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EXPLORING FACTORS INFLUENCING NUTRITIONAL SUPPLEMENTATION WITH MORINGA OLEIFERA AMONG ADULT HIV PATIENTS ON DOLUTEGRAVIR BASED TREATMENT AT UNIVERSITY TEACHING HOSPITAL IN LUSAKA DISTRICT, ZAMBIA

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Abstract:
HIV remains a major public health problem globally having claimed 40.4 million lives since the start of the epidemic. HIV alters nutrition by inducing an increase in energy expenditure and nutrient requirements, driven by both the immune response and the direct effects of viral replication. Nutrition deficiencies can compromise the effectiveness of antiretroviral therapy making individuals with HIV more susceptible to opportunistic infections. Sub-Saharan Africa has the highest HIV prevalence and is home to some of the most nutritionally unsecured countries in the world. Advancements in HIV treatment have been made but several deaths are still attributed to nutritional deficiencies. In the quest for improved treatment outcomes, dolutegravir-based regimens have gained prominence due to superior efficacy and tolerability compared to efavirenz-based regimens. Zambia rolled out dolutegravir-based as the preferred first-line regimen in 2018. However, the utilization of Moringa oleifera among HIV patients on antiretroviral therapy is unknown. Therefore the study aimed to explore the knowledge, perception, attitude, cultural belief and utilization of Moringa oleifera nutrition supplements among adult HIV patients on dolutegravir-based treatment. The study used interviews to obtain data among adult patients aged 18 and above. Participants were selected using homogeneous purposive sampling until saturation of the ideas was reached. Data was analyzed through thematic analysis.

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Moringa utilization addressed nutritional deficiencies imperative to enhance the effectiveness of HIV treatment and improve the quality of life for individuals living with HIV. Conclusion and recommendation, the ministry of Health to consider strengthening policy that may promote the use of Moringa among patients on ART apart from cultural practices. Nutritional and health information is not enough to promote Moringa consumption and familiarity, but incorporating it into local foods with a high satiating power.

Keywords: antiretroviral therapy, dolutegravir, Human Immunodeficiency Virus, Moringa oleifera, nutrition

1. Introduction

The Human Immunodeficiency Virus (HIV) continues to be a significant global public health issue and has resulted in the loss of 40.4 million lives since the beginning of the epidemic. Towards the end of 2022, approximately 1.3 million people had acquired HIV, with an estimated 630,000 deaths from HIV-related causes worldwide. Low-middle income countries (LMICs) in Sub-Saharan Africa (SSA) have a 19% prevalence of HIV infection, carrying the largest disease burden globally (UNAIDS, 2021; WHO, 2023).

HIV is known to impact nutrition by increasing energy expenditure and nutrient requirements, influenced by both the immune response and the direct effects of viral replication. Micronutrient deficiencies can compromise the effectiveness of antiretroviral therapy, making individuals with HIV more susceptible to infections and opportunistic diseases (Heidkamp *et al*., 2022; Takarinda *et al*., 2017). While there have been significant advancements in HIV treatment and supportive measures, a considerable number of deaths in Acquired Immune Deficiency Syndromes (AIDS) are attributed to nutritional deficiencies. Nutritional deficiencies weaken the immune system and increase the likelihood of unsuppressed viral load. Nutrition interventions can enhance the immune system, optimize the benefits of antiretroviral therapy, and ultimately (Gambo *et al*., 2022; Shifera *et al*., 2022). Ultimately, nutritional support could delay or prevent the development of nutritional acquired immune deficiency syndromes (AIDS) and improve the quality of life of people living with HIV (PLHIV) (UNAIDS, 2021).

Aligned with the Sustainable Development Goal (SDG) target 3 of promoting "Good health and wellbeing," to end the AIDS epidemic by 2030. Nutrition care is an essential part of comprehensive care for patients undergoing antiretroviral therapy (UNAIDS, 2021). Antiretroviral therapy (ART) has significantly improved the quality of life and increased the life expectancy of people living with HIV, with the availability of newer, more potent, and less toxic antiretroviral (ARV) agents. In the pursuit of better treatment outcomes, dolutegravir-based regimens have gained prominence. They have demonstrated superior efficacy and tolerability compared to efavirenz-based regimens,

the previously preferred first-line ART in low- and middle-income countries, making dolutegravir a cornerstone in the management of first-line treatment of HIV (Kanter, 2016; WHO, 2019; Ministry of Health, 2020).

Dolutegravir, a second-generation integrase strand transfer inhibitor (INSTI), was declared the preferred first-line ART in LMICs by the World Health Organization (WHO) in 2018, owing to its high genetic barrier to resistance and low toxicity (WHO, 2018a, 2019b). Dolutegravir-based regimens in this context comprise tenofovir, lamivudine, and dolutegravir (TLD). Initial evaluations in controlled trials suggested that TLD produced more sustained and faster viral suppression compared to efavirenz-based regimens in ART naïve HIV patients across all time points (Dorward *et al*., 2019; Meireles *et al*., 2019; Vitoria *et al*., 2018). This signifies that TLD as first-line treatment may contribute to achieving the targets of the universal SDGs to end the AIDS epidemic by 2030 (UNAIDS, 2021).

Globally, over 800 million people are malnourished, while 1.5 to 2 billion have one or more chronic micronutrient deficiencies (Fusenini *et al*., 2022; Keats *et al*., 2019). According to the World Health Organization (WHO), in LMICs, particularly in sub-Saharan Africa, malnutrition and HIV often coexist. A substantial portion of the population with HIV faces deficiencies in essential micronutrients. The challenge is notably intensified for those with HIV globally, as deficiencies of vitamins, minerals, antioxidants, and micro/macronutrients coexist, potentially facilitating viral replication and HIV disease progression.

Sub-Saharan Africa is home to some of the most nutritionally insecure countries in the world. Poor infrastructure and limited resources compounded with conflict, HIV, and poor access to health services are the factors that contribute to the staggering levels of malnutrition and food insecurity. Low nutrition status remains an inexcusable unfinished agenda, and successfully closing the few remaining gaps is a precondition for wider progress towards human development for the continent (Heidkamp *et al*., 2022; UNAIDS, 2022). Consequently, HIV disease management demands continual exploration of advanced innovative interventions to enhance patient treatment outcomes (Stap *et al*., 2022).

Nutritional supplementation with Moringa oleifera can help fill the gaps related to nutritional deficiencies, as it is rich in both micro and macronutrients (Gambo *et al*., 2022; Shifera *et al*., 2022). Moringa oleifera is a tropical plant native to South Asia and is the most widely distributed species of the Moringaceae family (Wardana *et al*., 2022). The medicinal uses of Moringa oleifera stem from its wide range of functional and nutraceutical properties. It is rich in vitamins, minerals, antioxidants, and bioactive compounds, which have been reported to have immunomodulatory effects. Additionally, it contains high levels of proteins, carbohydrates, essential amino acids, and phytochemicals, supporting its therapeutic claims.

The use of Moringa oleifera in antiretroviral therapy (ART) is novel, cost-effective, culturally acceptable, efficacious, and regionally produced, making it a more sustainable option in resource-limited settings (Gandji & Assogbadjo, 2018). However,

there is a lack of its utilization in patients on ART in the context of HIV care. The World Health Organization (WHO) has emphasized the proper use of natural products and marked plant-based medicines as key study candidates. Therefore, understanding the interplay between dolutegravir-based treatment, nutritional status, and clinical outcomes in adult HIV patients supplemented with Moringa oleifera is crucial for optimizing therapeutic strategies and ensuring comprehensive care for this vulnerable population.

The impact of HIV is strongly felt in Lusaka, the capital city of Zambia in Sub-Saharan Africa, with a high prevalence of HIV (14.4%). Lusaka illustrates the urgent need for effective antiretroviral drug regimens (ZAMPHIA, 2021). Zambia introduced TLD as the preferred first-line regimen in 2018, and like many resource-limited settings, patients on ART experience deficiencies in essential nutrients. Nutritional status plays a crucial role in the overall health and well-being of HIV patients, affecting their immune function, medication adherence, and overall clinical outcomes. Addressing nutritional issues is essential to enhance the effectiveness of HIV treatment and improve the quality of life for individuals living with HIV (ZAMPHIA, 2021). Hence this study aims to explore nutritional supplementation of Moringa oleifera in ART.

2. Statement of the Problem

The impact of HIV is keenly felt in Zambia, with a high prevalence of HIV (14.4%). Consequently, patients on ART in Zambia experience deficiencies in essential nutrients, notably intensified for those with HIV weakening the immune system. Nutrition deficiencies facilitate viral replication and compromise the effectiveness of ART. Therefore, adequate nutrition is crucial for enhancing the body's ability to fight opportunistic infections maximizing the benefits of ART (Takarinda *et al*., 2017; UNAIDS, 2022).

