

Food Insecurity, Substance Use, and Sexual Transmission Risk Behavior Among People Living with HIV: A Daily Level Analysis

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Abstract People living with HIV in poverty have limited tangible and mental resources coupled with competing demands for these resources. Competing demands require individuals to make choices that may be beneficial to them in the short term but not in the long term. Past research has shown that food insecurity is related to sexual risk behaviors among people living with HIV. Individuals who are food insecure may sell sex in order to obtain food or lack of food may lead to a depletion of mental resources to negotiate safe sex. Substance use may also create additional constraints on these already limited resources. The current study tested the relation between food insecurity and day-level sexual risk behavior and the possible mediating role that alcohol/substance use may play. Men and women living with HIV were enrolled in a 28-day prospective study between October 2012 and April 2014 in which they completed daily text message surveys regarding their sex behaviors and substance/alcohol use in the context of sex. A total of 796 participants reported sex on 3894 days. On days in which sex occurred, baseline food insecurity was negatively associated with daily condom use. There was also a significant effect of substance use in the context of sex on the rates of change in condom use over time, and this interaction between substance use

and time was a partial mediator of the relation between food insecurity and condom use. Gender did not moderate this mediation. Situation-specific alcohol and drug use should be integrated into interventions that target food insecurity and HIV prevention.

Keywords Food insecurity · Condom use · HIV · Substance use · Multilevel modeling

Introduction

In the U.S., the HIV epidemic is largely concentrated among socially marginalized groups including racial minorities, sexual minorities, injection drug users and individuals living in poverty (Pellowski, Kalichman, Matthews, & Adler, 2013). Food insecurity, defined as “the limited availability of nutritionally adequate or safe food, or the inability to procure food in socially acceptable ways” (Weiser et al., 2013, p. 91), can be interpreted as a marker of extreme socioeconomic marginalization. Among people living with HIV, food insecurity is particularly detrimental because of its added burden to an already suppressed immune system. Additionally, food insecurity is associated with poorer health behaviors including lower medication adherence and higher levels of sexual risk behavior (Anema, Vogenthaler, Frongillo, Kadiyala, & Weiser, 2009; Singer, Weiser, & McCoy, 2015).

High levels of food insecurity among people living with HIV are not surprising given that HIV is largely concentrated within poverty in which there is a scarcity of resources. Resources can be construed as tangible resources (e.g., food, transportation to get to a grocery store) or mental resources/personal characteristics (e.g., coping, depression, social support; Hobfoll, 1988, 1989; Johnson et al., 2010). Competing demands for these limited resources require individuals to make choices that may be beneficial to them in the short term but not in the long term. There is a fairly robust literature that links food insecurity to sexual risk behaviors. For

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example, Vogenthaler et al. (2013) found that food insecurity was independently associated with unprotected sex and having multiple sex partners even after accounting for homelessness, education, and income. Fielding-Miller, Mnisi, Adams, Baral, and Kennedy (2014) found that HIV positive female sex workers in Swaziland often pointed to hunger, both their own and that of their children's, as the main reason for starting and continuing to engage in sex work. Studies of sexually active women in Brazil, Botswana, and Swaziland find food insecurity is associated with less consistent condom use and symptoms of sexually transmitted infections (STIs; Tsai, Hung, & Weiser, 2012; Weiser et al., 2007). In the context of limited resources/competing demands, individuals may be making explicit or implicit survival-related choices. For example, if an individual is food insecure, they may sell sex in order to obtain food (Whittle et al., 2015). Additionally, lack of food may lead to a depletion of mental resources (e.g., through depression, stress, or social support) to negotiate safer sex.

Given the inevitability of competing resource demands among those living in poverty, it is not surprising that substance use intersects with food insecurity and subsequent risk behaviors. Alcohol and illicit drugs may be used to alleviate the stress from living in poverty. Among injection drug users, Shannon et al. (2011) found that individuals who were food insecure were more than twice as likely to have unprotected sex. In a study that examined individuals who were recently released from prison, those who did not eat for an entire day were more likely to report drinking alcohol or using drugs before sex (Wang et al., 2013). Kalichman, Watt, Sikkema, Skinner, and Pieterse (2012) found that for men recruited from drinking venues in South Africa, both methamphetamine use and food insufficiency were related to unprotected intercourse for men but for women only food insufficiency was related to sexual risk. In a study conducted in impoverished South African townships, alcohol use was tested as an explicit mediator of the association between food insecurity and sexual risk behavior (Eaton et al., 2014). Results of this study showed that women's alcohol use fully mediated the relation between food insecurity and sexual risk behavior; however, men's drinking did not. Although Eaton et al. found that gender played a moderating role in the mediation, gender power dynamics also vary across countries and contexts. Additionally, although alcohol use may play a role in the association between food insecurity and sexual risk, these associations have not been examined longitudinally among people living with HIV.

