

UCSF

UC San Francisco Previously Published Works

Title

Association between e-cigarette use and food insecurity among low-income adults

Permalink

<https://escholarship.org/uc/item/3vx2h0fk>

Author

Sung, Hai-Yen

Publication Date

2022-03-12

Peer reviewed

The association between e-cigarette use and food insecurity among low-income adults

Dian Gu, Ph.D.^{1,2}

Wendy B Max, Ph.D.¹

Tingting Yao, Ph.D.¹

Yingning Wang, Ph.D.¹

Courtney Keeler, Ph.D.³

Hai-Yen Sung, Ph.D.¹

¹Institute for Health & Aging, School of Nursing, University of California, San Francisco, CA

²Center for Tobacco Control Research and Education, University of California, San Francisco, CA

³Department of Population Health Sciences, School of Nursing, University of San Francisco, San Francisco, CA

Corresponding author: Dian Gu, Ph.D., Institute for Health & Aging, School of Nursing, University of California, San Francisco, 490 Illinois St., Floor 12, Box 0646, San Francisco, CA 94143, USA. Email: Dian.Gu@ucsf.edu

Keywords: food insecurity, e-cigarettes, cigarettes, low-income

ABSTRACT

Introduction. Previous research quantifying the relationship between tobacco use and food insecurity has focused on cigarette smoking. E-cigarette use has become popular in recent years. Drawing on large, population-based survey data, this study augments the previous research, considering the association of e-cigarette use with food insecurity among low-income adults.

Methods. We analyzed data from the California Health Interview Survey in 2014-2019. The study sample consisted of 25,948 respondents aged 18-64 who lived in low-income (<200% of the FPL) households. Multivariable logistic regression models were estimated to examine the associations of e-cigarette use as well as dual use of e-cigarettes and cigarettes with food insecurity.

Results. Of California low-income adults, 6.4% identified as current e-cigarette users (3.0% dual users of e-cigarettes and cigarettes, and 3.4% sole e-cigarette users), and 43.0% reported food insecurity. After controlling for confounding factors, food insecurity was significantly more likely to be reported among current e-cigarette users (adjusted odds ratio [AOR]=1.67; 95% confidence interval [CI]=1.25, 2.23) compared to never e-cigarette users, and among dual users (AOR=2.21; 95% CI=1.63, 3.00), current sole e-cigarette users (AOR=1.66; 95% CI=1.15, 2.40), and current sole cigarette smokers (AOR=1.46; 95% CI=1.22, 1.76) compared to never tobacco users. The odds of food insecurity among dual users were significantly greater than sole cigarette smokers but not statistically different from sole e-cigarette users.

Conclusions. Using e-cigarette is an associated risk factor for food insecurity among low-income adults. Dual use of e-cigarettes and cigarettes has a significantly greater risk of food insecurity compared with smoking cigarettes alone.

What is already known on this topic

- The previous studies which quantify the relationship between tobacco use and food insecurity have focused on cigarette smoking. The relationship between e-cigarette use and food insecurity is largely understudied.

What this study adds

- This study augments previous research on tobacco use and food insecurity by considering the impact of e-cigarette use during recent years when the use is high.

How this study might affect research, practice or policy

- This study demonstrates that using e-cigarettes is an associated risk factor for food insecurity among low-income adults, and that dual use of e-cigarettes and cigarettes has a significantly greater risk of food insecurity compared with smoking cigarettes alone. Our findings support that public assistance policies need to address the food insecurity burden associated with e-cigarette use in addition to cigarette smoking.

INTRODUCTION

Cigarette smoking in the United States has declined considerably; the adult cigarette smoking prevalence dropped by two thirds from 42.4% in 1965 to 14.0% in 2019.^{1,2} Yet, challenges remain —disparities in cigarette smoking continue to persist across sociodemographic groups.^{2,3} Among adults, those with annual household income below \$35,000 smoked at three times the rate of wealthier groups whose incomes were at least \$100,000 (21.4% vs. 7.1% in 2019).² Furthermore, despite the marked decline in cigarette smoking, the tobacco product landscape is rapidly evolving in the United States with electronic cigarette (e-cigarette) emerging as the most commonly used tobacco product among youth since 2014⁴ and the second most commonly used tobacco product, following cigarettes, among adults since 2013/14.^{5,6} Between 2014 and 2019, the percentage of adults aged 18 or older who were current e-cigarette users^{2,7} in the United States remained stable in the range from 3.7% to 4.5%^{2,7}. E-cigarette use has also been consistently higher among low-income adults compared to high-income adults; as of 2019 the prevalence of e-cigarette use was 5.0 % among those with annual household income below \$35,000 compared to 3.8% among those whose income were at least \$100,000.²

Largely due to the higher smoking prevalence, the literature has documented that low-income individuals bear a disproportionate burden of tobacco-related morbidity and mortality.^{8,9} In addition, low-income individuals are also vulnerable to food insecurity, which “occurs when access to enough food for an active and healthy living is limited by a lack of money or other resources, or when there are limitations in the ability to acquire personally acceptable foods in socially acceptable ways”.¹⁰ Food insecurity is a worldwide problem even in high-income countries. In the United States, 10.5% of all households reported food insecurity in 2020 and the prevalence of food insecurity was particularly high among those living below 185% of the

poverty threshold (28.6%).¹¹ A growing literature suggests that food insecurity is linked to poorer physical and mental health, more comorbid conditions, greater healthcare utilization and cost, and higher risk of premature mortality.¹²⁻¹⁴

