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The Moderating Role of Health Status on the Association Between Depressive Symptoms and Cannabis Vaping

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ABSTRACT

Objective: Cannabis vaping is increasing among college students. There is little information on risk factors for vaping cannabis. Consistent with the self-medication hypothesis, experiencing depressive symptoms and having a chronic medical condition (CMC) are associated with cannabis use among young adults. Individuals who experience both risk factors may be at higher risk for cannabis vaping. This study examined cross-sectional associations between depressive symptoms, CMC status, and cannabis vaping, and identified the moderating role of CMC status on depressive symptoms and cannabis vaping. **Method:** College students (N = 3,742) self-reported on depressive symptoms, CMC status, and lifetime and current cannabis vaping (i.e., cannabis vaporizers; electronic nicotine devices to use cannabis). Data were collected Fall 2017 until Spring 2021. The sample was predominantly female (70.9%) and White (75.4%). Regression analyses were used. **Results:** Greater depressive symptoms were related to increased likelihood of cannabis vaping across outcomes. Having a CMC was related to lifetime history of cannabis vaporizing. CMC status moderated the associations between depressive symptoms and lifetime cannabis vaporizing. Depressive symptoms were only a risk factor for cannabis vaporizing among college students without a CMC, not those with a CMC. **Conclusions:** Interventions that teach adaptive ways of coping with depressive symptoms and the potential demands of managing a CMC in college are needed. Comprehensive programs for college students, with and without CMCs, are needed to support those with comorbid depression and cannabis vaping use.

Key words: = college student; cannabis vaping; depression; chronic medical condition; COVID-19; self-medication hypothesis

While the deleterious health effects of long-term, heavy cannabis use have been documented (Fergusson, Horwood, & Swain-Campbell, 2002; Hall et al., 2016; NASEM, 2017), health effects of vaping cannabis are not well understood (Jones et al., 2016). The danger of vaping cannabis with electronic cigarettes (e-cigarettes) was highlighted recently during an outbreak of lung injuries: In the US, 2,807 individuals were hospitalized or died due to E-cigarette, or Vaping, product use-Associated Lung Injury (EVALI), with 68 confirmed deaths (CDC, 2020). Yet,

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among those who have used cannabis, 72% believe that cannabis vaping is healthier than cannabis smoking (Lee et al., 2016); perceptions that cannabis vapes result in less harm are associated with more frequent use, earlier initiation, and intensification of use or addiction (Budney et al., 2015). Importantly, cannabis vaping is increasing among college students, rising dramatically from 5% in 2017 to 14% in 2019 (NIDA, 2020), with similar rates during the COVID-19 pandemic (12%; Schulenberg et al., 2021). Other research suggests that cannabis use has increased during the COVID-19 pandemic (Bartel et al., 2020; Sznitman et al., 2021). This is important given that cannabis use has been linked to poorer COVID-19 survival (Huang et al., 2022).

Given the rising rates of cannabis vaping among college students, literature on the associated health effects, and because earlier initiation of cannabis use is associated with increased risk for developing cannabis use disorder (Borodovsky et al., 2017; DeWit et al., 2000; Swift et al., 2008), it is important to understand the risk factors for cannabis vaping among college students. Yet, to date, there is a lack of research focused on identifying risk factors for cannabis vaping among college students, an important step for prevention and intervention programming. In general, cannabis use during adolescence is highly comorbid with other varying psychiatric concerns (Gattamorta et al., 2017; Gobbi et al., 2019). Jones and colleagues (2016) investigated how psychological distress related to cannabis vaping among college students (N = 482). Their results identified that psychological distress (i.e., aggregate score of anxiety, depressive, and stress symptoms) was unrelated to cannabis vaping; however, greater psychotic-like experiences were related to an increased likelihood of past-year cannabis vaping. Other risk factors for past-year cannabis vaping included more frequent nicotine vaping and cannabis use (i.e., using modalities other than vaping), being younger, being male, being White or Latinx, having higher socioeconomic status (SES), using other substances, having positive attitudes about cannabis, and being more open to experiencing something new (Jones et al., 2016). Other research with college students found that risk factors for vaping cannabis with a vape pen included greater positive cannabis expectancies, cannabis peer injunctive norms, and alcohol intake (Frohe et al., 2018). Boakye and colleagues (2021) found that individuals who reported vaping cannabis also reported having other substance use disorders (SUDs) and depression symptoms (Boakye et al., 2021). In addition, individuals who use more than one substance simultaneously are at greater risk for negative health outcomes, such as cognitive deficits, mental health concerns, and premature death as a result of co-occurring substance use (Connor et al., 2014; Schulte & Hser, 2014). Studies with samples of young adult populations also identified several risk factors for cannabis vaping, including but not limited to: using e-cigarettes, using cannabis more frequently (i.e., using modalities other than vaping), being male, being younger, not identifying as African American, greater impulsivity, having a higher education, using nonmedical stimulants, and being a returning medical cannabis patient (Cranford et al., 2017; Lee et al., 2016; Morean et al., 2017).

