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Climate Change, Malnutrition, and HIV: The Impact of Food Insecurity on HIV Response in  
Sub-Saharan Africa

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Fall 2023

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## **Abstract**

Climate change is a key driver of an unprecedented global food crisis, exacerbated by rising temperatures and the vulnerability of crop yields. Sub-Saharan Africa is particularly susceptible, and case studies demonstrate the fragility of food systems in the region, leading to severe food insecurity and famine in the face of climate shocks.

There are a variety of health implications, particularly the syndemic relationship between malnutrition and HIV. HIV interacts bidirectionally with malnutrition, creating a vicious cycle of poor clinical outcomes. Expanding access to antiretroviral therapy in Sub-Saharan Africa is hindered by rampant food insecurity, including inadequate food intake, reduced dietary diversity, and compromised treatment adherence for people living with HIV.

Studies show that nutritional interventions positively impact ART adherence and clinical outcomes. Contrasting approaches of aid organizations reveal successes, like UNAIDS, WFP, and PATH, against pitfalls, such as PEPFAR in Mozambique. Despite progress, challenges persist, including the recent focus on climate change resilience, underlying inequalities, and the need for more diversified and climate-resilient nutrition programs.

Mitigation efforts should focus on building resilience in Sub-Saharan Africa's food systems, integrating diversified nutrition support into HIV treatment programs, and collaborative efforts among major aid organizations to effectively address food security and HIV response.

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## I. Introduction

Food systems encompass a wide range of human and environmental activities from production to consumption (B. Syme, personal communication, September 14th, 2023). They are fundamental to public health, economies, and ecosystems worldwide (Ericksen, 2008). There have been tremendous advances in food system productivity throughout the ages, but in spite of these advances, chronic food insecurity persists in multiple regions of the world (Ericksen, 2008). A primary factor in this trend is global climate change (Teng et al., 2015). Food systems are susceptible to the ongoing changes in nutrient cycles, hydrological cycles, and pollution, which has resulted in decreased food security (Ericksen, 2008). The malnutrition resulting from this food crisis has a profound impact on public health issues, especially concerning the treatment of the Human Immunodeficiency Virus (HIV) /Acquired Immunodeficiency Syndrome (AIDS).

In 2022, there were over 39 million people diagnosed with HIV (*HIV and AIDS epidemic global statistics, 2023*). In that same year, it was estimated that 76% of people with HIV were accessing antiretroviral therapy (ART) globally (*HIV and AIDS epidemic global statistics, 2023*). However, malnutrition significantly impacts the mortality rates of populations living with HIV, as well as ability to adhere to ART treatment (Wanke, 2005). Adequate nutrition is vital for optimal immune system functioning (Grobler et al., 2013). Malnutrition further compromises HIV positive individuals and decreases the effectiveness of ART (Wanke, 2005).

This independent study project aims to explore how malnutrition influences treatment for HIV in the context of food security and climate change in Sub-Saharan Africa. This project will evaluate to what extent different aid organizations account for nutrition when designing and implementing HIV treatment programs, and will synthesize observations of the impact of

malnutrition on HIV response. The purpose of this study is to evaluate why nutrition is important in HIV response, and how sustainable treatment programs are in the face of the changing climate. There are multiple research gaps being addressed by this study. Many food insecurity studies do not account for people living with HIV/AIDS (PLWHA), and while some prominent international aid organizations account for nutrition when designing treatment programs, those programs are threatened by climate change. Furthermore, there are very few studies examining these topics combined. This study will combine the value of field research and secondary data to approach this issue from a new angle. This study will incorporate concepts of planetary health, global climate change, and public health to review the connections between nutrition, food security, climate change, and HIV.

This study will focus specifically on the region of Sub-Saharan Africa due to a variety of factors. Sub-Saharan Africa is the region most severely affected by food insecurity worldwide (Dyvik, 2023). Compounding this issue, Sub-Saharan Africa is also disproportionately affected by HIV/AIDS (*HIV and AIDS epidemic global statistics*, 2023). Approximately 64% of people living with HIV/AIDS live in Sub-Saharan Africa (Nabatanzi & Nakalembe, 2016). The double burden of HIV/AIDS and food insecurity presents a significant challenge for this resource-limited region, resulting in serious increases in morbidity and mortality (Nabatanzi & Nakalembe, 2016).

The analysis will progress through three main sections. First, this paper will review the regional impact of climate change on food systems in Sub-Saharan Africa, as well as to what extent these food systems are resilient to the changing climate. Next, this paper will review the public health perspective of HIV and nutrition. Finally, this paper will compare and contrast a variety of aid organizations active in Sub-Saharan Africa, in order to establish optimal practices.

This study will evaluate access and adherence to ART, and map from a pragmatic perspective effective methods for addressing nutrition in the context of HIV and climate change.

## **II. Research Methodology**

This research study utilizes a multisectoral approach to complete a comprehensive analysis of malnutrition, climate change, and HIV treatment. This mixed-methods strategy includes the collection of qualitative primary data as well as the collection of published gray literature and peer-reviewed scientific articles. This paper utilizes both qualitative and quantitative data to portray an accurate picture of the research objective. This topic was chosen for its interdisciplinary nature, with connections to environmental studies, planetary health, public health, policy development, humanitarian action, and more. Exploring this topic from a variety of angles was fundamental to an integrated research approach, and as such, this study utilizes both a case study approach and a comparative analysis approach.

In terms of secondary data collection, the process began with a broad review of gray literature and scientific articles in order to develop a basic understanding of the relationship between climate change and food security, as well as the relationship between HIV and malnutrition. This process utilized academic journals, research reports, online databases, and publications from prominent non-governmental organizations (NGOs). The problem statement matrix was utilized to isolate the threat malnutrition poses toward HIV, who is most affected by this issue, and what is being done to solve this issue. Academic information was sourced through JSTOR, PubMed, Google Scholar, EBSCOhost, The Lancet, Journal of Global Health, and The National Library of Medicine. Keywords and phrases included, but were not limited to, “food security,” “malnutrition,” “HIV/AIDS,” “climate change,” “Sub-Saharan Africa,” “Kenya,” “Mozambique,” “Antiretroviral therapy,” and “treatment programs.” This data collection method



also utilized publications from the World Health Organization (WHO), the World Food Programme (WFP), and other prominent organizations working in food security or HIV.