Since the early 2000s, there have been studies exploring the relationship between tobacco use and food insecurity. In low- and middle-income countries, some studies have examined the crowding-out effect of tobacco use and reported that tobacco expenditures diverted household resources for food¹⁵⁻²⁰, contributing to hunger and malnutrition especially for low-income families.¹⁵⁻²⁰ However, very few studies have specifically examined the relationship between tobacco use and food insecurity.²¹⁻²² A cross-sectional study of rural households in Indonesia showed that paternal smoking was associated with increased household food insecurity.²¹ Another cross-sectional study of a nationally representative sample of households in Nepal found that households in which men used any form of tobacco (smoking and smokeless tobacco) were associated with higher food insecurity score.²² More studies have quantified the relationship between tobacco use and food insecurity in high-income countries.¹⁰ The majority of those studies were conducted in the United States,¹⁰ most of which were based on cross-sectional data analyses.²³⁻³¹ Some of these cross-sectional studies showed that cigarette smoking is a risk factor for food insecurity,²³⁻²⁶ but conversely, some reported that food insecurity may be a risk factor for current smoking²⁷⁻²⁹ while others reported no evidence of association between smoking and food insecurity.³⁰⁻³¹ Three studies conducted in the United States used longitudinal data.³²⁻³⁴ One found that cigarette smoking status at baseline predicted greater food insecurity severity at 12-month follow-up;³² however, another study found that among baseline nonsmokers, becoming food insecure was independently associated with a higher likelihood of starting smoking at follow-up,³³ and the third study found evidence of a longitudinal bidirectional association

between smoking and food insecurity.³⁴ Almost all of the abovementioned studies focused on assessing the relationship between cigarette smoking and food insecurity. The association between other tobacco product use and food insecurity is largely unknown. One exception is a recent study by Mayer and colleagues,³⁵ which showed that cigar use was significantly associated with increased odds of very low food insecurity (a severe form of food insecurity that involves reduced food intake and disrupted eating patterns), but neither smokeless tobacco nor e-cigarette use was significantly associated with food insecurity among adults in the United States.³⁵

Given the growing prevalence of e-cigarette use, it is important to understand the relationship between e-cigarette use and food insecurity. Although Mayer and colleagues explored the association between e-cigarette use and food insecurity,³⁵ their study was based on a small sample (N=4,729 adults regardless of income level) using the 2013-2014 National Health and Nutrition Examination Survey data. The small sample size of their study might have limited its statistical power to detect significant associations. The current study augments previous research on tobacco use and food insecurity by considering e-cigarette use during recent years when the use is high. Using data from a large population-based survey in 2014-2019, we addressed the research question: Is e-cigarette use associated with an increased risk of food insecurity among low-income adults? Since many e-cigarette users concurrently used cigarettes,⁶ we also addressed another research question: Are dual users of e-cigarettes and cigarettes more likely to be associated with food insecurity compared to sole users of e-cigarettes, and sole users of cigarettes? The results of this study will provide a deeper understanding of the public health challenges of food insecurity compounded by tobacco use.

METHODS

Data Source

This study used data from the 2014-2019 California Health Interview Survey (CHIS), which has been conducted every other year since 2001 and annually beginning in 2011. CHIS is the largest population-based state health survey in the United States. It collects extensive information on health status, health conditions, health behaviors such as cigarette smoking and e-cigarette use, health insurance coverage, access to and use of health care services, food insecurity, public program participation, and sociodemographic characteristics from a representative sample of California's non-institutionalized population living in households. We used data starting from 2014 because it was the first survey year when CHIS asked e-cigarette use questions. More detailed information regarding the CHIS can be found at <http://chis.ucla.edu>.

Outcome Variable

The outcome variable is food insecurity. Past-year food insecurity was assessed by the 6-item Household Food Security Survey Short Form,³⁶ which is a validated subset of the 18-item Food Security Survey developed by the U.S. Department of Agriculture. The CHIS asked the following 6-item questions about respondent's experience of food insecurity during the last 12 months: 1) "How true was it that the food we bought just didn't last, and we didn't have money to get more?" (often, sometimes, never); 2) "How true was it that we couldn't afford to eat balanced meals?" (often, sometimes, never); 3) "Did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?" (yes, no); 4) "How often did the above situation happen?" (almost every month, some but not every month, only in 1 or 2 months); 5) "Did you ever eat less than you felt you should because there wasn't

enough money to buy food?” (yes, no); and 6) “Were you ever hungry but didn't eat because you couldn't afford enough food?” (yes, no). These questions were coded as affirmative if the answers were “often true” or “sometimes true” vs. “never true”, “yes” vs. “no”, and “almost every month” or “some but not every month” vs. “only in 1 or 2 months”. Food insecurity was measured by a dichotomous variable which equals 1 for respondents with at least two affirmative responses and 0 otherwise.^{27 31 36}

The food insecurity module in the CHIS was administered to adults whose household incomes fell at or below 200% of the Federal Poverty Level (FPL). In the CHIS questionnaire, household income was measured as household’s total annual income before taxes in the last year from all sources, which includes earnings from jobs, social security payment, retirement income, unemployment payments, public assistance such as Supplemental Security Income, interest, dividends, net income from business and farms, rental income, and any other money income. The FPL is set annually by the U.S. Department of Health and Human Services, and it varies by household. For example, according to the 2019 Poverty Guidelines, the 100% FPL was \$12,490 for a 1-person household and \$25,750 for a 4-person household, and the 200% FLP was \$24,980 for a 1-person household and \$51,500 for a 4-person household in the contiguous United States.³⁷

Explanatory Variables

To address the two research questions in this study, two sets of explanatory variables were used to analyze the association of e-cigarette use status with the likelihood of being food insecure (Model 1), and the association of tobacco use status with the likelihood of being food insecure (Model 2).

For Model 1, the key explanatory variable of interest was e-cigarette use status. E-cigarette use status was categorized as current, former, and never e-cigarette users. The 2014-2019 CHIS contained the following two e-cigarette use questions: “Have you ever used an e-cigarette or other electronic vaping product, even just once in your lifetime?”, and “In the past 30 days, on how many days did you use an e-cigarette or other electronic vaping product?”. Those who answered “yes” to the first question and a number between 1 and 30 to the second question were defined as current e-cigarette users. Those who answered “yes” to the first question and “0” to the second question were defined as former e-cigarette users. Those who answered “no” to the first question were defined as never e-cigarette users.

