Cigarette Smoking among Women Who Are Homeless or Unstably Housed: Examining the Role of Food Insecurity

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Abstract Smoking prevalence remains high among individuals who are homeless, partly due to stressors related to homelessness. Beyond housing insecurity, homelessness involves financial stresses and unmet subsistence needs. In particular, food insecurity contributes to negative health outcomes and other health risks. This study examined associations between food insecurity severity and smoking among homeless and marginally housed women in San Francisco, California. We used data from 247 women from a longitudinal cohort study. Generalized estimating equations were used to estimate longitudinal associations between study factors and smoking based on data from five biannual assessment points between 2009 and 2012. The longitudinal adjusted odds of smoking were higher among severely food insecure individuals compared to those who were not food insecure (AOR = 1.68, 95% CI [1.02, 2.78]), while associations with other study factors, including demographics, time, HIV status, mental health, and substance use (except marijuana use), did not reach levels of significance. Similar adjusted longitudinal results were observed when food insecurity was the dependent variable and smoking an independent variable, suggesting the possibility of a bidirectional association. Considering unmet needs, such as food and hunger, may improve comprehensive smoking cessation strategies targeting individuals for whom mainstream tobacco control efforts have not been effective. Similarly, offering

improved access to smoking cessation resources should be considered in efforts to address food insecurity among individuals experiencing homelessness.

Keywords Homelessness · Cigarette smoking · Women · Food insecurity

Smoking prevalence among homeless individuals is about four times higher than that of the general population, with studies estimating that greater than 70% of persons experiencing homelessness are current smokers [1]. Even among especially high-risk populations, such as women who use crack cocaine, cigarette smoking is more common among those who are homeless compared to those who are not homeless [2]. In parallel, lung cancer is the most common type of cancer and the leading cause of cancer deaths among homeless persons [3]. Addressing tobacco use is one of the critical solutions to reduce cancer and other tobacco-related health disparities in homeless people [3].

Although many homeless individuals who smoke are interested in cessation [4], a number of barriers and competing priorities complicate efforts to quit [5]. In a study assessing smoking characteristics and barriers to cessation among smokers experiencing homelessness, smoking to relieve the stress and anxiety associated with homelessness was the most common barrier to cessation [6]. Stressors of homelessness extend beyond housing insecurity and include many unmet needs associated with overall financial situation [7]. Examining the role of proximal and specific unmet needs can inform targets

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of interventions aimed at more comprehensively reducing disproportionately high tobacco use in homeless populations [8].

Hunger and access to food are key concerns and sources of stress for many homeless individuals [9, 10]. Food insecurity refers to the lack of physical and economic access to adequate and appropriate foods needed to live a healthy life [11]. It is a notable problem that affected 38% of US households in poverty and 13% of all US households in 2015 [12]. Food insecurity is related to poor physical health [13], largely because of its impact on various aspects of dietary intake and nutritional deficits [14]. It is also associated with poor mental health [15, 16], in part due to the anxiety, stress, and worry about food access and adequacy [17, 18]. Approximately 5% of the US general population, and 17% of the population living below poverty, struggles with food insecurity that is considered to be severe [12]. Severe food insecurity refers to not only problems in accessing food but also actual disruptions in eating patterns and reduced food intake due to lack of money and other resources [12].

Severe food insecurity disproportionately affects people experiencing homelessness or unstable housing [10]. For instance, one study of 153 single-room occupancy hotel residents in Chicago reported that 52% were severely food insecure during the past 30 days [10]. Competing demands (e.g. securing housing and income) and logistic barriers (e.g. kitchen and grocery store access) increase susceptibility to experiencing hunger and food shortages [19]. Among homeless individuals, food insecurity has been linked to depression [20] and poor medication adherence [21], and it also predicts acute health care utilization among homeless people living with HIV [22]. Among women, food insecurity has been linked to high-risk survival sex [23, 24].

