NIH Public Access
Author Manuscript
AIDS. Author manuscript; available in PMC 2013 March 25.

Published in final edited form as:
AIDS. 2012 January 2; 26(1): 67–75. doi:10.1097/QAD.0b013e32834cad37.

Food insecurity is associated with morbidity and patterns of healthcare utilization among HIV-infected individuals in a resource-poor setting

Sheri D. Weiser[a], **Alexander C. Tsai**[b], **Reshma Gupta**[c], **Edward A. Frongillo**[d], **Annet Kawuma**[e], **Jude Senkungu**[e], **Peter W. Hunt**[a], **Nneka I. Emenyonu**[e,f], **Jennifer E. Mattson**[a], **Jeffrey N. Martin**[g], and **David R. Bangsberg**[e,f]

[a]Division of HIV/AIDS, San Francisco General Hospital, University of California, San Francisco, San Francisco, California [b]Robert Wood Johnson Health and Society Scholars Program, Harvard University, Cambridge, Massachusetts [c]Department of Internal Medicine, University of Washington, Seattle; Seattle, Washington [d]Department of Health Promotion, Education, and Behavior, Arnold School of Public Health, University of South Carolina, Columbia, South Carolina [e]Mbarara University of Science and Technology, Mbarara, Uganda [f]Massachusetts General Hospital Center for Global Health, Ragon Institute of MGH, MIT and Harvard Medical School, Boston, Massachusetts [g]Department of Epidemiology and Biostatistics, University of California, San Francisco, San Francisco, California

Abstract

Objective—We undertook a longitudinal study in rural Uganda to understand the association of food insecurity with morbidity and patterns of healthcare utilization among HIV-infected individuals enrolled in an antiretroviral therapy program.

Design—Longitudinal cohort study.

Methods—Participants were enrolled from the Uganda AIDS Rural Treatment Outcomes cohort, and underwent quarterly structured interviews and blood draws. The primary predictor was food insecurity measured by the validated Household Food Insecurity Access Scale. Primary outcomes included health-related quality of life measured by the validated Medical Outcomes Study-HIV Physical Health Summary (PHS), incident self-reported opportunistic infections, number of hospitalizations, and missed clinic visits. To estimate model parameters, we used the method of

---

Correspondence to Sheri Weiser, MD, MPH, Division of HIV/AIDS, San Francisco General Hospital, POB 0874, UCSF, San Francisco, CA 94143, USA. Tel: +1 415 314 0665; fax: +1 415 869 5395; Sheri.Weiser@ucsf.edu.

Author contributions: S.D.W. was the principal investigator of this study, devised the idea for the study and this specific analysis, designed and implemented the study, created the data analysis plan, wrote the first draft of the manuscript, and took the lead on all subsequent drafts of the manuscript. A.C.T. conducted the data analysis for the study and helped with editing of the manuscript. R.G. assisted with writing and editing of the manuscript. E.A.F. helped with study design and implementation, data analysis, and editing of the manuscript. A.K. helped with study implementation, and editing of the manuscript. J.S. helped with study implementation and editing of the manuscript. P.W.H. helped with study implementation and editing of the manuscript. N.I.E. helped with study implementation and editing of the manuscript. J.E.M. assisted with writing and editing of the manuscript. J.N.M. assisted with design of survey instruments, study implementation, and editing of the manuscript. D.R.B. is the principal investigator of UARTO (the parent study), was responsible for study implementation for UARTO, advised on all aspects of study implementation of the food insecurity substudy as well as on the formulation of this specific manuscript, advised on data analysis, and helped with editing of the manuscript.

Conflicts of interest

There are no conflicts of interest.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

generalized estimating equations, adjusting for sociodemographic and clinical variables. Explanatory variables were lagged by 3 months to strengthen causal interpretations.

Results—Beginning in May 2007, 458 persons were followed for a median of 2.07 years, and 40% were severely food insecure at baseline. Severe food insecurity was associated with worse PHS, opportunistic infections, and increased hospitalizations (results were similar in concurrent and lagged models). Mild/moderate food insecurity was associated with missed clinic visits in concurrent models, whereas in lagged models, severe food insecurity was associated with reduced odds of missed clinic visits.

Conclusion—Based on the negative impact of food insecurity on morbidity and patterns of healthcare utilization among HIV-infected individuals, policies and programs that address food insecurity should be a critical component of HIV treatment programs worldwide.

Keywords

AIDS; food insecurity; healthcare utilization; HIV; morbidity; Uganda

Introduction

In Uganda, AIDS is the leading cause of mortality, accounting for 12% of annual deaths among persons 15 to 49 years old [1], and the prevalence of HIV/AIDS among adults is estimated at 6% [2]. Food insecurity, defined as ‘the limited or uncertain availability of nutritionally adequate, safe foods or the inability to acquire personally acceptable foods in socially acceptable ways,’ [3] is also highly prevalent in Uganda and elsewhere in sub-Saharan Africa, particularly among people living with HIV/AIDS (PLWHA) [4]. Nearly all HIV-affected households in a recent Kenyan survey were considered to be moderately or severely food insecure [5].

