THE MODERATING ROLE OF HEALTH STATUS ON THE ASSOCIATION BETWEEN DEPRESSIVE SYMPTOMS AND CANNABIS VAPING

By

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Abstract:
Objective: Cannabis use has significantly increased among college students, and cannabis vaping is a common modality. There is little information on the 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 the associations between depressive symptoms, CMC status, and cannabis vaping, and identified the moderating role of CMC status on the association between depressive symptoms and cannabis vaping.
Methods: College students (N= 3,742) self-reported on depressive symptoms (CESD-20), CMC status, and lifetime and current cannabis vaping (i.e., cannabis vaporizers; electronic nicotine devices to use cannabis). Regressions were used to examine aims.
Results: Greater depressive symptoms were related to an increased likelihood of cannabis vaping across all outcomes. Having a CMC was only related to having a lifetime history of cannabis vaporizing (B=0.52, p=.01, CI: 0.118-0.923). CMC status only moderated the associations between depressive symptoms and lifetime cannabis vaporizing (B= -0.023, p =.004, CI: -0.039 - 0.008): Depressive symptoms were only a risk factor for cannabis vaporizing among healthy young adults (B= -0.023, p =.004, CI: -0.039 - 0.008), but not those with a CMC (B = 0.007, p=.303, CI: -0.007 - 0.022).
Conclusions: Comprehensive programs for college students, with and without CMCs, are needed to support those with comorbid depressive symptoms and cannabis vaping.

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CHAPTER I

INTTRODUCTION

Cannabis is the most widely used illicit drug among young adults aged 18-25 in the United States (National Survey of Drug Use and Health, 2013). Additionally, cannabis use has significantly increased across time among college students (Odani et al., 2019; National Institute on Drug Abuse, 2020), with daily cannabis use now being the highest it has been in 40 years (Schulenberg et al., 2021). In 2019, 43% of college students had used cannabis during the past year, and 14% had used cannabis during the past month (National Institute on Drug Abuse, 2020). Data collected during the pandemic (collected from March-November 2020) reflected similar annual prevalence rates (44%), but higher past month use (25%) (Schulenberg et al., 2021). There are several different methods to use cannabis products, including, but not limited to, smoking cannabis (joints, bowls, bongs, hookahs, blunts), consuming edibles, and vaping (Raber et al., 2015). Vaping cannabis is an increasingly popular mode of administering cannabis (Cranford et al., 2017). In fact, cannabis vaping has been steadily increasing among college students since 2017, with 5% of students reporting past month cannabis vaping in 2017 and 14% reporting past month cannabis vaping in 2019 (National Institute on Drug Abuse, 2020). Data collected during the pandemic suggested a slight decrease in past month vaping

(12%) (Schulenberg et al., 2021). 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. Therefore, the current study investigated depressive symptoms as a risk factor for cannabis vaping among college students, and how having a chronic medical condition may moderate this association.

Adverse Effects of Cannabis Use

Understanding cannabis use during adolescence and young adulthood is important given that earlier initiation of cannabis use is associated with increased risk for developing cannabis use disorder (DeWit et al., 2000; Swift et al., 2008; Borodovsky et al., 2017) and because long-term, heavy cannabis use is associated numerous negative consequences (Fergusson, Horwood, & Swain-Campbell, 2002; Hall et al., 2016; National Academies of Sciences Engineering and Medicine, 2017). Examples of these deleterious outcomes include increased risk of other illicit drug use, crime, depression, suicidal behaviors, impaired respiratory functioning, low birth weight, and other negative health outcomes (Fergusson & Horwood, 2000; Fergusson, Horwood, & Swain-Campbell, 2002; Fergusson, Horwood, & Northstone, 2002; Taylor et al., 2002; Lynskey et al., 2003; Hall et al., 2016; National Academies of Sciences Engineering and Medicine, 2017). The existing research focused on the health consequences of cannabis use is predominately focused on cannabis smoking, with less data available for cannabis vaping. Regular cannabis smoking is linked to the development of psychotic symptoms and disorders, cannabis dependence, the use of other illicit drugs, impaired educational attainment, and impaired respiratory functioning (Hall & Degenhardt, 2014; Hall et al., 2016; Baron, 2015).

Importantly, 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). However, the health effects of vaping cannabis are not well understood (Jones et al., 2016). Some data suggests that vaping cannabis reduces that amount of smoke-related toxin and carcinogen (i.e. tar, ammonia, carbon monoxide, and hydrogen cyanide) exposure relative to cannabis smoking (Abrams et al., 2007; Moir et al., 2008; Pomahacova et al., 2009; Budney et al., 2015; Giroud et al., 2015b). One small study (N=22) identified there was a small improvement in one measure of lung functioning (Forced Volume Capacity), but not another (Forced Expiratory Volume), for cannabis smokers who switched to cannabis vaping for one month and did not experience respiratory illness during the study period (Van Dam & Earleywine, 2010). The danger of vaping cannabis with e-cigarettes was highlighted recently during an outbreak of lung injuries: In the United States, 2,807 individuals were hospitalized or died due to E-cigarette, or Vaping, product use-Associated Lung Injury (EVALI), with 68 confirmed deaths as of February 18, 2020 (Centers for Disease Control and Prevention (CDC), 2020). Symptoms of EVALI are characterized by cough, dyspnea, chest pain, vomiting, nausea, diarrhea, as well as fatigue, weight loss and headaches (Kalininskiy et al., 2019). Overall, the health correlates of chronic, heavy cannabis use are well documented, with a current paucity of data specific to cannabis vaping.

Risk Factors for Vaping Cannabis

There is scant literature focused on identifying risk factors for cannabis vaping, with few studies to date focused on college students. In the only study to date investigating how psychological distress relates to cannabis vaping among college students, Jones et al. (2016) identified the prevalence and predictors of lifetime and past year use of vaporizers to consume nicotine and cannabis among 482 college students. There were high lifetime rates of nicotine vaping (37%) and cannabis vaping (29%), and high rates of past year nicotine vaping (30%) and cannabis vaping (23%). Among students with a history of cannabis vaping, 65% reported that the top reasons that they vaped cannabis were the convenience and the discretion of vaping in public places (Jones et al., 2016). Importantly, more frequent nicotine vaping and cannabis use (i.e., using modalities other than vaping) were strong risk factors for cannabis vaping. This study also investigated two measures of psychological functioning as risk factors for cannabis vaping: 1) an aggregate score of anxiety, depressive, and stress symptoms (as measured by the Depression, Anxiety, and Stress Scale- 21 item) and 2) psychotic-like features (as assessed via 12 item Yale University PRIME Screening Test). The anxiety/depressive/stress symptom score was not related to cannabis vaping; it is unclear how depressive symptoms may independently relate to cannabis vaping. On the other hand, greater psychotic-like experiences were related to an increased likelihood of past year cannabis vaping. Other risk factors for past year cannabis vaping included being younger, being male, being White or Latinx, having higher socioeconomic status (SES), using other substances (i.e. alcohol, illicit drug), having positive attitudes about cannabis, and being more open to experiencing something new (Jones et al., 2016). Among a

sample of 270 college students, over 10% had vaped cannabis with a vape-pen, with risk factors including greater positive cannabis expectancies, cannabis peer injunctive norms (peer approval), and alcohol intake (Frohe et al., 2018).

Given the paucity of research focused on college students, the research that included young adults is also described below; of note, the average age of participants in these three studies ranged from 32-45. Lee et al. (2016) conducted a study with 2,910 adults who used cannabis (age range: 18-90; M age=32) to identify risk factors for cannabis vaping. Of note, most adults who had vaped cannabis in the past month reported using several modalities to use cannabis, with the most common route of administration being smoking. Importantly, 75% of adults reported that after they initiated cannabis vaping their cannabis smoking rate remained the same. Furthermore, individuals who had vaped cannabis reported a younger age of initiation for cannabis use compared to those with no history of cannabis vaping. Risk factors for cannabis vaping included: using e-cigarettes, being male, being younger, and not identifying as African American. Among participants who endorsed they preferred cannabis vaping compared to other modalities for using cannabis, they described vaping tastes better, is healthier, is more satisfying, and generates better effects (Lee et al., 2016).

Morean et al. (2017) assessed cannabis vaping among adults who use e-cigarettes (N = 522; M_{age}=34.07; 72% White), with 18% endorsing a lifetime history of cannabis vaping (18%) and 12% endorsing past-month cannabis vaping. Participants endorsed the following motives for vaping cannabis instead of smoking cannabis: vaping cannabis tastes better, is easier to hide, is healthier, does not smell as strong, is more convenient, and generates a better high. This study assessed numerous potential predictors of past

month cannabis vaping, including demographics, e-cigarette use, age of initiation for e-cigarette use, the legal status of cannabis where they lived, cannabis vaping motives, preferences for cannabis type (hash oil; THC wax; dried bud), impulsivity, and poor self-control. Only greater impulsivity and frequency of e-cigarette were associated with past month cannabis vaping (Morean et al., 2017).

