

# Patterns in Mental Health Symptomatology and Cigarette, E-cigarette, and Marijuana Use Among Texas Youth and Young Adults Amid the Coronavirus Disease 2019 Pandemic

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## Abstract

**Introduction:** This study examined patterns in mental health symptomatology and smoking and vaping behaviors among youth and young adults over a 1-year period from before to during the first year of the Coronavirus Disease 2019 (COVID-19) pandemic.

**Aims and Methods:** Participants ( $n = 2148$ ) were 16–24-year-olds who completed three waves of the Texas Adolescent Tobacco and Marketing Surveillance Study (TATAMS). Descriptive statistics and mixed effects logistic regression models were used to examine changes in anxiety symptoms, depressive symptoms, perceived stress, and cigarette, e-cigarette, and marijuana use from before COVID-19 (fall 2019) to 6-month follow-up (spring 2020) and 12-month follow-up (fall 2020) periods during COVID-19. Longitudinal associations between mental health symptomatology and smoking and vaping were examined.

**Results:** Modest increases in symptoms of anxiety and depression were observed from before to during COVID-19. Perceived stress remained high and unchanged. Ever marijuana use increased at 6- and 12-month follow-up, while ever cigarette and e-cigarette use increased significantly only at 12-month follow-up. Marijuana use frequency increased significantly at 6- and 12-month follow-ups. Adjusting for sociodemographic factors, increased symptoms of anxiety and depression predicted increases in ever cigarette, e-cigarette, and marijuana use, and past 30-day cigarette and e-cigarette use, but not past 30-day marijuana use. Higher perceived stress predicted increases in ever use of cigarettes and e-cigarettes and past 30-day cigarette use.

**Conclusions:** Changes in mental health symptomatology and smoking and vaping behaviors among young people in Texas varied during this period of the COVID era. Increases in mental health symptomatology predicted increases in cigarette, e-cigarette, and marijuana use behaviors.

**Implications:** This study adds to the limited research on the longitudinal impact of anxiety symptoms, depressive symptoms, and perceived stress on cigarette, e-cigarette, and marijuana use from before to during the first year of the COVID-19 pandemic. Findings warrant health messaging and interventions that address the significant impact of worse mental health on increased smoking and vaping behavior, especially during crises like COVID-19 that may exacerbate mental health and substance use behaviors.

## Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic has affected the lives of people globally since its start in December 2019. Economic and social changes, like shelter-in-place orders, physical distancing practices (i.e. “social distancing”), and job loss, as well as experiencing personally, or among one’s family and friends, the physical health effects of COVID-19, may exacerbate mental health problems.<sup>1</sup> The mental health effects of COVID-19 may be particularly prominent among youth and young adults since they are in an important developmental and transitional life stage.<sup>2,3</sup> Many youth and young adults are students who experienced prominent changes in their academic and social environments

amid COVID-19,<sup>4</sup> and studies have largely shown COVID-19-related disruptions (e.g. social isolation) have negatively impacted mental health.<sup>2,5–8</sup> Although a few studies have reported stable trajectories in mental health across the COVID-19 pandemic, among youth and young adults,<sup>9,10</sup> as well as improved mental health such as decreased anxiety and depression after switching from traditional to online learning.<sup>11</sup>

Adolescence and young adulthood are characterized by experimentation and solidification of smoking and vaping behaviors,<sup>12</sup> which have been impacted by COVID-19 with studies showing various patterns of use in response to COVID-19 including increasing, decreasing, and stable use as well as switching to other substance use.<sup>13,14</sup> In a nationally

representative sample of U.S. youth and young adults from the Monitoring the Future (MTF) study, marijuana use among college students was at an all-time high in 2020, during the first year of the COVID-19 pandemic.<sup>15</sup> Among noncollege attending young adults and youth, marijuana use was stable from previous years but has remained historically high. The prevalence of past 30-day (current) marijuana use was 6.6%–26.8% among youth (8th, 10th, and 12th graders) and young adult (college and noncollege students) samples.<sup>15</sup> Electronic cigarette (e-cigarette) use has increased drastically among youth and young adults over the past decade, such that in 2018 it was declared an epidemic among youth by the U.S. Surgeon General.<sup>16</sup> However, in 2020, e-cigarette use among youth and young adults remained stable from recent years. In the 2020 MTF study, past 30-day e-cigarette use prevalence was 12.2%–19.0% among youth and young adult samples. Cigarette use was at an all-time low, 2.3%–9.5% among youth and young adults in the 2020 MTF study.<sup>15</sup>

Studies show that smoking and vaping are associated with a greater risk of and worsening symptoms of COVID-19,<sup>17–19</sup> and this knowledge may be a contributing factor to the recent leveling-off of e-cigarette use and declines in cigarette use among youth and young adults.<sup>20,21</sup> Mental health is strongly associated with smoking and vaping with studies showing worse mental health is associated with initiating and increasing smoking and vaping behaviors.<sup>22,23</sup> Thus, it is important to understand how mental health symptomatology and smoking and vaping behaviors have changed amid the COVID-19 pandemic and how mental health symptomatology and substance use are related in the context of COVID-19. To date, investigations into these subject areas have been limited, especially those that examine the relationship between mental health symptomatology and substance use.<sup>24,25</sup>