## **Interviews**

This study collected primary qualitative data through two formal interviews, and one informal interview. These interviewees were selected based on their status as practitioners in health and development with field or research knowledge on HIV treatment programs active in Sub-Saharan Africa. The first interview, Dr. Medhin Tsehau, was chosen because she is the Joint United Nations Programme on HIV/AIDS (UNAIDS) Country Director for Kenya. She was identified to provide information on how UNAIDS is active in this region, and in what ways they factor nutrition into strategies for treatment. She was also selected because she was previously a research officer in a nutrition laboratory at the Institute of Biodiversity Conservation in Ethiopia, lending her expertise to all dimensions of this project. The second interview, Rikka Trangsrud, was chosen because she was the Program for Appropriate Technology in Health (PATH) Country Director for Kenya. She is a seasoned global health professional with considerable knowledge on nutrition within HIV treatment, who also has extensive experience in this region of Africa. The third interview is Benjamin Syme, a guest lecturer for this program and an external partnerships officer for the World Food Programme. He was chosen due to his knowledge of the WFP as well as nutrition and HIV treatment.

A majority of the information gathered from these professionals is utilized in the third section of the analysis. However, this was intentional. There is a large wealth of information regarding the first two sections in the analysis, and as a result there was no need to seek out professional knowledge. The interviewees were chosen primarily to provide insight into the third section of the analysis concerning the strategies and thought processes behind the actions of aid

organizations, for which there is not much literature. These interviewees were selected to gather first-hand observations, record expert knowledge, and expand the perspectives included in this study.

### **Limitations and Ethics**

This study was, first and foremost, limited by time. The research discussed, analyzed, and presented by this study was conducted on a condensed timeline due to the nature of the program. Due to this time constraint, the collection of primary data was severely limited. As there are only three interviews included, the sample size of interviewees is small.

Another significant limitation for the collection of primary data was non-responses from potential interviewees. Despite repeated efforts to reach out to over 40 experts in this field, only a few were available to respond or participate in interviews. Furthermore, the primary data in this study is limited by a last-minute formal interview cancellation. Due to this last-minute cancellation, the structure of a formal interview had to be shifted to a very brief informal interview with a professional encountered earlier in the research process. As the collection of primary data was limited, the style and structure of this paper had to shift in order to account for this limitation. This led to the inclusion of substantial secondary data review in the analysis, and a condensed version of a literature review. The collection of secondary data was limited by lack of open access, as well as a lack of material critiquing the actions of aid organizations active in Sub-Saharan Africa.

Finally, this project is limited by design. This study project covers two very expansive topics in the form of climate change and food security, and nutrition and HIV response. Both of these topics are large enough to merit an independent study project individually; however, these broad topics were combined intentionally. As will be discussed, there is a wealth of information

and literature examining climate change and food security and examining nutrition and HIV respectively. However, there is a gap when it comes to examining these two issues together, and that is the gap this study aims to fill.

It should be noted that a full Human Subject Review for this study was completed, submitted, and approved by the Local Research Board at the start of the research process. Ethical guidelines of confidentiality, anonymity, and privacy were discussed with all interviewees. For the recording and transcription of all interviewees, informed oral consent was obtained. This project will be made available to any of the participants included in this study upon request. All the content gathered from interviews and utilized in this study was approved by the participants. No vulnerable populations were identified to be involved in this study, so there were not many ethical obstacles.

### **III. Literature Review**

There is an expansive body of literature on the first chapter of the analysis, concerning the impact of climate change on food security in Sub-Saharan Africa. Research on this topic is often directed towards the impact of climate change on crop and livestock productivity, as well as assessing food system resiliency. In order to clearly define what food security is and outline the threat that climate change poses, Ericksen (2008), Adesete et al. (2022), Teng et al. (2015), and Dasgupta & Robinson (2022) are fundamental publications. Ericksen (2008) defines food security as “all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs”. Building off of similar definitions, Adesete et al. (2022) discusses the risk that food insecurity poses to nutrition, and Teng et al. (2015) discusses the two factors that make a food system vulnerable to climate change - geographic location, and level of exposure. Dasgupta & Robinson (2022) agrees with these authors that climate change

has a negative effect on food security, and stresses the importance of focusing action toward changes in food insecurity that can be attributed to climate change.

To link this analysis more specifically to countries in Sub-Saharan Africa, this study analyzed the work of Kabubo-Mariara & Kabara (2015), Verschuur, Wolski, & Otto (2021), and publications from ReliefWeb and PreventionWeb. ReliefWeb published an article titled *Food security and nutrition receive a boost in Mozambique* (2023), which analyzes the agricultural sector in Mozambique and its vulnerability to climate change. PreventionWeb published an article titled *the impacts of climate change on food security and livelihoods in Karamoja* (2017), which analyzes the threat that changing weather patterns pose to food security in Uganda. Kabubo-Mariara & Kabara (2015) conducted a study assessing the availability, accessibility, utilization, and stability of four major crops in Kenya, including maize and beans. Verschuur et al. (2021) conducted a study analyzing the role that droughts play in food shocks in Lesotho. Similar to Kabubo-Mariara & Kabara (2015), this study focused mainly on the production of maize, which is a staple food in Lesotho. All four publications agree that the agricultural systems in Sub-Saharan are extremely vulnerable to climate change.

Several of these articles also specifically discuss the impact of climate change on crop yields. Kabubo-Mariara & Kabara (2015), Adesete et al. (2022), Teng et al. (2015), in conjunction with Masson-Delmotte (2022) all state that increased temperatures and variability of precipitation result in a decreased crop yield. Masson-Delmotte (2022) calls attention to maize and wheat as being particularly at risk in lower-latitude regions such as Sub-Sahara. Kabubo-Mariara & Kabara (2015) specifically states that by 2050, there will be a 21% decline per person in food availability in Sub-Saharan. This decline is largely due to the vulnerability of rice, wheat, and maize to changing climatic conditions (Kabubo-Mariara & Kabara, 2015). It is generally

accepted that climate change is having a negative impact on food security. The literature agrees that Sub-Saharan Africa is a region with high food insecurity and climate change vulnerability. According to the literature, crop yields will continue to decrease significantly, and by correlation nutritional issues will increase. This trend poses a significant threat to public health by increasing the double burden of disease.

The previous sources are used to establish the threat of climate change to food security and implicate nutritional issues within that process. The second chapter of the analysis seeks to establish and investigate the relationship between malnutrition and HIV. Adesete et al. (2022) is a pivotal source for establishing a link between the climate change and food security chapter, and the nutrition and HIV chapter. Building off of that link, there is also a well-developed body of literature examining the relationship between nutrition and HIV. In order to round out the other part of this analysis, Dyvik (2023), Wanke (2005), and a publication from the World Health Organization (WHO) (2023) are critical sources regarding the definition of malnutrition in the context of HIV/AIDS. Dyvik (2023) and WHO (2023) discuss the impact of nutrition on HIV disease progression, while Wanke (2005) discusses malnutrition as a prediction for mortality and morbidity. CDC (2022) and a publication from the United States (US) Department of Health and Human Services are utilized to explain the mechanics of HIV in order to establish the framework in which nutrition is a factor for this virus.

