Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_Catherine W. Bennett_____ _12/12/2020_____
Student's Name Date

The Association Between Psychological Distress and Electronic Cigarette Use in the United States, 2016-2018

By

Catherine Weston Bennett
Master of Public Health

Epidemiology

_____Michael Goodman, MD, MPH_____
Committee Chair

_____Benjamin Druss, MD, MPH_____
Committee Member

The Association Between Psychological Distress and Electronic Cigarette Use in the United States, 2016-2018

By

Catherine Weston Bennett

Bachelor of Science
Davidson College
2015

Thesis Committee Chair: Michael Goodman, MD, MPH

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Epidemiology
2021

Abstract

The Association Between Psychological Distress and Electronic Cigarette Use in the United States, 2016-2018

By Catherine Weston Bennett

Background: Electronic cigarettes (e-cigarettes) have been marketed as alternatives to traditional tobacco cigarettes. In 2016, the FDA issued a regulation that defined e-cigarettes as tobacco products and required more stringent sales and marketing regulations. E-cigarettes can have deleterious health effects, and patients with mental illness are vulnerable to these health effects. Studies have shown that patients with mental illness are more likely to use e-cigarettes, and the risk of using e-cigarettes is higher among people who have a history of mental illness.
Methods: In this cross-sectional study, we sought to investigate the association between psychological distress and e-cigarette use among participants in the National Health Interview Survey (NHIS) from 2016-2018. Using binary logistic regression, we modelled the primary outcome of interest, ever e-cigarette use, as a function of psychological distress, measured using the Kessler 6 (K6) scale.
Results: Psychological distress was associated with e-cigarette use in a dose-response fashion, although the magnitude of the association differed somewhat among never, former, and current traditional cigarette smokers. For example, based on the 2016 NHIS data, the odds ratios (95% CI) estimates for K6 scores of 1-2, 3-5, 6-10 and 11-24 (using persons with K6 score of 0 as reference) were 1.62 (1.19-2.22), 2.04 (1.51-2.75), 3.78 (2.62-5.47), and 4.71 (2.54-8.75), respectively, among persons who had never smoked traditional cigarettes. The results for 2017 and 2018 were generally similar. When e-cigarette use was analyzed using K6 score as a dichotomous variable (0-12 versus 13-24), the odds of e-cigarette use were higher among participants with K6 scores between 13 and 24 across all years and all smoking groups.
Conclusions: This study indicates that patients with psychological distress are more likely to use electronic cigarettes and that this risk is modified by traditional cigarette smoking status. Moving forward, longitudinal research is necessary to better understand the direction of the association between mental and physical health and e-cigarette use in order to guide clinical recommendations and counseling efforts. In addition, clinicians need to understand the risks associated with e-cigarettes and work to counsel patients on these risks as well as on safer alternatives.

The Association Between Psychological Distress and Electronic Cigarette Use in the United States, 2016-2018

By

Catherine Weston Bennett

Bachelor of Science
Davidson College
2015

Thesis Committee Chair: Michael Goodman, MD, MPH

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Epidemiology
2021

Table of Contents

Abbreviations: Electronic cigarette (e-cigarette); Food and Drug Administration (FDA); Post Traumatic Stress Disorder (PTSD); Serious Mental Illness (SMI); First Episode Psychosis (FEP); Center for Epidemiologic Depression Scale (CED-S); National Health Interview Survey (NHIS); Kessler K6 (K6); Odds Ratio (OR); Confidence Interval (CI)

Background

Overview of Electronic Cigarettes

Electronic cigarettes (e-cigarettes; also called electronic nicotine delivery systems, ENDS) first appeared on the market in China in 2003 as an alternative to traditional tobacco cigarettes.[1] In 2018, the prevalence of e-cigarette use in the United States was 3.2%, which was a significant increase from 2.8% in 2017.[2] E-cigarette use is more common among males, persons aged 18-24 years, and adults who currently smoke tobacco cigarettes.[3] Moreover, e-cigarette use has been associated with deleterious health effects. For example, in the summer and fall of 2019, an outbreak of lung injury associated with e-cigarette (a.k.a. vaping) product use was reported and attributed to the addition of vitamin E acetate to the vaping liquid.[4] While e-cigarettes are not approved by the Food and Drug Administration (FDA) as a treatment for tobacco cessation, several studies have found that smokers who used e-cigarettes were more successful at quitting compared to smokers who used other nicotine-free treatments or smoking cessation treatments.[5-7] Results from these studies indicate that e-cigarettes could be used to help current smokers stop smoking but should not be used as alternatives to tobacco cigarettes or as novel tobacco products.

Patients with mental health conditions are particularly likely to use e-cigarettes and may be disproportionally vulnerable to the adverse health effects of these products. While traditional tobacco cigarette use has been extensively studied in this population, the association between e-cigarette use and mental illness is less clear.

Tobacco Cigarettes and Mental Illness

Patients with mental illness are more likely to smoke cigarettes compared to persons without mental illness. For example, it has been shown that adults with at least one psychiatric diagnosis account for 36.4% of the US population, but consume 56.4% of all cigarettes in the United States.[8] Individuals

diagnosed with schizophrenia, bipolar disorder, post-traumatic stress disorder (PTSD), and alcohol or illicit drug use disorders use cigarettes at almost 5 times the rate of people without these disorders.[9] In another study, the odds of smoking among participants with any psychiatric disorder were 3.23 times higher than the odds of smoking among participants without a psychiatric disorder.[10] In addition, a recent meta-analysis reported a bidirectional relationship between tobacco use and depression.[11] Finally, while the rate of smoking declined from 19.2% to 16.5% among adults without mental illness in the United States between 2004 to 2011, the rate of smoking among adults with mental illness only declined from 25.3% to 24.9% during the same time period.[12]

Persons suffering from a serious mental illness (SMI, defined by the National Institutes of Mental Health as "a mental, behavioral, or emotional disorder resulting in serious functional impairment, which substantially interferes with or limits one or more major life activities")[13] have a particularly high prevalence of smoking and are at risk for contracting medical conditions related to cigarette use. For example, one study found that the odds of smoking among patients with a severe psychotic disorder was 4.6 times the odds of smoking among patients without a severe psychotic disorder.[14] Additionally, studies have shown that patients with schizophrenia are more likely to smoke cigarettes than patients with other psychiatric diagnoses,[15] and patients with first episode psychosis (FEP) have higher rates of smoking compared to patients with long-standing psychosis.[16] Furthermore, patients with schizophrenia who smoke cigarettes have higher scores on the positive and negative syndrome scale as well as on the negative symptoms subscale, poor cognitive functioning, social impairment, increased aggression, and require higher antipsychotic doses.[17-20] These results indicate that smoking contributes to poor mental health outcomes, which can have deleterious long-term health consequences.

Bipolar disorder is another condition associated with a high prevalence of cigarette use. In a meta-analysis of published studies, the pooled odds ratio comparing current smoking among patients with bipolar disorder to the general population was 3.5.[21] Among patients with bipolar disorder, smoking is associated with a more than five-fold increase in the risk of attempting suicide compared to nonsmokers.[22] Moreover, in persons with bipolar disorder, smoking is associated with increased manic symptoms, an increased risk of psychiatric hospitalization, and an increased risk of comorbid substance abuse.[23]

Finally, and most importantly, smoking is associated with an increased risk of mortality among patients with serious mental illness.[24,25] Patients with schizophrenia and bipolar disorder have decreased life expectancy (18.7 and 16.3 years fewer for men and women with schizophrenia, respectively; and 13.6 and 12.1 years fewer for men and women with bipolar disorder, respectively).[26] Several studies postulate that smoking contributes to the years of life lost in patients with schizophrenia and bipolar disorder, in particular due to medical conditions caused by tobacco.[27-29]

Electronic Cigarettes and Mental Illness

While the use of tobacco cigarettes among patients with mental illness is well-described in the literature, the data on electronic cigarette use in this population are relatively sparse. For example, one cross-sectional study found that 14.8% of participants with a mental health condition (classified as anxiety, depression, or other illness) had tried e-cigarettes, compared with 6.6% of participants without a mental illness.[30] Additionally, 3.1% of participants with a mental health condition reported currently using e-cigarettes, compared to 1.1% of participants without a mental illness.[30] This association varied by tobacco cigarette smoking status, and current smokers had higher rates of e-cigarette use than never smokers.[30] In another study, 24.4% of participants with a mental health condition had used e-cigarettes

compared to 15.5% of the participants without a mental health condition, and as the number of mental health diagnoses increased, so did the rate of electronic cigarette use.[31]

There are many reasons why people use e-cigarettes. In general, e-cigarette users view these devices as safer alternatives to tobacco cigarettes and as possible smoking cessation tools.[1] Additionally, people are curious about the novelty of e-cigarettes.[32] The reasons for using e-cigarettes among people with mental illness appear to be similar to those reported in the general population. One study found that participants with serious mental illness who used e-cigarettes thought that e-cigarettes were a healthier alternative to tobacco cigarettes and were associated with less negative stigma than tobacco cigarettes.[33] In another study, people with mental illness reported viewing e-cigarettes as less harmful than tobacco cigarettes; pointed out that they can use them in the non-smoking areas; and indicated that they enjoyed the variety of e-cigarette flavors.[34]

In the overall population, e-cigarette use is more common in younger age groups (18-39), and among current smokers and those who drink alcohol.[35] In the population with mental illness, there is a specific concern about e-cigarette use among adolescents and young adults. E-cigarette use is more common in young adults with mental illness and has found to be associated with increased alcohol use.[36] Furthermore, higher internalizing and externalizing symptoms have been found among young people who use e-cigarettes compared to young people who do not use e-cigarettes.[37,38]

Among patients with depression, studies have shown that depressive symptoms are associated with increased e-cigarette use. Indeed, in a large study of French citizens, researchers found a dose-response relationship between depressive symptoms on the Center for Epidemiologic Depression scale (CED-S) and e-cigarette use.[39] Moreover, in a study among Texas college students, higher depressive symptoms on the CED-S predicted future e-cigarette use.[40] Additionally, another study suggested that there is a bidirectional association between e-cigarette use and depression,[41] and e-cigarette use has been

found to predict depressive symptoms among Texas college students;[42] a large cohort representative of the Canadian population;[43] and in studies using 2016 and 2017 Behavioral Risk Factor Surveillance System data, a large representative sample of adults in the United States.[44,45]

In addition to depression, e-cigarette use is associated with other mental illnesses, including schizophrenia. For example, one study found that 37% of participants with schizophrenia had tried e-cigarettes, while 7% of participants were currently using e-cigarettes.[46] Moreover, several studies have suggested that e-cigarettes may be useful as smoking cessation tools for nicotine replacement in patients with schizophrenia who currently smoke.[47-50] While e-cigarettes may be less harmful than tobacco cigarettes, there is limited data on their long-term effects. Moreover, increased nicotine levels could exacerbate psychotic symptoms and have been reported to increase blood clozapine levels in patients with schizophrenia, which could affect symptom control and side effect profiles of antipsychotic medications.[51,52]

Current Study

In 2016, the FDA issued a regulation that defined e-cigarettes as tobacco products and gave the FDA authority to regulate e-cigarettes under the Federal Food, Drug, and Cosmetic Act.[53] This legislation required e-cigarette companies to comply with branding laws and disclose ingredients in e-cigarettes; required e-cigarette companies to register products and places where products are manufactured; banned e-cigarette companies from marketing their products as safer alternatives to tobacco cigarettes; required e-cigarette companies to undergo review of products before coming on the market; prohibited e-cigarettes from being sold to minors; and required warnings about the deleterious effects of tobacco and nicotine to be printed on all products.[53]

It is unclear if recent changes in legislation have had an effect on e-cigarette use among patients with mental health conditions. The current study seeks to examine the association between mental health

and e-cigarette use and to investigate if this association has changed over time. To address these issues, we analyzed the data from the National Health Interview Survey (NHIS), which is a nationally representative sample of the population of the United States. To examine possible changes after the e-cigarette regulatory policy passed in 2016, we analyzed NHIS data from 2016, 2017, and 2018.