Among first-line antiretroviral regimens, dolutegravir-based treatment has demonstrated substantial promise in terms of viral suppression with a high genetic barrier to resistance. Hence the need to optimize its treatment outcome in nutritional deficiencies (Heidkamp *et al*., 2022; Takarinda *et al*., 2017; UNAIDS, 2022). Nutritional deficiencies persist in resource limited settings and the current strategies fall short in addressing the problem attributed to cost implications and poor infrastructure in resource limited settings. Consequently, increase the likelihood of unsuppressed viral load, susceptibility to opportunistic infection, and ultimately treatment failure if not addressed.

Moringa oleifera presents a promising solution to the intricate nutritional challenges faced by individuals living with HIV. Moringa oleifera is rich in various vitamins, minerals, antioxidants and proteins. Studies suggest that Moringa oleifera supplementation have potential health benefits, and it may serve as a complementary intervention to improve the nutritional status and clinical outcomes of HIV patients on ART. Moreover, there exist a critical knowledge gap particularly regarding the

utilization and nutritional implications of moringa supplementation in patient on dolutegravir based regimen (Alba *et al*., 2023; Fuseini *et al*., 2022). Therefore, the findings will inform evidence-based interventions tailored to the specific needs of adult HIV patients on ART, ultimately improving nutritional status (Cai *et al*., 2019).

3. Research Objectives

Exploration of factors influencing the utilization of Moringa oleifera nutrition supplements among adult HIV patients on dolutegravir based treatment - a case study of University Teaching Hospital in Lusaka, Zambia.

4. Literature Review

The review of literature was done Heidkamp *et al*. (2022; UNAIDS, 2022) that reports that, HIV disease remains a critical concern in global public health. HIV is known to increase in energy expenditure and nutrient requirements due to viral replication. Micronutrient deficiencies can compromise the effectiveness of ART making PLHIV more susceptible to infections and opportunistic diseases. Therefore, good nutrition is crucial for the maximizing the benefits of ART in terms of improving CD4 and reducing the viral load. Dolutegravir based regimen has demonstrated substantial promise with high genetic barrier to resistance and reduction in viral load.

This prompts exploration of the utilization nutritional supplementary intervention in ART with medicinal plants such as Moringa oleifera to optimize the treatment outcome of dolutegravir based regimen (Wardana *et al*., 2022). Therefore,this chapter will review the current state of knowledge and the gaps regarding the utilization and influence of Moringa oleifera on ART (Cai *et al*., 2019). Articles will be reviewed in terms of the methodology, study design, findings, conclusion and recommendation. HIV affects nutritional status early in the course of the infection, even before other symptoms appear (Takarinda *et al*., 2017; UNAIDS, 2022). Early and intensive dietary interventions should be a fundamental part of management of HIV-infected individuals at the level of ART. Good nutrition prevents HIV disease progression by enhancing the body's ability to fight opportunistic infections. Several gaps exist in the current approaches posing challenges to achieving optimal nutritional status and overall well-being for individuals living with HIV on ART (Gambo *et al*., 2022; Shifera *et al*., 2022).

Similarly, Fathima *et al*., (2022) conducted a narrative review in Switzerland and looked at nutritional aspects of people living with HIV amidst COVID-19. Evidence was gathered by conducting a thorough search of the literature using the keywords; people living with HIV, nutritional habits, COVID-19, antiretroviral therapy and malnutrition. As a criterion for selecting, literature and linguistic filters were used. The narration included a large quantity of recent data but old literature was also included based relevance. HIV was found to have a deleterious impact on nutritional health by

enhancing energy demands, lowering intake of food, and reducing nutrient absorption and metabolism. Cultural attitudes and food preferences were significant indicators of eating behaviors. Individuals maintaining nutritional status and treating or preventing malnutrition reduced unfavorable outcomes in PLHIV and benefited from healthy diet. In conclusion, the study recommended nutritional intervention, such as the use of dietary supplements that could help prevent nutrient deficiencies, optimizing ART and nutritional status of PLHIV. This prompts the exploration of Moringa oleifera as nutritional supplementation in ART (Fathima *et al*., 2022).

Sub-Saharan Africa is home to some of the most nutritionally unsecured countries. Poor infrastructure and limited resources compounded with conflict, HIV, and poor access to health services are the factors that contribute to malnutrition and food insecurities. Fanzo *et al.* (2012) in a study on nutrition challenge in Sub-Saharan Africa (SSA) concluded that there was still room for research in developing the technical and scientific evidence underpinning nutritional interventions tailored towards what works on the ground. Similarly, Keats *et al*. (2019) conducted a systematic review with the aim to determine the real-world impact of key fortified micronutrients (vitamin A, iodine, iron, folic acid) on improving nutrition status in SSA. All applicable published and unpublished evidence was systematically retrieved and analyzed. Studies were not restricted by age or sex. Meta-analyses were performed for quantitative outcomes and noted an age-specific effect of fortification, with women (aged >18 y) attaining greater benefit. However, context and implementation factors were important when assessing programmatic sustainability and impact however data was quiet limited in LMIC studies. Hence, the study recommended a coordination of various efforts to reduce micronutrient malnutrition. The need to address critical gaps in the evidence through further research, strengthening of existing programs, and implementation of additional programs across the globe. For instance, nutritional intervention with Moringa oleifera may effectively contribute in resolving nutritional deficits in a cost-effective manner (Keats *et al*., 2019).

Similarly, a descriptive, prospective trial was performed at ARV roll-out centres in Northern Cape Province of South Africa. Letegan *et al*. (2010) aimed to describe the nutritional status and determine the impact of current nutrition intervention strategies on weight changes in adult HIV-infected patients on ART. Participants' body mass index (BMI) was determined before and after a four-month intervention period of nutritional supplementation with an instant, enriched maize product. The study suggested that nutritional supplementation in combination with ARVs, nutritionally benefited approximately half of the patients in the ARV program in the Northern Cape. Immunocompromised patients clearly needed both ARV therapy and nutritional support. The study recommended a more aggressive supplementation to be investigated to increase the success rate in terms of weight gain. Hence this study will investigate the influence of Moringa oleifera nutritional supplementation in ART to contribute in filling the gap (Letegan *et al*., 2010).

Ewune *et al*. (2021) conducted a study that aimed to explore nutrition management challenges among people living with HIV on ART in primary health centers in Addis Ababa, Ethiopia. Hermeneutic (interpretive) phenomenological study design was engaged. The study used in-depth interviews to describe lived experiences among adult patients aged 18 and above. Participants were selected purposively until the saturation of the idea reached. The data was analyzed through inductive thematic analysis. Nutrition management challenges for HIV patients were described using six significant themes. The major themes were: acceptance of the disease and the health status; facilitators and barriers to treatment adherence, behavioral changes in eating patterns, experience of food insecurity issues, nutrition knowledge, and support. The themes explained how patients using ART were challenged to manage nutrition ever since their diagnosis. Of all challenges, food insecurity was found to be the core reason for poor nutrition management. Therefore, this study investigates Moringa oleifera nutritional supplementation in ART. Cost effective, rich in vitamins and minerals with the potential to improve the treatment outcome of ART contributing in filling gaps (Ewune *et al*., 2021).

Nutrition interventions increase compliance with treatment regimens and optimize the benefits of antiretroviral drugs. Mengie *et al*. (2018) also conducted a study in Ethiopia with the aim to assess the nutritional knowledge, dietary practice and associated factors among adult PLWHA on anti-retroviral therapy (ART) in Felege Hiwot Referral Hospital in Ethiopia. It was a cross-sectional study, involved systematic random sampling technique and a semi-structured and pretested questionnaire. The study revealed that 30.4% of respondents had poor, average and good dietary practice scores respectively. The study recommended nutrition education and counseling to be given by health care workers for patients on ART to improve their nutritional knowledge. The media to also strengthen its role in disseminating nutrition information. Moringa oleifera is rich in minerals and vitamins with potential to fill in the gaps in addressing food security (Megie *et al*., 2018).

Ghana may face challenges in achieving the SDG targets 3.3 and 3.4 targets stopping AIDS epidemic and preventing premature deaths from malnutrition by 2030. Nanewortor *et al*. (2021) conducted a descriptive cross-sectional study and examined the nutritional status and associated factors among HIV positive clients accessing Highly Active Anti-Retroviral Therapy (HAART) at a public hospital in Ghana. Data were analyzed using SPSS 22.0, descriptive and analytical statistics comprising frequency, percentage, and binary logistic regression were adopted. About 74% -79% of the clients had good nutrition knowledge and attitude, respectively and 42% were malnourished. There was a high prevalence of malnutrition among the clients working against progress towards achieving SDGs target.

