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Abstract

Introduction
Electronic nicotine delivery systems (ENDS) use with nicotine or THC among adolescents and young adults is increasing. The goal of our research was to examine relationships between symptoms of anxiety or depression and ENDS use, whether with nicotine or THC, among young people in four major metropolitan areas of Texas.

Methods
The sample was 57.6% female and 37.6% Hispanic. Data were derived from Wave 9 (Spring, 2019) and Wave 10 (Fall, 2019) of the Texas Adolescent Tobacco and Marketing Surveillance system. Logistic regression analyses examined associations between symptoms of depression, anxiety, or comorbid depression and anxiety in the Spring, 2019 and use of nicotine or THC in ENDS in Fall, 2019, controlling for sociodemographic characteristics and use of ENDS in Fall, 2019.

Results
Past 30-day ENDS use in Wave 10 was 11.6% with nicotine and 12.4% with THC. Symptoms of anxiety were present in 4.9% of young people, depression in 7.9%, and comorbid depression and anxiety in 15.2%. In stratified analyses, symptoms of anxiety alone at Wave 9 were related to increased odds of past 30-day use of ENDS with nicotine among individuals one-year post-high school at Wave 10 ($P<0.05$). Symptoms of comorbid depression and anxiety were associated with increased odds of ENDS use with THC in the entire sample of young people ($P<0.01$), Hispanic young people ($P<0.01$), other races ($P<0.05$), males ($P<0.05$), and individuals one-year post-high school ($P<0.01$).

Discussion
Results suggest symptoms of comorbid depression and anxiety may be particularly important in future use of ENDS with THC.

Introduction

Electronic nicotine delivery systems (ENDS), or e-cigarettes, are devices that use electronic heating to deliver an inhaled aerosol containing nicotine to a user (vaping), and are considered alternatives to combustible tobacco products.[1] In 2016, the U.S. Surgeon General published a report after analysis of the 2014 National Youth Tobacco Survey (NYTS) showing that e-cigarettes had become the most commonly used tobacco product among youth in 2014, surpassing combustible products like cigarettes.[2] Not only were e-cigarettes the most commonly used tobacco products, but prevalence of current use of e-cigarettes was shown to increase with increasing age, and ever use among middle schoolers increased from 1.4% in 2011 to 13.5% in 2015.[2] Ever use among high schoolers, in a similar but more stark fashion, increased from 4.7% in 2011 to 37.7% in 2015.[2] In 2014, ever use among young adults ages 18-24 was similarly high, at 35.8%, according to results from the 2013-2014 National Adult Tobacco Survey.[2] By the year 2019, nearly 30 percent of high school students reported current use of e-cigarettes.[3, 4] In fact, between the years of 2017 and 2019, prevalence current use of e-cigarettes among high schoolers in the United States over doubled, from 11.7% to 27.5%.[4, 5] While ENDS were originally intended for vaporization of nicotine-containing liquids, as suggested by the name, ENDS are increasingly being used to vaporize cannabis. In a 2014 study of high school students in Connecticut, 5.4% of participants were found to vape cannabis via e-cigarettes; a 2017 study of high school students in North Carolina found that 9.4% of the sample had ever vaped cannabis.[6, 7] Results from Monitoring the Future, a nationally representative sample of 8th, 10th and 12th graders in the United States, revealed that marijuana vaping increased from 2017 to 2019 in all grade levels, with the largest increase among 12th graders (5.0% to 14.0%).[8, 9] According to

estimates from the National Survey on Drug Use and Health (NSDUH), past year marijuana use in 2019 overall was 13.2% in youth ages 12 to 17 and 35.4% in young adults ages 18-25.[10]

The use of ENDS with nicotine or with marijuana (in our study, referred to as the principal psychoactive component of marijuana, tetrahydrocannabinol [THC]), varies by race/ethnicity, gender, age, and SES. Among middle school students surveyed in the 2014 NYTS, prevalence of ever use of an e-cigarette (use of an e-cigarette, even once or twice), past 30-day use, and susceptibility to use were highest among Hispanic or Latino youth compared to all other race/ethnicities.[11] This gap decreased or disappeared by high school, where ever use and susceptibility to e-cigarette use remained the highest in Hispanic or Latino youth, but past 30-day use was lower than in White and other race/ethnicity categories.[2] These observations remained true for the most part in the 2019 NYTS, with Hispanic middle school students having higher rates of ever or past 30-day use than non-Hispanic White middle school students, but ever or past 30-day use being highest in non-Hispanic White high school students.[4] In the 2019 NYTS, ENDS use was similar between males and females. Another 2014 study suggested that initiation of ENDS use increased up to age 18 before slowing down in young adulthood.[12] Studies have shown that individuals of intermediate or higher education and SES were more likely to be users of ENDS.[13]