An understudied risk factor for cannabis vaping is depression. Depression is a major concern among many college students (Karmakar & Behera, 2017). The self-medication hypothesis posits that individuals with depressive symptoms use cannabis to reduce depressive symptoms (Khantzian, 1985; 1997). Prior longitudinal research supports the self-medication hypothesis in the context of general cannabis use among young adults, identifying depressive symptoms and suicidal ideation as risk factors for later cannabis use (Bolanis et al., 2020; Crane et al., 2015; Hooshmand et al., 2012; Lazareck et al., 2012 ; Rhew et al., 2017;Weinberger et al., 2020; Wilkinson et al., 2016; Womack et al., 2016; Zhang & Wu, 2014). The self-medication hypothesis also overlaps with the coping motives literature that demonstrates that coping motives are important risk factors for cannabis use, including problematic cannabis use (Cooper, 1994; Otto et al., 2004; Stewart et al., 1997; Zvolensky et al., 2005). To date, the self-medication hypothesis has not been investigated for cannabis vaping; this is an important gap in the literature given the increasing rates of cannabis vaping among college students (NIDA, 2020).

The current study investigated the self-medication hypothesis in the context of depressive symptoms and cannabis vaping among college

students and investigated if this hypothesis is stronger for those with chronic medical conditions (CMCs). CMCs are defined as illnesses that require ongoing medical attention and/or limit activities of daily living (CDC, 2022). This research addresses a critical gap in the literature, given that over 6% of college students have a CMC (American College Health, 2018; Traino et al., 2019). It can be difficult for college students with CMCs to adapt to college compared to their peers without a CMC: First-year college students with a CMC have lower health-related quality of life and more loneliness compared to their peers without a CMC (Hall & Degenhardt, 2013; Herts et al., 2014). Along with the usual stressors of transitioning to college, college students with CMCs are also experiencing stressors associated with managing their CMC (Tuchman et al., 2008). Specifically, there are increased academic and personal responsibilities and changes in relationships (Brougham et al., 2009; Compas et al., 1986; Dusselier et al., 2005; Eddington et al., 2010), and students are also transitioning to more independent management of their medical condition and treatments (Traino et al., 2021). It is also common for individuals with CMCs to have comorbid depressive symptoms, and depressive symptoms among these individuals are associated with poorer health outcomes (Egede, 2007; Ferro et al., 2015; Katon, 2011). Furthermore, adults with a CMC (45.5%) are more likely use cannabis compared to those without a CMC (21.8%; Dai & Richter, 2019). It seems plausible that individuals who experience both risk factors for cannabis use (i.e., depressive symptoms and having a CMC) may be at higher risk for cannabis vaping given the self-medication hypothesis.

Furthermore, there are important associations among mental health, CMCs, and substance use (Gandhi et al., 2022). Gandhi and colleagues (2022) examined the burdens of behavioral health concerns and CMCs in rural communities. Overall, the authors found that mental health conditions were associated with SUDs and CMCs; however, SUDs and CMCs were not significantly related (Gandhi et al., 2022). These findings, along with the self-medication hypothesis, further support the aims of the current study: to examine associations between depressive symptoms, CMC status, and cannabis vaping, and whether CMC status would moderate the association between depressive symptoms and cannabis vaping.

Collectively, this study had three aims to enhance our understanding of the associations between depressive symptoms, CMC status, and cannabis vaping among college students. For all aims, four measures of cannabis vaping were evaluated: 1) lifetime use of cannabis vaporizers, 2) current use of cannabis vaporizers, 3) lifetime use of ENDS devices to use cannabis, and 4) current use of ENDS devices to use cannabis. The first aim assessed the associations between depressive symptoms and lifetime and past-month cannabis vaping. Consistent with the self-medication hypothesis (Bolanis et al., 2020; Crane et al., 2015; Hooshmand et al., 2012; Lazareck et al., 2012; Rhew et al., 2017; Weinberger et al., 2020; Wilkinson et al., 2016; Womack et al., 2016) and other recent, relevant literature (e.g., Gandhi et al., 2022), it was hypothesized that experiencing greater depressive symptoms would be associated with an increased likelihood of vaping cannabis. The second aim assessed the associations between CMC status and lifetime and current cannabis vaping; it was hypothesized that college students with CMCs would be more likely to vape cannabis compared to those without CMCs. The final aim assessed the moderating role of CMC status on the association between depressive symptoms and cannabis vaping. It was hypothesized that the association between depressive symptoms and cannabis vaping would be stronger among those with a CMC compared to those without a CMC.

METHODS

Participants and Procedures

Participants (N = 3,742) were college students from a large midwestern university who completed a broader study of psychosocial functioning. This study was approved by the Institutional Review Board and followed APA ethical guidelines. Participants were recruited through an online survey system, consented to the study, and completed online questionnaires. Like many universities, undergraduate psychology courses require a research component. Students who completed this study were compensated with course credit. Data collection for the larger study

is still ongoing; the current study includes data from every semester from Fall 2017 until Spring 2021. The current study is cross-sectional because different participants enrolled each semester. Sample size varied across analyses due to missing data on the dependent variables; however, missing data rates were minimal (cannabis vaporizing: missing =1.8%; using e-cigarette to vape cannabis: missing = 1.7%).

