Food Insecurity is Associated with Poor Virologic Response among HIV-Infected Patients Receiving Antiretroviral Medications

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BACKGROUND AND OBJECTIVE: Food insecurity negatively impacts HIV disease outcomes in international settings. No large scale U.S. studies have investigated the association between food insecurity and severity of HIV disease or the mechanism of this possible association. The objective of this study was to examine the impact of food insecurity on HIV disease outcomes in a large cohort of HIV-infected patients receiving antiretroviral medications.

DESIGN: This is a cross-sectional study.

PARTICIPANTS AND SETTING: Participants were HIV-infected patients enrolled in the Veterans Aging Cohort Study between 2002–2008 who were receiving antiretroviral medications.

MAIN MEASUREMENTS: Participants reporting “concern about having enough food for you or your family in the past 30 days” were defined as food insecure. Using multivariable logistic regression, we explored the association between food insecurity and both low CD4 counts (<200 cells/ μ L) and unsuppressed HIV-1 RNA (>500 copies/mL). We then performed mediation analysis to examine whether antiretroviral adherence or body mass index mediates the observed associations.

KEY RESULTS: Among 2353 HIV-infected participants receiving antiretroviral medications, 24% reported food insecurity. In adjusted analyses, food insecure participants were more likely to have an unsuppressed HIV-1 RNA (AOR 1.37, 95% CI 1.09, 1.73) compared to food secure participants. Mediation analysis revealed that neither antiretroviral medication adherence nor body mass index contributes to the association between food insecurity and unsuppressed HIV-1 RNA. Food insecurity was not independently associated with low CD4 counts.

CONCLUSIONS: Among HIV-infected participants receiving antiretroviral medications, food insecurity is associated with unsuppressed viral load and may render treatment less effective. Longitudinal studies are needed to test the potential causal association between food

insecurity, lack of virologic suppression, and additional HIV outcomes.

KEY WORDS: food insecurity; HIV; patients; antiretrovirals.

J Gen Intern Med 26(9):1012–8

DOI: 10.1007/s11606-011-1723-8

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INTRODUCTION

Food insecurity, defined as “limited or uncertain availability of nutritionally adequate safe foods or the inability to acquire personally acceptable foods in socially acceptable ways,” has been on the rise in the U.S. since the early 1990s.¹ In 2008, approximately 45 million people (15% of the population) lived in households experiencing food insecurity, compared to only 7% in 1992.¹ Food insecurity is more common among low income individuals, women, and racial and ethnic minorities, and is associated with disparities in health care access and health outcomes in marginalized populations.^{2–8} Given these demographics, HIV-infected individuals are at a significantly increased risk for food insecurity compared to the general population.^{9,10}

Food insecurity is recognized as a key contributor to the HIV pandemic worldwide and an important cause of worse health outcomes among HIV-infected individuals.¹¹ International studies suggest that food insecurity is associated with decreased access to antiretroviral treatment and care, incomplete virologic suppression, and decreased survival.^{2,11–13} Several small studies in the U.S. have found that food insecurity is associated with worse virological response and poor health outcomes, including HIV wasting. A study of 104 HIV-infected homeless and marginally housed individuals found that 50% of participants were food insecure and that food insecurity independently increased the risk of unsuppressed viral load.¹⁴ Another cross-sectional study of 119 HIV-infected drug users in Miami found that HIV-related wasting was highly prevalent and that food insecurity was an independent predictor of wasting.¹⁵ Researchers have hypothesized that both behavioral and biological mechanisms may

Received November 5, 2010

Revised March 30, 2011

Accepted April 5, 2011

Published online May 15, 2011

mediate the association between food insecurity and HIV disease outcomes. Limited access to food is associated with worse antiretroviral therapy (ART) adherence.^{14,16,17} In addition, HIV-infected patients' nutritional status or body mass, which has been associated with worse immunologic and virologic response among HIV-infected individuals,^{18,19} is associated with limited access to food.