Although nutrition-related knowledge and attitude among PLWHA were good, it did not correspond to the high prevalence of malnutrition. This finding implied that most PLWHA are at risk of deteriorating immunity as a result of poor nutrition. Potentially, increasing the risk of exposure to opportunistic infections reducing survival

rates and quality of life. In order for Ghana to achieve the targets of the SDGs, there was a need for innovative approaches to nutritional education and counselling for PLWHA. Additionally, social support focuses on assisting PLWHIV to ensure food security for individuals with low socio-economic status. Hence, the findings justify the need for the implementation of innovative interventions such as Moringa oleifera to improve the nutritional status of people living with the disease (Naneworter *et al*., 2021).

Saka *et al*., (2023) also conducted a comparative cohort study in Ghana assessing dietary habits and determined nutritional status. The study showed that macro and micronutrient intakes, especially among PLWH were not adequately met by all groups. The type of HAART used by respondents had no significant effect on serum concentrations of Se, Zn and Cu. Patients on AZT+3TC+NVP had lower Zn concentration compared to the respondents on other medications. Dietary intake of Se, Zn and Cu were highest among the controls and least, among the HAART treatment naïve group although serum concentrations were significantly lower, the respondents required general dietary counselling to assist improve their nutritional status, especially for PLWH, since they were more vulnerable and at risk of high morbidity and mortality. More controlled intervention studies were needed to investigate the effect of HAART on serum concentration of Se, Cu and Zn for PLWHA. This prompts the exploration of Moringa oleifera as nutritional supplementation in the current study to fill in the gaps in ART (Saka *et al*., 2023).

Moramarco *et al.* (2016) conducted a retrospective study on Zambian malnourished children. Nutritional status was evaluated according to WHO methodology the program outcomes met international standards. The finding suggested that early detection of HIV with adequate antiretroviral treatment and extending the duration of feeding supplementation improved weight gain and prevention of deterioration in severe acute malnutrition. Nutritional supplementation is crucial for ensuring full recovery and lowering mortality rates in malnourished Zambian children. Hence, Moringa oleifera may contribute in sealing the gaps (Moramarco, *et al*., 2016).

A phase III trial was conducted in Zambia and Tanzania by Filteau *et al*., (2015), on effects of nutrition on malnourished adult HIV patients on ART. High-dose vitamin and mineral supplementation in lipid-based nutritional supplements (LNS) compared to LNS alone, did not decrease mortality in malnourished African adults initiating ART, but improved CD4 count. The intervention did not decrease mortality although it did benefit a secondary outcome, CD4 count. Nevertheless, the benefit for CD4 count in the large trial, added to previous information from smaller trials of micronutrient supplements for HIV patients, suggesting that micronutrient supplementation should be pursued. The study recommended that addition of micronutrient supplements to ART could provide clinical benefits in ART patients. Further research was made to address how to improve compliance with similar nutritional interventions.

Literature on nutritional deficiencies in ART reveals several gaps requiring intervention. Resource limitations in healthcare settings especially in low-income regions hinder the implementation of comprehensive nutritional support programs. Adequate supplementation and dietary support may be challenging to provide consistently. Moringa oleifera supplementation is rich in micro and macronutrients and cost effective hence may help bridge the gaps. Therefore, may enhance the nutritional well-being of adult HIV patients on ART and improve their overall health outcomes in terms of nutrition status and clinical outcome signifying the need for the current study (Fuseini *et al*., 2021).

Ewetola *et al*. (2019) also noted that Moringa oleifera leaves contain magnesium, Vitamin C, and Calcium. Other nutritional properties include Potassium, Iron and numerous phytochemicals including carotenoids and phenolic acid. Oyepata & Tosin, (2021) further underscored that the plant is a good source of proteins and amino acids. Similarly, a study involving elemental and chemical analysis of powdered, solid, and liquid samples of Moringa oleifera dried leaves produced a total of 35 elements (14 macroelements and 21 microelements). The macroelements in the powdered leaf samples included S, Ca, K, Mg, Na, P, Si, Cl, Al, Fe, and Mn. The minor elements produced by the analyses in the decreasing order were V, Ba, Cr, Y, Ba, Zn, Rb, Ce, La, Cu, Cs, Sn, Co, Ni, and Zr. The concentrations of all the elements were within the recommended daily allowance (RDA) limits (Chapter *et al*., 2017).

Nigeria conducted a number of studies on Moringa oleifera, Aproku *et al*., (2022) investigated the beneficial role of Moringa oleifera supplementation in HIV positive patients receiving antiretroviral drugs. Adult HIV positive individuals attending the medical outpatient clinic in a tertiary health institution in Nigeria receiving highly active anti-retroviral therapies (HAARTs) were recruited in a randomized fashion for the study. Half of the subjects received Moringa supplement while the others received only HAART and represented the control group. All participants were monitored for 3 months during which their immunological status. Baseline levels of CD4 increased in the Moringa supplemented groups ($p < 0.01$). In addition, baseline hematological abnormalities such as anemia, thrombocytopenia, leucopenia, lymphopenia, and neutropenia improved most significantly in the moringa supplemented participants. The conclusion was that Moringa oleifera had beneficial properties and improved CD4 count and hematological abnormalities in HIV positive individuals receiving antiretroviral therapy. However, the study did not look at the influence of Moring oleifera on viral load leaving the gap (Aprioku *et al*., 2022).

Dietary diversity and impact of Moringa oleifera Lam. leaves supplementation was investigated in another study in Nigeria. It was a double-blind randomized trial on impact on nutritional status on patients receiving antiretroviral therapy. The study revealed a poor dietary diversity amongst PLHIV. Supplementation of regular diet with Moringa oleifera Lam. leaves did not have influence on nutritional status but could improve the immune response of HIV positive adults (Gambo, Gqaleni, *et al*., 2022). Another study in Nigeria looked at other aspects; the impact of Moringa oleifera

on quality of life of people living with HIV in a double-blind randomized controlled trial. The findings revealed that supplementation with Moringa oleifera leaves during ART improved the quality of life domains of physical, psychological, level of independence, and social relationships. Both studies did not establish the influence of Moringa oleifera supplementation on viral load and BMI leaving gaps (Gambo *et al*., 2021).

Similarly, another study on CD4 pattern in people living with HIV on HAART exposed to Moringa oleifera (MO) leaf powder was conducted. The study concluded that Moringa oleifera had the potential of improving the CD4 count of HIV patients on HAART translating to better treatment outcome. However, the study did not look at the influence of Moringa oleifera on viral load (Njonge *et al*., 2019). Amlogu *et al.* (2016) assessed the short and long term effects of a nutrition sensitive intervention to delay the progression of human immune-deficiency virus (HIV) to AIDS among people living with HIV in Abuja, Nigeria. Evidence indicated that the prevalence of macro and micronutrient deficiencies (particularly magnesium, selenium, zinc, and vitamin C) had a negative impact on optimal immune function, through the progressive depletion of CD4 T-lymphocyte cells, thereby increasing susceptibility to morbidity and mortality among PLWH. The achieved results suggested that a prolong consumption of nutrition intervention is suitable to sustain the gained improvements in CD4 count, anthropometric and biochemical indices of PLWHIV. The study findings signified the need for Moringa oleifera in ART to improve CD4 and BMI but did not look at viral load hence the gap (Amlogu *et al*., 2016).

Nworu *et al*., (2013) conducted a study on Moringa oleifera Lam in Nigeria, leaf extracts revealed selective inhibition of HIV-1 infectivity hence could serve as a source of antiretroviral lead molecule. The outcome of the investigation could partly explain the antiviral benefits claimed in the use of extracts of M. oleifera in the management/treatment of people living with HIV/AIDS in African traditional medicine (Nworu *et al*., 2013). Nkirote *et al*. (2021) also carried a study on determinants of use and antiviral activity of moringa oleifera extracts among people living with HIV and AIDS attending comprehensive care clinic at referral hospital in Kenya. The study demonstrated that specific phytochemicals are responsible for antiviral activity against HSV-1 in aqueous and methanol extracts and further investigation for anti- HSV-1 activity in vivo (Nkirote, 2021).

Similarly, a study done in Carolina USA on Moringa oleifera demonstrated increase in CD4 T- cell numbers in patients on ART. The study established that Moringa oleifera had the potential to remediate the immune suppressive effects of malnutrition but did not establish the effects on viral load (Pilotos *et al*., 2020). A study conducted in Indonesia revealed the molecular mechanism of compounds from Moringa oleifera with antiviral effects for HIV-1 through a bioinformatics approach. Kaempferitrin and β-sitosterol from Moringa oleifera were predicted to be HIV-1 antiviral agents. Both compounds could produce more negative binding affinity and weak bond interactions

indicating the stability of the binding interaction that triggers the inhibitory activity (Murtadlo *et al*., 2022).