Food insecurity and HIV/AIDS are inextricably linked, with each enhancing vulnerability to and exacerbating the severity of the other condition [6]. HIV-related disability exacerbates food insecurity by decreasing household economic capacity and increasing caregiver burden [6]. Food insecurity in turn predisposes women to risky sexual practices and negatively affects their empowerment, exacerbating the spread of HIV/AIDS in sub-Saharan Africa and elsewhere [7,8]. Among people infected with HIV, food insecurity has been associated with worse HIV treatment outcomes including reduced antiretroviral therapy (ART) adherence [9–11], reduced bioavailability and pharmacokinetic efficacy of ART [12,13], worse immunologic and virologic response [9,14–16], and increased mortality [17]. Additionally, studies from the United States among the general population have shown that urban poor individuals may be forced to prioritize food over healthcare needs [18,19], leading to medication nonadherence, reduced outpatient follow-up, and increased acute care use [20–22]. Qualitative studies from Uganda [11,23] have previously reported that the competing demands of food and medical expenses may lead people to default from ART, or to give up food and wages to obtain treatment.

Few studies have examined the relationship of food insecurity with morbidity and health-related quality of life among PLWHA, and there are no studies to our knowledge looking at the association of food insecurity with patterns of healthcare utilization in resource-poor settings. In addition, few studies have used longitudinal data in examining negative health impacts of food insecurity, and most studies in this field have been limited by the absence of validated measures of food security or health status. Finally, no quantitative studies from resource-poor settings or among PLWHA have examined trade-offs between food and healthcare needs. Such information is critical to help interrupt the cycle of food insecurity and HIV/AIDS in resource-limited settings.

To address the gaps in the literature, we undertook a longitudinal study to understand the association of food insecurity with morbidity and patterns of healthcare utilization among individuals accessing ART in rural Uganda. We hypothesized that food insecurity is associated with increased HIV-associated morbidity; reduced outpatient clinic attendance, related to competing demands between food and other resources; and increased hospitalizations, as a result of missed clinic visits as well as other adverse health impacts of food insecurity. Understanding the effects of food insecurity on morbidity and healthcare utilization patterns among PLWHA in sub-Saharan Africa will help inform the development of programs and policies to improve health and quality of life among PLWHA.

Methods

Participants and study design

Our study took place in Mbarara town (population 65 000), within the rural Mbarara District. The Uganda AIDS Rural Treatment Outcomes (UARTO) prospective cohort study was initiated in July 2005 and participants were recruited from the Regional Referral Hospital Immune Suppression Syndrome (ISS) Clinic, which dispenses free ART [24]. Beginning in August 2007, we conducted a substudy within UARTO with the aim of evaluating the impact of food insecurity on HIV health outcomes and HIV transmission risk behaviors. Eligibility criteria for the food security substudy were identical to the UARTO eligibility criteria. Participants were approached for recruitment into the parent study (UARTO) if they were ART-naive patients above 18 years of age who lived within 20 km of the Mbarara Hospital HIV clinic. All patients who were initiating free ART were approached for recruitment in the study.

Quarterly assessments were conducted using standardized interviewer-administered instruments, detailed anthropometric measures, and phlebotomy for plasma HIV RNA levels and $CD4^+$ T-cell counts. We collected information about sociodemographic characteristics, health behaviors, food security, dietary intake, inpatient and outpatient healthcare utilization, and physical health-related quality of life using validated scales. All surveys were translated and back-translated into Runyankole, pilot tested with 97 Ugandan HIV-infected individuals and administered by a native Runyankole speaker. Ethical approval was obtained from ethical review boards at the University of California at San Francisco, Partners Healthcare, Mbarara University of Science and Technology, and the Uganda National Council of Science and Technology.

Measures

The primary explanatory variable for this analysis was household food insecurity over the 30 days prior to the interview, as measured by the Household Food Insecurity Access Scale. This nine-item scale, based on validation studies in eight countries [25–27], was developed using the same approach that was used to develop the officially adopted and annually implemented national measure of household food insecurity in the United States. Validation studies have demonstrated that this measure is able to distinguish food-secure from food-insecure households across different cultural contexts. Questions cover three domains of experience of food insecurity including anxiety and uncertainty about the household food supply, insufficient quality (variety, preferences and types of food), and insufficient food intake and its physical consequences. Participants were identified as being food secure, or mildly, moderately, and severely food insecure. The internal consistency of this measure was high in this sample, with a Cronbach's alpha of 0.91.

Our outcomes of morbidity and healthcare utilization were measured over the previous 3 months, and included physical health-related quality of life, incident opportunistic infections, number of hospitalizations, and missed clinic visits. Physical health-related quality of life (continuous variable) was measured with the Medical Outcomes Study-HIV (MOS-HIV) Physical Health Summary (PHS). This measure consists of 35 items grouped into 11 domains, and a higher score reflects a better health-related quality of life [28,29]. This questionnaire has been translated into various languages and has undergone cultural adaptation and validation [30]. It has been shown to be internally consistent, correlated with increased AIDS-related events [29], and has been studied among a variety of patient groups with HIV/AIDS, including asymptomatic and treatment-naive individuals and those with advanced AIDS and opportunistic infections. Incident opportunistic infections (any versus none over the previous three months) were measured by participant-report, and included incident *Pneumocystis* pneumonia, esophageal candidiasis, cryptococcal meningitis, cryptococcal pneumonia, lymphoma, toxoplasmosis, Kaposi's sarcoma, cryptosproridiosis, recurrent typhoid, pulmonary or extrapulmonary tuberculosis, cytomegalovirus retinitis, and herpes zoster. The number of hospitalizations over the previous 3 months was measured by participant-report. Missed clinic visits were measured by participant-report and defined as zero visits over the previous quarter, as the norm in this setting is to have all patients seen in clinic at least once per quarter.