To our knowledge, no large or multisite study has been conducted in the U.S. examining the association between food insecurity and HIV outcomes, or examining ART adherence and body mass index (BMI) as plausible mediators of the observed associations. To address these gaps, we used data from the multicenter Veterans Aging Cohort Study (VACS) to examine the association between food insecurity and low CD4 count and unsuppressed HIV-1 RNA in HIV-infected individuals and to determine whether ART adherence or BMI mediates these associations.

METHODS

Sample and Setting

We analyzed baseline data on 2353 HIV-infected participants receiving ART enrolled in VACS. The VACS is an observational cohort of HIV-infected patients that began in 2002 and was designed to examine the role of comorbid medical and psychiatric disease in determining clinical outcomes in HIV infection. A full description of the study and measures collected are described elsewhere.²⁰ Briefly, VACS assesses participants using a combination of self-reported, administrative, and clinical data from eight Veterans Affairs Medical Centers' infectious disease clinics (Atlanta, GA, Baltimore, MD, Bronx, NY, New York City, NY, Houston, TX, Los Angeles, CA, Pittsburgh, PA, Washington, DC). Overall, 58% of HIV-infected patients at the eight sites were enrolled, with only 9% of those approached refusing to participate. The Veterans Health Administration (VHA) is the largest single provider of HIV care in the U.S., serving in 2008 more than 21,500 HIV-infected Veterans. Data collected included socio-demographics, AIDS-defining conditions, comorbidities, measures of patients' health and habits, including history of drug and alcohol use, homelessness, and health behaviors. The institutional review boards at all locations approved the study, and all Veterans provided written informed consent prior to enrollment. The study sample for these analyses includes the subset of VACS participants who completed the baseline survey between 2002 and 2008 and who used antiretroviral medications (n=2353).

MEASUREMENTS

Food Insecurity

To capture the broadest domain of food insecurity, uncertainty about food access, VACS incorporated the first question of the 18-item Household Food Insecurity Access Scale (HFIAS) in the baseline patient survey: "In the past 4 weeks, have you

been concerned about having enough food for you or your family?" HFIAS is a previously validated scale designed to assess household food insecurity in multiple international settings.²¹ Participants who answered "yes" were categorized as being food insecure.

HIV Clinical Outcomes

For each participant, the CD4 cell count and HIV-1 RNA level closest to enrollment date in VACS were used and taken from VHA laboratory data. Poor HIV outcomes were defined by CD4 counts <200 cells/ μ L or unsuppressed HIV-1 RNA, as indicated by a HIV-1 RNA >500 copies/mL. Because many of the VACS sites used multiple types of viral load test between 2002–2008, we chose the cut off of the least sensitive type of test run, which was 500 copies/mL.

Confounders

Covariates for the study included age (continuous), gender (male/female), race/ethnicity (white/black/Latino/other), income (<\$25,000/year vs. $\geq$ \$25,000/year), education (<high school graduation, high school graduation to some college, or college graduate and beyond), married or long-term partner, employment status, recent homelessness, and site of enrollment. Current alcohol consumption was also assessed using the 3-item Alcohol Use Disorders Identification Test (AUDIT-C).^{22–24} Persons were classified as having hazardous alcohol use if they drank in the past year and their total score was four or greater. If participants reported that they drank six or more drinks in one sitting at least once a month, they were classified as engaging in binge drinking. Self-report of opiate, marijuana, cocaine, or stimulant use, defined according to whether a participant reported using more than 1–3 times/month in the past year, was considered as having recent drug use. Finally, we used the Patient Health Questionnaire-9 (PHQ-9) to assess active depressive symptoms.²⁵ The PHQ-9 is a modified version of the Primary Care Evaluation of Mental Disorders that specifically addresses major depressive disorder. A cutoff score of 10 or more has a sensitivity of 88% and a specificity of 88% for clinicians' diagnosis of depression.