Methods

Data Sources and Study Population

The present study uses data from the 2016, 2017, and 2018 NHIS. The NHIS is a national cross-sectional survey that is conducted annually in the United States and includes noninstitutionalized civilians across all 50 states.[54] It uses a complex survey design that enables capturing a representative sample of households as well as other living quarters such as college dormitories.[54] The survey collects demographic data on study participants as well as information on lifestyle and various health issues.[54]

For each year, data were restricted to NHIS participants who were 18 years of age or older. Individuals with missing information for any of the analytic variables were excluded from the final dataset (Figure 1). This study was conducted with publicly available de-identified data, and therefore IRB approval was not required.

Variables of Interest

The main dependent variable of interest in the current analysis was self-reported ever vs. never e-cigarette use. Ever users were participants who had used an e-cigarette at least once.

The primary independent variable of interest, psychological distress, was measured using the Kessler 6 (K6) scale, which is included in the NHIS questionnaire. The K6 scale was created to measure psychological distress in the population and has been used in previous studies as an indicator of serious mental illness.[55-59] Participants are asked if they have felt sad, nervous, restless or fidgety, hopeless, that everything was an effort, and worthless over the past 30 days. Each category is scored on a Likert scale of 0-4 (where 0 is none of the time; 1 is a little of the time; 2 is some of the time; 3 is most of the time; and 4 is all of the time). For the purposes of this analysis, the scores were added to give a total score between 0 and 24. In order to create a categorical variable of K6 scores, scores were grouped into the following categories: 0, 1-2, 3-5, 6-10, and 11-24. These categories have been used before in studies of

psychological distress as a possible predictor of e-cigarette use[57] and mortality.[60] A sensitivity analysis was conducted in which K6 score was treated as a dichotomous variable to examine e-cigarette use based on serious mental illness. Consistent with previous research, K6 scores of 0-12 were classified as no SMI, and scores of 13-24 were classified as SMI.[55,61]

The covariates in all analyses included sex (male, female), census region (Northeast, Midwest, South, West), age (18-24, 25-34, 35-44, 45-54, 55-64, and 65 and older), race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, Asian, Other), highest level of education completed (did not finish high school, GED/high school diploma, some college/associate's degree, bachelor's degree, higher education), current employment status (employed within the past year, not employed within the past year, never employed), marital status (married/living with partner, separated/divorced, widowed, never married), insurance status (private insurance, Medicare/dual enrolled, Medicaid/other public insurance, uninsured), alcohol use (lifetime abstainer, former use, current use) and traditional cigarette use (never, former, current). Persons who reported having smoked more than 100 cigarettes in their lifetime were subcategorized as "current smokers" if they reported smoking traditional cigarettes every day or some days at the time of the survey, or "former smokers", i.e., those who reported not currently smoking traditional cigarettes. "Never smokers" were persons who reported smoking fewer than 100 cigarettes in their lifetime.

Statistical Analysis

Descriptive statistics were performed for each variable of interest by ever e-cigarette use. To examine the association between psychological distress and e-cigarette use, multivariate logistic regression was used with K6 score category as the primary exposure and ever e-cigarette use (yes/no) as the primary outcome with covariates included in the models to control for confounding. A separate model was constructed for each survey year, and all models were examined for interaction between the

main variable of interest K6 score (as a continuous variable) and traditional cigarette use (never, former current). The results of the multivariable analyses were expressed as adjusted odds ratios (OR) and 95% confidence intervals (CI). To account for the complex survey design, data were analyzed with weights provided by the NHIS. Data were analyzed using SAS version 9.4 (Cary, NC).

Results

Demographic Characteristics of Study Participants

Among 22,116 persons who provided data for the 2016 survey, the average K6 score was 2.60 (95% CI 2.53-2.67). For ever-e-cigarette users and never-e-cigarette users, the average K6 scores were 4.12 (95% CI 3.88-4.36) and 2.33 (95% CI 2.26-2.40), respectively. The average age of participants was 48 years (95% CI 47.5-48.4). Ever e-cigarette users accounted for 15.3% of the 2016 sample (n=3,290), and never e-cigarette users accounted for 84.7% of the sample (n=18,826). With respect to traditional cigarette use, 62.3% of participants were never smokers (n=13,070); 22.6% of participants were former smokers (n=5,494); and 15.2% of participants were current smokers (n=3,552). All other demographic data, both overall and by e-cigarette use, are presented in Table 1a.

The 2017 dataset included 18,161 survey respondents with an average K6 score of 2.66 (95% CI 2.60-2.73). The K6 score was higher among ever-e-cigarette users (4.39; 95% CI 4.15-4.62) than among never-e-cigarette users (2.38; 95% CI 2.31-2.45). The 2017 survey participants were on average 48 years of age (95% CI 47.8-48.7). Ever e-cigarette users accounted for 14.1% of the sample (n=2,597). Current traditional cigarette users accounted for 13.9% (n=2,706), former smokers of traditional cigarettes accounted for 22.4% (n=4,509), and never smokers accounted for 63.7% (n=10,946). The remaining characteristics of the 2017 NHIS participants are summarized in Table 1b.

Among the 17,192 participants in the 2018 survey, the average K6 score was 2.86 (95% CI 2.79-2.94). Similar to the 2016 and 2017 datasets, the average K6 score was higher among ever e-cigarette users compared to never e-cigarette users, 4.43 (95% CI 4.19-4.67) and 2.59 (95% CI 2.51-2.66), respectively. The average age of participants was 49 years (95% CI 48.0-49.0). Ever e-cigarette users accounted for 15.1% of the sample (n=2,501), and never e-cigarette users accounted for 84.9% of the sample (n=14,691). In terms of traditional cigarette use, 64.3% of participants were never smokers

(n=10,412); 21.8% of participants were former smokers (n=4,213); and 13.9% of participants were current smokers (n=2,567). All other demographic data for the 2018 dataset are presented in Table 1c.

Multivariable Analyses of the Association between K6 Score and Electronic Cigarette Use

The multivariable logistic regression models demonstrated significant interaction between K6 score and traditional cigarette use, indicating that the association between psychological distress and e-cigarette use may be modified by traditional cigarette smoking status. For this reason, the adjusted results for each year are presented separately for never, former, and current users of traditional cigarettes (Figure 2a-2c; Table 2a-2c). Results from the sensitivity analysis are presented in supplemental Table 1a-c. Across all years and smoking groups, serious mental illness (i.e. a K6 score of 13-24) was associated with increased odds of ever e-cigarette use.

Never Smokers

Among 2016 survey participants who were never smokers, the adjusted ORs reflecting the association between e-cigarette use and K6 score increased in a monotonic fashion. Using a K6 score of 0 as reference, the OR was 1.62 (95% CI: 1.19-2.22) for persons who scored 1-2 points, 2.04 (95% CI: 1.51-2.75) for those who scored 3-5 points, 3.78 (95% CI: 2.62-5.47) for those who scored 6-10 points, and 4.71 (95% CI: 2.54-8.75) for the highest K6 score category of 11-24 (Table 2a). Similar patterns were seen among never smokers who responded to the 2017 and 2018 surveys (Table 2b and 2c).

Former Smokers

The association between K6 score and use of e-cigarettes among former smokers was similar to that observed in persons who never smoked. In 2016, the OR (95% CI) estimates for K6 score of 1-2 and 11-24, relative to the score of 0, were 1.46 (1.09-1.94) and 3.09 (1.91-5.00), respectively (Table 2a). The corresponding results were 1.20 (95% CI: 0.90-1.60) and 5.09 (95% CI 3.46-7.50) using the 2017 survey, and 1.11 (95% CI 0.84-1.46) and 3.03 (2.01-4.58) based on the 2018 data (Table 2b and 2c).

Current Smokers

As in the previous analyses, the ORs comparing current smokers who had elevated K6 score to those who scored 0 points increased with each increasing K6 category. However, the dose-response effect appeared to be less pronounced than that observed in never or former smokers, especially in the earlier survey years (Table 2a-2c). Based on the 2016 data, the largest OR associated with the highest K6 score of 11-24 was 1.75 (95% CI 1.29-2.37; Table 2a). The highest K6 score category was also associated with the largest OR among current smokers in both subsequent surveys with estimates of 2.55 (95% CI: 1.81-3.60) in 2017, and 2.75 (95% CI: 2.00-3.80) in 2018 (Table 2b and 2c).

Discussion

Overview of Results

In the present study, we found that as levels of psychological distress increase, the odds of ever e-cigarette use also increase. This trend is seen across all three survey years and across all smoking groups; however, the dose-response slopes differed depending on the year and on the smoking status of participants. The association appeared stronger among never and former smokers compared to current smokers, and the difference between the highest and the lowest K6 category was more pronounced in 2016 and 2017 than in 2018. When the analyses relied on a dichotomous categorization of K6 scores (i.e., SMI versus no SMI), the odds of ever e-cigarette use were consistently higher among participants with SMI compared to participants without SMI, across all years and smoking groups.

Comparison to Previous Studies

Our results are comparable to previous reports on the association between mental illness and e-cigarette use. One previous study examined the association between e-cigarette and tobacco cigarette use and psychological distress using NHIS data from 2014. The results were similar to ours with respect to the observed dose response association between increasing levels of psychological distress and the odds of e-cigarette only use, current e-cigarette and cigarette use, former cigarette and ever e-cigarette use, and current cigarette use.[57] While the smoking strata in that study were different from those used in our analyses, the two sets of results are comparable given that this study also used NHIS data and used the same measures of psychological distress. As in our study, the association between K6 score and e-cigarette use was relatively weaker among current smokers than among other groups.[57]

In a more recent analysis that evaluated the association between mental illness and e-cigarette use among 2016 NHIS survey participants, the prevalence of ever e-cigarette use was higher among participants with a chronic mental illness compared to participants without a mental illness.[62] E-cigarette

use did not differ significantly between participants with anxiety, depression, or emotional problems and participants with attention deficit disorder, bipolar disorder, schizophrenia, or other psychiatric disorders.[62]

An even more recent study addressed similar research questions using 2014-2017 NHIS data.[56] These results were consistent with our analysis indicating that SMI may be a risk factor for using both e-cigarettes and other tobacco products. Notably, the authors of that study defined SMI as a K6 score of 14 or higher, while other studies, including ours, used the 13-point cutoff.

Interpretation of Results

Taken together, the NHIS data indicate that it is the level of psychological distress, and not necessarily the underlying psychiatric diagnosis, that is associated with increased e-cigarette use. Similar trends are seen for traditional tobacco cigarettes because persons experiencing psychological distress turn to cigarettes as a way to self-medicate and alleviate psychiatric symptoms.[59,63] For example, among persons with schizophrenia, many patients report that their negative symptoms decrease when they smoke cigarettes, which is thought to be due to an increase in dopamine in the prefrontal cortex and nucleus accumbens.[64] In addition, the self-medication hypothesis has been used to explain increased rates of smoking among patients with bipolar disorder as a way to improve depressive symptoms.[65]

In the present study, the association between psychological distress and e-cigarette use was higher among never and former smokers compared to current smokers. It is possible that current smokers with mental illness are less likely to take up e-cigarettes because they are already self-medicating with traditional cigarettes. In contrast, never and former smokers do not have other sources of nicotine and thus may begin to use e-cigarettes to satisfy cravings and to decrease psychiatric symptoms.

Another possible explanation for the observed differences in results between current smokers and the other two groups is that current smokers may want to quit smoking combustible tobacco products and thus are more likely to use e-cigarettes regardless of their levels of psychological distress. Indeed, in a study conducted among current smokers with serious mental illness who had been hospitalized for exacerbation of psychiatric symptoms, rates of e-cigarette use increased over 18 months of follow-up and were significantly higher among participants who expressed a desire to quit smoking.[66] These results indicate that both current smoking status and a desire to quit smoking are associated with e-cigarette use, and that the desire to stop smoking may influence the association between psychiatric symptoms and e-cigarette use.

There is a concern that e-cigarettes may serve as a gateway to combustible tobacco product use among non-smokers with high levels of psychological distress. While no direct evidence exists for the gateway hypothesis among patients with mental illness, studies have shown that among adolescents and young people, e-cigarette use may result in increased tobacco cigarette use as they age.[67] A better understanding of the association between e-cigarettes and cigarette use among patients with SMI is warranted through longitudinal studies that are designed to track the use of these devices over time.