In order to analyze the relationship between ART and nutrition, Koethe et al. (2014), Juma et al. (2016), Byron et al. (2008), Grobler et al. (2013), and a publication by UNAIDS titled *HIV, Food Security, and Nutrition* (2008) are fundamental sources. Koethe et al. (2014) and Juma et al. (2016) both state that expanded access to ART for PLWHA in Sub-Saharan Africa has occurred within the context of poverty, underdevelopment, and food insecurity, which

links to the previously mentioned concepts of climate change and food security. Byron et al. (2008) calls for a deeper understanding of HIV treatment and chronic food insecurity. Answering this call, Grobler et al. (2013) and UNAIDS (2008) discuss the effectiveness of nutrition supplementation interventions in HIV treatment programs. UNAIDS (2008) agrees that nutrition supplementation results in greater adherence and reduced side effects of ART. However, while Grobler et al. (2013) did find that macronutrient interventions result in increased protein and energy intake, they found no evidence supporting the conclusion that macronutrient supplementation reduces HIV progression and disease complications. While this is a very prominent disagreement, Grobler et al. (2013) is the only source that was discovered in the process of secondary data gathering to come to this conclusion. A multitude of other studies have found evidentiary support that nutrition supplementation improves HIV health outcomes in Sub-Saharan Africa.

Onyango, Walingo, and Othuon (2009) and Agatha et al. (2010) set the context for these studies. Onyango et al. (2009) examined the nutrient intake of HIV affected households in Kenya, and found that households mostly consumed starch foods, since low-income farming meant they could not purchase nutritious foods. Building off of that study, Agatha et al. (2010) examined the expenditure patterns on food and non-food items in Kenya, and found that HIV positive households spend more on medication than food, leading to greater food insecurity in those households. Chesire et al. (2012) and Nagata et al. (2014) also conducted studies in Kenya, and found that integrated nutrition programs can improve the nutritional status of children with HIV, as well as raise the body mass index of HIV positive adults respectively.

Palermo et al. (2013) and Weiser et al. (2010) both conducted studies in Uganda. Palermo et al. (2013) investigated the relationship between household food access and quality of life for

PLWHA, while Weiser et al. (2010) investigated the mechanisms through which food security leads to ART treatment adherence issues. Both studies concluded that food access is vital to effective and tolerable ART treatment. Saloojee et al. (2007) and Musakwa et al. (2020) both conducted studies in South Africa. Saloojee et al. (2007) identified HIV as a risk factor for child malnutrition, while Musakwa et al. (2020) investigated the challenges in confronting nutritional issues among children living with HIV.

A majority of the literature agrees that malnutrition acts as a dangerous syndemic for HIV/AIDS. Research on this topic is largely directed towards antiretroviral therapy because of how ARTs increase nutritional requirements beyond that of HIV alone. While Grobler et al. (2013) did disagree with the conclusions of other authors referenced in this study, a vast majority of the literature exploring this issue agrees that malnutrition accelerates HIV progression, contributes to increased morbidity and mortality, and complicates ART adherence. A great number of the authors discussed agree that an integrated nutrition supplementation response should be established within HIV treatment programs to improve health outcomes.

The third and final chapter of this analysis looks into a variety of aid organizations that are active in Sub-Saharan Africa. One of the more notable aid organizations analyzed in this study is PEPFAR. Kalofonos (2010) and Zakumumpa et al. (2021) are integral sources when it comes to analyzing the work of PEPFAR. Kalofonos (2010) critiques PEPFAR for a lack of attention towards food insecurity when creating programs for treatment in Sub-Saharan Africa. Zakumumpa et al. (2021) explores the donor transition period when PEPFAR is withdrawing from a location, and this source was included in order to contribute towards the analysis of long-term sustainable aid efforts. Another notable aid organization that is critical to this analysis is the World Food Programme. In order to assess the WFP's mission and current works, information

was cited directly from their website, including *HIV/AIDS and tuberculosis*. The analysis of this organization relies primarily on the primary data collected.

The final two aid organizations included in this analysis are UNAIDS and the Program for Appropriate Technology in Health (PATH). Supporting sources used to analyze PATH were all gathered directly from their website, including *Better Health Moves Humanity Forward*, *HIV/AIDS*, and *Kenya*. These sources were used to support the collection of primary data on this organization, establish PATH's mission and general contributions, and their role in HIV/AIDS response. A majority of the information gathered on UNAIDS was done so through primary data collection.

This section concludes with the analysis of several research projects that provide nuanced, climate-sensitive approaches to confronting nutritional issues in HIV/AIDS response. Nicastro et al. (2022) confirms that much of existing literature demonstrates the interconnectedness of food insecurity, malnutrition, and HIV health, and expands on this body of literature by investigating how agricultural livelihood interventions may affect these domains. Nabatanzi & Nakalembe (2016) and Wamono et al. (2011) are similar in that they investigate wild plant food species (WIFPs) and bananas respectively, and how the promotion of these local foods can aid in nutritional efforts within HIV response. Koethe et al. (2014) analyzes a nutrient supplementation program in resource constrained settings, with broader implications for cost effectiveness and program retention.

In combination with Koethe et al., these sources set the groundwork for future research and collaborative HIV response. Finally, Orago (2017) supports the framework that food security strategies in Sub-Saharan should be implemented on a human rights basis, which is a concept supported by the work of UNAIDS. These sources lay the groundwork for an analysis of the



ways that HIV treatment programs can evolve and collaborate with climate resiliency initiatives to improve health outcomes for PLWHA in Sub-Saharan Africa.

## IV. Analysis

### Regional Impact of Climate Change on Food Security

#### *A Global Food Crisis*

The current scale of the hunger crisis is enormous. In 2023, two billion people were in situations of moderate to severe food insecurity (Verschuur et al., 2021). Of this number, 345 million new people faced high levels of food insecurity, which is more than double the amount of people in 2020 (B. Syme, personal communication, September 14th, 2023.). One of the factors of this crisis is climate change (B. Syme, personal communication, September 14th, 2023).

The four elements of food security include the access, utilization, stability, and availability of food (B. Syme, personal communication, September 14th, 2023). These elements are directly and indirectly impacted by climate change (Kabubo-Mariara & Kabara, 2015). Climate imposed risks to food security are driven by more frequent weather events, exposure to climate extremes, changing precipitation patterns and rising global temperatures (Masson-Delmotte, 2022). Natural disasters lead to the destruction of infrastructure, which results in a decreased availability of food and a rise in food prices (B. Syme, personal communication, September 14th, 2023). Extended climate extremes, such as drought or variable precipitation events, also lead to high food loss and damages (Teng et al., 2015).