Potential Mediators

To measure ART adherence, we used the algorithm of Steiner and colleagues to estimate the proportion of medication doses consumed as directed based upon pharmacy refill data from the Veterans Affairs national Pharmacy Managements Benefits Services database.^{26–28} This algorithm keeps a running tally of whether a patient would have run out of medications at any particular time based on the dates and number of medication doses given with previous refills and determines what proportion of time the patient should have medications available (i.e., has not run out of medications). We averaged adherence to all ART medications to yield a summary adherence measure and performed our analysis over the first year of therapy from the time of VACS

enrollment. The Steiner algorithm has previously been validated by demonstrating that its estimates were highly correlated with drug plasma levels.²⁸ Body mass index was calculated as the ratio of weight (kg) over height (m) squared. Weight and height were recorded as part of routine clinical care and captured through the electronic medical record.

Analyses

HIV-infected participants with and without food insecurity were first compared for baseline sociodemographic characteristics, HIV clinical outcomes, and potential explanatory risk factors of disease using Mann-Whitney and chi-squared tests as appropriate. We next examined the independent association between food insecurity and poor HIV outcomes, namely CD4 count <200 cells/ μ L and HIV-1 RNA >500 copies/mL, using multivariable logistic regression by adjusting for all other covariates associated with poor HIV outcomes with $p < 0.2$ in unadjusted analyses. P-values <0.05 were considered statistically significant. To determine the role of ART adherence and BMI in influencing the relationship between food insecurity and poor HIV outcomes, adherence and BMI were controlled for in logistic regression analyses and were examined as possible mediators using Baron and Kenny mediation analysis.²⁹ This is a three-step process to determine whether (1) food insecurity is associated with poor HIV outcomes, (2) food insecurity is associated with the potential mediators, namely ART adherence and BMI, and (3) the association between food insecurity and poor HIV outcomes is

attenuated, after adjustment for the potential mediators.²⁹ Additionally, we used a score test of trend to assess whether there was a dose-dependent association between food insecurity and ART adherence and body mass index.

RESULTS

Among 2353 HIV-infected Veterans receiving ART, 24% reported food insecurity (Table 1). With respect to food security status, participants who were food insecure were more likely to be of a racial and ethnic minority group, low income, unemployed, recently homeless, and consume excessive alcohol or use illicit drugs. Food insecure participants also had poorer ART adherence (Fig. 1), $p = 0.02$. The proportion of patients with food insecurity ranged from 21% in those who were out of their medications less than 20% of the time to 38% in patients who were out of their medications more than 80% of the time in the year prior to enrollment (test for trend, $p = 0.001$). Veterans with food insecurity were also more likely to have a lower median BMI compared to food secure Veterans (Table 1). However, when we categorized BMI in clinically relevant categories (BMI <18.5, $18.5 \leq 25$, $25 \leq 30$, >30), we found that the association between food insecurity and these categories of weight (under-, normo-, and overweight and obese) is not statistically significant, nor is there a linear trend of association (Fig. 2).

Compared to food secure participants, those with food insecurity were also more likely to have worse health

Table 1. Baseline Sociodemographic, Medical, and Psychosocial Characteristics of VACS Participants Recruited from 2002–2008 by Food Security Status, N=2353