When comparing results across years, we found that results were similar in 2016 and 2017 compared to 2018 in never, former, and current smokers. In the 2018 dataset, however, never and former smokers had lower ORs for higher K6 score categories compared to 2016 and 2017. One explanation for the difference in results in 2018 among never and former smokers compared to current smokers is that current smokers are less likely to be swayed by regulations surrounding tobacco products compared to never and former smokers.

In a sensitivity analysis using a dichotomous categorization of K6 scores, we found that participants with serious mental illness (i.e. K6 scores of 13-24) had increased odds of using e-cigarettes

compared to participants without mental illness (i.e. K6 scores of 0-12). Patients with SMI are at high risk of psychiatric decompensation, and nicotine is associated with such decompensation.[68] A disadvantage of the dichotomous classification of K6 scores is that it does not allow assessing the associations with lower levels of psychological distress. We observed that subclinical psychological distress is an important determinant of e-cigarette use. Thus, by focusing on early signs of psychological distress, clinicians and public health officials can work to prevent and mitigate e-cigarette use in patients before they develop SMI.

Limitations and Future Directions

Perhaps the most important limitation of this study is its cross-sectional design, which precludes assessment of temporality and does not allow causal interpretation of the association between psychological distress and e-cigarette use. Further, the data in the NHIS are self-reported and therefore subject to both recall and social acceptability bias. Mental illness, psychological distress, and substance use are sensitive topics, and participants may not be willing to share data on levels of psychological distress or e-cigarette use. If e-cigarette use or levels of psychological distress were differentially under-reported, the results from this study could be affected by misclassification bias. In addition, the NHIS excludes prisoners and institutionalized individuals as well as persons who are homeless, three groups that are known to experience higher rates of substance use and mental illness.[69-71] While this exclusion does not affect the internal validity of the study, it does affect the generalizability of results.

Public Health Implications

There are several important public health implications of understanding the association between mental health and e-cigarettes. First, as e-cigarettes become more popular, it will be important to understand why patients, particularly patients with mental health diagnoses, use e-cigarettes. Among smokers, one study found that participants with SMI held positive beliefs regarding the effects of e-cigarettes on weight control and using e-cigarettes in a social setting; these beliefs were stronger in patients with SMI compared to persons without SMI.[72] Interestingly, patients with and without SMI had fewer negative beliefs about e-cigarettes, compared to their beliefs about traditional cigarettes.[72] Another study reported that current smokers with SMI enjoyed using e-cigarettes because they believed that e-cigarettes were healthier than tobacco cigarettes, did not have a foul odor, and reduced social stigma associated with smoking tobacco cigarettes.[33]

Our study found a weaker association between psychological distress and e-cigarette use among current smokers compared to the corresponding results among never and former smokers. The relationship between mental health and e-cigarette use among never smokers is of particular importance because this group could be a target for clinical and public health interventions that focus on reducing e-cigarette use and preventing other tobacco use. For example, one study showed that e-cigarette use was associated with poor mental health outcomes among non-smokers.[43] Interestingly, another study found that e-cigarette use was not significantly associated with later tobacco cigarette use; however, tobacco cigarette use was associated with later e-cigarette use.[73] In order to better understand the relationship between mental health and e-cigarettes among non-smokers, additional longitudinal studies are needed to identify factors that motivate non-smokers, particularly those with SMI, to try e-cigarettes and to understand their perceptions about the safety of e-cigarette use.

From the clinical perspective, it will be important to test counseling approaches to educate persons experiencing psychological distress about the deleterious health effects of e-cigarettes, the possibility for addiction, and the possibility of psychiatric symptom exacerbation. In addition, given that increasing levels of psychological distress appear to be associated with increased e-cigarette use, clinicians should consider screening patients, especially those with underlying mental health diagnoses, for psychological distress. Subclinical levels of distress could be treated before they are symptomatic, thereby preventing self-medication (through use of e-cigarette or other substances).

Ultimately, widespread policy is needed to regulate the sale and production of e-cigarettes in the United States. Given the relative novelty of e-cigarettes, there are not uniform regulatory policies at the national or global level.[74] In addition, e-cigarette companies are often owned by cigarette companies that view e-cigarettes as alternatives to cigarettes in places where cigarette smoking has become stigmatized and has thus decreased.[74] These companies market e-cigarettes as safer alternatives and have used enticing advertising campaigns to try to increase e-cigarette sales.[74] Such advertising may be especially appealing for patients who are experiencing psychological distress. For all of the above reasons, it is imperative that governments and regulatory agencies work together to restrict e-cigarette marketing to vulnerable populations, including patients with mental illness.

References

1. Adkison SE, O'Connor RJ, Bansal-Travers M, et al. Electronic nicotine delivery systems: international tobacco control four-country survey. *Am J Prev Med.* 2013;44(3):207-215.
2. Creamer MR, Wang TW, Babb S, et al. Tobacco Product Use and Cessation Indicators Among Adults - United States, 2018. *MMWR Morb Mortal Wkly Rep.* 2019;68(45):1013-1019.
3. Syamlal G, Jamal A, King BA, Mazurek JM. Electronic Cigarette Use Among Working Adults - United States, 2014. *MMWR Morb Mortal Wkly Rep.* 2016;65(22):557-561.
4. Layden JE, Ghinai I, Pray I, et al. Pulmonary Illness Related to E-Cigarette Use in Illinois and Wisconsin - Final Report. *New Engl J Med.* 2020;382(10):903-916.
5. Etter JF, Bullen C. Electronic cigarette: users profile, utilization, satisfaction and perceived efficacy. *Addiction.* 2011;106(11):2017-2028.
6. Polosa R, Caponnetto P, Morjaria JB, Papale G, Campagna D, Russo C. Effect of an electronic nicotine delivery device (e-Cigarette) on smoking reduction and cessation: a prospective 6-month pilot study. *BMC Public Health.* 2011;11:786.
7. Siegel MB, Tanwar KL, Wood KS. Electronic cigarettes as a smoking-cessation: tool results from an online survey. *Am J Prev Med.* 2011;40(4):472-475.
8. Chou SP, Goldstein RB, Smith SM, et al. The Epidemiology of DSM-5 Nicotine Use Disorder: Results From the National Epidemiologic Survey on Alcohol and Related Conditions-III. *J Clin Psychiatry.* 2016;77(10):1404-1412.
9. Prochaska JJ, Das S, Young-Wolff KC. Smoking, Mental Illness, and Public Health. *Annu Rev Public Health.* 2017;38:165-185.
10. Smith PH, Mazure CM, McKee SA. Smoking and mental illness in the U.S. population. *Tob Control.* 2014;23(e2):e147-153.
11. Esmaeelzadeh S, Moraros J, Thorpe L, Bird Y. Examining the Association and Directionality between Mental Health Disorders and Substance Use among Adolescents and Young Adults in the U.S. and Canada-A Systematic Review and Meta-Analysis. *J Clin Med.* 2018;7(12):543.
12. Cook BL, Wayne GF, Kafali EN, Liu Z, Shu C, Flores M. Trends in smoking among adults with mental illness and association between mental health treatment and smoking cessation. *JAMA.* 2014;311(2):172-182.
13. National Institute of Mental Health. NIHM.gov. https://www.nimh.nih.gov/health/statistics/mental-illness.shtml. Updated February 2019. Accessed May 12, 2020.
14. Hartz SM, Pato CN, Medeiros H, et al. Comorbidity of severe psychotic disorders with measures of substance use. *JAMA Psychiatry.* 2014;71(3):248-254.
15. Cooper J, Mancuso SG, Borland R, Slade T, Galletly C, Castle D. Tobacco smoking among people living with a psychotic illness: the second Australian Survey of Psychosis. *Aust N Z J Psychiatry.* 2012;46(9):851-863.
16. Lally J, Spaducci G, Gardner-Sood P, et al. Tobacco smoking and nicotine dependence in first episode and established psychosis. *Asian J Psychiatr.* 2019;43:125-131.
17. Iasevoli F, Balletta R, Gilardi V, Giordano S, de Bartolomeis A. Tobacco smoking in treatment-resistant schizophrenia patients is associated with impaired cognitive functioning, more severe negative symptoms, and poorer social adjustment. *Neuropsychiatr Dis Treat.* 2013;9:1113-1120.
18. Mallet J, Le Strat Y, Schurhoff F, et al. Tobacco smoking is associated with antipsychotic medication, physical aggressiveness, and alcohol use disorder in schizophrenia: results from the FACE-SZ national cohort. *Eur Arch Psychiatry Clin Neurosci.* 2019;269(4):449-457.
19. Krishnadas R, Jauhar S, Telfer S, Shivashankar S, McCreadie RG. Nicotine dependence and illness severity in schizophrenia. *Br J Psychiatry.* 2012;201(4):306-312.
20. Depp CA, Bowie CR, Mausbach BT, et al. Current smoking is associated with worse cognitive and adaptive functioning in serious mental illness. *Acta Psychiatr Scand.* 2015;131(5):333-341.

21. Jackson JG, Diaz FJ, Lopez L, de Leon J. A combined analysis of worldwide studies demonstrates an association between bipolar disorder and tobacco smoking behaviors in adults. *Bipolar Disord.* 2015;17(6):575-597.
22. Ostacher MJ, Lebeau RT, Perlis RH, et al. Cigarette smoking is associated with suicidality in bipolar disorder. *Bipolar Disord.* 2009;11(7):766-771.
23. Thomson D, Berk M, Dodd S, et al. Tobacco use in bipolar disorder. *Clin Psychopharmacol Neurosci.* 2015;13(1):1-11.
24. Dickerson F, Origoni A, Schroeder J, et al. Natural cause mortality in persons with serious mental illness. *Acta Psychiatr Scand.* 2018;137(5):371-379.
25. Dickerson F, Origoni A, Schroeder J, et al. Mortality in schizophrenia and bipolar disorder: Clinical and serological predictors. *Schizophr Res.* 2016;170(1):177-183.
26. Laursen TM. Life expectancy among persons with schizophrenia or bipolar affective disorder. *Schizophr Res.* 2011;131(1-3):101-104.
27. Hjorthoj C, Sturup AE, McGrath JJ, Nordentoft M. Years of potential life lost and life expectancy in schizophrenia: a systematic review and meta-analysis. *Lancet Psychiatry.* 2017;4(4):295-301.
28. Brown S, Inskip H, Barraclough B. Causes of the excess mortality of schizophrenia. *Br J Psychiatry.* 2000;177:212-217.
29. Colton CW, Manderscheid RW. Congruencies in increased mortality rates, years of potential life lost, and causes of death among public mental health clients in eight states. *Prev Chronic Dis.* 2006;3(2):A42.
30. Cummins SE, Zhu SH, Tedeschi GJ, Gamst AC, Myers MG. Use of e-cigarettes by individuals with mental health conditions. *Tob Control.* 2014;23 Suppl 3:iii48-53.
31. Spears CA, Jones DM, Weaver SR, Pechacek TF, Eriksen MP. Use of Electronic Nicotine Delivery Systems among Adults with Mental Health Conditions, 2015. *Int J Environ Res Public Health.* 2016;14(1):10.
32. Boyle RG, Richter S, Helgertz S. Who is using and why: Prevalence and perceptions of using and not using electronic cigarettes in a statewide survey of adults. *Addict Behav Rep.* 2019;10:100227.
33. Pratt SI, Sargent J, Daniels L, Santos MM, Brunette M. Appeal of electronic cigarettes in smokers with serious mental illness. *Addict Behav.* 2016;59:30-34.
34. Spears CA, Jones DM, Weaver SR, Pechacek TF, Eriksen MP. Motives and perceptions regarding electronic nicotine delivery systems (ENDS) use among adults with mental health conditions. *Addict Behav.* 2018;80:102-109.
35. Jaber RM, Mirbolouk M, DeFilippis AP, et al. Electronic Cigarette Use Prevalence, Associated Factors, and Pattern by Cigarette Smoking Status in the United States From NHANES (National Health and Nutrition Examination Survey) 2013-2014. *J Am Heart Assoc.* 2018;7(14):e008178.
36. Hefner KR, Sollazzo A, Mullaney S, Coker KL, Sofuoglu M. E-cigarettes, alcohol use, and mental health: Use and perceptions of e-cigarettes among college students, by alcohol use and mental health status. *Addict Behav.* 2019;91:12-20.
37. Riehm KE, Young AS, Feder KA, et al. Mental Health Problems and Initiation of E-cigarette and Combustible Cigarette Use. *Pediatrics.* 2019;144(1):e20182935.
38. Leventhal AM, Strong DR, Sussman S, et al. Psychiatric comorbidity in adolescent electronic and conventional cigarette use. *J Psychiatr Res.* 2016;73:71-78.
39. Wiernik E, Airagnes G, Lequy E, et al. Electronic cigarette use is associated with depressive symptoms among smokers and former smokers: Cross-sectional and longitudinal findings from the Constances cohort. *Addict Behav.* 2019;90:85-91.
40. Bandiera FC, Loukas A, Li X, Wilkinson AV, Perry CL. Depressive Symptoms Predict Current E-Cigarette Use Among College Students in Texas. *Nicotine Tob Res.* 2017;19(9):1102-1106.
41. Lechner WV, Janssen T, Kahler CW, Audrain-McGovern J, Leventhal AM. Bi-directional associations of electronic and combustible cigarette use onset patterns with depressive symptoms in adolescents. *Prev Med.* 2017;96:73-78.

