# Psychological distress and cigarette smoking among U.S. households by income: Considering the role of food insecurity

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ABSTRACT

Psychological distress and tobacco use are known to co-occur for many reasons, including vulnerabilities associated with socioeconomic disadvantage. Food insecurity—a stressful condition due to inconsistent food access—is linked with increased psychological distress and is also an independent risk factor for smoking. We investigated the association between psychological distress and cigarette smoking, examining distress occurring with or without food insecurity, and variations in the associations by socioeconomic status. We analyzed data from the 2015 U.S. Panel Study of Income Dynamics ($n$ = 9048). A four-category variable was constructed based on responses to validated measures of psychological distress and of food insecurity: no distress and no food insecurity; food insecurity without distress; distress without food insecurity; and distress with food insecurity. Weighted, robust Poisson regression analysis examined associations with current smoking, with analyses stratified by socioeconomic status. Smoking prevalence was highest among respondents experiencing psychological distress with food insecurity (39%). Results showed that respondents with food insecurity alone had higher smoking prevalence (33%) than respondents with psychological distress alone (20%). Only among respondents above poverty, psychological distress without food insecurity was significantly associated with current smoking (prevalence ratio = 1.44; 95% CI [1.25, 1.65]). For respondents at/below poverty, psychological distress without food insecurity was not significantly associated with current smoking. Further examining how socioeconomic stressors, such as food insecurity, intersect with psychological distress is needed to address continued socioeconomic disparities in cigarette smoking and develop effective population-based interventions.

## 1. Introduction

Individuals with mental health problems smoke cigarettes at significantly higher rates than the general population (McClave et al., 2010), and are estimated to consume nearly half (44%) of cigarettes smoked in the U.S. (Lasser et al., 2000) Despite significant declines in smoking prevalence over the previous decades, people with mental health problems have had much smaller declines in smoking over the years (Lawrence and Williams, 2016). Data from the 2017 National Health Interview Survey showed that smoking prevalence among adults with serious psychological distress—an indicator of probable mental illness (Kessler et al., 2002)—was 35%, compared to 13% smoking prevalence among adults without serious psychological distress (Wang et al., 2018). Cigarette smoking remains a leading preventable cause of disease and death (U.S. Department of Health and Human Services,

2014), accounting for nearly one-third of all cancer deaths and one-third of deaths from cardiovascular disease in the U.S. (U.S. Department of Health and Human Services, 2014; Lortet-Tieulent et al., 2016) It is clear that currently existing tobacco control efforts have not been uniformly effective, and greater attention must be paid to curb growing tobacco-related health disparities.

Smoking and psychological distress are known to co-occur (Hagman et al., 2008), although the directionality, temporality, and mechanisms linking smoking and psychological distress are less clear and remain important areas of research. There are numerous potential explanations for the co-occurrence. Both smoking and psychological distress share risk factors associated with socioeconomic disadvantage. It is widely known that smoking prevalence is disproportionately high among individuals with lower socioeconomic status (Jamal et al., 2018). Within the framework of social determinants of health behaviors, it is

understood that many aspects of lower socioeconomic status—for example, neighborhood-level poverty (Cambron et al., 2019) and being in a working class occupation (Barbeau et al., 2004)—place individuals at higher risk for smoking and encountering more difficulties with quitting (Hiscock et al., 2012). Socioeconomic disadvantage and financial strain are also associated with increased prevalence of mental health problems (Isaacs et al., 2018). Studies find that the prevalence of serious psychological distress is greater among those with lower socioeconomic status, as measured by variables such as education and income, compared to counterparts with higher socioeconomic status (Isaacs et al., 2018; Sung et al., 2011). In a study of daily smokers, psychological distress was greater among lower-income than higher-income smokers, and only among lower-income smokers was there an association between psychological distress and nicotine dependence (Hobkirk et al., 2018). Taken together, socioeconomic disadvantage is interconnected with smoking and with psychological distress; identifying more specific aspects of socioeconomic stress that is related to smoking may inform tobacco control efforts aimed at cigarette use disparity groups.