Cranford et al. (2017) identified the prevalence and correlates of cannabis vaping among an adult sample (age > 20 years) who used medical cannabis (N = 1,485, M age= 45.1). Among medical cannabis patients, 39% reported past month cannabis vaping; of those, only 6% reported that they solely vaped to use cannabis, with 87% also using combustible cannabis. Risk factors for cannabis vaping among medical cannabis patients included: having a higher education, being younger than 44 years of age, using cannabis more frequently (i.e., using modalities other than vaping), using nonmedical stimulants, and being a returning medical cannabis patient (Cranford et al., 2017).

To date, there is little information on the risk factors for vaping cannabis, with only a few studies focused on college students (Jones et al., 2016; Frohe et al., 2018; Morean et al., 2017). Information about risk factors of use is essential to inform prevention and intervention efforts focused on decreasing cannabis use among young adults, yet only one study has investigated psychological distress as a risk factor (finding no association; (Jones et al., 2016)), and no studies have investigated chronic medical condition (CMC) status as a correlate of cannabis vaping. Given the broader literature documenting that depressive symptoms (Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012) and CMC status (Dai & Richter, 2019) are risk factors for *overall* cannabis use (Degenhardt et al., 2003), the present study will expand on the extant literature by

examining the independent role of depressive symptoms and CMC status on cannabis vaping, and by simultaneously examining if health status moderates the association between depressive symptoms and cannabis vaping.

Depression and Cannabis Use

Depression is a major concern among many college students (Karmakar & Behera, 2017). Depression is associated with a host of negative sequalae among college students, including but not limited to, noncompliance of medical treatment, poor eating habits, poor sleep, smoking, poor self-care, impaired concentration, low exercise, (Katon et al., 2010; DiMatteo et al., 2000; Doom & Haeffel, 2013) and poor academic performance (Meier et al., 2015; Meda et al., 2017; Suerken et al., 2016; Katon et al., 2010; DiMatteo et al., 2000; Doom & Haeffel, 2013). Importantly, depressive symptoms are also associated with greater cannabis use among young adults (Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012).

There are two primary hypotheses about the comorbidity between depressive symptoms and cannabis use: the self-medication hypothesis and the stress hypothesis. The self-medication hypothesis posits that individuals with depressive symptoms use cannabis to reduce depressive symptoms (Khantzian, 1985; Khantzian, 1997). On the other hand, the stress model hypothesis suggests that the use of cannabis may increase the likelihood of developing depressive symptoms because of the accompanying stressful circumstance that may surround substance use (Ge et al., 1994; Rudolph, 2002). Several longitudinal studies have simultaneously investigated the bidirectional associations between depressive symptoms and cannabis use, thereby simultaneously testing the self-medication and the stress hypotheses. Taking the results of all of these studies together,

there appears to be support for both hypotheses, with slightly more support for the self-medication hypothesis (Wilkinson et al., 2016; Womack et al., 2016; Hooshmand et al., 2012; Bolanis et al., 2020). Importantly, the study with some of the strongest methodological features (i.e., used a large nationally representative sample with assessments spanning 13-14 years) demonstrated more support for the self-medication versus stress hypothesis for adolescents and young adults (Wilkinson et al., 2016). Notably, Zhang and Wu (2014) used Add Health data (N= 3,342) to examine the longitudinal associations between cannabis use and suicidal ideation across four waves of data spanning 14 years. In models testing the stress hypothesis and self-medication hypothesis separately, both hypotheses were supported. However, when examining both hypotheses simultaneously, only the self-medication hypothesis was supported. More specifically, suicidal ideation across time was associated with increased risk for cannabis use across time (Zhang & Wu, 2014); however, cannabis use was not associated with increased risk of suicidal ideation across time. These findings are important due to the fact that depression and suicidal ideation are often seen together (Farabaugh et al., 2012).

Other longitudinal research has specifically examined depressive symptoms as a risk factor for cannabis use, thereby supporting the self-medication hypothesis. Earlier longitudinal research largely failed to support the self-medication hypothesis when examining the relations between depressive symptoms and cannabis use (Degenhardt et al., 2003). However, more recent longitudinal literature supports depression and suicidal ideation as risk factors for later cannabis use (Rhew et al., 2017; Weinberger et al., 2020; Zhang & Wu, 2014; (Crane et al., 2015); (Lazareck et al., 2012). Overall, the extant

longitudinal literature supports the self-medication hypothesis in regards to using cannabis to alleviate depressive symptoms.

The self-medication hypothesis utilizes a conceptual framework in this study for several reasons. First, as was seen in the above, there is empirical evidence supporting this hypothesis for adolescents and young adults (Wilkinson et al., 2016; Womack et al., 2016). Second, national data have demonstrated that adolescents with depression are twice as likely to use cannabis, and cannabis use rates have increased more rapidly since 2004 for adolescents with depression relative to those without depression (Weinberger et al., 2020). Third, data suggest that one of the most common motives for cannabis use is to attempt to manage the symptoms of disorders such as depression and anxiety (Bottorff et al., 2009). Fourth, the self-medication hypothesis overlaps with evidence-based models positing cognitive and affective motivators for cannabis use and identify 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). Notably, coping motives are associated with the poorest outcomes relative to other substance use motives (Cooper et al., 2015). In a study with emerging adults, using cannabis to cope with negative emotions was associated with meeting criteria for cannabis use disorder, greater cannabis disorder severity, more severe cannabis-related problems, and greater depressive symptoms and stress (Moitra et al., 2015). Importantly, these results emerged while controlling for the other substance use motives (using to cannabis to enhance excitement/joy; using cannabis to enhance social situations); enhancement motives and social motives were not associated with outcomes. The current study will investigate the self-medication hypothesis in the context of depressive symptoms and cannabis vaping

among college students and will investigate if this hypothesis is stronger for those with chronic medical conditions.

College students with Chronic Medical Conditions

In the United States, 6 in 10 adults have a chronic medical condition (CMC), with 4 in 10 having two or more CMCs (Centers for Disease Control and Prevention (CDC), 2021). Furthermore, 6.1% of college students have a CMC, including conditions such as asthma, cystic fibrosis, sickle cell disease, allergies, cancer, diabetes, fibromyalgia, inflammatory bowel disease, irritable bowel syndrome, celiac disease, and epilepsy, or other autoimmune conditions (American College Health, 2018; Traino et al., 2019). Importantly, it can be difficult for college students with CMCs to adapt to college compared to their healthy peers: First-year college students with a CMC have lower health-related quality of life and more loneliness compared to their healthy peers (Herts et al., 2014; Hall & Degenhardt, 2013). College students with CMCs experience stressors associated more generally with transitioning to college, such as 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 are also transitioning to more independent management of their medical condition and treatments (Tuchman et al., 2008). The increased demands and stressors experienced by college students with CMCs may contribute to poorer mental health outcomes (Brougham et al., 2009; Compas et al., 1986; Dusselier et al., 2005; Eddington et al., 2010).

It is common for individuals with CMCs to have comorbid depressive symptoms, and depressive symptoms among these individuals are associated with poorer health outcomes (Ferro et al., 2015; Egede; 2007; Katon, 2011). Young adults with CMCs are

also more likely to experience depressive symptoms relative to their healthy peers. For example, Ferro et al (2015) used longitudinal data from the National Longitudinal Survey of Children and Youth that assessed 2,825 youth from 10-11 years of age until 24-25 years of age to identify if having a CMC was associated with depressive trajectories across time. Individuals with a CMC had poorer depressive symptom trajectories over time: Relative to youth without a CMC, youth with a CMC had faster increases in depressive symptoms from the ages of 12-16, followed by slower decreases in depressive symptoms from 17-23 years of age, and then faster increases in depressive symptoms from 24-25 years of age (Ferro et al., 2015). Importantly, depressive symptoms among individuals with CMCs have been linked to poorer adherence to self-care and greater medical symptom burdens, functional impairment/disability, healthcare utilization, lost productivity, and medical costs (Egede, 2007; Katon, 2011). On the other hand, effective treatment of depression is associated with improvements in symptom burden, quality of life, and adaptation among individuals chronic medical condition (Katon, 2011). Given the enhanced stressors, depression, and health risks associated with depression among young adults with CMCs (Brougham et al., 2009; Compas et al., 1986; Dusselier et al., 2005; Eddington et al., 2010; Ferro et al., 2015; Egede; 2007; Katon, 2011), it is important to understand how depressive symptoms relate to substance use, a maladaptive approach to coping, among these at-risk youth (Cooper et al., 2015).