Measures

Demographic Information. Participants self-reported on age, sex (referent: male), family income, first generation college student status (referent: no), and education level (Freshmen/ Sophomores: 0; Juniors/ Seniors:1). Race and ethnicity were conceptualized as sociocultural constructs that reflect differential exposure to systemic influences affecting power, oppression, and privilege among different populations (Palermo et al., 2021). Race and ethnicity were coded using dummy coding, with non-Hispanic, White serving as the referent for: African American/Black, Hispanic/Latinx, Asian, American Indian, Multiracial, and "Other background." The date of survey completion was used to create a pandemic onset variable: Data collected prior to Spring 2020 were coded as pre-pandemic (0), and data collected during or after Spring 2020 were coded as collected during the pandemic (1).

Depressive Symptoms. Past-week depressive symptoms were measured using the 20-item Center for Epidemiologic Studies Depression (CESD) scale (Radloff, 1977). Total scores were created by summing item responses, after rescaling necessary items by computing a total score. Prior research has shown that this scale has good psychometric properties (Radloff, 1977), and is a valid tool for screening depressive symptoms (Vilagut et al., 2016). Cronbach's alpha for the current sample was .83, indicating good internal consistency.

Chronic medical conditions (CMC). Participants self-reported on if they had a CMC and identified their diagnosis from a list of diagnoses (e.g., asthma, type 1 diabetes, type 2 diabetes, sickle cell disease). An overall CMC status variable was created for analyses. Participants in the group without a CMC did not endorse a CMC (coded as 0); participants who did not endorse a CMC but endorsed a mental health diagnosis were also included in the group without a CMC. Participants who endorsed a CMC were coded as 1; participants who endorsed a CMC and a mental health diagnosis were included in the CMC group.

Cannabis Vaping. The questions used to assess cannabis vaping frequency were modeled after standardized assessments of cannabis use from the PATH Study (Hyland et al., 2017). Prior research has documented the convergent, concurrent criterion and construct validity of self-reported brief assessments of cannabis use (similar to the present study's assessment; Ramo, Hall, et al., 2012; Shiplo et al., 2016). Prior research also supports the use of self-reported assessments of cannabis vaporizer use (Jones et al., 2016; Shiplo et al., 2016). There are two modes of cannabis delivery that were assessed: cannabis vaporizers and ENDS devices to use cannabis. Cannabis vaporizers can be used to vaporize products in the form of dry herbs, wax, and oil, and then turn these products into vapor; these devices are used to heat the cannabis to a point where THC is vaporized and then ingested/inhaled (CDC, 2019). In contrast, ENDS devices are used for the purposes of delivering nicotine, but they can be manipulated to deliver cannabis (CDC, 2019).

Cannabis Vaporizer Use. Participants self-reported on their frequency of using cannabis vaporizers to deliver cannabis ("How often do you use cannabis electronic vaporizers to deliver THC?"). Lifetime history of cannabis vaporizer use was coded as follows: No history (never tried, not even once; coded as 0) versus lifetime history (any level of use, including having tried cannabis vaporizers; coded as 1). As defined in prior literature (Schulenberg et al., 2021), current use of cannabis vaporizer variable was coded as follows: No current use (never tried; only tried; used cannabis vaporizers only yearly; 0) versus current use (monthly, weekly, or daily use; 1).

Use of Electronic Nicotine Devices to use Cannabis. Participants self-reported on their frequency of using ENDS devices to deliver cannabis ("How often do you use electronic nicotine devices to deliver THC?"). This question was modeled after prior research (Morean et al., 2018). The same coding scheme as above was used

to create a lifetime history of use of electronic nicotine devices to use cannabis variable and a current use of electronic nicotine devices to use cannabis variable.

Data Analytic Plan

IBM SPSS Statistics (Version 24) was used for all analyses. Prior literature and results from bivariate associations between the demographic variables (e.g., age, race/ethnicity, college level, SES, sex) and dependent variables were executed to identify covariates for primary analyses; covariates included: data collected during the pandemic, age, sex, income, and race/ethnicity.

Eight separate logistic regressions were performed. To examine Aims 1 and 2, four main effects only models were used to identify the main effects of depressive symptoms (Aim 1) and CMC status (Aim 2) on the dependent variables (i.e., lifetime cannabis vaporizing, current cannabis vaporizing, lifetime use of ENDS devices to use cannabis, and current use of ENDS devices to use cannabis). To examine Aim 3, four models were conducted to examine the main effects and the interaction between depressive symptoms and CMC status in predicting the dependent variables (Aim 3). For Aim 3, MODPROBE (SPSS macro) was used to estimate the logistic regression models and to probe significant two-way interactions (Hayes & Matthes, 2009). Based on the provided macro output, betas rather than odds ratios were presented for Aim 3 results. When a significant interaction was identified, the conditional effects of depressive symptoms on the dependent variables at each level of the moderator were identified (Hayes, 2016).

RESULTS

Participants predominantly identified as non-Hispanic White (75.4%) and female (70.9%), with an average age of 19.4 years old (*SD* = 3.23); the most indicated annual family income category was $100,000 or more (41.6%). All participant demographics and descriptive statistics on variables of interest are presented in Table 1. Results of main effects regression models predicting lifetime and current cannabis vaping, and lifetime and current use of ENDS devices to deliver cannabis (Aims 1 & 2), are presented in Tables 2 and 3, respectively.