Initially thought of as safer alternatives to combustible cigarettes, ENDS have since been recognized as public health threats by many health professionals.[14] There are many brands and types of ENDS, making study of health effects a complex endeavor; the variety of chemicals used by different manufacturers, in fact, may increase the chances of irritant or even carcinogenic compounds being present in ENDS.[15] In fact, carcinogens like formaldehyde and acetaldehyde, among other chemicals, have been shown to be present in some ENDS products,

and inhalation of vaporized liquid in ENDS may cause acute changes in pulmonary function.[15] Chronic ENDS use with nicotine is associated with higher odds of myocardial dysfunction in adults and increased rates of chronic brochitic symptoms in adolescents.[14, 16] Moreover, while heralded as a smoking cessation aid among adults, ENDS with nicotine have been shown to increase odds of subsequent smoking of combustible tobacco products and marijuana among adolescents and young adults, with likelihood of subsequent combustible tobacco use increasing as much as 3.6 times compared to non-users of ENDS and likelihood of subsequent marijuana use increasing twofold.[17-19] The use of marijuana (whether vaporized in ENDS or in a more traditional form) has a host of acute and chronic health effects when used by young people. Consumption of THC can lead to acute paranoia, psychosis, cannabis hyperemesis syndrome, impaired short term memory, impaired motor coordination, and/or altered judgment.[20] Additionally, vaping cannabis-derived products has recently been associated with e-cigarette or vaping-associated lung injuries (EVALI), a condition marked by severe respiratory symptoms, gastrointestinal involvement, fever, chills and weight loss that can occur among children, adolescents, young adults and older adults and that may require intubation.[21] Chronic effects of cannabis smoking can include depression, suicidality, altered brain development, poor educational outcome, and cognitive impairment especially when started as a preadolescent or adolescent.[22, 23]

The rise in use of ENDS with psychoactive substances such as nicotine and THC has coincided with increasing rates of depression and anxiety in young people in the United States. Depression, at a broad level, is a mood disorder marked by persistent sadness and/or loss of interest, sometimes leading to functional impairment. In adolescents ages 12 to 17 in the United States, the percentage of major depressive episode in the last year increased from 11.7% in 2014

to 15.7% in 2019, according to estimates from the NSDUH.[10] The prevalence of major depressive episode was similarly high among young adults ages 18 to 25, growing from 10.3% in 2015 to 15.2% in 2019.[10] Rates of major depressive episode with severe impairment were over 10% in 2019 among both age groups. Anxiety disorders are diverse and include such entities as generalized anxiety disorder, panic disorder, and phobias. While anxiety in itself is not an unexpected feeling, it can impair ability to function when it is excessive or persistent and occurs over a wide range of daily situations. Results from the 2016 National Survey of Children's Health (NSCH) estimated prevalence of diagnosed anxiety disorders to be 10.5% among individuals ages 12-17, with the highest rates being among non-Hispanic White youth.[24] Among young adults ages 18-25, 14.66% reported anxiety in 2018.[25] Furthermore, comorbidity of generalized anxiety disorder with major depressive disorder is high, with estimates ranging from 48-71.7%.[26, 27] Comorbid anxiety and depression has been connected with more severe functional impairment, and is important to consider when examining mental health in both public health and clinical contexts.[28]

Symptoms of anxiety, depression, or comorbidity have consistently been shown to be related to ENDS product use among youth and young adults. A longitudinal study of college students in Texas revealed that elevated depressive symptoms predicted ENDS use at 6-month and 1-year follow-up; and another study in California revealed a bidirectional relationship.[29, 30] Symptoms of anxiety have not been consistently shown to be associated with ENDS use, although internalizing symptoms (which include both anxious and depressive feelings) are higher in those who use ENDS compared to never users in cross-sectional studies.[31-33] The relationship between depression and past 30-day ENDS use appears to be consistent across categories of race/ethnicity.[34] To our knowledge, studies have not examined the directionality of the

relationship between symptoms of anxiety (or depression) and use of THC in ENDS. However, previous research has shown that marijuana use is associated with depression, with depression increasing likelihood of future use of marijuana.[22, 35, 36] Anxiety is positively associated with cannabis use.[37]

In light of the rise in ENDS use with nicotine and THC nationwide and the high rates of anxiety and depression among young people, we sought to identify associations between symptoms of depression, anxiety, and comorbid depression and anxiety and future use of ENDS products in a large sample of young people (ages 16-23) from the four largest cities in Texas (Houston, Dallas/Ft. Worth, San Antonio, and Austin). This study examines the relationship between symptoms of depression alone, symptoms of anxiety alone, and symptoms of comorbid depression and anxiety at Wave 9 (Spring, 2019) of the TATAMS survey and subsequent past 30-day use of ENDS with nicotine or ENDS with THC at Wave 10 (Fall, 2019). As prevalence of anxiety and depression, as well as ENDS use, differs by socidoemographic characteristics, we also investigate the role of symptoms of depression, anxiety, and comorbidity on subsequent ENDS use within certain categories of race/ethnicity, gender, and grade level.