The current study aims to examine the association between food insecurity and condom use in a sample of HIV positive men and women from a large southeastern city in the U.S. We address some of the gaps in the literature, such as recall bias in self-report and cross-sectional data collection by utilizing daily prospective sexual behavior data collection. Additionally, previous studies have observed the daily relation between alcohol use and risk behaviors among people living with HIV (Barta et al., 2008); however, no studies, to our knowledge, have tested daily alcohol/substance use in the context of sex as a mediator of the association between food insecurity and daily sexual risk behaviors. We predicted

that higher levels of food insecurity would be associated with a lower likelihood of condom use on a given day. Additionally, we predicted that alcohol and drug use in the context of sex would mediate the relation between food insecurity and daily condom use. Finally, we predicted that gender of the participant would moderate the relation between food insecurity and daily alcohol use as well as the relation between alcohol and drug use in the context of sex and condom use.

Methods

Participants

This study was conducted between October 2012 and April 2014 in Atlanta, Georgia, an area with a substantial and established HIV epidemic. Georgia has over 41,000 people living with HIV/AIDS (Georgia Department of Public Health, 2013). Participants were recruited from Atlanta-metro area HIV clinics and through word of mouth. Study participants consisted of 1100 men and women living with HIV/AIDS. Eligibility criteria for this study were (a) being 18 or older, (b) name-matching proof of positive HIV status and photo identification, and (c) self-reported sexual behavior in the past month.

Procedure and Measures

Demographic and Health Characteristics

The current study employed a prospective observational design. Participants completed 28 days of daily text message surveys reporting sexual and drinking/drug use behaviors for the previous day. Participants also completed a baseline audio-computer assisted self-interview (ACASI) that included demographic information as well as health and psychosocial correlates of sexual risk behaviors. Finally, participants provided a chart-abstracted CD4 (T cell) count and HIV RNA viral load. Participants were compensated for all completed study activities and the University of Connecticut institutional review board approved the study protocol. Informed consent was obtained from all individual participants included in the study.

Following informed consent, all participants completed intake measures including demographic and psychosocial information via ACASI. Demographic characteristics included race, education, income, and employment. Additionally, participants completed a variety of measures focused on health and psychosocial variables that previous research has shown to be predictors of sexual risk behavior. These included the year he/she tested HIV positive and the number of times he/she had been hospitalized in the past year due to HIV. A 14-item scale was used to assess the number of HIV symptoms experienced by participants (Kalichman, Rompa, & Cage, 2000). We calculated a composite using the summation of all 14 HIV symptoms, $\alpha = 0.85$. The full 20-item

Centers for Epidemiological Studies Depression scale (CESD) was used to assess emotional distress (Radloff, 1977). Items focused on how often a participant had specific thoughts, feelings and behaviors in the last 7 days. Responses were 0 = 0 days, 1 = 1–2 days, 2 = 3–4 days, 3 = 5–7 days. Scores range from 0 to 60, and scores greater than 16 indicate possible depression, $\alpha = 0.82$.

To assess food insecurity, participants answered three questions adapted from Coates, Swindale, and Bilinsky (2007). These items were answered on a three-point scale with 0 = Never True, 1 = Sometimes, 2 = Often. The items are as follows: “I worried whether my food would run out before I got money to buy more,” “the food that I bought just didn’t last and I didn’t have money to get more,” “were you ever hungry, but didn’t eat because you couldn’t afford enough food.” For the analyses, these items were averaged, $\alpha = 0.85$.

