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Relationships Between Depressive Symptoms, Anxiety, Impulsivity and Cigarette and E-cigarette Use Among Young Adults

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Abstract

Depression and anxiety have been associated with cigarette use among young people. Higher impulsivity has also been associated with increased smoking behavior. However, relatively less is known about the associations between depression, anxiety, impulsivity and e-cigarette use and how these associations compare with the associations between depression, anxiety, impulsivity and cigarette smoking. In addition, little is known about how impulsivity influences the relationships between depression, anxiety, cigarette, and e-cigarette use. This study tested the hypothesis that higher depression and anxiety symptoms are associated with higher e-cigarette use and cigarette smoking in a similar way, and that these associations would be stronger among those with higher impulsivity. A sample of 2,622 young adults (18-25 year olds; 54% women) enrolled in 4-year and 2-year colleges in Hawai'i participated in a cross-sectional survey. Approximately 68% of the sample reported no use of either e-cigarettes or cigarettes, 13% reported only e-cigarette use, 9% reported only cigarette smoking, and 11% reported use of both. The study found that higher depressive and anxiety symptoms and higher impulsivity were significantly associated with current cigarette and e-cigarette use. For example, one unit increases in depression, anxiety, and impulsivity were associated with 34%, 17%, and 38% increased odds of e-cigarette use versus non-use, respectively. Impulsivity was found to significantly moderate the association between higher anxiety and higher cigarette smoking, such that the association was stronger among those with higher impulsivity. Impulsivity was not found to moderate any other association. Results suggest that tobacco product use prevention education should target children and young adults with higher internalizing symptoms, with particular attention to those who show higher impulsivity.

Keywords

Depressive symptoms, Anxiety symptoms, Impulsivity, Cigarettes, E-Cigarettes, Young Adults

Introduction

Electronic or e-cigarettes are becoming more commonly used by United States (US) high and middle school students than combustible cigarettes,[1] despite having been marketed widely for only about a decade. The risks of cigarette smoking and second-hand exposure to cigarette smoke have been known for decades.[2] However, as e-cigarettes are a relatively new product on the market, little is known regarding their potential risks. E-cigarettes appear to be less harmful than cigarettes; as a result, some people perceive them to be safer or healthier alternatives to combustible cigarettes.[3] Unfortunately, however, now many young people are being introduced to nicotine use through e-cigarettes, especially in Hawai'i.[4] In 2017, more Hawai'i high school students reported themselves as current e-cigarette users (26%) than cigarette smokers (8%).[5] Nationally, approximately, 3.6 million youths are current e-cigarette users.[6] E-cigarettes are available in many different flavors, which young people tend to find highly attractive.[7]

Apart from flavors, young people find e-cigarettes attractive because e-cigarette aerosol is easier to inhale, does not smell bad, is considered less harmful, and yet is able to deliver nicotine.[8] For some young people, the motive of e-cigarette use is social enhancement, such as an increase in popularity among peers and an enhanced social image.[8] Although cigarette smokers commonly use e-cigarettes for help with smoking cessation, some do not find e-cigarettes to be helpful in managing their cigarette smoking behavior.[9] Another potential risk of e-cigarettes is that individuals who have never smoked cigarettes, or who are novice

smokers, may find e-cigarettes as a more appealing cigarette alternative for nicotine delivery.[8,9] Smokers consume cigarettes primarily because of nicotine, which is a psychostimulant and addictive. However, cigarette smoke smells relatively harsh and tastes bitter. These characteristics may deter never or novice smokers from smoking, even though they may like the pleasurable effects of nicotine. E-cigarette aerosol, on the other hand, is less harsh and bitter. Furthermore, because e-cigarette aerosol is usually flavored, it smells and tastes good. Hence, individuals who might have been deterred from smoking cigarettes for nicotine intake may find e-cigarettes as a better alternative for delivery of nicotine.