We selected sociodemographic and clinical covariates for adjusted models based on prior literature and theory [8,15,17,31]. Sociodemographic variables were measured at baseline and included age (continuous), sex (male versus female), marital status (married versus unmarried), education (at least high school graduation versus less than high school graduation), distance to clinic measured in hours of travel time (continuous), and any lifetime smoking (yes versus no). To measure household wealth at baseline, we used 25 variables denoting household assets and characteristics to create a household asset index following the methodology proposed by Filmer and Pritchett [32]. Higher values of the asset index indicate greater household wealth relative to others in the sample, and the asset index was entered into the regression models as a continuous variable. We included several time-varying clinical variables including positive test for heavy drinking as measured by the three-item consumption subset of the Alcohol Use Disorders Identification Test (AUDIT-C) [33]; duration of ART in months; CD4 cell count measured in 50 cell increments; and BMI (BMI < 18.5 versus ≥ 18.5 to adjust for being underweight).

Analysis

Data were analyzed with STATA statistical software, version 11.0 (Stata Corporation LP, College Station, Texas, USA). Descriptive statistics using conventional means and proportions were used to examine sample characteristics and experiences of competing demands between food and other resources. We specified a regression model for physical health-related quality of life as a function of household food insecurity (concurrently measured) and potential confounding variables. To estimate the parameters of the marginal model, we used the method of generalized estimating equations with an exchangeable correlation structure and identity link. The bootstrap resampling method was used for variance estimation in which the bootstrap samples were composed from resampling the panels with replacement. Similar models were specified to analyze incident opportunistic infections (logit link), missed clinic visits (logit link), and number of hospitalizations (negative binomial link). We also conducted sensitivity analyses with the explanatory variables lagged by 3 months to strengthen the plausibility of the estimated associations.

Results

Description of study population

In total, 458 participants were recruited in the food insecurity study. Only the 406 individuals (89%) who had no missing data on any variables were included in this analysis. There were no statistically significant differences between the 52 excluded individuals and the 406 included individuals in terms of any of our key predictors and outcomes of interest. In addition, there was no more than 6% missing data on any variables of interest, and most variables had less than 2% missing data. The median duration of follow-up was 2.1 years [interquartile range (IQR) = 1.9–2.8 years]. There were 292 women (72%), median age was 35 (+IQR = 29–40 years); 93 (24%) of participants had completed high school, and 123 participants (30%) were unemployed (Table 1). In terms of food security status, 92 participants (22.7%) were categorized as food secure, 30 (7.4%) as mildly food insecure, 125 (30.8%) as moderately food insecure, and 155 (38.2%) as severely food insecure. Median baseline CD4 cell count was 198. Two hundred and forty-two participants (59%) were ART-naive, and initiating ART at the baseline of the food insecurity study, and the rest had been on ART for a median of 14 months (IQR = 9.2–16.9 months).

Longitudinal factors associated with physical health status and opportunistic infections

At baseline, participants had a median PHS score of 48.8 (IQR = 39.6–55.8). In both unadjusted and adjusted analyses, moderate and severe food insecurity were negatively associated with physical health-related quality of life over follow-up (Table 2). Increasing age, female sex, being married and being underweight were also all negatively associated with PHS. Conversely, increased length of time on ART and increasing CD4 cell counts were positively associated with PHS. When the explanatory variables were lagged by one quarter, severe food insecurity retained a statistically significant association with PHS [$b = -1.58$, 95% confidence interval (CI) = −2.77 to −0.40]. Increasing age, female sex, and being married remained negatively associated with PHS, and increased length of time on ART remained positively associated with PHS (data not shown).

In total, 63 participants (15.5%) reported a new opportunistic infection during follow-up. In unadjusted analyses, severe food insecurity was significantly associated with higher incident opportunistic infections [odds ratio (OR = 1.99, 95% CI = 1.13–3.48, $P < 0.05$)], but mild and moderate food insecurity were not. In adjusted analyses, increased duration of ART was associated with lower odds of incident opportunistic infections, and there was a nonstatistically significant trend toward an association for severe food insecurity (AOR = 1.77, 95% CI = 0.95–3.34, $P = 0.073$). When the explanatory variables were lagged by one quarter, severe food insecurity was associated with increased incident opportunistic infections [adjusted odds ratio (AOR = 1.85, 95% CI = 1.01–3.41), $P < 0.05$)], and increased duration of ART was associated with lower odds of incident opportunistic infections.

Longitudinal factors associated with patterns of healthcare utilization

We found that 160 participants (39.4%) had missed clinic visits, and 68 participants (16.8%) were hospitalized during the course of follow-up. Over the follow-up period, individuals who were mildly (AOR = 1.93, 95% CI = 1.25–2.99, $P < 0.01$) or moderately (AOR = 1.68, 95% CI = 1.19–2.35, $P < 0.01$) food insecure were more likely to have missed clinic visits in adjusted analyses, but this was not the case for individuals who were severely food insecure (Table 3). The only other factor associated with missed clinic visits in adjusted analyses was longer duration on ART. In contrast to these results, when the explanatory variables were lagged by one quarter, individuals who were moderately (AOR = 0.68, 95% CI = 0.51–0.90, $P < 0.01$) or severely (AOR = 0.70, 95% CI = 0.49–0.99, $P < 0.05$) food insecure were less likely to have missed clinic visits, and there was no association between mild food insecurity and missed clinic visits. In lagged models, screening positive for heavy drinking was associated with increased odds of missed clinic visits, and having greater assets was associated with decreased odds of missed clinic visits.

