The Association Between Food Insufficiency and HIV Treatment Outcomes in a Longitudinal Analysis of HIV-Infected Individuals in New York City

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Background: To date, there have been few longitudinal studies of food insecurity among people living with HIV (PLWH). Food insufficiency (FI) is one dimension of the food insecurity construct that refers to periods of time during which individuals have an inadequate amount of food intake because of limited resources. The aim of this analysis was to examine the relationship between FI and HIV treatment outcomes among HIV-infected individuals in New York City (NYC).

Methods: Associations between FI ("consistent"—food insufficient on both of the last 2 assessments, "inconsistent"—food insufficient on 1 of the last 2 assessments, or neither) and clinical indicators of HIV disease progression (viral load $>$ 200 copies per milliliter, CD4 count $<$ 200 cells per cubic millimeter) were analyzed for NYC Ryan White Part A food and nutrition program clients who were matched to the NYC HIV Surveillance Registry and completed 2 FI assessments between November 2011 and June 2013.

Results: Among 2,118 PLWH in food and nutrition programs, 61% experienced consistent FI and 25% experienced inconsistent FI. In multivariate analyses controlling for sociodemographic characteristics, consistent FI was independently associated with unsuppressed viral load (adjusted odds ratio = 1.6, confidence interval: 1.1 to 2.5). Consistent FI was only associated with low CD4 counts at the bivariate level.

Conclusions: Future studies should examine biological, structural, and psychosocial factors that may explain the relationship between FI and HIV treatment outcomes to inform intervention development. Persistent FI among food and nutrition program clients suggests that services are needed to address underlying needs for financial stability (eg, vocational counseling) for PLWH.

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INTRODUCTION

Food insecurity is defined as "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways."[1] This definition implies that people who are food insecure consume insufficient and/or poor-quality food and/or engage in legally or socially "undesirable" activities to obtain food.[2] Although the issue of food insecurity is commonly associated with resource-poor countries, there is preliminary evidence that HIV-infected individuals in resource-rich countries are at a significantly increased risk for food insecurity compared with the general population. The US Department of Agriculture reported that 14.5% (17.6 million) of 121.5 million households in the United States were food insecure at some time during 2012,[3] whereas studies of people living with HIV (PLWH) in the United States and Canada have reported food insecurity prevalence estimates that range from 24% to 83%.[2,4–10] Food insecurity is more common among low-income individuals and racial/ethnic minorities who are also disproportionately affected by HIV/AIDS.[11] In 2012, rates of food insecurity were higher than the national average for non-Hispanic black (24.6%) and Hispanic households (23.3%) and households with incomes below 185% of the poverty threshold (34.3%), regardless of HIV status.[3]

Food insecurity may present significant challenges to maintaining physical health for PLWH, particularly in terms of viral suppression and CD4 counts, both of which are critical indicators in predicting the clinical progression of HIV to AIDS[12] and the risk of transmission.[13] Studies have found that HIV-infected food insecure individuals are less likely to be virally suppressed [adjusted odds ratios (AOR) = 0.23–0.73][4,14] and more likely to be virally unsuppressed (AOR = 1.29–1.37).[8,15] Studies of the relationship between food insecurity and CD4 counts have yielded mixed findings. In a study of 592 PLWH who had completed ≥4 food security assessments over a 10-year period, increases in CD4 counts were on average 99.5 cells less for individuals with at least one episode of food insecurity compared with those who were consistently food secure.[16] Food insecurity was independently

associated with low CD4 counts (AOR = 1.26) in a longitudinal study of HIV-infected homeless and marginally housed individuals in San Francisco.[15] Another study, however, found that food insecurity was associated with low CD4 counts only at the bivariate level [odds ratio (OR) = 1.45].[8] Only one study to date has identified a specific pathway that might explain the relationship between food insecurity and HIV treatment outcomes. Weiser et al[15] found that antiretroviral treatment (ART) adherence was a weak mediator of the association between food insecurity and both viral suppression and CD4 counts. In another study, however, neither ART adherence nor body mass index (BMI) mediated the relationship between food insecurity and HIV treatment outcomes.[8]