Cigarettes have been known to cause cancer (especially lung cancer), asthma, diabetes, gum disease, heart disease, and stroke.[2] However, the definite harms caused by e-cigarettes are not as well-known. E-cigarettes may cause asthma,[10] decreased lung function,[11] an increased innate immune response in the lung,[12,13] and cardiovascular disease.[14] Even though in smaller amounts than cigarettes, e-cigarettes are known to contain dangerous carcinogens such as nitric oxide, which when burned creates formaldehyde.[15] Second-hand exposure to e-cigarette aerosol may also be risky, although the level of risks are currently unknown.[16] In 2019, the CDC investigated a national outbreak of e-cigarette or vaping product use associated lung injury (EVALI).[17,18] As of October 2019, there were 1,604 reported cases of EVALI, and 34 EVALI-related deaths in 24 states.[17,18] Therefore, despite popular notions about e-cigarettes being safer than cigarettes, there are still many potential risks that e-cigarettes may pose.

An area of research that has been understudied is the use of e-cigarettes by youth and young adults with symptoms of poor mental health. Data from the 2016 National Survey of Children's Health (NSCH) found that among children aged 3-17 years in the US, 7.1% had been diagnosed with anxiety and 3.2% had been diagnosed with depression.[19,20] Thirteen percent of youth aged 12-17 years report having at least one major depressive episode in the past year.[21] Research shows that cigarette smoking and dependence are strongly associated with higher depression and anxiety.[22,23] Some evidence suggests that use of e-cigarettes is higher among people with psychiatric and substance use disorders.[24,25] Individuals with higher levels of depression and anxiety are more likely to smoke cigarettes because of the need to self-medicate, as nicotine is believed to alleviate the symptoms of anxiety and depression.[23] People with symptoms of poor mental health may be attracted to use e-cigarettes for similar reasons. In addition, higher impulsivity has also been associated with an increase in risky behaviors and undesirable outcomes. Impulsivity is a strong correlate of cigarette smoking.[26-28] This is because higher impulsivity is an indicator of poor self-control.[29]

Currently, findings from studies examining the associations between anxiety, depression, and e-cigarette use have been mixed. Some studies have found significant positive associations between depressive symptoms and e-cigarette use,[30,31] whereas others have not.[22] This study tested the associations between depression, anxiety, and e-cigarette use and cigarette smoking among young adults in Hawai'i. The study also examined impulsivity as a moderator of the association between mental health symptoms and cigarette and e-cigarette use. The hypotheses were: (1) higher depression and anxiety symptoms would be associated with higher cigarette smoking and e-cigarette use, and (2) the associations between depression and anxiety symptoms and cigarette smoking/e-cigarette use would be stronger among those who show higher impulsivity.

Methods

Procedures

This study was conducted in 2018-2020. The study protocol was approved by the University of Hawai'i (UH) Human Studies Program under CFR 46.110 and 21 CFR 56.110, Category (7) (CHS#23645). Students from two, 4-year and four, 2-year (community) colleges under the same university system in Hawai'i were approached with the opportunity to participate in the study. To be eligible to participate in the study, participants had to be 18-25 years old and enrolled in a 2- or 4-year program within the UH system. E-mail addresses were obtained for all 18-25 year olds enrolled across the college campuses. A link to the screener survey was e-mailed to 7000 randomly selected e-mail addresses, inviting potential participants to participate in the study, which was described in generic terms, as a study on marketing and young adult health behavior. The screener survey included questions on age, sex, tobacco, alcohol, and dietary behaviors. In addition, the survey collected potential participants' basic contact information such as phone number and university e-mail address. Of 7000 students invited to complete the screener survey, 60% completed the screener survey at baseline.

However, respondents to the e-mail invitation were predominantly women, never cigarette smokers. To increase the proportion of men in the sample and for adequate representation of cigarette smokers and experimenters in the sample (relative to nationally representative samples of 18-25 year olds), classroom-based recruitment was conducted. Participants were approached in the classroom with the assumption that more men and cigarette smokers would complete the screener survey. Since students are a captive audience in the classrooms, they are more likely to pay attention to the invitation to participate in a research study if the opportunity to do so is presented face-to-face by research staff.