Severe food insecurity (but not mild or moderate food insecurity) was associated with increased number of hospitalizations in both unadjusted [incidence rate ratio (IRR) = 3.48, 95% CI = 1.70–4.69, $P < 0.01$] and adjusted (incidence rate ratio = 3.24, 95% CI = 1.77, $P < 0.01$) analyses (Table 3). Results trended in the same direction in the lagged model. Individuals who were married, unemployed, and had higher asset scores had significantly more hospitalizations in adjusted analyses. Conversely, individuals who were on ART for longer duration had fewer hospitalizations.

Competing demands

Over the course of follow-up, 71 participants (17%) gave up ART in order to get food and 98 participants (24%) gave up obtaining other medications for food (Table 4). Moreover, 122 participants (30%) did not access outpatient medical care when needed, and 131 participants (32%) did not access inpatient medical care when needed due to competing demands with food. Participants who were severely food insecure were significantly more likely than those who were not severely food insecure to report giving up ART for food (Table 4).

A higher proportion of participants gave up food in order to access medical care. Most participants [349 (86%)] had forgone adequate food for themselves or their families in order to obtain ART; 325(80%)had forgone food in order to access outpatient care, and 197 participants (49%) had forgone food in order to access inpatient care. Individuals who were severely food insecure were significantly more likely than participants who were not severely food insecure to give up food in order to access outpatient and inpatient care (Table 4).

Discussion

To our knowledge, this is the first study to determine whether food insecurity is associated with increased morbidity, missed clinic visits, and increased hospitalizations among HIV-positive adults accessing ART in a resource-limited setting. This is also the first study in any setting to examine these relationships longitudinally. We found that a majority of adults accessing ART in rural Uganda were food insecure, and that food insecurity was associated with increased markers of morbidity in longitudinal analyses. Food insecurity also negatively impacted patterns of healthcare utilization as a result of competing demands between food needs and healthcare needs.

Our findings on the associations between food insecurity and HIV-related morbidity are supported by previous cross-sectional research linking food insecurity with worse physical and mental health status [14], lower CD4 cell counts [9,14], lower ART adherence [9,15,34], and reduced viral load suppression [9,15]. They are also supported by findings from a longitudinal study in Vancouver that found that food insecurity was associated with mortality among ART-treated individuals after controlling for clinical and socioeconomic variables [17].

In this study, the relationships observed among food insecurity, socioeconomic status, and patterns of healthcare utilization reflect the fact that accessing healthcare (either primary care or acute care services) is the product of both need and means; that is, an observed hospitalization results when one has the need for acute healthcare and has the means to pay for it. Consistent with this, we found in concurrent models that severe food insecurity was associated with number of hospitalizations, and that mild and moderate food insecurity were associated with missed clinic visits. Declining physical health status likely outweighed the financial constraints to accessing healthcare and need for hospitalizations for severely food-insecure individuals. This interpretation is supported by the lagged models in which individuals who were severely food insecure were significantly less likely to miss outpatient clinic visits. The increased risk of hospitalization seen among severely food-insecure individuals may also be a consequence of missed clinic visits and failure-to-receive necessary medical treatment among those with mid-to-moderate food insecurity. Greater asset wealth was also associated with an increased number of hospitalizations in concurrent models and with decreased odds of missed clinic visits in lagged models, possibly because individuals with greater resources were better able to access hospitalizations and outpatient care when needed. Addressing food insecurity will not only help reduce the need for hospitalization by increasing outpatient care utilization and decreasing morbidity, but may also help reduce overall costs of healthcare if individuals are accessing health services at earlier stages of illness.

Consistent with previous research [11,21,23,35], participants in our study grappled with trade-offs between subsistence needs and healthcare needs, and as a result forewent hospitalizations, clinic visits and ART in order to procure food. Even more striking was the extent to which participants in this study gave up adequate food for themselves or their families in order to access healthcare. This suggests that the negative impact of food insecurity on patterns of healthcare utilization may become even more pronounced over the long term, when these tradeoffs are no longer sustainable, and when HIV comes to be appreciated as a chronic, manageable condition in Uganda. The strong links between food insecurity and HIV/AIDS morbidity and access to care have important policy implications. Poverty, deteriorating infrastructure, and inadequate capacity for service provision in many parts of sub-Saharan Africa are tied to the dual epidemics of HIV/AIDS and food security. Although governments have invested in ART provision, less funding has directly targeted the building blocks underlying ART success, including improved food insecurity. Moreover, policies surrounding food security in the region have been primarily focused on increasing food self-sufficiency at an aggregate national level rather than increasing food security at the household level. This policy stance leads to less resource allocation for the poor, and can hinder the political and institutional reforms necessary to achieve food security in the longer run [36].

To improve food insecurity and hence health outcomes among PLWHA, WHO, UNAIDS, and the World Food Programme have recommended integrating sustainable food production strategies into HIV/AIDS programming [37,38]. Yet, the most effective strategy for improving food security among PLWHA has yet to be elucidated. Several small studies in developing countries have demonstrated the potential for macronutrient supplementation to improve health outcomes among PLWHA [39,40]. Macronutrient supplementation provides critical nutritional support, but does not address all of the downstream health consequences of food insecurity and also causes dependency on health programs [40]. Moreover, relying on health programs for food may be socially unacceptable, or may contribute to ongoing anxiety and uncertainty about food supply. Other solutions for improving food security that have been discussed in the literature include income transfers for food, micro-credit interventions, and livelihood interventions [6,40]. These may better address some of the root causes of food insecurity, and hence may have a better chance of improving health outcomes. One small study in rural Kenya showed that a microirrigation water pump combined with a microfinance loan led to increases in crop yields, household income, BMI, and CD4 cell counts [41]. Further research is critical to provide empirical evidence to guide policies to integrate structural interventions into the expansion of HIV care, treatment, and prevention programs.

