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Symptoms of depression and anxiety and subsequent use of nicotine and THC in electronic cigarettes

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Abstract

Objectives: This study examines whether symptoms of depression, anxiety, or comorbid depression and anxiety are associated with future use of nicotine or THC in e-cigarettes.

Methods: Data were from an online survey of youth and young adults in urban areas of Texas with complete data (n=2,307) in spring 2019 (baseline) and spring 2020 (12-month follow-up). Multivariable logistic regression models examined associations between self-reported symptoms of depression, anxiety, or comorbid depression and anxiety at baseline and past 30-day e-cigarette use with nicotine or THC at 12-month follow-up. Analyses adjusted for baseline demographics and baseline past 30-day e-cigarette, combustible tobacco, marijuana, and alcohol use and stratified by race/ethnicity, gender, grade level, and SES.

Results: Participants were 16–23 years old, 58.1% female and 37.9% Hispanic. At baseline, 14.7% reported symptoms of comorbid depression and anxiety, 7.9% depression, and 4.7% anxiety. Prevalence of past 30-day e-cigarette use at 12-month follow-up was 10.4% with nicotine and 10.3% with THC. Symptoms of depression and comorbid depression and anxiety at baseline were significantly associated with both nicotine and THC use in e-cigarettes 12 months later. Symptoms of anxiety were associated with nicotine use in e-cigarettes 12 months later.

Conclusions: Symptoms of anxiety and depression may be important indicators of future nicotine and THC vaping among young people. Clinicians should be aware of groups most at risk who may benefit from substance use counselling and intervention.

Keywords

Adolescents; Young Adults; Vaping Marijuana; Anxiety; Depression

Introduction

Prevalence of past 30-day e-cigarette use among high school students in the United States (U.S.) almost doubled between 2017 (11.7%) and 2019 (27.5%) but saw a decline in

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2020 (19.5%) and 2021 (11.3%) (Park-Lee et al., 2021; Wang et al., 2018; Wang et al., 2019; Wang et al., 2021). Despite recent declines, e-cigarette use prevalence rates remain alarmingly high among young people. In 2021, a nationally representative study of students in the U.S. found that 19.6% of 12th graders reported past 30-day e-cigarette use with nicotine (i.e., nicotine vaping) (National Institute on Drug Abuse [NIDA] 2021). E-cigarettes are also used to vaporize tetrahydrocannabinol (THC; Harrell et al., 2022), the principal psychoactive component of marijuana. THC use in e-cigarettes (i.e., THC or marijuana vaping) is concerning, as THC consumption has negative health effects for young people, from neuropsychiatric disorders to e-cigarette or vaping-associated lung injuries (EVALI) (Chadi et al., 2021; Gobbi et al., 2019; Hengartner, Angst, Ajdacic-Gross, & Rössler, 2020; Siegel et al., 2019; Volkow, Baler, Compton, & Weiss, 2014). In 2021, 12.4% of 12th graders reported past 30-day use of e-cigarettes with marijuana (NIDA, 2021).

In the U.S. the prevalence of major depressive episode (i.e., having symptoms of depression for at least two weeks) among adolescents aged 12–17 years in the last year increased from 11.7% in 2014 to 15.7% in 2019, and was similarly high among young adults ages 18–25 years, growing from 10.3% in 2015 to 15.2% in 2019 (Substance Abuse and Mental Health Services Administration [SAMHSA], 2020). Anxiety disorders have a similar prevalence; results from the 2016 National Survey of Children’s Health estimated prevalence of diagnosed anxiety disorders to be 10.5% among individuals ages 12–17 years (Ghandour et al., 2019). Among young adults ages 18–25 years, 14.6% reported anxiety in 2018 (Goodwin, Weinberger, Kim, Wu, & Galea, 2020). Furthermore, comorbidity of clinically-diagnosed generalized anxiety disorder with major depressive disorder (hereafter referred to as comorbidity) is high, with estimates ranging from 48–71.7% (Cummings, Caporino, & Kendall, 2014; Moffitt et al., 2007; Zhou et al., 2017).

Evidence regarding the relationship between symptoms of anxiety, depression, or comorbidity, and e-cigarette use among young people is emerging. Several studies have shown cross-sectional associations between depression and e-cigarette use with nicotine among young people (Bandiera, Loukas, Wilkinson, & Perry, 2016; King, Reboussin, Spangler, Ross, & Sutfin, 2018; Lee & Lee, 2019). A longitudinal study of college students in Texas revealed elevated depressive symptoms predicted e-cigarette use with nicotine at 6-month and 12-month follow-up, and another study in California revealed a bidirectional relationship (Bandiera, Loukas, Li, Wilkinson, & Perry, 2017; Lechner, Janssen, Kahler, Audrain-McGovern, & Leventhal, 2017). Among adolescents, a few studies have shown depressive symptoms are associated with increased frequency and progression of e-cigarette use with nicotine over time (Audrain-McGovern, Rodriguez, Testa, Alexander, & Pianin, 2021; Marsden, Loukas, Chen, Perry, & Wilkinson, 2019; Moustafa, Testa, Rodriguez, Pianin, & Audrain-McGovern, 2021). Symptoms of anxiety alone have not consistently been associated with e-cigarette use with nicotine, although internalizing symptoms (which include both anxious and depressive feelings) are higher among those who use e-cigarettes with nicotine compared to never users in cross-sectional studies (Grant, Lust, Fridberg, King, & Chamberlain, 2019; Green, Conway, & Silveira, 2018; Leventhal et al., 2016; Riehm et al., 2019). Limited studies have examined relationships between symptoms of anxiety or depression and e-cigarette use with THC among young people, but previous research has shown that future and current marijuana use in any form is associated with