42. Marsden DG, Loukas A, Chen B, Perry CL, Wilkinson AV. Associations between frequency of cigarette and alternative tobacco product use and depressive symptoms: A longitudinal study of young adults. *Addict Behav.* 2019;99:106078.
43. Pham T, Williams JVA, Bhattarai A, Dores AK, Isherwood LJ, Patten SB. Electronic cigarette use and mental health: A Canadian population-based study. *J Affect Disord.* 2020;260:646-652.
44. Saeed OB, Chavan B, Haile ZT. Association Between E-cigarette Use and Depression in US Adults. *J Addict Med.* 2020;14(5):393-400.
45. Obisesan OH, Mirbolouk M, Osei AD, et al. Association Between e-Cigarette Use and Depression in the Behavioral Risk Factor Surveillance System, 2016-2017. *JAMA Netw Open.* 2019;2(12):e1916800.
46. Miller BJ, Wang A, Wong J, Paletta N, Buckley PF. Electronic cigarette use in patients with schizophrenia: Prevalence and attitudes. *Ann Clin Psychiatry.* 2017;29(1):4-10.
47. Caponnetto P, Auditore R, Russo C, Cappello GC, Polosa R. Impact of an electronic cigarette on smoking reduction and cessation in schizophrenic smokers: a prospective 12-month pilot study. *Int J Environ Res Public Health.* 2013;10(2):446-461.
48. Gilbody S, Peckham E, Bailey D, et al. Smoking cessation for people with severe mental illness (SCIMITAR+): a pragmatic randomised controlled trial. *Lancet Psychiatry.* 2019;6(5):379-390.
49. Hickling LM, Perez-Iglesias R, McNeill A, et al. A pre-post pilot study of electronic cigarettes to reduce smoking in people with severe mental illness. *Psychol Med.* 2019;49(6):1033-1040.
50. Caponnetto P, DiPiazza J, Signorelli M, Maglia M, Polosa R. Existing and emerging smoking cessation options for people with schizophrenia spectrum disorders. *J Addict Dis.* 2018;37(3-4):279-290.
51. Kocar T, Freudenmann RW, Spitzer M, Graf H. Switching From Tobacco Smoking to Electronic Cigarettes and the Impact on Clozapine Levels. *J Clin Psychopharmacol.* 2018;38(5):528-529.
52. Khorassani F, Kaufman M, Lopez LV. Supatherapeutic Serum Clozapine Concentration After Transition From Traditional to Electronic Cigarettes. *J Clin Psychopharmacol.* 2018;38(4):391-392.
53. Food and Drug Administration, Department of Health and Human Services. Deeming Tobacco Products to be Subject to the Federal Food, Drug, and Cosmetic Act. Federal Register; 2016. Vol 81: 902016. Published on May 10, 2016. Accessed May 7, 2020.
54. Centers for Disease Control and Prevention. CDC.gov. About the National Health Interview Survey. https://www.cdc.gov/nchs/nhis/about_nhis.htm. Updated January 16, 2019. Accessed May 20, 2020.
55. Kessler RC, Barker PR, Colpe LJ, et al. Screening for serious mental illness in the general population. *Arch Gen Psychiatry.* 2003;60(2):184-189.
56. Weinberger AH, Zhu J, Barrington-Trimis JL, Wyka K, Goodwin RD. Cigarette use, e-cigarette use, and dual product use is higher among adults with serious psychological distress in the United States: 2014-2017. *Nicotine Tob Res.* 2020;22(10):1875-1882.
57. Park SH, Lee L, Shearston JA, Weitzman M. Patterns of electronic cigarette use and level of psychological distress. *PloS one.* 2017;12(3):e0173625.
58. Streck JM, Weinberger AH, Pacek LR, Gbedemah M, Goodwin RD. Cigarette Smoking Quit Rates Among Persons With Serious Psychological Distress in the United States From 2008 to 2016: Are Mental Health Disparities in Cigarette Use Increasing? *Nicotine Tob Res.* 2020;22(1):130-134.
59. Lawrence D, Williams JM. Trends in Smoking Rates by Level of Psychological Distress-Time Series Analysis of US National Health Interview Survey Data 1997-2014. *Nicotine Tob Res.* 2016;18(6):1463-1470.
60. Pratt LA. Serious psychological distress, as measured by the K6, and mortality. *Ann Epidemiol.* 2009;19(3):202-209.
61. Kessler RC, Green JG, Gruber MJ, et al. Screening for serious mental illness in the general population with the K6 screening scale: results from the WHO World Mental Health (WMH) survey initiative. *Int J Methods Psychiatr Res.* 2010;19(Suppl 1):4-22.
62. Bianco CL. Rates of electronic cigarette use among adults with a chronic mental illness. *Addict Behav.* 2019;89:1-4.
63. Degenhardt L, Hall W. The relationship between tobacco use, substance-use disorders and mental health: results from the National Survey of Mental Health and Well-being. *Nicotine Tob Res.* 2001;3(3):225-234.

64. Kumari V, Postma P. Nicotine use in schizophrenia: the self medication hypotheses. *Neurosci Biobehav Rev.* 2005;29(6):1021-1034.
65. Heffner JL, Strawn JR, DelBello MP, Strakowski SM, Anthenelli RM. The co-occurrence of cigarette smoking and bipolar disorder: phenomenology and treatment considerations. *Bipolar Disord.* 2011;13(5-6):439-453.
66. Prochaska JJ, Grana RA. E-cigarette use among smokers with serious mental illness. *PloS one.* 2014;9(11):e113013.
67. Chatterjee K, Alzghoul B, Innabi A, Meena N. Is vaping a gateway to smoking: a review of the longitudinal studies. *Int J Adolesc Med Health.* 2016;30(3):20160033.
68. Sagud M, Mihaljevic Peles A, Pivac N. Smoking in schizophrenia: recent findings about an old problem. *Curr Opin Psychiatry.* 2019;32(5):402-408.
69. Hawthorne WB, Folsom DP, Sommerfeld DH, et al. Incarceration among adults who are in the public mental health system: rates, risk factors, and short-term outcomes. *Psychiatr Serv.* 2012;63(1):26-32.
70. Fazel S, Geddes JR, Kushel M. The health of homeless people in high-income countries: descriptive epidemiology, health consequences, and clinical and policy recommendations. *Lancet.* 2014;384(9953):1529-1540.
71. Greenberg GA, Rosenheck RA. Jail incarceration, homelessness, and mental health: a national study. *Psychiatr Serv.* 2008;59(2):170-177.
72. Miller ME, Tidey JW, Rohsenow DJ, Higgins ST. Electronic Cigarette Expectancies in Smokers with Psychological Distress. *Tob Regul Sci.* 2017;3(1):108-114.
73. Selya AS, Rose JS, Dierker L, Hedeker D, Mermelstein RJ. Evaluating the mutual pathways among electronic cigarette use, conventional smoking and nicotine dependence. *Addiction.* 2018;113(2):325-333.
74. Stone E, Marshall H. Tobacco and electronic nicotine delivery systems regulation. *Transl Lung Cancer Res.* 2019;8(Suppl 1):S67-S76.

Tables and Figures

Figure 1. Participant selection and inclusion criteria.

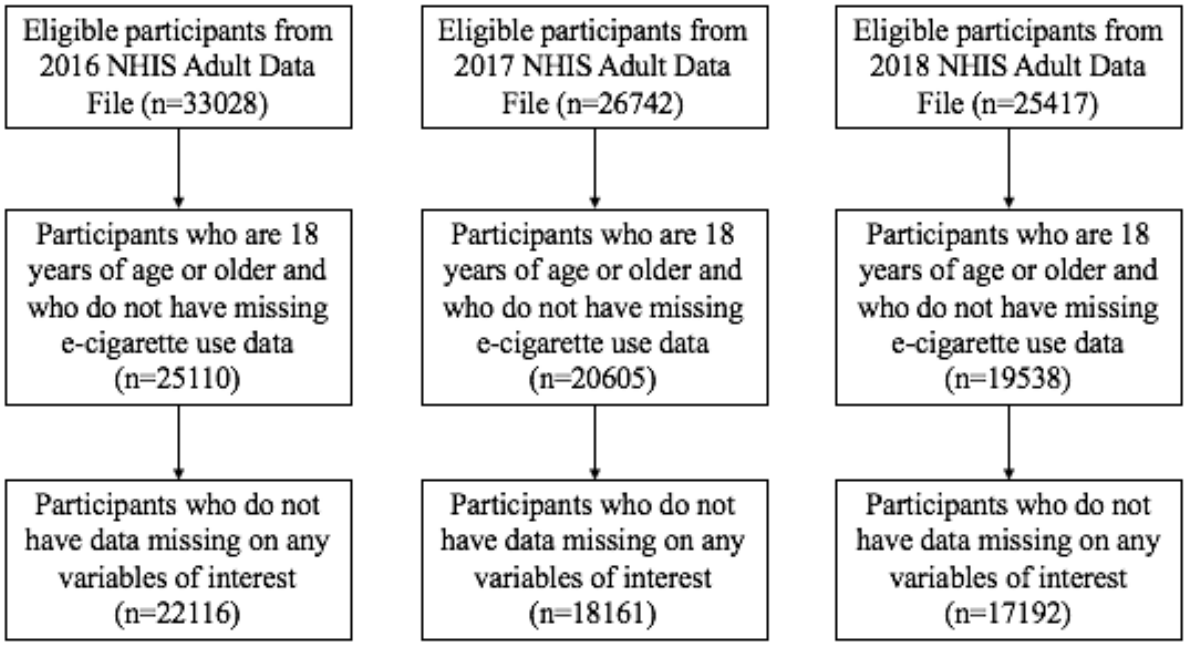

Table 1a. Descriptive characteristics of ever and never e-cigarette users, NHIS 2016.