Based on the published studies that examined the factors associated with food insecurity,^{10 28 30 31} while taking into consideration variables available in the CHIS data, we included the following other explanatory variables: cigarette smoking status, sociodemographic characteristics, obesity status, and survey year dummies. Cigarette smoking status was classified into current, former, and never smokers. Current smokers were those who reported having smoked ≥ 100 cigarettes in their lifetime (i.e., ever smokers) and now smoke cigarettes every day or some days. Former smokers were those ever smokers who reported that they currently do not smoke at all. Never smokers were those who reported having never smoked more than 100 cigarettes in their lifetime.

Sociodemographic characteristics included gender (men and women), age (18-25, 26-34, 35-49, and 50-64), race/ethnicity (non-Hispanic White, Hispanic, non-Hispanic Black, non-Hispanic Asian, and non-Hispanic Other), education (less than high school, high school diploma or equivalent, some college, and college degree or above), marital status (married, never married, and other [widowed, separated, divorced, and living with partner]), poverty level (0%-99% of the

FPL, and 100%-199% of the FPL), employment status (employed, unemployed and looking for a job, and unemployed but not looking for a job), and household size (a continuous variable for the number of household members). Obesity status was classified as underweight (body mass index in kg/m² (BMI) <18.5), normal (18.5 ≤ BMI <25), overweight (25 ≤ BMI <30), and obesity (BMI ≥30.0). To capture secular variation, a dummy variable for each survey year was also included as a covariate.

For Model 2, we constructed a tobacco use status variable as an alternative key explanatory variable, which was classified into 5 mutually exclusive categories: dual users of e-cigarettes and cigarettes, current sole e-cigarette users, current sole cigarette smokers, former tobacco users, and never tobacco users. Dual users were those who were both current e-cigarette users and current smokers. Current sole e-cigarette users were those who were current e-cigarette users but not current smokers. Current sole cigarette smokers were those who were current smokers but not current e-cigarette users. Never tobacco users were those who were never e-cigarette users and never smokers. Former tobacco users referred to former e-cigarette users who were not a current smoker or former smokers who were not a current e-cigarette user.

Other explanatory variables for Model 2 were the same as defined above for Model 1 except excluding the cigarette smoking status variable.

Final Study Sample

Our study sample was restricted to CHIS respondents aged 18-64 who lived in low-income (<200% of the FPL) households. The pooled 2014-2019 CHIS data contained 77,978 respondents aged 18-64. Among them, 26,011 were low-income individuals. After excluding those whose survey was completed by proxy interview (N=63), there was no incomplete

information for the outcome variables and explanatory variables. The final study sample contained 25,948 low-income adults.

Statistical Analyses

We conducted descriptive analysis to examine the sample distribution by the outcome variable and explanatory variables. Then, we estimated the prevalence of food insecurity by subgroups of each categorical explanatory variable. The bivariate analysis chi-squared tests were used to determine if there were significant differences in the prevalence across the subgroups of each categorical explanatory variable. A univariate logistic regression was run to determine if the prevalence differed by household size. Lastly, to determine whether e-cigarette use was associated with an increased risk of food insecurity, we estimated a multivariable logistic regression model on food insecurity using e-cigarette use status as the key explanatory variable (Model 1). To determine whether dual users of e-cigarettes and cigarettes were associated with an increased risk of food insecurity compared to sole e-cigarette users and sole cigarette smokers, we estimated another multivariable logistic regression model on food insecurity using tobacco use status as the key explanatory variable (Model 2). Each model controlled for all the other explanatory variables stated above.

All analyses were performed using the SAS version 9.4 (SAS Institute Inc., Cary, North Carolina) procedure — PROC SURVEYFREQ and PROC SURVEYLOGISTIC — that accounted for the CHIS sampling weights and complex survey design. Estimates were considered to be statistically significant if the two-tailed p-value was $<.05$.

RESULTS

Of the final study sample, 43.0% respondents reported experiencing past-year food insecurity,

and 6.4% were current e-cigarette users including 3.0% as dual users and 3.4% as sole e-cigarette users (Table 1). Also, 15.8% of the study sample identified as current cigarette smokers, including 3.0% being dual users and 12.8% being sole cigarette smokers. More than half were women, 23.1% were young adults aged 18–25, 59.9% were Hispanic, 32.0% had less than a high school education, 37.8% were never married, 48.4% lived below 100% of the FPL, 62.1% were employed, and 33.8% were obese. The average household size was 4.0.

The prevalence of food insecurity was reported by 55.1% of current e-cigarette users, 48.3% of former e-cigarette users, and 41.2% of never e-cigarette users (Table 2). Among current e-cigarette users, 60.2% of those who concurrently smoked cigarettes reported food insecurity in contrast to 50.5 % of sole e-cigarette users. The prevalence of food insecurity was 52.7% among all current cigarette smokers, and 51.0% among current sole cigarette smokers. Across the subgroups stratified by other categorical explanatory variables, food insecurity prevalence was the highest among non-Hispanic Blacks (53.5%), followed by non-Hispanic Others (53.2%); it was the lowest among non-Hispanic Asians (29.3%), followed by college graduates (33.3%). The bivariate analyses showed significant differences in prevalence of food insecurity with respect to all categorical explanatory variables. The univariate logistic regression indicated a significant negative relationship between household size and food insecurity (p-value=0.023, data not shown).

The results from multivariable logistic regression Model 1 showed that after adjusting for other explanatory variables, food insecurity was significantly more likely to be reported by current e-cigarette users (adjusted odds ratio [AOR]=1.67; 95% confidence interval [CI]=1.25, 2.23) and former e-cigarette users (AOR=1.32; 95% CI=1.11, 1.58) compared to never e-cigarette users (Table 3). The results from multivariable logistic regression Model 2 showed that

food insecurity was significantly more likely to be reported by dual users (AOR=2.21; 95% CI=1.63, 3.00), current sole e-cigarette users (AOR=1.66; 95% CI=1.15, 2.40), current sole cigarette smokers (AOR=1.46; 95% CI=1.22, 1.76), and former tobacco users (AOR=1.17; 95% CI=1.02, 1.34) compared to never tobacco users. Based on pairwise comparisons, the odds of reporting food insecurity among dual users were significantly greater than current sole cigarette smokers (AOR=1.51; 95% CI=1.08, 2.12) and former tobacco users (AOR=1.89; 95% CI=1.38, 2.60), but were not statistically different from current sole e-cigarette users (AOR=1.33; 95% CI=0.87, 2.02; p-value=0.182) (data not shown).