Methods

Sample

Data from Waves 9 and 10 of the Texas Adolescent Tobacco and Marketing Surveillance system (TATAMS) were used for this study. TATAMS is a longitudinal, population-based surveillance study of tobacco product use, factors associated with use, and exposure to tobacco product marketing in youth and young adults in the four largest cities in Texas (San Antonio, Dallas, Houston, and Austin).[38] At Wave 1, in Spring 2014, a total of 3,907 adolescents in the

6th, 8th, and 10th grades across 79 schools were enrolled. At Wave 9, conducted in Spring 2019, 2,440 young people participated; 2,335 participated in Wave 10; 2,226 completed both surveys. The inclusion criteria for the current study was completion of both Wave 9 and Wave 10 surveys; as such, the sample size was 2,226. TATAMS was approved by the University of Texas School of Public Health Committee for the Protection of Human Subjects (HSC-SPH-13-0377) and by local school districts. A more detailed description of the study design and methods has been published previously.[38]

Measures

Sociodemographics

Data were collected on age, grade level, gender (male or female), race/ethnicity, and self-reported SES for all participants. In the Wave 1 survey, students were asked if they were of Hispanic or Latino/a ethnicity; this question was used to determine ethnicity for our analysis. Furthermore, all individuals at Wave 1 were asked to indicate what race or races they considered themselves to be; response options included "White," "Black or African American," "Asian," "American Indian or Alaska Native," "Native Hawaiian or other Pacific Islander," or "Other." Ethnicity and race were combined such that all those who indicated they were Hispanic or Latino/a were incorporated into the "Hispanic" group for analyses. Those who indicated they were not Hispanic were placed in three different groups depending on their race: non-Hispanic White, non-Hispanic Black, or non-Hispanic other (which included "Asian," "American Indian or Alaska Native," "Native Hawaiian or other Pacific Islander," or "Other" races). SES at Waves 9 and 10 was assessed by asking, "In terms of income, what best describes your family's standard of living in the home where you lived most of the time? Would you say your family is:" and involved the following answer choices: "very well off," "living comfortably," "just getting

by," "nearly poor," "poor." Those considered to have low income selected one of the latter three, and those considered to be of middle income and high income, "living comfortably" and "very well off," respectively. At the time of the Wave 10 survey, individuals in the cohorts participating in the survey were in either 11th grade, one year post high school, or three years post high school.

Mental Health Symptoms

Wave 9 was the first survey in which responses were collected using the Patient Health Questionnaire-9 item scale (PHQ-9) and Generalized Anxiety Disorder-7 item scale (GAD-7) to measure symptoms of depression and anxiety, respectively. The PHQ-9 asks about experiences of 9 symptoms of depression over the last two weeks, on a 4-point Likert scale from "not at all" to "nearly every day"; there is a maximum score of 27 with a score of 10 or above indicative of depression.[39, 40] We did not calculate scores for participants with more than two missing values in the PHQ-9. The GAD-7 asks about experiences of 7 symptoms of anxiety over the last two weeks, using the same 4-point Likert scale as the PHQ-9. As with the PHQ-9, we did not calculate scores for participants with more than two missing values in the GAD-7, and considered scores ≥10 indicative of anxiety.[41] Individuals participating in Wave 9 of the survey were allocated to four groups based on their responses to PHQ-9 and GAD-7 items: no symptoms of depression or anxiety (PHQ-9 < 10 and GAD-7 < 10), symptoms of depression alone (PHQ-9 ≥ 10 and GAD-7 < 10), symptoms of anxiety alone (GAD-7 ≥ 10 and PHQ-9 <10), and symptoms of comorbid depression and anxiety (PHQ-9 ≥ 10 and GAD-7 ≥ 10).

ENDS Use Behaviors

Survey participants were asked about ever use ("Have you EVER used an electronic cigarette, even one or two puffs?") and past 30-day use of ENDS with nicotine (examples

including vape pens, JUUL/pod vapes, e-hookahs, hookah pens, MODS, tank systems, e-cigars, and personal vaporizers were given). Participants were reminded in question prompts that these questions were specifically about use of nicotine in e-cigarettes, and marijuana did not count. Those reporting past 30-day use were asked to enter the number of days they used ENDS products in the last 30; if one or more days of use were endorsed, they were considered to be past 30-day users.

Additionally, participants were asked about ever use ("Have you EVER smoked marijuana (liquid THC) from an electronic cigarette, vape pen, or e-hookah?") and past 30-day use of ENDS with THC. Those reporting past 30-day use were asked to enter the number of days they used ENDS products with THC in the last 30; if one or more days of use were endorsed, they were considered to be past 30-day users.