There are several limitations to our study. Many of our measures (including those related to our key outcomes and predictors) were self-reported, which can result in correlated measurement errors that introduce bias. There were few participants who fell into the ‘mildly food insecure’ category, which may limit our ability to draw conclusions about this group. Although we controlled for many relevant demographic, socioeconomic, and clinical variables, unobserved confounders may explain some of the associations detected. Our longitudinal design and analysis with both concurrent and lagged models provided some strength in understanding the causal direction and in mitigating the effects of unobserved variables. Nevertheless, randomized intervention studies are needed to fully understand the causal relationships among food insecurity, HIV-related morbidity, and patterns of healthcare utilization and the impacts that can be gained by addressing food insecurity.

In summary, we found that food insecurity is highly prevalent among PLWHA accessing ART in rural Uganda and that it is associated with HIV-related morbidity, increased hospitalizations and decreased utilization of outpatient care services as a result of competing demands for resources. Our findings support the need for food insecurity interventions as an integral component of HIV programs serving impoverished populations [38,42]. Interventions should aim to address upstream causes of food insecurity, rather than the downstream consequences, in order to interrupt the vicious cycle of food insecurity and HIV/AIDS and contribute to improved health-related quality of life, access to healthcare, and decreased morbidity and mortality among PLWHA.

Acknowledgments

We thank the UARTO participants who made this study possible by sharing their experiences; Annet Kembabazi for providing study coordination and support; and Doreen Akello, Marcy Mutumba, Christine Ngabirano, Ruth Ssentongo, and Florence Turyashemererwa for research assistance. We also thank Abigail Hatcher for support with editing of the manuscript. Although these individuals are acknowledged for their assistance, no endorsement of manuscript contents or conclusions should be inferred.

The study was funded by the National Institutes of Health (R01 MH054907, K23 MH079713 and MH-79713-03S1, K24 MH087227, and P30 AI027793) and the Meyer Family Foundation. S.D.W. received additional support from the Burke Family Foundation. A.C.T. received salary support from the Robert Wood Johnson Health and Society Scholars Program.

References

1. The National Agricultural Advisory Services. The impact of HIV/AIDS on the agricultural sector and rural livelihoods in Uganda. Uganda: The National Agricultural Advisory Services; 2003.
2. ORC/Macro. Uganda HIV/AIDS Sero-Behavioral Survey, 2004–2005. UMoHa; Kampala, Uganda: 2006.
3. Normen L, Chan K, Braitstein P, Anema A, Bondy G, Montaner JS, et al. Food insecurity and hunger are prevalent among HIV-positive individuals in British Columbia, Canada. J Nutr. 2005; 135:820–825. [PubMed: 15795441]
4. Bukusuba J, Kikafunda JK, Whitehead RG. Food security status in households of people living with HIV/AIDS (PLWHA) in a Ugandan urban setting. Br J Nutr. 2007; 98:211–217. [PubMed: 17381879]
5. Mbugua, S.; Andersen, N.; Tuitoek, P.; Yeudall, F.; Sellen, D.; Karanja, N., et al. Assessment of food security and nutrition status among households affected by HIV/AIDS in Nakuru Municipality, Kenya. XVII International AIDS Conference; Mexico City. 2008.
6. Gillespie, S.; Kadiyala, S. HIV/AIDS and food and nutrition security: from evidence to action. Washington, DC: International Food Policy Research Institute; 2005.
7. Weiser SD, Leiter K, Bangsberg DR, Butler LM, Percy-de Korte F, Hlanze Z, et al. Food insufficiency is associated with high-risk sexual behavior among women in Botswana and Swaziland. PLoS Med. 2007; 4:1589–1597. [PubMed: 17958460]