Food insecurity is one particularly prominent socioeconomic stressor that has gained considerable attention over the previous decade, particularly since the 2008 economic recession. Food insecurity occurs when access to adequate food to live an active and healthy life is limited by a lack of money or other resources (Coleman-Jensen et al., 2018). Approximately 12% of U.S. households were affected by food insecurity in 2017 (Coleman-Jensen et al., 2018), with a disproportionate impact on individuals and households with lower income. In 2017, 37% of U.S. households living below the federal poverty level (FPL) experienced food insecurity, compared to 6% of households living at or above 185% of FPL (Coleman-Jensen et al., 2018). The adverse health outcomes that are uniquely associated with food insecurity have been well described (Gundersen and Ziliak, 2015) yet remains a key public health challenge.

A growing body of literature has identified significant associations between food insecurity and tobacco use, particularly cigarette smoking, with associations that are independent of demographic factors, socioeconomic variables such as income and education, and mental health variables including psychological distress (Kim and Tsoh, 2016; Hosler and Michaels, 2017; Castro et al., 2015; Sreeramareddy and Ramakrishnareddy, 2017). The relationship is hypothesized to be bidirectional and mutually reinforcing, such that spending on cigarettes worsens food insecurity, yet the psychological stress associated with food insecurity, as well as the physical feelings of hunger that occurs when food insecurity is particularly severe, may promote smoking and impede efforts at cessation. Data from the National Health Interview Survey (from years 2000, 2005, 2010, and 2015) showed that in 2015, the majority of ever smokers—nearly two-thirds—had quit smoking (Babb et al., 2017). Yet a population-based longitudinal study following smokers in 2003 and in 2015 reported that smokers who were food insecure had significantly lower odds of stopping smoking by 2015, as compared to smokers without food insecurity, and this effect was independent of poverty (Kim-Mozeleski et al., 2019).

Experiencing food insecurity is highly stressful, and previous findings have reported that food insecurity is associated with psychological distress (Allen et al., 2017), depressive symptoms (Leung et al., 2015), and overall poorer mental health (Jones, 2017). It is plausible that the association between psychological distress and smoking is in part driven by socioeconomic stressors, such as food insecurity. One study examining a representative sample of lower-income ever smokers found that 36% of current smokers reported both psychological distress and food insecurity (Kim-Mozeleski and Tsoh, 2019). Specifically this co-occurrence was associated with significantly lower odds of having quit smoking, whereas psychological distress in and of itself, without food insecurity, was not associated. Building on evidence suggesting differential associations with smoking when psychological distress occurs in the presence or absence of food insecurity, it is not yet known how this applies to the general population, beyond those who have ever smoked,

and whether there are variations by socioeconomic status.

The current study sought to examine psychological distress in association with smoking, particularly when it co-occurs alongside a known and prominent socioeconomic stressor—food insecurity. To build on previous research, this study examined a broader sample of the population including smokers and non-smokers, as well as those above and below federal poverty guidelines, to yield population-based estimates of smoking prevalence by psychological distress with and without food insecurity. The analyses were stratified by the federal poverty level to examine whether psychological distress and food insecurity have differential associations with smoking across socioeconomic status groups. The analyses would allow further understanding of the determinants associated with higher smoking prevalence observed among those living in poverty. Importantly, we sought to bring together multiple areas of research, by examining smoking and psychological distress, smoking and food insecurity, and smoking and socioeconomic status, through an understanding that these factors are complexly interconnected with one another.

## 2. Methods

### 2.1. Data source and sampling

Data for this study came from the Panel Study of Income Dynamics (PSID), which is a biennial longitudinal survey of U.S. households and individuals residing in those households (Panel Study of Income Dynamics, Public Use Data Set, 2017). PSID assesses a host of demographic, socioeconomic, and health-related factors of the general population, including lower-income population groups, using a sampling methodology that collects detailed information from and about individual heads of households as well as information about other household members. Detailed information on the PSID and the publicly available data can be found online at https://psidonline.isr.umich.edu.

