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ORIGINAL PAPER

Food Security in the Context of HIV: Towards Harmonized Definitions and Indicators

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Abstract Integration of HIV and food security services is imperative to improving the health and well-being of people living with HIV. However, consensus does not exist on definitions and measures of food security to guide service delivery and evaluation in the context of HIV. This paper reviews definitions and indicators of food security used by key agencies; outlines their relevance in the context of HIV; highlights opportunities for harmonized monitoring and evaluation indicators; and discusses promising developments in data collection and management. In addition to the commonly used dimensions of food availability, access, utilization and stability, we identify three components of food security—food sufficiency, dietary quality, and food safety—that are useful for understanding and measuring food security needs of HIV-affected and other vulnerable people. Harmonization across agencies of food security indicators in the context of HIV offers opportunities to improve measurement and tracking, strengthen coordination, and inform evidence-based programming.

Keywords Food security · HIV/AIDS · Food insufficiency · Dietary diversity · Food safety · Monitoring and evaluation (M&E) · Indicators

Introduction

Food insecurity, undernutrition, and HIV/AIDS continue to be major problems in the world. Over 1 billion people are estimated to suffer from insufficient consumption of food [1]. Approximately 115 million children under 5 years are underweight and 178 million are stunted, which can prevent them from growing up to lead healthy and productive lives [2]. Poor dietary diversity in many parts of the world has resulted in over 2 billion people living with micronutrient deficiencies, such as deficiencies of iodine, vitamin A or iron [3]. Poor dietary diversity can also contribute to the growing obesity epidemic in both high and low resource settings [4–6]. The World Health Organization (WHO) [7]

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estimates that 2.2 million people die per year from food and water-borne diarrheal diseases. Determinants of food insecurity include poverty, conflict, protracted crises, disease, and environmental degradation [1, 8]. Food insecurity has an unprecedented impact on global health outcomes. Malnutrition is estimated to be a top health risk worldwide, contributing to more deaths annually than HIV/AIDS, malaria and tuberculosis combined [9], and its reduction is a global priority as stipulated by the Millennium Development Goals (Target 1.C).

Existing in parallel to the global food security crisis is the HIV/AIDS pandemic. At the end of 2011, there were an estimated 34 million people living with HIV, including 2.5 million new infections, and 1.7 million AIDS-related deaths [10]. The advent of highly active antiretroviral therapy (ART) has changed the trajectory of the epidemic, reducing HIV-related morbidity and mortality [11–13], lowering risk of transmission between sero-discordant contacts [14–16], and decreasing incidence of HIV at the population level in most countries [17–19]. Global access to ART is expanding rapidly. An estimated 8 million people were receiving ART in low and middle-resource countries in 2011, representing an increase of 1.4 million compared to the year before and 54 % of individuals deemed clinically eligible for treatment, according to recent WHO guidelines [10]. Dramatic improvements in ART uptake globally over the past ten years and recognition of its public health impacts have led the Joint United Nations Programme on HIV/AIDS (UNAIDS) to ambitiously launch a global effort to "get to zero"—that is, to achieve "zero new HIV infections, zero AIDS-related deaths and zero HIV-related discrimination" by the year 2015 [20].

Food insecurity and HIV have been described as "syndemic", meaning epidemics that coexist and perpetuate each other [21]. The geographic overlap in prevalence of food insecurity and HIV is most pronounced in sub-Saharan Africa, which has both the highest proportion of people who are undernourished [22] and the highest proportion of people who are HIV-positive in the world [20, 22]. The dual epidemics are also marked in Asia, which has the highest number of undernourished people in the world [22] and which has seen very large increases in new HIV infections over the past 10 years [20, 22]. Similarly, high rates of food insecurity and HIV have been shown to exist in high resource settings among specific populations. The demographic overlap between these health crises has left certain groups particularly vulnerable, notably women and children, as well as people suffering from mental health disorders and addiction [23, 24].