Statistical Analysis

Chi-square analyses were used to examine differences in sociodemographics and ENDS use with nicotine or THC, by symptoms of depression and/or anxiety (Tables 1a and 1b). Informal analysis of residuals was used to assess the level of each sociodemographic variable implicated in the difference in prevalence of mental health symptomatology. Longitudinal multivariable logistic regression analyses controlling for grade level, gender, SES, and past 30-day ENDS use with nicotine (or THC) at Wave 9 were used to assess associations between symptoms of depression alone OR symptoms of anxiety alone OR symptoms of comorbid depression and anxiety and subsequent past 30-day use of ENDS with nicotine (or THC) at Wave 10 (Tables 2a and 3a). Analyses were further stratified by race/ethnicity (Tables 2a and 3a), gender (Tables 2b and 3b), and grade level (Tables 2c and 3c), with stratified analyses controlling for other sociodemographic variables and previous use behaviors. A type I error level

of 0.05 was used to determine statistical significance. All analyses were conducted using Stata version 15.1 (StataCorp LLC).

Results

Sample Characteristics

The mean age of the sample at Wave 9 was 18.5 years (*SD*=1.6 years) and 57.6% were female. Over one-third (37.6%) of the sample reported being Hispanic, and 49.9% of non-Hispanic young people were White. Table 1a shows sociodemographic characteristics by report of symptoms of poor mental health. Differences existed in prevalence of symptoms of anxiety, depression, and comorbid anxiety and depression in all sociodemographic characteristics. With regard to grade level, symptoms of comorbid depression and anxiety between individuals two years post-high school and individuals in 12th grade is implicated in the statistical difference (17.7% vs. 12.3%). Higher prevalences of symptoms of anxiety and symptoms of comorbid depression and anxiety were seen in females as compared to males (6.4% vs. 2.8% and 19.6% vs. 9.1%, respectively). Additionally, higher prevalences than expected of symptoms of anxiety were seen in non-Hispanic White young people. Hispanic young people experienced a high prevalence of symptoms of comorbid depression and anxiety. Young people reporting to have low SES had a higher prevalence of comorbidity than those in the middle and high SES groups (23.7% vs. 12.6% vs. 10.6%).

Young people in the non-Hispanic "other" group were heterogeneous. Of individuals in this group, 201 (55.7%) considered themselves to be of Asian race, 39 (10.8%) were American Indian or Alaska Native, 9 (2.5%) were Native Hawaiian or other Pacific Islander, 96 (26.6%) were of other racial identities not specified, and 14 (3.9%) chose not to respond.

[Table 1a]

ENDS Use Behaviors

Table 1b shows differences in use of ENDS products, whether with nicotine or THC, by mental health symptomatology. Past 30-day use of ENDS with nicotine at Wave 9 was highest among young people with symptoms of comorbid depression and anxiety (19.3% vs 13.0% with no symptoms). Past 30-day use of ENDS with THC at Wave 9 was highest among young people with symptoms of depression alone (22.2% vs. 12.9% with no symptoms).

[Table 1b]

Mental Health Symptomatology and Subsequent Use of ENDS with Nicotine

Tables 2a-2c contain results of adjusted logistic regression analyses examining the impact of symptoms of depression alone, anxiety alone, or comorbid depression and anxiety at Wave 9 on subsequent past 30-day use of ENDS with nicotine. No symptoms of anxiety or depression was used as the referent group. Across the entire sample, mental health symptomatology at Wave 9 was not significantly associated with ENDS use with nicotine at Wave 10, after controlling for grade level, gender, SES, and Wave 9 past 30-day ENDS use with nicotine (Table 2a). When stratifying by race/ethnicity, there were no significant associations between Wave 9 mental health symptomatology and subsequent past 30-day use of ENDS with nicotine at Wave 10 after controlling for grade level, gender, SES, and past 30-day ENDS use at Wave 9 (Table 2a). Among non-Hispanic Black young people, symptoms of depression or anxiety alone at Wave 9 perfectly predicted no past 30-day use of ENDS with nicotine at Wave 10.

[Table 2a]

On stratifying by gender, a similar pattern was observed (Table 2b). Symptoms of depression alone, anxiety alone, or comorbidity at Wave 9 were not associated with significantly higher odds of past 30-day ENDS use with nicotine at Wave 10 for either gender after controlling for grade level, race/ethnicity, SES, and Wave 9 past 30-day ENDS use with nicotine.