This study examined changes in mental health symptomatology and ever and past 30-day smoking and vaping behaviors before and during the COVID-19 pandemic, as well as interrelationships between these two. Specifically, we examined how depression and anxiety symptoms, perceived stress, and ever and past 30-day cigarette, e-cigarette, and marijuana use changed among a cohort ( $n = 2148$ ) of Texas youth and young adults from one assessment period (fall 2019) prior to the COVID-19 pandemic to two assessment periods (spring and fall 2020) during the first year of COVID-19 in Texas. We also examined the impact of anxiety symptoms, depressive symptoms, and perceived stress on ever and past 30-day cigarette, e-cigarette, and marijuana use over this 1-year period, and whether interrelationships between these changed from pre- to during COVID-19. To date, research is limited in examining these patterns from before to during the COVID-19 pandemic, especially longitudinal studies utilizing a U.S. sample of youth and young adults. This study seeks to address this important research gap.

Based on our synthesis of previous studies, we hypothesized that symptoms of depression, anxiety, and perceived stress, as well as ever and past 30-day use of cigarettes, e-cigarettes, and marijuana would increase from before to during the COVID-19 pandemic among our sample of youth and young adults. We also hypothesized that increases in mental health symptomatology would predict increases in smoking and vaping behaviors.

## Methods

### Study Population

At baseline (wave 1) during the 2014–2015 academic school year, the Texas Adolescent Tobacco and Marketing Surveillance Study (TATAMS) used a complex probability design to recruit 6th, 8th, and 10th grade students from 79 schools in Houston, Dallas-Ft. Worth, San Antonio, and Austin. This study draws from TATAMS data collected in waves 10–12 (2019–2020) when participants were in 11th grade, and one and three years post-high school. Youth and young adults participating in TATAMS were assessed bi-annually, in 2019–2020, prior to the COVID-19 outbreak and throughout the first year of the COVID-19 outbreak. The total sample size for this study was 2148 participants who completed three waves (waves 10–12; fall 2019—fall 2020) of the TATAMS online survey (73% of the eligible sample). Compared with respondents, the prevalence of cigarette, e-cigarette, and marijuana use were all higher among nonrespondents (e.g. baseline ever cigarette use prevalence was 43% among nonrespondents and 28% among respondents). Respondents were more likely to be female (59% vs. 50%). Participants received a \$25 Amazon gift card upon completion of each of the three online surveys. More details about the TATAMS study from which this sample was drawn have been published previously.<sup>26</sup> More details about the TATAMS data and samples included in this study are provided in Table 1. Figure 1 displays the incidence of new COVID-19 cases in Texas across the study period.

### Measures

#### Mental Health Symptomatology

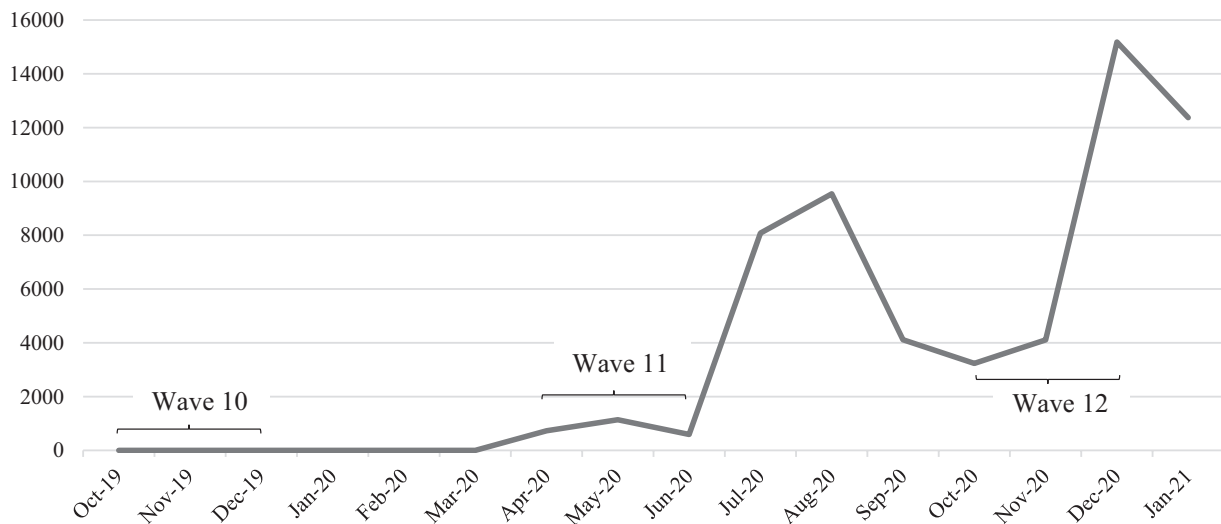
##### Anxiety.

Symptoms of anxiety were assessed via the Generalized Anxiety Disorder 7-item survey (GAD-7).<sup>27</sup> Participants were asked, “Over the last 2 weeks, how often have you been bothered by the following problems? Feeling nervous, anxious or on edge; not being able to stop or control worrying; worrying too much about different things; trouble relaxing; being so restless that it is hard to sit still; becoming easily annoyed or irritable; and feeling afraid as if something awful might happen.” Response options “not at all,” “several days,” “more than half the days,” and “nearly every day” were assigned

**Table 1.** Data Collection and Study Sample ( $n = 2148$ )

Wave #	Sample size	Response rate	Semester	Months	Phase of COVID-19	Participant age range	Participant age, mean (SD)
Wave 10	2335	79%	Fall 2019	Oct–Dec 2019	Pre-COVID-19	16–23	18.95 (1.57)
Wave 11	2501	85%	Spring 2020	Apr–Jun 2020	COVID-19 Phase I	16–24	19.49 (1.59)
Wave 12	2389	81%	Fall 2020	Oct–Dec 2020	COVID-19 Phase II	17–24	19.96 (1.57)

2148 of 2957 eligible participants (73%) completed waves 10, 11, and 12.