depression among young people (Gobbi et al., 2019; Leventhal, Bae, Kechter, & Barrington-Trimis, 2020; Womack, Shaw, Weaver, & Forbes, 2016). Anxiety is positively associated with marijuana use among young people (Hines et al., 2020), with one meta-analysis showing that marijuana use predicts anxiety at long-term (>1 year) follow-up (Kedzior & Laeber, 2014).

Very few studies have examined relationships between anxiety or depression and past 30-day e-cigarette use with nicotine or THC among young people across such key sociodemographic characteristics as race/ethnicity, gender, age or grade level, and socioeconomic status (SES). Womack et al. (2016) showed marijuana use predicted depressive symptoms among low SES young adult males. Moreover, these sociodemographic characteristics have been established as important influences on substance use behaviors and mental health outcomes, which warrants their examination in relationships between the two (U.S. Department of Health and Human Services [HHS], 2012; Wang et al., 2022). Studies show that females compared to males, lower SES individuals, and adolescents and young adults compared to other age groups have higher prevalence rates of anxiety and depression; non-Hispanic black adolescents are less likely to have depression than non-Hispanic white adolescents (Ghandour et al., 2019; Lemstra et al., 2008; McLean, Asnaani, Litz, & Hofmann, 2011; Mojtabai, Olfson, & Han, 2016; SAMHSA, 2020).

Past 30-day prevalence of e-cigarette use with nicotine and THC in the U.S. increases with higher SES and grade level, with high levels of use in young adulthood (Bao, Liu, Du, Snetselaar, & Wallace, 2021; Miech et al., 2020; Perry et al., 2018; Rogers et al., 2021; Schulenberg et al., 2020; Simon et al., 2018). Later in adolescence and early adulthood, prevalence of e-cigarette use with nicotine and THC has been shown to be higher among males (Kritikos et al., 2021; Miech et al., 2020; Schulenberg et al., 2020). Past 30-day use of e-cigarettes with nicotine is consistently higher among non-Hispanic white adolescents compared to Hispanic and non-Hispanic black adolescents; however, e-cigarette use with marijuana is similar between Hispanic and non-Hispanic white adolescents (Miech et al., 2020). Morean et al. (2021) reported e-cigarette use with marijuana was more prevalent among male and white high school students compared to other forms of marijuana use.

Study aims & hypotheses

In this study, we sought to identify whether symptoms of depression, anxiety, and comorbidity were associated with past 30-day e-cigarette use with nicotine or THC at 12-month follow-up among a large cohort of individuals in late adolescence and early adulthood (ages 16–23) from the four largest metropolitan areas in Texas. To identify specific populations that are at greater risk for e-cigarette use, we investigated the role of mental health symptomatology on subsequent e-cigarette use with nicotine or THC within categories of race/ethnicity, gender, grade level, and SES. Findings should aid in identification of groups of young people with symptoms of poor mental health most likely to benefit from additional education and counseling on e-cigarette use.

Methods

Procedures and participants

Data were from Waves 9 (this study's baseline) and 11 (12-month follow-up) of the Texas Adolescent Tobacco and Marketing Surveillance (TATAMS) study. TATAMS is a longitudinal, population-based surveillance study of e-cigarette use in youth and young adults in major metropolitan areas in Texas (San Antonio, Dallas/Fort Worth, Houston, and Austin) (Pérez et al., 2017). Details regarding the sampling procedures, design and methods for this study, which originally included students in the 6th, 8th, and 10th grades at wave 1 in 2014, are provided elsewhere (Pérez et al., 2017). At Wave 9/baseline, participants were in the 10th grade, 12th grade, or 2 years post high school (ages 16–23 years); 2,441 people participated at baseline, 2,501 participated at 12-month follow-up, and 2,307 completed both surveys. Attrition analyses revealed there were no significant differences in demographic variables between those completing one or both surveys. The inclusion criteria for the current study was completion of both baseline and follow-up surveys. TATAMS was approved by the University of Texas School of Public Health Committee for the Protection of Human Subjects (HSC-SPH-13-0377).

Measures

Mental Health Symptoms—Wave 9 was the first survey in which responses were collected using the Patient Health Questionnaire-9 (PHQ-9) and Generalized Anxiety Disorder-7 (GAD-7) item scales to measure symptoms of depression and anxiety. The PHQ-9 asks about experiences of nine symptoms of depression over the last two weeks, on a 4-point Likert scale from “not at all” to “nearly every day”; a score ≥ 10 was considered indicative of significant symptoms of depression (Arroll et al., 2010; Kroenke, Spitzer, & Williams, 2001). A score was not calculated for one participant with >2 missing values in the PHQ-9. The GAD-7 asks about experiences of seven symptoms of anxiety over the last two weeks, using the same 4-point Likert scale. No participants had >2 missing values in the GAD-7. A score ≥ 10 was considered indicative of significant symptoms of anxiety (Spitzer, Kroenke, Williams, & Löwe, 2006). Individuals participating at baseline either had 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), or symptoms of comorbidity (PHQ-9 ≥ 10 and GAD-7 ≥ 10).

