The Journal of Nutrition
Nutrition and Disease

See corresponding commentary on page 179.

Persistent Food Insecurity Is Associated with Adverse Mental Health among Women Living with or at Risk of HIV in the United States

Emily L Tuthill,[1] Lila A Sheira,[3] Kartika Palar,[3] Edward A Frongillo,[5] Tracey E Wilson,[6] Adebola Adedimeji,[7] Daniel Merenstein,[8] Mardge H Cohen,[9] Eryka L Wentz,[10] Adaora A Adimora,[11] Ighovwerha Ofotokun,[12,13] Lisa Metsch,[14] Margot Kushel,[15] Janet M Turan,[16] Deborah Konkle-Parker,[17] Phyllis C Tien,[2,18] and Sheri D Weiser[3,4]

[1]Department of Community Health Systems, School of Nursing, [2]Department of Medicine, [3]Division of HIV, Infectious Disease, and Global Medicine, [4]Center for AIDS Prevention Studies, University of California, San Francisco, San Francisco, CA; [5]Department of Health Promotion, Education, and Behavior, University of South Carolina, Columbia, SC; [6]Department of Community Health Sciences, State University of New York Downstate Medical Center, School of Public Health, Brooklyn, NY; [7]Department of Epidemiology and Population Health, Albert Einstein College of Medicine, Bronx, NY; [8]Department of Family Medicine, Georgetown University Medical Center, Washington, DC; [9]Department of Medicine, Stroger Hospital, Chicago, IL; [10]Bloomberg School of Public Health, Department of Epidemiology, Johns Hopkins University, Baltimore, MD; [11]School of Medicine and Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC; [12]School of Medicine, Emory University, Atlanta, GA; [13]Grady Healthcare System, Atlanta, GA; [14]Department of Sociomedical Sciences, Mailman School of Public Health, Columbia University, New York, NY; [15]Division of General Internal Medicine at San Francisco General Hospital, University of California, San Francisco, San Francisco, CA; [16]Department of Health Care Organization and Policy, School of Public Health, University of Alabama at Birmingham, Birmingham, AL; [17]Division of Infectious Diseases, Department of Medicine, University of Mississippi Medical Center, Jackson, MS; and [18]Medical Service, Department of Veteran Affairs Medical Center, San Francisco, CA

Abstract

Background: Food insecurity and mental health negatively affect the lives of women in the United States. Participants in the Women's Interagency HIV Study (WIHS) provided the opportunity to understand the association of food insecurity with depression and mental well-being over time.

Objective: We investigated the association between current and persistent food insecurity and depression among women at risk of or living with HIV in the United States.

Methods: We used longitudinal data from the WIHS, a prospective cohort study in women at risk of or living with HIV from multiple sites in the United States. Participants completed 6 semiannual assessments from 2013 to 2016 on food security (FS; high, marginal, low, and very low) and mental health (i.e., depressive symptoms and mental well-being). We used multiple regression analysis to estimate the association between these variables.

Results: Among 2551 participants, 44% were food insecure and 35% reported depressive symptoms indicative of probable depression. Current marginal, low, and very low FS were associated with 2.1-, 3.5-, and 5.5-point (all $P < 0.001$) higher depression scores, respectively. In models adjusting for both current and previous FS, previous marginal, low, and very low FS were associated with 0.2-, 0.93-, and 1.52-point higher scores, respectively (all $P < 0.001$). Women with very low FS at both time points (persistent food insecurity) had a 6.86-point higher depression score ($P < 0.001$). In the mental health models, there was a dose-response relation between current FS and worse mental health even when controlling for previous FS (all $P < 0.001$). Previous low FS was associated with worse mental health. These associations did not differ by HIV status.

Conclusions: Food insecurity placed women at risk of depression and poor mental well-being, but the risk was substantially higher for women experiencing persistent food insecurity. Future interventions to improve women's mental health call for multilevel components that include addressing food insecurity. *J Nutr* 2019;149:240–248.

Keywords: food insecurity, HIV, mental health, women, United States

Manuscript received May 1, 2018. Initial review completed June 4, 2018. Revision accepted August 2, 2018.
First published online February 8, 2019; doi: https://doi.org/10.1093/jn/nxy203.

Introduction

Food insecurity and mental health illnesses, including depression, are 2 public health threats that continue to disproportionately affect women in the United States. In 2015, >15 million households in the United States were food insecure, defined as having inadequate quality, quantity, or ability to acquire nutritious food in socially acceptable ways (1). Being food insecure is associated with depression and worse subjective well-being (2), which increases morbidity and mortality and contributes to worse outcomes for individuals living with HIV and other chronic illnesses (3). Depression rates are high among women in the United States. The CDC reported that, in 2015, 1 out of every 10 US women experienced symptoms of depression (4, 5). Women are also 1.5 times more likely than men to experience depressive symptoms (6, 7) and 2–4 times more likely than men to experience seasonal or atypical depressive symptoms (8). HIV acquisition and treatment adherence are inextricably linked to experiencing food insecurity and depression (3, 9–11). Disability from HIV worsens food insecurity because of the economic vulnerability it creates (12). In turn, those experiencing food insecurity and depressive symptoms are more likely to miss or skip HIV treatment doses, thus worsening their HIV outcomes (13, 14). Consequently, according to the syndemic theory (15), the existence of co-occurring conditions, such as food insecurity, depression, and HIV, results in a synergistic response, worsening the effects of each state (16, 17).

Existing evidence from US-based cross-sectional studies (18–20) and one longitudinal study (13) showed an association between food insecurity and worsening depressive symptoms among cohorts composed mostly of men living with or at risk of HIV. Several questions remain unanswered about *1*) the co-occurrence of food insecurity and depressive symptoms among women in the United States, *2*) the directionality of this relation, and *3*) if the relation differs between HIV-infected and uninfected individuals.

With the use of longitudinal data from the Women's Interagency HIV Study (WIHS), the current study aimed to fill these gaps in knowledge. We hypothesized that women who are food insecure experience more depressive symptoms than do women who are food secure. We also hypothesized that women experiencing persistent food insecurity and more severe levels of food insecurity have higher levels of depressive symptoms than do women with short-term food insecurity or lower levels of food security, respectively. Finally, we hypothesized that there would be a stronger association between food insecurity and depressive symptoms among women living with HIV.