Both HIV and food insecurity affect a significant proportion of New York City (NYC) residents. At the end of 2010, the NYC metropolitan statistical area had the second highest prevalence of diagnosed HIV infection among metropolitan statistical areas in the United States, at an estimated rate of 757.9 per 100,000 population.[17] Furthermore, New York county (all 5 boroughs) had a higher food insecurity rate (17.7%) than the US county average (14.7%) during 2011. New York county also had the second highest number of food-insecure individuals (1.4 million) of any county in the United States.[18]

Although there is evidence to support the association between food insecurity and HIV treatment outcomes,[4,8,14] few studies to date have used longitudinal data to examine these relationships, with some exceptions.[15,16] These data will be critical in informing the development of interventions and services to address food insecurity for PLWH, particularly in areas like NYC that are affected by both food insecurity and HIV. In a cohort sample of PLWH in the New York metropolitan area from 2008 to 2011, more than 2 out of every 5 study participants (42%) experienced food insecurity (defined in this study as not having enough money for food, at least sometimes not having enough to eat, not having anything to eat for a whole day, or reporting problems or the need for services regarding food, groceries, or meals).[4]

This analysis will focus on food insufficiency (FI), which is one dimension of the construct of food insecurity, and refers to periods of time when individuals or households have an inadequate amount of food intake because of a lack of social or economic resources.[19] The aim of this analysis was to examine the association between FI and HIV treatment outcomes (unsuppressed viral load, low CD4 counts) in a longitudinal analysis of Ryan White Part A–funded food and nutrition service clients. Our hypothesis is that clients with consistent FI over time will be more likely to have unsuppressed viral load and lower CD4 counts compared with clients with inconsistent or no FI.

METHODS

Client Population

The sample for this analysis is based on data collected from HIV-infected individuals who received food and nutrition services from 1 of 11 agencies in NYC funded to provide congregate meals (meals served in a communal setting), home-delivered meals, pantry bags, emergency food vouchers, and/or nutritional counseling through Ryan White Part A, which funds supportive services for PLWH through the Health Resources and Services Administration. From November 2011 to June 2013, 19,561 HIV-infected individuals received services funded by Ryan White Part A in NYC, 24% (n = 4,692) of whom received food and nutrition services. To be eligible for Ryan White Part A programs, individuals must live in the New York Eligible Metropolitan Area and have an income below 435% of the federal poverty level. Additional eligibility requirements apply for certain food and nutrition service programs. For example, to be eligible for home-delivered meals, clients must be homebound because of a mental or physical condition and provide documentation from a medical provider that the service is needed.

Data were analyzed for 2,118 HIV-infected individuals who (1) were enrolled in a Ryan White Part A–funded food and nutrition service program between November 2011 and June 2013, (2) completed at least 2 FI assessments during this period (if a client completed more than 2 consecutive FI assessments, the most recent 2 assessments were used), and (3) had a viral load value and/or a CD4 count reported to the NYC HIV Surveillance Registry with a test date in the 6-month period after the most recent FI assessment (Fig. 1).

Data Sources

The NYC HIV Surveillance Registry (the Registry) contains comprehensive information on HIV diagnoses and HIV-related laboratory results from medical providers and laboratories and is continuously updated with new deduplicated data on PLWH in NYC. The Registry was used as the source of HIV diagnosis and viral load and CD4 count data. New York State requires named reporting of all diagnoses of HIV and AIDS, HIV-related illnesses, positive Western blot tests for HIV antibody, viral loads, and CD4 cell count values, and HIV genotypes.[20]

All other data for this analysis were collected through the Electronic System for HIV/AIDS Reporting and Evaluation (eSHARE), a secure web-based data system for contractually required reporting of client-level demographic, psychosocial, clinical, behavioral, and service-related data by NYC Department of Health and Mental Hygiene (DOHMH)–funded HIV service providers. FI data were collected by staff (eg, nutritionists) at provider agencies who are responsible for administering assessments at the time of program intake and every 6 months throughout a client's participation in a food and nutrition services program.

The collection of fully identified data (including client names) in eSHARE from DOHMH-funded HIV care and treatment programs permits deduplication and merging of programmatic data with the Registry. eSHARE data were merged with laboratory data reported to the Registry as of June 30, 2014. For the purpose of this analysis, the datasets were de-identified. Because we used de-identified limited datasets, the NYC DOHMH Institutional Review Board deemed this analysis to be exempt from the board's review because it would pose minimal risk for clients' privacy and data confidentiality.