[Table 2b]

Stratification by grade level revealed that symptoms of anxiety at Wave 9 were associated with significantly higher odds of past 30-day ENDS use with nicotine at Wave 10 (Table 2c; *AOR*=3.20, *P*=0.013, 95% CI=1.27-8.05). There were no other statistically significant associations between mental health symptomatology at baseline and past 30-day use of ENDS with nicotine at Wave 10 when stratified by grade level.

[Table 2c]

Mental Health Symptomatology and Subsequent Use of ENDS with THC

Tables 3a-3c contain results of adjusted logistic regression analyses examining the impact of symptoms of depression alone, anxiety alone, or comorbid depression and anxiety at Wave 9 on subsequent past 30-day use of ENDS with THC. No symptoms of anxiety or depression was used as the referent group. Across the entire sample symptoms of comorbid depression and anxiety at Wave 9 were associated with 65% higher odds of past 30-day use of ENDS with THC at Wave 10, after controlling for race/ethnicity, grade level, gender, SES, and Wave 9 past 30-day ENDS use with THC (Table 3a; *AOR*=1.65, *P*=0.009, 95% CI=1.13-2.39). Upon stratifying by race/ethnicity, symptoms of comorbid anxiety and depression in Hispanic young people at Wave 9 were associated with 2.2 times higher odds of past 30-day ENDS use with THC after controlling for grade level, gender, SES, and Wave 9 past 30-day ENDS use with THC (Table

3a; *P*=0.008, 95% CI=1.23-3.94). Among young people in the non-Hispanic "other" group, symptoms of comorbid depression and anxiety were associated with 2.83 times higher odds of ENDS use with THC compared to those without symptoms (*P*=0.043, 95% CI=1.03-7.73).

[Table 3a]

Stratification by gender revealed that male young people with symptoms of comorbid depression and anxiety at Wave 9 had 2.29 times higher odds of past 30-day ENDS use with THC at Wave 10 compared to males with no symptoms after controlling for grade level, race/ethnicity, SES, and Wave 9 past 30-day ENDS use with THC (Table 3b; *P*=0.017, 95% CI=1.16-4.53).

[Table 3b]

On stratifying by grade level, individuals one year post high school with symptoms of comorbid depression and anxiety at Wave 9 were found to have significantly higher odds of past 30-day use of ENDS with THC compared to individuals 1 year post high school without symptoms, after controlling for gender, race/ethnicity, SES, and Wave 9 past 30-day ENDS use with THC (Table 3c; *AOR*=2.53, *P*=0.004, 95% CI=1.35-4.74).

[Table 3c]

Discussion

Our study reveals a strong association between past symptoms of comorbid depression and anxiety and later use of ENDS with THC among participants in Waves 9 and 10 of TATAMS. Specifically, this relationship was found among young people who were Hispanic or "other" race/ethnicities, males, and those one-year post-high school. The fact that comorbid depression and anxiety, and not depression or anxiety alone, was associated with subsequent use

of ENDS containing THC suggests that a feature that is common to both anxiety and depression, which may be amplified in comorbidity, increases the likelihood of young people adopting THC use in highly popular ENDS devices. While anxiety and depression are both described as internalizing disorders (rooted in distress emotions such as sadness and fear), they are considered separate entities and there are several theoretical models for understanding the comorbidity of anxiety and depression.[28, 32] The tripartite model emphasizes the role of negative affect as a shared distress factor in anxiety and depression.[42] Thus, it may be that negative affect is particularly associated with subsequent use of THC; THC's ability to promote relaxation and euphoria can temporarily decrease the burden of negative emotions on its users.[43] Other models that aim to describe the comorbidity of anxiety and depression implicate a highly active behavioral inhibition system (increased sensitivity to punishment).[28] We are unable to determine which common factor between depression and anxiety is most likely to be implicated in the relationship between comorbidity and subsequent use of ENDS with THC when compared to young people with no symptoms; additional analyses are needed. It must also be considered that certain aspects of being Hispanic and/or male decrease barriers to THC use when these individuals have experienced a combination of symptoms of depression and anxiety. Reasons for this require future study and will not be fully considered here.

Furthermore, young individuals with past symptoms of anxiety were significantly more likely to be past 30-day users of ENDS with nicotine if they had recently finished high school. This finding is interesting, as nicotine is thought to increase symptoms of anxiety; however, nicotine may also be used in an attempt to self-medicate for symptoms of anxiety.[44] That being said, the transition out of high school may be an important factor in connecting symptoms of poor mental health to use of psychoactive substances. Taking into account also the observed

significant relationship between past comorbidity and future use of ENDS with THC among recent graduates, our results suggest that the transition out of high school (whether to higher education, employment, or otherwise) may be a developmental stage in which symptoms of poor mental health are particularly predictive of current ENDS use. In a study by Carey et al. examining the transition from non-susceptiblity to susceptibility to e-cigarettes by grade level, youth transitioning from middle school to high school were found to experience a high number of risk factors for e-cigarette susceptibility, including social norms promoting acceptability of e-cigarette use, belief that e-cigarette use is common, higher sensation seeking, and lower positive affect.[45] Other studies have found that cigarette smoking escalates the most during the first year of college, and marijuana use may be highest during early college.[46, 47] Periods of transition, especially between high school and college, may involve more freedom in decision-making and less oversight from other adults, perhaps increasing the likelihood of ENDS use. Moreover, participants in TATAMS Wave 9 and 10 responded prior to the signing of federal legislation raising the minimum age for tobacco product sales (including e-cigarettes) from 18 to 21 years; individuals turning 18 (right around the typical transition out of high school) may have been more likely to be current ENDS users as a product of age.