E-cigarette Use Behaviors

E-cigarette use with nicotine. All participants were asked: “Have you ever used an electronic cigarette, even one or two puffs? Remember marijuana does not count.” Response options were “yes” or “no.” Participants that responded “yes” at any wave were considered lifetime e-cigarette with nicotine users. Lifetime users were asked: “During the past 30-days, on how many days did you use an electronic cigarette? Remember, marijuana does not count. Please enter the number of days (from 0 to 30 days).” Response options ranged from 0–30. Participants that reported zero days were considered non-past 30-day users and those that reported use on 1–30 days were considered past 30-day users of e-cigarettes with nicotine.

E-cigarette use with THC: All participants were asked: “Have you ever smoked marijuana (liquid THC) from an electronic cigarette, even one or two puffs?” Response options were “yes” or “no.” Participants that responded “yes” at any wave were considered lifetime e-cigarette with THC users. Lifetime users were asked: “During the past 30-days, on how many days did you smoke marijuana (liquid THC) from an electronic cigarette? Please enter the number of days (from 0 to 30 days).” Response options ranged from 0–30. Participants that reported zero days were considered non-past 30-day users and those that reported use on 1–30 days were considered past 30-day users of e-cigarettes with THC.

Other Tobacco, Marijuana and Alcohol Use Behaviors—Participants were also asked about their use of tobacco and marijuana in various forms other than use in e-cigarettes. Similar to measures of e-cigarette use, participants were asked about past 30-day use of cigarettes; little filtered cigars and cigarillos; large cigars; and hookah. Participants were also asked about past 30-day use of marijuana in tobacco products (i.e., spliffs, blunts, and in hookah) as well as any other form of marijuana use like edibles. Participants were asked on how many days during the past 30 days they had at least one alcoholic drink. Participants that reported zero days were considered non-past 30-day users and those that reported use on 1–30 days were considered past 30-day users of these substances.

Sociodemographics—Participants were asked if they were Hispanic or Latino/a and then indicated what race/races they considered themselves to be. Those indicating they were not Hispanic were placed in three different groups based on self-reported race: non-Hispanic white, non-Hispanic black, or non-Hispanic other (“Asian,” “American Indian or Alaska Native,” “Native Hawaiian or other Pacific Islander,” or “Other”). SES was assessed by asking, “In terms of income, what best describes your family’s standard of living in the home where you live most of the time? Would you say your family is very well off, living comfortably, just getting by, nearly poor, or poor?” Those considered to be of low SES selected “just getting by,” “nearly poor,” or “poor.” Those of middle SES and high SES selected “living comfortably” and “very well off,” respectively (Gore, Aseltine Jr, & Colten, 1992). Data were also collected on age, grade level, and gender (male or female).

Statistical Analysis

Chi-square tests were conducted to examine differences in prevalence rates of sociodemographic characteristics (race/ethnicity, gender, grade, and SES) among those with symptoms of anxiety, symptoms of depression, comorbidity, and those with no symptoms at baseline (Table 1). Chi-square tests were used to examine differences in prevalence of past 30-day e-cigarette use with nicotine and e-cigarette use with THC at 12-month follow-up by symptoms of depression and anxiety at baseline (Table 1). Multivariable logistic regression analyses were conducted to examine associations between symptoms of depression and/or symptoms of anxiety at baseline and subsequent past 30-day use of e-cigarette with nicotine or THC at 12-month follow-up (Table 2). Analyses where nicotine vaping was the outcome controlled for grade level, gender, SES, and baseline past 30-day nicotine vaping as well as past 30-day combustible tobacco use (cigarettes, cigars, and hookah), past 30-day marijuana use in any form, and past 30-day alcohol use. Analyses where THC vaping was the outcome controlled for grade level, gender, SES, baseline past 30-day THC vaping as well as past

30-day any other marijuana use, past 30-day any tobacco use (e-cigarettes with nicotine, cigarettes, cigars, and hookah), and past 30-day alcohol use. Analyses were further stratified by race/ethnicity (Table 2), gender (Table 3), grade level (Table 4), and SES (Table 5), controlling for other sociodemographic variables and previous use behaviors. A 2-sided type I error level of 0.05 was used to determine statistical significance. No symptoms of anxiety or depression was used as the referent group in all regression analyses. Analyses were conducted using Stata version 15.1 (StataCorp LLC).

Results

Sample Characteristics

The mean age of the sample at baseline (wave 9) was 18.5 years ($SD=1.6$ years) and 58.1% were female; 37.9% of the sample reported being Hispanic, and 30.8% of non-Hispanic young people were white (Table 1). Comorbidity occurred in 340 (14.7%) individuals, with symptoms of depression alone in 183 (7.9%) and anxiety alone in 108 (4.7%). With regard to past 30-day e-cigarette use, a total of 512 (22.2%) individuals used e-cigarettes; 336 (14.6%) individuals used with nicotine, 323 (14.0%) used with THC, and 147 (6.4%) used with both nicotine and THC. There were significant differences in the proportion of individuals with symptoms of poor mental health by race/ethnicity, gender, grade and SES (Table 1).