The current study used de-identified and publicly available cross-sectional data from the 2015 survey year of PSID, which included responses from 9048 households. This study stratified households according to whether respondent households were living at or below 100% of the federal poverty level (FPL) or above 100% FPL. FPL is set annually by the U.S. Department of Health and Human Services, and is used to determine eligibility for various federal and state services and programs. To determine poverty status, household income was assessed against the poverty threshold for the corresponding year, taking into account family size and composition. Although poverty thresholds such as 185% or 200% are commonly used in studies to classify lower income, the current study used 100% based on national figures showing that food insecurity prevalence is particularly prominent among individuals below 100% of FPL, compared to 185% (Coleman-Jensen et al., 2018). This secondary analysis study was exempted by the University of Massachusetts Amherst Institutional Review Board.

### 2.2. Measures

The dependent variable was current smoking status. Head-of-household respondents self-reported their current smoking status in a yes/no format to the question "Do you smoke cigarettes?" Those who answered "yes" were asked about the average number of cigarettes per day usually smoked, and age when first began smoking regularly. Those who answered "no" were asked about whether one has ever smoked. Among current smokers, we calculated number of years smoked regularly by taking the difference between current age and age when first began smoking regularly.

Food insecurity was assessed using the U.S. Department of Agriculture's 10-item Household Food Security Survey Module, assessing food insecurity in reference to the past year (Bickel et al., 2000). The survey module is administered in a 3-stage design such that individuals who answer affirmatively to initial screening questions (such

as "The food that I bought just didn't last and I didn't have money to get more," answered as often true, sometimes true, or never true) are asked subsequent questions that reflect increasing severity of food insecurity (such as "In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?" answered as yes/no). Following standard scoring instructions, responses were dichotomized as any food insecurity (3 or more affirmative responses) or no food insecurity (0–2 affirmative responses).

Psychological distress for the head-of-household was assessed using the 6-item Kessler Psychological Distress Scale (K6), assessing non-specific psychological distress symptoms such as hopelessness and worthlessness experienced in the past 30 days (Kessler et al., 2002). Responses were dichotomized as any psychological distress (K6 scores of 5+, which includes moderate to serious distress) and no psychological distress (K6 scores of 0–4, which includes no or mild distress) (Prochaska et al., 2012).

The primary independent variable—psychological distress and food insecurity—was created by combining the dichotomous responses to recent psychological distress and to past-year food insecurity. We grouped responses into four categories, similar to previous research (Kim-Mozeleski and Tsoh, 2019): no psychological distress and no food insecurity (referent group), food insecurity without psychological distress, psychological distress without food insecurity, and psychological distress with food insecurity.

Covariates were initially identified on the basis of prior research on the topic of food insecurity and cigarette use (Kim-Mozeleski et al., 2019). Demographic characteristics of the head-of-household respondent included sex (female or male), age (18–39 years, 40–54 years, or 55 years and older), race/ethnicity (Black/African American, non-Hispanic White, or other race/ethnicity), highest education level (< 12 years, 12 years, or 13 or more years), marital status (currently married or not married), and employment status (currently working or not working). We also included any past-year use of alcohol (yes or no), which has been associated with higher smoking prevalence (Higgins et al., 2016).

### 2.3. Analysis

Weighted descriptive statistics were used to describe overall sample characteristics and compare characteristics by socioeconomic status. We examined smoking prevalence by psychological distress and food insecurity categories, also stratified by socioeconomic status. For categorical variables, $p$-values were derived using chi-square tests that accounted for the survey design, and for continuous variables, Wald tests were used.

We conducted Poisson regression analyses with robust variance to examine whether categories of psychological distress and food insecurity were associated with current smoking (versus non-smoking). We controlled for demographic characteristics and covariates listed above, included in the multivariable model on the basis of significant bivariate associations ($p < 0.05$). We conducted the analysis for the full sample, followed by stratification by poverty status to examine whether there were differential associations by socioeconomic status. Analyses were conducted in Stata Version 15.1 using the *svy* command that accounted for the complex survey design and weighting in deriving estimates. In instances where there were missing responses (i.e., education and psychological distress variables), we noted the raw sample sizes on which the analysis was based.

