የ24 ሰአት አትክልት፣ ፍራፍሬና ጣፋጭ ምግቦች አመጋገብ

702	በትላንትናው 24 ሰአት ውስጥ (ከትላንት ንጋት እስከ ዛሬ ንጋት) ቀጥለው ከተዘረዘሩት ፍራፍሬዎችን (በጭማቂ መልክ የተወሰዱትን ሳይጨምር) ምን ያህል ተምግበዋል? መረጃ ሰብሳቢ፡ ፍራፍሬውን ተመግበው መጠኑን በጭራሽ ሊገምቱ ካልቻሉ 99 ተብሎ ይሞላ።	
702ሀ	ብርቱካን/መንደሪን (በፍሬ ብዛት)	_____
702ለ	ሙዝ (በፍሬ ብዛት)	_____
702ሐ	ማንጎ (በፍሬ ብዛት)	_____
702መ	ፓፓያ (በፍሬ ብዛት)	_____
702ሠ	አናናስ (አንድ ቁራጭ (ስላይስ))	_____
702ረ	አፕል (በፍሬ ብዛት)	_____
702ሰ	ወይን/ የደረቅ ዘቢብ (በፍሬ ብዛት)	_____
702ሸ	አቦካዶ (በፍሬ ብዛት)	_____
702ቀ	እንጆሪ (በፍሬ ብዛት)	_____
702በ	ቴምር (በፍሬ ብዛት)	_____
702ቨ	ሎሚ (በፍሬ ብዛት)	_____
702ተ	ሃብ ሃብ (አንድ ቁራጭ (ስላይስ))	
702ቸ	የተለየ ፍራፍሬ ከመጠኑ ጋር ይጠቀስ	_____

703	በትላንትናው 24 ሰአት ውስጥ (ከትላንት ንጋት እስከ ዛሬ ንጋት) ቀጥለው ከተዘረዘሩት አትክልቶች ምን ያህል ተምግበዋል? መረጃ ሰብሳቢ፡ አትክልቱን ተመግበው መጠኑን በጭራሽ ሊገምቱ ካልቻሉ 99 ተብሎ ይሞላ።	
703ሀ	ድንች (በፍሬ ብዛት)	_____
703ለ	ቀይ ስር (በፍሬ ብዛት)	_____
703ሐ	ቲማቲም (በፍሬ ብዛት)	_____
703መ	ካሮት (በፍሬ ብዛት)	_____
703ሠ	ስኳር ድንች (በፍሬ ብዛት)	_____
703ረ	ጎመን፣ ቆስጣ፣ ሰላጣ	_____
703ሰ	እበባ ጎመን፣ ብሮንኮሊ፣ ጥቅል ጎመን (በቡና ስኒ መጠን)	_____
703ሸ	ዱባ፣ ዝኩኒ (አንድ ቁራጭ (ስላይስ))	_____
703ቀ	ኪያር (በፍሬ ብዛት)	_____
703በ	የተለየ አትክልት፡ ከመጠኑ ጋር ይጠቀስ	_____

	ክፍል ስድስት: የክትትል መረጃ መሰብሰቢያ ቅጽ				
ተ. ቁ	የመረጃ አይነት	**የመጀመሪያ ጉብኝት**	**ሁለተኛ ጉብኝት**	**ሶስተኛ ጉብኝት**	**አራተኛ ጉብኝት**
801	ክብደት(k/g)				
802	ቁመት(cm)				
803	የሰውነት አቋም መመዘኛ መጠን/(k/g)				
804	የሲዲፎር መጠን (cells/mm3)				
805	የቫይረስ ጫና (copies/mL)				

እናመሰግናለን !!!

Assurance of principal investigator

I, the undersigned agree to accept all responsibilities for the scientific and ethical conduct of the research project and for the provision of required progress reports as per terms and conditions of the research publications office in effect at the time of grant is forwarded as the result of this application. I will provide timely progress report to my advisors and seek the necessary advice and approval from my primary advisor in the course of the research.

- Name of the PhD student: **Dube Jara Boneya** Signature:  Date: **28/05/2025**
  Approval of the primary supervisor
- Name of the primary advisor: **Prof. Ahmed Ali** Signature: _____Date: _____