A study by Dasgupta & Robinson (2022) found that for every 1 °C temperature increase, global food insecurity increased by 2.14% in 2019. The results of this study not only showed that

rising temperatures and food insecurity are directly related, but also tracked this trend throughout time (Dasgupta & Robinson, 2022). In 2014 food insecurity increased by 1.4% for every 1 °C, and in 2019 it nearly doubled, showcasing that the magnitude of this issue is growing as time is passing (Dasgupta & Robinson, 2022). As a result of these increasing temperatures, the distribution of crop yields is changing over time as well (Ericksen, 2008). Climate change is making it difficult for farmers to predict weather patterns (Teng et al., 2015). In fact, Verschuur et al. (2021) found that climate variability accounts for 30% of variability on agricultural yields. Crop heat tolerance severely limits the ability of certain agricultural production regions to adapt to these changes (Teng et al., 2015). Due to all of these climate factors, food insecurity can be expected to continue to worsen as global temperatures continue to rise.

As discussed in the literature review, there are two factors that determine the susceptibility of a food system to climate change (Teng et al., 2015). Both due to its geographic location and level of exposure, Sub-Saharan Africa is particularly threatened by the changing climate. A majority of the countries in this region have been repeatedly exposed to severe weather events, as well as rising climate temperatures and decreased crop yields (Masson-Delmotte, 2022). Studying food security in this region is vital to ensuring that those most at risk are given the tools and knowledge necessary to adapt to these issues.

### *Case Studies in Sub-Sahara: Challenges and Resiliency*

In Kenya, Kabubo-Mariara & Kabara (2015) investigated the effects of climate change on food security from 1975 to 2012, and also predicted the future impacts of climate change on food security. This study focused on the availability of the four most important crops for Kenya, including maize, millet, sorghum, and beans (Kabubo-Mariara & Kabara, 2015). Kabubo-Mariara & Kabara (2015) concluded that, as a result of climate change mechanisms, the highest

incidence of food insecurity is associated with maize, followed by beans and sorghum. This has severe implications for the nutritional status of Kenyans, who rely on these crops as fundamental sources of food.

Furthermore, Kenya relies on rain-fed agriculture, making their food systems particularly susceptible to droughts (Orago, 2017). In fact, there is currently an ongoing drought in northern Kenya, which has resulted in massive losses in livestock and agriculture, including harvest failure, deteriorating pasture conditions, and decreased water availability (M. Tsehau, personal communication, November 21st, 2023). In other regions of Kenya, heavy floods caused by an El Nino are destroying people's livelihoods (M. Tsehau, personal communication, November 21st, 2023). This has exposed the people in this region to food insecurity and famine (M. Tsehau, personal communication, November 21st, 2023).

Similarly, Verschuur et al. (2021) evaluated the extent to which the 2007 drought in Lesotho and South Africa resulted in a period of severe food insecurity. The study found that this drought led to a synchronous crop failure in both countries, which had the largest impact on maize production (Verschuur et al., 2021). Similar to Kenya, maize is a staple food in both Lesotho and South Africa, accounting for 80% of rural diets (Verschuur et al., 2021). As a result of the drought, maize production dropped 40% (Verschuur et al., 2021). The second most fundamental crop for this region, sorghum, dropped in production 42% (Verschuur et al., 2021). On top of this production loss, the price of maize spiked 41%, which exposed small farmers with low incomes to disproportionate impacts of this drought (Verschuur et al., 2021). Over 20% of the population in Lesotho was considered severely food insecure (Verschuur et al., 2021). All of the studies conducted in Kenya and Lesotho demonstrate that the food systems in this region are incredibly fragile when faced with climate shocks, which directly lead to famine.

Similar trends can be seen in Mozambique and Uganda. In Mozambique, small farmers provide 94% of the food locally consumed (*Food security and nutrition receive a boost in Mozambique*, 2023). However, Mozambique has been experiencing more frequent and intense weather events, and a recent cyclone destroyed over 66,000 hectares of agricultural land, which exposed the country to increased food insecurity (*Food security and nutrition receive a boost in Mozambique*, 2023). Similarly, in the Karamoja region of Uganda, the rainy season has grown longer by two months in the last 35 years, and the rains are increasingly unpredictable in volume and duration, which has undermined food production and increased food insecurity (*The impacts of climate change on food security and livelihoods in Karamoja*, 2017).

As seen in all of these specific case studies, the food systems in Sub-Saharan Africa are incredibly vulnerable to climate change mechanisms. It has been proven multiple times that past climate events have resulted in increased food insecurity and famine. As climate change continues to increase global temperatures and weather event variability, crop yields for staple foods like maize will continue to decrease. Due to the lack of resilience and adaptability of crops like these, the public health implications of climate change and food insecurity are severe.

### ***Malnutrition and Health***

Food insecurity is one of the primary causes of poor public health (B. Syme, personal communication, September 14th, 2023). As a result of climate change, achieving nutrition security is a major health challenge in Sub-Saharan Africa (Adesete et al., 2022). According to Orago (2017), a quarter of the world's undernourished live in Sub-Saharan Africa, and this number has consistently increased by over 38 million since 1990. Average temperatures and precipitation variabilities are expected to keep increasing in the coming years (Adesete et al., 2022). Kabubo-Mariara & Kabara (2015) predicts that by 2050, yields from rain-dependent

agriculture could drop by 50%. Based on the trends seen and discussed so far, the result will be a massive increase in malnutrition in Sub-Saharan Africa. Malnutrition poses a significant threat to public health, especially when combined with other prominent diseases (Dyvik, 2023). One such double burden combination is malnutrition and HIV.

## **A Public Health Perspective: Nutrition and HIV**

### *The Human Immunodeficiency Virus*

HIV is a virus that destroys CD4 T lymphocyte cells, which play a major role in the human immune system (*HIV treatment: The basics*, n.d.). HIV uses CD4 cell mechanisms to multiply and spread throughout the body, where it continues to destroy the immune system (CDC, 2022). If HIV goes untreated, it progresses through an acute infection stage, a chronic infection stage, and then is classified as AIDS (CDC, 2022). Since HIV primarily attacks the human immune system, it leaves the body vulnerable to opportunistic infections, which are commonly pneumonia, tuberculosis, candidiasis, toxoplasmosis, and more (*HIV treatment: The basics*, n.d.). HIV has no cure, but it can be treated through antiretroviral therapies, which target a variety of steps in the HIV life cycle (*HIV treatment: The basics*, n.d.). The main goal of this treatment is to reduce the viral load to an undetectable level, which is often expressed as Undetectable = Untransmittable (M. Tsehau, personal communication, November 21st, 2023).

### *Why Nutrition Matters in HIV Response*

Food is a basic requirement of living, and it is vital to the functioning of the human immune system (Kalofonos, 2010). Malnutrition results from an inadequate intake of calories, increased energy demands, or inadequate intake of micronutrients (Wanke, 2005). In regions

where both malnutrition and HIV are common, such as Sub-Saharan Africa, there are a variety of causes for concern. The health of those who are malnourished is further compromised by HIV infection (Dyvik, 2023).