Our results have several public health and even clinical implications. Given the high use of ENDS products among young people, and the capacity for ENDS to be modified for delivery of substances beyond nicotine, public health interventions should focus on increasing regulation of ENDS devices and decreasing access, especially among adolescents and young adults. Furthermore, as symptoms of depression and anxiety are associated with subsequent use of ENDS, especially to deliver THC, it is important for health professionals to screen for depression and anxiety in order to identify individuals at highest risk of being current users of ENDS

products and counsel individuals effectively, as endorsed by others.[48] Our findings also suggest the public health importance of examining the relationship between symptoms of poor mental health – especially comorbidity – among older adolescents/young adults and substance use in ENDS.

It is worthwhile to note that, while most relationships between past symptoms of anxiety and depression were non-significant, there were several instances in which adjusted odds ratios were greater than two. This suggests that sociodemographic characteristics and past use behaviors may be important in the variance of subsequent use of ENDS depending on mental health symptoms; additionally, our sample may lack power among specific sociodemographic subgroups for prediction of past 30-day ENDS use by symptoms of depression or anxiety.

There are strengths and limitations to our study. Our study included a diverse sample in terms of race, ethnicity, gender, and SES, with a large proportion of Hispanic young people, allowing us to assess differential impact of symptoms of anxiety and depression on subsequent ENDS use over a variety of demographic factors. Furthermore, given the longitudinal nature of our study, we were able to establish temporality in the relationship between symptoms of poor mental health and later ENDS use. The cutoffs used for depression (PHQ-9) and anxiety (GAD-7) are highly sensitive for clinical major depressive disorder and generalized anxiety disorder; the use of more conservative cutoffs may reveal larger magnitudes of association between mental health symptomatology and subsequent ENDS use. Limitations include that ENDS use and mental health symptoms were self-reported, and may be subject to recall and social desirability bias. Furthermore, our sample cannot be generalized to youth in other cities or states outside of Texas. However, our study's sample includes young people from four major metropolitan areas in Texas with a large population of youth. Additional study is needed to examine other

behavioral, psychological and social factors associated with ENDS use with THC or nicotine. Moreover, there was a relatively small sample of some races, including Asian, American Indian or Native Alaskan, and Hawaiian Native or other Pacific Islanders; studies with larger samples of these populations should be conducted.

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Tables

Table 1a. Differences* in sociodemographic characteristics in participants completing waves 9 and 10 of the Texas Adolescent Tobacco and Marketing Surveillance Study (TATAMS), by symptoms of depression, anxiety, and comorbid depression and anxiety.^ Data represented here are from Wave 9 (n=2,226).

	Total sample	No symptoms, n (%)	Anxiety[¥], n (%)	Depression[†], n (%)	Comorbid depression and anxiety, n (%)	P value
Total		1604 (72.1)	108 (4.9)	176 (7.9)	337 (15.2)	
Grade						0.009
10th	624 (28.0)	460 (73.7)	29 (4.7)	41 (6.6)	94 (15.1)	
12th	754 (33.9)	556 (73.7)	47 (6.2)	58 (7.7)	93 (12.3)	
2 years post high school	847 (38.1)	588 (69.4)	32 (3.8)	77 (9.1)	150 (17.7)	
Gender						<0.001
Female	1282 (57.6)	847 (66.1)	82 (6.4)	102 (8.0)	251 (19.6)	
Male	943 (42.4)	757 (80.3)	26 (2.8)	74 (7.9)	86 (9.1)	
Race/Ethnicity						0.009
Hispanic	836 (37.6)	582 (69.6)	29 (3.5)	73 (8.7)	152 (18.2)	
Non-Hispanic White	693 (31.2)	515 (74.3)	44 (6.4)	41 (5.9)	93 (13.4)	
Non-Hispanic Black	335 (15.1)	244 (72.8)	17 (5.1)	27 (8.1)	47 (14.0)	
Non-Hispanic Other[#]	361 (16.2)	263 (72.9)	18 (5.0)	35 (9.7)	45 (12.5)	
Self-Reported SES						<0.001
High	273 (12.3)	211 (77.3)	14 (5.1)	19 (7.0)	29 (10.6)	
Middle	1400 (62.9)	1057 (75.5)	64 (4.6)	102 (7.3)	177 (12.6)	
Low	552 (24.8)	336 (60.9)	30 (5.4)	55 (10.0)	131 (23.7)	

***** (Unadjusted) Chi-square tests used to examine differences.

^"Symptoms of depression and anxiety" is used rather than depression and anxiety as neither disorder can be diagnosed based on results of the screening tests used in the survey.