The results from Model 1 indicated that food insecurity was significantly more likely to be reported among those aged 35-64, non-Hispanic Blacks, those whose marital status was neither married nor never married, those living below <100% of the poverty, and those who were obese, but was significantly less likely among men, non-Hispanic Asians, and those with at least some college education compared with the respective reference groups. Additionally, there was a slightly negative relationship between household size and food insecurity (p-value=0.044).

Similar results were also found from Model 2.

DISCUSSION

This study found that, after controlling for confounding factors, the odds of reporting food insecurity were 1.7 times higher among current e-cigarette users compared with never e-cigarette users. Furthermore, this study found that compared with never tobacco users, the odds of reporting food insecurity was 2.2 times higher among dual users, 1.7 times higher among current sole e-cigarette users, and 1.5 times higher among current sole cigarette smokers. Our finding that dual use was associated with a higher magnitude of the odds of food insecurity than sole use

of either product is consistent with a study which found that relative to no use of four tobacco products (cigarettes, cigars, smokeless tobacco, and e-cigarettes), single product use was associated with increased odds of food insecurity and multiple product use was associated with a higher magnitude of the association.³⁵

Our finding that e-cigarette use was significantly associated with increased odds of food insecurity provides a new insight on the potential harms of e-cigarettes. E-cigarette use has recently increased rapidly in popularity. While e-cigarettes are generally regarded as posing less risk to an individual than combustible cigarettes,^{38 39} whether e-cigarette use may provide a potential benefit in increasing cessation of combustible cigarettes has been controversial.³⁹ A recent meta-analysis of 9 randomized clinical trials and 55 observational studies on e-cigarettes concluded that provision of free e-cigarettes as a therapeutic intervention was associated with increased smoking cessation; however, as consumer products, e-cigarettes were not associated with increased smoking cessation in adult smokers.⁴⁰ As of today, no e-cigarette has been approved as a smoking cessation medication by the U.S. Food and Drug Administration.⁴¹ A 2018 report from the National Academies of Sciences, Engineering, and Medicine concluded that the long-term effects of e-cigarettes on morbidity and mortality are not yet clear, and the net public health outcome of e-cigarette use at the population level depends on the balance between positive and negative consequences.³⁹ This study illustrated a potential negative consequence of e-cigarette use.

Our finding that among low-income individuals, sole cigarette smoking was significantly associated with increased odds of food insecurity is consistent with previous cross-sectional studies which found a positive relationship between cigarette smoking and food insecurity.²³⁻²⁶ Furthermore, we found that in this population, dual use of e-cigarettes and cigarettes — the most

common combination among all the polytobacco use patterns⁶— was significantly associated with increased odds of food insecurity compared to sole cigarette smoking. While the literature has shown that dual users of e-cigarettes and cigarettes had higher exposure of nicotine and toxicants and exhibited worse health outcomes than cigarette smoking alone,^{42 43} our finding suggests an additional negative public health outcome of dual use of e-cigarettes and cigarettes. In summary, our results reinforce the reported association of cigarette smoking with food insecurity and expand our understanding of the notable burden of food insecurity associated with e-cigarette use as well as dual use of e-cigarettes and cigarettes on low-income individuals.

Considering the negative consequences of tobacco use and food insecurity on health outcomes,^{3 8 9 12-14} it is vital to characterize the pathways linking these two public health problems in order to develop effective intervention strategies. Previous studies from low-, and middle, and high-income countries have explored a mechanism through financial strain and hypothesized that money spent on tobacco products might create or exacerbate financial strain and divert available funds from household necessities such as food.^{10 15-20 23-25 32 34} These studies parallel the literature on smoking-induced deprivation.⁴⁴ Based on this mechanism, our finding that sole e-cigarette use was associated with increased odds of food insecurity suggests the possibility that food purchases may also be crowded out by e-cigarette spending in impoverished households. Future research is needed to quantify the crowding-out effect of spending on e-cigarettes and other tobacco products to validate this possibility. Another mechanism is through the physiological effects of nicotine on curbing appetite to suppress hunger pangs.⁴⁵ Therefore, food-insecure individuals may increase nicotine intake to tolerate hunger.¹⁰ This mechanism would be more pertinent when linking food insecurity and e-cigarette use because of the wide accessibility of flavored e-cigarettes. Flavorings, such as coffee and vanilla, could mimic the

effect of eating; hence, flavored e-cigarettes may have an enhanced curbing effect on replacing food.⁴⁶ More research is needed to assess the role of e-cigarette flavorings in moderating the association between e-cigarette use and food insecurity.

Tobacco use remains a leading cause of preventable disease and death and is increasingly concentrated among socioeconomically disadvantaged populations in the United States.³ Food insecurity also disproportionately affects low-income population.¹⁰ There have been various interventions targeting tobacco use and food insecurity among the low-income population.¹⁰ For example, California implemented the Medi-Cal Incentives to Quit Smoking program (known as MIQS) in 2011-2015 to provide incentives to Medi-Cal smokers to call the California Smokers Helpline.⁴⁷ Also, California offers the Supplemental Nutrition Assistance Program (SNAP, formerly known as the Food Stamp Program; the program is also known as CalFresh in California) for individuals with household incomes $\leq 130\%$ of the FPL.⁴⁸ However, very few programs are integrated to address these two issues simultaneously. Some researchers advocate strategies to incorporate partnerships between community-based tobacco cessation programs and food assistance programs, proposing that the consolidated resources could improve tobacco cessation rates for low-income smokers.^{10 25 33} Further research investigating the interventions best suited for curbing the compounded public health burden due to tobacco use and food insecurity among this vulnerable population is warranted.