Population-based studies of lower income individuals have demonstrated that food insecurity is associated with higher smoking prevalence, even after controlling for socioeconomic status and other aspects of poverty [25–27]. Among young adults (aged 18–30) in California who were living in or near poverty, food insecurity was associated with increased odds of daily smoking, suggesting that food insecurity is a psychological stressor that promotes smoking for stress relief and maintains tobacco addiction [27]. Another possible pathway is the role of hunger. Although food insecurity and hunger are not one in the same, food insecurity is an important risk factor for hunger [28]; nicotine's physiologic effects

include appetite and hunger suppression [29]. These pathways remain in need of investigation, but it is possible that cigarettes may be a strategy to psychologically and physiologically cope with food insecurity and its consequences. In turn, smoking itself may contribute to the experience of food insecurity given that the cost of purchasing cigarettes may compete with spending on food. In a cross-national study of smokers, 28% of smokers in the US reported smoking-related deprivation, defined as having spent money on cigarettes that would be better spent on household essentials like food [30].

Research conducted with low-income populations suggests a positive association between food insecurity and smoking. Whether similar associations would be observed in homeless populations is unknown, as individuals experiencing homelessness tend to have disproportionately high prevalence of both food insecurity and cigarette use. An independent association between food insecurity and smoking in this group would provide further evidence for the need to examine the possible underlying pathways or mechanisms. An understanding of these pathways is important, as it has implications for developing and testing strategies to enhance the effectiveness of smoking cessation interventions targeting tobacco use disparity groups who are socioeconomically disadvantaged, with particular emphasis on addressing the role of social determinants on health behaviors.

The current study sought a better understanding of the association between food insecurity and smoking status among homeless and marginally housed women. It augments prior research by recruiting a sample of women rather than being comprised of mostly men [31–33], and rather than considering any food insecurity, it considers the degree of food insecurity experienced. In addition, this study updates concepts of scarcity and how they influence health in an urban setting where gentrification has contributed to the experience of food insecurity among vulnerable populations [23]. We hypothesized stronger population-level associations between smoking and severe forms of food insecurity than mild food insecurity, even after adjusting for substance use and mental health.

Methods

The current study used data from the Shelter, Health, and Drug Outcomes among Women (SHADOW) study, a

cohort study assessing the health and various health risks of homeless and unstably housed women living with and without HIV in San Francisco, California. Details of SHADOW and recruitment procedures are published elsewhere [34, 35]. To summarize here, between 2008 and 2010, a mobile outreach team recruited a probability sample of women from homeless shelters, food assistance programs (free meal programs serving more than 100 meals per day), and a random sample of low-income single-room occupancy hotels. Study eligibility screening took place on designated study recruitment days, in which either all persons present on those days were invited to participate (when recruitment took place at smaller venues), or a subset of persons present was invited to participate (e.g. every third person, when recruitment took place at larger venues). To be eligible, women had to be 18 years of age or older, assigned female sex at birth, and report a history of homelessness or housing instability. Homelessness or housing instability was defined as sleeping in a homeless shelter, in public (e.g. cars, parks, abandoned buildings, or stairwells), or at someone else's place for one or two nights because there was nowhere else to go. To address study aims, HIV-positive women were oversampled (HIV testing occurred during the eligibility screening visit for SHADOW) such that half of recruited participants were HIV-positive. Eligible participants who provided written informed consent were interviewed every six months.

Food insecurity questions were introduced to the SHADOW study on interview questionnaire 3, and the current analysis included interviews 3 through 7 (i.e. the "initial assessment" for food insecurity was SHADOW study visit 3). Data reported here come from a subset of the SHADOW study sample (N of 247 for the current study out of 300 for the entire SHADOW cohort) with available data from interviews 3–7. Data for the current study were collected between 2009 and 2012. All study procedures were approved by the institutional review board at the University of California, San Francisco.

Measures

The dependent variable of the study was current smoking status. Smoking status was assessed by the question "On average, how many cigarettes did you smoke in the past six months?" Response choices included "Don't smoke or didn't smoke in the past six months," "Less than one cigarette per month," "At least one cigarette per month," "At least one cigarette per

week," "At least one cigarette per day," and "At least a pack a day." Response choices were collapsed into "current smoker" vs. "non-smoker" such that individuals who smoked at least one cigarette per month or more were considered current smokers.