Characteristics	Food insecure N=559 (24%)	Food secure N=1794 (76%)	P value
Age, years (mean +/- SD)	48±7.3	50±9.3	<0.0001
Male	540 (97%)	1756 (98%)	0.09
Race			<0.0001
White	85 (15%)	411 (23%)	
Black	363 (65%)	1162 (64%)	
Latino	81 (15%)	156 (9%)	
Other	30 (5%)	65 (4%)	
<High school education	49 (9%)	116 (7%)	0.001
High school-some college	449 (81%)	1371 (77%)	
College graduate	57 (10%)	290 (16%)	
Married/long-term relationship	111 (20%)	451 (25%)	0.01
Number of individuals in household, median (IQR)	2 (1, 3)	1 (1, 3)	0.10
Low income (<\$25,000/yr)	479 (89%)	1261 (72%)	<0.0001
Employed	80 (14%)	524 (29%)	<0.0001
Recent homelessness (<30 days)	120 (26%)	111 (6%)	<0.0001
Marijuana use (>1-3 times/month)	73 (13%)	185 (11%)	0.07
Cocaine use (>1-3times/month)	49 (9%)	132 (7%)	0.29
Stimulant use (>1-3times/month)	20 (4%)	20 (1%)	<0.0001
Opioid use (>1-3times/month)	35 (7%)	66 (4%)	0.009
Hazardous alcohol consumption (AUDIT-C ≥ 4 and drank in past year)	142 (26%)	405 (23%)	0.12
Binge drinking monthly (≥ 6 drinks at once)	147 (27%)	391 (22%)	0.02
Depression (PHQ-9 score), median (IQR)	8 (3, 13)	3 (0, 7)	<0.0001
Depression (PHQ-9 > 10)	222 (40%)	276 (16%)	<0.0001
CD4 count, median (IQR)	300 (160, 500)	364 (212, 550)	<0.0001
CD4 count <200 cells/ μ L	170 (31%)	399 (23%)	<0.0001
HIV-1 RNA, median (IQR)	400 (75, 15572)	359 (75, 3384)	<0.0001
HIV-1 RNA >500 copies/mL	258 (48%)	659 (38%)	<0.0001
ART adherence, median (IQR)*	0.85 (0.65, 1)	0.9 (0.72, 1.0)	0.004
Body mass index, median (IQR)	24.4 (21.6, 27.2)	25 (22.2, 27.5)	0.02

Abbreviations: AUDIT=Alcohol Use Disorders Identification Test; PHQ=Patients' Health Questionnaire, IQR=Interquartile range, SD=Standard Deviation
*Adherence is measured as % time with ART medications in one year (1 reflects that the patient was never out of ART medications)

Figure 1. Percent of VACS participants with food insecurity by antiretroviral medication adherence Quintiles. Chi-squared test, $p=0.02$; test of trend, $p=0.001$.

outcomes—a CD4 count <200 cells/ μL (unadjusted OR 1.45 (95% CI 1.14, 1.86), Table 2) and an unsuppressed HIV-1 RNA level (unadjusted OR 1.49 (95% CI 1.17, 1.81)), Table 3). After adjustment for covariates associated with poor HIV clinical outcomes, including age, race/ethnicity, recent drug use, lower income, homelessness, depression, and site of recruitment, food insecurity was no longer associated with low CD4 count (adjusted OR 1.13 (95% CI 0.86, 1.47)). Multivariable adjustment did not significantly alter the association between food insecurity and unsuppressed HIV-1 RNA levels (adjusted OR 1.37 (1.09, 1.73)). After adjusting for ART adherence and BMI separately, the association between food insecurity and unsuppressed HIV-1 RNA remained statistically significant, indicating that neither ART adherence nor BMI appears to play a mediating role in the association between food insecurity and unsuppressed HIV-1 RNA levels. Variance inflation factors (VIFs) were assessed for each multivariate model. All VIFs were below 2, indicating that multicollinearity was not an issue in these models.

DISCUSSION

In a large multisite study, we found that 24% of HIV-infected Veterans were food insecure and that food insecurity independently increased the likelihood of incomplete HIV viral suppression. While the prevalence of food insecurity in this study is lower than other estimates in HIV-infected populations in the U.S.,^{9,30} this study was conducted among patients who have accessed care through the Veterans Health Administration and are ostensibly less disenfranchised than previously studied homeless or drug using populations. Nonetheless, a quarter of participants in this study reported food insecurity, suggesting that food insecurity is more common among HIV-infected individuals in the U.S. compared to the general population.¹