NIH-PA Author Manuscript
NIH-PA Author Manuscript

8. Shannon K, Kerr T, Milloy M, Anema A, Zhang R, Montaner JS, Wood E. Severe food insecurity is associated with elevated unprotected sex among HIV-seropositive injection drug users independent of HAART use. AIDS. 2011 [Epub ahead of print].
9. Kalichman SC, Cherry C, Amaral C, White D, Kalichman MO, Pope H, et al. Health and treatment implications of food insufficiency among people living with HIV/AIDS, Atlanta, Georgia. J Urban Health. 2010; 87:631–641. [PubMed: 20419478]
10. Peretti-Watel P, Spire B, Schiltz MA, Bouhnik AD, Heard I, Lert F, et al. Vulnerability, unsafe sex and nonadherence to HAART: evidence from a large sample of French HIV/AIDS outpatients. Soc Sci Med. 2006; 62:2420–2433. [PubMed: 16289743]
11. Weiser SD, Tuller DM, Frongillo EA, Senkungu J, Mukiibi N, Bangsberg DR. Food insecurity as a barrier to sustained anti-retroviral therapy adherence in Uganda. PLoS One. 2010; 5:e10340. [PubMed: 20442769]
12. Gustavson, L.; Lam, W.; Bertz, R.; Hsu, A.; Rynkiewicz, K.; Ji, Q., et al. Assessment of the bioequivalence and food effects for liquid and soft gelatin capsule co-formulations of ABT-378/ritonavir (ABT-378/r) in healthy subjects. 40th Interscience Conference on Antimicrobial Agents and Chemotherapy; Toronto, Canada. 2000.
13. Bardsley-Elliot A, Plosker GL. Nelfinavir: an update on its use in HIV infection. Drugs. 2000; 59:581–620. [PubMed: 10776836]
14. Weiser SD, Bangsberg DR, Kegeles S, Ragland K, Kushel MB, Frongillo EA. Food insecurity among homeless and marginally housed individuals living with HIV/AIDS in San Francisco. AIDS Behav. 2009; 13:841–848. [PubMed: 19644748]
15. Weiser SD, Frongillo EA, Ragland K, Hogg RS, Riley ED, Bangsberg DR. Food insecurity is associated with incomplete HIV RNA suppression among homeless and marginally housed HIV-infected individuals in San Francisco. J Gen Intern Med. 2009; 24:14–20. [PubMed: 18953617]
16. Wang EA, McGinnis KA, Fiellin DA, Goulet JL, Gibert CL, Mattocks K, et al. Food insecurity is associated with poor virologic response among HIV-infected patients receiving antiretroviral medications. J Gen Intern Med. 2011; 26:1012–1018. [PubMed: 21573882]
17. Weiser SD, Fernandes KA, Brandson EK, Lima VD, Anema A, Bangsberg DR, et al. The association between food insecurity and mortality among HIV-infected individuals on HAART. J Acquir Immune Defic Syndr. 2009; 52:342–349. [PubMed: 19675463]
18. Kersey MA, Beran MS, McGovern PG, Biros MH, Lurie N. The prevalence and effects of hunger in an emergency department patient population. Acad Emerg Med. 1999; 6:1109–1114. [PubMed: 10569382]
19. Gelberg L, Gallagher TC, Andersen RM, Koegel P. Competing priorities as a barrier to medical care among homeless adults in Los Angeles. Am J Public Health. 1997; 87:217–220. [PubMed: 9103100]
20. Baggett TP, Singer DE, Rao SR, O'Connell JJ, Bharel M, Rigotti NA. Food insufficiency and health services utilization in a national sample of homeless adults. J Gen Intern Med. 2011; 26:627–634. [PubMed: 21279455]
21. Kushel MB, Gupta R, Gee L, Haas JS. Housing instability and food insecurity as barriers to healthcare among low-income Americans. J Gen Intern Med. 2006; 21:71–77. [PubMed: 16423128]
22. Nelson K, Brown ME, Lurie N. Hunger in an adult patient population. JAMA. 1998; 279:1211–1214. [PubMed: 9555762]
23. Tuller DM, Bangsberg DR, Senkungu J, Ware NC, Emenyonu N, Weiser SD. Transportation costs impede sustained adherence and access to HAART in a clinic population in southwestern Uganda: a qualitative study. AIDS Behav. 2010; 14:778–784. [PubMed: 19283464]
24. Geng EH, Bwana MB, Kabakyenga J, Muyindike W, Emenyonu NI, Musinguzi N, et al. Diminishing availability of publicly funded slots for antiretroviral initiation among HIV-infected ART-eligible patients in Uganda. PLoS One. 2010; 5:e14098. [PubMed: 21124842]
25. Coates, J.; Swindale, A.; Bilinsky, P. Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development; 2006.

26. Frongillo EA, Nanama S. Development and validation of an experience-based measure of household food insecurity within and across Seasons in Northern Burkina Faso. J Nutr. 2006; 136:1409S–1419S. [PubMed: 16614438]
27. Swindale A, Bilinsky P. Development of a universally applicable household food insecurity measurement tool: process, current status, and outstanding issues. J Nutr. 2006; 136:1449S–1452S. [PubMed: 16614442]
28. Wu AW, Rubin HR, Mathews WC, Ware JE Jr, Brysk LT, Hardy WD, et al. A health status questionnaire using 30 items from the Medical Outcomes Study. Preliminary validation in persons with early HIV infection. Med Care. 1991; 29:786–798. [PubMed: 1875745]
29. Wu AW, Revicki DA, Jacobson D, Malitz FE. Evidence for reliability, validity and usefulness of the Medical Outcomes Study HIV Health Survey (MOS-HIV). Qual Life Res. 1997; 6:481–493. [PubMed: 9330549]
30. Stangl AL, Wamai N, Mermin J, Awor AC, Bunnell RE. Trends and predictors of quality of life among HIV-infected adults taking highly active antiretroviral therapy in rural Uganda. AIDS Care. 2007; 19:626–636. [PubMed: 17505923]
31. Anema A, Vogenthaler N, Frongillo EA, Kadiyala S, Weiser SD. Food insecurity and HIV/AIDS: current knowledge, gaps, and research priorities. Curr HIV/AIDS Rep. 2009; 6:224–231. [PubMed: 19849966]
32. Filmer D, Pritchett LH. Estimating wealth effects without expenditure data – or tears: an application to educational enrollments in states of India. Demography. 2001; 38:115–132. [PubMed: 11227840]
33. Bush K, Kivlahan DR, McDonell MB, Fihn SD, Bradley KA. The AUDIT alcohol consumption questions (AUDIT-C): an effective brief screening test for problem drinking. Ambulatory Care Quality Improvement Project (ACQUIP). Alcohol Use Disorders Identification Test. Arch Intern Med. 1998; 158:1789–1795. [PubMed: 9738608]
34. Kalichman SC, Pellowski J, Kalichman MO, Cherry C, Detorio M, Caliendo AM, et al. Food insufficiency and medication adherence among people living with HIV/AIDS in urban and peri-urban settings. Prev Sci. 2011; 12:324–332. [PubMed: 21607719]
35. Ware NC, Idoko J, Kaaya S, Biraro IA, Wyatt MA, Agbaji O, et al. Explaining adherence success in sub-Saharan Africa: an ethnographic study. PLoS Med. 2009; 6:e11. [PubMed: 19175285]
36. Duncan A. The food security challenge for South Africa. Food Policy. 1998; 23:459–475.
37. Nutrition and HIV/AIDS. Statement by the Administrative Committee on Coordination, Sub-Committee on Nutrition at its 28th Session. Nairobe, Kenya: United Nations Administrative Committee on Coordination, Sub-Committee on Nutrition; 2001.
38. Programming in the Era of AIDS: WPF's Response to HIV/AIDS. Rome, Italy: World Food Programme; 2003.
39. Cantrell RA, Sinkala M, Megazinni K, Lawson-Marriott S, Washington S, Chi BH, et al. A pilot study of food supplementation to improve adherence to antiretroviral therapy among food-insecure adults in Lusaka, Zambia. J Acquir Immune Defic Syndr. 2008; 49:190–195. [PubMed: 18769349]
40. Byron E, Gillespie S, Nangami M. Integrating nutrition security with treatment of people living with HIV: lessons from Kenya. Food Nutr Bull. 2008; 29:87–97. [PubMed: 18693472]
41. Pandit JA, Sirotin N, Tittle R, Onjolo E, Bukusi EA, Cohen CR. Shamba Maisha: a pilot study assessing impacts of a micro-irrigation intervention on the health and economic well being of HIV patients. BMC Public Health. 2010; 10:245. [PubMed: 20459841]
42. UNAIDS. HIV, food security, and nutrition. Geneva: Joint United Nations Programme on HIV/AIDS; 2008.