Participant Characteristics	Ever E-cigarette Users (n=3,290, 15.3%)	Never E-cigarette Users (n=18,826, 84.7%)	Total (n=22,116)
K6 Score			
0	941 (4.7%)	8676 (40.2%)	9617 (44.9%)
1-2	644 (3.1%)	4212 (19.1%)	4856 (22.2%)
3-5	705 (3.1%)	3051 (13.5%)	3756 (16.5%)
6-10	602 (2.9%)	1910 (7.9%)	2512 (10.8%)
11-24	398 (1.7%)	977 (4.0%)	1375 (5.6%)
Sex			
Male	1599 (7.6%)	8786 (39.6%)	10385 (47.2%)
Female	1691 (7.8%)	10040 (45.0%)	11731 (52.8%)
Region			
Northeast	605 (2.7%)	3353 (15.3%)	3958 (18.0%)
Midwest	705 (3.2%)	3998 (18.1%)	4703 (21.3%)
South	1128 (5.3%)	6504 (29.0%)	7632 (34.3%)
West	852 (4.1%)	4971 (22.3%)	5823 (26.4%)
Age Category			
18-24	377 (1.8%)	2074 (9.3%)	2451 (11.2%)
25-34	567 (2.6%)	3129 (14.5%)	3696 (17.1%)
35-44	536 (2.5%)	3161 (14.0%)	3697 (16.5%)
45-54	539 (2.5%)	3323 (15.0%)	3862 (17.5%)
55-64	541 (2.6%)	3158 (14.2%)	3699 (16.7%)
65+	730 (3.3%)	3981 (17.7%)	4711 (21.1%)
Race/Ethnicity			
Non-Hispanic White	2253 (10.5%)	12796 (57.8%)	15049 (68.3%)
Non-Hispanic Black	331 (1.5%)	1919 (8.5%)	2250 (10.0%)
Asian	194 (0.9%)	1095 (5.1%)	1289 (6.0%)
Hispanic	462 (2.2%)	2722 (11.9%)	3184 (14.1%)
Other	50 (0.3%)	294 (1.4%)	344 (1.7%)
Marital Status			
Married/Living with Partner	2019 (9.3%)	11586 (51.9%)	13605 (61.2%)
Separated/Divorced	385 (1.8%)	2189 (9.7%)	2574 (11.5%)
Widowed	199 (0.9%)	1110 (5.0%)	1309 (5.9%)
Never Married	687 (3.3%)	3941 (18.1%)	4628 (21.4%)
Insurance Status			
Private Insurance	2277 (10.5%)	12842 (57.8%)	15119 (68.3%)
Medicaid	326 (1.6%)	2005 (9.2%)	2331 (10.8%)
Medicare/Dual Enrolled	360 (1.6%)	2084 (9.3%)	2444 (11.0%)
Uninsured	327 (1.7%)	1895 (8.4%)	2222 (10.0%)
Highest Level of Education			
Did not finish high school	439 (2.1%)	2543 (11.4%)	2982 (13.4%)
GED/high school diploma	883 (4.1%)	4975 (22.2%)	5858 (26.3%)

Some college/associate degree	989 (4.6%)	5620 (25.6%)	6609 (30.1%)
Bachelor's Degree	628 (2.9%)	3607 (16.1%)	4235 (19.1%)
Higher education	351 (1.6%)	2081 (9.4%)	2432 (11.0%)
Employment			
Employed in past year	2450 (11.9%)	11607 (56.1%)	14057 (68.0%)
Not employed in past year	767 (3.1%)	6334 (23.8%)	7101 (26.9%)
Never employed	73 (0.4%)	885 (4.7%)	958 (5.1%)
Alcohol Use			
Lifetime abstainer	176 (0.9%)	3911 (18.3%)	4087 (19.1%)
Former User	459 (1.9%)	2973 (11.8%)	3432 (13.7%)
Current User	2655 (12.6%)	11942 (54.6%)	14597 (67.2%)
Cigarette Use			
Never Smoker	653 (3.7%)	12417 (58.5%)	13070 (62.3%)
Former Smoker	799 (3.7%)	4695 (18.9%)	5494 (22.6%)
Current Smoker	1838 (8.0%)	1714 (7.2%)	3552 (15.2%)

Table 1b. Descriptive characteristics of ever and never e-cigarette users, NHIS 2017.

Participant Characteristics	Ever E-cigarette Users (n=2,597, 14.1%)	Never E-cigarette Users (n=15,564, 85.9%)	Total (n=18,161)
K6 Score			
0	687 (3.9%)	7046 (40.3%)	7733 (44.2%)
1-2	501 (2.7%)	3449 (18.5%)	3950 (21.2%)
3-5	570 (3.0%)	2622 (14.2%)	3192 (17.2%)
6-10	522 (2.9%)	1706 (9.2%)	2228 (12.1%)
11-24	317 (1.7%)	741 (3.8%)	1058 (5.4%)
Sex			
Male	1179 (6.4%)	7289 (40.1%)	8468 (46.5%)
Female	1418 (7.7%)	8275 (45.8%)	9693 (53.5%)
Region			
Northeast	465 (2.6%)	2624 (14.7%)	3089 (17.3%)
Midwest	608 (3.5%)	3545 (19.7%)	4153 (23.1%)
South	918 (4.8%)	5687 (31.4%)	6605 (36.2%)
West	606 (3.3%)	3708 (20.1%)	4314 (23.4%)
Age Category			
18-24	309 (1.8%)	1709 (9.4%)	2018 (11.2%)
25-34	425 (2.3%)	2561 (14.3%)	2986 (16.6%)
35-44	391 (2.1%)	2502 (14.0%)	2893 (16.1%)
45-54	478 (2.6%)	2727 (14.8%)	3205 (17.4%)
55-64	421 (2.3%)	2695 (14.8%)	3116 (17.1%)
65+	573 (3.0%)	3370 (18.6%)	3943 (21.6%)
Race/Ethnicity			
Non-Hispanic White	1785 (9.9%)	10640 (58.7%)	12425 (68.5%)
Non-Hispanic Black	258 (1.3%)	1673 (9.3%)	1931 (10.6%)
Asian	160 (0.9%)	895 (4.9%)	1055 (5.8%)
Hispanic	358 (1.9%)	2169 (11.9%)	2527 (13.8%)
Other	36 (0.2%)	187 (1.1%)	223 (1.3%)
Marital Status			
Married/Living with Partner	1556 (8.5%)	9559 (52.6%)	11115 (61.2%)
Separated/Divorced	307 (1.7%)	1845 (10.3%)	2152 (12.0%)
Widowed	158 (0.8%)	911 (5.0%)	1069 (5.8%)
Never Married	576 (3.1%)	3249 (18.0%)	3825 (21.1%)
Insurance Status			
Private Insurance	1729 (9.6%)	10643 (58.8%)	12372 (68.4%)
Medicaid	280 (1.6%)	1581 (8.7%)	1861 (10.3%)
Medicare/Dual Enrolled	307 (1.5%)	1808 (10.0%)	2115 (11.5%)
Uninsured	281 (1.4%)	1532 (8.4%)	1813 (9.8%)
Highest Level of Education			
Did not finish high school	317 (1.7%)	1796 (9.9%)	2113 (11.6%)
GED/high school diploma	657 (3.5%)	3989 (22.4%)	4646 (26.0%)

Some college/associate degree	758 (4.1%)	4736 (25.6%)	5494 (29.7%)
Bachelor's Degree	536 (3.0%)	3128 (17.4%)	3664 (20.4%)
Higher education	329 (1.8%)	1915 (10.6%)	2244 (12.4%)
Employment			
Employed in past year	1944 (10.8%)	9799 (58.4%)	11743 (69.2%)
Not employed in past year	587 (2.8%)	5060 (22.9%)	5647 (25.8%)
Never employed	66 (0.5%)	705 (4.6%)	771 (5.0%)
Alcohol Use			
Lifetime abstainer	135 (0.8%)	3088 (18.9%)	3223 (19.7%)
Former User	385 (1.9%)	2345 (11.4%)	2730 (13.2%)
Current User	2077 (11.4%)	10131 (55.6%)	12208 (67.1%)
Cigarette Use			
Never Smoker	558 (3.4%)	10388 (60.3%)	10946 (63.7%)
Former Smoker	668 (3.6%)	3841 (18.8%)	4509 (22.4%)
Current Smoker	1371 (7.1%)	1335 (6.7%)	2706 (13.9%)

Table 1c. Descriptive characteristics of ever and never e-cigarette users, NHIS 2018.

Participant Characteristics	Ever E-cigarette Users (n=2,501, 15.1%)	Never E-cigarette Users (n=14,691, 84.9%)	Total (n=17,192)
K6 Score			
0	638 (4.0%)	6374 (37.3%)	7012 (41.2%)
1-2	533 (3.1%)	3370 (19.2%)	3903 (22.3%)
3-5	517 (3.2%)	2540 (14.7%)	3057 (17.9%)
6-10	505 (3.2%)	1633 (9.3%)	2138 (12.5%)
11-24	308 (1.7%)	774 (4.4%)	1082 (6.1%)
Sex			
Male	1120 (6.9%)	6864 (39.7%)	7984 (46.6%)
Female	1381 (8.3%)	7827 (45.1%)	9208 (53.4%)
Region			
Northeast	396 (2.3%)	2346 (13.4%)	2742 (15.7%)
Midwest	542 (3.4%)	3320 (19.0%)	3862 (22.4%)
South	965 (5.8%)	5379 (31.4%)	6344 (37.3%)
West	598 (3.6%)	3646 (21.0%)	4244 (24.6%)
Age Category			
18-24	279 (1.8%)	1558 (9.1%)	1837 (10.8%)
25-34	414 (2.5%)	2381 (13.8%)	2795 (16.3%)
35-44	382 (2.2%)	2434 (13.9%)	2816 (16.1%)
45-54	437 (2.7%)	2620 (15.0%)	3057 (17.7%)
55-64	416 (2.5%)	2479 (14.3%)	2895 (16.8%)
65+	573 (3.4%)	3219 (18.9%)	3792 (22.3%)
Race/Ethnicity			
Non-Hispanic White	1665 (10.3%)	9782 (56.6%)	11447 (66.8%)
Non-Hispanic Black	260 (1.5%)	1481 (8.7%)	1741 (10.2%)
Asian	151 (1.0%)	969 (5.6%)	1120 (6.6%)
Hispanic	386 (2.2%)	2238 (12.7%)	2624 (14.8%)
Other	39 (0.2%)	221 (1.4%)	260 (1.6%)
Marital Status			
Married/Living with Partner	1547 (9.4%)	9148 (52.8%)	10695 (62.2%)
Separated/Divorced	290 (1.8%)	1616 (9.5%)	1906 (11.3%)
Widowed	148 (0.9%)	851 (4.9%)	999 (5.8%)
Never Married	516 (3.1%)	3076 (17.7%)	3592 (20.8%)
Insurance Status			
Private Insurance	1670 (10.1%)	10007 (57.6%)	11677 (67.7%)
Medicaid	250 (1.5%)	1562 (9.3%)	1812 (10.8%)
Medicare/Dual Enrolled	310 (1.9%)	1674 (9.7%)	1984 (11.6%)
Uninsured	271 (1.7%)	1448 (8.2%)	1719 (10.0%)
Highest Level of Education			
Did not finish high school	325 (2.0%)	1771 (10.0%)	2096 (11.9%)
GED/high school diploma	629 (3.8%)	3622 (21.1%)	4251 (24.9%)

Some college/associate degree	720 (4.5%)	4393 (25.7%)	5113 (30.3%)
Bachelor's Degree	510 (3.1%)	3044 (17.4%)	3554 (20.5%)
Higher education	317 (1.8%)	1861 (10.7%)	2178 (12.5%)
Employment			
Employed in past year	1899 (12.0%)	9149 (57.4%)	11048 (69.4%)
Not employed in past year	552 (2.7%)	4889 (22.9%)	5441 (25.7%)
Never employed	50 (0.4%)	653 (4.6%)	703 (4.9%)
Alcohol Use			
Lifetime abstainer	146 (1.0%)	2913 (18.7%)	3059 (19.7%)
Former User	351 (1.7%)	2335 (11.9%)	2686 (13.6%)
Current User	2004 (12.4%)	9443 (54.3%)	11447 (66.7%)
Cigarette Use			
Never Smoker	585 (4.2%)	9827 (60.0%)	10412 (64.3%)
Former Smoker	680 (4.0%)	3533 (17.8%)	4213 (21.8%)
Current Smoker	1236 (6.9%)	1331 (7.0%)	2567 (13.9%)

Figure 2a. Adjusted odds ratios by K6 score with 95% CI by smoking status: Never Smokers, 2016-2018 NHIS.