**Figure 1.** Incidence of new COVID-19 cases in Texas across the TATAMS study period (waves 10–12; fall 2019–20).

scores of 0, 1, 2, and 3, respectively. A total score was calculated by summing the scores on all seven items, ranging from 0 to 21. A cutoff of 10 was used to derive a dichotomous variable, with a score of 10 or higher being categorized as the presence of anxiety symptoms.

#### *Depression.*

Symptoms of depression were assessed via the Patient Health Questionnaire 9-item survey (PHQ-9).<sup>28</sup> Participants were asked, “Over the last 2 weeks, how often have you been bothered by the following problems? Little interest or pleasure in doing things; feeling down, depressed, or hopeless; trouble falling or staying asleep, or sleeping too much; feeling tired or having little energy; poor appetite or overeating; feeling bad about yourself or that you are a failure or have let yourself or your family down; trouble concentrating on things, such as reading the newspaper or watching television; moving or speaking so slowly that other people could have noticed. Or the opposite—being so fidgety or restless that you have been moving around a lot more than usual; thoughts that you would be better off dead, or of hurting yourself.” Response options “not at all,” “several days,” “more than half the days,” and “nearly every day” were assigned scores of 0, 1, 2, and 3, respectively. A total score was calculated by summing the scores on all nine items, ranging from 0 to 27. A cutoff of 10 was used to derive a dichotomous variable, with a score of 10 or higher being categorized as the presence of anxiety symptoms.

#### *Stress.*

Perceived stress was assessed via the 10-item Perceived Stress Scale (PSS).<sup>15</sup> Participants were asked, “In the last month, how often have you . . . been upset because of something that happened unexpectedly; felt that you were unable to control the important things in your life; felt nervous or stressed; felt confident about your ability to handle your personal problems; felt that things were going your way; found that you could not cope with all the things that you had to do; been able to control irritations in your life; felt that you were on top of things; been angered because of things that were outside of your control; felt difficulties were piling up so high that you could not overcome them.” Response options “never,” “almost never,” “sometimes,” “fairly often,” and

“very often” were assigned scores of 0, 1, 2, 3, and 4, respectively. A total score was calculated by summing the scores on all 10 items, ranging from 0 to 40. A cutoff of 14 was used to derive a dichotomous variable, a score of 14 or higher being categorized as “high perceived stress” and a score of less than 14 categorized as “low perceived stress.”

All substance use measures were adapted from valid and reliable measures from the Population Assessment of Tobacco and Health (PATH) study,<sup>29</sup> the National Youth Tobacco Survey (NYTS),<sup>30</sup> and the Monitoring the Future (MTF) study.<sup>31</sup>

### *Ever Substance Use*

#### *Cigarette Use.*

Participants were asked, “Have you ever tried cigarette smoking, even one or two puffs?” Response options were “yes” and “no.” Participants who responded “yes” were considered ever (lifetime) cigarette users.

#### *E-cigarette Use.*

Participants were asked, “Have you ever used an electronic cigarette, even one or two puffs?” Response options were “yes” and “no.” Participants who responded “yes” were considered ever (lifetime) e-cigarette users. Participants were asked to answer only about the use of e-cigarettes without marijuana.

#### *Marijuana Use.*

Participants were asked, “Have you ever smoked, used, or consumed marijuana in any form including joints, vaping, edibles, dabbing, sprays, etc.?” Response options were “yes” and “no.” Participants who responded “yes” were considered ever (lifetime) marijuana users.

### *Past 30-day Substance Use*

#### *Cigarette Use.*

Ever cigarette users were asked, “During the past 30 days, did you smoke a cigarette?” Response options were “yes” and “no.” Participants who responded “yes” were considered past 30-day (current) cigarette users. Past 30-day cigarette users were asked how many days during the past 30 days they smoked cigarettes with response options ranging from 1 to 30 days.

### E-cigarette Use.

Ever e-cigarette users were asked, “During the past 30 days, did you use an electronic cigarette?” Response options were “yes” and “no.” Participants who responded “yes” were considered past 30-day (current) e-cigarette users. Past 30-day e-cigarette users were asked how many days during the past 30 days they used e-cigarettes with response options ranging from 1 to 30 days.

### Marijuana Use.

Ever marijuana users were asked, “During the past 30 days, did you smoke, use or consume marijuana in any form including joints, vaping, dabbing, sprays, etc.?” Response options were “yes” and “no.” Participants who responded “yes” were considered past 30-day (current) marijuana users. Past 30-day marijuana users were asked how many days during the past 30 days they used marijuana with response options ranging from 1 to 30 days.

### Covariates

Covariates included age as a continuous variable; biological sex (male or female); race/ethnicity (Hispanic, African American, non-Hispanic white, and other); and survey wave as a categorical variable (10, 11, and 12) with wave 10 serving as the reference category.