Our study has several limitations. First, this study cannot determine the causality between e-cigarette use and food insecurity due to the observational cross-sectional study design. Well-designed longitudinal studies are needed to understand the causal effect of e-cigarette or other tobacco use on food insecurity or vice versa. Second, the study sample was limited to the California population, so our findings may not be generalizable to other states. However, given

the wide diversity of California's population, our findings still shed light on research on the relationship between e-cigarette use and food insecurity among different populations and has important implications for tobacco control and food insecurity. Third, recall and measurement biases may occur because of the self-reported data. Fourth, we only included two types of tobacco products in this study due to data limitation. Fifth, the CHIS did not collect detailed information about the consumption of e-cigarettes and cigarettes, such as intensity of e-cigarette use and nondaily smokers' smoking frequency, as well as the money spent on e-cigarettes and/or cigarettes. According to a recent study, over the period of 2012-2017, California's average real price (in 2017 dollars) of e-cigarettes was \$9.80 per disposable e-cigarette and \$19.11 per reusable e-cigarette, while the corresponding real price per pack of 20 cigarettes was \$5.86.⁴⁹ Without such information, we cannot speculate how the consumption of and spending on these two products may affect the degree of food insecurity. Sixth, the CHIS did not ask how long a former e-cigarette or cigarette user has stopped using e-cigarettes or cigarettes. Because the food insecurity measure was based on respondent's experience in the last 12 months, those former e-cigarette or cigarette users who stopped using the product within the last 12 months might still be more likely than never users to experience food insecurity in the last 12 months. E-cigarette is a relatively new tobacco product; therefore, the percentage of former e-cigarette users who quit e-cigarettes within the last 12 months is likely greater than the percentage of former cigarette smokers who quit smoking within the last 12 months in our study sample. This probably explains why our study found that food insecurity was positively associated with former e-cigarette use but not associated with former smoking. Examining the role of time since quitting in the association of former use of different tobacco products with food insecurity merits further research. Finally, this study focused on all low-income adults. Previous studies comparing the

crowding-out effects of tobacco expenditures across different income groups have shown mixed results: some found a greater effect for low-income households,¹⁹ while some found a similar effect for both low- and high-income households¹⁵ Therefore, future research is needed to compare the associations between tobacco use and food insecurity across populations of all socioeconomic statuses.

CONCLUSIONS

Using e-cigarettes is an associated risk factor for food insecurity among low-income adults. Dual use of e-cigarettes and cigarettes has a significantly greater risk of food insecurity compared with smoking cigarettes alone. Public assistance policies need to address the food insecurity burden arising from e-cigarette use in addition to cigarette smoking. This is especially true for the concurrent use of multiple tobacco products. Effective integrated intervention programs are needed to reduce the double burden of tobacco use and food insecurity faced by the low-income population.

Funding: This research was funded by the California Tobacco-Related Disease Research Program (TRDRP) under grant 28IR-0041 and National Cancer Institute Grant CA-113710.

Competing interests: None declared.

Patient consent for publication: Not required.

Provenance and peer review: Not commissioned; externally peer reviewed.

Data availability statement: Data are available in a public, open access repository.

REFERENCES

1. Giovino GA, Schooley MW, Zhu BP, et al. Surveillance for selected tobacco-use behaviors--United States, 1900-1994. *MMWR CDC Surveill Summ.* 1994;43(3):1-43
2. Cornelius ME, Wang TW, Jamal A, et al. Tobacco product use among adults—United States, 2019. *Morbidity and Mortality Weekly Report* 2020;69(46):1736.
3. U.S. Department of Health and Human Services. The Health Consequences of Smoking—50 years of Progress: A Report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.2014
4. Park-Lee E, Ren C, Sawdey MD, et al. Notes from the Field: E-Cigarette Use Among Middle and High School Students - National Youth Tobacco Survey, United States, 2021. *MMWR Morb Mortal Wkly Rep* 2021;70(39):1387-89. doi: 10.15585/mmwr.mm7039a4 [published Online First: 2021/10/01]
5. Hu SS, Neff L, Agaku IT, et al. Tobacco Product Use Among Adults - United States, 2013-2014. *MMWR Morb Mortal Wkly Rep* 2016;65(27):685-91. doi: 10.15585/mmwr.mm6527a1 [published Online First: 2016/07/16]
6. Sung H-Y, Wang Y, Yao T, et al. Polytabacco use and nicotine dependence symptoms among US adults, 2012–2014. *Nicotine and Tobacco Research* 2018;20(suppl_1):S88-S98.
7. Dai H, Leventhal AM. Prevalence of e-Cigarette Use Among Adults in the United States, 2014-2018. *JAMA* 2019;322(18):1824-27. doi: 10.1001/jama.2019.15331
8. Stringhini S, Sabia S, Shipley M, et al. Association of socioeconomic position with health behaviors and mortality. *Jama* 2010;303(12):1159-66.

9. Henley SJ, Thomas CC, Sharapova SR, et al. Vital signs: disparities in tobacco-related cancer incidence and mortality—United States, 2004–2013. *Morbidity and mortality weekly report* 2016;65(44):1212-18.
10. Kim-Mozeleski JE, Pandey R. The Intersection of Food Insecurity and Tobacco Use: A Scoping Review. *Health Promotion Practice* 2020;21(1_suppl):124S-38S.
11. Coleman-Jensen A, Rabbitt MP, Gregory CA, Singh A Household Food Security in the United States in 2020, ERR-298, U.S. Department of Agriculture, Economic Research Service, 2021.
12. Gundersen C, Ziliak JP. Food insecurity and health outcomes. *Health affairs* 2015;34(11):1830-39.
13. Dean EB, French MT, Mortensen K. Food insecurity, health care utilization, and health care expenditures. *Health services research* 2020;55:883-93.
14. Sun Y, Liu B, Rong S, et al. Food Insecurity Is Associated With Cardiovascular and All-Cause Mortality Among Adults in the United States. *Journal of the American Heart Association* 2020;9(19):e014629.
15. John RM. Crowding out effect of tobacco expenditure and its implications on household resource allocation in India. *Social science & medicine* 2008;66(6):1356-67.
16. Husain MJ, Datta BK, Virk-Baker MK, et al. The crowding-out effect of tobacco expenditure on household spending patterns in Bangladesh. *PloS one* 2018;13(10):e0205120.
17. San S, Chaloupka FJ. The impact of tobacco expenditures on spending within Turkish households. *Tobacco control* 2016;25(5):558-63.
18. Hu TW, Mao Z, Liu Y, et al. Smoking, standard of living, and poverty in China. *Tob Control* 2005;14(4):247-50. doi: 10.1136/tc.2004.010777 [published Online First: 2005/07/28]