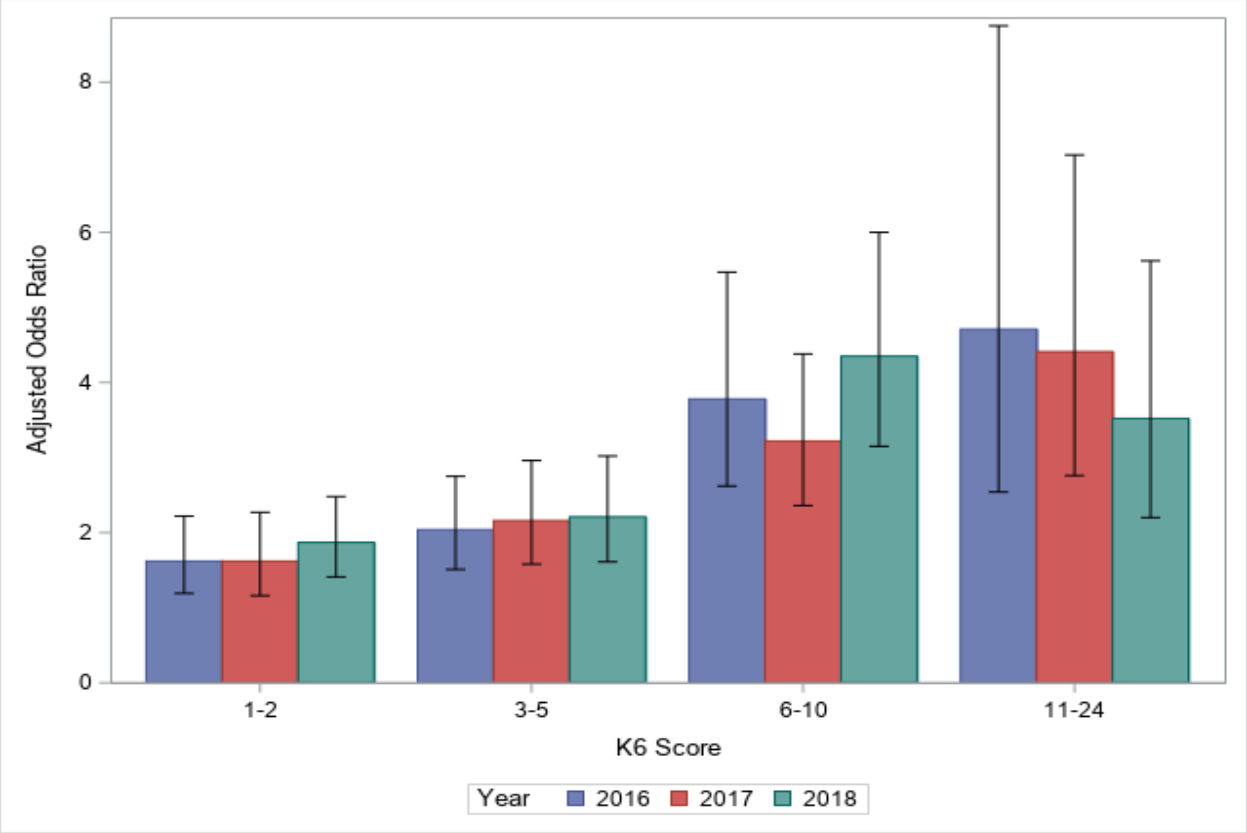

Figure 2b. Adjusted odds ratios by K6 score with 95% CI by smoking status: Former Smokers, 2016-2018 NHIS.

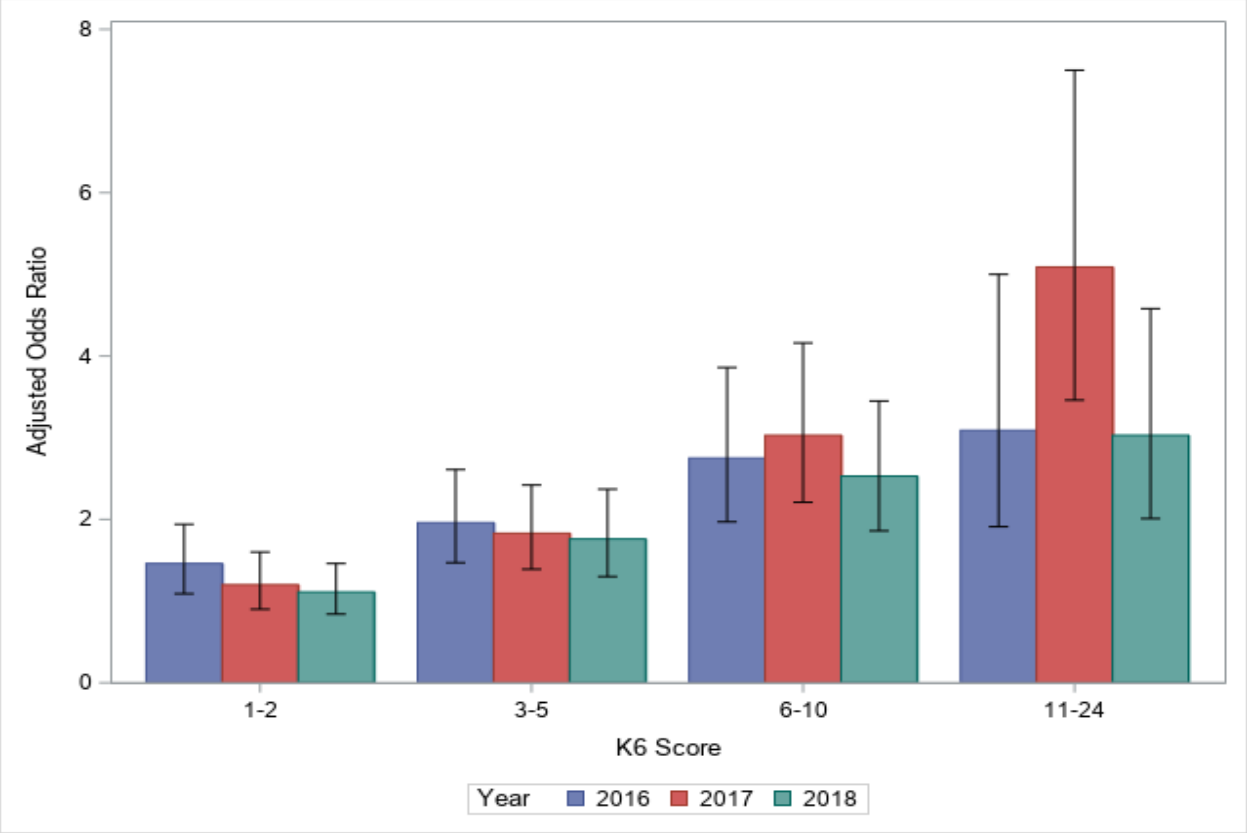

Figure 2c. Adjusted odds ratios by K6 score with 95% CI by smoking status: Current Smokers, 2016-2018 NHIS.

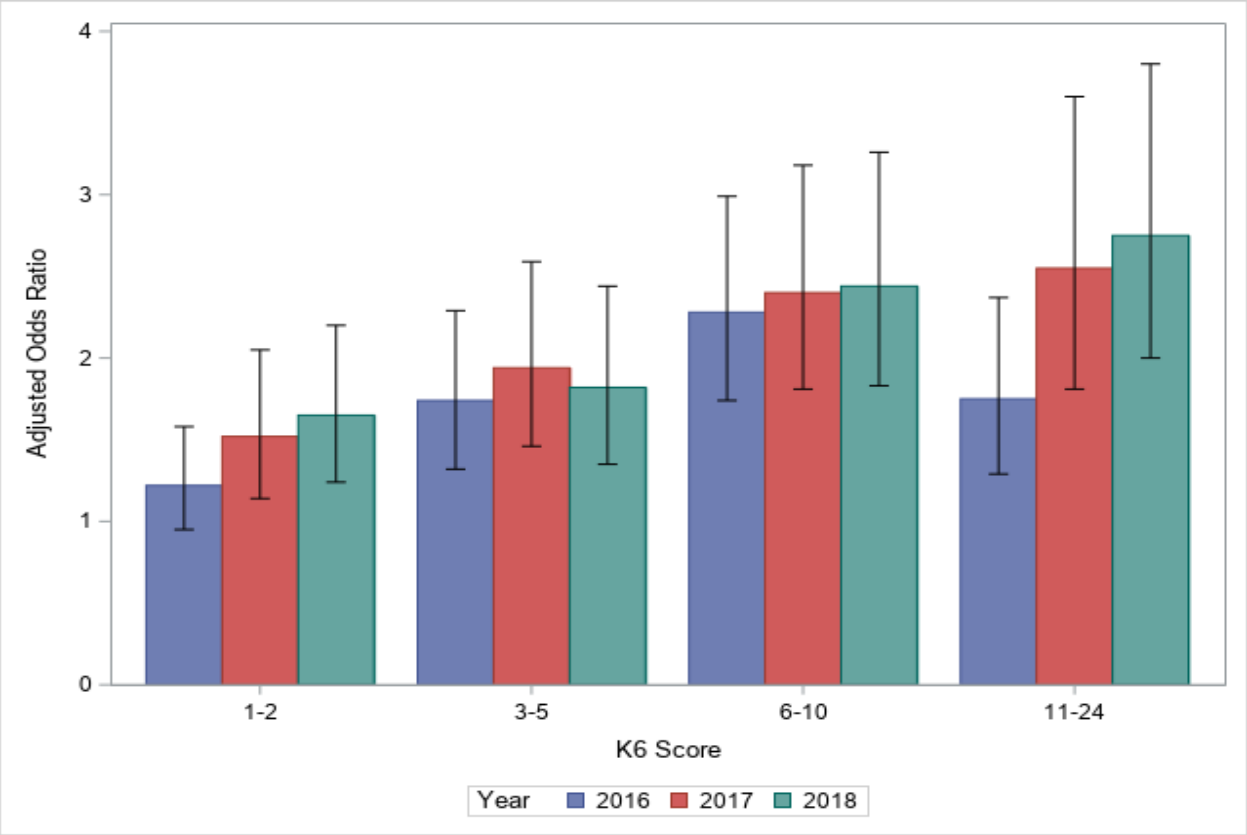

Table 2a. Multivariable Analyses of Factors Associated with Electronic Cigarette Use, 2016 NHIS.

Participant Characteristics	Never smokers (n=13,070)		Former smokers (n=5,494)		Current smokers (n=3,552)	
	OR	95% CI	OR	95% CI	OR	95% CI
K6 score						
0	Ref		Ref		Ref	
1-2	1.62	(1.19-2.22)	1.46	(1.09-1.94)	1.22	(0.95-1.58)
3-5	2.04	(1.51-2.75)	1.96	(1.47-2.61)	1.74	(1.32-2.29)
6-10	3.78	(2.62-5.47)	2.75	(1.97-3.86)	2.28	(1.74-2.99)
11-24	4.71	(2.54-8.75)	3.09	(1.91-5.00)	1.75	(1.29-2.37)
Sex						
Male	Ref		Ref		Ref	
Female	0.85	(0.67-1.07)	0.77	(0.63-0.95)	0.98	(0.82-1.17)
Region						
Northeast	Ref		Ref		Ref	
Midwest	0.70	(0.49-1.01)	1.32	(0.95-1.83)	1.35	(1.00-1.82)
South	0.77	(0.54-1.09)	1.23	(0.91-1.65)	1.29	(0.98-1.72)
West	0.71	(0.49-1.02)	1.21	(0.87-1.68)	1.23	(0.92-1.64)
Age						
18-24	Ref		Ref		Ref	
25-34	1.04	(0.60-1.78)	1.14	(0.73-1.77)	0.77	(0.53-1.11)
35-44	1.05	(0.63-1.76)	1.04	(0.66-1.63)	0.70	(0.47-1.04)
45-54	1.00	(0.60-1.67)	1.13	(0.71-1.82)	0.63	(0.42-0.94)
55-65	1.24	(0.70-2.19)	0.99	(0.61-1.62)	0.72	(0.47-1.10)
65+	1.03	(0.58-1.84)	1.26	(0.75-2.11)	0.82	(0.53-1.29)
Race/ethnicity						
Non-Hispanic White	Ref		Ref		Ref	
Non-Hispanic Black	0.75	(0.49-1.16)	1.14	(0.83-1.58)	0.98	(0.70-1.36)
Asian	1.15	(0.71-1.87)	0.93	(0.59-1.45)	0.82	(0.53-1.28)
Hispanic	1.18	(0.81-1.72)	1.16	(0.84-1.61)	0.91	(0.68-1.21)
Other	1.08	(0.35-3.35)	1.98	(0.77-5.10)	0.74	(0.39-1.41)
Marital status						
Married/w partner	Ref		Ref		Ref	
Separated/divorced	1.31	(0.93-1.83)	1.15	(0.81-1.62)	0.91	(0.68-1.20)
Widowed	1.41	(0.82-2.43)	1.10	(0.70-1.72)	0.94	(0.61-1.44)
Never married	1.35	(0.93-1.96)	1.06	(0.79-1.42)	0.73	(0.55-0.98)
Insurance Status						
Private Insurance	Ref		Ref		Ref	
Medicaid	0.95	(0.60-1.51)	1.31	(0.93-1.85)	0.77	(0.54-1.10)
Medicare/Dual Enrolled	0.95	(0.57-1.59)	1.02	(0.63-1.63)	0.76	(0.52-1.13)
Uninsured	1.19	(0.77-1.84)	1.28	(0.86-1.88)	0.93	(0.66-1.30)
Highest Level of Education						
Did not finish high school	Ref		Ref		Ref	