Table 1. *Descriptive Statistics*

	***N*= 3,742**
Demographic Variables	*M* (SD))/ n (%)
Data Collected during the Pandemic	947 (25.3%)
Female	2653 (70.9%%)
Age	19.4 (3.23) (17-24)
Family Income [a]	
$0 - 9,999	64 (1.7%)
$10,000 - 19,999	85 (2.3%)
$20,000 - 29,000	172 (4.6%)
$30,000 - 39,999	192 (5.2%)
$40, 000 - 49,999	230 (6.2%)
$50,000 - 59,999	262 (7.1%)
$60,000 - 69,999	272 (7.3%)
$70,000 - 79,999	288 (7.8%)
$80,000 - 89,999	320 (8.6%)
$90,000 - 99,999	279 (7.5%)
$100,000 or more	1, 541 (41.6%)
Race/Ethnicity	
White	2821(75.4%)

African American	214 (5.7%)
Hispanic	134 (3.6%)
Asian	99 (2.6%)
American Indian	243 (6.5%)
Multi-Racial	159 (4.2%)
Other	56 (1.5%)
Missing	16
Independent Variables	
Depressive symptoms	16.32 (12.42)
Has chronic medical condition	550 (14.7%)
Dependent Variables	
Lifetime Use of Cannabis Vaping	
Lifetime History	850 (22.7%)
Current Use of Cannabis Vaping	
Current Use	242 (6.5%)
Lifetime Use of Electronic Nicotine Devices	
Lifetime History	666 (17.8%)
Current Use of Electronic Nicotine Devices	
Current Use	181 (4.8%)

Note. N's ranged due to missing data. [a] Income was treated as a continuous variable in the analyses, with coding ranging 1 to 11 ($M = 8.39$, $SD = 2.93$).

Table 2. *Main Effects Only Model for Lifetime and Current Cannabis Vaping*

	B	*SE*	*p*	OR	OR 95% CI	
					LL	*UL*
Lifetime History of Cannabis Vaping						
Independent Variables						
Depressive symptoms	.026	.003	**<.001**	1.026	1.020	1.033
Has a chronic medical condition	.010	.116	.934	1.010	.805	1.266
Demographic Variables						
Data collected during COVID-19 pandemic [a]	.730	.094	**<.001**	2.075	1.725	2.497
Age	.054	.032	.093	1.055	.991	1.124
Female [b]	-.118	.093	.207	.889	.741	1.067
Income	.041	.015	**.008**	1.041	1.010	1.073
Race/ Ethnicity [c]						
African American	-.050	.196	.799	.951	.648	1.397
Hispanic	.049	.233	.833	1.050	.666	1.658
Asian	-.498	.303	.100	.608	.336	1.101
American Indian	.008	.168	.961	1.008	.725	1.402
Multiracial	.363	.193	.060	1.438	.985	2.099
Other Ethnicity	-.377	.364	.300	.686	.336	1.400

Current Cannabis Vaping						
Independent Variables						
Depressive symptoms	.034	.005	**<.001**	1.035	1.024	1.046
Has a chronic medical condition	-.035	.193	.856	.966	.661	1.410
Demographic Variables						
Data collected during COVID-19 pandemic [a]	.763	.152	**<.001**	2.144	1.591	2.888
Age	-.017	0.42	.683	.983	.905	1.068
Female [b]	-.372	.154	**.016**	.689	.509	.933
Income	.023	.026	.384	1.023	.972	1.077
Race/ Ethnicity [c]						
African American	-.635	.404	.116	.530	.240	1.171
Hispanic	.059	.406	.885	1.060	.479	2.349
Asian	-.224	.475	.637	.799	.315	2.029
American Indian	-.425	.325	.191	.654	.346	1.236
Multiracial	.218	.318	.493	1.244	.667	2.320
Other Ethnicity	-1.528	1.01	.134	.217	.029	1.597

Note. Total N = 3,468. CI = confidence interval; *LL* = lower limit; *UL* = upper limit. Control variables in the model included: pre/post COVID, age, sex, income, race/ethnicity.[a]0=data collected pre-pandemic 1= during pandemic, [b] 0=female 1=male, 0[c]=non-Hispanic, White.

Table 3. *Main Effects Only Model for Lifetime and Current Use of Electronic Nicotine Devices to Deliver Cannabis*

	B	*SE*	*p*	OR	OR 95% CI	
					LL	*UL*
Lifetime History of Using Electronic Nicotine Devices to Deliver Cannabis						
Independent Variables						
Depressive symptoms	.023	.004	**<.001**	1.023	1.016	1.030
Has a chronic medical condition	-.195	.131	.135	.823	.637	1.063
Demographic Variables						
Data collected during the COVID-19 pandemic[a]	.681	.102	**<.001**	1.976	1.618	2.413
Age	.010	.011	.376	1.010	.988	1.033
Female[b]	.120	.104	.250	1.127	.919	1.382
Income	.050	.017	**.003**	1.051	1.017	1.087
Race/ Ethnicity						
African American	-.271	.230	.239	.763	.486	1.197
Hispanic	.126	.249	.614	1.134	.696	1.849
Asian	-.418	.333	.209	.659	.343	1.264
American Indian	-.074	.188	.693	.929	.643	1.342
Multiracial	.256	.213	.230	1.292	.850	1.963
Other Ethnicity	.019	.364	.959	1.019	.499	2.079