19. Chelwa G, Van Walbeek C. Assessing the causal impact of tobacco expenditure on household spending patterns in Zambia. *Economic Research Southern Africa* 2014;1-40.
20. Efroymson D, Ahmed S, Townsend J, et al. Hungry for tobacco: an analysis of the economic impact of tobacco consumption on the poor in Bangladesh. *Tob Control* 2001;10(3):212-7.
21. Semba RD, Campbell AA, Sun K, et al. Paternal smoking is associated with greater food insecurity among poor families in rural Indonesia. *Asia Pac J Clin Nutr* 2011;20(4):618-23. [published Online First: 2011/11/19]
22. Sreeramareddy CT, Ramakrishnareddy N. Association of adult tobacco use with household food access insecurity: results from Nepal demographic and health survey, 2011. *BMC Public Health* 2017;18(1):48. doi: 10.1186/s12889-017-4579-y [published Online First: 2017/07/26]
23. Iglesias-Rios L, Bromberg JE, Moser RP, et al. Food insecurity, cigarette smoking, and acculturation among Latinos: data from NHANES 1999–2008. *Journal of immigrant and minority health* 2015;17(2):349-57.
24. Hernandez DC, Reesor L, Reitzel LR, et al. Smoking, financial strain, and food insecurity. *Health Behavior and Policy Review* 2017;4(2):182-88.
25. Armour BS, Pitts MM, Lee C-w. Cigarette smoking and food insecurity among low-income families in the United States, 2001. *American journal of health promotion* 2008;22(6):386-90.
26. Cutler-Triggs C, Fryer GE, Miyoshi TJ, et al. Increased rates and severity of child and adult food insecurity in households with adult smokers. *Archives of pediatrics & adolescent medicine* 2008;162(11):1056-62.

27. Kim JE, Tsoh JY. Peer reviewed: cigarette smoking among socioeconomically disadvantaged young adults in association with food insecurity and other factors. *Preventing chronic disease* 2016;13:E08
28. Poghosyan H, Scarpino SV. Food insecure cancer survivors continue to smoke after their diagnosis despite not having enough to eat: implications for policy and clinical interventions. *Cancer Causes & Control* 2019;30(3):241-48.
29. Hosler AS. Association between food distress and smoking among racially and ethnically diverse adults, Schenectady, New York, 2013–2014. *Preventing chronic disease* 2017;14:E71
30. Brostow DP, Gunzburger E, Thomas K. Food insecurity among veterans: findings from the health and retirement study. *The journal of nutrition, health & aging* 2017;21(10):1358-64.
31. Jih J, Stijacic-Cenzer I, Seligman HK, et al. Chronic disease burden predicts food insecurity among older adults. *Public health nutrition* 2018;21(9):1737-42.
32. Kim-Mozeleski JE, Tsoh JY, Ramirez-Forcier J, et al. Smoking predicts food insecurity severity among persons living with HIV. *AIDS and Behavior* 2018;22(9):2861-67.
33. Kim-Mozeleski JE, Seligman HK, Yen IH, et al. Changes in food insecurity and smoking status over time: analysis of the 2003 and 2015 panel study of income dynamics. *American Journal of Health Promotion* 2019;33(5):698-707.
34. Kim JE, Flentje A, Tsoh JY, et al. Cigarette smoking among women who are homeless or unstably housed: Examining the role of food insecurity. *Journal of Urban Health* 2017;94(4):514-24.

35. Mayer M, Gueorguieva R, Ma X, et al. Tobacco use increases risk of food insecurity: An analysis of continuous NHANES data from 1999 to 2014. *Prev Med* 2019;126:105765. doi: 10.1016/j.ypmed.2019.105765 [published Online First: 2019/07/02]
36. Blumberg SJ, Bialostosky K, Hamilton WL, et al. The effectiveness of a short form of the Household Food Security Scale. *American journal of public health* 1999;89(8):1231-34.
37. Department of Health and Human Services. 2019 Poverty Guidelines. The poverty guidelines updated periodically in the Federal Register by the U.S. Department of Health and Human Services under the authority of 42 U.S.C. 9902(2). <https://aspe.hhs.gov/topics/poverty-economic-mobility/poverty-guidelines> (Last accessed January 6, 2022)
38. Goniewicz ML, Lingas EO, Hajek P. Patterns of electronic cigarette use and user beliefs about their safety and benefits: an internet survey. *Drug Alcohol Rev* 2013;32(2):133-40. doi: 10.1111/j.1465-3362.2012.00512.x [published Online First: 2012/09/22]
39. National Academies of Sciences, Engineering, and Medicine; Health and Medicine Division; Board on Population Health and Public Health Practice; Eaton DL, Kwan LY, Stratton K, et al., eds. *Public Health Consequences of E-Cigarettes*. Washington (DC): National Academies Press (US); January 23, 2018.
40. Wang RJ, Bhadriraju S, Glantz SA. E-Cigarette Use and Adult Cigarette Smoking Cessation: A Meta-Analysis. *Am J Public Health* 2021;111(2):230-46. doi: 10.2105/ajph.2020.305999 [published Online First: 2020/12/23]
41. FDA warns JUUL labs for marketing unauthorized modified risk tobacco products including in outreach to youth. Food and Drug Administration. <http://www.fda.gov/news-events/press-announcements/fda-warns-juul-labs-marketing-unauthorized-modified->