Similar to previous single site studies, we also found that food insecurity was associated with a 1.3 greater odds of lack of viral suppression when we controlled for other covariates, including measures of socioeconomic status, homelessness,

and drug and alcohol use. While there is growing concern that food insecurity may compromise treatment effectiveness in ART treatment programs in developing countries,^{31–33} our findings suggest that food insecurity may be compromising treatment efficacy in well-resourced settings as well. Food insecurity was associated with ART non-adherence in a linear fashion. The finding that food insecurity is associated with lower levels of adherence is especially important given that lower ranges of adherence are more likely to be associated with incomplete viral suppression with currently available regimens.³⁴ However, our data, like that of others, suggest that the association between food insecurity and viral suppression is not explained by a difference in adherence, in this case, an average yearly adherence.¹⁴ Veterans in this study received 98% of their medications from a VA pharmacy, making our use of administrative pharmacy data one of the best available adherence measurement strategies; however, these data may not capture patterns of adherence including treatment interruptions, that may be associated with viral rebound.³⁴

Food insecurity was also associated with lower body mass index. However, when BMI was truncated into clinically meaningful categories, the association was marginally statistically significant. HIV-infected Veterans who were food insecure were more likely to be normo-weight or obese. Like others, our study found that obese individuals report anxiety about obtaining sufficient and high quality food.^{7,35} This finding deserves further exploration to better understand how to improve health outcomes among obese HIV-infected patients.

Another plausible biologic mechanism for the relationship between food insecurity and viral suppression is that food may impact the pharmacokinetics of antiretroviral medications. Several protease inhibitors including atazanavir, lopinavir, nelfinavir and ritonavir require food for maximal absorption, and the absence of timely access to food may negatively affect the absorption of these drugs.¹⁴ Since we did not assess the use of specific ART regimens, we cannot infer the effect of particular regimens on the association between food insecurity and viral suppression. Another possible mechanism is psychological distress which has been demonstrated in past studies to be associated with food insecurity and to impact HIV treatment outcome.³⁶ Further research needs to be conducted to explore

Figure 2. Percent of VACS participants with food insecurity among underweight, normo-weight, overweight, and obese Veterans. Chi-squared test, $p=0.06$; test of trend, $p=0.32$.

Table 2. Factors Associated with Low CD4 Count (<200 cells/ μ L) among HIV-infected Veterans, N=1860

Characteristic	Odds ratio (OR, 95% CI)	Adjusted OR with covariates† (OR, 95% CI)	Adjusted OR with covariates and ART adherence (OR, 95% CI)	Adjusted OR with covariates and BMI (OR, 95% CI)
Food insecure	1.45 (1.14, 1.86)*	1.13 (0.86, 1.47)	1.10 (0.83, 1.44)	1.10 (0.84, 1.44)
Age (per year)	0.98 (0.97, 0.99)*	0.97 (0.96, 0.99)*	0.98 (0.97, 1.0)*	0.98 (0.96, 0.99)*
Black (vs.White)	1.23 (0.94, 1.63)	1.13 (0.85, 1.51)	1.05 (0.79, 1.41)	1.15 (0.87, 1.54)
Latino (vs.White)	1.41 (0.93, 2.11)	1.27 (0.84, 1.92)	1.27 (0.84, 1.94)	1.32 (0.87, 2.01)
Other (vs.White)	0.89 (0.47, 1.70)	0.83 (0.43, 1.60)	0.78 (0.40, 1.50)	0.89 (0.45, 1.71)
Male (vs. female)	0.70 (0.38, 1.35)	—	—	—
High school and some college (vs. < high school)	1.06 (0.67, 1.69)	—	—	—
>College grad (vs. < high school)	0.99 (0.59, 1.66)	—	—	—
Married/long-term relationship	0.82 (0.63, 1.1)	0.89 (0.68, 1.15)	0.89 (0.68, 1.17)	0.91 (0.69, 1.19)
Employed	0.55 (0.42, 0.73)*	0.57 (0.42, 0.77)*	0.58 (0.42, 0.78)*	0.57 (0.42, 0.77)*
>\$25,000 annual income	0.72 (0.55, 0.93)*	0.92 (0.69, 1.25)	0.96 (0.71, 1.29)	0.94 (0.62, 1.44)
Recent homelessness	2.00 (1.45, 2.57)*	1.66 (1.15, 2.38)*	1.63 (1.13, 2.34)*	1.58 (0.95, 2.63)*
Binge drinking	1.28 (0.99, 1.65)	1.22 (0.94, 1.59)	1.16 (0.89, 1.51)	1.15 (0.88, 1.51)
AUDIT-C ≥ 4	1.16 (0.91, 1.50)	—	—	—
Marijuana use (>1-3 $\times$ /month)	0.93 (0.65, 1.32)	—	—	—
Cocaine use (>1-3 $\times$ /month)	1.41 (0.97, 2.08)	0.97 (0.64, 1.48)	0.87 (0.57, 1.33)	0.94 (0.62, 1.44)
Stimulant use (>1-3 $\times$ /month)	1.60 (0.75, 3.4)	—	—	—
Opioid use (>1-3 $\times$ /month)	1.82 (1.13, 2.93)*	1.53 (0.92, 2.55)	1.65 (0.99, 2.78)	1.58 (0.95, 2.63)
PMD score >10 (unit)	1.40 (1.09, 1.81)*	1.14 (0.86, 1.42)	1.11(0.85, 1.46)	1.15 (0.87, 1.52)
Body mass index (per unit)	0.93 (0.90, 0.96)*	—	—	0.84 (0.75, 0.93)*
% time out of antiretroviral therapy	5.70 (3.52, 9.21)*	—	5.4 (3.19, 9.16)*	—

