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Food Insecurity, Depression and the Modifying Role of Social Support among People Living with HIV/AIDS in Rural Uganda

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Abstract

Depression is common among people living with HIV/AIDS and contributes to a wide range of worsened HIV-related outcomes, including AIDS-related mortality. Targeting modifiable causes of depression, either through primary or secondary prevention, may reduce suffering as well as improve HIV-related outcomes. Food insecurity is a pervasive source of uncertainty for those living in resource-limited settings, and cross-sectional studies have increasingly recognized it as a critical determinant of poor mental health. Using cohort data from 456 men and women living with HIV/AIDS initiating HIV antiretroviral therapy in rural Uganda, we sought to (a) estimate the association between food insecurity and depression symptom severity, (b) assess the extent to which social support may serve as a buffer against the adverse effects of food insecurity, and (c) determine whether the buffering effects are specific to certain types of social support. Quarterly data were collected by structured interviews and blood draws. The primary outcome was depression symptom severity, measured by a modified Hopkins Symptom Checklist for Depression. The primary explanatory variables were food insecurity, measured with the Household Food Insecurity Access Scale, and social support, measured with a modified version of the Functional Social Support Questionnaire. We found that food insecurity was associated with depression symptom severity among women but not men, and that social support buffered the impacts of food insecurity on depression. We also found that instrumental support had a greater buffering influence than emotional social support. Interventions aimed at improving food security

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and strengthening instrumental social support may have synergistic beneficial effects on both mental health and HIV outcomes among PLWHA in resource-limited settings.

Keywords

AIDS/HIV; international health; social support; food; food insecurity; depression; Uganda

INTRODUCTION

Depression is common among people living with HIV/AIDS (PLWHA) in the U.S. (Bing et al., 2001). This is important clinically because untreated or sub-optimally treated depression may result in worsened HIV-related outcomes (Anastos et al., 2005; Burack et al., 1993; Carrico et al., 2011; Cook et al., 2004). Conversely, alleviation of depressed mood may improve HIV-related outcomes (Tsai et al., 2010). Policies and programming for PLWHA in sub-Saharan Africa focus primarily on improving access to HIV antiretroviral therapy. Yet although the prevalence of depression may be as high among PLWHA in sub-Saharan Africa as among PLWHA in the U.S., little research has emphasized the treatment or prevention of depression among PLWHA in sub-Saharan Africa to optimize HIV outcomes (Kaharuza et al., 2006; Martinez et al., 2008).

Food insecurity, defined as having uncertain or limited availability of nutritionally adequate food or as being unable to procure food in socially acceptable ways (Anderson, 1990), may be a risk factor for depression that can be modified to improve HIV outcomes. Although there are no population-based estimates of the prevalence of food insecurity among PLWHA, small-sample evidence from Canada, the U.S., and Uganda suggest that the prevalence is high (Bukusuba, Kikafunda, & Whitehead, 2007; Weiser et al., 2009a; Weiser et al., 2009b). Several analyses based on data from both resource-limited and resource-rich settings suggest an association between food insecurity and poor mental health (Cole & Tembo, 2011; Carter et al., 2011; Gupta et al., 2010; Maes et al., 2010; Okechukwu et al., 2011).

Several cross-sectional studies have also described an association between food insecurity and depression among PLWHA (Anema et al., 2011; Vogenthaler et al., 2011; Wu et al., 2008). Because of the clinical importance of both food insecurity and depression to HIV outcomes, and because of the elevated prevalence of both factors among PLWHA in sub-Saharan Africa, there is a need for heightened attention to issues of reverse causality and potential confounding. More robust statistical designs would help to strengthen the case for integrated food security interventions to improve the health of PLWHA in these settings. We therefore undertook this longitudinal study of PLWHA initiating HIV antiretroviral therapy (ART) in rural Uganda to estimate the association between food insecurity and depression symptom severity.

Our conceptual framework draws heavily from the literature on social structure and its influence on depression. The stress process model, first elaborated by Pearlin and colleagues (Pearlin, 1989; 1999; Pearlin et al., 1981), directs attention to eventful experiences and life strains in the production of stress and psychological distress. Role-related strains have been found to be more strongly associated with depressed mood than discrete life events (Kessler, Price, & Wortman, 1985). Given the centrality of food production as a primary role for persons engaged in subsistence livelihoods to support their households, especially women (Quisumbing et al., 1995), food insecurity may be even more strongly associated with depressed mood than other psychosocial stressors. In many sub-Saharan African settings,

food insecurity is the predominant form of uncertainty experienced in daily living (Pike & Patil, 2006).