Minutolo *et al*. (2021) in Italy also carried out a study on plant microRNA from Moringa oleifera associated with immune response and HIV infection. The study revealed that plant microRNAs from Moringa oleifera may restore the immune system and reduce replication of HIV-infection. The study also recommended Moringa oleifera to be used as a standard in HIV treatment to contribute to the long-term control of the disease). The two studies by Murtadlo, Minutolo and collogues signified the potential antiviral effects of Moringa oleifera on viral load that needs further exploration to fill in the gap (Minutolo *et al*., 2021).

On the other hand, Biswas *et al.* (2020) in India conducted an article review and revealed that several studies reported regarding the medicinal activity of Moringa oleifera plant, a pronounced bioprospective aspirant. In African traditional medicine, the plant was popularly used against AIDS and related secondary infections associated with HIV. Study findings showed significant activities against viruses including HIV. In some cases, active molecules with mode of actions were documented by authors. However, a number of studies neither reported on lead compounds nor the relevant mechanisms regarding the viral inhibitory activities of crude plant extract. The recommendations were that immense studies should be going on to resolve those unanswered motifs along with the well planned studies of clinical application of already discovered potent phytochemicals (Biswas *et al.,* 2020).

While specific research on the influence of Moringa oleifera on CD4 count and viral load in the context of dolutegravir-based regimen in Lusaka may be limited, the above studies provides insights into the potential effects of Moringa oleifera on CD4 count and viral load in people living with HIV. The studies do not directly address the specific context of dolutegravir-based regimens in Lusaka, but provide valuable information that acts as a basis for exploring the impact of Moringa oleifera supplementation on CD4 counts and viral load in the target population. Moreover, there are still gaps, the limited scientifically robust studies specifically focusing on the influence of Moringa oleifera on viral load the standard monitoring parameter of HIV disease progression (Sztam *et al*., 2013, Gambo, 2021).

Despite the potential benefits of Moringa oleifera supplementation, adaptability to different climates and considerable economic importance, its utilization among adult patients on dolutegravir based regimen in Lusaka remains a subject of limited exploration. Existing studies show gaps in our understanding of why patients choose to use or not use Moringa oleifera in ART. This could be attributed to the fact that the barriers to utilization differ in different regions which warrant comprehensive investigation. Understanding the factors is crucial to optimize the potential benefits, address barriers and improve healthcare practices involving Moringa oleifera (Crop *et al*., 2018; Gandji *et al*., 2018; Stevens *et al*., 2015, 2015; Velasco & Canada, 2022).

Similarly, a study examined households 'perception, awareness and willingness to pay for Moringa oleifera powder for nutrition supplementation. The findings revealed that the level of education, age, marital status, price of moringa, level of awareness, occupation and gender were statistically significant factors affecting households' willingness to pay for Moringa oleifera. The study revealed a positive correlation between level of awareness and households' willingness to pay for Moringa oleifera supplements. The study recommended that efforts were to be made at ensuring that Moringa was made available and accessible. Governments, NGO's and corporate bodies to create awareness for the general public (Famuyide & Adio, 2014).

Oke *et al*. (2020) also conducted a study in Nigeria that revealed that age, membership of Moringa farmers' association, non-farm income, and access to extension and involvement in agroforestry practices were significant factors influencing the adoption of Moringa oleifera. The study emphasized on awareness on the benefits of Moringa in order to increase demand for its product in order to have access (Oke *et al*., 2020). In Philippines a study conducted on determinants of willingness to cultivate Moringa oleifera, also revealed that lack of awareness was the main contributing factors (Valasco *et al*, 2022, Gandji & Assogbadjo, 2018).

Michela *et al.* (2018) reviewed that, in Zambia the acceptability and the safety of dietary supplementation with MO powder in malnourished children for 30 days. A daily dose of 14 g daily was safe and well accepted. Therefore, its regular use in the menu of local populations and ART may be viable proposition. Therefore, it is imperative that conditioned situations of factors contributing to underutilization of Moringa oleifera in Zambia are analysed using a Bayesian Network Model (Puga *et al*., 2015; Repaka *et al*., 2019). A probability statistical tool that would address the problem objectively and more effectively. Moreover bring out new knowledge from conditioned situations to help optimize and maintain TLD as the current preferred first line in ART (Ganapathy *et al*., 2023; Stap *et al*., 2022).

4. Methodology

An exploratory case study design that involved collecting data through interviews was used. The data described the knowledge, perception, attitude, cultural beliefs and utilization of Moringa oleifera among adult HIV patients on dolutegravir based regimen. Participants were selected using purposive sampling (homogenous) and the sample size of 15 participants was arrived at after reaching saturation. Data on knowledge, perception, attitude, cultural beliefs, accessibility and utilization of Moringa oleifera among HIV patients on TLD was collected using interviews. Reflexive thematic analysis was used to analyze qualitative data obtained through interviews. The data collected was used to generate main themes and sub themes emerged based on the subject matter.

This study was conducted at University Teaching Hospitals in Lusaka, Zambia- The largest tertiary referral public hospital in Zambia providing high chances of obtaining the required sample size. The target population was adult male and female HIV patients initiated on TLD regimen self-supplemented with Moringa oleifera in the community and those not on any supplements meeting the criteria.

5. Research Findings and Discussions

In relation to knowledge to the findings of the study, the researcher incorporated the following codes, sub-themes and emergent themes. The major findings of this study were that patients on ART were alternatively using moringa without proper health guidelines as it is taken to be normal nutritional supplement on their health. The study established the knowledge, utilization and accessibility of Moringa oleifera supplements among adult HIV patients on TLD.

5.1 The Benefits of Moringa to Patients on ART

The findings show clearly that Moringa oleifera is a natural nutrition supplement that improves health in ART patients and the benefits of using moringa and there are no signs of quitting in the use of the product. Moringa results in the study prove to be very effective in preventing different illnesses. Participant 1 complemented that:

> *"Moringa is naturally given by God I take it because it frees me from minor illnesses because it can cure 99 diseases and gives strength to the body to fight diseases."*

There are many reasons why patients are safe and motivated to take this medicinal food. One of the prominent issues that arose from the interview was that taking moringa gave patients energy especially when they felt weak. Participant 2 affirms:

> *"When I take moringa it provides me with energy to carry out my daily activities it is a natural energizer I take it all the time."*

Some books and literature that have been read about moringa and the experiences proved correctly in the field as the researcher found similarities when it came to what moringa does to the body. Participant number 3 support that:

> *"I take it to naturally cleanse toxins from the blood to keep my body in good shape and when I take it at night I sleep peacefully like a baby."*

When it came to the dosage of the use of moringa the findings show that patients on art that use the product face several challenges and there is no cultural dosage in using moringa even if they take moringa excessively. Some face diarrhoea headache

and body pains. However, others, about they said it was fine and didn't face problems in using moringa. Participant number 4 when asked on the use of moringa stated that,

> *"When I take more than twice in a day or more than two tablespoons of moringa I feel bad, I vomit, develop diarrhoea and headache."*

5.2 Limited Knowledge of the Use of Moringa in ART

A study found that most health personnel do not support the use of moringa in patients on antiretroviral therapy (ART). Moringa oleifera, a multipurpose herb, is not widely supported or recommended for ART use. The study found that participants used Moringa for various purposes such as a food supplement when they couldn't access better meals, as a relish, and for its affordability. Some participants used moringa as vegetables, salads, or mixed with groundnuts. Participants 2 reviewed that:

> *"It was found that Moringa was cheaper. I use moringa as vegetables and salads or mixed with groundnuts as relish."*

The continuity of Moringa use was also attributed to religious education from churches in the neighborhood. Some churches provided more information about Moringa than health personnel. Limited information was provided by health personnel regarding the use of Moringa in comparison to the teachings from religious groups, such as the Seventh-day Adventists (SDA), who consider Moringa as a traditional belief teaching on health. Participant 3 reviewed that:

> *"An SDA friend at college introduced it to me to use it for reducing stress and for health, he was trained at SDA School of health for herbs when studying, it provides the sense of wellbeing*."