For classroom-based recruitment, approximately 40 classes from each participating campus were randomly selected, and instructors of those classes were approached with requests for a classroom visit. On average, 25% of the instructors who were

approached (approximately 10 classes per college) either did not respond to the research team's request or actively denied participation. Hence, the research staff visited about 30 class-rooms per college and presented the study and the opportunity to participate in the study to the students. Interested students (total 2700) completed the paper-and-pencil version of the screener survey. Participants provided consent either online or on paper before completing the screener survey.

Initially, the only eligibility criterion for participation was age: participants had to be 18-25 years old. However, as recruitment progressed and a higher percentage of females than males enrolled in the study, eligibility criteria was adjusted to ensure a more balanced men to women ratio. Similarly, once the pre-determined percentage of non-cigarette smokers was fulfilled in the sample, eligibility criteria were adjusted to exclude further enrollment of nonsmokers going forward, in order to ensure that cigarette smokers were adequately represented in the sample. Of the students who completed the screener survey, either online or in the classroom, 3,664 students were eligible to participate in the study. Research staff explained the follow up survey procedure to the participants in person or by telephone. Participants were first e-mailed a link to the online consent form. After participants indicated their consent to participate in the study by clicking the "I agree to participate" button, they were sent unique links to the survey via e-mail. Of these, informed consent was obtained from 2,884 (79%) potential participants; the remainder could not be reached for consent procedure. A total of 2,622 participants completed the survey. The survey was programmed on Inquisit 4.0 computer software (Millisecond Software, Seattle, WA, 2015). No incentive was provided to complete the screener survey. Participants who completed the main survey received a $40 Amazon gift card.

Measures

Demographic Variables

Demographic variables assessed included age, sex, ethnicity, and annual household income. Age and sex were assessed both in the screener survey and the main study survey. Age, sex, and household income were assessed with single items. To determine ethnicity, participants were asked, "What is your ethnic background?" and were provided with a list of ethnici-ties common in Hawaii and the US. The question was asked in two different ways. The first question asked participants to refer to the list and "check all that apply." The second question asked participants to choose the ethnic background that they identify with most. The response to the second question was utilized to assign mixed-ethnicity individuals to a particular racial/ethnic category. These items have been used successfully in past research.[8]

E-Cigarette and Cigarette Use

Cigarette smoking was assessed in the screener survey and the main survey. E-cigarette use was assessed only in the main survey. As in most national surveys,[4,32] current e-cigarette use and cigarette smoking were assessed in terms of past-30-day use. For example, "During the last 30 days (1 month), on how many days did you use an electronic cigarette (e-cigarette) or a similar vaping device?" (8-point scale: "0 days," "1-2 days," "3-5 days," up to "All days"). For logistic regression analyses, the variables were dichotomized to use (1) vs non-use (0). In addition, different patterns of e-cigarette and cigarette use, namely cigarette-only smoking, e-cigarette-only use, dual use of cigarette and e-cigarette, and use of neither product were also compared (see Table 1).

Mental Health Symptoms

Depression was assessed using the Center for Epidemiological Studies Depression (CES-D) scale,[33] which asks 20 questions about feelings in the past week. Each question was scored from 0 to 3, and the scores were added with a total range from 0 to 60. A previously defined cut-point ≥16 was used for presence of depressive symptoms.[34,35] Anxiety symptoms were defined using the Generalized Anxiety Disorder 7-item (GAD-7) scale,[36] which asked 7 questions about feelings in the past 2 weeks. Each question was scored from 0 to 3, and the scores were added with a total range from 0 to 21. A previously defined cut-point ≥ 10 was used for presence of anxiety symptoms.[36]

Impulsivity

Impulsivity was defined using a modified version of the Kendall Wilcox Impulsivity Scale for Children (Self-Control Rating Scale),[37] which asked 7 questions about impulsivity, each rated on a 5-point scale (1=never, 2=a little, 3=sometimes, 4=pretty often, 5=usually), for a sum score ranging from 5 to 35. High impulsivity was defined using a cut-point ≥ 10 based on median score.