We further hypothesize that food insecurity is related to depression symptom severity only, or primarily, for persons without social supports. This "buffering" hypothesis has been elaborated in the more general context of social support exerting a moderating influence on the potentially depressogenic effects of life strains (Cassel, 1976; Cobb, 1976). Further, the buffering effect will be most effective when the type of support provided "matches" the stress experience (Cohen & McKay, 1984; Cohen & Wills, 1985). Food shortfalls will be most effectively met with support in the form of tangible assistance. For example, Kawachi hypothesized that "Even apparently trivial differences in the willingness of neighbors to help each other (e.g., through cash loans or labor in kind) might conceivably affect the health of individuals living in deprived communities" (p.121) (Kawachi, 1999). Thus, instrumental social support -- as distinguished from emotional, informational, or diffuse social support (Cohen & Wills, 1985) -- may be the most relevant form of social support to consider when assessing potential moderating influences on the food insecurity-depression relationship.

Studies based on longitudinal data are needed to disentangle the complicated relationship between food insecurity and depression, as two potential concerns could undermine interpretations of associational estimates based on cross-sectional data, namely: reverse causality and inability to adjust for unobserved confounding. First, given that the course of depressive illness is often characterized by functional decline (Judd et al., 1998), the observed relationship between food insecurity and depression could be explained by depression undermining one's ability to effectively procure food or cope with the uncertain availability of food. Second, qualitative studies conducted in diverse cultural contexts identify feelings of helplessness, shame, suffering, and humiliation as central to the experience of food insecurity (Coates et al., 2006a; Hamelin, Beaudry, & Habicht, 2002; Nordanger, 2007; Nanama & Frongillo, 2012). Thus, there may be simple overlap between the scales used to measure both constructs. A related concern is that personality type may affect the reporting of both food insecurity and depression symptom severity (Epstein, 1992): for example, if certain types of personalities are prone to over-report difficulties obtaining food *and* over-report symptoms of depression, then this could lead to detection of a spurious association. As described below, our design and analytic methods address both of these concerns.

METHODS

Study population, design, and data collection

Mbarara District is located in a rural area of Uganda southwest of Kampala, reachable by a five-hour automobile drive. Mbarara town (population 82,000) is the primary commercial hub, but the majority of district residents live in outlying rural areas. Data for this study were drawn from the Uganda AIDS Rural Treatment Outcomes (UARTO) study, a cohort of adult ART-naive patients initiating no-cost ART who have been recruited from the Mbarara Immune Suppression Syndrome Clinic on an ongoing basis since 2005. Ethical approval for all UARTO study procedures was obtained by the Committee on Human Research, University of California at San Francisco; the Partners Human Research Committee at Massachusetts General Hospital; the Institutional Ethical Review Committee, Mbarara University; and the Uganda National Council of Science and Technology. After providing written informed consent and enrolling in the study, participants are seen every three months for blood draws and structured interviews to assess depression symptom severity, food insecurity, health status, substance use, and HIV-related stigma. The UARTO survey instrument was translated into Runyankole, back-translated into English, and pilot-tested in a group of 97 ART-naive HIV+ Ugandans initiating ART.

Time-dependent variables

To measure depression symptom severity, we used the 15-item Hopkins Symptom Checklist for Depression (HSCL-D) (Derogatis et al., 1974a). Following prior studies of depression in Uganda, we modified the HSCL-D for the local context by adding a 16th item, "feeling like I don't care about my health" (Bolton & Ndogoni, 2001; Martinez et al., 2008). Previous research has demonstrated that inclusion of somatic items may inflate depression scores among PLWHA, due to overlap between symptoms of depression and symptoms of HIV infection (Kalichman, Rompa, & Cage, 2000; Kalichman, Sikkema, & Somlai, 1995). Therefore, we removed the four somatic items ("feeling low in energy, slowed down," "feeling fidgety," "poor appetite," and "having difficulty falling or staying asleep") and calculated the total score by averaging across the remaining 12 cognitive-affective items. Participants with a score of 1.75 or greater are classified as symptomatic, and this is typically used as the threshold for a positive screen of probable depression (Derogatis et al., 1974b). The Cronbach's alpha for the modified HSCL-D was 0.84, indicating excellent internal consistency.