## 3. Results

### 3.1. Sample characteristics

Table 1 displays overall sample characteristics for the head of household in this representative sample of 9048 U.S. households in 2015, and characteristics stratified by 100% FPL. Overall, 11.6% (95%

CI [9.7, 13.5], $n = 1485$) of households were considered to be at/below poverty, and 88.4% (95% CI [86.5, 90.3], $n = 7563$) were above poverty. All characteristics included in this study as listed on Table 1 differed significantly by poverty status at $p < 0.001$. Households living at/below poverty tended to be more evenly distributed in terms of head-of-household's sex, and a greater proportion were younger than those living above poverty. There was also a larger proportion of Black/African American respondents who were at/below poverty, and respondents at/below poverty generally had lower levels of education and higher levels of unemployment at the time of assessment.

In terms of psychological distress and food insecurity categories (Table 1), over two-thirds (68%) of the overall sample reported no recent psychological distress and no food insecurity in the past year. This differed significantly by poverty status, with 72% of those above poverty reporting no psychological distress and no food insecurity, compared to only 40% of those at/below poverty at $p < 0.001$. Similarly, a significantly larger proportion of respondents at/below poverty reported that they experienced psychological distress with food insecurity compared to those above poverty (28% vs. 7%, respectively), and food insecurity without psychological distress (15% vs. 6%, respectively). The prevalence of psychological distress without food insecurity was similar in both groups, at approximately 16%.

### 3.2. Current smoking prevalence

Table 2 displays estimates of current smoking prevalence, mean cigarettes per day, and mean number of years smoked regularly. Smoking prevalence among all heads of households was 17%, and this varied significantly by poverty status, with 32% among those at/below poverty, versus 15% among counterparts above poverty. Among current smokers, the average number of cigarettes per day was 12.4, and this differed significantly by socioeconomic status. Smokers above poverty reported 12.7 cigarettes per day, compared to 11.0 cigarettes per day among smokers at/below poverty ($p = 0.008$).

Table 2 also displays smoking prevalence estimates and 95% confidence intervals by psychological distress and food insecurity categories. For the overall sample, smoking prevalence was three times as high among respondents reporting psychological distress with food insecurity (39%) compared to counterparts reporting neither psychological distress nor food insecurity (13%). When considering those who reported one or the other but not both, smoking prevalence was higher when there was food insecurity alone (without psychological distress; 33%) compared to when there was psychological distress alone (without food insecurity; 20%). When examining smoking prevalence stratified by poverty status, the above pattern generally held. However, specifically among respondents at/below poverty, smoking prevalence was nearly as high among those reporting food insecurity only (41%) compared to those reporting both psychological distress and food insecurity (43%).

### 3.3. Factors associated with current smoking

Table 3 displays results from Poisson regression analyses examining factors associated with current smoking versus non-smoking. Adjusted prevalence ratios and corresponding 95% confidence intervals are summarized for the overall sample and by socioeconomic status stratification. For respondents above poverty, psychological distress with food insecurity was significantly associated with current smoking (adjusted prevalence ratio [adj PR] = 2.04), in reference to no psychological distress and no food insecurity. Food insecurity without psychological distress was also significantly associated with current smoking (adj PR = 1.79), as was psychological distress without food insecurity (adj PR = 1.44), in reference to no psychological distress and no food insecurity.

For respondents at/below poverty, similar to respondents above poverty, psychological distress with food insecurity was significantly

**Table 1**
Characteristics of head-of-household respondents, stratified by household poverty status: 2015 Panel Study of Income Dynamics.