Methods

Study population and procedures

We used longitudinal data from the WIHS, a prospective cohort study in women at risk of or living with HIV from multiple sites in the United States. The WIHS began in 1993 to study the impact of HIV progression among women living with HIV or at risk of HIV in the United States. Since then, the WIHS has had 4 additional enrollment periods to increase the representativeness of the cohort (21, 22). Women in the WIHS were recruited to be representative of women living with HIV in the United States from 10 cities: Bronx, New York; Brooklyn, New York; Washington, DC; Chicago, Illinois; San Francisco, California; Chapel Hill, North Carolina; Miami, Florida; Birmingham, Alabama; Jackson, Mississippi; and Atlanta, Georgia. Recruitment procedures, including detailed eligibility criteria, have been previously described (21, 22). As part of the ongoing WIHS, participant's complete interviewer-led questionnaires every 6 mo on demographic characteristics, mental health, violence, and other psychosocial factors. At every visit, participants also complete a clinical examination, including a physical examination and blood draw. The Food-Insecurity Substudy began in 2013 (visit 38) and added comprehensive measures on food insecurity biannually and diet quality and food aid annually among all WIHS participants through March 2016 (visit 43). The Food-Insecurity Substudy overlapped with the most recent WIHS recruitment wave (visits 39–42), in which the 5 sites in the southern United States were added. Thus, women in the original WIHS sites (Bronx, New York; Brooklyn, New York; Washington, DC; Chicago, Illinois; and San Francisco, California) could contribute a maximum of 6 visits, whereas women from the new southern WIHS sites (Chapel Hill, North Carolina; Miami, Florida; Birmingham, Alabama; Jackson, Mississippi; and Atlanta, Georgia) could contribute a maximum of 2–5 visits depending on their baseline enrollment visit.

All of the study participants provided written informed consent and were compensated for their participation. All procedures were approved by the institutional review boards at all study sites and by the WIHS Executive Committee.

Measures

Outcome variables.

Our primary outcomes were depressive symptoms and mental health well-being. Depressive symptoms were measured using the 20-item Center for Epidemiologic Studies–Depression (CES-D) scale, which was collected at every visit (every 6 mo) (23). The CES-D was created as a brief self-report scale designed to measure symptoms associated with depression experienced in the past week. The CES-D targets 6 major facets of depression: depressed mood, feelings of guilt and worthlessness, feelings of helplessness and hopelessness, psychomotor delay, loss of appetite, and sleep disturbance. Respondents reply on a scale of 1–4 in which 1 = "rarely or none of the time" and 4 = "most or almost all the time." Scores can range from 0 to 60, with higher scores indicating greater depressive symptoms. Because some of the 20

Supported by grant T32NR007081 from the National Institute of Nursing Research and grant R01MH095683 from the National Institute of Mental Health. Data in this manuscript were collected by the Women's Interagency HIV Study (WIHS). The contents of this publication are solely the responsibility of the authors and do not represent the official views of the NIH. WIHS offices (principal investigators) are as follows: University of Alabama at Birmingham WIHS (Michael Saag, Mirjam-Colette Kempf, and Deborah Konkle-Parker), U01-AI-103401; Atlanta WIHS (Ighovwerha Ofotokun and Gina Wingood), U01-AI-103408; Bronx WIHS (Kathryn Anastos), U01-AI-035004; Brooklyn WIHS (Howard Minkof and Deborah Gustafson), U01-AI-031834; Chicago WIHS (Mardge Cohen and Audrey French), U01-AI-034993; Metropolitan Washington WIHS (Seble Kassaye), U01-AI-034994; Miami WIHS (Margaret Fischl and Lisa Metsch), U01-AI-103397; University of North Carolina at Chapel Hill WIHS (Adaora Adimora), U01-AI-103390; Connie Wofsy Women's HIV Study, Northern California (Ruth Greenblatt, Bradley Aouizerat, and Phyllis Tien), U01-AI-034989; WIHS Data Management and Analysis Center (Stephen Gange and Elizabeth Golub), U01-AI-042590; Southern California WIHS (Alexandra Levine and Marek Nowicki), U01-HD-032632 (WIHS I–WIHS IV). The WIHS is funded primarily by the National Institute of Allergy and Infectious Diseases, with additional co-funding from the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, the National Cancer Institute, the National Institute on Drug Abuse, and the National Institute on Mental Health. Targeted supplemental funding for specific projects is also provided by the National Institute of Dental and Craniofacial Research, the National Institute on Alcohol Abuse and Alcoholism, the National Institute on Deafness and Other Communication Disorders, and the NIH Office of Research on Women's Health. WIHS data collection is also supported by UL1-TR000004 (UCSF Clinical and Translational Science Award) and UL1-TR000454 (Atlanta Clinical and Translational Science Award).

Author disclosures: ELT, LAS, KP, EAF, TEW, AA, DM, MHC, ELW, AAA, IO, LM, MK, JMT, DK-P, PCT, and SDW have no conflicts of interest.

Address correspondence to EAF (e-mail: efrongil@mailbox.sc.edu).

Abbreviations used: CES-D, Center for Epidemiologic Studies–Depression; HFSSM, Household Food Security Survey Module; MOS-HIV, Medical Outcome Study HIV Health Survey; WIHS, Women's Interagency HIV Study.

items may overlap with symptoms experienced from living with HIV or food insecurity, such as appetite loss and tiredness, some studies have excluded somatic items (24, 25). A recent study compared the CES-D with and without the somatic items among the entire sample of the WIHS cohort; however, it found no significant difference between the 2 versions (26). Cronbach's α for the full CES-D in our sample was 0.91, indicating high internal consistency. We used the standard cutoff of a CES-D score ≥16 to create a binary variable for probable depression. Mental health was measured using the Medical Outcome Study HIV Health Survey (MOS-HIV) (27) mental health summary scale, which was collected annually during the study period. The MOS-HIV is widely recognized as a preferred HIV-specific measure to capture mental well-being among people living with HIV (27–29). The MOS-HIV utilized in the WIHS consists of 21 items that assess 10 domains, including cognitive function, pain, health perceptions, and energy/fatigue (27). These domains can further be examined as 2 summary scores: mental health and physical health. The mental health summary score was generated from confirmatory factor analysis of MOS-HIV data in the sample; the factors were then rescaled to match the MOS-HIV range from 0 to 100, in which higher scores indicate better mental health.