Food insecurity was measured using the nine-item Household Food Insecurity Access Scale (HFIAS or simply food insecurity) (Coates, Swindale, & Bilinsky, 2006b). This experience-based measure of food insecurity was validated in eight countries, including one African country, and measures multiple domains of the food insecurity experience, including anxiety and uncertainty about food supply, insufficient quality, and insufficient food intake and its physical consequences (Coates et al., 2006b; Frongillo & Nanama, 2006). Consistent with recommended practice (Coates et al., 2006b), we adapted the food insecurity scale to the local context by conducting in-depth interviews with 15 key informants, modifying the draft scale with feedback from 10 patients from the ISS Clinic, and pilot-testing the translated and back-translated scale on 31 additional patients from the ISS Clinic. Further, we conducted in-depth qualitative studies on different aspects of the food insecurity experience (Miller et al., 2011; Tuller et al., 2010; Weiser et al., 2010). This work resulted in the addition of culturally specific probes and interviewer clarifications but did not suggest items for addition or deletion (see Electronic Appendix). The maximum food insecurity score is 27, with higher scores indicating more severe food insecurity. At baseline, the Cronbach's alpha was 0.91, indicating excellent internal consistency. Using a validated scoring algorithm, the scores on the raw scale were used to assign respondents to discrete categories of food insecurity severity: food secure, mildly food insecure, moderately food insecure, and severely food insecure (Coates et al., 2006b).

To measure perceived social support, we used the modified Duke-University of North Carolina Functional Social Support Questionnaire (Antelman et al., 2001; Broadhead et al., 1988) (see Electronic Appendix). Each of the 10 items was scored on a 4-point Likert scale. The mean across all items was computed to derive the overall score. In the original scale, higher levels of the mean score reflected lower levels of social support, but for ease of interpretation we reversed the scores of the individual scale items prior to calculating the mean score, so that higher scores reflected higher levels of social support. At baseline, the Cronbach's alpha was 0.91, indicating excellent internal consistency.

For this study of PLWHA we also accounted for HIV-related stigma given its potential associations with both food insecurity and depression (Simbayi et al., 2007; Tsai et al., 2011). We focused on internalized stigma, a process through which PLWHA accept their discredited status as valid and develop self-defacing internal representations of themselves (Steward et al., 2008). To measure internalized stigma we used the 6-item Internalized AIDS-Related Stigma Scale (Kalichman et al., 2009). Higher scores indicate a greater degree of internalized stigma. At baseline, the Cronbach's alpha was 0.73, similar to the reliability estimated in the original validation study.

We also adjusted for three clinical variables: self-reported opportunistic infection in the prior three months, the Medical Outcomes Study HIV Health Survey (MOS-HIV) Physical Health Summary (Wu et al., 1991), and CD+ T-lymphocyte cell count. We adjusted for two measures of substance use: any tobacco use in the prior three months and positive screening test for heavy drinking as measured by the three-item consumption subset of the Alcohol Use Disorders Identification Test (AUDIT-C) (Bush et al., 1998). Duration of ART was measured as cumulative months since treatment initiation (i.e., entry into the cohort).

Baseline socio-demographic variables

We adjusted for other baseline variables identified in prior studies as potentially important confounders of the relationship between food insecurity and depression (Carter et al., 2011; Gupta et al., 2010; Maes et al., 2010). Baseline socio-demographic variables included age in years, marital status, educational attainment, and household asset wealth. For the asset wealth measure, we applied principal components analysis to a series of 25 binary variables for household-owned assets and housing characteristics (Filmer & Pritchett, 2001). The first principal component was retained and used to define the wealth index and was entered into the regression models as a continuous variable, with higher values indicating greater asset wealth. We also included a binary variable for probable depression at baseline.

Statistical analysis

Conventional medians and proportions were employed to characterize the distributions of the variables. To test for baseline differences between men and women, we used Pearson's chi-squared test for categorical variables and the nonparametric equality-of-medians test for continuous variables. We fit a linear regression model to the pooled data with lagged covariates in order to ensure a temporal lag between the exposures and the outcome (Hill, 1965). The three-month lag is consistent with prior studies on the effects of psychosocial stressors, which have generally selected a three to six month time frame of event assessment preceding depressive onsets (Hammen, 2005). We modeled depression symptom severity for participant i at time $t+1$ as a linear function of food insecurity at time t, while adjusting for social support, HIV-related stigma, substance use, health status, and cumulative duration of ART at time t and socio- demographic variables at baseline. Cluster-correlated robust standard errors were employed to correct for clustering of observations within study participants over time (Froot, 1989; Rogers, 1993; Williams, 2000).