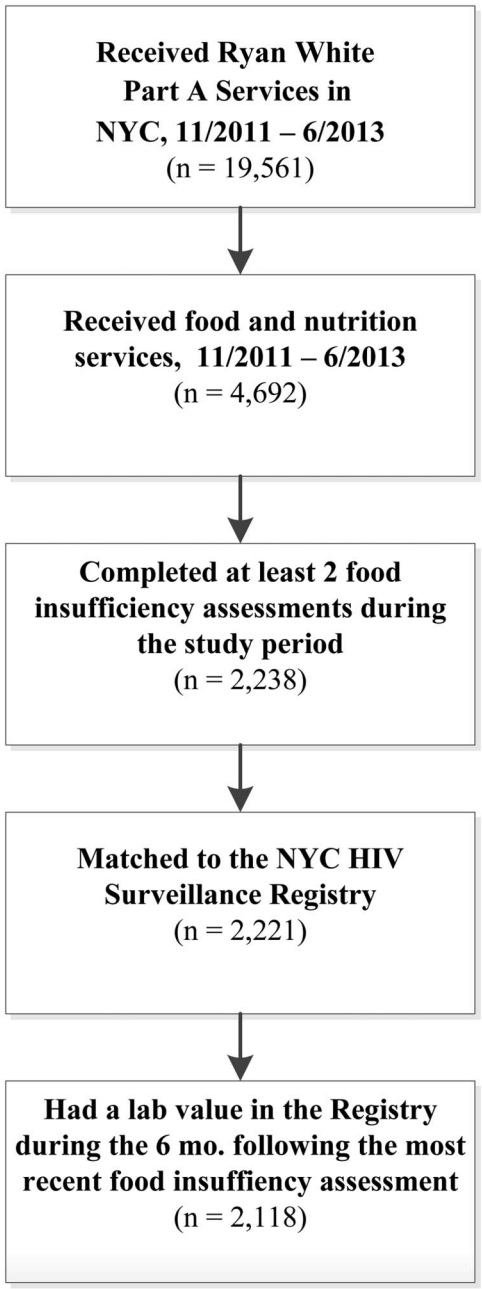

FIGURE 1. Client population flow.

Measures

Food Insufficiency

To assess FI, 3 items were adapted from the food security supplement to the US Census Bureau's Current Population Survey, which is used by the US Department of Agriculture to collect information annually on food access and adequacy, food spending, and sources of food assistance for the US population.[1] The original versions of the items were adapted for the Community Health Advisory and Information Network Project, an ongoing longitudinal study of PLWH in NYC for which follow-up interviews were not always a full year apart. FI is a particularly critical outcome in terms of monitoring the progress of food and nutrition program clients. Clients were classified as having FI if they reported (1) "once in a while," "fairly often," or "very often" not having enough money for food in the past 3 months; (2) "sometimes" or "often" not having enough to eat; or (3) going for a whole day without anything at all to eat in the past 30 days. We then created 3 categories based on the client's responses on the 2 most recent FI assessments: (1) consistently food insufficient (client reported FI on both assessments), (2) inconsistently food insufficient (client reported FI on one assessment and food sufficiency on the other assessment), and (3) consistently food sufficient (client reported food sufficiency on both assessments).

HIV Treatment Outcomes

For each participant, the viral load and CD4 count closest to the date of the second eligible FI assessment (and within the 6-month period after this assessment) were selected from the Registry. A low CD4 count was defined as <200 cells per cubic millimeter, which represents the CD4 count at which Stage 3 HIV is diagnosed for persons 6 years and older.[21] Unsuppressed viral load was defined as an HIV-1 RNA >200 copies per milliliter, which is the threshold for virologic failure.[22,23]

Sociodemographic, Behavioral, and Clinical Characteristics

Covariates for this study were based on previous studies of food insecurity and FI among PLWH[2,4–8,14–16] and included the following characteristics (as of the time of the most recent FI assessment): gender (male vs. female), race/ethnicity (white vs. black/Hispanic/other), age, education level ($\geq$ vs. $<$high school diploma/General Equivalency Diploma), employment status (employed vs. unemployed), income ($\geq$ vs. $<100\%$ of the federal poverty level), housing situation (stably vs. unstably housed), receipt of food aid (receipt of one or more congregate meals, home-delivered meals, pantry bags, or food vouchers between the dates of the 2 FI assessments used for analysis), recent hard drug use (any vs. no cocaine, crack, heroin, methamphetamines, or recreational use of prescription medication in the past 3 months), number of years living with HIV, ART prescription status (currently prescribed vs. not prescribed ART), and BMI (normal weight, BMI = 18.5–24.9 vs. underweight, BMI $<$ 18.5; or overweight and obese, BMI $\geq$ 25).[24]