Current Use of Electronic Nicotine Devices to Deliver Cannabis						
Independent Variables						
Depressive symptoms	.024	.006	**<.001**	1.024	1.011	1.037
Has a chronic medical condition	-.201	.240	.402	.818	.511	1.309
Demographic Variables						
Data collected during the COVID-19 pandemic[a]	.470	.181	**.009**	1.599	1.122	2.279
Age	-.063	.065	.332	.939	.826	1.067
Female[b]	-.331	.176	.059	.718	.509	1.013
Income	.056	.031	.073	1.058	.995	1.125
Race/ Ethnicity [c]						
African American	-.066	.385	.865	.936	.440	1.993
Hispanic	-.582	.597	.330	.559	.173	1.802
Asian	-.053	.527	.920	.949	.338	2.663
American Indian	-1.049	.515	**.042**	.350	.128	.962
Multiracial	.500	.330	.130	1.649	.863	3.151

Note. Total N = 3,468. CI = confidence interval; *LL* = lower limit; *UL* = upper limit. Control variables in the model included: pre/post COVID, age, sex, income, race/ethnicity. [a]0=data collected pre-pandemic 1= during pandemic, [b] 0=female 1=male, 0 [c]=non-Hispanic, White.

Moderation Models

Lifetime History of Cannabis Vaporizing

The overall model examining the main effects of depressive symptoms and CMC status and their interaction on lifetime cannabis vaporizing was significant, $x^2(1, N = 3433) = 8.38$, $p = .003$; Table 4. The depressive symptoms*CMC status interaction was significant, B = -0.023, $p = .004$, CI [-0.039, 0.008]. Follow-up analyses examining the conditional effects of depressive symptoms on having a lifetime history of vaping cannabis were investigated at each level of CMC status. Among individuals without a CMC, greater depressive symptoms were associated with an increased likelihood of having a history of cannabis vaporizing, B = 0.031, $p < .001$, CI [0.023, 0.038]. However, among individuals with a CMC, depressive symptoms were not related to having a lifetime history of cannabis vaporizing, B = 0.007, $p = .303$, CI [-0.007, 0.022]. The main effects were also significant: Greater depressive symptoms were related to an increased likelihood of currently vaporizing, B = 0.031, p<.001, CI [0.023, 0.038]. Individuals with a chronic medical condition had an increased likelihood of vaping cannabis. B = 0.52, $p = .01$, CI [0.118, 0.923]. Significant covariates included: income, data collected during the pandemic, and identifying as Asian.

Current Cannabis Vaporizing

The overall model was significant, $x^2(1, N = 3,433) = 0.399$, $p < .001$; Table 4). The interaction was not significant, B = -.008, $p = .527$, CI [-.034, .018]. Greater depressive symptoms were associated with an increased likelihood of cannabis vaporizing, B = 0.036, $p < .001$, CI [0.024, 0.048]. The CMC status main effect was nonsignificant. Significant covariates included: being female and having data collected during the pandemic.

Table 4. *Moderation Analyses for Current and Lifetime Cannabis Vaping*

	B	*SE*	P value Sig.	OR 95% CI	
				LL	*UL*

Lifetime Cannabis Vaping					
Depressive Symptoms	.031	.004	**<.001**	.0234	.0381
Chronic Medical Condition Status	.520	.206	**.011**	.118	.923
Depressive Symptoms*CMC	-.023	.008	**.004**	-.039	-.008
Age	.053	0.032	.098	-.010	.116
Female [a]	-.114	.093	.223	-.297	.069
Income	.041	.016	**.008**	.011	1.071
Race/ Ethnicity [b]					
African American	-.058	.196	.769	-.443	.327
Hispanic	.039	.233	.867	-.419	.496
Asian	-.504	.304	**.010**	-1.010	.091
Native American	.013	.168	.940	-.317	.342
MultiRacial	.376	.193	.051	-.002	.754
Other Ethnicity	-.401	.365	.273	-1.116	.316
American Indian	-1.048	.515	**.042**	-2.058	-.038
MultiRacial	.508	.331	.124	-.140	1.156
Other	-1.067	1.019	.295	-3.064	
Data collected during the COVID-19 Pandemic [c]	.735	.095	**<.001**	.549	.920
Current Cannabis Vaping					
Independent Variables					
Depressive Symptoms	.036	.006	**<.001**	.024	.048
Chronic Medical Condition Status (CMC)	.177	.382	.642	-.570	.925
Depressive Symptoms*CMC	-.008	.013	.527	-.034	.018
Demographic Variables					
Age	-.017	0.044	.692	-.103	.069
Female[a]	-.370	.154	**.016**	-.673	-.069
Income	.023	.026	.383	-.028	.074
Race/ Ethnicity [b]					
African American	-.636	.404	.116	-1.240	.157
Hispanic	.055	.406	.893	-.741	.850
Asian	-.223	.475	.639	-1.155	.709
American Indian	-.423	.325	.193	-1.060	.214
MultiRacial	.227	.318	.476	-.397	.850
Other Ethnicity	-1.535	1.019	.132	-3.532	.462
Data collected during the COVID-19 Pandemic [c]	.763	.152	**<.001**	.465	1.061

Note. Total N = 3,468. CI = confidence interval; *LL* = lower limit; *UL* = upper limit. Dependent Variable: 0= Not Current, 1 = Current; 0=Never, 1=Ever. [a]0=female 1=male, [b]0=non-Hispanic, White. [c]0=data collected pre-pandemic 1= during pandemic. Control variables in the model included: pre/post COVID, age, sex, income, race/ethnicity.