The primary independent variable of the study was food insecurity, assessed via the US Adult/Household Food Security Survey Short Form [36]. This is a validated subset of six items from the 18-item Food Security Survey developed by the US Department of Agriculture to monitor national levels of food insecurity [37]. In accordance with survey instructions, two to four affirmative responses were considered to be "mild/moderate food insecurity," whereas five to six affirmative responses were considered "severe food insecurity." One or no affirmative response was considered "no/marginal food insecurity." A sample item is "In the last six months, did you ever eat less than you felt you should because there wasn't enough money to buy food?" with a yes or no response. Kuder-Richardson 20 reliability score at the initial assessment was 0.90.

We adjusted for factors that have been associated with smoking, including mental health and daily alcohol use [38]. We also included substance use, given its high prevalence among smokers experiencing homelessness [39]. Other covariates included age, race, education level, HIV status, and marital status. Mental health was assessed through the mental health component summary derived from the Short Form-12 Health Survey (SF-12) [40]. The SF-12 consists of 12 items covering eight areas of health-related quality of life in reference to the past month. Mental health component scores were computed according to published instructions from survey developers [41]. Scores range from 0 to 100 with higher scores indicating better mental health-related quality of life. Daily alcohol use was assessed by the question "In the past six months, how often did you drink alcohol such as beer, wine, or hard liquor?" Individuals who responded that they drank alcohol "at least once a day" on average were considered daily alcohol users. Greater than one drink per day has been considered at-risk drinking among women who are homeless [42]. Substance use in the past six months assessed any use of marijuana, crack, cocaine, methamphetamine, and heroin.

Data Analysis

Participant characteristics at the initial assessment by smoking status (current smoker vs. non-smoker) were compared using chi-square tests and t tests. To examine

the longitudinal population-level association of food insecurity on smoking status, generalized estimating equations (GEE) using a logit link function, binomial distribution, and robust standard errors were conducted in two stages. Given that study visits were 6 months apart, and factors such as food insecurity were more likely to influence smoking concurrently rather than 6 months later, the dependent and independent variables were not lagged.

In the first stage, we examined univariate associations between food insecurity and smoking status, with adjustment for time. In the second stage, in addition to adjusting for time, we adjusted for participant characteristics (age, education, race, marital status, and HIV status), mental health, and substance use (alcohol and drugs) in a saturated model. Participant characteristics, measured at the initial assessment, were considered fixed effects in the model. Mental health and substance use, measured at each assessment, were considered as time-varying covariates in the model.

In a separate model, we considered bidirectional associations between smoking and food insecurity. While the dependent and independent variables were assessed in the same time period, potentially rendering unadjusted odds of smoking among food insecure persons roughly equivalent to the unadjusted odds of food insecurity among smokers, several possibilities existed that might influence potential differences. For example, it was possible that (1) other study covariates were differentially associated with these variables and (2) levels of each variable changed differentially over time. We therefore used the same analytic techniques to assess whether the adjusted longitudinal odds were the same in saturated models when smoking was included as an independent variable and food insecurity was included as the dependent variable.

Results

A total of 247 women had available data on food insecurity starting at the initial assessment. We conducted a comparison of the full sample from SHADOW ($N = 300$) versus those included in the current analysis, and they did not differ with respect to variables included in the current analysis ($p > 0.05$). Among the 247 participants, sample sizes for the 6-month follow-up visits were 245, 221, 177, and 153, respectively. The sample decreased over time for several reasons,

including an 11% loss to follow-up over 2 years, and recruitment later in the study that did not allow as much time for rescheduled follow-up visits. As shown on Table 1, participant mean age at the initial assessment was 47 years, and nearly two-thirds had attained a high school education. In terms of race/ethnicity, 43.3% were African-American, 30.4% were White, 5.3% were Latina, 2.4% were Asian or Pacific Islander, and 18.6% indicated “other” as their race/ethnicity. While all participants had a history of housing instability, 21.9% reported sleeping in a shelter or public place (street, park, stairwell, car), and 34.8% reported sleeping in someone else’s hotel room or apartment during the 6 months prior to the initial assessment. Consistent with the aims and recruitment strategy of the SHADOW study, 53.0% of women were HIV-positive.