Statistical Analyses

Chi-square tests, analysis of variance, and *t* tests were used to compare HIV-infected individuals with different levels of FI. Bivariate analyses of the relationship between each of the variables and HIV treatment outcomes (unsuppressed viral load, low CD4 counts) were conducted using logistic regression to estimate ORs. Both clients prescribed and not prescribed ART were included in analyses for HIV treatment outcomes based on the official recommendation of the NYC DOHMH in 2011 that all health care providers should offer ART to any person living with HIV, regardless of that individual's CD4 count.[25] Variables that had a *P* value

<0.05 in the unadjusted analyses or that met a priori expectations of relevance were included in multivariate logistic regression models to determine variables independently associated with HIV treatment outcomes. These results are shown as AOR with the corresponding 95% confidence intervals (CI). Data were analyzed using SAS statistical software version 9.2 (SAS Institute Inc., Cary, NC).

RESULTS

In a sample of 2,118 HIV-infected individuals receiving Ryan White Part A–funded food and nutrition services, 61% (n = 1290) experienced consistent FI and 25% (n = 530) experienced inconsistent FI, while only 14% (n = 298) were consistently food sufficient. Compared with clients who experienced consistent food sufficiency, clients who experienced consistent FI were more likely to be female, younger, unemployed, living below the federal poverty level, unstably housed, and receiving food aid. Clients who experienced consistent FI were also more likely to have low CD4 counts, to be virally unsuppressed, and to not be prescribed ART (Table 1).

In the multivariate analysis, consistent FI was independently associated with unsuppressed viral load (AOR = 1.6, 95% CI: 1.1 to 2.5, $P = 0.03$), whereas inconsistent FI was only associated with unsuppressed viral load at the bivariate level (OR = 1.8, CI: 1.2 to 2.7, $P = 0.003$). The relationships between unsuppressed viral load and ART prescription status (AOR = 2.5, CI: 1.6 to 4.0, $P < 0.0001$), housing status (AOR = 1.5, CI: 1.1 to 2.0, $P = 0.007$), and income (AOR = 1.5, CI: 1.1 to 2.0, $P = 0.01$) also remained significant in the multivariate model (Table 2). Although consistent FI was significantly associated with a low CD4 at the bivariate level (OR = 1.6, 95% CI: 1.1 to 2.4, $P = 0.01$), this relationship was not statistically significant in the multivariate analysis (Table 3).

DISCUSSION

We found that Ryan White Part A food and nutrition program clients who experienced consistent FI were more likely to be virally unsuppressed after controlling for potential confounders, which is consistent with the findings of previous studies.[4,8,14,15] To date, however, only 2 published studies have used longitudinal food insecurity/FI data in analyzing associations with HIV treatment outcomes.[15,16] The use of a longitudinal design and the independent relationship between FI and unsuppressed viral load in our analysis strengthens the evidence for a causal relationship between FI and poor HIV treatment outcomes among PLWH.

We found that 86% of the sample reported FI at one or more assessment, which is higher than the proportions found in other studies of FI or insecurity in the United States.[2,4–10] This disparity is most likely explained by the composition of the sample, the majority of which received food assistance (87%), including congregate meals, home meal delivery, food vouchers, and/or pantry bags. Consistent with prior studies, we found that FI was associated with the receipt of food aid.[4,7] Food insecurity is also influenced and shaped by structural (eg, poverty, access to education) and household (eg, family structure) factors.[26] Indeed, we found that FI was significantly associated with both being unstably housed and living below the federal poverty level in the multivariate analysis.

FI was not significantly associated with low CD4 counts in the multivariate analysis. Previous studies have found significant associations between food insecurity and CD4 counts at the bivariate[8] and multivariate levels.[15,16] Food insecurity or FI may fluctuate over time as a result of changes in an individual's income or housing status,[27] which could have affected our ability to see an association with CD4 counts, which do not change as quickly as viral load.[28] In our study population, 25% of clients had consecutive assessments that differed in terms of levels of FI, which suggests that FI may change fairly often over time. Future research should examine differences between consistently and inconsistently food-insecure clients over a longer period of time to determine if there is a significant association between food insecurity and CD4 counts. These studies could also use a higher number of consecutive reports of food insecurity to categorize risk and, ideally, also incorporate multiple lagged measures of CD4 counts to better capture the potentially more gradual effect of food insecurity on this clinical indicator. Future research should also incorporate other measures of viral load over time, such as viral rebound and sustained viral suppression to determine the nature of the observed viral load patterns.