### Statistical Analysis

Descriptive statistics were used to examine changes in mental health symptomatology (Table 2) and past 30-day substance use behaviors (Table 3) from fall 2019 through fall 2020. Prevalence and mean and median scores of anxiety symptoms, depressive symptoms, and perceived stress were

computed at each of the three assessment periods (waves 10–12). Incidence (ever use), prevalence (past 30 days), and mean and median number of days used in the past 30 days were computed for cigarette, e-cigarette, and marijuana use. McNemar’s tests (incidence, prevalence), paired *t*-tests (mean), and Wilcoxon signed rank tests (median) were used to test for significant differences between pre-COVID (wave 10) and during-COVID (6-month follow-up/wave 11 and 12-month follow-up/wave 12) levels of mental health symptomatology and substance use.

Then, mixed effects logistic regression models were conducted to examine associations between mental health symptomatology across three waves (10–12) and ever and past 30-day substance use across three waves (10–12) (Table 4). Each of three independent variables (anxiety symptoms, depressive symptoms, and perceived stress) and each of six outcome variables (ever and past 30-day cigarette, e-cigarette, and marijuana use) were assessed in separate models. At all three waves, all variables were measured. To build an appropriate regression model, we began each model by including the interaction between survey wave and mental health symptomatology, to allow the effect of mental health symptomatology on substance use to vary from pre- to during COVID-19 (from wave 10 to wave 11 and from wave 10 to wave 12). However, these interactions between survey wave and mental health symptomatology were not statistically significant, so the interaction term was removed. In other words, the impact of mental health symptomatology on vaping and smoking behaviors did not vary across time in this study. Therefore, in the final models, mental health symptomatology served as the independent variables, substance use behaviors were the dependent variables, and these models were adjusted for the survey wave. In addition, all models were controlled for age, race/ethnicity,

**Table 2.** Changes in Mental Health Symptomatology Among Texas Youth and Young Adults, from Pre-COVID-19 (Wave 10) to 6-Month (Wave 11) and 12-Month (Wave 12) Follow-Up Periods During the First Year of the COVID-19 Pandemic

	Pre-COVID-19 Baseline	COVID-19 6-month follow-up		COVID-19 12-month follow-up	
	Wave 10 (fall 2019)	Wave 11 (spring 2020)	<i>p</i> -Value <sup>a</sup>	Wave 12 (fall 2020)	<i>p</i> -Value <sup>b</sup>
<b>Anxiety</b>					
Presence of symptoms, n (%)	474 (22.07%)	503 (23.42%)	.291 <sup>c</sup>	528 (24.58%)	.053 <sup>c</sup>
Score (range: 0–21), M (SD)	5.49 (5.78)	5.79 (5.81)	.007 <sup>d,*</sup>	5.77 (5.87)	.015 <sup>d,*</sup>
Score (range: 0–21), Median	4	4	.007 <sup>e,*</sup>	4	.010 <sup>e,*</sup>
<b>Depression</b>					
Presence of symptoms, n (%)	528 (24.58%)	592 (27.56%)	.026 <sup>c,*</sup>	576 (26.82%)	.093 <sup>c</sup>
Score (range: 0–27), M (SD)	5.98 (6.58)	6.49 (6.58)	<.001 <sup>d,*</sup>	6.38 (6.87)	.002 <sup>d,*</sup>
Score (range: 0–27), Median	4	5	<.001 <sup>e,*</sup>	4	.006 <sup>e,*</sup>
<b>Stress</b>					
High (versus low) , n (%)	1,618 (75.33%)	1,581 (73.60%)	.194 <sup>c</sup>	1,628 (75.79%)	.722 <sup>c</sup>
Score (range: 0–40), M (SD)	17.37 (6.73)	17.34 (7.03)	.867 <sup>d</sup>	17.59 (6.84)	.109 <sup>d</sup>
Score (range: 0–40), Median	16	17	.737 <sup>e</sup>	17	.095 <sup>e</sup>

<sup>a</sup>Comparison is pre-COVID (wave 10) to 6-month follow-up (wave 11).

<sup>b</sup>Comparison is pre-COVID (wave 10) to 12-month follow-up (wave 12).

<sup>c</sup>McNemar’s test to test the difference between pre-COVID and during-COVID prevalence rates of mental health symptoms.

<sup>d</sup>Paired *t*-test to test the difference between pre-COVID and during-COVID mean score on mental health symptoms.

<sup>e</sup>Wilcoxon signed rank test to test the difference between pre-COVID and during COVID median score on mental health symptoms.

\* *p* < .05.