- risktobacco products-including-outreach-youth.(Last accessed April,2021) 42. Goniewicz ML, Smith DM, Edwards KC, et al. Comparison of nicotine and toxicant exposure in users of electronic cigarettes and combustible cigarettes. *JAMA network open* 2018;1(8):e185937-e37.
43. Wang JB, Olgin JE, Nah G, et al. Cigarette and e-cigarette dual use and risk of cardiopulmonary symptoms in the Health eHeart Study. *PLoS One* 2018;13(7):e0198681.
44. Siahpush M, Borland R, Yong HH. Sociodemographic and psychosocial correlates of smoking-induced deprivation and its effect on quitting: findings from the International Tobacco Control Policy Evaluation Survey. *Tob Control* 2007;16(2):e2. doi: 10.1136/tc.2006.016279 [published Online First: 2007/04/03]
45. Jo YH, Talmage DA, Role LW. Nicotinic receptor-mediated effects on appetite and food intake. *Journal of neurobiology* 2002;53(4):618-32.
46. Morean ME, Wedel AV. Vaping to lose weight: Predictors of adult e-cigarette use for weight loss or control. *Addictive behaviors* 2017;66:55-59.
47. Sung HY, Penko J, Cummins SE, et al. Economic Impact of Financial Incentives and Mailing Nicotine Patches to Help Medicaid Smokers Quit Smoking: A Cost-Benefit Analysis. *Am J Prev Med* 2018;55(6 Suppl 2):S148-s58. doi: 10.1016/j.amepre.2018.08.007 [published Online First: 2018/11/21]
48. Leung CW, Villamor E. Is participation in food and income assistance programmes associated with obesity in California adults? Results from a state-wide survey. *Public Health Nutr* 2011;14(4):645-52. doi: 10.1017/s1368980010002090 [published Online First: 2010/08/13]

49. Yao T, Sung HY, Huang J, et al. The impact of e-cigarette and cigarette prices on e-cigarette and cigarette sales in California. *Prev Med Rep* 2020;20:101244. doi: 10.1016/j.pmedr.2020.101244 [published Online First: 2020/11/27]

Table 1. Distribution of the Final Study Sample (N=25,948) by Outcome and Explanatory Variables among Low-income (<200% of the FPL) Adults Aged 18-64: California Health Interview Survey, 2014-2019

	N	Column %
Outcome variable:		
Food Insecurity		
Yes	11,592	43.0
No	14,356	57.0
Explanatory variables:		
E-cigarette use status		
Current e-cigarette use	1,565	6.4
Former e-cigarette use	3,444	12.6
Never e-cigarette use	20,939	81.0
Cigarette smoking status		
Current smoking	4,596	15.8
Former smoking	4,976	15.5
Never smoking	16,016	68.7
Tobacco use status		
Dual use of e-cigarettes and cigarettes	857	3.0
Current sole e-cigarette use	708	3.4
Current sole smoking	4,099	12.8
Former tobacco use	5,732	19.7
Never tobacco use	14,552	61.1
Gender		
Men	10,774	45.3
Women	15,174	54.7
Age group		
18-25	4,503	23.1
26-34	3,919	20.2
35-49	6,842	30.6
50-64	10,684	26.1
Race/ethnicity		
Non-Hispanic White	8,827	20.3
Hispanic	12,091	59.9
Non-Hispanic Black	1,640	6.0
Non-Hispanic Asian	2,123	11.0
Non-Hispanic Other	1,267	2.8
Education		
Less than high school	5,809	32.0
High school diploma	8,063	28.1
Some college	7,578	24.7
College degree or above	4,498	15.2
Marital status		
Married	8,405	35.7
Never married	9,023	37.8
Other marital status [#]	8,520	26.5
Poverty status		
0-99% FPL	12,647	48.4
100-199% FPL	13,301	51.6
Employment status		
Employed	14,392	62.1
Unemployed, looking for job	2,171	9.9
Unemployed, not looking for job	9,385	28.0
Household size (continuous)	25,948	4.0 (0.0)*
Obesity status		
Underweight	579	2.4
Normal	8,177	30.8
Overweight	8,074	33.0
Obesity	9,018	33.8
Survey year		
2014	3,930	18.0
2015	5,120	17.8
2016	5,211	17.2
2017	4,253	16.1
2018	4,357	15.7
2019	3,077	15.2

Note: All the percentages are estimated from the weighted analysis. FPL=Federal poverty level. [#]Includes widowed, separated, divorced, and living with partner. *Mean (standard error).

Table 2. Prevalence of Food Insecurity by Categorical Explanatory Variables among Low-income (<200% of the FPL) Adults Aged 18-64: California Health Interview Survey, 2014-2019 (N=25,948)