We fit separate models for men and women for several reasons. First, women in Uganda, as in many other sub-Saharan African countries, frequently assume or are assigned responsibility for household food production, acquisition, processing, and preparation (Quisumbing et al., 1995). Second, gendered patterning of food insecurity, depression, and mental health effects of social support are well established in different contexts (Berkman & Syme, 1979; Hadley et al., 2008; Kawachi & Berkman, 2001; Tsai et al., 2011). And finally, previously published analyses of cross-sectional data from resource-rich and resource-limited settings suggest gendered patterning specifically in the food insecurity-depression relationship (Carter et al., 2011; Gupta et al., 2010; Wu & Schimmele, 2005). Taken together, these findings suggest that women may have a differential vulnerability to the adverse mental health effects of food insecurity.

To test the buffering hypothesis, we re-fit a regression model with interaction terms between food insecurity and social support and then performed a Wald-type F-test to assess the joint statistical significance of the interaction terms. To determine whether the moderating effects differed for different forms of social support, we used the items from the Functional Social Support Questionnaire to construct two subscales, an *instrumental* social support subscale and an *emotional* social support subscale. These subscales were scored in a similar fashion:

we computed the mean across subscale items to derive the subscale score (see Electronic Appendix). We then re-fit the regression models sequentially using these two sub-scales and tested the interaction terms for joint statistical significance.

Even with lagged covariates to address issues of potential reverse causality, however, unmeasured variables such as personality type could still confound the observed association between food insecurity and depression symptom severity. We therefore estimated models with participant-level fixed effects (Mundlak, 1961). Under this specification, participants effectively serve as their own controls. Assuming that all unobservable heterogeneity is constant, then the unobserved heterogeneity is differenced away. Because only within-participant variation is used to estimate the associations, potential overlap in the exposure and outcome scales is also differenced away. Because the fixed effects are collinear with all time-invariant variables, the fixed-effects regression models contained only the time-varying variables: food insecurity, duration of treatment, CD4 count, self-reported opportunistic infection, MOS-HIV Physical Health Summary, heavy drinking, tobacco use, social support, and internalized stigma. Parameter estimates were interpreted as the association between changes (over time) in the explanatory variables and changes (over time) in depression symptom severity. Because a single measure of food insecurity combines both the qualitative and quantitative aspects of the food insecurity experience, we sought to assess the sensitivity of our results to alternative specifications: we disaggregated the food insecurity scale into a food quality subscale and a food quantity subscale and then entered these two subscales as continuous variables into fixed effects regression models (see Electronic Appendix)

RESULTS

The sample consisted of 456 participants: 324 women (71.1%) and 132 men (29.0%) (Table 1). At baseline, the median level of depression symptom severity was greater among women than among men (1.25 vs. 1.08, $p<0.001$), as was the prevalence of probable depression (20.4% vs. 3.9%, $p<0.001$). Overall, 340 (74.6%) participants reported any degree of food insecurity at baseline, and 173 (37.9%) participants reported severe food insecurity. Compared to men, women were more likely to be severely food insecure at baseline (41.7% vs. 28.8%, $p=0.01$). Study participants were followed from August 2007 to July 2010, for a median duration of follow-up of 2.1 years (interquartile range, 1.6–2.8 years). Twenty (4.4%) participants were lost to follow up. Over the study period, depression symptom severity showed variability both between and within participants, with an intraclass correlation coefficient of 0.38.

Among men, food insecurity did not have a statistically significant association with depression symptom severity (Table 2). Among women, however, severe food insecurity had a statistically significant association with depression symptom severity (b=0.070; 95% confidence interval [CI], 0.017–0.123). In relative terms, the *magnitude* of the effect of food insecurity was similar to or greater than that of the other variables. Evaluated at the mean of the other covariates averaged over the course of follow-up, the predicted mean depression score was 1.18 among food secure women and 1.25 among severely food insecure women, a 6% relative difference.