Explanatory variable.

Food insecurity was assessed by using the 18-item USDA Household Food Security Survey Module (HFSSM), a validated instrument to measure food insecurity in the US population (30). The HFSSM was administered at every visit (every 6 mo). The HFSSM assesses certainty of the food supply and sufficiency of the quality and quantity of food accessible to the household (30). The questionnaire was phrased to ask women about their experiences with food insecurity over the past 6 mo or since their last study visit. We classified households of participants as having high, marginal, low, or very low food security by using the standard scoring algorithm. We also examined previous food insecurity (defined as food security at the previous visit, 6 mo earlier). Persistent food insecurity was defined as food security at 2 consecutive visits (i.e., the current and previous visits).

Covariates.

We adjusted for relevant demographic and clinical characteristics previously found to be associated with food insecurity (31, 32) and considered the following as potential confounders: age (in years; continuous), annual household income [<$12,000 (reference), $12,001–$18,000, $18,001–$24,000, $24,001–$30,000, $30,001–$36,000, $36,001–$75,000, or ≥$75,001], the presence of child dependents in the household (yes or no), CD4 nadir (continuous), drug use (cocaine, crack, heroin, methamphetamine, hallucinogens, club drugs, or any other illicit recreational drugs not including marijuana since last visit; compared with no drug use), health insurance status (insured or uninsured), education (less than high school education, high school graduate, or some college or greater), heavy drinking (defined as >7 alcoholic drinks compared with ≤7 drinks/wk) (27), residence (marginally housed or homeless compared with stably housed), HIV status (HIV negative or positive), physical health status (measured using the validated MOS-HIV physical health summary score at first visit in the Food-Insecurity Substudy), and average number of adults living in the household with the participant in the previous year.

Statistical analysis

Baseline summary characteristics were obtained for the primary predictor, outcome variables, and covariates by using the data from the first visit of the Food-Insecurity Substudy in the WIHS. We assessed baseline bivariate associations between the predictor and covariates and the 2 outcomes using either a Kruskal-Wallis test for dichotomous and categorical covariates or linear regression for continuous covariates. To assess the associations of current food security with current depressive symptoms and mental health status, we used bivariate and adjusted longitudinal multiple linear regression models, with individual as a random effect to account for clustering for repeated measures within individuals, adjusting for time-varying and time-invariant covariates. To assess whether HIV status modified associations between food insecurity and the 2 outcomes, we conducted an adjusted model including an interaction term between the 2 variables. To determine if past food insecurity had an independent temporal effect on current mental health, we regressed CES-D and mental health status on both current and previous food security. Because the models were linear, we summed the coefficients of current and previous food security (i.e., one visit, 6 mo previously) to quantify the association of persistent food insecurity with depressive symptoms and mental health. To obtain corresponding SEs and P values, we used a postestimation command in Stata (StataCorp LP) for linear combinations. Differences were considered significant with a probability level ≤0.05. We also examined the association of current and previous food security with odds of screening positive for probable depression by conducting an adjusted longitudinal logistic regression with random effects. Finally, we performed a sensitivity analysis for the model with current and previous food security and covariates using the reduced CES-D scale (i.e., the version that excluded somatic items that may overlap with HIV/AIDS symptoms) as the outcome. All of the analyses were conducted using Stata 14.

Results

There were 11,852 person-visits from 2559 eligible women during the study period (comprising ≤6 visits). Food security and depression data were missing for 164 person-visits (1.4%) and 152 person-visits (1.1%), respectively. We thus analyzed longitudinal data from 1801 HIV-infected (8173 person-visits) and 750 HIV-negative (3457 person-visits) individuals with food security and depression data. Women from the original WIHS sites contributed, on average (± SD), 5.1 ± 1.5 visits, whereas the new recruits contributed, on average, 3.5 ± 1.2 visits. Women with missing data were more likely to have a higher income, be more educated, and be non-Hispanic white than those without missing data.

The mean age was 48 y (range 25-80 y) at the initial substudy visit (**Table 1**). A majority (72%) of women identified as non-Hispanic African American, 15% identified as Hispanic, and 11% as white. Fifty-four percent of participants reported an annual household income <$12,000, 33% had less than a high school education, 37% reported child dependents, and 11% reported use of an illicit substance (not including marijuana) since their last visit. At baseline, 44% of all participants reported food insecurity.

Depressive symptoms

At baseline, the mean ± SD CES-D score was 13.1 ± 11.6 (range: 0–58). At baseline, 35% of participants had a CES-D score indicative of probable depression (CES-D score ≥16). CES-D was associated with food security in bivariate analysis (**Table 2**). In adjusted analyses, current marginal, low, and very low food security were associated with 2.05- (SE: 0.236; $P < 0.001$), 3.44- (SE: 0.257; $P < 0.001$), and 5.48-point (SE: 0.309; $P < 0.001$) higher CES-D scores, respectively, compared with food-secure participants (**Table 3**). In separate adjusted logistic regression models considering probable depression as the outcome (results not shown), women with marginal, low, and very low food security had 2.26 (95% CI: 1.86, 2.75; $P < 0.001$), 3.21 (95% CI: 2.61, 3.95; $P < 0.001$), and 5.04 (95% CI: 3.94, 6.43; $P < 0.001$) times the odds of probable depression, respectively, compared with food-secure women. In the model that included both current and previous (i.e., 1 visit, 6 mo previously) food security, previous low, and very low food security were associated with 0.896- (SE: 0.297; $P < 0.01$) and 1.50-point (SE:

TABLE 1 Characteristics of sample at first visit for FIS and baseline bivariate associations with the outcomes: WIHS[1]