Past 30-day use of e-cigarettes with nicotine at 12-month follow-up was highest among young people with baseline symptoms of comorbidity (15.3% vs. 13.0% with anxiety, 10.9% with depression, and 9.1% with no symptoms). Past 30-day use of e-cigarettes with THC at 12-month follow-up was highest among young people with baseline symptoms of depression (16.4% vs. 15.6% with comorbidity, 8.9% with no symptoms, and 5.6% with anxiety).

Mental Health Symptomatology and Subsequent Use of E-Cigarettes

Table 2 demonstrates adjusted logistic regression analyses examining the impact of symptoms of depression alone, anxiety alone, or comorbidity at baseline on past 30-day use of e-cigarettes with nicotine and past 30-day use of e-cigarettes with THC at 12-month follow-up. Among the entire sample, symptoms of depression (AOR=1.45, 95% CI=1.02–2.08), anxiety (AOR=1.65, 95% CI=1.14–2.39), and comorbidity (AOR=1.58, 95% CI=1.06–2.37) were significantly associated with past 30-day e-cigarette use with nicotine at 12-month follow-up, controlling for race/ethnicity, biological sex, grade level, SES, and baseline past 30-day use of any tobacco, marijuana, and alcohol. Among the entire sample, symptoms of depression (AOR=1.58, 95% CI=1.14–2.20) and comorbidity (AOR=1.51, 95% CI=1.03–2.20) were significantly associated with past 30-day e-cigarette use with marijuana at 12-month follow-up, controlling for the same socio-demographic and substance use variables. Symptoms of anxiety was not significantly associated with past 30-day use of e-cigarettes with marijuana.

Upon stratifying by race/ethnicity, symptoms of depression (AOR=3.52, 95% CI=1.42–8.69), anxiety (AOR=3.27, 95% CI=1.25–8.52), and comorbidity (AOR=4.30, 95% CI=1.58–11.68) among young people of other races, including Asian, American Indian,

and multi-racial participants, were associated with higher odds of subsequent past 30-day e-cigarette use with nicotine after controlling for covariates. Among people of other races, depression (AOR=2.55, 95% CI=1.13–5.75) was significantly associated with higher odds of subsequent past 30-day use of e-cigarettes with THC after controlling for covariates. Among non-Hispanic white young people depression (AOR=2.52, 95% CI=1.27–4.99), anxiety (AOR=2.05, 95% CI=1.04–4.04), and comorbidity (AOR=3.24, 95% CI=1.53–6.85) were associated with higher odds of subsequent past 30-day e-cigarette use with nicotine controlling for covariates (Table 2).

Stratification by gender revealed males with symptoms of anxiety (AOR=2.48, 95% CI=1.32–4.64) and comorbidity (AOR=2.16, 95% CI=1.07–4.36) had significantly higher odds of past 30-day e-cigarette use with nicotine at 12-month follow-up compared to females. Males with symptoms of depression (AOR=1.95, 95% CI=1.12–3.41) had significantly higher odds of past 30-day e-cigarette use with THC at 12-month follow-up compared to females (Table 3).

Stratification by grade level revealed that symptoms of anxiety at baseline was associated with past 30-day e-cigarette use with nicotine at 12-month follow-up compared to individuals with no symptoms of depression or anxiety among individuals in 12th grade (AOR=1.86, 95% CI=1.02–3.38). Symptoms of depression at baseline was associated with past 30-day e-cigarette use with THC at 12-month follow-up among individuals in the 12th grade (AOR=2.04, 95% CI=1.13–3.69) and two years post high school (AOR=1.66, 95% CI=1.03–2.66).

Stratifying by SES, symptoms of depression (AOR=1.76, 95% CI=1.24–2.51), anxiety (AOR=2.19, 95% CI=1.52–3.17), and comorbidity (AOR=2.11, 95% CI=1.40–3.17) were significantly associated with past 30-day e-cigarette use with nicotine at 12-month follow-up, among individuals of middle to high SES compared to those of low SES. Among individuals of low SES, symptoms of depression (AOR=2.30, 95% CI=1.39–3.80) and comorbidity (AOR=1.93, 95% CI=1.12–3.80) were significantly associated with past 30-day e-cigarette use with THC at 12-month follow-up. Among individuals of middle to high SES, symptoms of depression (AOR=1.77, 95% CI=1.23–2.57) and comorbidity (AOR=1.64, 95% CI=1.05–2.55) were associated with past 30-day e-cigarette use with THC at 12-month follow-up.

Discussion

Our study reveals symptoms of depression, anxiety, and comorbid anxiety and depression were significantly associated with subsequent e-cigarette use with nicotine among youth and young adults. Symptoms of depression and comorbidity were significantly associated with subsequent e-cigarette use with THC, while anxiety alone was not. This study adds to limited longitudinal research on the relationship between mental health and popular substances used in e-cigarettes. Specifically, study findings indicate important associations between anxiety and depression and nicotine use in e-cigarettes and depression and THC use in e-cigarettes. These findings are consistent with previous research showing young people begin and continue using cigarettes, e-cigarettes, and other forms of nicotine to cope with

feelings of anxiety and depression and use marijuana to cope with feelings of depression (Feingold & Weinstein, 2021; Truth Initiative, 2021).