Lifetime History of Using Electronic Nicotine Devices to Use Cannabis

The overall model was significant. $x^2(1, N = 3{,}435) = 0.285$, $p < .001$; Table 5). The interaction was not significant, B = -.005, $p = .593$, CI [-.023, .013]. Greater depressive symptoms were associated with an increased likelihood of having a history of cannabis vaping, B = 0.024, $p < .001$, CI [0.016, 0.032]. The CMC status main effect was nonsignificant. Significant covariates included: having data collected during the pandemic and family income.

Current Use of Electronic Nicotine Devices to Use Cannabis

The overall model was significant, $x^2(1, N = 3,435) = .276$, $p < .001$; Table 5). The interaction and CMC main effect were not significant, B = -.009, $p = .600$, CI [-.041, .023]. Greater depressive symptoms were associated with an increased likelihood of cannabis vaping, B = 0.025, $p < .001$, CI [0.011, 0.039]. Having data collected during the pandemic was a risk factor; American Indian individuals were less likely to use ENDS devices to use cannabis.

Table 5. *Moderation Analyses for Lifetime and Current Use of Electronic Nicotine Devices to Deliver Cannabis*

	B	*SE*	P value Sig.	OR 95% CI	
				LL	*UL*
Lifetime History of Using Electronic Nicotine Devices to Deliver Cannabis					
Depressive Symptoms	.024	.004	**<.001**	.016	.032
Chronic Medical Condition Status	-.084	.245	.732	-.563	.396
Depressive Symptoms*CMC	-.005	.009	.593	-.023	0.013
Age	.011	.011	.352	-.012	.033
Female [a]	.121	.104	.246	.083	.325
Income	.050	.017	**.004**	.016	.083
Race/ Ethnicity [b]					
African American	-.272	.230	.237	-.723	.179
Hispanic	.123	.249	.621	-.365	.612
Asian	-.419	.333	.208	-1.072	.234
American Indian	-.073	.188	.696	-.441	.295
MultiRacial	.259	.213	.225	-.159	.677
Other	.015	.364	.968	-.699	.728
Data collected during the COVID-19 Pandemic [c]	.682	.102	**<.001**	.482	.881
Current Electronic Nicotine Devices to Deliver Cannabis					
Independent Variables					
Depressive Symptoms	.025	.007	**<.001**	.011	.039
Chronic Medical Condition Status (CMC)	.004	.449	.994	-.877	.884
Depressive Symptoms*CMC	-.009	.016	.600	-.041	.023
Demographic Variables					
Age	-.064	.065	.329	-.192	.064
Female[a]	-.330	.176	.060	-.674	.014
Income	.057	.031	.072	-.005	.118
Race/Ethnicity [b]					
African American	-.067	.386	.862	-.822	.689
Hispanic	-.586	.597	.327	-1.757	.585
Asian	-.052	.527	.922	-1.084	.981
American Indian	-1.048	.515	.042	-2.058	-.038
MultiRacial	.508	.331	.124	-.140	1.156
Other	-1.067	1.019	.295	-3.064	.929
Data collected during the COVID-19 Pandemic[c]	.470	.181	**.009**	.116	.825

Note. Total $N = 3{,}468$. CI = confidence interval; *LL* = lower limit; *UL* = upper limit. Dependent Variable: 0= Not Current, 1 = Current; 0=Never, 1=Ever.[a]0=female 1=male, [b]0=non-Hispanic, White [c]0=data collected pre-pandemic 1= during pandemic. Control variables in the model included: pre/post COVID, age, sex, income, race/ethnicity.

DISCUSSION

This study extended the limited research on predictors of cannabis vaping among college students by examining the moderating role of health status on the association between depressive symptoms and cannabis vaping. Across analyses, the most consistent risk factors for cannabis vaping were having greater depressive symptoms and having data collected during the pandemic. CMC status only moderated the associations between depressive symptoms and cannabis vaping when examining lifetime cannabis vaporizing, suggesting that depressive symptoms were only a risk factor for cannabis vaporizing among young adults without a CMC but not those with a CMC.

Notably, greater depressive symptoms were related to an increased likelihood of lifetime and current cannabis vaporizing and use of ENDS devices to deliver cannabis. This finding is consistent with other literature demonstrating depressive symptoms are a risk factor for *overall* cannabis use (i.e., via methods other than vaping; Crane et al., 2015; Lazareck et al., 2012)Rhew et al., 2017). However, the association between depressive symptoms and cannabis vaping was yet to be explored. Most closely related, Jones and colleagues (2016) investigated psychological distress – as defined as a composite of anxiety, depressive, and stress symptoms – in association with cannabis vaping specifically, but did not observe a relationship between psychological distress and cannabis vaping. These results contrast with the current findings of depressive symptoms predicting cannabis vaping; this discrepancy may be due to differences in the specific variables used (i.e., psychological distress vs. depression). Taken together, it seems that depression in particular – versus other psychological distress variables, such as anxiety or stress – may have a unique association with cannabis vaping.