Compromised immunity reduces the body's ability to absorb food, since there is a certain level of fats and nutrients required in order to absorb necessary vitamins (Kalofonos, 2010). Furthermore, malnutrition accelerates weight loss and immunosuppression (Koethe et al., 2014). Historically, "HIV-associated wasting" was one of the most common clinical presentations, so much so that HIV infection was sometimes referred to as "slim disease" (Wanke, 2005). Multiple studies have found that malnutrition predicts mortality in HIV positive populations, where even a 5% weight loss directly increases the risk of mortality (Wanke, 2005). It is for these reasons that malnutrition and HIV make a deadly combination.

HIV can also contribute to malnutrition in food insecure regions. HIV increases the resting energy expenditure of the human body (Kalofonos, 2010). Adults with HIV have a 30% increase in energy requirements, and children can have up to a 100% increase in energy requirements (*HIV, Food Security, and Nutrition*, 2008). An HIV diagnosis is often indistinguishable from severe malnutrition (Kalofonos, 2010). Therefore, the association of malnutrition and HIV is bidirectional, in that HIV impacts nutritional status and malnutrition impacts HIV progression (Wanke, 2005).

There is also a dimension within HIV treatment. Taking ART increases a person's resting energy expenditure beyond even that of HIV alone (Kalofonos, 2010). Furthermore, ART medications require good nutrition to function optimally, and malnutrition directly interferes with that process (B. Syme, personal communication, September 14th, 2023). Without the proper nutrition, PLWHA will get sick upon consumption of ART, which eventually leads to a lack of

adherence, an increase in viral load, and the further spread of HIV (B. Syme, personal communication, September 14th, 2023). This reinforcing process forms the basis for the syndemic relationship between malnutrition and HIV. There are a variety of studies based in Sub-Saharan Africa that analyze the relationship between nutrition and HIV treatment. The expansion of ART access in Sub-Saharan Africa has been compounded by rampant food insecurity, which as discussed, is an issue that is only growing worse (Juma et al., 2016).

### *Case Studies in Sub-Sahara*

In Kenya, Juma et al. (2016) found that over 70% of PLWHA seeking treatment at the Amref Clinic in Kibera had inadequate food intake. As discussed in the literature review, Onyango et al., (2009) found that HIV-affected households were more likely to consume less nutritious food like starches, which are cheaper to afford in local markets. In this same line of thought, Agatha et al. (2010) found that expenditure patterns for HIV affected households in Kenya tended to lean towards medication costs. Based on these three studies, it is likely that because households are spending a majority of earnings on HIV care and treatment, they cannot afford the proper nutrient-rich food, which fosters the perfect conditions for the syndemic of malnutrition and HIV. Furthermore, as demonstrated by Verschuur et al. (2021), climate shocks like the ones currently happening in Kenya increase food prices, which only compounds this issue.

The same trends can be seen in other countries in Sub-Sahara. In Uganda, Palermo et al. (2013) investigated HIV affected households to determine dietary diversity and health-related quality of life. On average, PLWHA had lower mental and physical health status scores (Palermo et al., 2013). Following that trend, Weiser et al. (2010) conducted a study investigating how food insecurity impacts ARV treatment in Kenya. Food insecurity was found to be one of the most

significant barriers to treatment adherence, because if people did not have enough food, they would skip doses (Weiser et al., 2010). Those that took ART on an empty stomach experienced severe stomach pain (Weiser et al., 2010).

In South Africa, Saloojee et al. (2007) found that HIV can be considered a risk factor. Musakwa et al. (2020) provides an explanation for this trend through assessing the challenges in reaching HIV-positive children. In this study, a majority of the children did not meet the World Health Organization's recommendation for nutrient intake (Musakwa et al., 2020). This is because at the beginning of the ART process, a majority of the children did not have access to foods high in fat, iron, and calcium, which resulted in increases in severe malnutrition and wasting (Musakwa et al., 2020).

In food insecure settings, sustained ARV therapy is compromised due to a lack of sufficient food. If the basic need of food is not met, not only is antiretroviral therapy rendered ineffective, but it also results in severely debilitating side effects, and the general mortality of PLWHA increases. It is reasonable to claim that food insecurity presents a significant barrier to HIV treatment. Food insecurity contributes to non-adherence by increasing intolerable hunger, exacerbating side effects, imposing financial burdens on patients, and as a result, prompting PLWHA to skip doses (Weiser et al., 2010).

### *Nutrition in Treatment*

Due to the actions of a variety of aid organizations, ART is growing increasingly widespread (Wanke, 2005). As a result, the nutritional requirements associated with HIV are more critical than ever. If people cannot put food on the table, they will not take ARTs (M. Tsehau, personal communication, November 21st, 2023). If malnourishment is a predictor for HIV mortality, it can be assumed that weight gain at the start of the ART process can be



considered a predictor of reduced mortality (Koethe et al., 2014). The WHO recommends that nutrient interventions should meet the energy requirements of HIV and ART, and as a result may lead to improved clinical outcomes (WHO, 2023). There are a variety of studies that support this claim.

Generally, a 2006 UNAIDS review found that HIV patients who were supported with nutritional supplementation while taking ART reported better adherence and fewer side effects (*HIV, Food Security, and Nutrition*, 2008). As discussed in the literature review, Byron et al. (2008), Grobler et al. (2013), Chesire et al. (2012), and Nagata et al. (2014) all conducted local studies in Kenya, investigating in different forms the impact that nutritional aid programs could have on malnutrition and HIV treatment. While Grobler et al. (2013) only supports the conclusion that nutritional aid increases protein and energy intake and does not make a definitive statement on HIV progression, all of the other studies agreed that food programs and nutritional interventions reduce malnutrition, reduce ART side effects, and improve clinical outcomes.

Chesire et al. (2012)'s study investigated the impact of nutritional programs on children in the Kilifi district and found that the percentage of underweight children dropped from 22.5% to 9.4%, and wasting dropped from 16.7% to 7.7%. Nagata et al. (2014) investigated a food by prescription program in the Nyanza Province of Kenya, which has the highest HIV prevalence and practically universal food insecurity for PLWHA. On average, every patient enrolled in the nutrition supplementation program increased their body mass index (Nagata et al., 2014). So, despite Grobler et al. (2013)'s lack of agreement, it is reasonable to conclude that nutrition interventions are an adherence factor in treatment services, and can reduce mortality (M. Tsehau, personal communication, November 21st, 2023).

## **Aid Organizations Active in HIV Treatment**

### *Comparative Analysis*

In an interview, Rikka Trangsrud, former PATH country director for Kenya, said that “anybody doing HIV work understands the important role of nutrition in that. It’s pretty much a given, I would say, that nutrition is very important” (R. Trangsrud, personal communication, November 20th, 2023). All of the aid organizations analyzed in this study are particularly active in Sub-Saharan Africa, and a majority do consider nutrition to be vital to treatment. However, this has not always been the case.