Cannabis Use among Individuals with CMCs

Substance use, including cannabis use, is more common among individuals with CMCs compared to those without CMCs during adolescence and adulthood (Dai & Richter, 2019; Wisk & Weitzman, 2016), with about 11% of young adults with a CMC

reporting daily cannabis use (Dai & Richter, 2019). Cross-sectional research shows that individuals with CMCs (compared to those without a CMC) are more likely to be current and daily marijuana users across young adulthood and into older adulthood (e.g., from 18-> 65 years of age) (Dai & Richter, 2019). To date, there is a paucity of longitudinal research exploring how CMC status predicts substance use across adolescence and into adulthood. Wisk and Weitzman (2016) conducted a longitudinal study that examined substance use behaviors (alcohol, tobacco, and cannabis use) from 12 years of age to 26 years of age among a nationally representative sample (N=2,719) of youth with and without CMCs. Regarding cannabis use, unadjusted models indicated that individuals with CMCs had higher rates of initiation during pre-adolescence and adulthood, but slightly lower initiation during adolescence and young adulthood. Unadjusted lifetime prevalence rates for cannabis use were significantly higher among those with CMCs compared to those without CMCs in pre-adolescence and then significantly (or nearly significantly) higher across young adulthood and adulthood. Both unadjusted and adjusted demonstrated a pattern where past month cannabis use was similar or higher among those with CMCs compared to those without CMCs, especially in pre-adolescence and early adulthood. Similar patterns of results emerged for alcohol and tobacco use. Importantly, this study defined CMCs as having medical conditions, psychological disorders, and learning disorders. Overall, this suggests that cannabis use among individuals with CMC, especially adolescents and young adults, is a public health problem and prevention and intervention efforts are needed to address this modifiable risk for this group of medically vulnerable young people.

The Association between Depressive Symptoms and Cannabis Use among Young Adults with and without CMCs

The current study will investigate the self-medication hypothesis in the context of depressive symptoms and cannabis vaping among college students and will investigate if this association is stronger for those with chronic medical conditions. To date, no existing research has examined if the association between depressive symptoms and cannabis vaping (or cannabis use more broadly) differs between young adults with CMCs relative to those without CMCs. This gap in the literature needs to be addressed for several reasons. First, prior longitudinal research supports that depressive symptoms are associated with increased risk for cannabis use among young adults (Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012). Second, the extant literature has documented that young adults with CMCs experience greater stressors, depressive symptoms, and cannabis use relative to their healthy peers (Brougham et al., 2009; Compas et al., 1986; Dusselier et al., 2005; Eddington et al., 2010; Ferro et al., 2015; Egede; 2007; Katon, 2011). Taken together, it seems plausible that individuals who experience both risk factors for cannabis use (i.e., depressive symptoms and having a CMC (and the increased stress and demands associated with having a CMC)) may be at higher risk for cannabis vaping given the self-medication hypothesis. Thus, it hypothesized that depressive symptoms will have a more robust association with cannabis vaping among those already at-risk for cannabis vaping (i.e., those with a CMC vs. those without a CMC).

The existing literature focused on examining how depressive symptoms relates to cannabis use among those with CMCs is limited to data from the medical marijuana literature, and yet no studies in this literature have examined the moderating role of CMC

status on the association between depressive symptoms and cannabis use. As noted in an earlier section, mental health difficulties are some of the most commonly reported reasons for using of medical marijuana (Walsh et al., 2013; Walsh et al., 2017), despite the insufficient evidence to support a therapeutic effect of medical marijuana for mental health symptoms (Hill, 2015; National Academies of Sciences Engineering and Medicine, 2017; Cousijn et al., 2018; (Whiting et al., 2015) and data suggesting that cannabis use coping motives are associated with poorer outcomes, including problematic cannabis use (Cooper, 1994; Otto et al., 2004; Stewart et al., 1997; Zvolensky et al., 2005). The current study examined the moderating role of CMC status on the relations between depressive symptoms and cannabis vaping among young adults.

Current Study

The current 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 as dependent variables: 1) lifetime of cannabis vaporizers, 2) current use of cannabis vaporizers, 3) lifetime use of electronic nicotine devices to use cannabis, and 4) current use of electronic nicotine devices to use cannabis. The first aim was to identify the associations between depressive symptoms and lifetime and past month cannabis vaping. Consistent with the self-medication hypothesis (Wilkinson et al., 2016; Womack et al., 2016; Weinberger et al., 2020; Bolanis et al., 2020; Hooshmand et al., 2012; Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012), it was hypothesized that experiencing greater depressive symptoms would be associated with an increased likelihood of vaping cannabis. The second aim was to identify the associations between CMC status and lifetime and current

cannabis vaping. Given the prior literature showing that adults with CMCs were more likely to use cannabis (Dai & Richter, 2019), it was hypothesized that college students with CMCs would be more likely to vape cannabis compared to college students without CMCs. The third and final aim was to identify 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 college students with a CMC compared to those without a CMC. Though no existing research has examined if the association between depressive symptoms and cannabis use is stronger for young adults with CMCS relative to those without CMCs, this hypothesis is proffered because of the increased stressors and demands that young adults with CMCs experience (Brougham et al., 2009; Compas et al., 1986; Dusselier et al., 2005; Eddington et al., 2010; Ferro et al., 2015; Egede; 2007; Katon, 2011), and the possibility that youth may be using cannabis to cope with these stressors and depressive symptoms (i.e., increased risk for self-medication model). These findings may inform the development of psychosocial screening efforts and interventions aimed at reducing cannabis use and promoting alternative (i.e. healthier) ways of coping among individuals experiencing depressive symptoms, especially those with CMCs.

CHAPTER II

LITERATURE REVIEW

This appendix will review the literature that is pivotal to the proposed study. The first section will discuss cannabis use and vaping cannabis among young adults/college students. The next section will discuss the general effects of cannabis use. The third section will focus on the health correlates of smoking and vaping cannabis. While it is not assessed in the current study, a brief overview of medical marijuana will also be provided given it is possible that medical marijuana may be being used for mental health concerns. The following sections will include discussions of how health status moderates the relationship between depression and vaping cannabis.

Cannabis is the most widely used illicit drug among young adults aged 18-25 in the United States (Substance Abuse and Mental Health Services Administration, 2014) and cannabis use has significantly increased across time among college students (Odani et al., 2019; National Institute on Drug Abuse, 2020). In fact, in the United States, cannabis is a widely used (and abused) substance by adolescents, adults, and college students (Johnston et al., 2015). In 2019, 43% of college students had used cannabis

during the past year and 14% had used cannabis during the past month (National Institute on Drug Abuse, 2020). Electronic cigarettes (e-cigarettes), and other electronic delivery devices, have become popular and are continuing to gain popularity, and it is vital to understand how they are being used to vaporize cannabis (Morean et al., 2015). In fact, among adults (18-90 years of age) who were experienced cannabis users (i.e., had a history of using cannabis), 61% had vaped cannabis at least once in their lifetime and 37% had vaped cannabis during the past month (Lee et al., 2016); those with a history of vaping cannabis were younger and started using cannabis at a younger age relative to those with no history of vaping cannabis. This same study documented variability in the cannabis vaping modalities used, with 45% using vape pens, 23% using tabletop devices, 15% using portable devices, and 11% using e-cigarettes to use cannabis (Lee et al., 2016). Cannabis vaping has been steadily increasing among college students since 2017, with 5% of students reporting past month cannabis vaping in 2017 and 14% reporting past month cannabis vaping in 2019 (National Institute on Drug Abuse, 2020). Yet, to date, there is a paucity of research focused on cannabis vaping among college students.

Before discussing the health effects and predictors of cannabis vaping, the properties of cannabis and processes involved in vaping cannabis will be reviewed. Cannabis has two main components (or cannabinoids): tetrahydrocannabinol (THC) and cannabidiol (CBD). THC is the main psychoactive component of cannabis that leads to the "high" when ingested or smoked (Baron, 2015; Borgelt et al., 2013). CBD has been proposed to be associated with some possible therapeutic effects (e.g., anticonvulsive effects, sedative and anxiolytic effects, and anti-inflammatory effect) (Mechoulam et al., 2002) relative to THC (Baron, 2015). This study will focus on the use of THC.

There are several different ways to use cannabis products. These methods include consuming cannabis through joints, bowls, bongs, hookahs, and blunts. Cannabis can also be consumed through food products, beverages, and vaping (Raber et al., 2015 pg. 2017). For the purposes of the current research study, vaporizing the substance will be emphasized.