GED/high school diploma	1.24	(0.82-1.89)	0.99	(0.69-1.42)	1.18	(0.87-1.59)
Some college/associate degree	1.30	(0.88-1.92)	1.06	(0.73-1.54)	1.03	(0.75-1.40)
Bachelor's degree	1.32	(0.85-2.06)	1.09	(0.72-1.66)	0.88	(0.62-1.24)
Higher education	1.18	(0.71-1.95)	1.11	(0.70-1.78)	1.01	(0.69-1.47)
Employment						
Yes within 1 year	Ref		Ref		Ref	
No within 1 year	0.26	(0.16-0.41)	0.34	(0.27-0.43)	0.67	(0.55-0.83)
Never worked	0.86	(0.46-1.59)	0.50	(0.22-1.12)	0.48	(0.25-0.92)
Alcohol Use						
Lifetime Abstainer	Ref		Ref		Ref	
Former User	1.51	(0.85-2.68)	1.23	(0.62-2.45)	1.65	(1.12-2.45)
Current User	3.45	(2.29-5.20)	2.03	(1.06-3.89)	2.16	(1.52-3.08)

Table 2b. Multivariable Analyses of Factors Associated with Electronic Cigarette Use, 2017 NHIS.

Participant Characteristics	Never smokers (n=10,946)		Former smokers (n=4,509)		Current smokers (n=2,706)	
	OR	95% CI	OR	95% CI	OR	95% CI
K6 score						
0	Ref		Ref		Ref	
1-2	1.62	(1.16-2.27)	1.20	(0.90-1.60)	1.52	(1.14-2.05)
3-5	2.16	(1.58-2.96)	1.83	(1.39-2.42)	1.94	(1.46-2.59)
6-10	3.22	(2.36-4.38)	3.03	(2.21-4.16)	2.40	(1.81-3.18)
11-24	4.41	(2.76-7.03)	5.09	(3.46-7.50)	2.55	(1.81-3.60)
Sex						
Male	Ref		Ref		Ref	
Female	1.20	(0.93-1.54)	1.08	(0.87-1.33)	0.97	(0.79-1.18)
Region						
Northeast	Ref		Ref		Ref	
Midwest	1.25	(0.86-1.83)	0.76	(0.55-1.06)	0.91	(0.66-1.26)
South	1.21	(0.88-1.67)	0.74	(0.56-0.99)	0.89	(0.65-1.22)
West	1.00	(0.68-1.47)	0.70	(0.51-0.98)	0.97	(0.71-1.33)
Age						
18-24	Ref		Ref		Ref	
25-34	1.17	(0.72-1.89)	0.65	(0.44-0.96)	0.80	(0.53-1.22)
35-44	0.97	(0.58-1.61)	0.66	(0.43-1.01)	0.71	(0.46-1.11)
45-54	1.03	(0.60-1.75)	1.03	(0.70-1.52)	0.89	(0.57-1.38)
55-65	1.18	(0.71-1.98)	0.70	(0.45-1.07)	0.79	(0.51-1.23)
65+	1.39	(0.74-2.63)	0.84	(0.53-1.32)	0.66	(0.39-1.11)
Race/ethnicity						
Non-Hispanic White	Ref		Ref		Ref	
Non-Hispanic Black	0.70	(0.47-1.04)	0.78	(0.54-1.15)	0.74	(0.51-1.07)
Asian	0.94	(0.56-1.58)	1.08	(0.69-1.67)	0.84	(0.57-1.23)
Hispanic	0.86	(0.57-1.28)	0.92	(0.65-1.30)	0.86	(0.64-1.17)
Other	0.99	(0.46-2.14)	2.07	(0.89-4.83)	0.77	(0.33-1.79)
Marital status						
Married/w partner	Ref		Ref		Ref	
Separated/divorced	0.83	(0.60-1.16)	1.01	(0.73-1.40)	1.01	(0.74-1.36)
Widowed	1.26	(0.80-1.98)	0.89	(0.53-1.52)	0.94	(0.61-1.46)
Never married	1.30	(0.89-1.90)	1.25	(0.93-1.70)	0.75	(0.56-1.01)
Insurance Status						
Private Insurance	Ref		Ref		Ref	
Medicaid	1.30	(0.89-1.90)	1.19	(0.81-1.73)	1.39	(1.01-1.92)
Medicare/Dual Enrolled	0.89	(0.56-1.41)	0.94	(0.62-1.41)	0.90	(0.59-1.38)
Uninsured	1.03	(0.68-1.56)	1.14	(0.79-1.64)	1.21	(0.86-1.70)
Highest Level of Education						
Did not finish high school	Ref		Ref		Ref	

GED/high school diploma	0.82	(0.54-1.22)	1.12	(0.74-1.69)	0.76	(0.54-1.08)
Some college/associate degree	0.97	(0.65-1.44)	1.11	0.76-1.62)	0.75	(0.52-1.08)
Bachelor's degree	1.15	(0.75-1.76)	1.13	(0.73-1.74)	0.81	(0.54-1.20)
Higher education	0.95	(0.60-1.50)	1.19	(0.74-1.93)	0.76	(0.52-1.12)
Employment						
Yes within 1 year	Ref		Ref		Ref	
No within 1 year	0.38	(0.25-0.56)	0.38	(0.30-0.48)	0.58	(0.46-0.73)
Never worked	1.51	(0.78-2.91)	0.56	(0.23-1.37)	0.81	(0.41-1.57)
Alcohol Use						
Lifetime Abstainer	Ref		Ref		Ref	
Former User	1.97	(1.07-3.63)	0.92	(0.53-1.62)	2.13	(1.41-3.21)
Current User	4.41	(2.72-7.16)	1.31	(0.76-2.27)	2.64	(1.83-3.82)

Table 2c. Multivariable Analyses of Factors Associated with Electronic Cigarette Use, 2018 NHIS.

Participant Characteristics	Never smokers (n=10,412)		Former smokers (n=4,213)		Current smokers (n=2,567)	
	OR	95% CI	OR	95% CI	OR	95% CI
K6 score						
0	Ref		Ref		Ref	
1-2	1.87	(1.41-2.48)	1.11	(0.84-1.46)	1.65	(1.24-2.20)
3-5	2.21	(1.61-3.02)	1.76	(1.30-2.37)	1.82	(1.35-2.44)
6-10	4.35	(3.15-6.00)	2.53	(1.86-3.45)	2.44	(1.83-3.26)
11-24	3.52	(2.20-5.62)	3.03	(2.01-4.58)	2.75	(2.00-3.80)
Sex						
Male	Ref		Ref		Ref	
Female	0.97	(0.79-1.20)	1.05	(0.85-1.29)	0.95	(0.77-1.16)
Region						
Northeast	Ref		Ref		Ref	
Midwest	1.21	(0.84-1.76)	0.84	(0.60-1.19)	1.00	(0.70-1.43)
South	1.25	(0.87-1.78)	0.77	(0.56-1.07)	1.11	(0.80-1.53)
West	1.08	(0.76-1.53)	0.84	(0.59-1.20)	1.03	(0.74-1.44)
Age						
18-24	Ref		Ref		Ref	
25-34	0.88	(0.57-1.37)	1.03	(0.66-1.60)	0.63	(0.42-0.94)
35-44	0.92	(0.58-1.47)	0.48	(0.29-0.81)	0.75	(0.49-1.15)
45-54	0.79	(0.49-1.26)	0.77	(0.49-1.22)	0.75	(0.49-1.16)
55-65	0.91	(0.58-1.42)	0.71	(0.45-1.12)	0.76	(0.50-1.18)
65+	0.80	(0.45-1.42)	0.68	(0.40-1.15)	0.67	(0.41-1.12)
Race/ethnicity						
Non-Hispanic White	Ref		Ref		Ref	
Non-Hispanic Black	1.00	(0.68-1.47)	1.10	(0.74-1.64)	0.87	(0.63-1.21)
Asian	0.85	(0.54-1.33)	1.12	(0.73-1.72)	1.04	(0.70-1.54)
Hispanic	0.75	(0.56-1.02)	0.90	(0.64-1.26)	0.98	(0.74-1.30)
Other	0.63	(0.26-1.53)	1.36	(0.73-2.54)	0.94	(0.36-2.47)
Marital status						
Married/w partner	Ref		Ref		Ref	
Separated/divorced	1.07	(0.77-1.48)	1.07	(0.75-1.53)	1.06	(0.78-1.43)
Widowed	1.18	(0.75-1.86)	0.96	(0.58-1.58)	0.91	(0.56-1.47)
Never married	0.87	(0.65-1.17)	0.88	(0.63-1.22)	0.92	(0.68-1.27)
Insurance Status						
Private Insurance	Ref		Ref		Ref	
Medicaid	0.98	(0.66-1.44)	0.73	(0.48-1.10)	1.11	(0.78-1.57)
Medicare/Dual Enrolled	1.06	(0.66-1.69)	0.97	(0.62-1.50)	1.28	(0.82-2.01)
Uninsured	1.27	(0.90-1.79)	1.00	(0.65-1.54)	1.11	(0.78-1.58)
Highest Level of Education						
Did not finish high school	Ref		Ref		Ref	

GED/high school diploma	0.73	(0.51-1.05)	0.96	(0.65-1.40)	1.15	(0.80-1.64)
Some college/associate degree	0.86	(0.61-1.21)	0.81	(0.54-1.22)	0.98	(0.69-1.38)
Bachelor's degree	0.74	(0.51-1.08)	0.83	(0.54-1.28)	1.17	(0.79-1.73)
Higher education	0.77	(0.52-1.16)	0.77	(0.48-1.22)	1.06	(0.70-1.60)
Employment						
Yes within 1 year	Ref		Ref		Ref	
No within 1 year	0.40	(0.28-0.58)	0.28	(0.22-0.36)	0.64	(0.52-0.79)
Never worked	1.06	(0.62-1.79)	0.37	(0.14-1.02)	0.58	(0.29-1.17)
Alcohol Use						
Lifetime Abstainer	Ref		Ref		Ref	
Former User	0.68	(0.37-1.24)	0.94	(0.52-1.71)	1.48	(0.96-2.29)
Current User	2.83	(2.02-3.98)	1.40	(0.80-2.46)	1.87	(1.28-2.73)

Supplemental Table 1a. Multivariable Analyses of Factors Associated with Electronic Cigarette Use with K6 as a Dichotomous Variable, 2016 NHIS.