			CES-D		Mental health	
	n	Value	Mean score[2]	*P*	Mean score[3]	*P*
Food security						
High	1420	55.7	9.73	0.001	74.4	0.001
Marginal	404	15.8	14.7		67.7	
Low	369	14.5	16.6		63.9	
Very low	358	14.0	21.0		56.7	
HIV status						
Negative	750	29.4	13.0	0.54	69.2	0.99
Positive	1801	70.6	13.1		69.4	
Age at visit per year, y	2551	47.7 (40.4, 53.8)	—	0.35[4]	—	0.0009[4]
Race/ethnicity						
White	255	10.0	14.0	0.078	63.6	0.001
Hispanic	377	14.8	11.8		70.4	
African American/black	1827	71.6	13.3		69.9	
Other	92	3.61	12.4		69.1	
Annual household income						
<$12,000	1262	51.9	15.3	0.001	66.0	0.001
$12,001–24,000	539	22.2	12.8		70.4	
$24,001–36,000	269	11.1	10.6		73.0	
$36,001–75,000	248	10.2	8.95		76.4	
≥$75,001	114	4.65	5.9		78.7	
Education						
Less than high school or equivalent	831	32.6	15.0	0.001	66.5	0.001
High school graduate or equivalent	803	31.5	13.1		70.5	
Some college or greater	915	35.9	11.4		70.8	
Homeless/marginally housed	54	2.12	20.0	0.0001	56.7	0.001
Health insured	2233	87.5	12.8	0.0019	69.4	0.38
Child dependents in house[5]	984	38.6	12.2	0.0002	71.2	0.0006
Heavy drinking[6]	388	15.2	14.8	0.0002	66.9	0.0071
Illicit substance use[7]	330	12.9	18.2	0.0001	61.3	0.001
Physical health status at baseline	2427	79.8 (59.9, 91.9)	—	<0.001[4]	—	<0.001[4]
Number of adults living in the household	2550	1.0 (0.0, 2.0)	—	0.146[4]	—	0.798[4]

[1]Values are means (−1 SD, +1 SD) or percentages unless otherwise indicated; $n = 2551$. *P* values were derived by using the Kruskal-Wallis test statistic unless otherwise indicated. CES-D, Center for Epidemiologic Studies-Depression; FIS, Food-Insecurity Substudy; MOS-HIV, Medical Outcome Study HIV Health Survey; WIHS, Women's Interagency HIV Study.
[2]CES-D scores range from 0 to 60; higher scores are indicative of more depressive symptoms.
[3]MOS-HIV scores range from 1 to 100; higher scores are indicative of better mental health.
[4]Derived by using *F* test.
[5]Self-reported child dependents living in the household since the last visit (yes or no).
[6]Heavy drinking defined as >7 alcoholic drinks/wk per the National Institute of Alcohol Abuse and Alcoholism.
[7]Illicit drugs defined as crack, cocaine, heroin, methamphetamines, nonprescribed methadone, hallucinogens, club drugs, and nonprescribed prescription drugs.

0.356, $P < 0.001$) higher CES-D scores than for consistently food-secure participants. Past marginal food security was not associated with increased depressive symptoms as measured by the CES-D. Persistent low and very low food security at 2 consecutive visits were associated with significantly worse depressive symptoms ($\beta = 4.15$; SE: 0.427; $P < 0.001$; and $\beta = 6.86$; SE: 0.489; $P < 0.001$), respectively, compared with women with intermittent food insecurity or women who were consistently food secure (Table 4). In terms of other covariates, higher income, being nonwhite, higher education, and time receiving antiretroviral therapy were all associated with lower CES-D scores.

HIV seropositivity did not modify the association between food insecurity and CES-D score or odds of screening positive for depression. In the sensitivity analysis, the reduced CES-D scale had similar high internal validity to the full CES-D scale (Cronbach's α: 0.90) and performed similarly in the models, indicating that the somatic items in the full CES-D were not driving the association.

Mental health status

At baseline, the mean ± SD mental health summary score was 69.3 ± 19.6. All levels of food insecurity were associated with worse mental health scores in bivariate analysis (Table 2) in a dose-dependent manner. In adjusted analyses, current marginal, low, and very low food security were associated with −2.61- (SE: 0.538; $P < 0.003$), −4.81- (SE: 0.577; $P < 0.001$), and −7.47-point (SE: 0.641; $P < 0.001$) lower mental health scores, respectively (Table 3). In the model adding previous food security (i.e., 1 visit, 6 mo previously), the associations with current food security increased in magnitude,

TABLE 2 Longitudinal bivariate associations between food security and mental health outcomes[1]

	CES-D[2] ($n = 11,630$ person-visits, 2551 unique women)		Mental health status summary score[3] ($n = 6229$ person-visits, 2551 unique women)	
	β (SE)	P	β (SE)	P
Current food security (reference = high)				
Marginal	2.61 (0.234)	<0.001	−4.24 (0.568)	<0.001
Low	4.26 (0.257)	<0.001	−7.62 (0.624)	<0.001
Very low	6.85 (0.310)	<0.001	−11.8 (0.710)	<0.001
Past food security (reference = high)				
Marginal	0.557 (0.275)	0.04	−3.33 (0.865)	<0.001
Low	2.11 (0.302)	<0.001	−7.52 (0.891)	<0.001
Very low	3.73 (0.362)	<0.001	−11.48 (1.04)	<0.001
HIV status (reference = negative)	−0.0318 (0.428)	0.94	0.511 (0.774)	0.51
Age at visit/y	−0.0319 (0.020)	0.12	−0.157 (0.0371)	<0.001
Race (reference = white)				
Hispanic	−2.75 (0.802)	<0.001	6.53 (1.45)	<0.001
African American/black	−2.09 (0.663)	<0.001	6.48 (1.20)	<0.001
Other	−1.90 (1.20)	0.11	4.33 (2.18)	0.047
Annual household income (reference = <$12,000)				
$12,001–$24,000	−1.13 (0.237)	<0.001	2.29 (0.567)	<0.001
$24,001–$36,000	−2.08 (0.325)	<0.001	4.45 (0.747)	<0.001
$36,001–$75,000	−2.57 (0.378)	<0.001	6.41 (0.857)	<0.001
≥$75,001	−3.74 (0.582)	<0.001	7.59 (1.30)	<0.001
Education (reference = less than high school or equivalent)				
High school graduate or equivalent	−1.73 (0.484)	<0.001	3.32 (0.878)	<0.001
Some college or greater	−3.03 (0.469)	<0.001	3.48 (0.853)	<0.001
Homeless/marginally housed	3.05 (0.699)	<0.001	−2.37 (1.64)	0.15
Health insured	−1.11 (0.349)	<0.001	0.280 (0.778)	0.72
Child dependents in house[4]	−0.130 (0.244)	0.59	1.57 (0.549)	0.004
Heavy drinking[5]	1.55 (0.276)	<0.001	−1.91 (0.657)	0.004
Illicit substance use[6]	3.95 (0.341)	<0.001	−7.01 (0.771)	<0.001
Physical health status at baseline	−0.280 (0.00755)	<0.001	0.628 (0.0111)	<0.001
Number of adults living in the household	0.382 (0.0764)	<0.001	−0.225 (0.208)	0.281