Youth and young adults of other races/ethnicities including Asians, American Indians and Alaska Natives (AIAN), and Native Hawaiians and other Pacific Islanders (NHOPI) may be most at-risk for the effects of depression, anxiety, and comorbidity on past 30-day e-cigarette use with nicotine compared to white, Hispanic, and black young people, and for the effect of depression on past 30-day e-cigarette use with THC compared to Hispanic and black young people. White, non-Hispanic youth and young adults may be most at-risk for the effects of depression, anxiety, and commodity on past 30-day e-cigarette use with THC compared to Hispanic and black young people. There is a lack of research on predictors of e-cigarette use among Asians, AIAN, and NHOPI (Shi, Gette, Gissandaner, Cooke, & Littlefield, 2020). Asian Americans have the lowest rates of tobacco use compared to other racial/ethnic groups in the U.S. while AIAN have the highest (Wang et al., 2019). Thus, while Asians are typically at a lower risk for substance use, findings from this study suggest those experiencing poorer mental health may become more at-risk than their peers of other racial/ethnic groups; and existing disparities in substance use risk may be further exacerbated by poorer mental health among AIAN. More research that parses out patterns in and predictors of e-cigarette use among minority racial/ethnic subgroups in the U.S. is needed.

While research shows females compared to males have higher rates of anxiety and depression, rates of e-cigarette use with nicotine are higher among males (Miech et al., 2020; SAMHSA, 2020). Findings from this study reveal males may be particularly vulnerable to the effect that anxiety and comorbidity have on past 30-day e-cigarette use with nicotine and to the effect that depression has on past 30-day e-cigarette use with THC. A previous study reported adolescent e-cigarette only users had a higher prevalence of depression and suicidality among females compared to males (Lee & Lee, 2019). Another study reported significant longitudinal associations between depression and poly-substance use (alcohol, e-cigarette, and marijuana use) for both males and females, but no association between poly-substance use and anxiety (Williams, Patte, Ferro, & Leatherdale, 2021). To our knowledge, the present study is the first to examine how longitudinal associations between depression and anxiety and e-cigarette use with nicotine and THC vary between males and females.

Compared to 10th graders and participants two years out of high school, 12th graders may be most at-risk for the effect of anxiety on past 30-day e-cigarette use with nicotine. Compared to 10th graders, 12th graders and those two years post high school may be most at-risk for the effect of depression on past 30-day e-cigarette use with THC. Thus, emerging adulthood may be a stage in which symptoms of anxiety are predictive of current e-cigarette use with nicotine and symptoms of depression are predictive of current e-cigarette use with THC. The transition from adolescence to adulthood is marked by identity exploration, changes in role, and changes in social context and frequently involves more freedom in decision-making and less oversight from other adults (Andrews & Westling, 2016; Stone, Becker, Huber, & Catalano, 2012). In one study, individuals who supported the notion that emerging adulthood is a time for experimentation were more likely to use e-cigarettes

(Allem, Forster, Neiberger, & Unger, 2015). The period immediately after high school, which often coincides with the beginning of adulthood, may thus be a stage where young people with internalizing symptoms are more likely to use e-cigarettes. However, emerging adulthood, and all the changes therein, may also act as a shared risk factor for both poor mental health and e-cigarette use. It is also possible, as in Carey et al., that transitions in grade level are characterized by experience of a high number of risk factors for e-cigarette susceptibility, including social norms promoting acceptability of e-cigarette use and lower positive affect (Carey et al., 2019). Of note, participants in TATAMS in 2019 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 e-cigarette users as a product of age.

In this study, youth and young adults of middle to high SES compared to low SES may be most at-risk for the effects of depression, anxiety, and comorbidity on past 30-day e-cigarette use with nicotine, while the effects of depression and comorbidity on past 30-day e-cigarette use with THC were significant for low and middle to high SES youth and young adults. Study findings for e-cigarette use with nicotine are consistent with previous research showing higher SES is associated with e-cigarette use with nicotine (Simon et al., 2018). Historically lower SES has been associated with marijuana use (Jeffers, Glantz, Byers, & Keyhani, 2021), however findings from this study indicate the effect of depression on marijuana vaping may transcend categories of SES, especially as marijuana vaping has become so universally popular among young people (Harrell et al., 2022).

Strengths and Limitations

Our study included a diverse sample by race, ethnicity, gender, and SES, allowing us to assess differential impact of symptoms of anxiety and depression on subsequent past 30-day e-cigarette use over a variety of demographic factors. However, we were unable to conduct this analysis among never users, as few individuals began use of e-cigarettes in the timeframe of our study. We were unable to address frequency or potency of THC or nicotine used in e-cigarettes due to sample size limitations. Future research should consider these important nuances of e-cigarette use. E-cigarette use and mental health symptoms were self-reported, and may be subject to recall and social desirability bias. Our sample cannot be generalized to youth in other cities or states outside of Texas, however, e-cigarette use in this sample is on par with other studies nationwide (Braymiller et al., 2020; Kowitt et al., 2019; Perry et al., 2018; Trivers, Phillips, Gentzke, Tynan, & Neff, 2018; Wang et al., 2019). Moreover, there was a relatively small sample of some groups, including Asian, AIAN, and NHOPI. These participants comprised 16% of the baseline sample, which does not support more detailed examination of research questions among and between these racial/ethnic demographics; studies with larger samples of these populations should be conducted, as e-cigarette use is high among AIAN and NHOPI youth (Odani, Armour, & Agaku, 2018).