Participant Characteristics	Never smokers (n=13,070)		Former smokers (n=5,494)		Current smokers (n=3,552)	
	OR	95% CI	OR	95% CI	OR	95% CI
K6 score						
0-12	Ref		Ref		Ref	
13-24	3.15	(1.59-6.24)	2.14	(1.22-3.75)	1.40	(1.01-1.94)
Sex						
Male	Ref		Ref		Ref	
Female	0.87	(0.68-1.10)	0.77	(0.63-0.95)	0.99	(0.83-1.18)
Region						
Northeast	Ref		Ref		Ref	
Midwest	0.72	(0.51-1.04)	1.30	(0.94-1.79)	1.33	(0.97-1.80)
South	0.79	(0.55-1.12)	1.22	(0.91-1.64)	1.24	(0.93-1.66)
West	0.74	(0.51-1.05)	1.20	(0.86-1.67)	1.20	(0.89-1.62)
Age						
18-24	Ref		Ref		Ref	
25-34	1.03	(0.58-1.82)	1.14	(0.74-1.76)	0.77	(0.54-1.11)
35-44	1.06	(0.63-1.76)	1.06	(0.67-1.66)	0.69	(0.46-1.02)
45-54	0.96	(0.57-1.62)	1.13	(0.71-1.82)	0.63	(0.43-0.94)
55-65	1.22	(0.70-2.16)	1.01	(0.62-1.65)	0.73	(0.48-1.11)
65+	1.00	(0.55-1.79)	1.25	(0.75-2.09)	0.83	(0.53-1.29)
Race/ethnicity						
Non-Hispanic White	Ref		Ref		Ref	
Non-Hispanic Black	0.76	(0.49-1.17)	1.13	(0.82-1.56)	0.98	(0.71-1.36)
Asian	1.21	(0.76-1.93)	1.01	(0.66-1.54)	0.81	(0.52-1.27)
Hispanic	1.18	(0.81-1.72)	1.16	(0.84-1.61)	0.90	(0.68-1.21)
Other	1.06	(0.36-3.17)	1.86	(0.78-4.44)	0.71	(0.40-1.28)
Marital status						
Married/w partner	Ref		Ref		Ref	
Separated/divorced	1.25	(0.89-1.75)	1.14	(0.81-1.62)	0.91	(0.68-1.21)
Widowed	1.43	(0.80-2.53)	1.04	(0.67-1.63)	0.88	(0.57-1.35)
Never married	1.36	(0.93-1.98)	1.07	(0.80-1.43)	0.73	(0.55-0.96)
Insurance Status						
Private Insurance	Ref		Ref		Ref	
Medicaid	0.96	(0.60-1.52)	1.30	(0.93-1.83)	0.75	(0.53-1.08)
Medicare/Dual Enrolled	0.94	(0.57-1.57)	1.04	(0.64-1.67)	0.74	(0.50-1.10)
Uninsured	1.19	(0.74-1.91)	1.26	(0.86-1.85)	0.91	(0.65-1.27)
Highest Level of Education						
Did not finish high school	Ref		Ref		Ref	
GED/high school diploma	1.20	(0.80-1.82)	1.00	(0.70-1.43)	1.12	(0.83-1.50)
Some college/associate degree	1.27	(0.85-1.88)	1.06	(0.73-1.53)	0.99	(0.73-1.35)

	Bachelor's degree	1.29	(0.83-2.00)	1.08	(0.71-1.65)	0.87	(0.61-1.22)
	Higher education	1.14	(0.68-1.91)	1.10	(0.69-1.76)	0.96	(0.66-1.39)
Employment							
	Yes within 1 year	Ref		Ref		Ref	
	No within 1 year	0.27	(0.17-0.42)	0.34	(0.27-0.43)	0.71	(0.57-0.87)
	Never worked	0.90	(0.49-1.65)	0.54	(0.25-1.18)	0.50	(0.27-0.94)
Alcohol Use							
	Lifetime Abstainer	Ref		Ref		Ref	
	Former User	1.50	(0.85-2.64)	1.24	(0.63-2.43)	1.74	(1.17-2.58)
	Current User	3.54	(2.37-5.30)	2.04	(1.07-3.86)	2.26	(1.59-3.22)

Supplemental Table 1b. Multivariable Analyses of Factors Associated with Electronic Cigarette Use with K6 as a Dichotomous Variable, 2017 NHIS.

Participant Characteristics	Never smokers (n=10,946)		Former smokers (n=4,509)		Current smokers (n=2,706)	
	OR	95% CI	OR	95% CI	OR	95% CI
K6 score						
0-12	Ref		Ref		Ref	
13-24	3.08	(1.77-5.33)	3.14	(2.02-4.87)	1.63	(1.11-2.38)
Sex						
Male	Ref		Ref		Ref	
Female	1.20	(0.94-1.54)	1.09	(0.89-1.34)	0.94	(0.77-1.15)
Region						
Northeast	Ref		Ref		Ref	
Midwest	1.25	(0.87-1.81)	0.75	(0.55-1.03)	0.88	(0.64-1.21)
South	1.18	(0.86-1.63)	0.76	(0.57-1.01)	0.85	(0.62-1.16)
West	1.01	(0.70-1.48)	0.73	(0.53-1.01)	0.93	(0.68-1.27)
Age						
18-24	Ref		Ref		Ref	
25-34	1.22	(0.76-1.96)	0.63	(0.43-0.94)	0.78	(0.51-1.18)
35-44	1.00	(0.61-1.65)	0.64	(0.41-0.99)	0.71	(0.46-1.09)
45-54	1.03	(0.61-1.76)	1.05	(0.71-1.54)	0.87	(0.57-1.34)
55-65	1.20	(0.72-2.01)	0.71	(0.46-1.10)	0.78	(0.51-1.20)
65+	1.43	(0.77-2.66)	0.86	(0.54-1.35)	0.67	(0.40-1.11)
Race/ethnicity						
Non-Hispanic White	Ref		Ref		Ref	
Non-Hispanic Black	0.71	(0.48-1.05)	0.79	(0.54-1.15)	0.77	(0.54-1.09)
Asian	0.97	(0.58-1.63)	1.16	(0.75-1.79)	0.83	(0.57-1.23)
Hispanic	0.87	(0.58-1.30)	0.94	(0.66-1.33)	0.88	(0.65-1.19)
Other	0.80	(0.36-1.76)	2.13	(0.94-4.83)	0.76	(0.32-1.80)
Marital status						
Married/w partner	Ref		Ref		Ref	
Separated/divorced	0.86	(0.62-1.20)	1.00	(0.72-1.39)	0.99	(0.73-1.33)
Widowed	1.24	(0.80-1.94)	0.93	(0.54-1.61)	0.88	(0.58-1.34)
Never married	1.30	(0.90-1.88)	1.25	(0.92-1.69)	0.75	(0.56-1.00)
Insurance Status						
Private Insurance	Ref		Ref		Ref	
Medicaid	1.34	(0.93-1.94)	1.17	(0.80-1.70)	1.37	(0.99-1.89)
Medicare/Dual Enrolled	0.89	(0.56-1.40)	0.92	(0.61-1.40)	0.91	(0.61-1.37)
Uninsured	1.04	(0.69-1.56)	1.16	(0.81-1.65)	1.18	(0.85-1.65)
Highest Level of Education						
Did not finish high school	Ref		Ref		Ref	
GED/high school diploma	0.84	(0.56-1.24)	1.13	(0.75-1.71)	0.78	(0.55-1.09)
Some college/associate degree	0.97	(0.66-1.44)	1.13	(0.78-1.63)	0.77	(0.54-1.10)

	Bachelor's degree	1.14	(0.75-1.75)	1.16	(0.75-1.78)	0.84	(0.57-1.25)
	Higher education	0.95	(0.61-1.49)	1.17	(0.73-1.89)	0.78	(0.54-1.14)
Employment							
	Yes within 1 year	Ref		Ref		Ref	
	No within 1 year	0.39	(0.26-0.59)	0.41	(0.32-0.51)	0.64	(0.51-0.80)
	Never worked	1.47	(0.78-2.75)	0.61	(0.27-1.41)	0.79	(0.42-1.49)
Alcohol Use							
	Lifetime Abstainer	Ref		Ref		Ref	
	Former User	1.99	(1.08-3.68)	1.01	(0.58-1.76)	2.27	(1.50-3.44)
	Current User	4.59	(2.85-7.38)	1.39	(0.81-2.37)	2.81	(1.94-4.08)

Supplemental Table 1c. Multivariable Analyses of Factors Associated with Electronic Cigarette Use with K6 as a Dichotomous Variable, 2018 NHIS.

Participant Characteristics	Never smokers (n=10,412)		Former smokers (n=4,213)		Current smokers (n=2,567)	
	OR	95% CI	OR	95% CI	OR	95% CI
K6 score						
0-12	Ref		Ref		Ref	
13-24	2.01	(1.17-3.47)	2.05	(1.31-3.21)	2.40	(1.70-3.40)
Sex						
Male	Ref		Ref		Ref	
Female	1.00	(0.81-1.22)	1.06	(0.86-1.30)	0.96	(0.78-1.17)
Region						
Northeast	Ref		Ref		Ref	
Midwest	1.26	(0.87-1.82)	0.85	(0.60-1.18)	0.95	(0.66-1.36)
South	1.31	(0.92-1.87)	0.79	(0.57-1.09)	1.08	(0.78-1.50)
West	1.12	(0.79-1.59)	0.85	(0.60-1.21)	1.01	(0.72-1.42)
Age						
18-24	Ref		Ref		Ref	
25-34	0.87	(0.56-1.35)	1.03	(0.67-1.60)	0.58	(0.39-0.87)
35-44	0.92	(0.58-1.47)	0.51	(0.30-0.85)	0.67	(0.44-1.03)
45-54	0.80	(0.50-1.29)	0.79	(0.50-1.25)	0.73	(0.47-1.11)
55-65	0.89	(0.57-1.39)	0.73	(0.46-1.15)	0.71	(0.46-1.10)
65+	0.77	(0.43-1.38)	0.70	(0.41-1.19)	0.66	(0.40-1.07)
Race/ethnicity						
Non-Hispanic White	Ref		Ref		Ref	
Non-Hispanic Black	0.96	(0.65-1.41)	1.07	(0.73-1.58)	0.85	(0.61-1.18)
Asian	0.84	(0.53-1.32)	1.10	(0.71-1.71)	1.01	(0.69-1.50)
Hispanic	0.75	(0.55-1.01)	0.91	(0.65-1.27)	0.99	(0.75-1.30)
Other	0.57	(0.23-1.42)	1.50	(0.82-2.76)	1.02	(0.43-2.43)
Marital status						
Married/w partner	Ref		Ref		Ref	
Separated/divorced	1.09	(0.79-1.50)	1.06	(0.74-1.52)	1.01	(0.74-1.38)
Widowed	1.23	(0.77-1.95)	0.96	(0.59-1.56)	0.87	(0.55-1.39)
Never married	0.86	(0.64-1.15)	0.90	(0.65-1.26)	0.89	(0.65-1.21)
Insurance Status						
Private Insurance	Ref		Ref		Ref	
Medicaid	0.93	(0.64-1.36)	0.73	(0.48-1.11)	1.15	(0.81-1.64)
Medicare/Dual Enrolled	1.06	(0.66-1.70)	0.98	(0.64-1.50)	1.24	(0.79-1.93)
Uninsured	1.27	(0.90-1.79)	1.03	(0.67-1.57)	1.15	(0.81-1.63)
Highest Level of Education						
Did not finish high school	Ref		Ref		Ref	
GED/high school diploma	0.75	(0.52-1.08)	0.93	(0.64-1.36)	1.12	(0.79-1.60)
Some college/associate degree	0.90	(0.64-1.26)	0.79	(0.53-1.19)	0.95	(0.67-1.34)

	Bachelor's degree	0.76	(0.52-1.10)	0.83	(0.54-1.28)	1.17	(0.80-1.71)
	Higher education	0.79	(0.53-1.19)	0.77	(0.49-1.22)	0.98	(0.64-1.48)
Employment							
	Yes within 1 year	Ref		Ref		Ref	
	No within 1 year	0.41	(0.29-0.59)	0.29	(0.22-0.37)	0.67	(0.54-0.82)
	Never worked	1.11	(0.65-1.89)	0.37	(0.14-0.98)	0.55	(0.28-1.09)
Alcohol Use							
	Lifetime Abstainer	Ref		Ref		Ref	
	Former User	0.71	(0.39-1.29)	1.00	(0.56-1.79)	1.63	(1.06-2.51)
	Current User	3.03	(2.17-4.22)	1.44	(0.82-2.51)	1.97	(1.35-2.87)