The link between depression and cannabis vaping found in the present study is consistent with the self-medication hypothesis (Bottorff et al., 2009; Crane et al., 2015; Lazareck et al., 2012; Rhew et al., 2017; Weinberger et al., 2020) and other relevant, recent literature (e.g., Gandhi et al., 2022). The self-medication hypothesis posits that individuals with depressive symptoms use cannabis to reduce depressive symptoms (Khantzian, 1985; 1997), and this has been supported for adolescents and young adults when examining overall cannabis use (Wilkinson et al., 2016; Womack et al., 2016) and across longitudinal studies that identified depression and suicidal ideation as risk factors for later, overall cannabis use (Crane et al., 2015; Lazareck et al., 2012; Rhew et al., 2017; Weinberger et al., 2020; Wu, 2014). The current finding that depression predicted lifetime and current cannabis use via vaping methods is in line with this hypothesis and suggests that college students with depression may vape cannabis as a method of managing their depressive symptoms. Collectively, the current cross-sectional findings coupled with the extant longitudinal literature support the self-medication hypothesis: certain individuals use cannabis via various delivery modes to alleviate depressive symptoms. These findings have important public health implications given the use of substances to cope with distress is associated with the poorest outcomes (Cooper et al., 2015).

The self-medication hypothesis would also predict that CMC status is associated with cannabis vaping; this hypothesis was only minimally supported. CMC status was only related to having a lifetime history of cannabis vaporizing, with those with a CMC being more likely to have a history of cannabis use; however, this was in a model with a significant interaction.

This finding is consistent with prior research that demonstrated that overall cannabis use is more common among individuals with CMCs compared to those without CMCs during adolescence and adulthood (Dai & Richter, 2019; Wisk & Weitzman, 2016). Several potential factors may have contributed to CMC status only being related to a lifetime history of cannabis vaporizing. For example, greater access and ease of using cannabis vaporizers relative to using ENDS devices to deliver cannabis may have supported greater use of cannabis vaporizers over other modalities. Further, the publicized EVALI outbreak may have deterred use of ENDS devices to use cannabis, given their association with EVALI, but not use of cannabis vaporizers. Cannabis use among individuals with CMCs is a public health problem, and prevention and intervention efforts are needed to address this modifiable risk for medically vulnerable young people.

Finally, consistent with the self-medication hypothesis, it was hypothesized that individuals with both depressive symptoms and a CMC would be more likely to vape cannabis because of the increased demands and stressors associated with having CMCs (Brougham et al., 2009; Compas et al., 1986; Dusselier et al., 2005; Eddington et al., 2010) that may be intersecting with depressive symptoms to contribute to greater cannabis use for coping.; this hypothesis was unsupported. CMC status only moderated the associations between depressive symptoms and cannabis vaping when examining lifetime cannabis vaporizing; depressive symptoms were only a risk factor for cannabis vaporizing among young adults without a CMC but were unrelated to lifetime cannabis vaporizing for those with a CMC. This finding was unexpected. This could be explained by other factors such as: 1) ENDS devices have gained popularity; thus, young adults without a CMC may have become curious about the product rather than using the product to self-medicate; 2) Other motives for cannabis use such as social enhancement, relaxation, experimenting, and enjoyment/fun may be influencing cannabis use (Lee et al., 2007); and/or 3) Cannabis use has significantly increased across time among college students, which could impact patterns of cannabis use observed (Odani et al., 2019; NIDA, 2020). Overall, the current study's investigation of substance use behaviors rather than substance use motives (coping or social enhancement, relaxation, experimenting, and enjoyment/fun) may have reduced the ability to draw firm conclusions regarding reasons for cannabis use among those with and without CMCs. However, this methodology is supported in the extant literature (Bolanis et al., 2020; Hooshmand et al., 2012; Wilkinson et al., 2016; Womack et al., 2016). Among college students with a CMC, it is also possible that there are more influential predictors of cannabis vaping than depressive symptoms that were not examined and warrant attention, such as illness-related perceptions and/or management of physical symptoms of medical conditions. Future research should assess cannabis use motives and/or other potential predictors to further elucidate risk factors for cannabis vaping among young adults with and without CMCs.

The most consistent covariate that was related to cannabis vaping was data being collected during the pandemic. This is consistent with literature suggesting that cannabis use has increased during the COVID-19 pandemic (Bartel et al., 2020; Sznitman et al., 2021). However, this finding may also be related to other contextual factors that somewhat coincided with the onset of the COVID-19 pandemic, such as increased cannabis legalization across the United States (Borodovosky et al., 2017) and the increase in vape shops following the medical legalization of cannabis in 2018 in the state where data were collected.