*Statistically significant at $p < 0.05$

†Only covariates with $p < 0.2$ in bivariate analyses were included in multivariable model (age, race/ethnicity, married, employment, income, recent homelessness, binge alcohol, cocaine use, opioid use, PMD score)

Abbreviations: AUDIT-C=Alcohol Use Disorders Identification Test; PMD=Prime MD Survey, IQR=Interquartile range

the mechanisms of the association between food insecurity and unsuppressed HIV-1 RNA in order to tailor interventions to improve the health outcomes for food insecure HIV-patients.

Finally, while several studies have demonstrated positive associations between food security and immunological status,

we did not find such an association. One possible explanation for this discrepancy is that previous studies have reported that food insecure individuals had significantly lower CD4 counts prior to initiation of antiretroviral therapy,⁹ whereas our study examined the association among individuals already prescribed

Table 3. Factors Associated with Unsuppressed HIV-1 RNA (>500 copies/mL) among HIV-infected Veterans, N=1911

Characteristic	Odds ratio (OR, 95% CI)	Adjusted OR with covariates† (OR, 95% CI)	Adjusted OR with covariates and ART adherence (OR, 95% CI)	Adjusted OR with covariates and BMI (OR, 95% CI)
Food insecure	1.49 (1.17, 1.81)*	1.37 (1.09, 1.73)*	1.32(1.05, 1.68)*	1.35 (1.07, 1.70)*
Age (per year)	0.97 (0.96, 0.98)*	0.97 (0.96, 0.98)*	0.97 (0.96,0.98)*	0.96 (0.96, 0.98)*
Black (vs.White)	1.14 (0.91, 1.44)	1.05 (0.83, 1.33)	0.95 (0.74, 1.21)	1.06 (0.84, 1.35)
Latino (vs.White)	0.76 (0.53, 1.10)	0.69 (0.47, 1.00)	0.67 (0.46, 0.99)*	0.71 (0.49, 1.03)
Other (vs.White)	1.29 (0.79, 2.12)	1.19 (0.72, 1.98)	1.09 (0.65, 1.82)	1.23 (0.74, 2.05)
Male (vs. female)	1.10 (0.61, 2.01)	—	—	—
High school and some college (vs. < high school)	1.48 (0.98, 2.21)	1.23 (0.81, 1.86)	1.29 (0.84, 1.97)	1.23 (0.81, 1.87)
>College grad (vs. < high school)	1.46 (0.93, 2.23)	1.34 (0.84, 2.14)	1.50 (0.93, 2.41)	1.36 (0.85, 2.17)
Married/long-term relationship	0.99 (0.79, 1.23)	—	—	—
Employed	0.90 (0.73, 1.11)	—	—	—
<\$25,000 annual income	1.09 (0.89, 1.36)	—	—	—
Recent homelessness	1.41 (1.03, 1.94)*	1.15 (0.82, 1.63)	1.13 (0.80, 1.61)	1.15 (0.82, 1.62)
AUDIT-C (≥ 4)	1.33 (1.07, 1.65)*	1.22 (0.98, 1.53)	1.08 (0.86, 1.36)	1.21 (0.97, 1.51)
Binge drinking	1.05 (0.85, 1.32)	—	—	—
Marijuana use (>1-3 $\times$ /month)	1.13 (0.85, 1.51)	—	—	—
Cocaine use (>1-3 $\times$ /month)	1.59 (1.12, 2.22)*	1.32 (0.92, 1.89)	1.21 (0.85, 1.76)	1.32 (0.92, 1.88)
Stimulant use (>1-3 $\times$ /month)	0.96 (0.45, 2.03)	—	—	—
Opioid use (>1-3 $\times$ /month)	0.79 (0.49, 1.27)	—	—	—
PMD score >10	1.33 (1.0, 1.04)	1.18 (0.93, 1.49)	1.15 (0.90, 1.46)	1.19 (0.94, 1.51)
Body mass index (per unit)	0.97 (0.95, 0.99)*	—	—	0.91 (0.84, 0.99)*