Daily Text Message Assessments

All participants were provided with a text message enabled phone to complete 28 days of surveys. Each day participants reported on the events of the previous day. Participants were asked whether they had vaginal sex and whether they had anal sex. A yes on either of these questions was coded as having sex yesterday. Participants were also asked if a condom was used, 0 = No, 1 = Yes. Additionally, participants were asked about their drinking and drug use within the context of sex. Participants reported whether they, their partner, both or neither were drinking or using drugs prior to sex yesterday. These responses were recoded as the following: 0 = Neither of us drank or used drugs OR My partner drank or used drugs, 1 = I drank or used drugs OR We both drank or used drugs. Participants were paid \$2 for each completed text message survey on day 15 and day 29 of the study.

Viral Load and CD4 Cell Counts

Participants were asked to obtain their latest viral load and CD4 cell counts from their health care provider, and these records could be no older than 3 months. If the viral load was undetectable, these records still had to specify a number value determining the cut-off value of the test (i.e., <40 copies/mL). Blood was drawn by a certified phlebotomist for participants unable to obtain current reports from their health care provider (<5%). Because health care providers and blood assays use several cut-offs to determine undetectable viral load, we defined undetectable viral load as ≤ 50 copies/mL for consistency across viral load chart values.

Statistical Analysis Plan

To characterize the sample, means and rates were calculated using demographic information collected in the baseline ACASI. Logistic multilevel models with fixed and random effects were con-

ducted using R version 3.1.3 (R Core Team, 2015) and the libraries “lme4: Linear mixed-effects models using Eigen and S4” (version 1.7; Bates et al., 2014) and “mediation” (version 4.4.2; Tingley, Yamamoto, Hirose, & Keele, 2014a; Tingley, Yamamoto, Hirose, Keele, & Imai, 2014b). The term “event record” describes a text message survey for a single day and contains information about alcohol/drug use, as well as the daily sex behavior data. All of the analyses used a multilevel framework such that event records are treated as a statistical unit of analysis (or “Level 1 unit”), nested within a participant (or “Level 2 unit”). Only complete cases were used. An unstructured but positive definite variance–covariance matrix was used to model the repeated data (Mackinnon, 2008). Day was modeled as the only random effect. To account for time variation in the Level 1 variables, interactions between these variables and time were included in the fixed effects part of the model. All Level 2 variables were also modeled as fixed effects. Standardized betas are reported for all direct and indirect paths within the models. Direct effects and casual mediation effects are also reported, and confidence intervals (95%) were calculated using quasi-Bayesian methods (Tingley et al., 2014a).

Prior to hypothesis testing, the impact of time was examined to determine whether there was any indication of reactivity to the daily measurement. If habituation or sensitization effects occurred over the course of the study, we would expect to observe a significant upward or downward trend in the rates at which condom use occurs. To test our mediation hypotheses, first, the model of path “a” was tested within a multilevel framework such that alcohol/drug use (Level 1) was regressed on food insecurity (Level 2). Next, the full mediation of food insecurity and condom use (Level 1) through drinking and drug use was tested within a multilevel framework; condom use was simultaneously regressed on alcohol/drug use (path b) and food insecurity (c prime). Thus, condom use was regressed on food insecurity and alcohol/drug use to determine the indirect effect of food insecurity on condom use through alcohol/drug use and the direct effect of food insecurity on condom use when taking alcohol/drug use into account. Finally, the impact of gender (Level 2) on these relations was assessed. Gender was entered into the full mediation model as a moderator of the association between food insecurity and drinking/drug use as well as a moderator of the association between drinking/drug use and condom use. All analyses controlled for education (Level 2) and income (Level 2). Complete case analysis was used for the initial tests of these models. We also include a missing data sensitivity analysis by imputing data for days where sex was reported but the rest of the daily survey contains missing data ($N = 157$ partially completed surveys from 26 participants). Multiple imputation by chained equations (MICE; van Buuren & Groothuis-Oudshoorn, 2011) for R was used to estimate the missing variables in two ways: (1) imputing all the variables with missing data in the models and (2) imputing all the variables with missing data except for the day-level outcomes (Little, 1992). Data were imputed five times using each procedure, creating five data sets with all variables imputed and five data sets with all variables except for the day-level outcomes.