Data Analysis

Data were analyzed using SAS software, version 9.2 (SAS Institute Inc., Cary, NC).[38] General Linear Models (GLM) and chi-square tests were used to compare means and proportions of variables across the 4 smoking/e-cigarette use categories: "no use," "cigarette-only use," "e-cigarette-only use," and "dual use." GLMs were also used to examine the associations between 4 smoking categories and depressive symptoms, anxiety symptoms and impulsivity after adjusting for demographic variables such as age, sex, ethnicity, and family/household income. Logistic regression was used to test the associations between depres-sion, anxiety, impulsivity and cigarette and e-cigarette use. The logistic regression models adjusted for demographic covariates (age, sex, ethnicity, and family/household income) and cigarette

Table 1. Demographic Characteristics of the Entire Sample and by Smoking and E-cigarette Use Status						
Variables	Entire sample (N = 2,622, 100%)	No smoking/ No e-cigarette use (n=1,750, 67.9%)	E-cigarette use only (n=324, 12.6%)	Cigarette smoking only (n=233, 9.0%)	Dual use of e-cigarette and cigarette (n=271, 10.5%)	P value
Age: yrs (SD)	21.2 + (2.2)	21.0 + 0.05	20.9 + 0.12	22.4 + 0.14	21.6 + 0.13	P <.001
Sex						
Female	54.4%	56.5%	39.6%	64.0%	50.2%	P <.001
Male	45.6%	43.5%	60.4%	36.1%	49.8%	
Ethnicity						
Asian	26.0%	27.3%	23.2%	18.0%	26.2%	P <.001
White	24.3%	24.1%	18.2%	35.6%	24.4%	
NHPI	21.2%	19.9%	24.4%	22.3%	24.0%	
Filipino	17.9%	17.5%	24.7%	11.6%	18.5%	
Other	10.6%	11.2%	9.6%	12.5%	7.0%	
Annual Household Income						
Low (<$60K/yr)	40.1%	39.6%	42.9%	41.9%	40.3%	P =.126
Medium ($60 000-$99 999)	29.0%	29.2%	29.8%	21.8%	31.7%	
High (>$100K/yr)	30.9%	31.3%	27.3%	36.2%	28.0%	
Depressive Symptoms	38.5%	37.8%	41.4%	57.0%	58.0%	P <.001
Anxiety Symptoms	25.5%	23.2%	22.7%	35.6%	37.2%	P <.001
High Impulsivity	52.6%	48.6%	54.6%	61.2%	69.7%	P <.001

SD = standard deviation, NHPI = Native Hawaiian or Pacific Islander

smoking or e-cigarette use, depending on the outcome (ie, cigarette smoking for e-cigarette use outcome and vice-versa). Interaction effects of impulsivity on the associations between the mental health symptoms and cigarette and e-cigarette use were tested using GLMs as well. All continuous variables used in the regression analysis were standardized, centering the mean at zero. After standardization, Depression X Impulsivity and Anxiety X Impulsivity interaction terms were created. Next, the interaction terms were entered as independent variables along with depression/anxiety, impulsivity, and demographic covariates, with cigarette/e-cigarette use as the dependent variable.

Results

Participants

Table 1 shows participants' (N = 2622) characteristics. The mean age of the participants was 21.2 (SD = 2.2). There were 1423 females and 1194 males who completed the survey. Ethnically, participants included 26% Asians, 24% Whites, 21% Native Hawaiian and Pacific Islanders (NHPI), 18% Filipinos and 11% Other ethnicities. Overall, women were slightly more represented than men (55% vs 45%). Forty-three percent of the students were enrolled in 2-year or community colleges. Almost half of the participants were Asian or Pacific Islanders.