The overlap of food insecurity and HIV is not arbitrary, as each condition has been found to adversely impact the other. The relationship between food insecurity and HIV is frequently referred to as a "vicious cycle", because each condition increases the risk and exacerbates the outcomes of the other at individual, household and population levels [23–26]. HIV affects an individual's nutritional status by increasing metabolic rate and nutrient requirements, and may simultaneously impede nutrient absorption, reduce appetite and constrain access to food. Additionally, poor nutritional status increases mortality risk among HIV-infected individuals, both among those on ART [27] and among those not on ART [28]. HIV contributes to household food insecurity by reducing household labor resources, depleting income and assets and interrupting intergenerational knowledge transfer [25]. HIV-related morbidity and mortality contribute to reductions in agricultural production and economic development [25]. Furthermore, food insecurity is believed to lead to adverse HIV clinical outcomes through diverse behavioral, nutritional and mental health pathways [24]. It has been associated with numerous adverse HIV outcomes in both high and low resource settings [23], including increased risk of transmission [29–31], poor healthcare utilization and HAART uptake [32, 33], non-adherence to ART [34–36], poor immunologic and virologic ART response [35, 37–39], and increased risk of ART [40, 41].

Given the links between HIV and food insecurity, integration of the various programs dealing with food security, nutrition, and HIV emerges as critical in many contexts [42]. Integration efforts have highlighted the necessity for harmonization of operational definitions and indicators of food security among stakeholders in order to assess population needs, evaluate programmatic impacts, and inform evidence-based policies and interventions. To inform this process, this paper reviews operational definitions of food security; identifies components and dimensions of food security; describes indicators that can be used to monitor and evaluate integrated food security and HIV interventions; and discusses opportunities for strengthening evidence-based policies and programs for integrated HIV and food activities.

Definitions, Dimensions and Components of Food Security

Definitions of Food Security

Definitions of food security have evolved and proliferated considerably over the past half century, with literature citing over 200 definitions and 450 indicators [43]. The concept of global food security was first promulgated within public policy and operational agencies at the United Nations (UN) World Food Summit in 1974 [44]; this conceptualization emphasized the volume and stability of food supplies at the population level, defining food security

as the "*availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices*" [45]. The UN Food and Agriculture Organization (FAO) and World Bank adapted this policy definition in the 1980s to emphasize that food security is also experienced at the household and individual levels. The revised definitions included the requirement "*that all people at all times have both physical and economic access to the basic food that they need*" [46] and have "*enough food for an active, healthy life*" [47]. A comprehensive definition, incorporating all these considerations, was affirmed at the 1996 World Food Summit, advocating that "*food security, at the individual, household, national, regional and global levels* [*is achieved*] *when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*" [48]. In 2001, The World Food Programme (WFP) and FAO, multilaterals charged within the UN system with responsibility for global food aid and information systems [49], updated the definition to additionally include the notion of "social" access to food [50]. The current globally accepted definition of food security operationalized by multilateral agencies is: "*when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*" [22]. Implicit in this definition is the concept that a person or household that is food insecure may experience food insufficiency, poor dietary quality or diversity, or poor food safety. Food insecurity may affect a population on a permanent (chronic) or temporary (transitory) basis, or in cycles (e.g., seasonal fluctuations) [51]. Most national governments draw on this current UN definition to frame their domestic and foreign aid operations and policies regarding food security. The United States Agency for International Development (USAID), the single largest national government contributor to both global food aid and HIV care and treatment [52, 53] draws on the same wording, but does not explicitly include the role of 'social access' to food or 'food safety' [54].

Within academia, definitions of food security grew largely from qualitative research and empirical testing within the US. An expert panel convened in 1989 by the Life Sciences Research Office (LSRO) [55] contributed to the foundation for a standardized operational definition. Preliminary studies informing this panel had applied an ethnographic approach to building the concept of food security through in-depth interviews among low-income individuals [56]. These studies found that food insecurity was experienced differently at the household, individual (adult) and child levels; and that food security was constituted of four components (quantity, quality, certainty and acceptability), with the first two related to physical food use and the last two related to psychological and social experiences. Research also concluded that food insecurity existed along a continuum, progressing from uncertainty and anxiety about food, to the severe manifestation of hunger from not having enough to eat [56, 57]. Validation of this early work [58, 59] became the basis for subsequent modifications of the definition and measure of food security used by researchers and domestic public health agencies today [60–62].

The Committee on World Food Security, composed of UN agencies, civil society and non-governmental organizations, research organizations, financial institutions, private sector associations and foundations, met in 2012 to standardize terminology for food security, nutrition, and nutrition security. The resulting report distinguishes food security from nutrition security, as two complementary but overlapping concepts, with the latter understood as constituting individual and household food consumption and biological utilization of food. The FAO further clarifies that nutrition security differs from food security in that it includes aspects of "adequate caring practices, health and hygiene" [22]. The Committee endorses the term "food and nutrition security" to emphasize the conceptual linkage between these and places them within a human rights paradigm. This global initiative may lead to further nuanced definitions and uses of these terms and greater harmonization of terminology across agencies [63].