| Characteristics | Total, N = 9048 | At/below poverty (≤ 100% FPL), n = 1485 | Above poverty (> 100% FPL), n = 7563 | P value |
|---|---|---|---|---|
| | % (95% CI) | % (95% CI) | % (95% CI) | |
| Sex | | | | < 0.001 |
| Female | 30.4 (28.6, 32.2) | 50.6 (46.3, 55.0) | 27.8 (26.0, 29.5) | |
| Male | 69.6 (67.8, 71.4) | 49.4 (45.0, 53.7) | 72.2 (70.5, 74.0) | |
| Age | | | | < 0.001 |
| 18–39 years | 30.1 (28.5, 31.6) | 41.0 (36.0, 46.0) | 28.6 (27.2, 30.0) | |
| 40–54 years | 27.3 (26.2, 28.3) | 24.7 (20.4, 28.9) | 27.6 (26.6, 28.6) | |
| 55 and older | 42.7 (41.1, 44.2) | 34.4 (29.4, 39.3) | 43.8 (42.2, 45.3) | |
| Race/ethnicity | | | | < 0.001 |
| Black/African American | 13.9 (10.9, 16.9) | 30.2 (23.9, 36.5) | 11.8 (9.1, 14.4) | |
| White, non-Hispanic | 79.3 (76.1, 82.6) | 61.1 (54.8, 67.4) | 81.7 (78.7, 84.7) | |
| Another race/ethnicity | 6.7 (5.5, 8.0) | 8.7 (6.0, 11.4) | 6.5 (5.3, 7.7) | |
| Education level[a] | | | | < 0.001 |
| < 12 years | 13.4 (11.8, 15.0) | 31.1 (26.8, 35.4) | 11.1 (9.7, 12.4) | |
| 12 years | 26.9 (24.8, 29.0) | 33.5 (29.8, 37.2) | 26.1 (23.8, 28.3) | |
| 13 or more years | 59.7 (57.0, 62.3) | 35.3 (30.7, 40.0) | 62.9 (60.3, 65.4) | |
| Marital status | | | | < 0.001 |
| Married | 45.5 (43.6, 47.4) | 16.1 (12.4, 19.8) | 49.4 (47.6, 51.2) | |
| Not married | 55.5 (52.6, 56.4) | 83.9 (80.2, 87.6) | 50.6 (48.8, 52.4) | |
| Employment status | | | | < 0.001 |
| Working now | 64.5 (62.7, 66.3) | 35.4 (31.7, 39.2) | 68.3 (66.4, 70.2) | |
| Unemployed, looking for work | 4.5 (3.8, 5.2) | 17.3 (14.2, 20.5) | 2.8 (2.3, 3.3) | |
| Retired | 22.1 (20.6, 23.5) | 16.2 (12.9, 19.6) | 22.9 (21.4, 24.4) | |
| Other | 9.0 (7.9, 10.0) | 31.0 (26.5, 35.5) | 6.0 (5.1, 7.0) | |
| Alcohol use, past year | | | | < 0.001 |
| No | 33.0 (31.2, 34.8) | 52.7 (48.5, 56.9) | 30.4 (28.5, 32.3) | |
| Yes | 67.0 (65.2, 68.8) | 47.3 (43.1, 51.5) | 69.6 (67.7, 71.5) | |
| Psychological distress[b] | | | | < 0.001 |
| None or mild | 75.1 (73.5, 76.6) | 55.4 (51.3, 59.6) | 77.6 (76.0, 79.1) | |
| Moderate or severe | 24.9 (23.4, 26.5) | 44.6 (40.4, 48.7) | 22.4 (20.8, 24.0) | |
| Food insecurity | | | | < 0.001 |
| Food secure (high or marginal food security) | 84.0 (82.4, 85.7) | 57.1 (52.9, 61.2) | 87.6 (86.2, 89.0) | |
| Food insecure (low or very low food security) | 16.0 (14.3, 17.6) | 42.9 (38.8, 47.1) | 12.4 (11.0, 13.8) | |
| Psychological distress[b] and food insecurity categories | | | | < 0.001 |
| No psychological distress and no food insecurity | 68.1 (66.1, 70.1) | 40.1 (35.9, 44.2) | 71.7 (69.8, 73.6) | |
| Food insecurity without psychological distress | 7.0 (6.0, 7.9) | 15.4 (12.2, 18.6) | 5.8 (5.1, 6.6) | |
| Psychological distress without food insecurity | 15.9 (14.8, 16.9) | 16.1 (12.9, 19.4) | 15.8 (14.7, 16.9) | |
| Psychological distress with food insecurity | 9.1 (8.0, 10.2) | 28.4 (25.3, 31.6) | 6.6 (5.6, 7.6) | |

Note. *P* values were derived from chi-square tests. FPL = federal poverty level; CI = confidence interval.
[a] Education level is based on *n* of 8923 due to missing or non-responses.
[b] Psychological distress is based on *n* of 8876 due to missing or non-responses.

associated with current smoking (adj PR = 1.82), in reference to no psychological distress and no food insecurity. Food insecurity without psychological distress was also significantly associated with current smoking (adj PR = 1.73). However, psychological distress alone (i.e., psychological distress without food insecurity) had no significant association with current smoking among respondents at/below poverty.