PEPFAR is a remarkable initiative dedicated towards combatting HIV/AIDS in high-risk regions (Kalofonos, 2010). In 2004, PEPFAR made ARTs in Mozambique completely free to PLWHA (Kalofonos, 2010). By 2009, over 140,000 people were enrolled in this ARV treatment program, which seemed to be blinding proof of concept intervention (Kalofonos, 2010). Prior to PEPFAR, it was assumed that interventions to that scale were impossible to achieve, but PEPFAR moved to prove that given enough resources and technology, hundreds of thousands of lives can be saved (Kalofonos, 2010). This narrative painted a success story of high-technology treatment provided within resource constrained settings. However, to the perspective of the people of Mozambique, there was a different element to this success story (Kalofonos, 2010).

PEPFAR did not anticipate or account for the food insecurity of Mozambique, and this already existing hunger was magnified by the widespread access of ART (Kalofonos, 2010). Hunger was the principal complaint of members of this program, which led to the creation of the statement “All I Eat are ARVs” (Kalofonos, 2010). In fact, many participants of this program, while grateful for the access to medicine, considered the hunger to be a form of torture (Kalofonos, 2010). Furthermore, PEPFAR’s actions were not sustainable in the long term.

During transition periods when PEPFAR would gradually withdraw support from a region, there were multiple reports of reduced quality of services, creations of program gaps, and loss of personnel (Zakumumpa et al., 2021).

PEPFAR is responsible for considerable progress in the fight against HIV, but in this case, PEPFAR's failure resulted in a decreased adherence to treatment, and directly reduced the effectiveness of the program (Kalofonos, 2010). While this intervention was well-meaning, this only proves that HIV treatment programs need to account for food security conditions, and then allow adjustment and flexibility once that intervention is in place. Furthermore, intervention programs need to have a local, community-based focus in order to create long-term sustainability. There are currently a variety of organizations that do this very well.

When it comes to evaluating HIV response, one of the most notable organizations is UNAIDS. UNAIDS is a joint United Nations program that coordinates and guides the actions of 11 cosponsors (M. Tsehau, personal communication, November 21st, 2023). UNAIDS does not necessarily create or implement HIV treatment programs, but creates general initiatives based in a human-rights perspective (M. Tsehau, personal communication, November 21st, 2023). UNAIDS has ten official recommendations on ending inequalities to end AIDS (M. Tsehau, personal communication, November 21st, 2023). While nutrition is not one of these ten recommendations, UNAIDS still considers it to be important to HIV treatment (M. Tsehau, personal communication, November 21st, 2023).

The UNAIDS office in Kenya has a primary focus to make community-driven initiatives in order to ensure that all populations of PLWHA in Kenya get access to prevention and treatment services (M. Tsehau, personal communication, November 21st, 2023). This is a part of the wider global AIDS strategy and is accomplished through the application of an inequality lens

(M. Tsehau, personal communication, November 21st, 2023). This lens allows UNAIDS to look beyond just HIV treatment services into other areas that need consideration, such as nutrition (M. Tsehau, personal communication, November 21st, 2023). Essentially, UNAIDS is active in anything that could reduce vulnerability to HIV (M. Tsehau, personal communication, November 21st, 2023). The UNAIDS main mitigation strategy is to empower communities so that they can identify and solve their own issues, and to support and link communities to care (M. Tsehau, personal communication, November 21st, 2023).

One example of this is UNAIDS role in scaling up of dolutegravir, an ARV that is considered to be one of the most optimal regimens produced (M. Tsehau, personal communication, November 21st, 2023). HIV treatment used to require large pill cocktails, where PLWHA had to take over seven pills at one time every morning and night (M. Tsehau, personal communication, November 21st, 2023). However, dolutegravir is one tablet, and has been proven to have less side effects, and be easier to tolerate without food (M. Tsehau, personal communication, November 21st, 2023). Dr. Medhin Tsehau stressed the importance of science when it comes to treatment regimens, in order to ensure ARVs are convenient and accessible (M. Tsehau, personal communication, November 21st, 2023). The scaling up of dolutegravir is an excellent practice when it comes to considering nutrition within HIV response.

The implementation modality of UNAIDS moves through a division of services among all the cosponsors, and the WFP and the United Nations International Children's Emergency Fund are the two cosponsors most active in nutrition services for HIV (M. Tsehau, personal communication, November 21st, 2023). UNAIDS exhibits a variety of good practices when it comes to the consideration of nutrition within HIV, primarily through their role of bringing together different organizations, encouraging their comparative advantages, and integrating their

actions with other programs (M. Tsehau, personal communication, November 21st, 2023).

UNAIDS is a well-coordinated, multisectoral, strategic program that catalyzes action from the most prominent organizations within nutrition response, in order to address any gaps in nutrition within HIV response.

To further elaborate on this collaboration, the World Food Programme is the largest humanitarian organization working towards zero hunger worldwide (B. Syme, personal communication, September 14th, 2023). Improving nutrition is one of the core ideals of the WFP, and specifically looks to target PLWHA (*HIV/AIDS and tuberculosis*, n.d.). In regions like Kenya, the WFP provides a nutrition supplement in conjunction with HIV treatment programs (M. Tsehau, personal communication, November 21st, 2023). The WFP also works to strengthen local food systems, strengthens social protection systems that aim to reduce hunger, and supports local governments in climate risk reduction practices (B. Syme, personal communication, September 14th, 2023). Essentially, the WFP helps to construct safety nets for the food insecure, including PLWHA, and also is responsible for alerting communities to natural disasters, and mobilizing funds towards climate resiliency (B. Syme, personal communication, September 14th, 2023). The WFP and UNAIDS are stellar examples of the linking of food insecurity, health, and community-oriented initiatives for HIV response, highlighting the lapses exhibited by the PEPFAR program in Mozambique.

The final aid organization analyzed by this study is PATH, a nonprofit organization that is working to deliver resources and technology in order to improve health equity (*Better Health Moves Humanity Forward*, n.d.). PATH is very active in the field of HIV, collaborating with local and global partners to optimize the quality and convenience of HIV treatment (*HIV/AIDS*, n.d.). PATH has been active in Kenya for over three decades, collaborating with the Ministry of

Health and with PEPFAR to increase access to ART (*Kenya*, n.d.). PATH's work is primarily donor driven, so interventions are often created based on donor priorities (R. Trangsrud, personal communication, November 20th, 2023). This didn't always afford much flexibility when it came to focus areas for treatment programs, but PATH does consider nutrition to be vital to HIV treatment and has historically incorporated nutrition counseling into treatment programs (R. Trangsrud, personal communication, November 20th, 2023).