The definition of food security does not differ in the context of HIV but interpretation of the components, resources, and interventions needed to address food insecurity may differ, as discussed in greater detail below.

Dimensions of Food Security

Food security is often characterized as consisting of three broad and intersecting dimensions: *food availability*; *food access*; *food utilization* [25, 64]. Some frameworks, including those of FAO and the U.S. Government Feed the Future Initiative, include an additional, overarching component of *food stability* [51] in order to emphasize the importance of sustained food availability, access, and utilization. The widely used dimensions of availability, access, utilization and stability help to define the nature of food insecurity, the indicators measured, and the interventions needed to address it. These dimensions describe an individual's or household's relationship to food: Is food in adequate quantity and quality available? Can people access it? Can they utilize it properly? Is access stable? The dimensions do not describe the characteristics of the food itself (although utilization does encompass some characteristics such as nutritional value and hygiene).

Table 1 Dimensions and components of food security

Dimensions	Components		
	Sufficiency	Quality	Safety
Availability	Sufficient quantities of nutritious food are available to individuals or in reasonable proximity to them	Foods comprising an adequately diverse diet to meet nutritional needs are available to individuals	Foods are available to individuals that will not harm them if prepared and eaten according to intended use
Access	Individuals have adequate income, production, or other resources to obtain sufficient quantities of nutritious food	Individuals have adequate income, production or other resources to obtain a diverse diet that meets nutritional needs	Individuals have adequate financial, production and food preparation and storage resources to obtain and prepare safe foods
Utilization	Individuals are able to prepare, consume, and biologically utilize sufficient quantities of nutritious food	Individuals can prepare, consume, and biologically utilize the foods in a diverse diet, e.g. through adequate knowledge, dietary practices, and health	Individuals can prepare, consume, and biologically utilize safe foods, and poor food or water hygiene causing infections that impede utilization are minimized
Stability	Individuals consistently have availability, access and utilization of sufficient quantities of nutritious food	Individuals consistently consume foods comprising an adequately diverse diet	The safety of the food individuals consume is consistently assured

Components of Food Security

The UN definition cited earlier identifies three characteristics of the food that one must have access to in order to be food secure: "*sufficient, safe and nutritious foods*". Based on this definition, we identify three components of food security: food sufficiency, dietary quality, and food safety. This typology can be useful for assessing the extent to which the food people consume meets their needs and for identifying specific gaps in food security that need to be addressed. Applying the four dimensions of food security (availability, access, utilization, stability) to each of these components enables more specific measurement and analysis of the nature of food security or insecurity among populations of interest (see Table 1). The sections below review definitions of each of these components as they relate to food insecurity and their relevance in HIV contexts.

Food Sufficiency

Food insufficiency has been described in several ways in the literature, ranging from objective clinical definitions of undernutrition to more subjective qualitative descriptions of hunger and resource shortages. For example, the WHO has defined food insufficiency in terms of clinical definitions of underweight based on body mass index (BMI) and other anthropometric measures [65, 66]. The FAO and the European Union (EU) use the terms 'food deprivation', 'undernourishment' and 'hunger' interchangeably [22, 51], describing them as a state where caloric intake is below the minimum dietary energy requirement for a period of over a year [22]. These organizations justify the interchangeable use of these terms on the basis that 'food deprivation' is merely a scientific term to denote 'hunger', which is *"an uncomfortable or painful sensation caused by insufficient food energy consumption"* [51]. While hunger and food deprivation can affect an individual, a household or a larger group, undernourishment is defined at the population level, based on assumptions about the availability of food and the food needs of a given population based on its composition. Epidemiological researchers have also defined food insufficiency in terms of hunger, emphasizing aspects of frequency and resources. For example, surveys used in various North American settings have defined food insufficiency *as an "inadequate amount of food intake due to a lack of resources"* [67], *as "the recurrent and involuntary lack of access to food"* [55], and as a state where an individual is *"sometimes or often hungry, but (does not) eat because (s/he) can't afford enough food"* [56]. Definitions of household food insufficiency describe it as a state characterized by *"restricted household food stores"* or *"too little food intake"* among adults or children in a household [68].