Moringa was believed to be helpful in curing various health complications such as eye problems, strokes, gases, and blood cleansing. Participants who were knowledgeable about Moringa commonly used methods such as chewing seeds, boiling leaves for tea, and mixing dried powdered leaves with other foods. Moringa was also used to treat ailments like high blood pressure, diabetes, eye problems, stroke, and bloating. Participant 2 said that:

> *"Seeds when chewed, leaves are boiled and taken as tea; also dried leaves are in the shed powdered and mixed with other foods. Mixed of moringa leaves in hot water under a blanket helps refresh and feel better when tired or sick."*

Some participants believed that a tablespoonful of Moringa powder or a handful of Moringa leaves could heal sicknesses and provide nutritional benefits. However, participants expressed uncertainty about the role of Moringa in supporting patients on

ART, indicating a lack of knowledge and awareness in this regard. Participant 3 argued that:

> *"I use a tablespoonful of powder or a handful of moringa leaves for treating my gases and stomach ulcers I am not sure its use in ART."*

5.3 Moringa Oleifera Affordable and Easily Accessed by Patients on ART

The findings indicates that Moringa plant grown in homes, easily accessed without spending money, can survive with little watering. The four participants gave their living experiences and it was easy to grasp the meaning out of their experiences as they answered Moringa oleifera was affordable and easily accessible. One participant stated that, "*powder and capsules on sale in the community is really accessed*". Participant 1 stated:

> *"Moringa is easy to access I have 5 plants at my home, I dry the leaves it in the shed and come up with powder which I mix when taking other foods. I also boil fresh leaves direct from the plant to make tea."*

The other findings indicate that, the growing of Moringa was simple and its growth was without much stress and difficulties for the farmers. Participant 2 declared:

> "*Moringa can easily grow with little water hence easy to sustain very affordable, I have moringa plants at my home."*

The understanding is that certain medicine related to HIV involves costs to travel to and from to the hospital and clinics but the use of Moringa is faster is it is able to be accessed on the street or in markets. The finding shows that beneficiaries of Moringa are very comfortable with its effects. Through semi-structural interview with participant number 3, the participant stated that:

> *"I access moringa powder in the community it is sold on the street very affordable"*

Participants 1 mentioned:

> *"I view moringa as a substance that sustain my life because it is nutritious as a result I take it for the wellbeing of my life."*

Additionally, the fourth participant brought the aspect of price that, accessing the medicine was very cheap and it was affordable to handle and administer the medicine. Families that are underprivileged or coming from low class families it was very easy to use Moringa than other drugs. Participant 4 argued that:

"Moringa is everywhere in the neighborhood I easily access the plant from the community where I stay I do not spend any money"

Participant 3 mentioned:

"I use it as relish very cheap I grow it from home and I learnt that it improves health hence I continue to use it."

Moringa oleifera appreciated as a multipurpose herb by patient on ART Moringa is really appreciated by members of the communities those who had information on its function on patients who are on ART. The study noticed that through the use of moringa some participants were able to acknowledge its heath importance such as providing energy and boosting appetite to be able to have meals. Participant 2 commented that: from the time I started taking it I don't get sick easily so I am motivated to use it regularly. P3 said:

"Moringa provides energy for carrying out daily activities motivating patients on ART to take it regularly. It prevents illnesses associated with low immunity and there are no concerns or reservation about its use while on ART considering that majority experience no side effects while on ART. The benefits of Moringa outweighs the risks hence the growing interest by the community."

5.4 Cultural Beliefs and the Community Influence Moringa Utilization on ART

In the research conducted, it was discovered that families of individuals undergoing antiretroviral therapy (ART) incorporate Moringa into their health practices, utilizing it for a wide range of health issues beyond those related to HIV. Participant 1 emphasized the alignment of Moringa use with cultural beliefs, noting that a majority of individuals using Moringa hail from families that place their trust in traditional herbal remedies. Moreover, families of ART patients believe in the broad healing properties of Moringa, extending beyond HIV-related conditions. Participant 1 recounted their first encounter with Moringa, recounting how their sister boiled the leaves and administered it, asserting that it would expedite recovery and provide a substantial energy boost. Participant 1 said that:

"I learnt about Moringa for the first time from my sister, she boiled the leaves and gave me to take saying I was going to recover and quickly and it gave me a lot of energy."

One participant shared her experience of learning about Moringa while visiting Chirundu, "*when I visited Chiriundu I found that the community often prepared Moringa as a relish with groundnuts*". They also mentioned experimenting with Moringa tea, although she had to discontinue it due to its adverse effect of causing diarrhoea. Participant number 4 acquired knowledge about Moringa from their aunt in the village, who used

it for preventative health measures, and they have since incorporated it into their health regimen.

6. Discussion

6.1 The Perception, Attitude and Cultural Belief Regarding Moringa Oleifera Supplementation

The researcher in this study performed a thematic analysis of the reasons given by the participants to explain their own experiences as patients on using moringa. The study found that it was so easy and accessible for patients to use moringa and the major factor was that there is a cultural belief that moringa heals all diseases in communities. Findings from the participants' discussion shows that moringa has become part of food such as tea and vegetables as indicated in our findings and barriers to healthy eating show that there is a gap between healthy eating knowledge and eating habits. Despite the high level of awareness of the importance of nutritional intake, most of the study participants on ART consume moringa healthy foods without proper dosage. Maponga and Monera (2012) adds that, even though there is evidence to support Moringa oleifera's health benefits and nutritional value, little is known about the effects when taken in conjunction with conventional medical therapies such as antiretroviral drugs. When herbs are taken concomitantly with antiretroviral drugs, there is a potential for clinically significant interactions.

6.2 Purchase Constraint on HIV Related Diseases

The findings show that Herbal medicine use may replace or complement conventional medicines, usually on a self-selection basis, since herbs are available over the counter. Moringa oleifera is commonly advocated for use in HIV positive people in the tropics and sub-tropics as a nutritional supplement and immune booster. According to Maponga and Monera (2012), this herb is rich in vitamins and nutrients including beta carotene, potassium, calcium, magnesium, sulphur, iron and phosphorus and has a high protein and carbohydrate content, 7,8. The hypotensive, hypocholesterolemic, hypoglycemic, anti-ulcer, antibacterial, anti-inflammatory, antispasmodic and diuretic activities of M. oleifera have been demonstrated in laboratory studies.

6.3 Food and Energy in the Use of Moringa

Another frequently mentioned reason for moringa choice of food for patients on ART was energy. For patients sounded that in times when they feel weak was better to use moringa food because was important to eat such foods as it gave energy to them and it was noted that energy affects "mood" and it was necessary that when patients on ART are trying to do certain work such as manual work moringa food is taken. One of the participants on energy indicated that moringa traditional foods contain minerals, proteins, carbohydrates and all those things they go back to energy. Indeed eating

energetic food comprising moringa according to their traditional was also important for patients to have energy apart from medicine factors.

6.4 Utilization and Accessibility of Moringa Oleifera Supplements among Adult HIV Patients

The study findings are in line with the health believe model in that participants took Moringa oleifera to improve their health acknowledging that nutritional deficiencies risks opportunistic infections and low energy levels. In line with a study by Gumbo *et al.* (2023) that revealed that moringa improved nutrition status and CD4 count in HIV patients on ART. However majority of HIV patients are self-supplemented with moringa recommended by non-healthcare providers (family members, friends and the community).

6.5 Perception on Moringa and Diseases

The most important thing that keeps participants from eating moringa and moringa supplemented foods is the lack of knowledge about this plant and its benefits: to others showed that they take the product with lack of knowledge and didn't have an idea about n how it works well. The findings showed that there is need of more knowledge about Moringa, in its powder form, or as a tree, or a pill. In addition, moringa was suggested as an example of leafy vegetables by participants because of a lack of knowledge. To other participants felt moringa its supplementary medicine that cures many diseases like arthritis and cancer. The findings of this study is in agreement with Seifu and Teketay (2020) who did a study on local knowledge, perceptions, and uses of the potentially conflict-generating plant species, Moringa oleifera Lam: A case study in Limpopo Province, South Africa found that, *"Moringa is used to treat and prevent chronic diseases such as high blood pressure, diabetes, heart conditions, cancer (lung, leg, womb, and skin), anaemia, arthritis, asthma, migraines, and ulcers. It is a medicine; moringa has the ability to treat high blood pressure, sugar diabetes and cancer"*(p2).

6.6 Nutrition and Nutrients

The sample population had a positive general perception about moringa. Participants recognized that nutrition is an important reason determining food choices of mothers and children. The participants were clear that when you are consume food you have to know what you are going to gain as nutrition and from their belief and understanding is that moringa play a serious role of health nutrition. Although the medicinal values of moringa leaves and pods are well documented, our results demonstrated that the majority of the participants had opinion about the medicinal values of moringa leaves. However, there no information to the citizens in our area of study on official health guidelines on moringa.

6.7 Lack of Sensitization on the Value of Moringa

It was found that, much need to be done to support patients, families and communities to appreciate the importance of moringa. As it stands the findings shows that much as not been done to promote the multipurpose nutrition product. However, Mashamaite *et al.,* (2021:5) reports in his study that a study on Moringa oleifera in South Africa: A review on its production, growing conditions and consumption as a food source in his findings shows that "*even though moringa is fast becoming a cultivated crop in South Africa, perceptions about, and uses of, this plant are relatively undocumented, this similar on the part of undocumentation and lack of policy formulation which guides the beneficiaries in Zambia."* This could be due to a lack of awareness and media sensitization about the medicinal values of Moringa. The slow increase of Moringa tree farmers from the yards and meals of could also be a plausible cause for a lack of interest and awareness about its medicinal values. This is supported by the study by Farinola *et al.* (2014:2) who stated that, despite the abundant benefits of this plant, it seems that "*there is a lack of awareness and/or an unwillingness to exploit it*".