**Table 3.** Changes in Substance Use Behaviors Among Texas Youth and Young Adults, from Pre-COVID-19 (Wave 10) to 6-month (wave 11) and 12-month (Wave 12) Follow-up Periods During the First Year of the COVID-19 Pandemic

	Pre-COVID-19 baseline		COVID-19 6-month follow-up		COVID-19 12-month follow-up	
	Wave 10 (fall 2019)		Wave 11 (spring 2020)	<i>p</i> -Value <sup>a</sup>	Wave 12 (fall 2020)	<i>p</i> -Value <sup>b</sup>
<b>Cigarette Use</b>						
Lifetime use, <i>n</i> (%)	601 (27.98%)		646 (30.07%)	.135 <sup>c</sup>	687 (31.98%)	.004 <sup>c,*</sup>
Past 30-day use, <i>n</i> (%)	123 (5.73%)		87 (4.05%)	.010 <sup>c,*</sup>	109 (5.07%)	.344 <sup>c</sup>
No. of days during past 30 days, M (SD)	8.00 (9.80)		9.15 (10.43)	.763 <sup>d</sup>	6.96 (8.38)	.913 <sup>d</sup>
No. of days during past 30 days, Median	3		4	.990 <sup>e</sup>	3	.719 <sup>e</sup>
<b>E-cigarette Use</b>						
Lifetime use, <i>n</i> (%)	1,011 (47.07%)		1,062 (49.44%)	.122 <sup>c</sup>	1,104 (51.40%)	.004 <sup>c,*</sup>
Past 30-day use, <i>n</i> (%)	244 (11.36%)		211 (9.82%)	.101 <sup>c</sup>	234 (10.89%)	.631 <sup>c</sup>
No. of days during past 30 days, M (SD)	15.24 (11.45)		17.14 (11.43)	.559 <sup>d</sup>	15.96 (11.58)	.210 <sup>d</sup>
No. of days during past 30 days, Median	15		20	.644 <sup>e</sup>	15	.388 <sup>e</sup>
<b>Marijuana Use</b>						
Lifetime use, <i>n</i> (%)	725 (33.75%)		915 (42.60%)	<.001 <sup>c,*</sup>	1,018 (47.39%)	<.001 <sup>c,*</sup>
Past 30-day use, <i>n</i> (%)	357 (16.62%)		370 (17.23%)	.596 <sup>c</sup>	401 (18.67%)	.078 <sup>c</sup>
No. of days during past 30 days, M (SD)	10.06 (9.98)		12.61 (10.83)	<.001 <sup>d,*</sup>	12.36 (11.26)	<.001 <sup>d,*</sup>
No. of days during past 30 days, Median	5		10	<.001 <sup>e,*</sup>	7	<.001 <sup>e,*</sup>

<sup>a</sup> Comparison is pre-COVID (wave 10) to 6-month follow-up (wave 11).

<sup>b</sup> Comparison is pre-COVID (wave 10) to 12-month follow-up (wave 12).

<sup>c</sup> McNemar's test to test the difference between pre-COVID and during-COVID lifetime and past 30-day prevalence rates of substance use.

<sup>d</sup> Paired *t*-test to test the difference between pre-COVID and during-COVID mean # of days substances used during the past 30 days.

<sup>e</sup> Wilcoxon signed rank test to test the difference between pre-COVID and during COVID median # of days substances used during the past 30 days.

\* *p* < .05.

**Table 4.** Longitudinal Associations between Mental Health Symptomatology and Lifetime and Past 30-Day Substance Use Across a 1-Year Period from Before to During the COVID-19 Pandemic

	Lifetime cigarette use	Lifetime e-cigarette use	Lifetime marijuana use
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Anxiety symptoms	1.35 (1.20 to 1.53)***	1.18 (1.05 to 1.32)**	1.43 (1.28 to 1.61)***
Depressive symptoms	1.46 (1.29 to 1.64)***	1.38 (1.23 to 1.54)***	1.68 (1.50 to 1.88)***
High perceived stress	1.38 (1.22 to 1.57)***	1.20 (1.07 to 1.34)***	1.04 (0.93 to 1.16)
	Past 30-day cigarette use	Past 30-day e-cigarette use	Past 30-day marijuana use
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Anxiety symptoms	1.62 (1.29 to 2.04)***	1.29 (1.09 to 1.53)**	1.11 (0.94 to 1.30)
Depressive symptoms	1.78 (1.42 to 2.22)***	1.42 (1.21 to 1.68)***	1.17 (1.00 to 1.37)
High perceived stress	1.86 (1.41 to 2.47)***	1.15 (0.96 to 1.36)	0.94 (0.79 to 1.11)

\*\*\* *p* < .001 \*\* *p* < .01.

All models controlled for age, sex, race/ethnicity, and survey wave.

and biological sex. Adjusted odds ratios (AOR) and 95% confidence intervals (95% CI) are reported (Table 4).

## Results

Mean and median scores on anxiety and depression scales increased significantly, yet moderately, from before to 6 months and 12 months after COVID-19 onset, indicating more anxiety symptoms and depressive symptoms among our sample after COVID-19. The prevalence of depressive

symptoms increased significantly from pre-COVID baseline to 6-month follow-up (from 24.5% to 27.5%). Perceived stress and the prevalence of anxiety symptoms stayed the same, on average, within our study sample, from before to after COVID-19 (Table 2).

Ever cigarette use increased significantly at 12-month follow-up, from 27.9% to 31.9%, and past 30-day cigarette use among our sample decreased significantly from 5.7% to 4.0% at 6-month follow-up. Ever e-cigarette use increased significantly at 12-month follow-up, from 47.0% to 51.4%. Ever

marijuana use increased significantly at 6- and 12-month follow-up, from 33.7% to 42.6% and 47.3%, respectively. The mean and median number of days marijuana was used during the past 30 days, among past 30-day users, increased significantly. The mean number of marijuana use days was 10.06 (SD: 9.98) before COVID-19 and 12.61 (10.83) and 12.36 (11.26) at 6- and 12-month follow-ups, respectively. The median number of marijuana use days was 5 before COVID-19 and 10 and 7 at 6- and 12-month follow-ups, respectively (Table 3).