Table 2 displays sample size information at each assessment point by the primary dependent variable (smoking status), primary independent variable (food insecurity), and time-varying covariates (mental health and substance use). We compared participants who completed all study assessments and those who did not (including those who were lost to follow-up), using t tests and chi-square tests. Participants did not differ with respect to smoking status ($p = 0.54$), levels of food insecurity ($p = 0.20$), mental health ($p = 0.44$), and substance use (p ranged from 0.11–0.80), with the exception of heroin use ($p = 0.03$). A greater proportion of participants using heroin (compared to those who did not use heroin) did not complete all study visits.

At the initial assessment, 70.9% of women were current smokers. Of the 175 women considered current smokers in the past 6 months, 92.0% smoked daily and approximately half of daily smokers (52.8%) reported smoking at least a pack (20+ cigarettes) a day. Smoking status did not change significantly over the study period ($p = 0.39$). Table 1 displays participant characteristics at the initial assessment by smoking status.

In terms of food insecurity at the initial assessment, 59.5% of study participants reported any food insecurity and 37.7% reported severe food insecurity during the past 6 months. Smokers reported higher levels of food insecurity than non-smokers, with 42.3% of smokers experiencing severe food insecurity compared to 26.4% of non-smokers ($p = 0.02$). Food insecurity status did not change significantly over the study period ($p = 0.72$). The association between food insecurity and smoking status stayed relatively consistent across each study assessment (Fig. 1).

Table 1 Participant characteristics at the initial assessment by smoking status

	Total (<i>N</i> = 247)	Smokers (<i>n</i> = 175)	Non-smokers (<i>n</i> = 72)	<i>p</i>
%	100.0	70.9	29.1	
Age, <i>M</i> (SD)	47.4 (8.5)	46.5 (8.5)	49.6 (7.9)	0.01
Race/ethnicity, <i>n</i> (%)				0.96
Asian/Pacific Islander	6 (2.3)	4 (2.3)	2 (2.8)	
Black/African-American	107 (41.3)	77 (44.0)	30 (41.7)	
Latina/Hispanic	13 (5.0)	10 (5.7)	3 (4.2)	
Multiracial/other	46 (17.8)	33 (18.9)	13 (18.1)	
White	75 (30.4)	51 (29.1)	24 (33.3)	
Recent homelessness (past 6 months), <i>n</i> (%)	54 (21.9)	40 (22.9)	14 (19.4)	0.55
Graduated high school, <i>n</i> (%)	161 (65.2)	109 (62.3)	52 (72.2)	0.14
Married, <i>n</i> (%)	38 (15.4)	28 (16.0)	10 (13.9)	0.68
HIV-positive, <i>n</i> (%)	131 (53.0)	93 (53.1)	38 (52.8)	0.96
Sexual orientation, identifies as non-heterosexual, <i>n</i> (%)	59 (23.9)	44 (25.1)	15 (20.8)	0.52
Mental health score, SF-12, <i>M</i> (SD)	41.8 (12.3)	41.1 (11.9)	43.5 (13.1)	0.18
Substance use, <i>n</i> (%)				
Daily alcohol use	60 (24.3)	47 (26.9)	13 (18.1)	0.14
Marijuana	118 (47.8)	88 (50.3)	30 (41.7)	0.22
Crack	97 (39.3)	87 (49.7)	10 (13.9)	<0.01
Cocaine	17 (6.9)	11 (6.3)	6 (8.3)	0.56
Methamphetamine	38 (15.4)	31 (17.7)	7 (9.7)	0.11
Heroin	39 (15.8)	34 (19.4)	5 (6.9)	0.01
Food insecurity score, <i>M</i> (SD)	2.9 (2.5)	3.1 (2.5)	2.3 (2.3)	0.03
Any food insecurity ^a , <i>n</i> (%)	147 (59.5)	110 (62.9)	37 (51.4)	0.10
Severe food insecurity, <i>n</i> (%)	93 (37.7)	74 (42.3)	19 (26.4)	0.02

P values derived from *t* tests and chi-square tests

^a Includes participants with severe food insecurity

The univariate GEE analysis showed that, on average, homeless and unstably housed women experiencing severe food insecurity had twice the odds of being a current smoker compared to those experiencing no/marginal food insecurity (odds ratio [OR] = 2.00, 95% CI [1.24, 3.25]); however, the odds of being a current smoker among women experiencing mild/moderate food insecurity were not significantly different from those with no/marginal food insecurity (Table 3). Marijuana use was also significantly associated with smoking in unadjusted analysis. In the adjusted model, the population average for severe food insecurity remained significant (adjusted odds ratio [AOR] = 1.68, 95% CI [1.02, 2.78]).