7. Conclusion and Recommendation

7.1 Conclusion

The main purpose of the study was explore of the utilization of Moringa oleifera nutrition supplements among adult HIV patients on dolutegravir based treatment a case study of University Teaching Hospital in Lusaka, Zambia. This study showed that knowledge and consumption habits of Moringa were different among the participants in the study. The majority of the participants were university and college graduates. However, the researcher had had challenges in giving out responses due to lack of knowledge on molinga benefits.

7.2 Recommendations

Following recommendations were made, among others, considering the study's findings:

1) The study recommends that Ministry of Health in Zambia may consider formulating a policy framework that will strengthen the use of molinga on patients that are on ART to improve their nutritional habits. furthermore,
2) There should be active promotion of and increased planting of Moringa oleifera trees. Working with the Ministry of Agriculture to encourage large-scale planting of Moringa oleifera trees would ensure a steady supply of seeds that will help our patients on ARTs.

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Conflict of Interest Statement

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

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References

Alba, G., Dakhaoui, H., Santa-Maria, C., Palomares, F., Cejudo-Guillen, M., Geniz, I., Sobrino, F., Paz, S. M., & Lopez-Enriquez, S. (2023). Nutraceuticals as potential therapeutic modulators in immunometabolism. *Nutrients*, *15*(3), 1–23.

Amlogu, A. M., Tewfik, S., Wambebe, C., & Tewfik, I. (2016). A comparative study: Long and short term effect of a nutrition sensitive approach to delay the progression of HIV to AIDS among people living with HIV (PLWH) in Nigeria. *International Journal of Food, Nutrition and Public Health*, *6* (December 2012), 79–90.

Aprioku, J. S., Robinson, O., Obianime, A. W., & Tamuno, I. (2022). Moringa supplementation improves immunological indices and hematological abnormalities in seropositive patients receiving HAARTs. *African Health Sciences*, *22*(2), 1–11. https://doi.org/10.4314/ahs.v22i2.2

Biswas, D., Nandy, S., Mukherjee, A., Pandey, D. K., & Dey, A. (2020). Moringa oleifera Lam. and derived phytochemicals as promising antiviral agents: A review. *South African Journal of Botany*, *129*, 272–282. https://doi.org/10.1016/j.sajb.2019.07.049

Dorward, J., & Hamers, R. L. (2019). Dolutegravir in sub-Saharan Africa: Context is crucial. *The Lancet HIV*, *6*(2), e72–e73. https://doi.org/10.1016/S2352-3018(18)30331-X

Dorward, J., Lessells, R., Drain, P. K., Oliveira, T. D., Pillay, Y., Karim, S. S. A., & Garrett, N. (2019). Dolutegravir for first-line antiretroviral therapy in low-income and middle-income countries: Uncertainties and opportunities for implementation and research. *The Lancet HIV*, *5*(7), 1–11. https://doi.org/10.1016/S2352-3018(18)30093-6

Ewetola, E. A., Oyeyiola, Y. B., Owoade, F. M., & Farotimi, M. F. (2019). Influence of soil texture and compost on the early growth and nutrient uptake of Moringa oleifera Lam. *Journal of Plant Sciences*, *2019*(2), 26–33.

Fadoyin, A. S., Oyewole, S. O., Ayanrinde, F. A., Baba, G. A., & Erhabor, T. A. (2014). Socio-economic factors influencing adoption of Moringa oleifera water purification by farmers in Kaduna State, Nigeria. *International Letters of Natural Sciences*, *20*, 85–90. https://doi.org/10.18052/www.scipress.com/ilns.20.85

Famuyide, F. L. A., & Adio, O. O. A. F. (2014). Households' perception, awareness and willingness to pay for Moringa oleifera Lam powder in Oyo State. *Journal of Agricultural Science*, *2*(June), 94–103.

Fuseini, H., Gyan, B. A., Kyei, G. B., Heimburger, D. C., & Koethe, J. R. (2022). Undernutrition and HIV infection in sub-Saharan Africa: Health outcomes and therapeutic interventions. *Current HIV/AIDS Reports*, *18*(2), 87–97. https://doi.org/10.1007/s11904-021-00541-6

Gambo, A., Gqaleni, N., & Babalola, T. K. (2022). Dietary diversity and impact of Moringa oleifera Lam. leaves supplemented – Diet on the nutritional status and CD4 cell counts of patients receiving antiretroviral therapy in Nigeria: A double-blind randomized trial. *Heliyon*, *8*(May), e09524. https://doi.org/10.1016/j.heliyon.2022.e09524

Gambo, A., Moodley, I., Babashani, M., & Babalola, T. K. (2021). Impact of Moringa oleifera leaves supplementation on quality of life of people living with HIV: A double-blind randomized controlled trial. *Quality of Life Research*. https://doi.org/10.1007/s11136-021-02842-0

Gambo, A., Moodley, I., Babashani, M., Babalola, T. K., & Gqaleni, N. (2021). A double-blind, randomized controlled trial to examine the effect of Moringa oleifera leaf powder supplementation on the immune status and anthropometric parameters of adult HIV patients on antiretroviral therapy in a resource-limited setting. *PLOS ONE*, *16*(12). https://doi.org/10.1371/journal.pone.0261935

Ganapathy, S., Harichandrakumar, K., Tamilarasu, K., Penumadu, P., & Nair, N. S. (2023). An auxiliary approach to prediction of binary outcome with Bayesian network model: Exploration with data for recurrence of breast cancer. *Journal of Clinical and Diagnostic Research*, *17*(3), 13–17. https://doi.org/10.7860/jcdr/2023/59472.17598

Gandji, K., & Assogbadjo, A. E. (2018). Factors determining the use and cultivation of Moringa oleifera in the Republic of Benin. *Economic Botany*, *72*(3), 332–345. https://doi.org/10.1007/s12231-018-9424-4

Heidkamp, R. A., Piwoz, E., Gillespie, S., Keats, E. C., Alimonte, M. R. D., Menon, P., Das, J. K., Flory, A., Clift, J. W., Ruel, M. T., Vosti, S., Akuoku, J. K., & Bhutta, Z. A. (2022). Nutraceuticals: Regulatory process across the world. *The World Journal of Biological Psychiatry*, *23*(January), 1–23. https://doi.org/10.1136/bmj.k2252

Jiang, J., Xu, X., Guo, W., Su, J., Huang, J., Liang, B., Chen, H., Zang, N., Kanters, S., Vitoria, M., Zoratti, M., Doherty, M., Penazzato, M., Rangaraj, A., Ford, N., Thorlund, K., Anis, P. A. H., Karim, M. E., Mofenson, L., ... Bansback, N. (2016). Dolutegravir (DTG, S/GSK1349572) combined with other ARTs is superior to RAL- or EFV-based regimens for treatment of HIV-1 infection: A meta-analysis

of randomized controlled trials. *EClinicalMedicine*, *28*, 1–10. https://doi.org/10.1186/s12981-016-0115-x

Jia, X. C., Xia, Z. H., Shi, N., Wang, Y. P., Luo, Z. X., Yang, Y. L., & Shi, X. Z. (2020). The factors associated with natural disease progression from HIV to AIDS in the absence of ART, a propensity score matching analysis. *Epidemiology and Infection*, *148*, e87. https://doi.org/10.1017/S0950268820000540

Keats, E. C., Neufeld, L. M., Garrett, G. S., Mbuya, M. N. N., & Bhutta, Z. A. (2019). Improved micronutrient status and health outcomes in low- and middle-income countries following large-scale fortification: Evidence from a systematic review and meta-analysis. *The American Journal of Clinical Nutrition*, *109*(6), 1696–1708.

Kekana, T. W., Marume, U., Muya, C. M., & Nherera-Chokuda, F. V. (2021). Moringa oleifera leaf meal as a feed supplement for dairy calves. *South African Journal of Animal Science*, *51*(5), 550–559. https://doi.org/10.4314/sajas.v51i5.1

Lecher, S., Ellenberger, D., Kim, A. A., Fonjungo, P. N., Agolory, S., Borget, M. Y., Broyles, L., Carmona, S., Chipungu, G., De Cock, K. M., Deyde, V., Downer, M., Gupta, S., Kaplan, J. E., Kiyaga, C., Knight, N., MacLeod, W., Makumbi, B., Muttai, H., ... Nkengasong, J. (2015). Scale-up of HIV viral load monitoring — Seven sub-Saharan African countries. *MMWR. Morbidity and Mortality Weekly Report*, *64*(46), 1287–1290. https://doi.org/10.15585/mmwr.mm6446a3

Mabapa, M. P., Ayisi, K. K., Mariga, I. K., Mohlabi, R. C., & Chuene, R. S. (2017). Production and utilization of Moringa by farmers in Limpopo Province, South Africa. *International Journal of Agricultural Research*, *12*(4), 160–171. https://doi.org/10.3923/ijar.2017.160.171

Mahomoodally, M. F., Ragoo, L., Sreekeesoon, P. D., & Khedoo, Z. M. (2013). The potential of complementary and alternative medicines in the management of HIV infection and related complications. *Spatula DD*, *3*(4), 127–140. https://doi.org/10.5455/spatula.20131025123323

Maryam, M., & Manzoor, A. (2023). Exploring the commercial versatility of Moringa oleifera: A valuable resource for diverse industries. *Journal of Plant Sciences*, *1*(1), 1–9.