Results

A total of 1100 participants were enrolled in the current study. Of these, there were 796 participants that reported sex on at least 1 day and 304 participants never reported a sex event. Participants who never reported a sex event were excluded from the current analyses. These participants were not significantly different from the included participants on gender, race, education, income, employment, times hospitalized in the past year, viral load or CD4 count. However, participants who never reported having sex were more likely to have lower levels of food insecurity ($df=574.36$, $t=$

-4.28 , $p<.001$), lower levels of depression ($df=1094$, $t=-2.54$, $p<.05$), and were experiencing less HIV symptoms ($df=1098$, $t=-2.14$, $p<.05$).

The sample was largely male ($N=591$; 74.2%), and African-American ($N=735$; 92.3%; see Table 1). A majority of the sample completed high school or received their GED. The sample was severely impoverished with more than half of all participants earning between \$0 and \$10,000 a year. About half of the sample was on disability and another quarter was unemployed. Overall, the sample consisted of participants who had been living with HIV for some time, with the median year of diagnosis being 2000. The sample did

Table 1 Demographic characteristics of participants who had at least one sexually active day during the 28-day study

	Total sample ($N=796$) ^a		Males ($N=591$)		Females ($N=204$)		χ^2
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	
Race							
White	44	5.5	28	4.7	16	7.8	4.48
African-American	735	92.3	548	92.7	186	91.2	
Hispanic/Latino	8	1.0	7	1.2	1	50.0	
Asian	1	0.1	1	20.0	0	0.0	
Other	8	1.0	7	1.2	1	50.0	
Education							
Less than 12	182	22.9	117	19.8	76	31.4	20.52***
High school/GED	263	33.0	187	31.6	85	37.3	
More than HS	351	44.1	287	48.6	81	31.4	
Income							
\$0–\$10,000	516	64.8	362	61.6	154	75.5	16.40***
\$11,000–\$20,000	187	23.5	148	25.2	38	18.6	
\$21,000–\$30,000	63	7.9	52	8.8	11	5.4	
Over \$30,000	27	3.4	26	4.4	1	50.0	
Employment							
Unemployed	244	30.7	192	32.5	52	25.5	10.55*
Working	124	15.6	99	16.8	24	11.8	
On disability	395	49.6	274	46.4	121	59.3	
Student	15	1.9	11	1.9	4	2.0	
Other	17	2.1	14	2.4	3	1.5	
Viral load							
Undetectable (≤ 50 copies/mL)	504	63.3	378	68.4	126	63.3	1.68
Detectable	249	31.3	175	31.6	73	36.7	
CD4 T Cell count							
Less than or Equal to 200	135	17.0	98	17.9	35	17.7	0.04
Over 200	615	77.3	450	82.1	163	82.3	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>
Median Year Tested Positive	2000		2001		1999		
Times Hospitalized Past Year	1.14	1.64	1.05	1.59	1.4	1.75	-2.50*
HIV Symptoms (0–14)	3.85	3.53	3.65	3.49	4.47	3.59	-2.86**
CES-D (0–60)	20.28	8.88	20.1	8.93	20.87	8.75	-1.07
Food Insecurity (0–2)	0.69	0.58	0.69	0.59	0.67	0.57	0.56

^a One participant did not report their gender

not report high rates of symptoms; out of 14 possible HIV-related symptoms, participants experienced an average of 3.8 (SD = 3.5) and over half (63.3%) of all participants had undetectable viral loads.

Significant differences existed between men and women on several of the demographic characteristics. Women were less likely to have an education higher than a high school diploma, more likely to have an income of less than \$10,000, and more likely to be on disability. Additionally, women were hospitalized more often in the past year due to their HIV and had greater HIV symptoms.

Day-Level Characteristics

Of the 30,774 days of collected data, sex was reported on 3894 days (12.7%; see Table 2). The median number of sex days reported was 2. On days when sex was reported, nearly half reported using a condom (1848 days; 48.2%). A total of 588 participants reported at least one sex event without a condom. Anal sex was the most commonly reported sex type (1751 days; 45.2%) followed by vaginal sex (1422 days; 36.7%), and on 703 days both anal and vaginal sex was reported (18.1%). Partner gender was largely male (76.8%), and the participants' partners were often regular or steady partners (71.2%). On days when sex was reported, the participant or the