First, e-cigarettes are becoming especially popular in individuals who smoke tobacco (Etter et al., 2011). There is a difference between e-cigarettes and e-vaporizers. In fact, e-cigarettes are made up of a battery, a tank that holds the liquid substance that is heated up and vaporized, and an atomizer which is the electrically heated coil). E-cigarettes can be used to deliver cannabis; however, they are commonly used to deliver nicotine. On the other hand, cannabis vaporizers (e-vaporizers) are used to vaporize materials that are dry or even used to vaporize oils (*Magic Flight*, 2021; *PAX*, 2021; Abrams et al., 2007). These devices are made up of a battery, a metallic coil, and a compartment to place the material (cannabis) such as buds, hashish oil, and etc. (Young, 2014). The primary difference between the e-cigarette and the e-vaporizer is that e-cigarettes use materials that are primarily in liquid form where e-vaporizers use materials are used in their raw form (Centers for Disease Control and Prevention, 2019; Etter, 2015).

Cannabis vaping is increasing among adolescents and young adults (Jones et al., 2016; Morean et al., 2015) and yet remains poorly understand. Researchers are citing similar concerns and questions regarding vaping cannabis as they have for vaping nicotine (Budney et al., 2015). For example, research has documented that people perceive that vaping cannabis is a safer alternative to cannabis smoking (Malouff et al.,

2014), and noted concerns regarding the increased risk of cannabis use initiation (Budney et al., 2015), earlier age of onset, riskier use patterns (Budney et al., 2015) and increased use of cannabis in public places among those who vape cannabis (Giroud et al., 2015; Jones et al., 2016; Morean et al, 2015 from Borodovsky, 2017). Further, investigating the use of e-cigarettes to deliver cannabis is important given the increasing co-administration of nicotine and cannabis (i.e., using the substances at the same time and mixing the substances in the same delivery device) and the potential increased health risks associated with co-administration (Schauer et al., 2017). Importantly, Tucker et al. (2019) found that 14% of young adults engaged in the co-administration of both cannabis and nicotine/tobacco, with over 3% using electronic devices to co-administer cannabis and nicotine. Overall, it is concerning that young adults are using electronic nicotine delivery systems to vape cannabis, whether it contains nicotine or not, because the short and long-term health effects of vaping cannabis among young adults are not fully understood (Cranford et al., 2017; Giroud et al., 2015b; Ramo, Liu, et al., 2012).

Adverse Effects of Cannabis Use

This section provides an overview of some of the adverse effects of *overall* cannabis use; the following sections will summarize the literature on cannabis *smoking* and cannabis *vaping*. These sections will be followed by a brief discussion of medical marijuana.

Understanding cannabis use during adolescence and young adulthood is important given that earlier initiation of cannabis use is associated with increased risk for developing cannabis use disorder (DeWit et al., 2000; Swift et al., 2008; Borodovsky et al., 2017) and because long-term, heavy cannabis use is associated numerous negative

consequences. Examples of these deleterious outcomes include increased risk of other illicit drug use, crime, depression, suicidal behaviors, impaired respiratory functioning, low birth weight, and other negative health outcomes(Fergusson & Horwood, 2000; Fergusson, Horwood, & Swain-Campbell, 2002; Fergusson, Horwood, & Northstone, 2002; Taylor et al., 2002; Lynskey et al., 2003; Hall et al., 2016; National Academies of Sciences Engineering and Medicine, 2017).

Cannabis intoxication is correlated with impaired memory and attention and increased risk for motor vehicle crashes/ traffic injuries (Hall et al., 2016; National Academies of Sciences Engineering and Medicine, 2017; Augsburger et al., 2005; Menetrey et al., 2001).

Health Correlates of Cannabis Smoking

Cannabis smoke contains some of the similar components as tobacco smoke (i.e. carcinogenic chemicals) (Hoffmann et al., 1975; Moir et al., 2008; Novotný et al., 1982), Yet, the data comparing the health effects of cannabis smoking versus tobacco smoking are mixed (Wu et al., 1988; Melamede, 2005). Data support the deleterious effects of cannabis smoking among the general population on respiratory, cardiovascular, immunological, and psychosocial functioning (Hall et al., 2016; National Academies of Sciences Engineering and Medicine, 2017); further, dual cannabis and tobacco smoking is associated with increased cancer risks (i.e. lung cancer, head and neck cancers (Zhang et al., 2015); Hall et al., 2016). More specifically, regular cannabis smoking is linked to the development of psychotic symptoms and disorders, cannabis dependence, the use of other illicit drugs, impaired educational attainment, and impaired respiratory functioning (Hall & Degenhardt, 2014;(Hall et al., 2016). Importantly, daily cannabis, especially use

of high potency cannabis (i.e skunk-type cannabis), is associated with an earlier onset of psychosis (Di Forti et al., 2014). In regard to respiratory functioning, short-term or acute cannabis smoking can cause short-term bronchodilation; however, long-term cannabis use is associated with obstruction and reduced lung functioning (Baron et al., 2015). It remains unclear if there is an association between cannabis use and asthma; though it is clear that more research is needed in this area (National Academies of Sciences Engineering and Medicine, 2017b). Importantly, the detriments of regular cannabis smoking have also been documented with young adults (Hall & Degenhardt, 2013), including impaired lung functioning (Taylor et al., 2002). A large, study conducted in New Zealand (N = 1,037) followed individuals from the age of 18 until the age of 26 and found that increases in cannabis use were associated with decreases in objective lung functioning (Taylor et al., 2002). Given the health consequences of cannabis smoking can begin in young adulthood, research is needed to inform prevention and intervention efforts.

Health Correlates of Vaping Cannabis

Vaping is an increasingly popular mode of administering cannabis (Cranford et al., 2017), yet the health effects of vaping cannabis are not well understood (Jones et al., 2016). Some data suggests that vaping cannabis reduces that amount of smoke-related toxins and carcinogens (i.e. tar, ammonia, carbon monoxide, and hydrogen cyanide) relative to cannabis smoking (Abrams et al., 2007; Moir et al., 2008; Pomahacova et al., 2009; Budney et al., 2015; Giroud et al., 2015b) may result in fewer respiratory effects relative to cannabis smoking (Van Dam & Earleywine, 2010). Importantly, among those who have used cannabis, 72% believe that cannabis vaping is healthier than cannabis

smoking (Lee et al., 2016); and these 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). In fact, cannabis users may be drawn to the idea of vaping cannabis in order to decrease secondhand smoke exposure to those around them (Gartner, 2015). Furthermore, vaping may be thought of as a different way to smoke cannabis, however, not much is known about how much vaping takes place independently or if cannabis vaping is combined with cannabis smoking (Cranford et al., 2017). Finally, there is corroboration that cannabis vaping was associated with a reduction in total cannabis use (Etter, 2015).

Overall, there is a paucity of research investigating the health consequences of cannabis vaping/vaping cannabis. However, data suggest that vaping cannabis is associated with an increased likelihood of accessing cannabis at an early age and having positive experiences when vaping for the first time; these are important factors because both are linked to increased risk for longer term use and dependence (Okaneku et al., 2015; Pacek et al., 2015). The rapid development of e-cigarettes and vapes impedes the progress of our understanding of the health effects of vaping because safety testing is not able to keep up with the rapid development of these devices (Clapp et al., 2020). Yet, based on the current state of the literature on e-cigarettes in general, healthcare professionals are recommended to encourage abstinence from e-cigarettes (Polosa et al., 2016).

The dangerousness of vaping cannabis with e-cigarettes was highlighted recently during an outbreak of lung injuries. In the United States, 2,807 individuals were hospitalized or died due to E-cigarette, or Vaping, product use-Associated Lung Injury

(EVALI), with 68 confirmed deaths as of February 18, 2020 (Centers for Disease Control and Prevention (CDC), 2020). Symptoms of EVALI are characterized by cough, dyspnea, chest pain, vomiting, nausea, diarrhea, as well as fatigue, weight loss and headaches (Kalininskiy et al., 2019). Research implicated cannabis-containing e-cigarettes to the EVALI outbreak (Centers for Disease Control and Prevention (CDC), 2020). Specifically, the inhalation of vitamin E acetate, an additive in found in the cannabis-containing e-cigarettes or vapes, was identified as a major contributor to EVALI. Since the peak of EVALI cases in September of 2019, there has been a steady decline in cases due to the removal of vitamin E acetate from some products, an increase in public awareness of the risks surrounding the use of e-cigarette and vaping products containing cannabis, and law enforcement approaches to addressing illicit products (Centers for Disease Control and Prevention (CDC), 2020). Overall, the need for more research on the health sequalae of cannabis vaping and vaping cannabis is clear, especially given that the increasing legalization of cannabis in the US is leading to increased rates of cannabis vaping.

Medical Marijuana

In the United States, the legalization of cannabis is quickly evolving (Borodovosky et al., 2017). In fact, medical marijuana is legal in 36 states and 4 territories as of November 2020, allowing for the use cannabis for a variety of medical conditions (National Conference of State Legislatures, 2021). Within the United States, almost 10% of cannabis users have reported cannabis use for medical purposes (Compton et al., 2017). In fact, the prevalence of vaping cannabis was 18% among individuals who used cannabis for medicinal purposes, 3% among individuals who used cannabis for

recreation, and 36% among individuals who use cannabis both medically and recreationally (Pacula et al., 2016). Correlates of cannabis vaping among patients who use medical cannabis include being below the age of 44, using nonmedical stimulants, having higher education, being a returning medical cannabis patient, and using cannabis at a greater frequency (Cranford et al., 2017).