In the context of HIV, understanding and assessing food sufficiency requires taking into consideration HIV-positive individuals' special physiological and metabolic requirements, as well as an understanding of the context in which they live. Research suggests that people living with HIV have increased resting energy expenditure [69, 70], which requires them to consume 10–30 % additional energy/kilocalories depending on their stage of disease progression, compared to an uninfected individual [65, 71]. This means that food consumption levels that are sufficient for HIV-negative individuals may not be sufficient for HIV-positive

individuals of the same sex, age and activity level. Insufficient consumption of food may be further exacerbated by loss of appetite, oral abscesses, gastro-intestinal issues and other symptoms that commonly occur with HIV infection, as well as drug side effects. Thresholds of what is a 'sufficient' or 'insufficient' amount of food for a given individual will additionally vary depending on age, gender, physical activity level and presence of co-infections. Certain groups may require particularly elevated energy intake including HIV-infected pregnant and lactating women, infants, children and adolescents [65, 72–77]; persons with elevated physical activity level [74, 78]; and individuals with morbidities including hepatitis C virus (HCV), tuberculosis (TB) and malaria co-infection [65, 79–83].

Dietary Quality

The term 'dietary quality' can be used to encompass a number of characteristics of the food that makes up a diet, including its diversity, hygiene and nutrient density. Most commonly dietary quality refers to dietary diversity. Dietary diversity is important because an individual needs ~40 different nutrients, in different amounts, in order to grow, develop and remain healthy [84]. Meeting these nutrient needs requires consumption of an adequately diverse diet, such as breast milk, plant source foods (vegetables, fruits, staples), animal source foods (dairy, eggs, fish, meat) and fortified foods [85].

Laboratory-based measures of adequate macro- and micro-nutrient status focus on nutritional status, whereas dietary measures often focus on culture- and context-specific consumption of various foods or groupings of food types. For example, WHO focuses on nutrient adequacy, which it measures using laboratory biomarkers of key vitamins and minerals, such as Vitamin A and iron [86, 87]. FAO and EU define dietary diversity as a *"qualitative measure of food consumption that reflects household access to a variety of foods",* viewing this as a *"proxy for nutrient adequacy of the diet of individuals"* [88]. Many groups, including WFP and International Food Policy Research Institute (IFPRI), describe and measure dietary diversity in terms of the consumption of foods from different food groups over a specific period of time, which is distinct from frequency of consumption [89–91]. Some researchers emphasize that the specific content of dietary diversity cannot be universally defined, as what constitutes 'variety' will differ across cultures, developmental stages, and contexts [92–94].

Dietary diversity signifies different outcomes at the individual and household levels. At the individual level, dietary diversity reflects the micro- and macro-nutrient adequacy of diet consumed [95]. At the household level, dietary diversity is usually considered to be a measure of access to food [96], or of the economic ability to consume a variety of foods [97]. Recognition of the linkages between food security and micronutrient status has led to the development of the concept of 'nutrient security', which emphasizes the importance of meeting nutrient requirements at the individual, household and population levels [98].

Dietary quality is particularly relevant in the context of HIV, as in some contexts it is challenging for people living with HIV to obtain adequate intake of sufficient quantities of essential macro- and micro- nutrients. Approaches to assessing and improving dietary diversity in the context of HIV need to consider specific changes in energy and nutrient utilization associated with HIV disease progression and co-morbidities, as well as variability in nutritional status and needs with ART [65, 71, 74]. For example, people living with HIV (PLHIV) may experience losses in, or increased needs for, specific types of macro- and micronutrients depending on HIV disease progression, age, pregnancy and lactation status [65, 73, 75, 76] and co-infections [65, 79–83]. Like other populations with poor access to foods comprising diverse diets, PLHIV in various countries have been reported to consume diets rich in simple carbohydrates but lacking in other necessary micro and macro nutrients [99, 100].

Food Safety

Although research and programming for food security have tended to focus on the dimensions of food sufficiency and dietary quality, the WHO and FAO consider food safety to be an integral part of food security. Consequently, they have developed specific definitions as part of their efforts to establish scientifically based standards and approaches to food safety [101]. These organizations have defined food safety as "*the assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use*" [102]. Food safety also pertains to the protection of the food supply from microbial, chemical and physical hazards that may be introduced at any stage of *"food production, including growing, harvesting, processing, transporting, retailing, distributing, preparing, storing and consumption, in order to prevent foodborne illnesses"* [103]. Included in the FAO and WHO conceptions of food safety is the idea that foods should not be affected by adverse impacts of new food technologies, such as genetic engineering, irradiation of food, and modified-atmosphere packaging [104]. Other forms of foodborne hazards are caused by natural toxins, molds, rodents and industrial contaminants (chemicals, unclean equipment) [105].