In analyses examining a reciprocal association, smoking was longitudinally associated with increased odds of severe food insecurity (unadjusted OR = 1.90,

95% CI [1.25, 2.90], AOR = 1.68, 95% CI [1.08, 2.61]). In the adjusted model, worse mental health (AOR = 0.94, 95% CI [0.93, 0.96]) and heroin use (AOR = 2.80, 95% CI [1.47, 5.33]) were also significantly associated with increased odds of experiencing severe food insecurity. No other variables were significant in the adjusted model.

Discussion

Among homeless and unstably housed women, one of the most impoverished groups with disproportionately high smoking prevalence (70.9%), this study found that severe food insecurity is associated with increased longitudinal odds of smoking. The findings extend results of prior studies showing a cross-sectional association between

Table 2 Selected characteristics of study sample and retention information across five assessments

	Initial assessment	6-month follow-up	12-month follow-up	18-month follow-up	24-month follow-up
Sample size	247	245	221	177	153
% Retention, in reference to prior assessment	—	99.2	90.2	80.1	86.4
Dependent variable, <i>n</i> (%)					
Current smoker	175 (70.9)	172 (70.2)	153 (69.2)	115 (65.0)	105 (68.6)
Daily smoker	161 (92.0)	158 (91.9)	140 (91.5)	101 (87.8)	95 (90.5)
Non-daily smoker	14 (8.0)	14 (8.1)	13 (8.5)	14 (12.2)	10 (9.5)
Non-smoker	72 (29.1)	73 (29.8)	68 (30.8)	62 (35.0)	48 (31.4)
Primary independent variable ^a , <i>n</i> (%)					
No/marginal food insecurity	100 (40.5)	96 (39.2)	93 (42.1)	77 (43.5)	68 (44.4)
Mild/moderate food insecurity	54 (21.9)	60 (24.5)	47 (21.3)	38 (21.5)	26 (17.0)
Severe food insecurity	93 (37.7)	89 (36.3)	81 (36.7)	62 (35.0)	59 (38.6)
Time-varying covariates					
Substance use, <i>n</i> (%)					
Daily alcohol use	60 (24.3)	50 (20.4)	38 (17.2)	27 (15.3)	35 (22.9)
Marijuana use	118 (47.8)	121 (49.4)	105 (47.5)	87 (49.2)	80 (52.3)
Crack use	97 (39.3)	99 (40.4)	89 (40.3)	67 (37.9)	58 (37.9)
Cocaine use	17 (6.9)	20 (8.2)	19 (8.6)	11 (6.2)	10 (6.5)
Methamphetamine use	38 (15.4)	39 (15.9)	33 (14.9)	24 (13.6)	18 (11.8)
Heroin use	39 (15.8)	23 (9.4)	22 (10.0)	16 (9.0)	12 (7.8)
SF-12 Mental Health Component Score, <i>M</i> (SD)	41.8 (12.3)	42.5 (12.7)	43.4 (12.1)	42.6 (12.0)	42.8 (11.3)

^a Percentages may add up to more than 100% due to rounding

food insecurity and cigarette use [27], as this association persisted across the 2-year study period and adjusted for

within-individual correlation through GEE modeling. In addition, this association was consistent over time with