Table 1 shows differences between demographic and mental health variables across the following groups: no use, cigarette-only use, e-cigarette-only use, and dual use. No use of either e-cigarettes or cigarettes was reported in 68% of the sample, while 13% reported use of e-cigarette only, 9% reported use of cigarette only, and 11% reported use of both. Cigarette-only smokers were slightly older than other groups (P <.001). E-cigarette-only users were more likely to be men and cigarette-only smokers were more likely to be women, compared to other groups (P <.001). Household income was significantly different across the 4 categories.

After adjusting for age, sex, ethnicity and annual household income, multivariable analyses found significant stepwise associations between the 4 smoking categories and depressive symptoms (P <.001), anxiety symptoms (P <.001) and high impulsivity (P <.001) (see Figure 1). After stratifying into low and high impulsivity groups, the associations between depressive and anxiety symptoms and the 4 categories were stronger in the high impulsivity group (see Figure 2).

Table 2 shows the results of the logistic regression analysis. There were statistically significant associations found between depression, anxiety, impulsivity and cigarette and e-cigarette use, after adjusting for demographic covariates. The associations
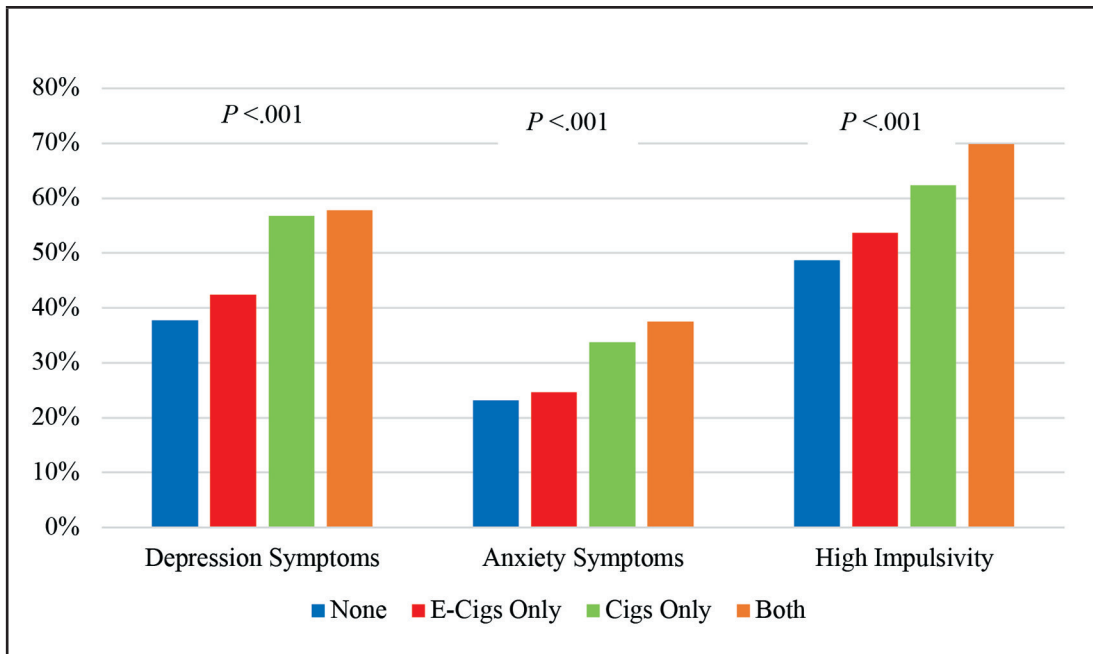
Figure 1. Adjusted Depression, Anxiety, and High Impulsivity by Tobacco Product Use[a]