Food safety is especially critical in the context of HIV because HIV-positive individual have increased susceptibility to foodborne illnesses due to their weakened immune systems. People living with HIV who contract foodborne illnesses often develop more severe symptoms, which can be recurrent and difficult to treat [106]. Diarrhea is a common side effect of HIV disease progression and ART use. However, when compounded by foodborne infections, diarrhea has been shown to pose life-threatening complications in both the pre- and post-ART eras [107]. The major pathogens seen in AIDS-related diarrhea previously identified in the literature are cryptosporidium, microsporidium, salmonella, and cytomegalovirus [108].

Harmonization of Food Security Indicators in the Context of HIV

Harmonization Challenges

With expanded efforts to integrate food security and HIV services comes the need for rigorous monitoring and evaluation (M&E) of food security interventions and their impacts in HIV programs and contexts. Given the growing number of interventions and the range of stakeholders involved in these efforts, harmonization of indicators is critical to enable consistency, comparability, global tracking, and learning.

A number of challenges to harmonization of indicators exist. Governments, donors, and implementing agencies have different objectives and approaches to food security and HIV, leading to distinct indicators, M&E systems, data collection approaches and capacities across programs. Definitions and conceptualizations of food insecurity have evolved differently among different stakeholders, highlighting the need for enhanced collaboration and knowledge transfer across groups. In many program contexts, HIV-related issues complicate the application of standard food security indicators. For example, measuring the prevalence of food insecurity among HIV-affected households requires accurate identification of which households are HIV-affected and which are not; this can be operationally challenging and sensitive information to obtain. Interpretation of indicators and program responses to them also differ in HIV contexts; for example the causes of malnutrition and steps to address it may differ among HIV-positive and HIV-negative individuals. Food security measurement tools for use among HIV-positive and affected individuals and households have been comprehensively reviewed elsewhere [109]. Efforts and opportunities for the harmonization of food security indicators in the context of HIV are described below.

Monitoring and Evaluation (M&E) Frameworks for Integrated Food Security and HIV Interventions

In 2011, the UN General Assembly Political Declaration on HIV and AIDS re-affirmed a resolution to integrate food and nutritional support as part of a comprehensive response to the global HIV epidemic [110]. Bilateral, multilateral and civil society organizations have developed operational frameworks and guidelines that consider the food and

Table 2 Harmonized indicators for nutrition, food security and HIV [115]

Nutrition care for PLHIV
Undernutrition in PLHIV The number and proportion of PLHIV in care and treatment that were identified as undernourished at any point during the reporting period
Provision of therapeutic or supplementary food to undernourished PLHIV The number and proportion of undernourished PLHIV that received therapeutic or supplementary food at any point during the reporting period
Nutrition assessment for PLHIV The number and proportion of PLHIV in care and treatment that were nutritionally assessed during the reporting period
Nutrition counseling for PLHIV The number and proportion of PLHIV in care and treatment that were nutritionally assessed with anthropometric measurement that also received nutrition counseling at any point during the reporting period
PMTCT and infant feeding
12-month infant HIV-free survival The percentage of infants born to HIV-positive women in PMTCT programs that are alive at 12 months of age and HIV negative
Maternal nutritional status in postnatal care The number and percentage of HIV-positive women that have a mid-upper arm circumference <220 mm at the first postnatal visit
Infant nutritional status The number and percentage of HIV-exposed infants with acute malnutrition at the 12-month follow-up visit
Infant feeding status The percentage of HIV-exposed infants who are exclusively breastfed at 3 months of age, the percentage of HIV-exposed infants who are replacement fed at 3 months of age, and the percentage of HIV-exposed infants who are mixed fed at 3 months of age
Food access and HIV
Food access of PLHIV The number and proportion of PLHIV receiving care and treatment services whose households have poor access to food based on the Household Hunger Scale
Per capita household expenditures in HIV-affected households The amount and percentage change in average per capita household expenditures among HIV-affected households.
Percentage of total expenditures spent on food in HIV-affected households The average percentage of total household expenditures that are spent on food in HIV-affected households
Referral to food security services The number and percentage of HIV care and treatment clients vulnerable to food insecurity who are referred from clinical facilities to food security services
Receipt of food security services The number and percentage of HIV-affected households that receive food security services

nutrition needs of people living with HIV. Multilateral, bilateral and other agencies have developed extensive monitoring and evaluation (M&E) frameworks to measure the performance of HIV interventions and the performance of food security and nutrition programs. For example, in the field of HIV, international agencies have been partnering to achieve the 'Three Ones': one agreed upon HIV/AIDS action framework for all country-level partners, one national AIDS coordinating authority, and one accepted country-level M&E system [111]. In the field of food security, a UN high level Task Force comprised of over 20 multilateral agencies developed a framework for food and nutrition security interventions, which includes a plan for information monitoring and accountability systems [112].