Fig. 1 Food insecurity score by smoking status by time

Table 3 Population-level associations between smoking and study factors

Variable	Unadjusted OR ^a [95% CI]	Adjusted OR ^b [95% CI]
Primary independent variable		
Food insecurity status		
No/marginal food insecurity	Referent	Referent
Mild/moderate food insecurity	1.17 [0.75, 1.85]	1.05 [0.66, 1.65]
Severe food insecurity	2.00* [1.24, 3.25]	1.68* [1.02, 2.78]
Covariates measured at initial assessment		
HIV status		
HIV-positive	0.82 [0.53, 1.35]	0.84 [0.50, 1.42]
HIV-negative	Referent	Referent
Marital status		
Married	0.94 [0.49, 1.79]	1.01 [0.52, 1.97]
Not married	Referent	Referent
Education level		
Graduated high school	0.88 [0.53, 1.47]	0.92 [0.52, 1.60]
Did not graduate high school	Referent	Referent
Race		
White	0.91 [0.52, 1.59]	0.86 [0.48, 1.54]
Non-White	Referent	Referent
Age	0.97 [0.94, 1.00]	0.98 [0.95, 1.01]
Time-varying covariates		
Mental health component score	0.99 [0.97, 1.01]	0.99 [0.98, 1.02]
Substance use		
Daily alcohol use		
≥1 drink per day	1.17 [0.78, 2.03]	1.06 [0.61, 1.85]
<1 drink per day	Referent	Referent
Marijuana use ^c	1.91* [1.19, 3.06]	1.84* [1.12, 3.01]
Cocaine use ^c	1.05 [0.51, 2.15]	0.61 [0.30, 1.24]
Methamphetamine use ^c	1.73 [0.88, 3.40]	1.16 [0.53, 2.56]
Heroin use ^c	1.72 [0.82, 3.60]	1.26 [0.60, 2.68]
Time		
Initial assessment		Referent
6-month follow-up		0.98 [0.79, 1.22]
12-month follow-up		0.99 [0.78, 1.25]
18-month follow-up		0.78 [0.59, 1.05]
24-month follow-up		0.90 [0.65, 1.25]

OR odds ratios, CI confidence interval

*Significance at $p < 0.05$

^a Unadjusted OR computed with assessment time points controlled in the generalized estimating equation model for the corresponding variable without adjusting for other covariates

^b Adjusted OR for multivariable model computed with the independent variables shown in the table

^c Referent category is no use in past 6 months

little variation in either food insecurity or smoking over the study period (Table 2 and Fig. 1). While smoking

cessation is greatly complicated by numerous competing risks among homeless individuals, multiple studies have

demonstrated that the high prevalence of cigarette smoking among homeless persons is not due to lack of motivation to quit [4, 32]. Homeless individuals make quit attempts at rates similar to the general population, but they are much less likely to succeed [43]. Considered in combination with results presented here, alleviation of severe food insecurity may have the potential to reduce the disparity in failed quit attempts between homeless and unstably housed persons and those who are housed, or enhance the effectiveness of treatment or cessation efforts.

Although there was no significant difference between smoking and non-smoking women in terms of the prevalence of any food insecurity, there was a significant difference when considering the severity of food insecurity. In this study, nearly half (42%) of smoking women and a quarter (26%) of non-smoking women experienced severe food insecurity at the initial assessment. Among individuals living below 100% of poverty, the national prevalence of severe food insecurity was about 19% in 2009 (i.e. around the time of the initial assessment for this study) [11]. Moreover, the analyses showed that severe food insecurity was the major factor significantly associated with smoking in this population. Demographic factors previously found to predict smoking in the general population, such as age and race [44], were not significantly associated with smoking in this study. Substance use, with the exception of marijuana use, and mental health were also not associated with smoking. As there was no change over time in terms of food insecurity severity and its association with smoking (Fig. 1), the findings suggest that without intervention efforts directly targeting the alleviation of severe food insecurity among homeless individuals who smoke, tobacco-related health disparities are likely to persist.

It is possible that the persistent stress from experiencing severe and chronic food insecurity is a pathway that contributes to continued smoking over time, in part by undermining smokers' efforts to quit. Although the current study did not assess quit attempts and motivation to quit, a previous investigation examining smoking cessation behaviors among current smokers experiencing homelessness found that nearly half (44%) of participants reported making a quit attempt during a 6-month period. Results from an ecological momentary assessment study of 57 homeless smokers seeking cessation treatment reported that experiencing reductions in stress and negative affect prior to the quit date were associated

with smoking abstinence [32]. In the current study, although we examined overall mental health status, we were unable to assess specifically for stress. The extent to which stress, particularly the stress from experiencing severe food insecurity, contributes to continued smoking is an area for future investigation.