	Food insecurity		P-value from bivariate analysis
	N	Prevalence (95% CI)	
E-cigarette use status			<.0001
Current e-cigarette use	876	55.1 (49.2, 61.0)	
Former e-cigarette use	1,804	48.3 (44.6, 52.0)	
Never e-cigarette use	8,912	41.2 (39.8, 42.6)	
Cigarette smoking status			<.0001
Current smoking	2,781	52.7 (49.2,56.3)	
Former smoking	2,267	44.9 (41.8,48.0)	
Never smoking	6,544	40.3 (38.6,42.0)	
Tobacco use status			<.0001
Dual use of e-cigarettes and cigarettes	525	60.2 (53.4, 67.0)	
Current sole e-cigarette use	351	50.5 (41.4, 59.7)	
Current sole cigarette smoking	2,256	51.0 (46.9, 55.0)	
Former tobacco use	2,560	43.4 (40.6, 46.2)	
Never tobacco use	5,900	39.9 (38.2, 41.6)	
Gender			0.0102
Men	4,495	41.0 (39.0, 43.0)	
Women	7,097	44.7 (42.8, 46.5)	
Age group			<.0001
18-25	1,728	37.8 (34.9, 40.7)	
26-34	1,773	42.0 (39.2, 44.9)	
35-49	3,281	46.3 (43.8, 48.8)	
50-64	4,810	44.4 (41.8, 47.1)	
Race/ethnicity			<.0001
Non-Hispanic White	4,005	44.4 (41.5, 47.3)	
Hispanic	5,379	43.5 (41.6, 45.4)	
Non-Hispanic Black	824	53.5 (48.7, 58.3)	
Non-Hispanic Asian	669	29.3 (25.3, 33.2)	
Non-Hispanic Other	715	53.2 (45.2, 61.3)	
Education			<.0001
Less than high school	2,963	47.9 (45.3, 50.4)	
High school diploma	3,572	43.3 (40.7, 45.8)	
Some college	3,483	42.3 (39.6, 45.0)	
College degree or above	1,574	33.3 (30.1, 36.5)	
Marital status			<.0001
Married	3,420	40.5 (38.4, 42.7)	
Never married	3,796	39.6 (37.3, 42.0)	
Other marital status [#]	4,376	51.1 (48.6, 53.5)	
Poverty status			<.0001
0-99% FPL	6,411	49.1 (47.2, 51.0)	
100-199% FPL	5,181	37.4 (35.4, 39.1)	
Employment status			0.0292
Employed	6,021	41.6 (39.9-43.3)	
Unemployed, looking for job	1,097	46.5 (41.8-51.3)	
Unemployed, not looking for job	4,474	44.8 (42.6-47.1)	
Obesity status			<.0001
Underweight	246	44.2 (34.3-54.0)	
Normal	3,297	38.6 (35.8-41.3)	
Overweight	3,534	42.1 (39.2-44.9)	
Obesity	4,515	47.8 (45.5-50.1)	
Survey year			0.0188
2014	1,630	40.4 (37.5, 43.3)	
2015	2,383	45.2 (42.8, 47.5)	
2016	2,402	45.8 (42.3, 49.3)	
2017	1,964	41.8 (38.6, 45.1)	
2018	1,853	39.6 (36.5, 42.7)	
2019	1,360	45.0 (41.0, 49.1)	

Note: All the estimates are obtained from the weighted analysis. CI=confidence interval; FPL=Federal poverty level. [#]Includes widowed, separated, divorced, and living with partner.

Table 3. Multivariable logistic Regression of Food Insecurity among Low-income (<200% of the FPL) Adults Aged 18-64: California Health Interview Survey, 2014-2019 (N=25,948)

	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)
E-cigarette use status		
Current e-cigarette use	1.67 (1.25, 2.23)***	
Former e-cigarette use	1.32 (1.11, 1.58)**	
Never e-cigarette use	REF	
Cigarette smoking status		
Current smoking	1.33 (1.10-1.60)**	
Former smoking	1.08 (0.92-1.26)	
Never smoking	REF	
Tobacco use status		
Dual use of e-cigarettes and cigarettes		2.21 (1.63, 3.00)***
Current sole e-cigarette use		1.66 (1.15, 2.40)**
Current sole cigarette smoking		1.46 (1.22, 1.76)***
Former tobacco use		1.17 (1.02, 1.34)*
Never tobacco use		REF
Gender		
Men	0.82 (0.72, 0.93)**	0.82 (0.72, 0.93)**
Women	REF	REF
Age group		
18-25	REF	REF
26-34	1.09 (0.91, 1.29)	1.10 (0.91, 1.28)
35-49	1.27 (1.06, 1.52)**	1.24 (1.04, 1.48)*
50-64	1.13 (0.92, 1.37)	1.08 (0.89, 1.31)
Race/ethnicity		
Non-Hispanic White	REF	REF
Hispanic	0.95 (0.80, 1.13)	0.94 (0.79, 1.11)
Non-Hispanic Black	1.36 (1.09, 1.70)**	1.35 (1.08, 1.68)***
Non-Hispanic Asian	0.62 (0.49, 0.78)***	0.61 (0.48, 0.77)***
Non-Hispanic Other	1.29 (0.90, 1.86)	1.30 (0.90, 1.87)
Education		
Less than high school	REF	REF
High school diploma	0.88 (0.74, 1.05)	0.89 (0.75, 1.06)
Some college	0.81 (0.68, 0.97)*	0.82 (0.69, 0.98)*
College degree or above	0.64 (0.52, 0.78)***	0.64 (0.52, 0.79)***
Marital status		
Married	REF	REF
Never married	0.94 (0.80, 1.11)	0.95 (0.81, 1.12)
Other marital status [#]	1.26 (1.09, 1.46)**	1.26 (1.09, 1.46)**
Poverty status		
0-99% FPL	1.54 (1.37, 1.74)***	1.54 (1.36, 1.74)***
100-199% FPL	REF	REF
Employment status		
Employed	REF	REF
Unemployed, looking for job	1.18 (0.94-1.49)	1.18 (0.94-1.49)
Unemployed, not looking for job	0.97 (0.86-1.10)	0.97 (0.86-1.10)
Household size (continuous)	0.97 (0.94-0.99)*	0.97 (0.94-0.99)*
Obesity status		
Underweight	1.20 (0.80-1.80)	1.19 (0.79-1.78)
Normal	REF	REF
Overweight	1.07 (0.87-1.32)	1.07 (0.87-1.32)
Obesity	1.25 (1.06-1.48)**	1.26 (1.06-1.49)**
Survey year		
2014	REF	REF
2015	1.18 (1.00, 1.39)*	1.18 (1.00, 1.39)
2016	1.24 (1.02, 1.50)*	1.23 (1.01, 1.49)*
2017	1.09 (0.91, 1.32)	1.09 (0.91, 1.32)
2018	0.99 (0.82, 1.18)	0.99 (0.82, 1.18)
2019	1.24 (1.00, 1.54)*	1.25 (1.01, 1.55)*

Note: All the estimates are obtained from the weighted analysis. AOR=Adjusted odds ratio; CI=Confidence interval; FPL=Federal poverty level; REF=Reference group. [#]Includes widowed, separated, divorced, and living with partner; * Statistically significant at p-value <.05; ** Statistically significant at p-value <.01; *** Statistically significant at p-value <.001.