Efforts have recently begun to develop M&E frameworks for integrated HIV and food security interventions. Some frameworks have identified key elements that stakeholders should consider in the M&E of food assistance programs in the context of HIV [113], and others have emphasized the need for diverse multilateral and bilateral organizations to identify and agree upon a standardized set of indicators as an essential next step [114]. The WHO, US Presidents Emergency Plan for AIDS Relief (PEPFAR) and other stakeholders have used a consultative process to establish program M&E frameworks for food security and HIV services in three programmatic areas: nutrition care, Prevention of Mother-to-Child Transmission (PMTCT) and infant feeding, and food access. These frameworks serve as the basis for the harmonized indicators in Table 2 [115].

Harmonized Indicators for Food Security and HIV

In 2006, the World Health Assembly (WHA) requested the WHO Director-General "*to provide support for development of appropriate indicators for measuring progress towards integration of nutrition into HIV programmes and impact of nutrition interventions*" [116]. As inter-institutional efforts are underway to harmonize measurement methods and indicators for food security and HIV, growing consensus is emerging about core food security indicators that can be used in the context of HIV treatment and care programs. For example, PEPFAR has identified indicators of nutrition components of HIV care and treatment services [117]. The USAID-funded Food an Nutrition Technical Assistance (FANTA-2) Project has developed core indicators for nutrition assessment, education and counseling of people living with HIV at the site, staff and client levels [118]. A recent review of over 336 site-level HIV programs serving 467,175 clients across nine sub-Saharan African countries found that nutrition counseling and anthropometric evaluation were the most common forms of nutrition support available to people living with HIV [119].

International stakeholders have been engaging in coordinated efforts to harmonize tools and indicators for measuring food security in the context of HIV. As mentioned above, a multi-stakeholder group including UN agencies, PEPFAR agencies, implementing organizations, and others have developed a set of harmonized indicators for nutrition, food security and HIV that have been included in the Joint United National Programme on HIV/AIDS (UNAIDS) Indicator Registry [120]. Some of these indicators have also been included in M&E guidance documents such as the Global Fund to Fight AIDS, Tuberculosis and Malaria Monitoring and Evaluation Toolkit [121]. These indicators are presented in Table 2, organized according to the three program areas of nutrition care, PMTCT and infant feeding, and food access.

Indicators of Food Sufficiency, Quality, and Safety

The challenge of arriving at commonly agreed upon indicator definitions at the intersection of agriculture, food security and health stems from the fact that the users come from different scientific disciplines and institutional backgrounds. In addition, there is often insufficient clarity about which indicators describe the individual versus the household, community or national level. Finally, care is needed to distinguish indicators that describe different stages of the causal chain, for example, to distinguish indicators of underlying causes of food insecurity such as poverty from effects of food insecurity such as poor health or nutritional status. A review of some of these indicators and the associated measurement tools demonstrated limited use in HIV endemic settings or with HIV-positive populations [109]. Given the relevance to HIV of the identified components—food sufficiency, quality and safety—defining indicators within each of these components sets the stage for a better understanding of the state of food insecurity and HIV.

Measures designed to capture the access dimension of food security often measure *food sufficiency*. The Household Hunger Scale (HHS) [122] is a three-question scale that measures household food deprivation. FAO quantifies 'food insecurity' in terms of undernourishment, using calories available per capita to measure the percentage of people in a country not consuming adequate calories [123]. FAO has recently revised its methodology for measuring undernourishment to account for, among other things, the effects that changes in income and food prices have on undernourishment [22]. While this is an indicator of food insufficiency, it is calculated at the national level, not the household level, so its application to HIV contexts is limited. Anthropometric indicators such as weight-for-height, mid-upper arm circumference, (MUAC) and BMI measure nutritional status which results from food sufficiency, dietary quality and food safety. They are also

commonly used as measures of undernutrition among people living with HIV [118]. This is a reminder that it is not food sufficiency, dietary quality and food safety alone that drive nutritional status, but also health, hygiene, and access to clean water and health services. For overnutrition, which can reflect 'over-sufficiency' of consumption, WHO has defined an anthropometric indicator of adult obesity based on BMI [124].