The high proportion of FI in a sample of PLWH—the majority of whom were receiving food services that are designed to address this issue—is particularly troubling and underscores that there might be persistent gaps in services for PLWH. This finding suggests that existing food and nutrition services, while critical in providing a safety net for individuals who have difficulty in meeting basic needs, are not sufficient to resolve FI. FI, particularly because food aid does not ultimately address the underlying economic issues that contribute to the persistence of food insecurity.[29,30] It is likely not feasible for programs to provide an adequate amount of food to sustain individuals over a longer period, without significantly reducing the number of people to whom they can provide services. Food and nutrition programs targeting this population should therefore incorporate the use of food and nutrition education materials and evidence-based skills building around shopping for inexpensive nutritious food items and preparing nutritionally balanced meals with limited resources,[31] in addition to providing nutritious food items and meals that are responsive to the cultural and dietary needs of clients.

More generally, there should be a call for services that go beyond providing temporary support in meeting basic needs to help individuals become as independent as possible. Not surprisingly, there is evidence that having a low income and a lack of assets are associated with food insecurity.[32,33] In a study of 331 families, increases in household income and obtaining full-time employment were associated with significant decreases in food insecurity.[27] Services are therefore needed that address the underlying need for financial stability (eg, job placement services, vocational counseling), which would be critical in significantly decreasing food insecurity among PLWH.

TABLE 1. A Comparison of Sociodemographic, Behavioral, and Clinical Characteristics by FI Status

Characteristics	Consistently Food Sufficient (n = 298)	Inconsistently Food Insufficient (n = 530)	Consistently Food Insufficient (n = 1290)	*P*
Gender, n (%)				
Male	214 (71.8)	386 (72.8)	848 (65.7)	0.005
Female	84 (28.2)	144 (27.2)	442 (34.3)	
Race/ethnicity, n (%)				
White	49 (16.7)	73 (13.8)	152 (11.9)	0.10
Black	135 (45.9)	276 (52.3)	691 (54.2)	
Hispanic	105 (35.7)	163 (30.9)	397 (31.1)	
Other*	5 (1.7)	16 (3.0)	36 (2.8)	
Age (Mean; SD)	55.0 (10.5)	51.1 (10.1)	50.2 (9.9)	<0.0001
Education level, n (%)				
≥High school/General Equivalency Diploma	205 (70.0)	345 (67.3)	802 (63.5)	0.06
<High school/General Equivalency Diploma	88 (30.0)	168 (32.8)	461 (36.5)	
Employment status, n (%)				
Employed	33 (11.1)	36 (6.8)	50 (3.9)	<0.0001
Unemployed	265 (88.9)	494 (93.2)	1240 (96.1)	
Income, n (%)				
≥100% federal poverty level	98 (38.4)	112 (24.8)	288 (24.9)	<0.0001
<100% federal poverty level	157 (61.6)	340 (75.2)	871 (75.2)	
Housing status, n (%)				
Stable/permanent	258 (88.7)	426 (81.8)	997 (78.5)	0.0003
Unstable/temporary	33 (11.3)	95 (18.2)	273 (21.5)	
Food aid, n (%)				
No food aid	82 (27.5)	71 (13.4)	132 (10.2)	<0.0001
Received food aid	216 (72.5)	459 (86.6)	1158 (89.8)	
Recent hard drug use, n (%)				
No	283 (96.6)	498 (95.4)	1215 (94.9)	0.47
Yes	10 (3.4)	24 (4.6)	65 (5.1)	
Years living with HIV (Mean; SD)	14.9 (6.6)	14.5 (6.4)	14.3 (6.5)	0.34
ART prescription status, n (%)				
Prescribed ART	288 (98.3)	493 (93.9)	1196 (93.3)	0.004
Not prescribed ART	5 (1.71)	32 (6.1)	86 (6.7)	
Viral load, n (%)				
Suppressed	252 (86.6)	410 (78.1)	900 (70.8)	<0.0001
Unsuppressed	39 (13.4)	115 (21.9)	372 (29.3)	
CD4 count, n (%)				
≥200	258 (88.7)	450 (86.7)	1050 (82.7)	0.01
<200	33 (11.3)	69 (13.3)	219 (17.3)	
BMI, n (%)				
Normal weight	118 (39.6)	204 (38.5)	507 (39.3)	0.63
Overweight/obese	168 (56.4)	294 (55.5)	726 (56.3)	
Underweight	12 (4.0)	32 (6.0)	57 (4.4)	