Mashamaite, C. V., Pieterse, P. J., Mothapo, P. N., & Phiri, E. E. (2021). Moringa oleifera in South Africa: A review on its production, growing conditions and consumption as a food source. *South African Journal of Science*, *117*(11/12), 8689.

Matsena Zingoni, Z., Chirwa, T. F., Todd, J., & Musenge, E. (2019). HIV disease progression among antiretroviral therapy patients in Zimbabwe: A multistate Markov model. *Frontiers in Public Health*, *7*(November), 1–15. https://doi.org/10.3389/fpubh.2019.00326

Meireles, M. V., Pascom, A. R. P., Duarte, E. C., & McFarland, W. (2019). Comparative effectiveness of first-line antiretroviral therapy: Results from a large real-world cohort after the implementation of dolutegravir. *AIDS*, *33*(10), 1663–1668. https://doi.org/10.1097/QAD.0000000000002254

Melinscak, F. (2019). Tutorial: Bayesian statistics (part 1). *arXiv preprint arXiv:1905.02516*.

Michela, B., Gianni, P., A, F. S., Benedetta, R., Martina, R., Erica, C., Simona, B., Alberto, B., Alessandro, L., Laura, I., Valentina, F., Giovanna, P., Chiara, P., Carlotta, B., Roberto, C., Serena, C., Patrizia, D. M., & Emanuele, C. (2018). Nutritional characterisation of Zambian Moringa oleifera: Acceptability and safety of short-term daily supplementation in a group of malnourished girls. *International Journal of Food Sciences and Nutrition*, *69*(8), 952–963. https://doi.org/10.1080/09637486.2018.1475550

Minutolo, A., Potestà, M., Roglia, V., Cirilli, M., Iacovelli, F., Cerva, C., Fokam, J., Desideri, A., Andreoni, M., Grelli, S., Colizzi, V., Muleo, R., & Montesano, C. (2021). Plant microRNAs from Moringa oleifera regulate immune response and HIV infection. *Frontiers in Pharmacology*, *11*, 1–14. https://doi.org/10.3389/fphar.2020.620038

Monera, T. G., & Maponga, C. C. (2012). Prevalence and patterns of Moringa oleifera use among HIV positive patients in Zimbabwe: A cross-sectional survey. *Journal of Public Health in Africa*, *3*(1), 22–24. https://doi.org/10.4081/jphia.2012.e6

Mulugeta, G., & Fekadu, A. (2014). Industrial and agricultural potentials of Moringa. *Journal of Natural Sciences Research*, *4*(14), 57–63.

Murtadlo, A. A. A., Wahyuningsih, S., Turista, D. D. R., Wiguna, A., Wijayanti, A., Rachmawati, Y., Dibha, A. F., Hasan, T., Wijaya, R. M., Hafidzhah, M. A., Utami, S. L., Listiyani, P., Hikam, A. M., Chandra, N., Tamam, M. B., & Ullah, M. E. (2022). Screening of reverse transcriptase inhibitor from Moringa oleifera bioactive compound through in silico study against HIV-1. *SAINSTEK International Journal on Applied Science, Advanced Technology and Informatics*, *1*(02), 46–53. https://doi.org/10.24036/sainstek/vol1-iss02/9

Musheke, M., Bond, V., & Merten, S. (2013). Self-care practices and experiences of people living with HIV not receiving antiretroviral therapy in an urban community of Lusaka, Zambia: Implications for HIV treatment programmes. *AIDS Research and Therapy*, *10*(1), 1–13. https://doi.org/10.1186/1742-6405-10-12

Nandra, R., Parry, M., Forsberg, J., & Grimer, R. (2017). Can a Bayesian belief network be used to estimate 1-year survival in patients with bone sarcomas? *Clinical Orthopaedics and Related Research*, *475*(6), 1681–1689. https://doi.org/10.1007/s11999-017-5346-1

National Institutes of Health. (2014). Plasma HIV-1 RNA (Viral Load) and CD4 count monitoring. *AIDS Info*, 1–14.

Njonge, F. K., Judith, N. N., Kikuvi, G. M., & Tolo, F. M. (2019). Determinants of Moringa oleifera utilization among HIV positive patients attending comprehensive care clinic at Migori County Referral Hospital, Kenya. *Journal of Health Medicine and Nursing*, *4*(6), 1–16.

Nkirote, J. N. (2021). *Antiviral activity of Moringa oleifera extracts among people living with HIV and AIDS attending comprehensive care clinic at Migori County Referral Hospital,*

Kenya [Master's thesis]. Jomo Kenyatta University of Agriculture and Technology.

Nworu, C. S., Okoye, E. L., Ezeifeka, G. O., & Esimone, C. O. (2013). Extracts of Moringa oleifera Lam. showing inhibitory activity against early steps in the infectivity of HIV-1 lentiviral particles in a viral vector-based screening. *African Journal of Biotechnology*, *12*(30), 4866–4873. https://doi.org/10.5897/ajb2013.12343

O'Donnell, K., & Igoe, D. (2022). World AIDS Day: Update on epidemiology of HIV in Ireland, November 2022. Health Protection Surveillance Centre.

Oh, J. H., Craft, J., Al-lozi, R., Vaidya, M., Meng, Y., & Joseph, O. (2015). Bayesian network inference for supporting clinical decisions in radiation oncology. *Physics in Medicine & Biology*, *60*(6), 1635–1651. https://doi.org/10.1088/0031-9155/56/6/008

Oke, D. O., Orumwense, L. A., Olugbire, O. O., Oloba, O. G., Awofadeju, J. O. H., & Akanbi, S. F. (2020). Factors influencing the dis-adoption of Moringa oleifera among farming households in Oyo State, Nigeria. *Journal of Applied Sciences and Environmental Management*, *24*(4), 673–679. https://doi.org/10.4314/jasem.v24i4.20

Oyepata, J. S., & Tosin, J. (2021). Effect of clinical study of Moringa oleifera on body mass index, low density lipoprotein and triglyceride level in patients on tenofovir/lamivudine/efavirenz combination therapy. *Journal of Advances in Medicine and Medical Research*, *6*(1), 14–27.

Park, E., Chang, H. J., & Nam, H. S. (2018). A Bayesian network model for predicting post-stroke outcomes with available risk factors. *Frontiers in Neurology*, *9*(SEP), 1–11. https://doi.org/10.3389/fneur.2018.00699

Pham, M. D., Nguyen, H. V., Anderson, D., Crowe, S., & Luchters, S. (2022). Viral load monitoring for people living with HIV in the era of test and treat: Progress made and challenges ahead – a systematic review. *BMC Public Health*, *22*(1), 1–23. https://doi.org/10.1186/s12889-022-13504-2

Phillips, A. N., Bansi-matharu, L., Venter, F., Havlir, D., Pozniak, A., Kuritzkes, D. R., Wensing, A., Lundgren, J. D., Pillay, D., Mellors, J., Cambiano, V., Jahn, A., Apollo, T., Mugurungi, O., Ripin, D., Silva, J. Da, Raizes, E., Ford, N., Siberry, G. K., ... Foundation, M. G. (2020). Updated assessment of risks and benefits of dolutegravir versus efavirenz in new antiretroviral treatment initiators in sub-Saharan Africa: Modelling to inform treatment guidelines. *The Lancet HIV*, *7*(3), e193–e200. https://doi.org/10.1016/S2352-3018(19)30400-X

Pilotos, J., Ibrahim, K. A., Mowa, C. N., & Opata, M. M. (2020). Moringa oleifera treatment increases Tbet expression in CD4+ T cells and remediates immune defects of malnutrition in Plasmodium chabaudi-infected mice. *Malaria Journal*, *19*(1), 1–16. https://doi.org/10.1186/s12936-020-3129-8

Praygod, G., Friis, H., & Filteau, S. (2018). Nutritional support to reduce mortality in patients with HIV? *The Lancet HIV*, *5*(5), e202–e204. https://doi.org/10.1016/S2352-3018(18)30047-X