The social construct of race and ethnicity also seems to be important in understanding cannabis vaping. American Indian and Asian individuals were less likely than non-Hispanic, White individuals to vape cannabis. This is consistent with prior research that found that being White or Latinx were risk factors for past-year cannabis vaping among college students (Jones et al., 2016); this study expanded on Jones and colleagues' (2016) study and the literature on cannabis vaping by utilizing a sample with more representation of American Indian college students (6.5% of the sample) and identifying that American Indian individuals were less likely to vape cannabis. Future research should examine promotive factors that may be supporting this reduced risk among American Indian and Asian

students. Like prior research, having a higher income and being male were also covariates associated with cannabis vaping among college students (Jones et al., 2016).

Public Health and Clinical Implications

Greater odds of cannabis vaping – across all outcomes – was associated with greater depressive symptoms, an important finding given prior research has documented that substance use coping is associated with the poorest outcomes (Cooper et al., 2015). This indicates that both interventions for individuals experiencing depressive symptoms and for individuals experiencing comorbid depressive symptoms and cannabis use are warranted to enhance healthier coping and reduce cannabis use. Unfortunately, there is inadequate access to treatment for college students with substance use or mental health difficulties (Sun, 2020). Cannabis use among young adults/college students could be addressed in primary care or university health settings by offering evidence based assessment, treatment, and harm reduction interventions for cannabis use (Halladay et al., 2019; Kansagara et al., 2019; Montemayor et al., 2022). Evidence-based interventions for individuals with comorbid cannabis use disorder and depressive symptoms include Cognitive Behavioral Therapy, Motivational Interviewing, Motivational Enhancement Therapy, and Contingency Management (Lees et al., 2021; Satre et al., 2018).

Limitations and Future Directions

Overall, data were collected from a predominately female college sample at a midwestern university with inadequate representation of diverse populations; thus, the generalizability of findings to other young adult populations (e.g., non-college students, more diverse young adults) may be limited. Future research should utilize samples with more representation of racially minoritized college students. Race and ethnicity were examined in the present study as proxy measures to reflect differential exposure to systemic influences affecting power, oppression, and privilege among different populations. Future research should more directly examine sociocultural constructs (e.g., cultural factors, racism, social determinants of health) that may impact cannabis vaping. Another limitation involves how we categorized individuals with a CMC versus those without a CMC based on self-reported physical health diagnoses, which excluded self-reported mental health diagnoses as a CMC. Future research should recruit large samples of individuals with and without physical and mental health diagnoses to further parse apart important behavioral differences related to cannabis use. Furthermore, the cross-sectional design limits the ability to draw causal conclusions; however, the cross-sectional data provides important preliminary information on the associations between depressive symptoms, CMCs, and cannabis vaping. Finally, this study did not include a measure of lifetime depression, which is a limitation.

Self-report of cannabis use may have led to underreporting of cannabis vaping (Harrison et al., 2007). However, prior research has documented the convergent, concurrent, criterion, and construct validity of self-reported brief assessments of cannabis use (similar to the present study's assessment; Ramo, Hall, et al., 2012; Shiplo et al., 2016). Research also supports the use of self-reported assessments of cannabis vaporizer use (Jones et al., 2016; Shiplo et al., 2016). Yet, future research should consider using cannabis use biomarkers to reduce any possibility of underestimating current cannabis use; the current results may even be more pronounced when cannabis vaping is objectively measured. The current study did not assess cannabis use motives or if participants used cannabis recreationally or medicinally (and if medicinally, for what diagnosis). These omissions may limit conclusions that can be drawn about if participants were using cannabis to ameliorate depressive symptoms or distress associated with having a CMC. Exploring whether cannabis use was recreational or medicinal is important to consider because medicinal use is legal in the state where data were collected. Medical marijuana could have been prescribed to participants for a variety of mental and medical conditions, despite the fact that 1) there is only conclusive or substantial evidence suggesting a therapeutic effect for chemo-induced nausea and vomiting, chronic pain, and multiple sclerosis

(Cousijn et al., 2018) and 2) there is insufficient evidence to support a therapeutic effect for mental health symptoms (Cousijn et al., 2018; Hill, 2015; NASEM, 2017; Whiting et al., 2015). Additionally, it is possible that individuals with a CMC may self-medicate via cannabis use to help manage their CMC or anxiety associated with their CMC. Future research should further explore these associations by recruiting large samples of individuals with CMCs who use cannabis. While there is not current evidence suggesting a therapeutic benefit of medical marijuana for depression or the most common medical conditions reported in the present sample, there is substantial research supporting that depression is a risk factor for cannabis use.

This study extends prior literature by identifying: that depressive symptoms were a consistent predictor of cannabis vaping among college students, consistent with prior self-medication literature identifying young adults' use of cannabis to reduce depressive symptoms (Bolanis et al., 2020; Hooshmand et al., 2012; Khantzian, 1985; Khantzian, 1997; Wilkinson et al., 2016; Womack et al., 2016), depressive symptoms may only be a risk factor for cannabis vaporizing among young adults without a CMC. These findings suggest the need for interventions to address depressive symptoms among college students with and without CMCs, and especially among those using cannabis use to cope with depression, to reduce overall cannabis vaping. Cannabis use among college students could be addressed in primary care or university health settings by offering evidence-based assessment, treatment, and harm reduction interventions for cannabis use (Halladay et al., 2019; Kansagara et al., 2019; Montemayor et al., 2022).

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