[1]CES-D, Center for Epidemiologic Studies–Depression; MOS-HIV, Medical Outcome Study HIV Health Survey.
[2]CES-D scores range from 0 to 60; higher scores are indicative of more depressive symptoms.
[3]MOS-HIV scores range from 1 to 100; higher scores are indicative of better mental health.
[4]Self-reported child dependents living in the household since the last visit (yes or no).
[5]Heavy drinking defined as >7 alcoholic drinks/wk by the National Institute of Alcohol Abuse and Alcoholism.
[6]Illicit drugs defined as crack, cocaine, heroin, methamphetamines, nonprescribed methadone, hallucinogens, club drugs, and nonprescribed prescription drugs.

and previous low food security was associated with worse mental health status ($\beta = -2.01$; SE: 0.864; $P < 0.001$). Combining the coefficients of current and previous low food security, persistent marginal, low, and very low food security were associated with $\beta = 3.02$- ($P = 0.005$), 7.13- ($P < 0.001$), and 10.3-point ($P < 0.001$) lower scores on the mental health summary scale, respectively, compared with women who were persistently food secure. HIV status was not significantly associated with worsened mental health status in either model. Having an undetectable viral load, higher education, and being nonwhite were associated with higher mental health status scores on the MOS-HIV.

Discussion

In this large longitudinal study, food insecurity and depression were prevalent, and food insecurity was associated with worse mental health outcomes. Both current (over the past 6 mo) and previous (6 mo earlier) food insecurity were associated with greater severity of depressive symptoms and worsening mental health status in a dose-response pattern. To our knowledge, this is the first longitudinal study showing that previous food insecurity is associated with subsequent depressive symptoms and persistent food insecurity is associated with worse depression and mental health status.

These findings are consistent with previous cross-sectional (33), qualitative (11, 34), and longitudinal (35), (13) study findings while extending previous longitudinal work in 3 important ways. First, any level of food insecurity (marginal, low, or very low food security) was associated with more depressive symptoms and worsened mental well-being; earlier studies found this association only for very low food insecurity. We also found strong dose-dependent relations for food insecurity and both depression and mental health status. For lagged food security and mental health, the magnitude of the association was strongest among those who experienced low food security compared with those who experienced marginal or very low food security; the magnitude of association was similar for those with low and very low food security, but

TABLE 3 Longitudinal adjusted associations between food insecurity and mental health outcomes: concurrent and concurrent and lagged models[1]

	CES-D[2]				Mental health summary score[3]			
	Concurrent model		Concurrent + lagged model (2 consecutive visits, 6 mo apart)		Concurrent model		Concurrent + lagged model (2 consecutive visits, 6 mo apart)	
	β (SE)	*P*	β (SE)	*P*	β (SE)	*P*	β (SE)	*P*
Current food security (reference = high)								
Marginal	2.05 (0.236)	<0.001	1.63 (0.279)	<0.001	−2.61 (0.5381)	<0.001	−2.70 (0.822)	0.001
Low	3.44 (0.257)	<0.001	3.25 (0.303)	<0.001	−4.83 (0.577)	<0.001	−5.17 (0.899)	<0.001
Very low	5.48 (0.309)	<0.001	5.36 (0.374)	<0.001	−7.47 (0.641)	<0.001	−8.48 (1.08)	<0.001
Past food security (reference = high)								
Marginal			−0.190 (0.270)	0.48			−0.365 (0.812)	0.65
Low			0.896 (0.297)	0.003			−2.01 (0.864)	0.020
Very low			1.50 (0.356)	<0.001			−1.79 (1.05)	0.089
HIV status (reference = negative)	0.165 (0.332)	0.62	0.137 (0.371)	0.71	0.612 (0.522)	0.241	1.10 (0.705)	0.12
Age at visit/y	−0.109 (0.0164)	<0.001	−0.0813 (0.0187)	<0.001	0.0567 (0.0264)	0.0315	0.0287 (0.0365)	0.43
Race (reference = white)								
Hispanic	−0.765 (0.638)	0.23	−1.03 (0.723)	0.16	1.41 (0.993)	0.154	1.98 (1.36)	0.15
African American/black	−1.22 (0.528)	0.021	−1.60 (0.602)	0.008	3.11 (0.826)	0.0002	4.01 (1.14)	<0.001
Other	−1.91 (0.933)	0.041	−1.45 (1.057)	0.17	2.94 (1.43)	0.04	2.76 (1.95)	0.16
Annual household income (reference = <$12,000)								
$12,001–$24,000	−0.481 (0.226)	0.034	−0.502 (0.265)	0.058	0.285 (0.489)	0.56	0.0375 (0.682)	0.96
$24,001–$36,000	−0.987 (0.312)	0.002	−1.36 (0.368)	<0.001	0.687 (0.651)	0.29	1.42 (0.915)	0.12
$36,001–$75,000	−0.802 (0.365)	0.028	−0.956 (0.428)	0.026	1.3 (0.735)	0.078	2.36 (1.04)	0.023
≥$75,001	−1.41 (0.560)	0.012	−1.24 (0.655)	0.058	2.09 (1.10)	0.056	1.91 (1.53)	0.21
Education (reference = less than high school or equivalent)								
High school graduate or equivalent	−0.787 (0.372)	0.034	−0.706 (0.414)	0.088	1.39 (0.576)	0.016	1.30 (0.777)	0.095
Some college or greater	−1.46 (0.377)	<0.001	−1.28 (0.420)	0.002	0.500 (0.590)	0.40	0.177 (0.799)	0.82
Homeless/marginally housed	2.43 (0.703)	0.001	2.17 (0.865)	0.012	0.16 (1.50)	0.92	2.04 (2.43)	0.40
Health insured	−0.351 (0.340)	0.302	−0.332 (0.421)	0.43	−0.926 (0.691)	0.18	−1.37 (1.11)	0.22
Child dependents in house [4]	−0.408 (0.235)	0.083	−0.0896 (0.271)	0.74	0.3 (0.468)	0.52	0.437 (0.662)	0.51
Heavy drinking[5]	1.01 (0.266)	<0.001	1.31 (0.308)	<0.001	−0.851 (0.571)	0.14	−0.721 (0.823)	0.38
Illicit substance use[6]	2.79 (0.331)	<0.001	3.00 (0.399)	<0.001	−4.04 (0.669)	<0.001	−5.52 (1.04)	0.00
Physical health status at baseline[7]	−0.244 (0.00742)	<0.001	−0.213 (0.00842)	<0.001	0.574 (0.0117)	<0.001	0.472 (0.0162)	0.00
Number of adults living in the household	0.339 (0.0769)	<0.001	0.402 (0.0941)	<0.001	−0.371 (0.181)	0.040	−0.620 (0.262)	0.018
Person-visits, *n*	10,859		8253		5746		3285	
Unique women, *n*	2397		2248		2367		2020	