In Oklahoma, there is not a list of qualifying medical conditions that medical marijuana is allowed to be prescribed for; physician may prescribe medical marijuana for any condition they believe may benefit from (The Oklahoman, 2018). Given this broad approach, medical marijuana may be being used to treat a variety of mental and medical conditions in Oklahoma. It is important to note that medical cannabis and recreation cannabis have similar THC concentration (Chan et al., 2021). While the current study is not specifically examining the use of medical marijuana, it is examining the association between depression and cannabis vaping, and how health status moderates this relationship. Given that medical marijuana may be used to treat some medical and mental health conditions, and because we are looking at depression and health status as predictors, a brief review of the topic of medical marijuana is presented below. Medical marijuana is also reviewed because there is some data to suggest that increased medical marijuana legalization has contributed to 1) perceptions that there is no or little health risk associated with cannabis use among young adults (Wen et al., 2019), and 2) higher rates of cannabis use in places that provide legal protection to medicinal cannabis dispensaries compared to the states that do not authorize medical cannabis or cannabis dispensaries (Hasin et al., 2015; Pacula, Powell, Heaton, & Sevigny, 2015).

Overall, medical marijuana is used to treat a variety of medical conditions (Sznitman & Zoloov, 2015; Whiting et al., 2015), including, but not limited, chemo-induced nausea and vomiting (Slatkin, 2007; Smith et al., 2015) low appetite among patients who have AIDS (Lutge, Gray, & Siegfried, 2013), glaucoma (Novack, 2016), epilepsy (Paolino et al., 2016; Verrotti et al, 2016), chronic pain (National Academics of Sciences Engineering and Medicine, 2017; Hill, 2015), and multiple sclerosis (Cousijn et al., 2017). Based on a critical review integrating the findings from the National Academics of Sciences Engineering and Medicine 2017 report (National Academies of Sciences Engineering and Medicine, 2017) and findings from the World Health Organization, there is conclusive or substantial evidence suggesting a therapeutic effect of medical marijuana for the following medical conditions: chemo-induced nausea and vomiting, chronic pain, and multiple sclerosis (Cousijn et al., 2018). The most common medical conditions reported in the college student sample used for the present study include diagnoses such as asthma, allergies, and diabetes; to date, it appears there is not strong evidence for the treatment of any of these conditions with medical marijuana (Cousijn et al., 2018).

Mental health difficulties are some of the most commonly reported reasons for using of medical marijuana (Walsh et al., 2013; Walsh et al., 2017), however, there is insufficient evidence to support a therapeutic effect of medical marijuana for mental health symptoms (Hill, 2015; National Academies of Sciences Engineering and Medicine, 2017; Cousijn et al., 2018; (Whiting et al., 2015). Further, given our examination of depressive symptoms in the current study, it is important to note that depression is not a qualifying diagnosis for medical marijuana in any state where medical

marijuana is legalized (Medical Marijuana Laws in the United States, 2021). Nevertheless, one of the primary motives for cannabis use is the relief of negative mood (Simons et al., 1998). In fact, Wadsworth et al (2020) found that medical cannabis users were more likely to report that they used cannabis to improve or manage their mental health compared to non-medical cannabis users. The literature on the associations between general cannabis use (i.e., studies not specifically focused on medical marijuana) and depression are reviewed in the next section; however, it is important to highlight that though is not current evidence suggesting a therapeutic benefit of medical marijuana for depression, depression is a common risk factor for cannabis use.

Risk Factors for Vaping Cannabis

Given the prevalence and known (e.g., EVALI) and unknown health correlates associated with vaping Cannabis, it is important to better understand predictors of use. Yet, to date, there are few studies focused on identifying risk factors for vaping cannabis among young adults, and only one that has focused specifically on college students. The present study will investigate depressive symptoms and health status as predictors of vaping cannabis, and the moderating role of health status on the relation between depressive symptoms and vaping cannabis. No studies to date have examined these aims; the scant research examining other risk factors for vaping cannabis are reviewed below.

There is scant literature focused on identifying risk factors for cannabis vaping, with few studies to date focused on college students. In one study focused on college students, Jones et al. (2016) recruited 482 participants from a large, US southwestern university (mean age =19.55; 49% female; 59% White students) and examined lifetime and past year frequency of cannabis, nicotine, alcohol, and illicit drug use, including the

use of vaporizers to consume nicotine and cannabis, and predictors of vaping. There were high lifetime rates of vaping nicotine (37%) and vaping cannabis (29%), and past year rates of vaping nicotine (30%) and vaping cannabis (23%). Among students with a history of vaping cannabis, 65% reported that top reason that they vaped cannabis was the convenience and the discretion of vaping in public places (Jones et al., 2016). Further, more frequent nicotine vaping and cannabis use were strong risk factors for cannabis vaping. Other risk factors for past year cannabis vaping included being younger, being male, being White or Latinx, having higher socioeconomic status (SES), using other substances (i.e. alcohol, illicit drug), having positive attitudes about cannabis, and being more open to experiencing something new (Jones et al., 2016). This study also investigated an aggregate score of anxiety, depressive, and stress symptoms (as measured by the Depression, Anxiety, and Stress Scale- 21 item) and psychotic-like features (as assessed via 12 item Yale University PRIME Screening Test) as risk factors. The anxiety/depressive/stress symptom score was not related to vaping cannabis; thus, it is unclear how depressive symptoms may independently relate to vaping cannabis. On the other hand, greater psychotic-like experiences were related to past year vaping cannabis. Additionally, Frohe (2018) discusses the correlates of cannabis use through the administration of vape-pens among college students. In fact, the study reports that 54.1% of students had tried cannabis in their life and 10.7% of students reported ever trying a vape-pen. Furthermore, significant predictors of cannabis vape-pen use include positive expectancies, cannabis peer injunctive norms, and alcohol intake (Frohe et al., 2018). There is little evidence on the impact of cannabis vaping (or other substance use) among college students (Kenne et al., 2017).

Given the paucity of research focused on college students, the research that included young adults is described; of note, the average age of participants in these two studies ranged from 32-45. Lee et al. (2016) conducted a study with 2,910 adults who used cannabis (age range: 18-90; M age=32) to identify risk factors for cannabis vaping. Of note, most adults who had vaped cannabis in the past month reported using several modalities to use cannabis, with the most common route of administration being smoking. In addition, 75% of adults reported that after they initiated cannabis vaping their smoking rate remained the same. E-cigarette use was associated with increased risk for vaping cannabis. Males who used cannabis were more likely to have vaped cannabis in their lifetime (63%) compared to females who used cannabis (50%). Furthermore, African Americans were less likely than other ethnic groups to have vaped cannabis in their lifetime. Additionally, being younger was associated with vaping cannabis, and individuals who had vaped cannabis in their lifetime reported a younger age of initiation for cannabis use compared to those with no history of vaping cannabis. Among participants who endorsed they preferred vaping cannabis compared to other modalities for using cannabis, they described that vaping tastes better, it is healthier, it is more satisfying, and it generates better effects. Psychological functioning and health status were not examined in the study (Lee et al., 2016).

Cranford et al., (2017) identified the prevalence and correlates of cannabis vaping among an adult sample (age > 20 years) who used medical cannabis (N = 1,485, M age= 45.1). Among medical cannabis patients, 39% reported past month cannabis vaping; of those, only 6% reported that they solely vaped to use cannabis, with 87% also using combustible cannabis. Risk factors for cannabis vaping among medical cannabis patients

included: having a higher education, being younger than 44 years of age, using cannabis more frequently, using nonmedical stimulants, and being a returning medical cannabis patient. Psychological functioning and health status were not examined (Cranford et al., 2017).

To date, there is little information on the risk factors for vaping cannabis, with only a few studies focused on college students (Jones et al., 2016; Frohe et al., 2018). Information about risk factors of use is essential to inform prevention and intervention efforts focused on decreasing cannabis use among young adults. As described in the below section, the broader literature identifies that depressive symptoms are a risk factor for *overall* cannabis use (Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012); however, only one study has investigated psychological functioning as a correlate of *cannabis vaping*, finding no association (Jones et al., 2016). The present study will expand on this study by examining the independent role of depressive symptoms in understanding cannabis vaping, and by also simultaneously examining how health status may moderate this role.