From fall 2019 through fall 2020, adjusting for participants' age, sex, race/ethnicity, and survey wave, increased anxiety symptoms were significantly associated with increased ever or lifetime cigarette (AOR: 1.35; 95% CI: 1.20 to 1.53), e-cigarette (1.18; 1.05–1.32), and marijuana use (1.43; 1.28–1.61). Increased depressive symptoms were also significantly associated with increased ever or lifetime cigarette (1.46; 1.29–1.64), e-cigarette (1.38; 1.23–1.54), and marijuana use (1.68; 1.50–1.88). High perceived stress, relative to low stress, was significantly associated with increased ever or lifetime cigarette (1.38; 1.22–1.57) and e-cigarette use (1.20; 1.07–1.34) (Table 4).

From fall 2019 through fall 2020, adjusting for participants' age, sex, race/ethnicity, and survey wave, increased anxiety symptoms were significantly associated with increased past 30-day cigarette (1.62; 1.29–2.04) and e-cigarette use (1.29; 1.09–1.53). Increased depressive symptoms were also significantly associated with an increased past 30-day cigarette (1.78; 1.42–2.22) and e-cigarette use (1.42; 1.21–1.68). High perceived stress, relative to low stress, was significantly associated with increased past 30-day cigarette use (1.86; 1.41–2.47) (Table 4).

Interactions between mental health symptomatology and survey wave were not statistically significant indicating that the effect of mental health symptomatology on substance use (i.e. smoking and vaping behaviors) did not vary across the study period.

## Discussion

This study examined changes in anxiety symptoms, depressive symptoms, and perceived stress, and marijuana, e-cigarette, and cigarette use from before the COVID-19 pandemic (fall 2019) to 6-month (spring 2020) and 12-month (fall 2020) follow-up, during the COVID-19 pandemic, as well as longitudinal associations between mental health symptomatology and smoking and vaping behaviors across this time. Study findings reveal symptoms of anxiety and depression showed moderate increases from pre- to during-COVID-19, while perceived stress remained stable but high. These findings are congruent with previous research, which primarily reports modest, but elevated mental health issues among U.S. youth and young adults during COVID-19.<sup>24</sup> Interestingly, studies outside of the U.S. including China, Spain, and Italy, have reported a greater impact of COVID-19 on increased anxiety, depression, and stress with age younger than 40 being a risk factor for greater adverse mental health symptoms.<sup>32</sup> There may be important cultural differences between U.S. and non-U.S. youth and young adults that contribute to these differential findings. Additional research is needed, especially among U.S. populations since research on this subject is limited.

Lifetime cigarette, e-cigarette, and marijuana use increased significantly in our sample at a 12-month follow-up, especially,

demonstrating that young people aged 16–24 years from these major metropolitan areas of Texas began smoking and vaping despite being in the midst of a pandemic of respiratory disease. This is a notable finding that suggests young people are motivated to try smoking and vaping in the context of COVID-19, when there may be substantial and increased risks for doing so, still.

In this study, we found that worse mental health predicted lifetime cigarette, e-cigarette, and marijuana use amid COVID-19, controlling for important demographic factors. This relationship was consistent across time, across data that were collected prior to the pandemic, and data that were collected at different time points during the pandemic. More research is needed to understand these and other potential motivations among never users, to inform prevention efforts such as effectively disseminating messages about the respiratory health effects associated with smoking and vaping, and the exacerbated impact that COVID-19 may have on the same.

Past 30-day cigarette use decreased significantly among study participants. A meta-analysis concluded that cigarette smoking is an independent risk factor for COVID-19 disease progression and mortality.<sup>33</sup> Furthermore, a previous study reported that most past 30-day cigarette users believed COVID-19-related health risk was greater for cigarette users compared to nonusers, and past 30-day cigarette users decreased their cigarette use in response to COVID-19 (compared to increasing or stable use).<sup>13</sup> COVID-19 may be a contributing factor in the decreasing cigarette use reported in this study and others nationwide.<sup>34</sup> The frequency of marijuana use (i.e. number of days in the past 30 days), among past 30-day users, increased significantly from pre- to during-COVID-19, while cigarette and e-cigarette use frequency among current users did not change significantly. This finding is similar to another study of college students that reported marijuana use days were 24% higher from before U.S. colleges closed to postclosure because of COVID-19,<sup>24</sup> and to the 2020 MTF study, which reported college student marijuana use was at a historic high during the first year of COVID-19.<sup>34</sup> Marijuana use among young people is becoming an increasingly important public health issue, especially as using marijuana in e-cigarettes (i.e. marijuana vaping) has grown radically in popularity in very recent years.<sup>34</sup> The 2020 MTF study showed a 140% and a 138% increase in ever and past 30-day marijuana vaping, respectively, from 2017 to 2020.<sup>34</sup>