[†] Symptoms of depression are measured using the PHQ-9, with scores ≥10 indicating a positive screen for depression

[¥] Symptoms of anxiety are measured using the GAD-7, with scores ≥10 indicating a positive screen for anxiety

[#]The "other" group is heterogeneous; it includes Asian, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, among other racial identities

Table 1b. Differences* in use of ENDS with nicotine and use of ENDS with marijuana in participants completing waves 9 and 10 of the Texas Adolescent Tobacco and Marketing Surveillance Study (TATAMS), by symptoms of depression, anxiety, and comorbid depression and anxiety.^ Data represented here are from Wave 9 (n=2,226).

	Total sample	No symptoms, n (%)	Anxiety[¥], n (%)	Depression[†], n (%)	Comorbid depression and anxiety, n (%)	P value
Total		1604 (72.1)	108 (4.9)	176 (7.9)	337 (15.2)	
Use of Nicotine						
Ever use in ENDS	982 (44.1)	677 (42.2)	41 (38.0)	92 (52.3)	172 (51.0)	0.002
Past 30-day use in ENDS	313 (14.1)	208 (13.0)	14 (13.0)	26 (14.8)	65 (19.3)	0.025
Use of THC						
Ever use in ENDS	566 (25.4)	369 (23.0)	31 (28.7)	68 (38.6)	98 (29.1)	<0.001
Past 30-day use in ENDS	318 (14.3)	206 (12.9)	15 (13.9)	39 (22.2)	58 (17.2)	0.003

***** (Unadjusted) Chi-square tests used to examine differences.
^"Symptoms of depression and anxiety" is used rather than depression and anxiety as neither disorder can be diagnosed based on results of the screening tests used in the survey.
[†] Symptoms of depression are measured using the PHQ-9, with scores ≥10 indicating a positive screen for depression
[¥] Symptoms of anxiety are measured using the GAD-7, with scores ≥10 indicating a positive screen for anxiety

Table 2a. Adjusted longitudinal logistic regression results for prediction of past 30-day ENDS use with nicotine in Wave 10 participants of TATAMS based on reported symptoms of anxiety and depression at Wave 9, stratified by ethnicity (n=2,224).

	Entire sample, n=2,224		**Hispanic, n=835**		**Non-Hispanic White, n=693**		**Non-Hispanic Black, n=335**		**Non-Hispanic Other, n=361**	
	AOR†	95% CI	AOR†	95% CI	AOR†	95% CI	AOR†	95% CI	AOR†	95% CI
Symptoms of depression^	0.97	(0.53, 1.79)	1.29	(0.54, 3.08)	2.15	(0.74, 6.26)	PFP		0.19	(0.03, 1.24)
Symptoms of anxiety^	1.77	(0.88, 3.55)	2.61	(0.78, 8.74)	1.71	(0.63, 4.62)	PFP		1.73	(0.26, 11.60)
Comorbid symptoms of depression and anxiety^	1.39	(0.91, 2.15)	1.28	(0.63, 2.62)	1.45	(0.73, 2.90)	2.16	(0.28, 16.9)	2.21	(0.78, 6.30)

CI, confidence interval
† Adjusted for grade level, gender, SES, and Wave 9 past 30-day ENDS use with nicotine. Entire sample includes adjustment for race/ethnicity.
^ Symptoms of depression and anxiety were measured at Wave 9.
*p<0.05, **p<0.01, ***p<0.001

Table 2b. Adjusted longitudinal logistic regression results for prediction of past 30-day ENDS use with nicotine in Wave 10 participants of the TATAMS based on reported symptoms of anxiety and depression at Wave 9, stratified by gender (n=2,224).

	Male (n=942)		**Female (n=1,282)**	
	AOR†	95% CI	AOR†	95% CI
Symptoms of depression^	0.63	(0.25, 1.60)	1.34	(0.59, 3.03)
Symptoms of anxiety^	2.30	(0.70, 7.54)	1.70	(0.71, 4.07)
Comorbid symptoms of depression and anxiety^	1.41	(0.67, 2.97)	1.35	(0.79, 2.32)

CI, confidence interval
† Adjusted for grade level, race/ethnicity, SES, and Wave 9 past 30-day ENDS use with nicotine
^ Symptoms of depression and anxiety were measured at Wave 9.
*p<0.05, **p<0.01, ***p<0.001

Table 2c. Adjusted longitudinal logistic regression results for prediction of past 30-day ENDS use with nicotine in Wave 10 participants of the TATAMS based on reported symptoms of anxiety and depression at Wave 9, stratified by grade level (n=2,224).