Depression and Cannabis Use

Depression is a major issue among many college students (Karmakar & Behera, 2017). Depression is associated with a host of negative sequalae among college students, including but not limited to, noncompliance of medical treatment, poor eating habits, poor sleep, smoking, poor self-care, concentration, and a lack of exercise (Katon et al., 2010; DiMatteo et al., 2000; Doom & Haeffel, 2013) and poor academic performance (Meier et al., 2015; Meda et al., 2017; Suerken et al., 2016). Additionally, depressive

symptoms are associated with cannabis use among young adults (Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012).

To date, there are two primary hypotheses about the comorbidity between depressive symptoms and cannabis use, with research that supports both theories (Degenhardt et al., 2003; Womack et al., 2016; Hoffmann, 2018; Wilkinson et al., 2016; Bolanis et al., 2020; Khantzian, 1997). The first hypothesis surrounding this comorbidity is the "depression first" or self-medication hypothesis, suggesting that individuals with depressive symptoms use cannabis to reduce depressive symptoms (Khantzian, 1985; Khantzian, 1997) On the other hand, the stress model hypothesis suggests that the use of cannabis may increase the likelihood of developing depressive symptoms via the accompanying stressful circumstance that may surround substance use(Ge et al., 1994; Rudolph, 2002). The present study is conceptualizing the comorbidity between depressive symptoms and vaping cannabis using the self-medication hypothesis, however, both research evaluating both hypotheses are reviewed below.

Longitudinal Research Simultaneously Investigating the Bidirectional Associations between Depressive Symptoms and Cannabis Use

Several longitudinal studies have simultaneously investigated the bidirectional associations between depressive symptoms and cannabis use, thereby simultaneously testing the self-medication and the stress hypotheses. Several studies evidenced support for both hypotheses. One longitudinal study investigated both hypotheses simultaneously in a sample of 264 male young adults from low socioeconomic backgrounds by investigating cross-lagged association between depressive symptoms and cannabis use at 17, 20, and 22 years of age (Womack et al., 2016). When using the full sample, no

significant cross-lagged paths were identified. However, when restricting the sample to those who were current cannabis users at either ages 20 or 22 (n=111), greater depressive symptoms at 17 years of age were associated with greater cannabis use at 20 years of age (Womack et al., 2016). When restricting the sample to those with mild depressive symptoms at age 17 (n=61), greater cannabis use at age 17 predicted greater depressive symptoms at age 20. This study suggests preliminary support for both hypotheses, at least among males (Womack et al., 2016). Wilkinson et al. (2016) also documented the longitudinal, bidirectional associations between depression and cannabis use using a nationally representative sample of youth followed across adolescence into young adulthood (N=9,816), supporting both the self-medication hypothesis and to a lesser degree the stress hypothesis (Wilkinson et al., 2016). More specifically, this study found that for males and females greater depressive symptoms at baseline (adolescence) were associated with steeper increases in cannabis use across time supporting the self-medication hypothesis. Additionally, this study found partial support for the stress hypothesis in that females with greater cannabis use was associated with greater depressive symptoms across time (Wilkinson et al., 2016).

Other studies have stronger support for the self-medication hypothesis. Bolanis et al. (2020) identified inconsistent bidirectional associations between depressive symptoms, suicidal ideation, and cannabis use among 1606 adolescents from Quebec. Information on the frequency of cannabis use, depressive symptoms and depression (youth with top 10% depressive score), and serious suicidal ideation was gathered at ages 15, 17, and 20 years of age. Youth with depression at age 15 had greater weekly consumption of cannabis use at age 17; this association held when adjusting for other

substance use. When examining a continuous measure of depressive symptoms, greater depressive symptoms at age 15 was predictive of greater cannabis use at ages 17 and 20. On the other hand, weekly cannabis use at age 15 was associated with increased suicidal ideation at age 17 but not 20; however, these associations became nonsignificant in models that adjusted for alcohol, tobacco, and other drug use (Bolanis et al., 2020). Cannabis use was not predictive of subsequent depression or depressive symptoms. Furthermore, Hooshmand et al., (2012) conducted a longitudinal study that followed 4,412 Canadian adolescents from 9^{th}-12^{th} grade and examined both the self-medication and stress hypothesis (though they described this as the "failure hypothesis"). This study included three cohorts of the adolescents who entered high school at different times (2002/2003, 2003/2004, and 2004/2005). The adolescents self-reported on their depressive symptoms with the Center for Epidemiological Studies Depression 20 item measure (CES-D 20) past year frequency of alcohol use, cigarette use, marijuana use, and hard drug use; and delinquency annually. Growth curve models were identified for depressive symptoms and health risk behaviors. The results support the self-medication hypothesis: Higher depressive symptoms in 9^{th} grade were associated with a faster increase in cannabis use, smoking, and hard drug use across high school. Additionally, the stress hypothesis was not supported.

On the other hand, Hoffman et al. (2018) found support for the stress hypothesis but not the self-medication hypothesis (or other related hypotheses). Hoffman (2018) examined the longitudinal unidirectional and bidirectional associations between depressive symptoms and cannabis use in children and adolescents. Four hypotheses were tested: 1) frequent marijuana use would predict more depressive symptoms (stress

hypothesis), 2) more depressive symptoms would predict greater marijuana use (self-medication hypothesis), 3) frequent marijuana use and symptoms of depression would be reciprocally relatedly (i.e., reinforcing each other over time) and 4) stressors would affect the likelihood of more frequent marijuana use and more depressive symptoms. Hypotheses were tested data (N = 861) from the Family Wellness and Health Study (FWHS), prospective cohort study conducted in the upper Midwestern United States that assessed behavior and development among youth across eight annual assessments (11-15 years old at baseline and 19-23 years old at the final assessment). Across waves, children (or their parents) reported on stressful life events, depressive symptoms, and cannabis use. Results demonstrated that cannabis use was associated with increases in depressive symptoms across time, supporting the stress hypothesis. On the other hand, depressive symptoms were not associated with changes in cannabis use across time, failing to support the self-medication hypothesis. The other two hypotheses were not supported.

In a study investigating how the self-medication and stress hypotheses relate to suicidal ideation, Zhang and Wu (2014) used Add Health data to examine the longitudinal associations between substance use and suicidal ideation across four waves of data spanning 14 years. The sample included 3,342 adolescents who completed all four waves. In models testing the stress hypothesis and self-medication hypothesis separately, both hypotheses were supported. However, when examining both hypotheses simultaneously, only the self-medication hypothesis was supported when examining cannabis use. More specifically, suicidal ideation across time was associated with increased risk for cannabis use across time (X. Zhang & Wu, 2014); however, drug use was not associated with increased risk of suicidal ideation across time. Overall, these

results are particularly relevant for those with depression given Farabaugh et al. (2012) finds support for those who have greater depression severity, increased levels of hopelessness, and poor quality of life are more likely to report suicidal ideation (Farabaugh et al., 2012). The role that cannabis may play in suicidal ideation has been documented in a recent meta-analysis of cannabis use and suicidality: Using data from twelve case-control and longitudinal studies, the authors found that chronic cannabis use was associated with suicidal ideation (Borges et al., 2016).

Taking the results of all of these studies together, there appears to be support for both hypotheses, with slightly more support for the self-medication hypothesis (Wilkinson et al., 2016; Womack et al., 2016; Hooshmand et al., 2012; Bolanis et al., 2020). Importantly, the study with some of the strongest methodological features (i.e., used large nationally representative sample with assessments spanning 13-14 years) demonstrated more support for the self-medication versus stress hypothesis for adolescents and young adults (Wilkinson et al., 2016). Finally, there is support to suggest that more suicidal ideation across time was associated with more cannabis across time (X. Zhang & Wu, 2014) which is important consideration to understand due to the fact that depression and suicidal ideation are likely seen together (Farabaugh et al., 2012).

Depression Predicting Cannabis Use (Self-Medication Hypothesis)

The previous section discussed longitudinal studies that simultaneously examined the bidirectional associations of depressive symptoms and cannabis use. Next, the current section specifically focuses longitudinal research examining depressive symptoms as a risk factor for cannabis use, thereby supporting the self-medication hypothesis. The self-medication hypothesis is being utilized a conceptual framework in this study for several

reasons. First, as was seen in the above section and this section, there is empirical evidence supporting this hypothesis for adolescents and young adults (Wilkinson et al., 2016; Womack et al., 2016). Second, national data have demonstrated that adolescents with depression are twice as likely to use cannabis and that the rates of cannabis use have increased more rapidly since 2004 for adolescents with depression relative to those without depression (Weinberger et al., 2020). Third, data suggest that one of the most common motives for cannabis use is to attempt to manage the symptoms of disorders such as depression and anxiety (Bottorff et al., 2009). Fourth, the self-medication hypothesis overlaps with models positing cognitive and affective motivators for cannabis use, and there is strong research support identifying 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). Additionally, coping motives are associated with the poorest outcomes relative to other substance use motives (Cooper et al., 2015). In a study with emerging adults, using cannabis to cope with negative emotions was associated with meeting criteria for cannabis use disorder, greater cannabis disorder severity, more severe cannabis-related problems, and greater depressive symptoms and stress (Moitra et al., 2015). Importantly, these results emerged while controlling for the other substance use motives (using to cannabis to enhance excitement/joy; using cannabis to enhance social situations); enhancement motives and social motives were not associated with outcomes. Longitudinal studies investigating the temporal precedence of depressive symptoms relative to cannabis use are described below.