## 4. Discussion

This investigation contributes to the literature on the link between psychological distress and smoking by considering the role of food insecurity, an important socioeconomic stressor that previous studies have shown is associated with psychological distress and with smoking. We found that over one in four (28%) head-of-household respondents living at/below the federal poverty level reported experiencing

**Table 2**
Current smoking prevalence by categories of psychological distress and food insecurity stratified by household poverty status: 2015 Panel Study of Income Dynamics.

| Characteristics | Total | At/below poverty (≤ 100% FPL) | Above poverty (> 100% FPL) | P value |
|---|---|---|---|---|
| | % or mean (95% CI) | % or mean (95% CI) | % or mean (95% CI) | |
| Smoking prevalence, % | 17.3 (13.3, 21.4) | 31.6 (21.2, 42.0) | 15.4 (12.4, 18.5) | < 0.001 |
| Cigarettes per day, M | 12.4 (11.6, 13.2) | 11.0 (9.8, 12.3) | 12.7 (11.9, 13.6) | 0.008 |
| Number of years smoked regularly, M | 27.6 (26.6, 28.7) | 25.0 (23.0, 27.0) | 28.3 (27.3, 29.3) | < 0.001 |
| Psychological distress and food insecurity categories, % | | | | |
| No psychological distress and no food insecurity | 12.6 (11.3, 13.8) | 22.6 (16.6, 28.7) | 11.8 (10.6, 13.0) | < 0.001 |
| Food insecurity without psychological distress | 32.5 (26.2, 38.7) | 40.8 (30.3, 51.4) | 29.7 (22.8, 36.5) | < 0.001 |
| Psychological distress without food insecurity | 20.4 (17.9, 23.0) | 31.3 (20.1, 42.5) | 19.0 (16.6, 21.5) | < 0.001 |
| Psychological distress with food insecurity | 38.8 (34.6, 43.1) | 43.1 (36.6, 49.7) | 36.5 (31.7, 41.3) | < 0.001 |

Note: P values were derived from chi-square tests for categorical variables, and Wald tests for continuous variables in comparing participants by household poverty status. FPL = federal poverty level; CI = confidence interval; Psychological distress and food insecurity variable based on *n* of 8876.

**Table 3**

Factors associated with current smoking among head-of-household respondents, stratified by household poverty status: 2015 Panel Study of Income Dynamics.

| Characteristics | Total sample | At/below poverty (≤ 100% FPL) | Above poverty (> 100% FPL) |
|---|---|---|---|
| | Adj PR (95% CI) | Adj PR (95% CI) | Adj PR (95% CI) |
| Sex | | | |
| Female | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Male | 1.37 (1.22, 1.54) | 1.39 (1.12, 1.72) | 1.37 (1.18, 1.60) |
| Age | | | |
| 18–39 years | 1.00 (0.87, 1.16) | 0.98 (0.74, 1.28) | 0.99 (0.82, 1.19) |
| 40–54 years | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| 55 and older | 0.67 (0.55, 0.81) | 0.56 (0.37, 0.83) | 0.72 (0.58, 0.90) |
| Race/ethnicity | | | |
| African American/Black | 0.86 (0.72, 1.03) | 0.72 (0.57, 0.92) | 0.90 (0.72, 1.12) |
| White, non-Hispanic | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Another race/ethnicity | 0.63 (0.47, 0.85) | 0.42 (0.22, 0.78) | 0.69 (0.49, 0.97) |
| Education level | | | |
| < 12 years | 1.31 (1.11, 1.55) | 1.01 (0.81, 1.25) | 1.42 (1.17, 1.73) |
| 12 years | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| 13 or more years | 0.52 (0.46, 0.59) | 0.51 (0.35, 0.75) | 0.53 (0.46, 0.62) |
| Marital status | | | |
| Married | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Not married | 1.84 (1.60, 2.11) | 1.29 (0.93, 1.79) | 1.86 (1.57, 2.20) |
| Employment status | | | |
| Working now | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Not working now | 1.07 (0.91, 1.26) | 1.15 (0.93, 1.44) | 0.97 (0.79, 1.19) |
| Alcohol use, past year | | | |
| No | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Yes | 1.16 (1.03, 1.32) | 1.29 (0.99, 1.67) | 1.17 (1.00, 1.36) |
| Psychological distress and food insecurity | | | |
| No psychological distress and no food insecurity | 1 (Ref) | 1 (Ref) | 1 (Ref) |
| Food insecurity without psychological distress | 1.85 (1.50, 2.27) | 1.73 (1.20, 2.49) | 1.79 (1.36, 2.37) |
| Psychological distress without food insecurity | 1.41 (1.23, 1.61) | 1.17 (0.72, 1.91) | 1.44 (1.25, 1.65) |
| Psychological distress with food insecurity | 2.06 (1.79, 2.36) | 1.82 (1.35, 2.45) | 2.04 (1.72, 2.40) |