Most measures of *dietary quality* focus on dietary diversity. Indicators of dietary diversity at the individual level are often used as measures of the quality and completeness of individual diets, while household dietary diversity indicators are often used to measure household food access. Extrapolating from household measures to individuals can be problematic because dietary needs differ among household members and often very little is known about intra-household food distribution. At the individual level, women's dietary diversity measures have been found to be good indicators of micronutrient adequacy and are used in many contexts [125, 126]. Given the interactions between nutritional status and HIV among women, these indicators are highly relevant to HIV contexts. WHO, USAID, IFPRI, FANTA, UN Children's Fund (UNICEF) and the University of California at Davis developed a summary indicator of minimum acceptable diet for infants and young children aged 6–23 months that is composed of dietary diversity and meal frequency [127]. Given that nutrition interventions play a key role in achieving HIV-free survival for HIV-exposed children, a high priority for HIV programs, dietary quality indicators such as this are important to food security, nutrition and HIV programming. WFPs Food Consumption Score measures household food consumption using 7-day recall of the frequency of consumption of different food groups [89, 128]. WFP has recently started to analyze dietary diversity for vulnerable household members such as young children separately. FANTA's Household Dietary Diversity Score measures household food access using 24-hour recall of the number of food groups consumed [129].

There is growing consensus among multilateral and bilateral agencies and researchers about threshold values for the laboratory and clinical measurement of micronutrient undernutrition [130]. Cut-off values have been established for hemoglobin concentration, for example, which is the most widely used indicator for assessing programmatic impact of micronutrient interventions [130].

Efforts are underway to harmonize the quantitative measurement of *food safety* hazards. The WHO and FAO are leading an initiative to estimate the global burden of foodborne diseases using standardized indicators [131] in collaboration with a global network of government-appointed food safety focal points [132], and the Codex Alimentarius Commission [133]. Historically, the WHO has used Food Consumption Cluster Diets to measure the occurrence of over 300 hazardous chemicals in food and the "acceptable daily intake" of pesticide residue [134]. A working group of the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation has identified food hygiene indicators to inform discussion of the next generation of global development goals beyond 2015. The indicators include measures of kitchen cleanliness, food storage, feeding practices, microbiology, food-borne illness, and others [135].

Data Collection and Management

Population-Level Measurement

The harmonization of indicators for food security and HIV creates a tremendous opportunity for generating reliable, aggregated data at the state and national levels. In addition to identifying population prevalence rates, needs, and programmatic responses, these data can be used to generate improved evidence about best practices. A variety of measurement tools are currently used to capture information about nutrition, food security and HIV program indicators at the population level, including nationally representative population-based surveys; specially designed behavioral and health service coverage surveys; patient tracking and health information systems; and sentinel surveillance systems [136]. Improved techniques for data collection and management can allow existing patient, site and program-level data to be used for epidemiological analysis and operations research that is essential to evidence-based decision-making. Several technologies have demonstrated effectiveness for strengthening data collection and use in the context of HIV and nutrition, including electronic medical records (EMR) and web-based health information systems.

Electronic Medical Records

EMR and web-based health information systems have been successfully used in several large, multi-country HIV programs and demonstrated high degrees of reporting completeness [137, 138]. The use of a unified national web-based health information system for HIV in China has strengthened the efficiency of data collection, reporting, analysis and use, while improving data accuracy and security [139]. In Haiti, the use of a national HIV treatment and care EMR facilitated identification of healthcare providers' professional development needs [140]. Implementation of EMR and same-day patient tracing in the context of HIV care in Uganda was associated with reduced missed appointments, less loss to follow-up and increased clinical

efficiency [141]. Implementation of provider-based EMR in large HIV programs in Uganda has in addition led to reduced errors in reporting of opportunistic infections, ART toxicities, regimen switching, and ART interruptions [138]. EMR was instrumental to reducing human error and improving data quality in rural HIV and TB care sites in Rwanda [142]. Nationally centralized health information systems have also been used to aggregate nutrition and food security data in countries such as Malawi [143]. In Louisiana, the use of a state-wide EMR allowed for real-time clinical surveillance of HIV/AIDS patients and rapid physician notification of gaps in treatment and support [144]. Some HIV health information systems have specifically included food and nutrition indicators. For example, the Drug Resources Enhancement against AIDS and Malnutrition (DREAM), which provides nutritional care and support as part of comprehensive HIV treatment, has expanded EMR use to ten sub-Saharan African countries [145]. Kenya has developed a national health management information system for HIV/AIDS that has mainstreamed process and outcome indicators for nutrition [146, 147].