Although statistically significant, it is worth noting that the changes in mental health symptomatology and smoking and vaping behaviors observed in this study were modest, which is consistent with previous studies.<sup>5,24,35</sup> Future research should continue to examine patterns in these important health indicators further into the COVID-19 pandemic and beyond. Despite modest changes in these behaviors, there were strong, longitudinal associations between increased anxiety and depressive symptoms and ever and past 30-day cigarette and e-cigarette use, and ever marijuana use. There were also strong associations between high perceived stress and ever and past 30-day cigarette use and ever e-cigarette use. These findings suggest that increased substance use may have been most problematic among subgroups of youth and young adults whose mental health was adversely affected by the COVID-19 pandemic. Our study findings are consistent with a previous study that reported greater depressive symptoms predicted increases

in e-cigarette use among young adults with low resilience, from fall 2019 to spring 2020.<sup>36</sup> Although changes in past 30-day marijuana use, given that changes in mental health symptomatology were not observed in this study, increases in the overall frequency of marijuana use among past 30-day users was seen. Thus, additional research is needed to determine what other risk factors, besides mental health symptomatology may be responsible for this increase in marijuana use.

### Limitations

This study has limitations. Measures were self-reports which introduces recall bias. The sample was comprised of youth and young adults in Texas so findings may not be generalizable outside the study setting. In 2019–2020, when data for this study were collected, recreational marijuana use in the state of Texas was illegal. Marijuana vaping among youth and young adults is consistently higher in locales where marijuana use is legal.<sup>37</sup> Study findings may differ from those in other locales where recreational marijuana use is not illegal. Finally, it is possible that stressors other than COVID-19 or navigating this life stage could have influenced the study findings. However, the timing of our data collection and the research questions that drove the development of this study were very unique to COVID-19. Despite limitations, this study followed a single cohort, across multiple (i.e. three) assessment periods to examine differences, on average, in patterns of and relationships between mental health symptomatology and smoking and vaping behaviors before and during the COVID-19 pandemic, which is a unique contribution of this study.

### Conclusion

Changes in mental health symptomatology among these young people varied during this period of the COVID-era, as did changes in vaping and smoking behaviors. Increases in mental health symptomatology were related to increases in cigarette, e-cigarette, and marijuana use.

Findings warrant health messaging and interventions that address the impact of mental health on smoking and vaping behavior, especially during crises like COVID-19 that may exacerbate mental health and substance use behaviors.

### Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at <https://academic.oup.com/ntr>.

### Funding

This work was supported by grant number [R01-CA239097] from the National Cancer Institute.

### Declaration of Interests

*Drs. Clendennen and Harrell are consultants in litigation involving the vaping industry. Other authors have no conflicts of interest to disclose.*

### Data Sharing

The data underlying this article will be shared on reasonable request to the corresponding author.

### References

- Galea S, Merchant RM, Lurie N. The mental health consequences of COVID-19 and physical distancing: the need for prevention and early intervention. *JAMA Intern Med.* 2020;180(6):817–818.
- Shah SMA, Mohammad D, Qureshi MFH, Abbas MZ, Aleem S. Prevalence, psychological responses and associated correlates of depression, anxiety and stress in a global population, during the coronavirus disease (COVID-19) pandemic. *Community Ment Health J.* 2021;57(1):101–110.
- Arnett JJ. Emerging adulthood: a theory of development from the late teens through the twenties. *Am Psychol.* 2000;55(5):469–480.
- Giuntella O, Hyde K, Saccardo S, Sadoff S. Lifestyle and mental health disruptions during COVID-19. *Proc Natl Acad Sci USA.* 2021;118(9), e2016632118.
- Copeland WE, McGinnis E, Bai Y, et al. Impact of COVID-19 pandemic on college student mental health and wellness. *J Am Acad Child Adolesc Psychiatry.* 2021;60(1):134–141.e2.
- Chen B, Sun J, Feng Y. How have COVID-19 isolation policies affected young people's mental health?—Evidence from Chinese college students. *Front Psychol.* 2020;11:1–6. Article No.: 1529. doi:10.3389/fpsyg.2020.01529.
- Loades ME, Chatburn E, Higson-Sweeney N, et al. Rapid systematic review: the impact of social isolation and loneliness on the mental health of children and adolescents in the context of COVID-19. *J Am Acad Child Adolesc Psychiatry.* 2020;59(11):1218–1239. e3.
- Samji H, Wu J, Ladak A, et al. Mental health impacts of the COVID-19 pandemic on children and youth—a systematic review. *Child Adolesc Ment Health.* 2022;27(2):173–189.
- Stroud I, Gutman LM. Longitudinal changes in the mental health of UK young male and female adults during the COVID-19 pandemic. *Psychiatry Res.* 2021;303:1–5. Article No.: 114074.
- McPherson KE, McAloney-Kocaman K, McGlinchey E, Faeth P, Armour C. Longitudinal analysis of the UK COVID-19 psychological wellbeing study: trajectories of anxiety, depression and COVID-19-related stress symptomology. *Psychiatry Res.* 2021;304:1–10. Article No.: 114138.
- Bolatov AK, Seisembekov TZ, Askarova AZ, Baikanova RK, Smailova DS, Fabbro E. Online-learning due to COVID-19 improved mental health among medical students. *Med Sci Educ.* 2021;31(1):183–192.
- Clendennen SL, Loukas A, Creamer MR, Pasch KE, Perry CL. Longitudinal patterns of multiple tobacco and nicotine product use among Texas college students: a latent transition analysis. *Prev Sci.* 2019;20(7):1031–1042.
- White AM, Li D, Snell LM, et al. Perceptions of tobacco product-specific COVID-19 risk and changes in tobacco use behaviors among smokers, e-cigarette users, and dual users. *Nicotine Tob Res.* 2021;23(9):1617–1622.
- Clendennen SL, Case KR, Sumbe A, Mantey DS, Mason EJ, Harrell MB. Stress, dependence, and COVID-19–related changes in past 30-day marijuana, electronic cigarette, and cigarette use among youth and young adults. *Tob Use Insights.* 2021;14: 1179173X211067211067439.
- Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav.* 1983;24(4):385–396.
- Sokolovsky AW, Hertel AW, Micalizzi L, White HR, Hayes KL, Jackson KM. Preliminary impact of the COVID-19 pandemic on smoking and vaping in college students. *Addict Behav.* 2021;115: 1–4. Article no.: 106783.
- Gupta AK, Nethan ST, Mehrotra R. Tobacco use as a well-recognized cause of severe COVID-19 manifestations. *Respir Med.* 2020;176:1–6. Article No.: 106233.