% time out of antiretroviral therapy	9.80 (6.14, 15.1)*	—	8.47 (5.20, 13.8)*	—

*Statistically significant at $p < 0.05$

†Only covariates with $p < 0.2$ in bivariate analyses were included in multivariable model (age, race, education, married, recent homelessness, cocaine use, PMD score)

Abbreviations: AUDIT-C=Alcohol Use Disorders Identification Test; PMD=Prime MD Survey, IQR=Interquartile range

antiretroviral medications. As a result, the effect of food insecurity on an individual's immunologic response to HIV was less likely to be detected given the marked improvements in CD4 counts when individuals are started on antiretroviral medications.

There are several important limitations to this study. No conclusions about cause and effect can be made from this study due to its cross-sectional design. One possible explanation of our findings is that individuals with more advanced disease and poor functional health status are less able to obtain food. Additionally, our measurement for food insecurity was a single item taken from the HFIAS survey and thus captured only one of the domains of food insecurity—*anxiety and uncertainty about food supply*. We, therefore, were lacking accurate information about other components of food insecurity, including insufficient food intake or quality of food, as well as the duration, frequency, or extent of food insecurity. This information would be useful for understanding the effect of various domains of food insecurity on HIV disease outcomes. We did not adjust for previous time on ART, which may confound the observed associations. Finally, because we measured average adherence rather than patterns of adherence such as treatment interruptions, we were unable to determine whether adherence was on the causal pathway between food insecurity and HIV-1 RNA suppression.

CONCLUSION

In a large, multisite study, food insecurity was independently associated with unsuppressed HIV-1 RNA level in HIV-infected Veterans, and neither ART adherence nor body mass index mediated the observed association. Longitudinal studies with detailed measures food insecurity and patterns of adherence are needed to better understand the relationships between food insecurity, antiretroviral adherence, and HIV RNA suppression and to inform specific interventions.

Acknowledgements: This work was funded by National Institute on Alcohol and Alcohol Abuse (U01 AA 13566 and U10 AA 13566), National Institute of Aging (K23 AG00826), Robert Wood Johnson Generalist Faculty Scholar Award, an Inter-agency Agreement between NIA, National Institute of Mental Health, and VA HSR&D Research Enhancement Award Program (REAP) PRIME Project (REA 08-266). The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs.

Conflicts of Interest: None disclosed.

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