Data on viral load and CD4 are from the NYC HIV/AIDS Surveillance Registry as reported by June 30, 2014.
*Includes clients who identified as Asian, Hawaiian, Pacific Islander, American Indian, Alaskan Native, multiracial, or other.

Although this study used longitudinal data, there are several limitations in terms of our ability to determine the nature of the relationship between FI and HIV treatment outcomes. For example, a more thorough analysis of viral load trajectories and/or other indicators over time would be needed to rule out the possibility that HIV disease progression is contributing to FI or that unsuppressed viral load and FI are related through a common risk factor that was not adequately measured in this analysis. However, the programmatic data source used in this analysis allowed for the inclusion of statistical controls for a wide range of socioeconomic variables, including education, employment, income, and housing situation, that would be expected to account for some of the plausible causal pathways from HIV disease progression to FI. We were also able to control for other factors, such as drug use, that might be expected to function as precursors to both FI and poorer HIV treatment outcomes.

TABLE 2. Factors Associated With Unsuppressed Viral Load (VL > 200 Copies per Milliliter)

Characteristic	VL ≤ 200 (n = 1562)	VL > 200 (n = 526)	Unadjusted OR (95% CI)	AOR (95% CI)
FI status, n (%)				
Food sufficient	252 (86.6)	39 (13.4)	Reference	Reference
Inconsistently food insufficient	900 (70.8)	372 (29.3)	2.7 (1.9 to 3.8)*	1.6 (1.1 to 2.5)†
Consistently food insufficient	410 (78.1)	115 (21.9)	1.8 (1.2 to 2.7)‡	1.2 (0.8 to 2.0)
Gender, n (%)				
Male	1083 (75.7)	348 (24.3)	Reference	—
Female	479 (72.9)	178 (27.1)	1.2 (0.9 to 1.4)	—
Race/ethnicity, n (%)				
White	232 (86.3)	37 (13.8)	Reference	Reference
Black	765 (70.4)	321 (29.6)	2.6 (1.8 to 3.8)*	2.5 (1.6 to 4.1)*
Hispanic	515 (78.4)	142 (21.6)	1.7 (1.2 to 2.6)‡	1.8 (1.1 to 3.0)†
Other§	38 (67.9)	18 (32.1)	3.0 (1.5 to 5.7)‡	3.1 (1.4 to 6.7)‡
Age (Mean; SD)	52.0 (10.1)	48.4 (9.7)	1.0 (1.0 to 1.0)*	1.0 (1.0 to 1.0)‡
Education level, n (%)				
≥High school/General Equivalency Diploma	1031 (77.3)	303 (22.7)	Reference	Reference
<High school/General Equivalency Diploma	491 (69.7)	214 (30.4)	1.5 (1.2 to 1.8)‡	1.3 (1.0 to 1.6)
Employment status, n (%)				
Employed	97 (82.9)	20 (17.1)	Reference	Reference
Unemployed	1465 (74.3)	506 (25.7)	1.7 (1.0 to 2.7)†	1.2 (0.7 to 2.2)
Income, n (%)				
≥100% federal poverty level	404 (82.6)	85 (17.4)	Reference	Reference
<100% federal poverty level	963 (71.3)	387 (28.7)	1.9 (1.5 to 2.5)*	1.5 (1.1 to 2.0)†
Housing status, n (%)				
Stable housing	1289 (77.9)	366 (22.1)	Reference	Reference
Unstable housing	243 (61.2)	154 (38.8)	2.2 (1.8 to 2.8)*	1.5 (1.1 to 2.0)‡
Food aid, n (%)				
No food aid	216 (77.1)	64 (22.9)	Reference	—
Received food aid	1346 (74.5)	462 (25.6)	1.2 (0.9 to 1.6)	—
Recent hard drug use, n (%)				
No	1494 (75.9)	475 (24.1)	Reference	Reference
Yes	52 (53.1)	46 (46.9)	2.8 (1.8 to 4.2)*	2.2 (1.4 to 3.6)‡
Years living with HIV (Mean; SD)	14.6 (6.4)	14.0 (6.4)	1.0 (1.0 to 1.0)	1.0 (1.0 to 1.0)
ART prescription status, n (%)				
Prescribed ART	1488 (76.3)	463 (23.7)	Reference	Reference
Not prescribed ART	61 (50.8)	59 (49.2)	3.1 (2.1 to 4.5)*	2.5 (1.6 to 4.0)*
CD4 count, n (%)				
≥200	1405 (81.1)	327 (18.9)	Reference	Reference
<200	131 (41.3)	186 (58.7)	6.1 (4.7 to 7.9)*	5.7 (4.3 to 7.7)*
BMI, n (%)				
Normal weight	586 (71.6)	233 (28.5)	Reference	Reference
Overweight/obese	916 (78.3)	254 (21.7)	0.7 (0.6 to 0.9)‡	0.8 (0.6 to 1.0)
Underweight	60 (60.6)	39 (39.4)	1.6 (1.1 to 2.5)†	1.7 (1.0 to 2.9)