Table 2 Day level reported behaviors based on 30,774 days of collected data

Behavior	N days	%
Non-sex days	24,442	79.4
Sex days	3894	12.7
Unknown	2438	7.9
On days when sex was reported (N = 3894)		
Reported using a condom	1848	48.2
Type of sex		
Vaginal sex	1422	36.7
Anal sex	1751	45.2
Both	703	18.1
Partner gender		
Male	2927	76.8
Female	798	20.9
Transgender	87	2.3
Partner type		
Regular/steady	2689	71.2
Casual	1089	28.8
Partner status		
Told HIV+	1368	36.3
Assumed HIV+	671	17.8
Told HIV–	493	13.1
Assumed HIV–	346	9.2
Status unknown	887	23.6
Before sex,		
I or We drank or used drugs	1140	30.5
My partner drank or used drugs	311	8.3
Neither of use drank or used drugs	2290	61.2

participant and their partner reported drinking or using drugs prior to sex (30.5%).

There were 2438 (7.9%) days in which participants did not answer any questions on the text message survey. The average number of days completed by each participant was 25.5 (SD = 4.9) with a median of 27 days. Completion rates were not associated with food insecurity ($r[794] = -0.061, p = 0.084$). However, completion rates were associated with number of sex events reported ($r[794] = 0.095, p < .01$).

Test of Reactivity to the Daily Measurement

To test whether there was any reactivity to the daily measurement, condom use was regressed on day. In this simple equation, we found that day did have a significant positive association with condom use ($B = 0.002, SE = 0.001, p = .03$); participants were more likely to report condom use as they continued through the study. Day was included in all subsequent analyses to control for these time effects.

Food Insecurity, Condom Use, and Substance Use

Among days in which sex occurred, there was a significant negative relation between food insecurity and condom use such that for individuals with higher levels of food insecurity at baseline, there was a lower likelihood of condom use on a given day ($B = -0.31, SE = 0.09, p < .01$). We hypothesized that substance use, in this case drinking and/or drug use, within the context of sex would be a mediator of the association between food insecurity and condom use. We found a significant positive association between food insecurity and substance use: for individuals with higher food insecurity, there was a higher likelihood of substance use on a given day (Path a: $B = 0.60, SE = 0.12, p < .001$; see Table 3). To complete the test of mediation, both food insecurity and substance use were included in a model predicting condom use. In this model, substance use before sex did not significantly predict condom use but the interaction between substance use and time did significantly predict condom use ($B = -0.03, SE = 0.01, p < .05$) meaning that rates of change in condom use over time differ by substance use. Furthermore, the effect of substance use in the context of sex on condom use depends on time within the study, such that as time goes on in the study, substance use has less of an impact on condom use. When accounting for substance use and the interaction between substance use and time, food insecurity still significantly predicted condom use ($B = -0.29, SE = 0.09, p < .01$).

Using quasi-Bayesian methods, the direct effect of food insecurity on condom use was significant ($B = -0.041, CI [-0.067, -0.02], p < .001$). Additionally, the causal mediation effect of food insecurity on condom use through the interaction between substance use within the context of sex and time was also significant indicating a significant partial mediation ($B = -0.0002, CI [-0.0006, -0.000003], p = .02$). When partner type was controlled for, these effects remained (direct effect: $B = -0.043,$

Table 3 Fixed effects and random effects estimates for multilevel mediation model of the predictors of condom use

Parameter	Model of path a	Model of paths b and c'
<i>Fixed effects</i>		
Intercept	-5.20 (0.85)***	0.13 (0.64)
Level 1 (daily level data)		
Drinking/drug use		-0.10 (0.19)
Level 2 (individual level data)		
Food insecurity	0.60 (0.12)***	-0.29 (0.09)**
Time-predictor interactions		
Day * drinking/drug use		-0.03 (0.01)*
<i>Random effects</i>		
Intercept (σ^2)	5.98 (2.44)	2.43 (1.56)
Level 1 (daily level data)		
Day	0.004 (0.06)	0.008 (0.09)

Direct effect = -0.041, 95% CI (-0.067, -0.02), $p < .001$

Causal mediation effect: -0.0002, 95% CI (-0.0006, -0.00003), $p = .02$

Standard errors and standard deviations are in parentheses; * $p < .05$, ** $p < .01$, *** $p < .001$; All analyses control for education and income as fixed effects

95% CI [-0.070, -0.018], $p < .001$; mediation effect: $B = -0.0003$, 95% CI [-0.0007, -0.00008], $p = .01$.