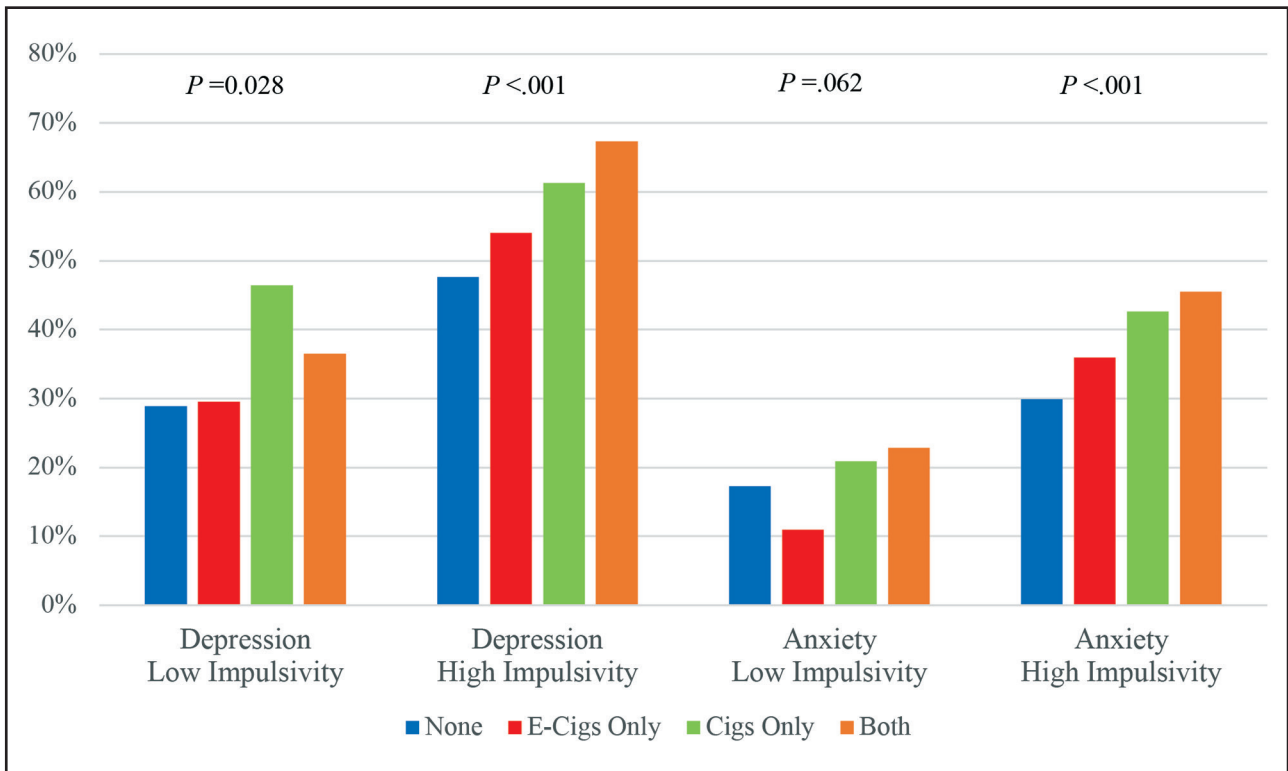[a] Adjusted for age, sex, ethnicity, and annual household income.

Figure 2. Adjusted Depression and Anxiety Symptoms by Tobacco Product Use Categories, Stratified by Impulsivity[a]

[a] Adjusted for age, sex, ethnicity, and annual household income.

of depression, anxiety, and impulsivity with cigarette use were stronger than with e-cigarette use. For example, a unit increase in depressive symptoms increased the odds of past-30-day cigarette smoking by 2.29 times compared with 1.34 times for past-30-day for e-cigarette use.

Table 3 shows the results of the interaction analysis. No statistically significant interaction effects of impulsivity on the associations between depression, anxiety, and past-30-day e-cigarette use were found. In addition, impulsivity was not found to moderate the effects of depression on past-30-day cigarette use. However, impulsivity was found to moderate the effects of anxiety on past-30-day cigarette smoking, such that the association between anxiety and cigarette smoking was stronger for those with higher impulsivity.