Conclusion

The relationships examined in this study occur in an age group known to be high risk for e-cigarette use and poor mental health (Ghandour et al., 2019; Goodwin et al., 2020;

Perry et al., 2018; SAMHSA, 2020). The prevalence of e-cigarette use with nicotine and THC remains high among adolescents transitioning into young adulthood (Schulenberg et al., 2020) with use of electronic devices to vaporize THC becoming common with legal restrictions on marijuana use loosening. This study revealed vulnerable sub-groups where targeted interventions are needed for e-cigarette smoking prevention and cessation in addition to alternative resources to address mental health concerns. When health professionals screen for depression and anxiety, contemporaneously screening for e-cigarette use (and specific substances vaped) particularly among high risk groups will serve to identify individuals who may benefit from substance use interventions such as education, motivational interviewing, or higher levels of counseling.

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Table 1. Participant characteristics by symptoms^a of depression and anxiety and e-cigarette use (TATAMS; Spring 2019; n=2,307)

	Total sample n (%)	No symptoms n (%)	Comorbidity n (%)	Depression ^b n (%)	Anxiety ^c n (%)	P value ^d	Past 30-day E-cig use with Nicotine n (%)	P value ^d	Past 30-day E-cig use with THC n (%)	P value ^d
Total	2307 (100)	1673 (72.5)	340 (14.7)	183 (7.9)	108 (4.7)		239 (10.4)		238 (10.3)	
Race/Ethnicity										
Hispanic	875 (37.9)	610 (69.8)	156 (17.8)	77 (8.8)	31 (3.5)		66 (7.5)		96 (11.0)	
White	710 (30.8)	533 (75.2)	93 (13.1)	41 (5.6)	43 (6.1)	0.003	125 (17.6)	<0.001	70 (9.9)	0.615
Black	344 (14.9)	255 (74.1)	46 (13.4)	27 (7.8)	16 (4.7)		9 (2.6)		30 (8.7)	
Other ^e	378 (16.4)	275 (72.9)	45 (11.9)	39 (10.3)	18 (4.8)		39 (10.3)		42 (11.1)	
Gender										
Female	1340 (58.1)	889 (66.4)	258 (19.3)	109 (8.1)	82 (6.1)	<0.001	124 (9.3)	0.040	137 (10.2)	0.862
Male	967 (41.9)	784 (81.2)	82 (8.5)	74 (7.7)	26 (2.7)		115 (11.9)		101 (10.5)	
Grade										
10 th	652 (28.3)	481 (73.9)	95 (14.6)	44 (6.8)	31 (4.8)		44 (6.8)		56 (8.6)	0.105
12 th	781 (33.9)	586 (75.1)	92 (11.8)	58 (7.4)	44 (5.6)	0.007	89 (11.4)	0.002	78 (10.0)	
2 years post high school	874 (37.9)	606 (69.4)	153 (17.5)	81 (9.3)	33 (3.8)		106 (12.1)		104 (11.9)	
SES										
Middle-High	1734 (75.2)	1320 (76.2)	209 (12.1)	125 (7.2)	79 (4.6)	<0.001	188 (10.8)	0.186	163 (9.4)	0.012
Low	573 (24.8)	353 (61.8)	131 (22.9)	58 (10.2)	29 (5.1)		51 (8.9)		75 (13.1)	
Marijuana Use										
Lifetime	1040 (45.1)	697 (67.0)	187 (18.0)	108 (10.4)	48 (4.6)	<0.001	199 (19.1)	<0.001	219 (21.1)	<0.001
Past 30-day	528 (22.9)	350 (66.3)	96 (18.2)	59 (11.2)	23 (4.4)	<0.001	129 (24.4)	<0.001	169 (32.0)	<0.001
Tobacco Use										
Lifetime	1142 (49.5)	794 (69.6)	195 (17.1)	105 (9.2)	47 (4.1)	<0.001	228 (20.0)	<0.001	204 (17.9)	<0.001
Past 30-day	420 (18.2)	275 (65.6)	88 (21.0)	39 (9.3)	108 (4.1)	<0.001	167 (39.8)	<0.001	110 (26.2)	<0.001
Past 30-day alcohol use	794 (34.5)	527 (66.4)	146 (18.4)	79 (7.9)	42 (4.7)	<0.001	160 (20.5)	<0.001	165 (20.8)	<0.001

^aSymptoms of depression and anxiety^a is used rather than “depression and anxiety” as neither disorder can be diagnosed based on results of the screening tests used in the online survey; rather the survey measures the presence of symptoms.

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^bSymptoms of depression measured using the PHQ-9, with scores 10 indicating a positive screen for depression symptoms.

^cSymptoms of anxiety measured using the GAD-7, with scores 10 indicating a positive screen for anxiety symptoms.

^d(Unadjusted) Chi-square tests used to examine differences in baseline characteristics by baseline mental health symptoms and by follow-up e-cigarette use.

^eThe “other” group is heterogeneous; it includes Asian, American Indian or Alaska Native (AIAN), Native Hawaiian or other Pacific Islander (NHOP), among other racial identities.