Among women, social support moderated the influence of food insecurity on depression symptom severity, but the extent of effect modification differed depending on the type of social support (Table 3). No effect modification was observed for emotional social support ($F=1.41$, $p=0.24$), but a statistically significant interaction between instrumental social support and food insecurity was estimated ($F=2.95$, $p=0.03$). Among women with the highest level of instrumental social support (score of 4), no category of food insecurity had a

statistically significant association with depression symptom severity. Among women with lower levels of instrumental social support (score of less than 4), severe food insecurity had a statistically significant association with depression symptom severity (b=0.127; 95% CI, 0.057–0.196). This estimated association was nearly twice as large in magnitude as the overall estimate.

To account for all observed and unobserved time-invariant confounders, we fit fixed-effects regression models to the pooled data (Table 4). Among men, changes in food insecurity did not have a statistically significant association with changes in depression symptom severity. Among women, increases in depression symptom severity were associated with increased food insecurity (b=0.005; 95% CI, 0.001–0.009) and decreased social support (b=−0.048; 95% CI, −0.095 to −0.002). Evaluated at the mean of the other covariates, an increase in food insecurity from the 25th to the 75th percentile of intensity was associated with an increase in the predicted depression score from 1.22 to 1.29 (5.7% increase), while an increase in social support from the 25th to the 75th percentile of intensity was associated with a decrease in the predicted depression score from 1.26 to 1.24 (1.6% decrease). Among both men and women, improved health (measured by increased CD4+ count or increased MOS-HIV Physical Health Summary score) was also associated with decreases in depression symptom severity, whereas increased internalized stigma was associated with increased depression symptom severity. In the sensitivity analysis, changes in both the food quality and food quantity subscales were associated with changes in depression symptom severity (see Electronic Appendix)

We identified other important patterns in the data as well. For both men and women, improved health was associated with improved mood. Increased cumulative duration of ART was associated with improved mood. The decline in predicted depression symptom severity (evaluated at the mean of the other covariates) was more twice as large with a one-standard deviation increase in MOS-HIV Physical Health Summary score than with a one-standard deviation increase in CD4+ count. Conversely, for both men and women, increased internalized stigma was associated with worsened mood.

DISCUSSION

This study contributes to the literature on food insecurity and mental health in several ways. In this sample of PLWHA initiating HIV antiretroviral therapy, we found that food insecurity was associated with depression symptom severity among women but not men, that social support moderated the estimated association, and that instrumental support had a greater moderating influence than emotional social support. These findings are consistent with predictions based on what is known about the local context as well as with theoretical hypotheses from the literature on social factors influencing mental health. Given the clinical and public health importance of both food insecurity and depression to the physical health of PLWHA, our findings have important implications for HIV care programs and policies worldwide and especially in resource-limited settings.

Our findings on the association between food insecurity and depression symptom severity confirm what has been documented in previously published analyses of data from general population samples (Carter et al., 2011; Maes et al., 2010; Okechukwu et al., 2011). The food insecurity-depression link has also been shown to be stronger among women (Carter et al., 2011; Gupta et al., 2010; Wu & Schimmele, 2005) and during the dry season (Cole & Tembo, 2011). However, only two U.S. studies have employed fixed-effects regression to adjust for potential time-invariant confounding (Heflin, Siefert, & Williams, 2005; Kim & Frongillo, 2007). This is of particular importance for research in this area given the potential for scale overlap and unobserved confounding by personality type. Fixed effects regression

eliminates both concerns. In Kim & Frongillo's (2007) analysis of data on middle-aged adults in the U.S., a lagged-covariate specification yielded a statistically significant association but a fixed-effects specification did not, suggesting that the observed association could be explained by unobserved confounding. Heflin et al. (2005) used a single-question measure of insufficiency and showed that changes in food sufficiency status among women in Michigan were associated with an increased odds of probable depression. We were unable to directly compare the relative magnitudes of our estimates due to reporting differences, but our findings are broadly consistent with theirs.

Social support was an effect modifier of the relationship between food insecurity and depression, consistent with the "buffering" hypothesis (Cassel, 1976; Cobb, 1976). Specifically, our analyses showed that food insecurity had a detrimental effect on mental health primarily among women with low levels of instrumental social support. Similar to our study, a previously published cross-sectional analysis of general population data from Canada showed that social support exerted a moderating influence on the association between food insecurity and depression (Wu & Schimmele, 2005). In related work, social support has been shown to modify the harmful effects of deprivation and substance abuse on HIV treatment adherence among PLWHA (Crane et al., 2006; Lehavot et al., 2011; Ware et al., 2009). We did not observe a similar moderating influence of emotional social support. This is consistent with the "matching" hypothesis and suggests that instrumental social support is the more directly relevant construct to measure in studies of this nature (Cohen & McKay, 1984; Cohen & Wills, 1985).