Note. FPL = federal poverty level; Adj PR = adjusted prevalence ratio; CI = confidence interval; Psychological distress and food insecurity variable based on *n* of 8876.

psychological distress with food insecurity, and smoking prevalence in this group was high at 43%. While a much smaller proportion of those above poverty reported psychological distress with food insecurity (7%), smoking prevalence in this group was similarly high at 37%. Examining patterns of smoking prevalence across the four categories of psychological distress and food insecurity (Table 2) showed that food insecurity, more so than psychological distress, was associated with higher prevalence of smoking.

Individuals experiencing mental health problems, such as psychological distress, are known to be at heightened risk for smoking (McClave et al., 2010), highlighting the critical need for tailored and effective population-level interventions to promote cessation. For instance, data from the National Health Interview Survey showed that from 2005 to 2015, there was a 31% relative decline in smoking prevalence among individuals without serious psychological distress (from 20% in 2005 to 14% in 2015), compared to only a 3% relative decline among individuals with serious psychological distress during this time period (from 42% to 41%) (Jamal et al., 2016). Estimates of current smoking prevalence reported here (Table 2) may not be directly comparable to other national figures. This is in part because our study dichotomized psychological distress at a level that includes moderate levels, not only serious levels, based on previous work demonstrating the clinical utility of considering moderate psychological distress (Prochaska et al., 2012). A previous study used similar categories of moderate/serious distress and food insecurity to examine quit ratios, or the proportion of ever smokers who have quit, among lower-income ever smokers in California (Kim-Mozeleski and Tsoh, 2019). The quit ratio was reported to be significantly lower among respondents with distress and food insecurity (41%), as compared to respondents who had no distress and no food insecurity (63%).

It is plausible that psychological distress that occurs with food insecurity qualitatively differs from psychological distress that occurs

without food insecurity. In the case of the former, food insecurity can significantly impact mental health, including directly contributing to one's experience of depression (Whittle et al., 2016). Food insecurity and related unmet subsistence needs can also exacerbate mental health symptoms that are already existing (Whittle et al., 2016). Attributions of distress is an important area to consider in further understanding the association between psychological distress, food insecurity, and smoking (Kim-Mozeleski and Tsoh, 2019), particularly with the current finding showing socioeconomic differences in the role of psychological distress on smoking. A quasi-experimental study of a poverty alleviation program in Bangladesh showed that reductions in food insecurity improved levels of distress, demonstrating that concerns about acquiring food was a significant driver of distress (Jalal et al., 2015). The extent to which food insecurity is the primary cause of psychological distress, which then leads to smoking, remains an important research question. Currently, however, the causal direction between food insecurity and smoking is not well understood. Whereas most smokers initiate smoking during their youth regardless of socioeconomic status, socioeconomic differences in smoking tend to emerge in the young adult years oftentimes due to lower rates of cessation among disadvantaged smokers (Chassin et al., 1996; Pampel et al., 2014). Therefore, investigating the role of household food insecurity in the initiation and progression of smoking among youth and young adults may provide important insights as to whether one precedes the other, and this is important towards informing prevention efforts for cigarette smoking, for food insecurity, or both in concert.