Table 2. Associations Between Depression, Anxiety, Impulsivity and Current Cigarette and E-cigarette Use (N = 2622)		
	Cigarette smoking	**E-cigarette use**
	Adjusted Odds Ratio [95% Confidence Interval]	
Depressive Symptoms	2.29 (1.92-2.72)	1.34 (1.14-1.56)
Anxiety Symptoms	1.57 (1.39-1.78)	1.17 (1.05-1.31)
Impulsivity	1.51 (1.35-1.70)	1.38 (1.25-1.53)

Note. The regression models adjusted for age, sex, ethnicity, annual household income, and cigarette smoking or e-cigarette use (depending on the outcome variable).

Table 3. Interaction Effects of Impulsivity in the Association Between Depression, Anxiety, and Current Cigarette and E-cigarette Use (N = 2622)			
		Cigarette	E-cigarette
		B (SE)	
Model 1			
	Depression	0.23 (0.04)***	0.08 (0.04)*
	Impulsivity	0.15 (0.03)***	0.13(0.04)***
	Depression X Impulsivity	0.04 (0.03)	0.05 (0.03)
Model 2			
	Anxiety	0.16 (0.04)***	0.04 (0.04)
	Impulsivity	0.17 (0.03)***	0.15 (0.04)***
	Anxiety X Impulsivity	0.06 (0.03)*	0.04 (0.03)

Note. * P = .05; ** P < .01, *** P <.001; The regression models adjusted for age, sex, ethnicity, annual household income, and cigarette smoking or e-cigarette use (depending on the outcome variable).

Discussion

The current findings are somewhat consistent with the existing literature. For example, a study among high school students found psychiatric co-morbidities among both cigarette-only and e-cigarette-only users.[39] Similarly, the French Constances cohort study found that depressive symptoms were associated with e-cigarette use in both cross-sectional and longitudinal analyses with a dose-dependent relationship.[31] A large study of 2460 adolescents (mean age at baseline 14.1 years), who had never previously used cigarettes or e-cigarettes found a bi-directional association between depressive symptoms and e-cigarette use. Those with higher depressive symptoms at baseline were more likely to start using cigarettes, e-cigarettes or both a year later. In addition, increase in depressive symptoms was associated with sustained use of e-cigarettes over 12 months' time.[40] However, another study of 5445 college students in Texas found that depressive symptoms predicted subsequent e-cigarette use, but e-cigarette use did not predict later increased depressive symptoms.[30] There are potential mechanisms to explain our findings. Nicotine use is believed to help cope with symptoms of depression and anxiety, and people with mental health conditions may choose to use nicotine for this reason. Higher impulsivity is an indicator of poor self-control and is associated with nicotine use behavior.[29]

The current study has many strengths. It was a large study and included use of both e-cigarettes and cigarettes among college students. The study included several ethnic groups that were representative of Hawai'i. Validated scales were used to measure depressive symptoms, anxiety symptoms, and impulsivity. Limitations of the current study are that the study is cross-sectional in design, so causal conclusions cannot be formed based on the statistically significant associations detected in the current data. Second, smoking behavior may be misclassified, because it was only documented over the past 30 days. Third, the study did not have access to longitudinal data about the negative effects on health of e-cigarette use or cigarette smoking. Finally, data were self-reported and were not verified against objective measures.

Future directions include a longitudinal replication of the current findings. Also needed are prospective studies on the negative outcomes of e-cigarette and cigarette use, especially among those with mental health symptoms. Currently, not much has been done in terms of e-cigarette use prevention. There is a need for e-cigarette use prevention programs and such programs need to address poor mental health symptoms. School-based smoking prevention programs have played a key role in reducing cigarette smoking prevalence among young people in the US over the past several decades.[41] The current data suggest that any school-based prevention program designed to address e-cigarette use may need to also address poor mental health symptoms. Our study suggests that smoking prevention education should target children and young adults, particularly those with high impulsivity scores.

Conflict of Interest

None of the authors identify a conflict of interest.

Acknowledgements

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