Another possible explanation of our findings is that severe food insecurity contributes to the physiologic experience of hunger, and cigarettes offer the immediate effect of suppressing appetite [29]. Controlled laboratory studies have shown a direct association between smoking and eating patterns, such that smoking participants used cigarettes to refrain from eating [45], and the ability to resist smoking was reduced when daily smoking participants were deprived of food for 12 h [46]. The extent to which these findings from laboratory studies translate to real-world situations among smokers experiencing severe food insecurity and other conditions of impoverishment are not yet known, but it raises the possible role of hunger in the pathway between food insecurity and cigarette use.

While data were not lagged for this investigation, limiting our ability to make causal inferences, we did find evidence of a longitudinal bidirectional association. Results showing that smoking is significantly associated with the continued experience of severe food insecurity are consistent with prior research among HIV-positive homeless adults [47]. This may point to the important role of cigarette addiction and nicotine dependence in competing with spending towards food and other subsistence needs [30], particularly given the high proportion of women in this study who reported smoking more than a pack a day on average. Furthermore, prior research has shown that smokers with lower income tend to be less affected by price increases in cigarettes than higher income counterparts in terms of reducing cigarette consumption [48]. Continuing to smoke despite rising cigarette prices can place a disproportionate economic burden that may exacerbate the experience of food insecurity, as well as illustrate the potential tradeoffs that smokers who are impoverished may face when resources are limited. It is also possible that cigarettes may be more readily available than food under extenuating circumstances, particularly given the relatively common practices of sharing cigarettes and smoking discarded butts among homeless persons [6]. The extent to which cigarettes are used to curb appetite, avoid withdrawal, and reduce stress among smokers who are food insecure remains to be further

investigated. An interesting research question that arose from our findings regarding the bidirectional association is whether or not increasing access to evidence-based smoking cessation resources to assist homeless smokers in quitting may have an effect on reducing severe food insecurity. Overall, our findings draw attention to the complexity by which food insecurity and smoking are related, and we have outlined several areas to be examined in future investigations.

Several limitations should be considered when interpreting results presented here. Participant attrition reduced the sample size of 247 at the initial assessment to 153 at the 24-month follow-up, although participant retention across each 6-month follow-up assessment was relatively high at 80–99%. Nevertheless, we believe that these longitudinal findings are important in light of the challenges of retaining participants in longitudinal studies, especially vulnerable populations experiencing unstable housing. The measure of smoking status captured average cigarette use over the past 6 months, assessed via participant self-report, and we did not have data on more granular levels of cigarette use or levels of nicotine dependence. In terms of patterns of smoking, a previous study found that past-year food insecurity was associated with increased odds of daily smoking among low-income young adults [27]. The extent to which the severity of food insecurity corresponds to patterns of smoking in an impoverished population remains an area for future investigation, in light of the possibility that when individuals are experiencing severe food insecurity, the financial and other resource burden of smoking every day may be particularly difficult. Another limitation is that we did not assess types of tobacco use outside of cigarette use. However, cigarette use still remains the most prevalent form of tobacco use, and one that largely contributes to socioeconomic disparities in health [49]. Lastly, our sample was drawn from homeless women from one US city, and we oversampled for HIV-positive persons. These factors may limit the generalizability of the study findings. These limitations outline areas for possible future investigation.

Conclusion

Tobacco-related diseases disproportionately impact population groups that are impoverished, such as individuals who are homeless or marginally housed [50].

This study found that factors associated with smoking in the general population, such as age and race, were not significantly associated with smoking among homeless and unstably housed women; however, severe food insecurity was strongly associated, and this effect persisted over time. We emphasize that food insecurity is a modifiable social determinant of health and mental health. These findings highlight the need to consider the role of unmet needs, such as food insecurity, to comprehensively and effectively develop smoking cessation strategies targeting individuals for whom mainstream tobacco control efforts have not been effective. Moreover, investigating whether successfully promoting smoking cessation among persons who are impoverished can reduce the severity of food insecurity deserves further research.

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