Table 1

Baseline characteristics of participants.

Characteristics	All participants (*N* = 406) *N* (%) or median (IQR)
Sociodemographic characteristics	
Age [median (IQR)]	35.0 (29.2–40.0)
Female	292 (71.9%)
Married	177 (43.6%)
Secondary education	93 (22.3%)
Asset index [median (IQR)]	−0.29 (1.47–1.17)
Unemployed	123 (30.3%)
Severely food insecure	155 (38.2%)
Distance to clinic in hours [median (IQR)]	0.63 (0.5–1.0)
Clinical characteristics	
Any lifetime smoking	95 (23.4%)
ART-naive at study baseline	242 (59.6%)
Duration on ART at baseline in months among participants on ART [median (IQR)]	13.9 (9.2–16.9)
Heavy drinking (AUDIT-C)	34 (8.4%)
CD4 cell count [median (IQR)]	197.5 (127.0–291.0)
BMI <18.5	45 (11.1)
Baseline PHS [median (IQR)]	48.8 (39.6–55.8)

ART, antiretroviral therapy; AUDIT-C, Alcohol Use Disorders Identification Test; IQR, interquartile range; PHS, Medical Outcomes Study-HIV Physical Health Summary. $n < 458$ for some characteristics due to missing data.

Table 2

Adjusted associations between food insecurity and physical health status and opportunistic infections (concurrent and lagged models).

	MOS-HIV physical health status		New opportunistic infection	
Characteristic	**Concurrent adjusted *b* (95% CI)**	**Lagged (3 months) adjusted *b* (95% CI)**	**Concurrent adjusted OR (95% CI)**	**Lagged (3 months) adjusted OR (95% CI)**
Food insecurity				
None	Reference	Reference	Reference	Reference
Mild	−1.06 (−2.20; 0.08)	0.71 (−0.60; 2.01)	0.83 (0.25; 2.79)	0.72 (0.23; 2.22)
Moderate	−1.98 (−2.88; −1.08)***	−0.76 (−1.91; 0.40)	0.69 (0.43; 1.13)	0.72 (0.34; 1.51)
Severe	−3.30 (−4.58; −2.02)***	−1.58 (−2.77; −0.40)**	1.78 (0.96; 3.29)	1.85 (1.01; 3.41)*
Sociodemographic characteristics				
Age	−0.55 (−1.08; −0.02)*	−0.70 (−1.31; −0.10)*	1.05 (0.88: 1.25)	1.04 (0.84; 1.27)
Female sex	−3.10 (−4.47; −1.74)***	−2.42 (−3.84; −1.00)**	1.11 (0.48; 2.58)	0.95 (0.46; 1.96)
Married	−1.43 (−2.70; −0.15)*	−1.23 (−2.47; 0.00)*	1.00 (0.54; 1.84)	1.15 (0.66; 2.00)
More than a high school education	−0.23 (−1.59; 1.14)	−0.24 (−1.57; 1.08)	1.05 (0.40; 2.76)	1.19 (0.54; 2.59)
Asset index	0.25 (−0.10; 0.60)	0.30 (−0.01; 0.62)	1.02 (0.86; 1.21)	1.00 (0.78; 1.28)
Unemployed	−0.30 (−1.83; 1.22)	−0.42 (−2.07; 1.23)	1.22 (0.73; 2.02)	1.41 (0.68; 2.93)
Distance to clinic	0.06 (−0.75; 0.88)	0.24 (−0.46; 0.94)	0.93 (0.64; 1.36)	0.92 (0.66; 1.27)
Clinical characteristics				
Any lifetime smoking	−1.28 (−2.65; 0.10)	−1.52 (−3.11; 0.07)	1.13 (0.58; 2.19)	1.22 (0.56; 2.66)
Duration of ART (months)	0.15 (0.11, 0.19)***	0.08 (0.04; 0.12)***	0.97 (0.95; 0.99)**	0.96 (0.93; 0.99)**
Heavy drinking (AUDIT-C)	−1.52 (−3.49; 0.45)	−1.15 (−3.01; 0.70)	0.50 (0.02; 12.72)	0.23 (0.00; 13.82)
Low BMI	−4.52 (−6.74; −2.30)***	−1.61 (−3.36; 0.15)	1.29 (0.52; 3.22)	1.01 (0.38; 2.70)
CD4 cell count (per 50 cells/μl increment)	0.13 (0.02; 0.24)*	−0.01 (−0.14; 0.12)	1.04 (0.98; 1.11)	1.05 (0.96; 1.14)