Boldface indicates statistical significance ($p < 0.05$).

Associations between symptoms of anxiety and depression and past 30-day e-cigarette use, entire sample, stratified by ethnicity

Table 2.

Outcome: Past 30-day e-cigarette use with nicotine at 12-month follow-up						
	Entire sample	Hispanic	White	Black	Other ^a	
	AOR ^b (95% CI)	AOR ^b (95% CI)	AOR ^b (95% CI)	AOR ^b (95% CI)	AOR ^b (95% CI)	
Total n	n=2,307	n=875	n=710	n=344	n=378	
Comorbidity ^c	1.58 [*] (1.06, 2.37)	1.15 (0.57, 2.31)	1.59 (0.84, 3.01)	0.80 (0.79, 8.11)	4.30 ^{**} (1.58, 11.68)	
Depression ^d	1.45 [*] (1.02, 2.08)	1.10 (0.60, 2.01)	1.47 (0.83, 2.62)	1.49 (0.24, 9.24)	3.52 ^{**} (1.42, 8.69)	
Anxiety ^e	1.65 ^{**} (1.14, 2.39)	1.38 (0.73, 2.62)	1.56 (0.88, 2.75)	1.82 (0.30, 11.03)	3.27 [*] (1.25, 8.52)	
Outcome: Past 30-day e-cigarette use with THC at 12-month follow-up						
	Entire sample	Hispanic	White	Black	Other ^a	
	AOR ^f (95% CI)	AOR ^f (95% CI)	AOR ^f (95% CI)	AOR ^f (95% CI)	AOR ^f (95% CI)	
Total n	n=2,307	n=875	n=710	n=344	n=378	
Comorbidity ^c	1.51 [*] (1.03, 2.20)	1.03 (0.56, 1.88)	3.24 ^{**} (1.53, 6.85)	1.00 (0.34, 2.91)	2.02 (0.76, 5.31)	
Depression ^d	1.58 ^{**} (1.14, 2.20)	1.42 (0.86, 2.33)	2.52 ^{**} (1.27, 4.99)	0.66 (0.24, 1.78)	2.55 [*] (1.13, 5.75)	
Anxiety ^e	1.21 (0.84, 1.73)	0.83 (0.46, 1.49)	2.05 [*] (1.04, 4.04)	1.08 (0.41, 2.81)	1.55 (0.62, 3.87)	

^a“Other” is heterogeneous; it includes Asian, American Indian or Alaska Native (AIAN), Native Hawaiian or other Pacific Islander (NHOP), among other racial identities.

^b Adjusted for grade level, gender, SES, and Wave 9 (baseline) past 30-day use of e-cigarettes with nicotine, marijuana in any form, alcohol, and combustible tobacco. Entire sample additionally includes adjustment for race/ethnicity.

^c Comorbidity is symptoms of depression and anxiety present at Wave 9 (baseline).

^d Symptoms of depression measured at Wave 9 (baseline) using the PHQ-9, with scores 10 indicating a positive screen for depression symptoms.

^e Symptoms of anxiety measured at Wave 9 (baseline) using the GAD-7, with scores 10 indicating a positive screen for anxiety symptoms.

^f Adjusted for grade level, gender, SES, and Wave 9 (baseline) past 30-day use of e-cigarettes with THC, marijuana in any other form, alcohol, and combustible tobacco. Entire sample additionally includes adjustment for race/ethnicity.

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^g Adjusted for grade level, gender, SES, and Wave 9 (baseline) past 30-day use of e-cigarette with nicotine, e-cigarettes with THC, marijuana in any other form, alcohol, and combustible tobacco. Entire sample additional includes adjustment for race/ethnicity.

Boldface indicates statistical significance (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).

Referent group is no symptoms of anxiety or depression.

AOR, adjusted odds ratio; CI, confidence interval; PNP, perfect association with no past 30-day e-cigarette use.

Associations between symptoms of anxiety and depression and past 30-day e-cigarette use, stratified by gender

Table 3.

	E-cigarette use with nicotine at 12-month follow-up		E-cigarette use with THC at 12-month follow-up	
	Male	Female	Male	Female
	AOR ^a (95% CI)	AOR ^a (95% CI)	AOR ^b (95% CI)	AOR ^b (95% CI)
Total n	n=967	n=1,340	n=967	n=1,340
Comorbidity ^c	2.16* (1.07, 4.36)	1.25 (0.77, 2.04)	1.70 (0.83, 3.51)	1.44 (0.92, 2.25)
Depression ^d	1.26 (0.70, 2.26)	1.37 (0.88, 2.14)	1.95* (1.12, 3.41)	1.44 (0.96, 2.17)
Anxiety ^e	2.48** (1.32, 4.64)	1.30 (0.83, 2.05)	1.45 (0.75, 2.80)	1.13 (0.73, 1.73)

^a Adjusted for grade level, race/ethnicity, SES, and Wave 9 (baseline) past 30-day use of e-cigarettes with nicotine, marijuana in any form, alcohol, and combustible tobacco.

^b Adjusted for grade level, race/ethnicity, SES, and Wave 9 (baseline) past 30-day use of e-cigarettes with THC, marijuana in any other form, alcohol, and combustible tobacco.