Data on viral load and CD4 are from the NYC HIV/AIDS Surveillance Registry as reported by June 30, 2014. Percentages may not total 100% because of rounding and the exclusion of missing/unknown responses.

*$P < 0.0001$.

†$P < 0.05$.

‡$P < 0.01$.

§Includes clients who identified as Asian, Hawaiian, Pacific Islander, American Indian, Alaskan Native, multiracial, or other.

Collection of data on FI is currently required for NYC Ryan White Part A food and nutrition service providers, although not for other NYC Part A programs, which limits the generalizability of the data in terms of understanding the prevalence and correlates of FI among PLWH in NYC. Although the FI data are not specifically used to determine eligibility for food and nutrition services, clients may perceive that this is the case and overreport FI. However, such a reporting bias could not account for the finding of a significant association with unsuppressed viral load, unless

TABLE 3. Factors Associated With Low CD4 Counts (CD4 < 200 Cells per Cubic Millimeter)

Characteristic	CD4 ≥ 200 (n = 1758)	CD4 < 200 (n = 321)	Unadjusted OR (95% CI)	AOR (95% CI)
FI status, n (%)				
Food sufficient	258 (88.7)	33 (11.3)	Reference	Reference
Inconsistently food insufficient	1050 (82.7)	219 (17.3)	1.6 (1.1 to 2.4)*	1.3 (0.9 to 2.2)
Consistently food insufficient	450 (86.7)	69 (13.3)	1.2 (0.8 to 1.9)	1.1 (0.7 to 1.8)
Gender, n (%)				
Male	1184 (83.3)	237 (16.7)	Reference	Reference
Female	574 (87.2)	84 (12.8)	0.7 (0.6 to 1.0)*	0.8 (0.6 to 1.1)
Race/ethnicity, n (%)				
White	235 (88.4)	31 (11.7)	Reference	Reference
Black	889 (81.9)	197 (18.1)	1.7 (1.1 to 2.5)*	1.6 (1.0 to 2.5)*
Hispanic	566 (87.1)	84 (12.9)	1.1 (0.7 to 1.7)	1.0 (0.6 to 1.6)
Other†	51 (89.5)	6 (10.5)	0.9 (0.4 to 2.2)	0.8 (0.3 to 2.0)
Age (Mean; SD)	51.3 (10.3)	49.9 (9.4)	1.0 (1.0 to 1.0)*	1.0 (1.0 to 1.0)‡
Education level, n (%)				
≥High school/General Equivalency Diploma	1137 (85.4)	195 (14.6)	Reference	—
<High school/General Equivalency Diploma	578 (82.8)	120 (17.2)	1.2 (0.9 to 1.6)	—
Employment status, n (%)				
Employed	103 (89.6)	12 (10.4)	Reference	—
Unemployed	1655 (84.3)	309 (15.7)	1.6 (0.9 to 3.0)	—
Income, n (%)				
≥100% federal poverty level	432 (87.5)	62 (12.6)	Reference	Reference
<100% federal poverty level	1111 (83.1)	226 (16.9)	1.4 (1.0 to 1.9)*	1.4 (1.0 to 1.9)*
Housing status, n (%)				
Stable housing	1417 (86.1)	229 (13.9)	Reference	Reference
Unstable housing	308 (77.6)	89 (22.4)	1.8 (1.4 to 2.4)§	1.5 (1.1 to 2.1)‡
Food aid, n (%)				
No food aid	245 (87.5)	35 (12.5)	Reference	—
Received food aid	1513 (84.1)	286 (15.9)	1.3 (0.9 to 1.9)	—
Recent hard drug use, n (%)				
No	1662 (84.8)	298 (15.2)	Reference	Reference
Yes	74 (77.1)	22 (22.9)	1.7 (1.0 to 2.7)*	1.2 (0.7 to 2.0)
Years living with HIV (Mean; SD)	14.2 (6.5)	15.7 (6.2)	1.0 (1.0 to 1.1)‡	1.1 (1.0 to 1.1)§
ART prescription status, n (%)				
Prescribed ART	1643 (84.6)	299 (15.4)	Reference	Reference
Not prescribed ART	100 (84.0)	19 (16.0)	1.0 (0.6 to 1.7)	0.7 (0.4 to 1.3)
BMI, n (%)				
Normal weight	659 (80.7)	158 (19.3)	Reference	Reference
Overweight/obese	1025 (88.1)	138 (11.9)	0.6 (0.4 to 0.7)§	0.6 (0.5 to 0.8)‡
Underweight	74 (74.8)	25 (25.3)	1.4 (0.9 to 2.3)	2.0 (1.2 to 3.3)*