[1] CES-D, Center for Epidemiologic Studies–Depression; MOS-HIV, Medical Outcome Study HIV Health Survey.
[2] Scores range from 0 to 60; higher scores are indicative of more depressive symptoms.
[3] Scores range from 1 to 100; higher scores are indicative of better mental health.
[4] Self-reported child dependents living in the household since the last visit (yes or no).
[5] Heavy drinking defined as >7 alcoholic drinks/wk by the National Institute of Alcohol Abuse and Alcoholism.
[6] Illicit drugs defined as crack, cocaine, heroin, methamphetamines, nonprescribed methadone, hallucinogens, club drugs, and nonprescribed prescription drugs.
[7] Measured using the MOS-HIV physical health summary score at first visit in the Food-Insecurity Substudy period.

TABLE 4 Association of persistent food security over the previous year with mental health outcomes[1]

	CES-D		Mental health summary score	
	β (SE)	*P*	β (SE)	*P*
Current + previous food security (reference = high)				
Persistent marginal	1.44 (0.402)	<0.001	−3.02 (1.08)	0.005
Persistent low	4.15 (0.427)	<0.001	−7.13 (1.08)	<0.001
Persistent very low	6.86 (0.489)	<0.001	−10.3 (1.17)	<0.001
Person-visits, *n*	8253		3285	
Unique women, *n*	2248		2020	

[1]The exponentiated linear combinations of the natural log of the adjusted ORs for current and previous food security within each level (i.e., marginal, low, and very low) from Table 3 are shown: i.e., persistent food security = e^[ln(adjusted $OR_{current}$) + ln(adjusted $OR_{previous}$)]. Estimates, CIs, and *P* values were obtained through postestimation commands for linear combinations in Stata. CES-D, Center for Epidemiologic Studies–Depression.

the SE for the latter was higher, reflecting fewer women. Second, women experiencing persistent food insecurity had more depressive symptoms than did women who experienced intermittent food insecurity or those with no food insecurity. Third, in all analyses, the magnitude of the association of food insecurity with depressive symptoms and mental health status was greater than that of income, highlighting that food insecurity is an aspect of poverty not well captured by income.

There are several possible explanations for the association of persistent food insecurity with more depressive symptoms and poorer mental health. Persistent food insecurity may trigger stress and maladaptive coping strategies. Stress and poor coping can lead to or exacerbate depression and poor mental well-being (11). In addition, women at risk of or living with HIV who are also socioeconomically disadvantaged and food insecure may be isolated from family, community, or health care support systems, increasing risk of internalized stigma and feelings of hopelessness and lack of worth (36, 37). Internalized stigma may further isolate women and threaten their resilience to seek supportive services (10, 11). This explanation is consistent with persistent food insecurity having the worst mental health outcomes, in that persistent food insecurity may cause chronic stress, feelings of disempowerment, and social isolation—conditions that contribute to depression.

Food insecurity is linked to many social and economic factors that affect depression and mental health. Despite adjusting for many of these factors, there may have been some residual confounding. Furthermore, although our results show a strong link between food insecurity and depressive symptoms both at the current and past visits, which adds to the plausibility of a causal association, these conditions may be related in a bidirectional manner. Depressive symptoms may result in less energy or individuals may be less effective in securing the economic resources to procure adequate and nutritious foods for themselves and their household. These effects may lead to increased household food insecurity. Several longitudinal studies support this bidirectional relation among other populations, including mothers (38, 39) and low-income adults living in the rural United States (40). Disentangling relations affected by complex social and structural factors requires natural experiments that allow for analyses that can control for causal factors (41).

The association between food insecurity and depressive symptoms did not differ by HIV status. Similarly, we did not find an association between HIV status and depression, which is contrary to earlier literature showing the prevalence of depression as being higher among people living with HIV (42). A possible explanation is that the WIHS HIV-negative (but at risk) women have similar psychosocial circumstances and challenges as the HIV-infected women and are not representative of the general population. Ultimately, more than one-third of women in the current study were both food insecure and had CES-D scores indicative of probable depression, regardless of HIV status, which highlights the harmful syndemic impact from co-occurring conditions on the health and well-being of all vulnerable women in the United States.

The co-occurrence of persistent food insecurity and more depressive symptoms among women in our sample represents an intergenerational public health threat, because nearly 40% of women in our sample have dependent children living at home whose health may also be affected by food insecurity. Household food insecurity has been associated with weight gain and chronic disease progression among children (43). Both food insecurity and depression in the household can affect child cognitive development (44) and increase the risk of depression in young children (45). In this way, public health efforts that aim to improve food insecurity and mental health disparities among vulnerable women in the United States may also have important health benefits for their families.