It is worth emphasizing that in the current study, food insecurity was significantly associated with current smoking regardless of socioeconomic status. The evidence continues to build in this area, adding to our understanding of the ways in which food insecurity influences smoking and quitting. For example, population-based findings from across 12 U.S. states show that current adult smokers with food

insecurity were more likely to have made a quit attempt in the past year compared to counterparts without food insecurity (Poghosyan et al., 2018). Yet in a separate longitudinal study, food insecurity was an independent risk factor for former smokers to start smoking again (Kim-Mozeleski et al., 2019). Considered together, the findings suggest that motivation and intention to quit is high, but that food insecurity poses a formidable barrier. Better understanding these pathways is critical to developing effective interventions aimed at reducing the disproportionate burden of cigarette smoking among food insecure populations, who may also be experiencing high levels of distress. Consideration of individual-level pathways must also be considered alongside social and environmental explanations, with research showing that tobacco advertisements are highly prevalent in retail stores in lower income neighborhoods that accept federal nutrition assistance benefits, such as the Supplemental Nutrition Assistance Program benefits (Hillier et al., 2015).

We note several limitations to this study, foremost being the cross-sectional nature of this self-reported data that precludes the ability to draw causal relations and is also subject to the biases of self-report. While we constructed a four-category variable based on validated measures of psychological distress and food insecurity status, we acknowledge that co-reporting is not necessarily the same as co-occurrence. That is, the time scale by which psychological distress and food insecurity were measured varied, with psychological distress capturing moderate or serious distress experienced in the past 30 days, whereas food insecurity captured moderate or severe food insecurity experienced in the past 12 months. A growing body of research has demonstrated that food insecurity is uniquely associated with cigarette smoking, but it is important to recognize that food insecurity exists alongside other important factors such as housing, employment, and economic insecurities. Furthermore, food insecurity is not a static condition but can and does fluctuate over time, which is not captured through cross-sectional data.

We also acknowledge measurement-related limitations. Cigarette smoking status was based on a single yes/no question on whether one smokes currently. As this item is unable to distinguish between daily or non-daily/occasional use of cigarettes, this may result in a less accurate estimate of current smoking prevalence (as non-daily or occasional smokers may answer "no" to a single question assessing current smoking). The current study's smoking prevalence among head-of-household respondents was 17.3%. This is higher than estimates of adult smoking from the general population within the same timeframe as the current study, such as 15.1% reported in the 2015 National Health Interview Survey (NHIS) (Jamal et al., 2016). It is plausible that our study figures are higher because there was a greater proportion of male compared to female respondents; in the 2015 NHIS, for instance, smoking prevalence among male respondents was 16.7% (95% CI [15.9, 17.6]), which is more similar to our study's prevalence. Aside from number of years smoked regularly and cigarettes per day, we were not able to assess pertinent information related to cigarette use, such as measures of nicotine dependence or levels of cotinine.

Among the current smokers in this study, cigarettes per day varied by socioeconomic status, such that smokers above the federal poverty level smoked approximately two additional cigarettes per day than smokers at/below poverty. These findings are somewhat contradictory to other published studies showing no significant difference in cigarettes per day by various measures of socioeconomic status (Hobkirk et al., 2018; Carlson et al., 2018). It is possible that the financial cost of smoking plays a role in consumption patterns, with prior study findings showing that smokers with lower socioeconomic status are more likely to report wanting to quit due to the cost of smoking, compared to smokers with higher socioeconomic status (Pisinger et al., 2011). As any amount of smoking has harmful health effects, future research should include measures of dependence towards developing more tailored recommendations and interventions that target specific cigarette smoking disparity groups. Although the covariates included here were

based on previous work, we note that we were not able to include a number of other important variables that would have been informative, such as health-related variables and aforementioned social and environmental factors (e.g., exposure to tobacco advertisements and retail outlets selling tobacco), and more specific variables related to alcohol use.

### 4.1. Public health implications

Findings from this study indicate that cigarette smoking prevalence is remarkably high among individuals reporting psychological distress with food insecurity, regardless of poverty levels. The analyses presented here suggest that food insecurity had a stronger association with smoking prevalence than psychological distress, and this was particularly the case for individuals living at/below the federal poverty level. These findings the highlight need to develop and deliver effective interventions to reduce the public health burden of smoking and the disproportionate burden of smoking's harms on socioeconomically disadvantaged populations, potentially by augmenting existing evidence-based methods with supports around food assistance and related subsistence needs.

### Declaration of competing interest

The authors have no conflicts of interests to declare.

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