Data on viral load and CD4 are from the NYC HIV/AIDS Surveillance Registry as reported by June 30, 2014. Percentages may not total 100% because of rounding and the exclusion of missing/unknown responses.

*$P < 0.05$.

†Includes clients who identified as Asian, Hawaiian, Pacific Islander, American Indian, Alaskan Native, multiracial, or other.

‡$P < 0.01$.

§$P < 0.0001$.

somehow the unsuppressed clients were also more likely to overreport FI.

Individuals had to have at least one CD4 count or viral load reported to the Registry within the 6 months after their most recent FI assessment. Therefore, individuals who were not receiving HIV medical care in NYC or who had laboratory work done less frequently than every 6 months would be excluded from this analysis. However, Ryan White Part A food and nutrition programs are required to link clients to care, and therefore nearly all clients who participate in these programs are engaged in HIV medical care. As a result, only 5% of clients in the overall program population were excluded from analyses because they did not have a CD4 count or viral load in the 6-month period.

The construct of food insecurity encompasses both adequate access to food and the nutritional adequacy of the

food that is available to an individual. We were only able to measure the former dimension (FI) because the number of items had to be limited to minimize the survey burden on both the clients and the workers, therefore we cannot make conclusions about the relationship between HIV treatment outcomes and the broader construct of food insecurity. Finally, although we were able to assess ART prescription status, we were not able to measure ART adherence. Previous studies have found that food insecurity is significantly associated with ART adherence,[34,35] and one study has found that adherence might mediate the relationship between food insecurity and HIV treatment outcomes.[15] ART adherence is an important factor in evaluating if there is an association between FI/insecurity and HIV disease progression that is independent of HIV treatment–related behaviors. The findings to this analysis, however, are strengthened by the use of longitudinal FI data in combination with HIV treatment outcomes from the Registry, which is considered to be the most comprehensive source of longitudinal HIV–related laboratory data on individuals diagnosed with HIV and/or receiving HIV care in NYC.

Our findings lend support to the existing evidence that food security is an important factor in maintaining the physical health of PLWH. Understanding the relationship between food insecurity and clinical health outcomes among PLWH is critical in planning interventions for this population, particularly among the urban poor and marginally housed individuals who are at significant risk for food insecurity and its negative health sequelae.[7]

Future studies should examine potential biological, psychosocial, and behavioral mediators of the relationship between food insecurity and HIV treatment outcomes, including nutrition, mental health, and ART adherence.[26] Findings from these types of studies could be used to develop food and nutrition interventions that consider the impact of both HIV and other comorbid conditions on health outcomes. Finally, more research is needed to understand how food insecurity affects HIV treatment outcomes among PLWH in resource-rich countries, particularly in the context of extreme socioeconomic disparities that significantly affect these 2 closely intertwined epidemics.

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