There are several opportunities to address the syndemic of food insecurity, depression, and poor mental well-being. First, the optimization of existing safety net programs such as the Special Supplemental Nutrition Program for Women, Infants, and Children (46) or the Supplemental Nutrition Assistance Program to better address food insecurity as a way to improve mental health is critical. These programs currently represent the backbone of supportive services for vulnerable women and children in the United States. They have effectively improved nutritional access and consumption, increased breastfeeding initiation and duration, and facilitated regular primary care visits, resulting in higher immunization rates (46, 47). Despite these successes, vulnerable women, including those living with HIV experiencing food insecurity and poor mental well-being, may require multilevel interventions that include mental health treatment (e.g., individual counseling) along with food provision or a livelihood component. Ultimately, embedding these types of multicomponent interventions into comprehensive HIV care may provide an opportunity to effectively engage vulnerable women to address their complex structural and individual health needs.

Our study has several important strengths and limitations. We used a large, demographically diverse sample of women living with or at risk of HIV in the United States. The longitudinal data allowed examination of the association of persistent food insecurity with depressive symptom severity and mental health. Given the observational design, we are limited in our ability to make causal inference. Although the highest prevalence of depression is among women aged 40–59 y (12%) in the United States (4), which includes the majority of women in our study (mean age: 48 y), younger women also experience high rates of depression; further investigation that captures experiences among younger women is warranted. Given that women in the WIHS cohort have been followed for many years, participants may be susceptible to social desirability bias. On the other hand, long-term

participation in the study may result in less social desirability bias because participants see themselves as contributing to the scientific enterprise. Our ability to generalize to women living with or at risk of HIV from geographical areas outside of the WIHS cohort areas may be limited; the WIHS cohort is composed of women at risk of or living with HIV from areas in the United States with the highest prevalence of HIV.

In conclusion, food insecurity, especially when persistent, was associated with more depressive symptoms, greater risk of probable depression, and poor mental well-being among HIV-infected and at-risk women. Development of multilevel programs and intervention strategies that are guided by a syndemic orientation is needed to optimize the health of HIV-infected and at-risk women (48, 49).

Acknowledgments

The authors' responsibilities were as follows—SDW: conceived of the study and obtained the funding, with input from KP, EAF, MK, and PCT; ELT, LAS, SDW, and EAF: designed the study analysis plan; LAS, EAF, and ELT: conducted the data analysis; ELT: developed the first draft of the manuscript, with significant writing contributions from LAS, EAF, and SDW; KP, TEW, AA, DM, MHC, ELW, AAA, IO, LM, MK, JMT, DK-P, and PCT, and made final revisions: critically reviewed and revised the manuscript; SDW and EAF: made final edits; and all authors: read and approved the final manuscript.

References

1. Anema A, Fielden SJ, Shurgold S, Ding E, Messina J, Jones JE, et al. Association between food insecurity and procurement methods among people living with HIV in a high resource setting. PLoS One 2016;11(8):e0157630.
2. Frongillo EA, Nguyen HT, Smith MD, Coleman-Jensen A. Food insecurity is associated with subjective well-being among individuals from 138 countries in the 2014 Gallup World Poll. J Nutr 2017;147(4):680–7.
3. Weiser SD, Young SL, Cohen CR, Kushel MB, Tsai AC, Tien PC, Hatcher AH, Frongillo EA, Bangsberg DR. Conceptual framework for understanding the bidirectional links between food insecurity and HIV/AIDS. Am J Clin Nutr 2011;94(Suppl):1729S–39S.
4. Pratt LA, Brody DJ. Depression in the U.S. household population, 2009–2012. NCHS data brief, no 172. 2014. Hyattsville, MD: National Center for Health Statistics.
5. CDC. Depression among women. 2017;1–2. Available from: https://www.cdc.gov/reproductivehealth/depression/. Accessed December 1, 2017.
6. Vos T, Barber RM, Bell B, Bertozzi-Villa A, Biryukov S, Bolliger I, Charlson F, Davis A, Degenhardt L, Dicker D, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet North Am Ed 2015;386(9995):743–800.
7. WHO. MH gap action plan 2013–2020. 2013;1–50. Geneva, Switzerland: World Health Organization.
8. Grigoriadis S, Robinson GE. Gender Issues in Depression. Ann Clin Psychiatry 2007;19(4):247–55.
9. Palar K, Frongillo EA, Escobar J, Sheira LA, Wilson TE, Adedimeji A, Merenstein D, Cohen MH, Wentz EL, Adimora AA, Ofotokun I, Metsch L, Tien PC, Turan JM, Weiser SD. Food Insecurity, Internalized Stigma, and Depressive Symptoms Among Women Living with HIV in the United States. AIDS Behav 2018 Jun 8. doi: 10.1007/s10461-018-2164-8. [Epub ahead of print]..
10. WHO. Mental health and work: Impact, issues and good practices. 2003;1–77. Geneva, Switzerland: World Health Organization.
11. Whittle HJ, Palar K, Seligman HK, Napoles T, Frongillo EA, Weiser SD. How food insecurity contributes to poor HIV health outcomes: Qualitative evidence from the San Francisco Bay Area. Soc Sci Med 2016;170:228–36.
12. Weiser SD, Tsai AC, Gupta R, Frongillo EA, Kawuma A, Senkungu J, Hunt PW, Emenyonu NI, Mattson JE, Martin JN, et al. Food insecurity is associated with morbidity and patterns of healthcare utilization among HIV-infected individuals in a resource-poor setting. AIDS 2012;26(1):67–75.
13. Palar K, Kushel M, Frongillo EA, Riley ED, Grede N, Bangsberg D, Weiser SD. Food insecurity is longitudinally associated with depressive symptoms among homeless and marginally-housed individuals living with HIV. AIDS Behav 2015;19(8):1527–34.
14. Weiser SD, Tuller DM, Frongillo EA, Senkungu J, Mukiibi N, Bangsberg DR. Food insecurity as a barrier to sustained antiretroviral therapy adherence in Uganda. PLoS One 2010;5(4):e10340.
15. Singer M, Clair S. Syndemics and public health: reconceptualizing disease in bio-social context. Med Anthropol Q 2003;17(4):423–41.
16. Oldenburg CE, Perez-Brumer AG, Reisner SL. Poverty matters. AIDS 2014;28(18):2763–9.
17. Mendenhall E, Kohrt BA, Norris SA, Ndetei D, Prabhakaran D. Non-communicable disease syndemics: poverty, depression, and diabetes among low-income populations. Lancet North Am Ed 2017;389(10072):951–63.
18. Hatsu I, Hade E, Campa A. Food security status is related to mental health quality of life among persons living with HIV. AIDS Behav 2017;21(3):745–53.
19. Vogenthaler NS, Hadley C, Rodriguez AE, Valverde EE, del Rio C, Metsch LR. Depressive symptoms and food insufficiency among HIV-infected crack users in Atlanta and Miami. AIDS Behav 2010;15(7):1520–6.
20. Siefert K, Heflin CM, Corcoran ME, Williams DR. Food insufficiency and the physical and mental health of low-income women. Women Health 2001;32(1–2):159–77.
21. Adimora AA, Ramirez C, Benning L, Greenblatt RM, Kempf M-C, Tien PC, Kassaye SG, Anastos K, Cohen M, Minkoff H, et al. Cohort profile: the Women's Interagency HIV Study (WIHS). Int J Epidemiol 2018;47(2):393–4i.
22. Barkan SE, Melnick SL, Preston-Martin S, Weber K. The Women's Interagency HIV Study. Epidemiology 1998;9(2):117–25.
23. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. Appl Psychol Meas 1977;1(3):385–401.
24. Kalichman SC, Rompa D, Cage M. Distinguishing between overlapping somatic symptoms of depression and HIV disease in people living with HIV-AIDS. J Nerv Ment Dis 2000;188(10):662–70.
25. Gay C. Psychometric limitations of the center for epidemiologic studies-depression scale for assessing depressive symptoms among adults with HIV/AIDS: a Rasch analysis. Depress Res Treat 2016;2016(1):1–11.
26. Adams LM, Wilson TE, Merenstein D, Milam J, Cohen J, Golub ET, Adedimeji A, Cook JA. Using the Center for Epidemiologic Studies Depression Scale to assess depression in women with HIV and women at risk for HIV: are somatic items invariant? Psychol Assess 2018;30(1):97–105.
27. Bozzette SA, Hays RD, Berry SH. Derivation and properties of a brief health status assessment instrument for use in HIV disease. J Acquir Immune Def Syndr Hum Retrovirol 1995;8(3):253–65.
28. Ion A, Cai W, Elston D, Pullenayegum E, Smaill F, Smieja M. A comparison of the MOS-HIV and SF-12v2 for measuring health-related quality of life of men and women living with HIV/AIDS. AIDS Res Ther 2011;8(1):5.
29. Wu A, Revicki DA, Jacobson D, Malitz FE. Evidence for reliability, validity, and usefulness of Medical Outcomes Study HIV Health Survey (MOS-HIV). 1997;6(6):481–93.
30. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to measuring household food security. Revised 2000. In: Measuring food security in the United States, Alexandria (VA): USDA; 2000. Available fro m: www.ers.usda.gov/briefing/foodsecurity. Accessed July 1, 2017.
31. 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 2008;24(1):14–20.
32. 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(4):224–31.