In Kenya, the package of care associated with ARTs included nutrition supplementation, which consisted of a heavily fortified powder or porridge mix that were intended to move PLWHA out of a malnourished state (R. Trangsrud, personal communication, November 20th, 2023). These nutrition supplements were prescribed much like ARTs (R. Trangsrud, personal communication, November 20th, 2023). However, one drawback of this program was that once an HIV positive patient was no longer considered malnourished, they were taken off of this program (R. Trangsrud, personal communication, November 20th, 2023). This meant the program was effective as moving people off of the malnourished line but wasn't designed for long term retention to keep people from falling back into a malnourished status.

PATH also worked on building up community health workers, which were primarily responsible for checking in on stable patients with HIV (R. Trangsrud, personal communication, November 20th, 2023). Interestingly, PATH has also done some work experimenting with edible insects as a method of nutrition supplementation (R. Trangsrud, personal communication, November 20th, 2023). A majority of aid programs create powders or porridge mixes containing high nutrient foods, so this was a surprising discovery. The idea was to take grasshoppers or termites and grind them into a meal that could then be added to flour and boost its protein content (R. Trangsrud, personal communication, November 20th, 2023).

PATH also has done considerable work in maternal and child health within HIV response. In Kenya, PATH worked with a local maternity hospital to create the first human milk bank of this region (R. Trangsrud, personal communication, November 20th, 2023). PATH also did a lot of work promoting exclusive breastfeeding, particularly with HIV-positive mothers since the nutritional benefits of breastfeeding outweighed the risk of transmitting HIV from the mother to the child (R. Trangsrud, personal communication, November 20th, 2023). In general, PATH exhibits many good practices when it comes to considering nutrition within HIV treatment. Despite the initial drawback discussed, a majority of PATH's work with nutrition in HIV response in Kenya has been effective and sustainable.

These organizations represent the different ways that aid organizations active in Sub-Saharan Africa consider nutrition within HIV response. While accounting for nutrition is not the only thing that contributed to these organizations' success, it was fundamental to ensuring interventions would succeed at promoting ART adherence and reducing HIV mortality. The progress is evident; in Kenya, where the WFP, PATH, and UNAIDS are all active, ART coverage has steadily increased over time, and AIDS related deaths have significantly decreased (M. Tsehau, personal communication, November 21st, 2023). While PEPFAR has failed to account for food security and nutrition in the past, UNAIDS, PATH, and the WFP are excellent examples of aid organizations that promote nutrition interventions while supporting local communities for long term sustainability.

### *Progress with HIV and Food Security Responses*

One of the leading conclusions of this study is that supporting food security inherently supports HIV response. In the past, these two issues have progressed in silos, and there wasn't much overlap between HIV response driven aid organizations and climate risk reduction aid

organizations (R. Trangsrud, personal communication, November 20th, 2023). However, this field is evolving, and there is improved collaboration on this combined issue.

UNAIDS believes that adequate food security includes PLWHA having enough food to adhere to treatment (M. Tsehau, personal communication, November 21st, 2023). UNAIDS also acknowledges the challenges that climate change poses to this combined effort (M. Tsehau, personal communication, November 21st, 2023). In Kenya, extensive droughts and variable flooding are severely limiting humanitarian responses (M. Tsehau, personal communication, November 21st, 2023). As a result of this, the UNAIDS office in Kenya has taken the initiative to assess to what extent food security is factored into social protection programs, particularly for vulnerable people like PLWHA (M. Tsehau, personal communication, November 21st, 2023).

PATH has also taken the initiative to step into the field of food security, by experimenting with building up community farms and gardens in Kenya (R. Trangsrud, personal communication, November 20th, 2023). PATH worked with the local government to get a piece of land donated, and then organized groups of volunteers to cultivate the land (R. Trangsrud, personal communication, November 20th, 2023). PATH also promotes specific foods like the orange flesh potato that are high in nutrients and vitamin A (R. Trangsrud, personal communication, November 20th, 2023). This process includes educating locals about how to grow these foods, and how to use them effectively (R. Trangsrud, personal communication, November 20th, 2023).

PATH's intervention is actually supported by a study conducted by Nicastro et al. (2022). Since agriculture is a main source of income and food for rural Kenyans, including PLWHA, Nicastro et al. (2022) sought to examine how agricultural livelihood interventions could impact food security and nutrition for PLWHA. This intervention targeted PLWHA who were actively



taking ART, and provided agricultural and finance training, as well as microloans that were directed towards agricultural technology (Nicastro et al. 2022). Nicastro et al. (2022) concluded that these interventions improved agricultural yields, level of income, increased weight gain, and improved ART adherence (Nicastro et al. 2022). Based on these results, there is no doubt that both PATH and Nicastro et al. (2022)'s interventions prove that agricultural interventions improve health outcomes for PLWHA through the pathways of food security and nutrition.

### *Challenges*

Both PATH and UNAIDS, which are primarily health driven organizations, have taken steps into the realm of food security. However, there are still multiple obstacles within this realm of humanitarian response. Climate change resiliency is a relatively new focus (R. Trangsrud, personal communication, November 20th, 2023). Climate change only started to become a main issue of global action dialogue eight years ago, so many organizations did not see it as a concern until very recently (R. Trangsrud, personal communication, November 20th, 2023). Today, it has been proven multiple times that climate change is impacting food security for countries in the global south, and for countries in Sub-Saharan Africa like Kenya, but it's not an issue that was given much attention in the past (R. Trangsrud, personal communication, November 20th, 2023). Awareness is growing, and funding is being made available to confront issues like climate change and food security, but its relatively new entrance onto the global stage still presents challenges (R. Trangsrud, personal communication, November 20th, 2023).

In combination with that challenge, underlying inequalities severely restrict action towards climate change. In countries like Kenya that have extremely low GINI coefficients, climate catastrophes only aggravate existing issues, making confronting those issues all the more difficult (M. Tsehau, personal communication, November 21st, 2023). Building on existing

issues, nutritional supplementation programs have also had issues with sharing among households (R. Trangsrud, personal communication, November 20th, 2023). If you take a food insecure household and prescribe one member of that family who is HIV positive with a nutrition mix, oftentimes that supplementation will be shared with the entire family (R. Trangsrud, personal communication, November 20th, 2023). This limits the effectiveness of nutrition supplementation on ART adherence, but the cause of that is pre-existing food insecurity and inequality.

While there has been improved collaboration on food security and HIV response, particularly with nutrition supplementation programs, there is a critical issue with the structure of these programs. As demonstrated by the work of PATH and Nagata et al. (2014), nutrition supplementation is often a powder or porridge mix consisting of maize and soybeans that are supplemented with additional vitamins. As discussed in earlier sections, both of these foods are quite fundamental to the Sub-Saharan region. An aspect of this design is well-intentioned, since the goal was to manufacture these supplements locally (R. Trangsrud, personal communication, November 20th, 2023). However, as seen in the analysis of climate change and food security, both maize and beans are critically threatened by the changing climate. As the yields of maize and beans are only expected to decrease with the changing climate, there are severe implications for the long-term sustainability of these locally produced nutritional programs.