^c Adjusted for grade level, race/ethnicity, SES, and Wave 9 (baseline) past 30-day use of e-cigarette with nicotine, e-cigarettes with THC, marijuana in any other form, alcohol, and combustible tobacco.

^d Comorbidity is symptoms of depression and anxiety present at Wave 9 (baseline).

^e Symptoms of depression measured at Wave 9 (baseline) using the PHQ-9, with scores 10 indicating a positive screen for depression symptoms.

^f Symptoms of anxiety measured at Wave 9 (baseline) using the GAD-7, with scores 10 indicating a positive screen for anxiety symptoms.

Boldface indicates statistical significance (*p<0.05, **p<0.01, ***p<0.001).

Referent group is no symptoms of anxiety or depression.

AOR, adjusted odds ratio; CI, confidence interval.

Associations between symptoms of anxiety and depression and past 30-day e-cigarette use, stratified by grade level

Table 4.

	E-cigarette use with nicotine at 12-month follow-up			E-cigarette use with THC at 12-month follow-up		
	10 th grade	12 th grade	2 years post high school	10 th grade	12 th grade	2 years post high school
Total n	n=652	n=781	n=874	n=652	n=781	n=874
Comorbidity ^d	2.10 (0.86, 5.13)	1.73 (0.89, 3.36)	1.25 (0.67, 2.33)	0.87 (0.34, 2.19)	1.76 (0.87, 3.58)	1.69 (0.98, 2.90)
Depression ^e	1.56 (0.69, 3.53)	1.53 (0.85, 2.75)	1.11 (0.65, 1.90)	0.93 (0.42, 2.03)	2.04 [*] (1.13, 3.69)	1.66 [*] (1.03, 2.66)
Anxiety ^f	2.24 (0.99, 5.03)	1.86 [*] (1.02, 3.38)	1.26 (0.71, 2.24)	0.73 (0.32, 1.69)	1.48 (0.77, 2.84)	1.30 (0.77, 2.19)

^a Adjusted for sex, race/ethnicity, SES, and Wave 9 (baseline) past 30-day use of e-cigarettes with nicotine, marijuana in any form, alcohol, and combustible tobacco.

^b Adjusted for sex, race/ethnicity, SES, and Wave 9 (baseline) past 30-day use of e-cigarettes with THC, marijuana in any other form, alcohol, and combustible tobacco.

^c Adjusted for grade level, race/ethnicity, SES, and Wave 9 (baseline) past 30-day use of e-cigarette with nicotine, e-cigarettes with THC, marijuana in any other form, alcohol, and combustible tobacco.

^d Comorbidity is symptoms of depression and anxiety present at Wave 9 (baseline).

^e Symptoms of depression measured at Wave 9 (baseline) using the PHQ-9, with scores 10 indicating a positive screen for depression symptoms.

^f Symptoms of anxiety measured at Wave 9 (baseline) using the GAD-7, with scores 10 indicating a positive screen for anxiety symptoms.

Boldface indicates statistical significance (*p<0.05, **p<0.01, ***p<0.001).

Referent group is no symptoms of anxiety or depression.

AOR, adjusted odds ratio; CI, confidence interval.

Associations between symptoms of anxiety and depression and past 30-day e-cigarette use, stratified by SES

Table 5.

	E-cigarette use with nicotine at 12-month follow-up		E-cigarette use with THC at 12-month follow-up	
	Low SES	Middle to High SES	Low SES	Middle to High SES
	AOR ^a (95% CI)	AOR ^a (95% CI)	AOR ^b (95% CI)	AOR ^b (95% CI)
Total n	n=573	n=1,734	n=573	n=1,734
Comorbidity ^d	1.80 (0.94, 3.43)	2.11 *** (1.40, 3.17)	1.93 * (1.12, 3.32)	1.64 * (1.05, 2.55)
Depression ^e	1.60 (0.88, 2.93)	1.76 ** (1.24, 2.51)	2.30 *** (1.39, 3.80)	1.77 ** (1.23, 2.57)
Anxiety ^f	1.47 (0.78, 2.76)	2.19 *** (1.52, 3.17)	1.53 (0.90, 2.61)	1.34 (0.89, 2.02)

^a Adjusted for sex, race/ethnicity, SES, and Wave 9 (baseline) past 30-day use of e-cigarettes with nicotine, marijuana in any form, alcohol, and combustible tobacco.

^b Adjusted for sex, race/ethnicity, SES, and Wave 9 (baseline) past 30-day use of e-cigarettes with THC, marijuana in any other form, alcohol, and combustible tobacco.

^c Adjusted for grade level, race/ethnicity, SES, and Wave 9 (baseline) past 30-day use of e-cigarette with nicotine, e-cigarettes with THC, marijuana in any other form, alcohol, and combustible tobacco.

^d Comorbidity is symptoms of depression and anxiety present at Wave 9 (baseline).

^e Symptoms of depression measured at Wave 9 (baseline) using the PHQ-9, with scores 10 indicating a positive screen for depression symptoms.

^f Symptoms of anxiety measured at Wave 9 (baseline) using the GAD-7, with scores 10 indicating a positive screen for anxiety symptoms.

Boldface indicates statistical significance (*p<0.05, **p<0.01, ***p<0.001).

Referent group is no symptoms of anxiety or depression.

AOR, adjusted odds ratio; CI, confidence interval; SES, socioeconomic status.