Longitudinal Studies Examining Depressive Symptoms as Risk Factors for Subsequent Cannabis Use

Other studies have focused on solely evaluating the self-medication hypothesis. Earlier longitudinal research largely failed to support the self-medication hypothesis when examining the relations between depressive symptoms and cannabis use (Degenhardt et al., 2003). A 2003 review demonstrated that across ten longitudinal studies depression was not a risk factor for subsequent cannabis use across adolescence and into adulthood (Degenhardt et al., 2003). However, more recent longitudinal literature supports depression and suicidal ideation as risk factors for later cannabis use (Rhew et al., 2017; Weinberger et al., 2020; Zhang & Wu, 2014) which are discussed further in the section below, along with additional studies.

Rhew et al. (2017) investigated if depressive symptoms during adolescence (13-15 years of age) predicted the risk for cannabis use disorders and alcohol use disorders at 18 years of age. Using a large, diverse sample (N= 521; 55% were youth of color), the authors identified that greater depressive symptoms during adolescence were associated with increased risk for cannabis use disorder, but not alcohol use disorder, at 18 years of age (Rhew et al., 2017).

Gender also appears to be important for understanding the self-medication hypothesis. Using data from the Social and Emotional Contexts of Adolescent Smoking Patterns (SECASP) study, Crane et al., (2015) examined the relationship between gender, cigarette smoking, marijuana use, and depressive symptoms across six years over the shift from adolescence to young adulthood. Participants were 15-16 years of age at baseline and self-reported on depressive symptoms and substance use at the 6 months, 15

months, and 2, 5, and 6 years follow-ups; this study only included participants who completed three or more waves (n = 1108). The results showed that depressive symptoms across time were significantly associated with greater cannabis use across time (Crane et al., 2015); however, an interaction demonstrated that depressive symptoms were only associated with greater cannabis use for males but not females. Cigarette use also interacted with gender and depression in predicting cannabis use: Among males, cigarette use was associated with cannabis use for those with high but not low depression. Among females, cigarette use correlated with cannabis use similarly among those with all levels of depressive symptoms. Overall, these results found that the self-medication hypothesis was only supported among males.

In a study that directly assessed using drugs to alleviate mood disorders symptoms, Lazareck et al., (2012) examined if self-reported self-medication with drugs was associated with a risk of comorbid mood and drug use disorders. Data was drawn from participants who completed both Wave 1 (2001-2002) and Wave 2 (2004-2005; N = 34,653) of the National Institute on Alcohol Abuse and Alcoholism and the National Epidemiological Survey on Alcohol and Related Conditions (NESARC). Participants were interviewed about their lifetime and past year history of mood and substance use disorders and if they had ever used drugs to alleviate symptoms of any endorsed mood disorders. Importantly, over 38% of people with a history of a mood disorder and who has used drugs in the past year reported that they had self-medicated with drugs. Cannabis use was commonly used by those who endorsed self-medication: About 65% of those with a baseline mood disorder who endorsed self-medication reported that they had used cannabis in the past year. Relatedly, among those with comorbid mood and drug use

disorders at baseline, 34% endorsed self-medication. Having a mood disorder at baseline was associated with increased risk for incident drug abuse and dependence. Furthermore, among those with a mood disorder at baseline, self-medicating mood symptoms was associated with greater risk for incident drug dependence; 25% of new incident drug dependence was attributed to self-medication. On the other hand, among adults with a baseline drug use disorder who also endorsed self-medicating mood symptoms, self-medication was not associated with incident mood disorders. The authors also investigated how self-medication with drugs related to the persistence of mood and drug use disorders. Among adults with lifetime comorbid mood and drug use disorders at baseline who reported self-medicating mood symptoms, self-medication was associated with persistence of drug use disorder (meets for either abuse or dependence), accounting for 20% of the persistence in drug use disorders at Wave 2. On the other hand, among this same group, self-medication was not associated with the persistence of mood disorders. Overall, this study supports the self-medication hypothesis as it relates to incident and persistent drug use disorders and documents that cannabis is frequently used to self-medicate mood symptoms (Lazareck et al., 2012).

Taken together, the studies discussed in this section support the self-medication hypothesis (Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012). More specifically, Rhew et al (2017) found that greater depressive symptoms during adolescence are associated with an increased risk for cannabis use disorder at 18 years of age. Second, Crane et al (2015) revealed that depression across time was significantly associated with greater cannabis use across time. Importantly, this relationship appears to vary by gender; an interaction demonstrated that depressive symptoms were only

associated with greater cannabis use for males but not females. Finally, Lazareck et al. (2012) also found support for the self-medication hypothesis using a large sample (N = 34,653): Depressive symptoms were associated with incident and persistent drug use disorders. Overall, the extant longitudinal literature supports the self-medication hypothesis in using cannabis to alleviate depressive symptoms. Next, the longitudinal literature on stress hypothesis is reviewed.

Cannabis Use Predicting Depressive Symptoms (Stress hypothesis).

Longitudinal Studies Examining Cannabis Use as Risk Factor for Depressive Symptoms

The current discussion provides information regarding the stress-hypothesis. More specifically, this section includes a discussion of the longitudinal research examining cannabis use as a predictor of depressive symptoms. Both the WHO report and the NASEM reports (National Academies of Sciences Engineering and Medicine, 2017) focused on the health effects of cannabis have indicated that cannabis use was related to an increased risk for subsequent depression (Cousijn et al., 2017). In a 2003 review of the longitudinal associations between cannabis and depression that included primarily adolescent and young adult populations, results demonstrated mixed support for the stress hypothesis (Degenhardt et al., 2003), with some studies demonstrating that early onset of regular cannabis use was associated with an increased risk for the development of later depression (Degenhardt et al., 2003). A meta-analysis of 14 longitudinal studies investigating the associations between cannabis use and the development of depression (Lev-Ran et al., 2013) found mixed results. Cannabis use (and heavy cannabis use) were associated with an increased risk for developing depressive disorders (Lev-Ran et al.,

2013); however, cannabis use was not associated with clinical diagnoses of depression. Several recent longitudinal studies have also investigated cannabis use as predictor of subsequent depressive symptoms.

Meier et al (2020) examined the how changes in cannabis use (frequency of cannabis use and years of weekly cannabis use) across time were associated with changes in internalizing problems across time among males (N=506) across adolescence through young adulthood. Participants were assessed annually and self-reported on cannabis use and depressive symptoms, and anxiety/depression problems from 15-26 years of age. Frequency of cannabis use (no use, less than weekly, or weekly use) and cumulative prior years of weekly cannabis use were assessed with the Substance Use Questionnaire. Depressive symptoms were assessed with the Short Mood and Feelings questionnaire; anxiety/depression problems were assessed with the Youth Self Report (YSR). After controlling for covariates, greater changes in cumulative years of weekly cannabis use were associated with greater increases anxiety and depressive symptoms (Meier et al., 2020); however, changes in cannabis use frequency were not predictive of changes internalizing symptoms.

Additionally, Hengartner et al (2020) examined the associations between adolescent cannabis use and adult depression, suicidality, and anxiety. Young adults (aged 19 and 20) from Zurich, Switzerland reported on their lifetime and current use of cannabis use and if they initiated cannabis use prior to age of 15/16. Furthermore, individuals were assessed at the ages of 20/21, 22/23, 27/28, 29/30, 34/35, 40/41, and 49/50 years for substance use, depression, suicidality, and anxiety disorders with the Structured Psychopathological interview and the Social consequences of Psychological

disturbances for Epidemiology survey (Angst et al., 1984). Furthermore, these measures were used to identify DSM-III-R diagnoses of depression. Overall, this longitudinal study spanning over 30 years established that cannabis use in adolescence was associated with clinical depression and suicidality in adulthood, but not anxiety disorders, after controlling for adult substance use. Furthermore, cannabis use initiation prior to the age of 15/16 and more frequent cannabis use during adolescence was associated with an increased risk of depression in adulthood (Hengartner et al., 2020). Moreover, Pedersen (2008) explained how young adults who use cannabis may have an increased risk of suicide ideation and suicide attempts (Pedersen, 2008). This study investigated of cannabis use led to depression, suicide, and suicide attempts. This longitudinal study included 2,033 individuals who were followed for a 13-year period from adolescence to their later twenties and collected information on their cannabis use, depression, suicide ideation, and suicide attempts. The results from the study revealed that during early adolescence, there were not any observed associations with later depression or suicidal behaviors. However, when individuals were in their twenties, they saw high association with suicide ideation and attempts. All things considered, cannabis does not lead to depression however it can be linked to later suicidal thoughts and suicidal attempts (Pedersen, 2008).