33. Weigel MM, Armijos RX, Racines M, Cevallos W, Castro NP. Association of household food insecurity with the mental and physical health of low-income urban Ecuadorian women with children. J Environ Public Health 2016;2016(3):1–14.
34. Chilton M, Booth S. Hunger of the body and hunger of the mind: African American women's perceptions of food insecurity, health and violence. 2007;39(3):116–25.
35. Tsai AC, Bangsberg DR, Frongillo EA, Hunt PW, Muzoora C, Martin JN, Weiser SD. Food insecurity, depression and the modifying role of social support among people living with HIV/AIDS in rural Uganda. Soc Sci Med 2012;74(12):2012–9.
36. Turan B, Stringer KL, Onono M, Bukusi EA, Weiser SD, Cohen CR, Turan JM. Linkage to HIV care, postpartum depression, and HIV-related stigma in newly diagnosed pregnant women living with HIV in Kenya: a longitudinal observational study. BMC Pregnancy Childbirth 2014;14(1):400.
37. Turan B, Rogers AJ, Rice WS, Atkins GC, Cohen MH, Wilson TE, Adimora AA, Merenstein D, Adedimeji A, Wentz EL, et al. Association between perceived discrimination in healthcare settings and HIV medication adherence: mediating psychosocial mechanisms. AIDS Behav 2017;20(1):1–9.
38. Huddleston-Casas C, Charnigo R, Simmons LA. Food insecurity and maternal depression in rural, low-income families: a longitudinal investigation. Public Health Nutr 2008;12(08):1133–8.
39. Garg A, Toy S, Tripodis Y, Cook J, Cordella N. Influence of maternal depression on household food insecurity for low-income families. Acad Pediatr 2015;15(3):305–10.
40. Hanson KL, Olson CM. Chronic health conditions and depressive symptoms strongly predict persistent food insecurity among rural low-income families. J Health Care Poor Underserved 2012;23(3):1174–88.
41. Costello EJ, Compton SN, Keeler G, Angold A. Relationships between poverty and psychopathology. JAMA 2003;290(15):2023–9.
42. Ciesla JA, Roberts JE. Meta-analysis of the relationship between HIV infection and risk for depressive disorders. Am J Psychiatry 2001;158(5):725–30.
43. Laraia BA. Food insecurity and chronic disease. Adv Nutr 2013;4(2):203–12.
44. Zaslow M, Bronte-Tinkew J, Capps R. Food security during infancy: implications for attachment and mental proficiency in toddlerhood. Matern Child 2009;13(1):66–80.
45. Whitaker RC, Phillips SM, Orzol SM. Food insecurity and the risks of depression and anxiety in mothers and behavior problems in their preschool-aged children. Pediatrics 2006;118(3):e859–68.
46. USDA. About WIC—how WIC helps. Food and Nutrition Service. 2017;1–4. Available from: https://www.fns.usda.gov/wic/about-wic. Accessed July 1, 2017.
47. Liu J, Kuo T, Jiang L, Robles B, Whaley SE. Food and drink consumption among 1–5 year-old Los Angeles County children from households receiving dual SNAP and WIC v. only WIC benefits. 2016;20(14):1–8.
48. Gonzalez-Guarda RM. Pushing the syndemic research agenda forward: a comment on Pitpitan et al. Ann Behav Med 2013;45(2):135–6.
49. Mendenhall E. Syndemics: a new path for global health research. Lancet North Am Ed 2017;389(10072):889–91.