The use of EMR tools has not only strengthened data collection and clinical efficiencies, but facilitated extensive epidemiological HIV research in both high and low resource settings [148]. Epidemiological analysis and operations research using routinely collected clinical and M&E data have contributed to evidence-informed decision-making regarding program design and service delivery. Ecologic analyses of aggregated clinical and M&E data have potential for generating inferences that are generalizable at the population level [137]. In the context of HIV and food insecurity, analyses of programmatic M&E indicators across multiple African countries have identified trends in the availability of nutrition support services at ART sites [119], and demonstrated that sites providing micronutrient support to ART patients were associated with higher retention [149].

While the emergence of aggregated, centralized population-level databases offers tremendous opportunity for understanding trends, gaps and opportunities in HIV and food security service delivery and program effectiveness, such databases are not without their challenges. The development of guidelines and standard operating procedures are critical for ensuring data quality. Enhanced capacity building and the development of standardized training curricula are needed to ensure consistency in data entry and management by frontline healthcare workers and program managers [150]. This issue is of particular relevance in settings where vertical and horizontal management structures have divergent systems for data production and management [151]. At the national level, improved government capacity in epidemiology and biostatistics is essential to appropriately analyze and report findings from aggregated datasets [150].

Conclusion

Food insecurity and HIV are synergistic and overlapping epidemics, and require integrated program strategies to mitigate adverse impacts associated with each condition. As international organizations are integrating nutrition and food security into the global HIV response, there is growing recognition of the need to clarify definitions of food security and to identify harmonized indicators that can be used across institutions. We reviewed salient definitions and indicators of food security used by donors, implementing agencies and researchers, and outlined their relevance to the context of HIV. In addition to the commonly used dimensions of food availability, access, utilization and stability, we identified three components of food security—food sufficiency, dietary quality, and food safety—that are useful for understanding and measuring the food security needs of vulnerable people such as HIV-affected populations. These components are useful in that they allow us to work back from an outcome such as wasting, stunting, underweight or iron-deficiency anemia to identify the causes that may have contributed to such an outcome. A more precise identification of the problem also allows a more appropriate intervention design. In the context of HIV, interpretation of food insecurity must consider additional biological, clinical and social vulnerabilities experienced by people living with, or affected by, HIV.

This paper highlights a new set of harmonized food security indicators that has been developed by global bilateral and multilateral stakeholders, and that can be applied across diverse programmatic and population contexts to monitor and evaluate integrated food security and HIV interventions. The proposed set is targeted at policy makers and program managers rather than clinicians. It does not replace the need to monitor a separate set of indicators at the patient level. Collection of indicators such as the proposed set using centralized, web-based data management systems offers valuable opportunities for strengthening understanding of food insecurity in HIV-affected populations, and for longitudinal tracking of programmatic performance to inform evidence-based operations and policies.

We found that most food security indicators are unidimensional in that they measure a particular dimension (availability, access, utilization, stability) of food security. This is valuable for assessing specific food security needs within populations, including HIV-affected populations, and for targeting and evaluating interventions aimed at addressing these needs. However, there may be value in

multidimensional indicators that measure the breadth of food security and nutrition deprivations that households experience across dimensions. Existing multidimensional measures of food security are measured at the country level, such as the International Food Policy Research Institute's Global Hunger Index and the Economist Global Food Security Index [152, 153]. Household level multidimensional food security indicators could be valuable for targeting programs to those most in need, evaluating comprehensive impacts of programs, and understanding the interactions among different dimensions of food security when they occur within the same household. This is an area for future work.

The process of harmonizing food security indicators in the context of HIV should continue with support for country adoption and roll-out of the identified indicators, as well as effective management, analysis and use of the information produced. In addition to the direct benefits to programs from rigorous, consistent and comparable M&E, harmonization of food security indicators across programs in HIV contexts will also help produce data that contribute to the wider learning agenda on food security and HIV.

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