A number of important patterns were observed in the data as well. We found that depression symptom severity declined with cumulative duration of ART. The psychological benefits of HIV treatment have been described in cross-sectional and longitudinal studies, although the biological mechanisms underlying the association remain unclear (Low-Beer et al., 2000; Munoz et al., 2010; Nieuwkerk et al., 2000; Rabkin et al., 2000). We also found that increases in internalized stigma were associated with worsened mood, consistent with previous theoretical work linking racial discrimination to depression in minority populations (Fernando, 1984; Krieger, 1999). Cross-sectional studies of PLWHA in both resource-rich and resource-limited settings have yielded findings consistent with theoretical work but have yet to be confirmed with longitudinal analyses (Lee, Kochman, & Sikkema, 2002; Simbayi et al., 2007; Steward et al., 2008).

This analysis highlights the economically disadvantaged status of women already marginalized due to their HIV status. In addition to depression, food insecurity is also known to contribute to worsened health outcomes among PLWHA (Anema et al., 2009; Weiser et al., 2009a; Weiser et al., 2009b; Weiser et al., 2010; Weiser et al., 2011). In our sample, the prevalence of both probable depression and severe food insecurity were higher among women compared to men. Our findings therefore identify a modifiable risk factor for poor mental health that, if addressed, has the potential to improve the health of PLWHA and attenuate the widening gender inequities observed in the distribution of HIV/AIDS harms worldwide (Farmer, 1996). Although multilateral organizations have recommended integrating food-security interventions into existing HIV/AIDS programs, there has been little research to date on the effectiveness of food security interventions to improve health outcomes among PLWHA (Pandit, Sirotin, Tittle, Onjolo, Bukusi, & Cohen, 2010; Tirivayi & Groot, 2011; World Food Programme, 2003; Yager, Kadiyala, & Weiser, 2011).

Interpretation of our findings is subject to several limitations. First, we lacked data on the extent to which study participants met formal diagnostic criteria for major depressive disorder. Sub-syndromal symptoms are commonly experienced during the course of mood disorders, however, and are associated with significant psychosocial impairment (Judd et al.,

1998; Judd et al., 2000). Second, we included several time-varying confounders in the multivariable regression models related to health status. Because food insecurity has shown to be associated with physical health status, opportunistic infections, and other types of morbidity (Weiser et al., 2012), our use of conventional methods for statistical adjustment could introduce bias in the presence of any unmeasured common cause of the health status variables and depression symptom severity. Third, extended famine conditions are known to induce compensatory responses that may worsen or improve mental health, so extrapolation of our findings to long-term food insecurity or nutritional deprivation may not be warranted (Shipton, 1990). Fourth, our study sample consists of PLWHA who are initiating ART. It is well known in this context that there are formidable structural and economic barriers to accessing HIV treatment, and PLWHA often need to mobilize social support in order to overcome these barriers (Crane et al., 2006; Tsai & Bangsberg, 2011; Tuller et al., 2010; Ware et al., 2009). It is therefore possible, or even likely, that the PLWHA in our sample have had greater access to social support than untreated PLWHA in the community. Ceiling effects would have diminished our ability to detect any potential buffering of food insecurity by social support, so this strengthens our confidence in the statistical significance of the interactions we identified.

CONCLUSION

Using validated scales and longitudinal data, we demonstrated a robust association between food insecurity and depression symptom severity among PLWHA initiating ART in rural Uganda, particularly among women who lack access to instrumental social support. Interventions aimed at improving food security and strengthening instrumental social support may have synergistic beneficial effects on both mental health and HIV outcomes among PLWHA in resource-limited settings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Research Highlights

- Examines food insecurity and depression among people living with HIV/AIDS in Uganda
- The effect was statistically significant and large in magnitude among women (not men)
- Social support buffered the adverse impacts of food insecurity
- Instrumental social support had a greater buffering effect than emotional social support