	11th grade (n=624)		**1 year post high school (n=754)**		**3 years post high school (n=846)**	
	AOR†	95% CI	AOR†	95% CI	AOR†	95% CI
Symptoms of depression^	1.46	(0.34, 6.35)	1.29	(0.48, 3.47)	0.69	(0.28, 1.73)
Symptoms of anxiety^	1.14	(0.18, 7.48)	3.20*	(1.27, 8.05)	0.66	(0.16, 2.67)
Comorbid symptoms of depression and anxiety^	0.97	(0.35, 2.67)	1.84	(0.91, 3.75)	1.47	(0.75, 2.89)

CI, confidence interval
† Adjusted for gender, race/ethnicity, SES, and Wave 9 past 30-day ENDS use with nicotine
^ Symptoms of depression and anxiety were measured at Wave 9.
*p<0.05, **p<0.01, ***p<0.001

Table 3a. Adjusted longitudinal logistic regression results for prediction of past 30-day ENDS use with THC in Wave 10 participants of TATAMS based on reported symptoms of anxiety and depression at Wave 9, stratified by ethnicity (n=2,223).

	Entire sample, n=2,223		**Hispanic, n=834**		**Non-Hispanic White, n=693**		**Non-Hispanic Black, n=335**		**Non-Hispanic Other, n=361**	
	AOR†	95% CI	AOR†	95% CI	AOR†	95% CI	AOR†	95% CI	AOR†	95% CI
Symptoms of depression^	1.21	(0.74, 1.97)	1.64	(0.79, 3.40)	1.12	(0.41, 3.05)	1.02	(0.28, 3.80)	0.59	(0.14, 2.49)
Symptoms of anxiety^	0.97	(0.49, 1.93)	0.42	(0.09, 2.08)	0.96	(0.41, 3.05)	1.09	(0.19, 6.35)	2.22	(0.49, 10.11)
Comorbid symptoms of depression and anxiety^	1.65**	(1.13, 2.39)	2.20**	(1.23, 3.94)	1.20	(0.59, 2.47)	1.00	(0.35, 2.88)	2.83*	(1.03, 7.73)

CI, confidence interval
† Adjusted for grade level, gender, SES, and Wave 9 past 30-day ENDS use with THC. Entire sample adjusted for ethnicity, as well.
^ Symptoms of depression and anxiety were measured at Wave 9.
*p<0.05, **p<0.01, ***p<0.001

Table 3b. Adjusted longitudinal logistic regression results for prediction of past 30-day ENDS use with THC in Wave 10 participants of TATAMS based on reported symptoms of anxiety and depression at Wave 9, stratified by gender (n=2,223).

	Male (n=942)		**Female (n=1,281)**	
	AOR†	95% CI	AOR†	95% CI
Symptoms of depression^	1.43	(0.67, 3.02)	1.06	(0.55, 2.02)
Symptoms of anxiety^	2.36	(0.74, 7.51)	0.70	(0.29, 1.67)
Comorbid symptoms of depression and anxiety^	2.29*	(1.16, 4.53)	1.40	(0.89, 2.19)

CI, confidence interval
† Adjusted for grade level, race/ethnicity, SES, and Wave 9 past 30-day ENDS use with THC.
^ Symptoms of depression and anxiety were measured at Wave 9.
*p<0.05, **p<0.01, ***p<0.001

Table 3c. Adjusted longitudinal logistic regression results for prediction of past 30-day ENDS use with THC in Wave 10 participants of the TATAMS based on reported symptoms of anxiety and depression at Wave 9, stratified by grade level (n=2,223).

	11th grade (n=624)		**1 year post high school (n=754)**		**3 years post high school (n=845)**	
	AOR†	95% CI	AOR†	95% CI	AOR†	95% CI
Symptoms of depression^	0.83	(0.21, 3.23)	1.17	(0.50, 2.75)	1.42	(0.72, 2.81)
Symptoms of anxiety^	0.53	(0.09, 3.22)	0.98	(0.35, 2.71)	1.11	(0.35, 3.56)
Comorbid symptoms of depression and anxiety^	0.96	(0.36, 2.58)	2.53**	(1.35, 4.74)	1.52	(0.89, 2.61)

CI, confidence interval
† Adjusted for gender, race/ethnicity, SES, and Wave 9 past 30-day ENDS use with THC.
^ Symptoms of depression and anxiety were measured at Wave 9.
*p<0.05, **p<0.01, ***p<0.001