Gender as a Moderator of the Mediation

Based on previous literature and sex differences observed in the current sample characteristics, gender was hypothesized as a potential moderator of the mediation for both the relation between food insecurity and substance use and the relation between substance use and condom use (see Table 4). To test whether gender moderated the association between food insecurity and substance use, substance use was regressed on food insecurity, gender and the interaction between food insecurity and gender. When controlling for gender, food insecurity did not significantly predict substance use ($B = 0.09$, $SE = 0.037$, $p = .81$). On days in which sex occurred, gender significantly predicted substance use such that men were more likely to use substances in the context of sex ($B = -0.99$, $SE = 0.28$, $p < .001$). The interaction between gender and food insecurity on substance use was only trending on statistical significance ($B = 0.55$, $SE = 0.28$, $p = .052$).

To test whether gender moderated the relation between substance use and condom use, condom use was regressed on substance use, gender, and the interaction between substance use and gender. Again, substance use in the context of sex did not significantly predict condom use but the interaction between substance use and time did ($B = -0.04$, $SE = 0.02$, $p < .05$). Gender did not significantly predict condom use ($B = -0.29$, $SE = 0.22$, $p = .19$).

Table 4 Fixed effects and random effects estimates for multilevel mediation model of the predictors of condom use with gender as a moderator

Parameter	Model of path a	Model of path b and c'
<i>Fixed effects</i>		
Intercept	-3.43 (0.95)***	0.54 (0.76)
Level 1 (daily level data)		
Drinking/drug use		-0.59 (0.46)
Drinking/drug use * gender		0.48 (0.35)
Level 2 (individual level data)		
Food insecurity	-0.09 (0.37)	-0.31 (0.10)**
Gender	-0.99 (0.28) ***	-0.29 (0.22)
Gender * food	0.55 (0.28)^	
Time-predictor interactions		
Day * drinking/drug use		-0.04 (0.02)*
<i>Random effects</i>		
Intercept (σ^2)	5.65 (2.38)	2.54 (1.59)
Level 1 (daily level data)		
Day	0.004 (0.06)	0.008 (0.09)

Direct effect: -0.043, 95% CI (-0.069, -0.015), $p < .001$

Causal mediation effect: 0.00005, 95% CI (-0.0004, 0.0005), $p = .78$

Standard errors and standard deviations are in parentheses; ^ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$; All analyses control for education and income

nor was the interaction between gender and substance use significant ($B = 0.48$, $SE = 0.35$, $p = .17$). The direct effect of food insecurity on condom use was significant ($B = -0.043$, CI [-0.069, -0.015], $p < .001$). However, the causal mediation effect of food insecurity on condom use through the interaction of time and substance use within the context of sex was not significant when testing gender as a moderator ($B = 0.00005$, CI [-0.0004, 0.0005], $p = .78$).

Missing Data Sensitivity Analyses

There were a total of 157 survey days in which participants reported having sex but did not finish completing the survey and an additional 4 surveys with other missing baseline data, which were eliminated from the complete case analysis above. We conducted missing data sensitivity analyses to assess whether the results from the mediation presented above hold when incorporating these partially completed surveys (see Supplemental Material). Using multiple imputation for all of the variables in the models yielded 3894 days of data from 796 participants. Replicating the significant mediation model testing the interaction of substance use and time as a mediator of the effect of food insecurity on condom use, the direct effect of food insecurity on condom use was significant in all 5 imputed datasets with estimates ranging from $B = -0.035$ to -0.040 . The causal mediation effect of food insecurity on condom use through substance use within the context of sex was significant 4 out of the 5

times ($p < .05$) with one estimate trending on significance ($p = .06$). Estimates ranged from $B = -0.00021$ to -0.00029 .

Using multiple imputation for all variables with missing data except for the day-level outcome (condom use) yielded data from 770 participants contributing 3733 days. The direct effect of food insecurity on condom use was significant in all five datasets with estimates ranging from $B = -0.040$ to -0.042 . The causal mediation effect of food insecurity on condom use through substance use within the context of sex was also significant in all five datasets with estimates ranging from $B = -0.00027$ to -0.00029 .