Table 1

Summary statistics at baseline

	Men	Women	
Variable name	**Median (interquartile range [IQR]) or No. (%)**	**Median (IQR) or No. (%)**	**Test statistic [§] (P-value)**
Hopkins Symptom Checklist for Depression (HSCL-D), total score	1.1 (1.0, 1.3)	1.3 (1.1, 1.7)	14.9 (<0.001)
Probable depression (HSCL-D >1.75)	5 (3.8%)	66 (20.4%)	25.4 (<0.001)
Household Food Insecurity Access Scale, total score	6 (0, 10)	8 (2, 14)	6.2 (0.01)
Household Food Insecurity Access Scale, category			11.3 (0.02)
Food secure	39 (29.6%)	73 (22.5%)	
Mildly food insecure	7 (5.3%)	25 (7.7%)	
Moderately food insecure	48 (36.4%)	87 (26.9%)	
Severely food insecure	38 (28.8%)	135 (41.7%)	
Age, years	38.5 (33.0, 44.9)	34 (28, 38.4)	
Married	87 (65.9%)	116 (35.8%)	34.4 (<0.001)
Achieved secondary education	34 (25.8%)	72 (22.2%)	1.0 (0.60)
Asset index	0.2 (−1.1, 1.3)	−0.5 (−1.6, 1.2)	2.7 (0.10)
Heavy drinking	16 (12.1%)	19 (5.9%)	6.1 (0.05)
Any tobacco use, prior three months	17 (12.9%)	6 (1.9%)	24.1 (<0.001)
CD4+ T-lymphocyte cell count, cells/mm^3	177 (107, 265)	210.5 (138, 304)	2.7 (0.10)
Opportunistic infection self-reported, prior three months	2 (1.5%)	12 (3.7%)	3.1 (0.21)
Physical Health Summary, total score	48.5 (41.1, 56.3)	49.3 (39.9, 55.9)	0.04 (0.83)
Functional Social Support Questionnaire, total score	4 (3.6, 4)	3.9 (3.5, 4)	1.8 (0.18)
Internalized AIDS-Related Stigma Scale, total score	1 (0, 2)	1 (0, 2)	2.0 (0.16)

[§]From Pearson's chi-squared test (categorical variables) or nonparametric equality-of-medians test (continuous variables)

Table 2

Linear regression estimates for the association between food insecurity and depression symptom severity, with lagged covariates

	Men		Women	
Variable name	**Adjusted coefficient**	**95% confidence interval (CI)**	**Adjusted coefficient**	**95% CI**
Household Food Insecurity Access Scale				
Food secure	Ref		Ref	
Mildly food insecure	0.038	(−0.016, 0.093)	0.028	(−0.041, 0.097)
Moderately food insecure	0.026	(−0.023, 0.074)	−0.004	(−0.050, 0.043)
Severely food insecure	0.044	(−0.014, 0.102)	**0.070**	**(0.017, 0.123)**
Age, per five years	0.010	(−0.007, 0.028)	0.006	(−0.010, 0.022)
Married	−0.044	(−0.096, 0.009)	0.008	(−0.045, 0.061)
Achieved secondary education	0.015	(−0.052, 0.083)	0.002	(−0.071, 0.075)
Asset index	−0.005	(−0.014, 0.005)	−0.001	(−0.016, 0.014)
Cumulative duration of treatment, per month	**−0.003**	**(−0.006, −0.001)**	**−0.005**	**(−0.007, −0.002)**
CD4+ T-lymphocyte cell count, per 100 cells/mm^3	−0.009	(−0.019, 0.001)	0.008	(−0.003, 0.019)
Opportunistic infection self-reported, prior three months	0.011	(−0.061, 0.083)	−0.008	(−0.086, 0.071)
Physical Health Summary, total score	−0.002	(−0.005, 0.001)	**−0.004**	**(−0.006, −0.001)**
Heavy drinking	0.047	(−0.046, 0.119)	0.148	(−0.053, 0.348)
Any tobacco use, prior three months	0.030	(−0.033, 0.093)	**−0.119**	**(−0.231, −0.007)**
Functional Social Support Questionnaire, total score	−0.082	(−0.184, 0.019)	−0.047	(−0.095, 0.001)
Internalized AIDS-Related Stigma Scale, total score	0.006	(−0.007, 0.02)	0.013	(−0.002, 0.028)
Depression, total score at baseline	**0.496**	**(0.198, 0.794)**	**0.171**	**(0.096, 0.246)**

Notes. Asset index was measured using the measure proposed by Filmer & Pritchett (2001). The Physical Health Summary was measured using the MOS-HIV. Screening for heavy drinking was based on the AUDIT-C (Bush et al., 1998).