18. Kaur G, Lungarella G, Rahman I. SARS-CoV-2 COVID-19 susceptibility and lung inflammatory storm by smoking and vaping. *J Inflamm (Lond)*. 2020;17(1):1–8.
19. Simons D, Shahab L, Brown J, Perski O. The association of smoking status with SARS-CoV-2 infection, hospitalization and mortality from COVID-19: a living rapid evidence review with Bayesian meta-analyses (version 7). *Addiction*. 2020;116(6):1319–1368.
20. Gaiha SM, Cheng J, Halpern-Felsher B. Association between youth smoking, electronic cigarette use, and COVID-19. *J Adolesc Health*. 2020;67(4):519–523.
21. Stokes AC. Declines in electronic cigarette use among US youth in the era of COVID-19—a critical opportunity to stop youth vaping in its tracks. *JAMA Network Open*. 2020;3(12):e2028221.
22. Primack BA, Land SR, Fan J, Kim KH, Rosen D. Associations of mental health problems with waterpipe tobacco and cigarette smoking among college students. *Subst Use Misuse*. 2013;48(3):211–219.
23. Lipari, R.N. and Van Horn, S.L. Smoking and mental illness among adults in the United States. *The CBHSQ Report*: March 30, 2017. Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration, Rockville, MD.
24. Schepis TS, De Nadai AS, Bravo AJ, *et al*. Alcohol use, cannabis use, and psychopathology symptoms among college students before and after COVID-19. *J Psychiatr Res*. 2021;142:73–79.
25. Capasso A, Jones AM, Ali SH, *et al*. Increased alcohol use during the COVID-19 pandemic: the effect of mental health and age in a cross-sectional sample of social media users in the US. *Prev Med*. 2021;145:1–18. Article no.: 106422.
26. Pérez A, Harrell MB, Malkani RI, *et al*. Texas adolescent tobacco and marketing surveillance system's design. *Tob Regul Sci*. 2017;3(2):151–167.
27. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: The GAD-7. *Arch Intern Med*. 2006;166(10):1092–1097.
28. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med*. 2001;16(9):606–613.
29. Hyland A, Ambrose BK, Conway KP, *et al*. Design and methods of the Population Assessment of Tobacco and Health (PATH) Study. *Tob Control*. 2017;26(4):371–378.
30. National Youth Tobacco Survey (NYTS). Centers for Disease Control and Prevention. Updated March 14, 2022. Accessed May 12, 2022. [https://www.cdc.gov/tobacco/data\\_statistics/surveys/nyts/index.htm](https://www.cdc.gov/tobacco/data_statistics/surveys/nyts/index.htm).
31. Johnston LD, O'Malley PM, Bachman JG, Schulenberg JE. *Demographic subgroup trends for various licit and illicit drugs, 1975–2005*. (Monitoring the Future Occasional Paper No. 63) [On-line]. Ann Arbor, MI: Institute for Social Research; 2006. Available: <http://monitoringthefuture.org/>.
32. Xiong J, Lipsitz O, Nasri F, *et al*. Impact of COVID-19 pandemic on mental health in the general population: a systematic review. *J Affect Disord*. 2020;277:55–64.
33. Patanavanich R, Glantz SA. Smoking is associated with worse outcomes of COVID-19 particularly among younger adults: a systematic review and meta-analysis. *BMC Public Health*. 2021;21(1):1–9.
34. Schulenberg, J. E., Patrick, M. E., Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Miech, R. A. (2021). Monitoring the Future national survey results on drug use, 1975–2020: Volume II, College students and adults ages 19–60. Ann Arbor: Institute for Social Research, The University of Michigan. Available at <http://monitoringthefuture.org/pubs.html#monographs>.
35. Rogers AH, Shepherd JM, Garey L, Zvolensky MJ. Psychological factors associated with substance use initiation during the COVID-19 pandemic. *Psychiatry Res*. 2020;293:1–6. Article No.: 113407.
36. Romm KE, Patterson B, Crawford ND, *et al*. Changes in young adult substance use during COVID-19 as a function of ACEs, depression, prior substance use and resilience. *Subst Abuse*. 2022;43(1):212–221.
37. Harrell MB, Clendennen SL, Sumbe A, Case KR, Mantey DS, Swan S. Cannabis vaping among youth and young adults: A scoping review. *Curr Addic Rep*. 2022;1–18.