ART, antiretroviral therapy; AUDIT-C, Alcohol Use Disorders Identification Test; CI, confidence interval; MOS-HIV, Medical Outcomes Study-HIV; OR, odds ratio.

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

Table 3

Adjusted associations between food insecurity and number of hospitalizations and missed clinic visits (concurrent and lagged models).

Characteristic	Number of hospitalizations		No clinic visits in 3 months	
	Concurrent adjusted IRR (95% CI)	Lagged adjusted IRR (95% CI)	Concurrent adjusted OR (95% CI)	Lagged adjusted OR (95% CI)
Food insecurity				
None	Reference	Reference	Reference	Reference
Mild	0.66 (0.04; 11.32)	0.66 (0.01; 32.41)	1.93 (1.10; 3.39) **	1.14 (0.75; 1.76)
Moderate	1.33 (0.69; 2.58)	0.88 (0.38; 2.08)	1.68 (1.10; 2.56) *	0.68 (0.51; 0.90) **
Severe	3.25 (1.74; 6.04) ***	1.70 (0.82; 3.53)	1.23 (0.80; 1.92)	0.70 (0.49; 1.00) *
Sociodemographic characteristics				
Age	0.93 (0.73; 1.20)	1.02 (0.80; 1.30)	0.90 (0.75; 1.07)	0.97 (0.84; 1.13)
Female sex	1.02 (0.45; 2.29)	1.52 (0.63; 3.67)	0.60 (0.32; 1.11)	0.76 (0.43; 1.35)
Married	2.26 (1.37; 3.74) **	2.67 (1.27; 5.63) **	1.10 (0.63; 1.94)	1.09 (0.67; 1.79)
More than a high school education	0.69 (0.37; 1.29)	0.88 (0.48; 1.61)	1.19 (0.68; 2.10)	1.31 (0.82; 2.10)
Asset index	1.14 (0.94; 1.39)	1.04 (0.84; 1.29)	0.91 (0.80; 1.03)	0.88 (0.79; 0.99) *
Unemployed	1.81 (0.80; 4.09)	0.95 (0.42; 2.12)	1.13 (0.73; 1.73)	0.97 (0.65; 1.43)
Distance to clinic	1.20 (0.84; 1.71)	0.97 (0.64; 1.48)	1.12 (0.84; 1.48)	1.17 (0.91; 1.49)
Clinical characteristics				
Any lifetime smoking	1.93 (0.74; 5.03)	1.00 (0.36; 2.75)	0.57 (0.33; 0.97) *	0.60 (0.36; 1.02)
Duration of ART (months)	0.94 (0.91; 0.98) **	0.97 (0.93; 1.01)	1.06 (1.04; 1.07) ***	1.03 (1.02; 1.05) ***
Heavy drinking (AUDIT-C)	0.27 (0.00; 56.97)	1.15 (0.06; 21.32)	0.67 (0.26; 1.74)	1.98 (1.08; 3.63) *
Low BMI	1.14 (0.27; 4.88)	1.47 (0.06; 33.35)	0.94 (0.46; 1.94)	1.13 (0.72; 1.77)
CD4 cell count (per 50 cells/μl increment)	0.97 (0.90; 1.05)	0.91 (0.81; 1.03)	1.02 (0.97; 1.07)	1.04 (1.00; 1.09)

ART, antiretroviral therapy; AUDIT-C, Alcohol Use Disorders Identification Test; CI, confidence interval; IRR, incidence rate ratio; OR, odds ratio.

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

Table 4

Competing demands between food and healthcare needs during follow-up.

	All participants (N = 406) N (%)	Not severely food insecure during follow-up (N = 247, 61%) N (%)	Severely food insecure during follow-up (N = 155, 39%) N (%)
Giving up medical care for food			
Giving up ART for food	71(17%) **	30 (12%) **	40 (26.0%) **
Giving up other medications for food	98 (24)	51 (21%)	45 (29%)
Giving up needed outpatient care for food	122 (30%)	70 (28%)	51 (33%)
Giving up needed inpatient care for food	131 (32%)	72 (29%)	58 (37%)
Giving up food for medical care			
Giving up food for ART	349 (86%)	207 (84%)	139 (89%)
Giving up food to access outpatient care	325 (80%) *	188 (76%) *	133 (86%) *
Giving up food to access inpatient care	197 (49%) **	105 (43%) **	89 (57%) **

ART, antiretroviral therapy. n < 406 for some characteristics due to missing data.

* $P < 0.05$.

** $P < 0.01$.

NIH-PA Author Manuscript

NIH-PA Author Manuscript