Praygod, G., Kasonka, L., Woodd, S., Rehman, A. M., Chisenga, M., Siame, J., Koethe, J. R., Changalucha, J., Michael, D., Kidola, J., Manno, D., Larke, N., Yilma, D., Heimburger, D. C., Friis, H., & Kelly, P. (2015). Effects on mortality of a nutritional intervention for malnourished HIV-infected adults referred for antiretroviral therapy: A randomised controlled trial. *BMC Medicine*, *13*(1), 1–13. https://doi.org/10.1186/s12916-014-0253-8

Puga, J. L., Krzywinski, M., & Altman, N. (2015). Points of significance: Bayesian networks. *Nature Methods*, *12*(9), 799–800. https://doi.org/10.1038/nmeth.3550

Qadir, R., Anwar, F., Bashir, K., Tahir, M. H., & Ibrahim, M. (2022). Variation in nutritional and antioxidant attributes of Moringa oleifera L. leaves at different maturity stages. *Frontiers in Energy Research*, *10*, 1–7. https://doi.org/10.3389/fenrg.2022.888355

Repaka, A. N., Ravikanti, S. D., & Franklin, R. G. (2019). Design and implementing heart disease prediction using naives Bayesian. In *Proceedings of the International Conference on Trends in Electronics and Informatics (ICOEI 2019)* (pp. 292–297). IEEE. https://doi.org/10.1109/icoei.2019.8862604

Roberts, T., Cohn, J., Bonner, K., & Hargreaves, S. (2016). Scale-up of routine viral load testing in resource-poor settings: Current and future implementation challenges. *Clinical Infectious Diseases*, *62*(8), 1043–1048. https://doi.org/10.1093/cid/ciw001

Ross, J. M., Ying, R., Celum, C. L., Baeten, J. M., Thomas, K. K., Murnane, P. M., van Rooyen, H., Hughes, J. P., & Barnabas, R. V. (2018). Modeling HIV disease progression and transmission at population-level: The potential impact of modifying disease progression in HIV treatment programs. *Epidemics*, *23*, 34–41. https://doi.org/10.1016/j.epidem.2017.12.001

Rutherford, G. W., & Horvath, H. (2016). Dolutegravir plus two nucleoside reverse transcriptase inhibitors versus efavirenz plus two nucleoside reverse transcriptase inhibitors as initial antiretroviral therapy for people with HIV: A systematic review. *PLOS ONE*, *11*(10), e0162775. https://doi.org/10.1371/journal.pone.0162775

Sauce, D., Larsen, M., Fastenackels, S., Pauchard, M., Ait-Mohand, H., Schneider, L., Guihot, A., Boufassa, F., Zaunders, J., Iguertsira, M., Bailey, M., Gorochov, G., Duvivier, C., Carcelain, G., Kelleher, A. D., Simon, A., Meyer, L., Costagliola, D., Deeks, S. G., ... Appay, V. (2011). HIV disease progression despite suppression of viral replication is associated with exhaustion of lymphopoiesis. *Blood*, *117*(19), 5142–5151. https://doi.org/10.1182/blood-2011-01-331306

Seifu, E., & Teketay, D. (2020). Introduction and expansion of Moringa oleifera Lam. in Botswana: Current status and potential for commercialization. *South African Journal of Botany*, *129*, 471–479.

Shifera, N., Yosef, T., Matiyas, R., Kassie, A., Assefa, A., & Molla, A. (2022). Undernutrition and associated risk factors among adult HIV/AIDS patients attending antiretroviral therapy at public hospitals of Bench Sheko Zone,

Southwest Ethiopia. *SAGE Open Medicine*, *10*, 1–10. https://doi.org/10.1177/23259582221079154

Sihag, G., Delcroix, V., Grislin-Le Strugeon, E., Piechowiak, S., Gaxatte, C., & Puisieux, F. (2021). Evaluation of risk factors for fall in elderly using Bayesian networks: A case study. *Computer Methods and Programs in Biomedicine Update*, *1*, 100035. https://doi.org/10.1016/j.cmpbup.2021.100035

Stap, L. Van Der, Haaften, M. F. Van, Marrewijk, E. F. Van, Heij, A. H. De, Jansen, P. L., Burgers, J. M. N., Sieswerda, M. S., Los, R. K., Reyners, A. K. L., & Linden, Y. M. Van Der. (2022). The feasibility of a Bayesian network model to assess the probability of simultaneous symptoms in patients with advanced cancer. *Scientific Reports*, *12*(1), 1–11. https://doi.org/10.1038/s41598-022-26342-4

Stevens, C. O., Ugese, F. D., & Baiyeri, K. P. (2015). Utilization potentials of Moringa oleifera in Nigeria: A preliminary assessment. *International Letters of Natural Sciences*, *40*, 30–37. https://doi.org/10.18052/www.scipress.com/ilns.40.30

Tosin, J. O., Wolfe, O. A., Iyeopu, S. M., Simeon, J. O., & Lubo, M. T. (2019). Clinical study on the effect of Moringa oleifera on serum level of glucose and triglyceride in subjects taken tenofovir, lamivudine and efavirenz combination regimen. *European Scientific Journal*, *15*(21), 280–293. https://doi.org/10.19044/esj.2019.v15n21p280

Tshingani, K., Donnen, P., Mukumbi, H., Duez, P., & Dramaix-wilmet, M. (2017). Impact of Moringa oleifera lam. leaf powder supplementation versus nutritional counseling on the body mass index and immune response of HIV patients on antiretroviral therapy: A single-blind randomized control trial. *BMC Complementary and Alternative Medicine*, *17*(1), 1–13. https://doi.org/10.1186/s12906-017-1920-z

Um, S., & Adhikari, S. (2022). Considerations in Bayesian agent-based modeling for the analysis of COVID-19 data. *Frontiers in Public Health*, *10*, 1–26.

United Nations. (2020). Sustainable Development Goals: Guidelines for the Use of the SDG Logo including the Color Wheel, and 17 Icons. United Nations Department of Global Communications, 1–68.

UNAIDS. (2021). Global HIV statistics. Fact Sheet 2021, 1–3.

UNAIDS. (2022). The sustainable development goals report. United Nations.

Velasco, C. R., & Canada, M. C. B. (2022). Determinants of farmers' willingness to cultivate Moringa oleifera: The case of Dipaculao, Aurora, Philippines. *Asian Journal of Agriculture and Rural Development*, *12*(4), 279–286. https://doi.org/10.55493/5005.V12I4.4671

Villarreal, M., Anyonge, C. H., Swallow, B., & Kwesiga, F. (2006). The challenge of HIV/AIDS: Where does agroforestry fit in? In *World Agroforestry into the Future* (pp. 181-192). World Agroforestry Centre.

Vitoria, M., Hill, A., Ford, N., Doherty, M., Clayden, P., Venter, F., Ripin, D., Flexner, C., & Domanico, P. L. (2018). The transition to dolutegravir and other new

antiretrovirals in low-income and middle-income countries: What are the issues? *AIDS*, *32*(12), 1551–1561. https://doi.org/10.1097/QAD.0000000000001845

Wardana, M. S., Jufri, M., & Mun'im, A. (2022). Physicochemical properties and nutrition of Moringa oleifera Lam. leaf extract: A preliminary study on preparation phytosomes as herbal supplement for children. *International Journal of Applied Pharmaceutics*, *14*(1), 281–287. https://doi.org/10.22159/ijap.2022v14i1.43477

World Health Organization. (2018). Dolutegravir (DTG) and the fixed dose combination (FDC) of tenofovir/lamivudine/dolutegravir (TLD) briefing note. World Health Organization, 1–10.

World Health Organization. (2019). Update of recommendations on first- and second-line antiretroviral regimens. World Health Organization.

World Health Organization. (2023). Epidemiological fact sheet HIV statistics, globally and by WHO region, 2023. World Health Organization.

World Health Organization. (2022). Update on the transition to dolutegravir-based antiretroviral therapy: Report of a WHO meeting, 29–30 March 2022. World Health Organization.

ZAMPHIA. (2016). Zambia Population-Based HIV Impact Assessment. *Journal of the International AIDS Society*, *20*(S7), 1–4.

ZAMPHIA. (2021). Zambia Population-Based HIV Impact Assessment 2021. ICAP at Columbia University.

Zandonà, A., Francescon, M., Bronfeld, M., Calvo, A., Chiò, A., & di Camillo, B. (2017). A dynamic Bayesian network model for simulation of disease progression in amyotrophic lateral sclerosis patients. *PeerJ*, *5*(Suppl 4), 1–11. https://doi.org/10.7287/peerj.preprints.3262v1

ZCGTP. (2020). Zambia Guidelines for Treatment and Prevention of HIV Infection. Zambia Ministry of Health.

Zhou, L., Shi, W., Assanangkornchai, S., Vichitkunakorn, P., & Tang, J. (2022). Application of Bayesian networks to identify factors influencing acceptability of HIV pre-exposure prophylaxis in Guilin, China. *Scientific Reports*, *12*(1), 1–12. https://doi.org/10.1038/s41598-022-24965-1

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