Table 3

Effect modification by social support, among women only[§]

	Adjusted coefficient	95% confidence interval
Interaction term between social support and food insecurity		
Main effect: Household Food Insecurity Access Scale		
Food secure	Ref	
Mildly food insecure	0.241	(−0.530, 1.012)
Moderately food insecure	**0.413**	**(−0.072, 0.753)**
Severely food insecure	**0.514**	**(0.138, 0.890)**
Main effect: Functional Social Support Questionnaire	0.041	(−0.024, 0.105)
Interaction terms		
Food secure × social support	Ref	
Mildly food insecure × social support	−0.056	(−0.258, 0.145)
Moderately food insecure × social support	**−0.111**	**(−0.204, −0.019)**
Severely food insecure × social support	**−0.120**	**(−0.220, −0.019)**
Wald-type F-test for the interaction: F=2.36 (P=0.07)		
Interaction term between instrumental social support and food insecurity		
Main effect: Household Food Insecurity Access Scale		
Food secure	Ref	
Mildly food insecure	0.030	(−0.291, 0.352)
Moderately food insecure	**0.254**	**(0.033, 0.475)**
Severely food insecure	**0.379**	**(0.144, 0.614)**
Main effect: instrumental social support sub-scale	0.028	(−0.014, 0.070)
Interaction terms		
Food secure × social support	Ref	
Mildly food insecure × social support	0.001	(−0.090, 0.091)
Moderately food insecure × social support	**−0.072**	**(−0.134, −0.010)**
Severely food insecure × social support	**−0.089**	**(−0.153, −0.024)**
Wald-type F-test for the interaction: F=2.95 (P=0.03)		
Interaction term between emotional social support and food insecurity		
Main effect: Household Food Insecurity Access Scale		
Food secure	Ref	
Mildly food insecure	0.512	(−0.844, 1.87)
Moderately food insecure	0.345	(−0.001, 0.692)
Severely food insecure	0.359	(−0.047, 0.765)
Main effect: instrumental social support sub-scale	0.027	(−0.033, 0.087)
Interaction terms		
Food secure × social support	Ref	
Mildly food insecure × social support	−0.126	(−0.473, 0.221)
Moderately food insecure × social support	−0.090	(−0.182, 0.001)
Severely food insecure × social support	−0.074	(−0.179, 0.032)
Wald-type F-test for the interaction: F=1.41 (P=0.24)		

§All estimates adjusted for baseline and time-dependent variables listed in Table 2.

Table 4

Fixed-effects regression estimates for the association between changes in food insecurity and changes in depression symptom severity

	Men		Women	
Variable name	**Adjusted coefficient**	**95% confidence interval (CI)**	**Adjusted coefficient**	**95% CI**
Household Food Insecurity Access Scale, total score	0.002	(−0.002, 0.007)	**0.005**	**(0.001, 0.009)**
Cumulative duration of treatment, per month	**−0.002**	**(−0.004, −0.001)**	**−0.007**	**(−0.010, −0.005)**
CD4+ T-lymphocyte cell count, per 100 cells/mm^3	**−0.014**	**(−0.025, −0.002)**	**−0.015**	**(−0.028, −0.003)**
Opportunistic infection self reported, prior three months	−0.012	(−0.105, 0.081)	0.032	(−0.087, 0.151)
Physical Health Summary, total score	**−0.006**	**(−0.009, −0.003)**	**−0.013**	**(−0.016, −0.010)**
Heavy drinking	−0.033	(−0.104, 0.039)	0.071	(−0.049, 0.191)
Any tobacco use, prior three months	−0.037	(−0.108, 0.033)	0.122	(−0.063, 0.307)
Functional Social Support Questionnaire, total score	−0.010	(−0.067, 0.046)	**−0.048**	**(−0.095, −0.002)**
Internalized AIDS-Related Stigma Scale, total score	**0.017**	**(0.002, 0.032)**	**0.024**	**(0.007, 0.042)**

Notes. The Physical Health Summary was measured using the MOS-HIV. Screening for heavy drinking was based on the AUDIT-C (Bush et al., 1998).