Discussion

This study examined the relation between food insecurity and condom use within a multilevel framework, and substance use in the context of sex was tested as a mediator of this association. In the current sample, higher levels of food insecurity were associated with a lower likelihood of condom use on a given day among people living with HIV. Previous research has shown a close relation between food insecurity and sexual risks for HIV in uninfected at-risk populations in the U.S. and worldwide (Justman et al., 2015; Steenkamp, Venter, Walsh, & Dana, 2014; Tsai & Weiser, 2014). The linkage between food insecurity in people living with HIV may stem from similar dynamics and may, therefore, merely reflect the broader context of poverty within the HIV epidemic (Pellowski et al., 2013). Recent qualitative research among people living with HIV finds that food insecurity contributes to transactional and unprotected sex despite safer sex knowledge and desires due to short-term food needs (Whittle et al., 2015). The current results add to the literature establishing a direct link between food insecurity and sexual risk, particularly among those already living with HIV.

Additionally, we found a significant effect of substance use in the context of sex on the rates of change in condom use over time and this interaction between substance use and time was a partial mediator of the relation between food insecurity and condom use. Given that substance use does not fully mediate this relation, it is important to consider both substance use and food insecurity in behavioral HIV secondary prevention. Although there have been several interventions and policy changes that focus on food insecurity and antiretroviral adherence (Aberman, Rawat, Drimie, Claros, & Kadiyala, 2014; Palar et al., 2015) as well as small pilot interventions focused on food insecurity and sexual risk (Zakaras et al., 2016), we are not aware of interventions that explicitly and concurrently focus on food insecurity, substance use, and sexual risk reduction for people living with HIV. Given the mounting evidence for robust relations between all facets of poverty, including food insecurity and substance use, there is compelling evidence for multilevel interventions to address multiple structural problems and individual behaviors simultaneously to address sexual risk behaviors.

Gender was also tested as a moderator of substance use as a mediator on days in which sex occurred. The interaction between

food insecurity and gender was not significant nor was the interaction between substance use and gender leading to the conclusion that, in our sample, gender did not moderate the observed mediation effects. This is directly in contrast to the results of Eaton et al. (2014) who found that in a South African HIV uninfected sample, alcohol use mediated the association between food insecurity and condom use for women but not for men. The findings of Eaton et al. in conjunction with the findings of the current study, which was conducted in the U.S., suggest that culture, socioeconomic status and/or gender power dynamics may all play roles in determining the strength and directionality of the relations between gender, food insecurity, substance use and condom use.

There were several limitations to this study that should be acknowledged. Although the sample size was fairly large, it was largely limited to African-Americans. Additionally, the sample was also mostly male and did not include many adolescents or young adults. Thus, these findings from this sample may not extend to other populations. Additionally, this study was conducted in one large southeastern U.S. city so these associations may not hold for other areas of the U.S. such or other countries.

In addition to sample characteristic limitations, there were also limitations with regard to the analyses. Using the R library “lme4” was necessary to model the mixed-effects logistic regressions; however, this library is limited in its ability to specify a variance-covariance matrix for residual effects. Thus, we were unable to deal with potential problems associated with autocorrelations and/or heteroscedasticity. Finally, only gender was tested as a moderator of the mediation. There are other variables that may moderate this relation such as sexual partners’ HIV status (Jennings et al., 2015; Purcell, Moss, Remien, Woods, & Parsons, 2005). In these analyses, partner type was controlled for but did not seem to impact these findings. Future research should elucidate the conditional effects for which substance use mediates the association between food insecurity and condom use.

This is the first study, to our knowledge, to test the relation between food insecurity and condom use with substance use as a mediator within a multilevel framework. Consistent with cross-sectional and correlational research, we found that higher levels food insecurity predicted a lower likelihood of condom use on a give day and this was partially mediated by substance use in the context of sex. Our findings therefore further support the potential impact of alleviating food insecurity on reducing sexual risks for HIV transmission. Situation-specific alcohol and drug use should also be integrated into interventions that target food insecurity and HIV prevention. For example, although efforts to reduce substance use are given in terms of intervention goals, a harm reduction approach may be of considerable use in this context. Specifically, the role of substance use in relationships should be addressed and directed toward strategies for increasing condom use in the context of alcohol and other drug use. In addition, preparations for condom use such as having condoms readily available and partners agreeing to use condoms in advance of sex may increase their use despite alcohol and other drug use. These and other intervention approaches to increase HIV

transmission risk reduction practices among people living with HIV in poverty should be an HIV prevention priority.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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