There have been some efforts to shift away from maize and beans as the main form of food supplementation. Both Nabatanzi & Nakalembe (2016) and Wamono et al. (2011) conducted studies in Uganda regarding the viability of local plants as a form of nutrition supplementation for PLWHA. Nabatanzi & Nakalembe (2016) investigated the presence of readily available wild food plant species (WIFPs) and their nutritional benefits. Over 84 WIFPs

were documented to be consumed by PLWHA, and this diversity was proven to play a critical role in supplementing nutrient deficiencies (Nabatanzi & Nakalembe, 2016). These foods are abundant, accessible, and are rooted in the local culture (Nabatanzi & Nakalembe, 2016). Similarly, Wamono et al. (2011) investigated the nutritional quality of the Matoke Banana. The product created with this banana was well accepted by the local population, and improved nutritional intake for PLWHA (Wamono et al., 2011). However, this study also utilized soybeans, which as discussed will present a future challenge as the climate changes. Furthermore, there is not much information as to the climate resiliency of WIFPs, so the same issue could come up in the future.

These challenges combine to widen the gap between climate change, food security, and HIV response. Both Rikka Trangsrud and Dr. Medhin Tsehau stated that one of the largest challenges for bridging this gap and providing nutritional support to PLWHA is cost. There is often a gap in funding when it comes to supporting nutritional interventions, largely because there are so many competing priorities that need attention in the realm of HIV response, and also in the realm of humanitarian action at large (M. Tsehau, personal communication, November 21st, 2023). Many countries have still not recovered economically from the pandemic, and there are also multiple peace and security issues in addition to climate change (M. Tsehau, personal communication, November 21st, 2023). In the face of all of these overwhelming challenges, it is difficult to decide where to allocate resources, especially when that country is resource constrained to begin with (M. Tsehau, personal communication, November 21st, 2023).

### *Practices for the Future*

There needs to be change in order to foster nutrition for PLWHA in light of the ongoing climate change crisis. One angle from which to do this is to make progress on the Sustainable

Development Goals (SDGs) (M. Tsehau, personal communication, November 21st, 2023). SDG 1 and 2 are directly related to this topic, calling for an end to poverty and hunger (M. Tsehau, personal communication, November 21st, 2023). However, as discussed throughout the study, all of these problem areas are interrelated and interconnected (M. Tsehau, personal communication, November 21st, 2023). The SDGs cannot be achieved in isolation, and the global community at large needs to collaborate across all sectors of inequality in order to bridge the gaps discussed (M. Tsehau, personal communication, November 21st, 2023).

From a more focused angle, this includes evaluating country systems and institutions to evaluate inequality within HIV response (M. Tsehau, personal communication, November 21st, 2023). This involves understanding the context in which intervention programs will exist in order to link care to critical areas (M. Tsehau, personal communication, November 21st, 2023). Furthermore, this multisectoral approach should include the promotion of climate sensitive agricultural production and consumption (M. Tsehau, personal communication, November 21st, 2023). Integrating these issues into a well-coordinated problem strategy, directing funds to areas with the most need, and accelerated collaboration across major aid organizations will allow the global community to utilize comparative advantages from a community and human rights based perspective to tackle issues with food security and HIV response (M. Tsehau, personal communication, November 21st, 2023).

## **V. Conclusion**

This study demonstrates an alarming escalation in food insecurity in Sub-Saharan Africa. This region faces a variety of climate challenges that disrupt food systems, resulting in crop failures and loss of livelihoods. The fragility of these systems leaves vulnerable populations exposed to famine. The consequences of this trend extend beyond immediate hunger, with wider

implications for public health. These climate-caused food system disruptions contribute to increased malnutrition, which poses as a deadly syndemic for people living with HIV.

Malnutrition is a significant barrier to ART adherence, resulting in severe side effects and increased mortality for PLWHA.

People living with HIV/AIDS need to be provided with the nutritional support needed for optimal ART effectiveness. Nutritional aid programs enhance adherence, reduce side effects, and improve clinical outcomes during HIV treatment. As demonstrated by PEPFAR's program in Mozambique, it does not matter how much funding or support a program has; if the basic need for food is not accounted for, HIV treatment programs will not only fail to be effective, but will actually produce harm. UNAIDS, PATH, and the WFP showcase successful models of community-driven, nutrition-focused interventions in HIV response. It is through these organizations that the potential for an integrated food security and HIV response is possible. However, challenges persist, including existing inequalities, the new arrival of climate change as a point of focus, and lack of funding and attention.

As demonstrated by Dasgupta & Robinson (2022), this issue will only grow in magnitude as climate change continues to worsen. Action towards a sustained, collaborative, climate-sensitive HIV response is critical for the long-term management of this disease. First and foremost, treatment supplementation programs need to investigate alternatives to maize and soybeans as the primary component of supplementation, which calls for scientific investigation into climate-resilient, nutritious, locally grown plants in Sub-Saharan Africa. This study also recommends a strengthening of policies on adaptation to climate change; as is demonstrated throughout this study, the impact that climate change has on food security is interconnected to the fight against HIV/AIDS, and progress on the climate change agenda will inherently aid in

HIV response. Furthermore, funds need to be directed towards a multisectoral HIV response that incorporates a climate resiliency perspective. In general, while programs such as UNAIDS and PATH are doing well with incorporating nutrition into HIV response, there needs to be a scaling up of focus on this issue.

Future research is needed to specifically address the different ways to bridge the gap between short-term and long-term nutritional support for HIV treatment programs, including the investigation of social security programming within specific countries. Future research could also look further into the structure of Sub-Saharan food systems, in order to determine to what degree large monocultures versus small farms are resilient to climate change. The role of science within the context of this study is imperative in a climate-sensitive response to HIV/AIDS. There needs to be a continued investigation into the creation of optimal ARV regimens that impose less of a burden on PLWHA.

This study underscores the interconnectedness of climate change, food insecurity, malnutrition, and HIV in Sub-Saharan Africa, revealing a complex network of challenges that demand comprehensive interventions. As global temperatures continue to rise, coordinated efforts are essential to address these multifaceted issues, safeguard food systems, and protect the health and well-being of PLWHA. The global community must collaborate across sectors to address the complex issues associated with food security and HIV response.

## **VI. Abbreviation List**

AIDS = Acquired Immunodeficiency Syndrome

ART = Antiretroviral therapy

ARV = Antiretroviral

HIV = Human Immunodeficiency Virus

NGOs = Non-Governmental Organizations

PATH = Program for Appropriate Technology in Health

PEPFAR= President's Emergency plan for AIDS Relief

PLWHA = People living with HIV/AIDS

SDGs = Sustainable Development Goals

UNAIDS = Joint United Nations Programme on HIV/AIDS

U.S. = United States

WHO = World Health Organization

WIFPs = Wild Plant Food Species

WFP = World Food Programme

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