Using an Australian birth cohort followed until the age of 21, Hayatbakhsh et al., (2007) investigated if cannabis use initiation before 15 years of age and daily/near daily cannabis use at 21 years of age were associated with anxiety and depression among young adults. Anxiety and depression (cutoff based on top 10% of scores) were measured via youth self-report at 14 and 21 years of age; cannabis use (frequency of use; age of

initiation) was measured at 21 years of age. Overall, individuals who initiated cannabis use before 15 years of age and used it frequently at 21 years of age were more likely to report elevated symptoms of anxiety and depression during early/young adulthood (Hayatbakhsh et al., 2007).

Using a sample of boys/men (N= 506), Bechtold et al (2015) identified different patterns of cannabis use from the ages 15-26 years, and then examined how cannabis use patterns related to self-reported physical conditions (i.e. asthma and high blood pressure) and mental health disorders (i.e. depression and psychosis) when individuals were in their mid 30s. Furthermore, the study also assessed if chronic cannabis use was associated more strongly with health problems in Black men compared White men. Individuals were assessed for the first time at 14 years of age and were then interviewed every 6 months for two and a half years. After these assessments, participants were interviewed once a year for 10 additional assessments, with the last assessment at age 26. Cannabis use was assessed until the age of 26. At 36 years of age, participants reported on current health problems, daily activities limitations due to a medical condition, and lifetime history of ever meeting criteria for an anxiety disorder, mood disorder, or psychotic disorder. The following four groups of cannabis users were identified: 1) early onset chronic users, 2) late increasing users, 3) adolescence-limited users, and 4) low/nonusers. Results showed that there were not any significant differences in physical and mental health during their mid-30s between the four cannabis use groups. Furthermore, race did not moderate the associations between cannabis use group membership and outcomes.

The articles reviewed above discuss cannabis use as risk factor for depression/mental health problems; the following article discusses how reductions in

cannabis use affect depression. Using a sample of adults in treatment for cannabis use (N=302; ages 18-50), Hser et al (2017) studied the longitudinal associations between reductions in cannabis use across time and changes in depression, sleep, quality of life, and anxiety across time. Reductions in cannabis use across the 12-week treatment period were associated with improvements in depression, anxiety, and quality of sleep, but not in the quality of life, across the same time period. These results suggest that reducing cannabis use may improve mental health (Hser et al., 2017).

Overall, there is mixed support for the stress hypothesis (Hall & Degenhardt, 2003; Lev-Ran et al., 2014); yet, some research suggest that reductions in cannabis use may lead to improvements in depression, anxiety, and quality of sleep (Hser et al., 2017). Given the literature summarized in this entire section, the current study is informed by the self-medication hypothesis and will investigate both the 1) main effects of depressive symptoms and health status (presence of chronic medical condition versus not) on cannabis vaping and 2) if health status moderates the association between depressive symptoms and cannabis vaping. The next section turns to the interrelations between depressive symptoms, health status, and cannabis vaping.

College students with CMCs

In the United States, 6 in 10 adults have a chronic medical condition (CMC), with 4 in 10 having two or more CMCs (Centers for Disease Control and Prevention (CDC), 2021). Furthermore, 6.1% of college students have a CMC, including conditions such as asthma, cystic fibrosis, sickle cell disease, allergies, cancer, diabetes, fibromyalgia, inflammatory bowel disease, irritable bowel syndrome, celiac disease, and epilepsy, or other autoimmune conditions (American College Health, 2018; Traino et al., 2019).

Importantly, it can be difficult for college students with CMCs to adapt to college compared to their healthy peers: First-year college students with a CMC have lower health-related quality of life and more loneliness compared to their healthy peers (Herts et al., 2014; Hall & Degenhardt, 2013). College students with CMCs experience stressors associated more generally with transitioning to college, such as 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 are also transitioning to more independent management of their medical condition and treatments (Traino et al., 2021). The increased demands and stressors experienced by college students with CMCs may contribute to poorer mental health outcomes (Brougham et al., 2009; Compas et al., 1986; Dusselier et al., 2005; Eddington et al., 2010).

It is common for individuals with CMCs to have comorbid depressive symptoms, and depressive symptoms among these individuals are associated with poorer health outcomes (Ferro et al., 2015; Egede; 2007; Katon, 2011). Young adults with CMCs are also more likely to experience depressive symptoms relative to their healthy peers. For example, Ferro et al (2015) used longitudinal data from the National Longitudinal Survey of Children and Youth that assessed 2,825 youth from 10-11 years of age until 24-25 years of age to identify if having a CMC was associated with depressive trajectories across time. Individuals with a CMC had poorer depressive symptom trajectories over time: Relative to youth without a CMC, youth with a CMC had faster increases in depressive symptoms from the ages of 12-16, followed by slower decreases in depressive symptoms from 17-23 years of age, and then faster increases in depressive symptoms from 24-25 years of age (Ferro et al., 2015). Importantly, depressive symptoms among

individuals with CMCs have been linked to poorer adherence to self-care and greater medical symptom burdens, functional impairment/disability, healthcare utilization, lost productivity, and medical costs (Egede, 2007; Katon, 2011) On the other hand, effective treatment of depression is associated with improvements in symptom burden, quality of life, and adaptation among individuals chronic medical condition (Katon, 2011). Given the enhanced stressors, depression, and health risks associated with depression among young adults with CMCs (Brougham et al., 2009; Compas et al., 1986; Dusselier et al., 2005; Eddington et al., 2010; Ferro et al., 2015; Egede; 2007; Katon, 2011)., it is important to understand how depressive symptoms relate to substance use, a maladaptive approach to coping, among these at-risk youth (Cooper et al., 2015).

Cannabis Use among Individuals with CMCs

Substance use, including cannabis use, is more common among individuals with CMCs compared to those without CMCs during adolescence and adulthood (Dai & Richter, 2019; Wisk & Weitzman, 2016), with about 11% of young adults with a CMC reporting daily cannabis use (Dai & Richter, 2019). Cross-sectional research shows that individuals with CMCs (compared to those without a CMC) are more likely to be current and daily marijuana users across young adulthood and into older adulthood (e.g., from 18-> 65 years of age) (Dai & Richter, 2019). To date, there is a paucity of longitudinal research exploring how CMC status predicts substance use across adolescence and into adulthood. Wisk and Weitzman (2016) conducted a longitudinal study that examined substance use behaviors (alcohol, tobacco, and cannabis use) from 12 years of age to 26 years of age among a nationally representative sample (N=2,719) of youth with and without CMCs. Regarding cannabis use, unadjusted models indicated that individuals

with CMCs had higher rates of initiation during pre-adolescence and adulthood, but slightly lower initiation during adolescence and young adulthood. Unadjusted lifetime prevalence rates for cannabis use were significantly higher among those with CMCs compared to those without CMCs in pre-adolescence and then significantly (or nearly significantly) higher across young adulthood and adulthood. Both unadjusted and adjusted demonstrated a pattern where past month cannabis use was similar or higher among those with CMCs compared to those without CMCs, especially in pre-adolescence and early adulthood. Similar patterns of results emerged for alcohol and tobacco use. Importantly, this study defined CMCs as having medical conditions, psychological disorders, and learning disorders. Overall, this suggests that cannabis use among individuals with CMC, especially adolescents and young adults, is a public health problem and prevention and intervention efforts are needed to address this modifiable risk for this group of medically vulnerable young people.

The Association between Depressive Symptoms and Cannabis Use among Young Adults with and without CMCs

To our knowledge, no existing research has examined if the association between depressive symptoms and cannabis vaping (or cannabis use more broadly) differs between young adults with CMCS relative to those without CMCs. Yet, prior longitudinal research supports that depressive symptoms are associated with increased risk for cannabis use (Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012). Furthermore, the extant literature has documented that young adults with CMCs experience greater stressors, depressive symptoms, and cannabis use relative to their healthy peers (Brougham et al., 2009; Compas et al., 1986; Dusselier et al., 2005;

Eddington et al., 2010; Ferro et al., 2015; Egede; 2007; Katon, 2011). Taken together, it seems plausible that individuals who experience both risk factors for cannabis use (i.e., depressive symptoms and having a CMC (and the increased stress and demands associated with having a CMC)) may be at higher risk for cannabis vaping. Thus, it hypothesized that depressive symptoms will have a more robust association with cannabis vaping among those already at-risk for cannabis vaping (i.e., those with a CMC vs. those without a CMC).

The existing literature focused on examining how depressive symptoms relates to cannabis use among those with CMCs is limited to data from the medical marijuana literature, and yet no studies in this literature have examined the moderating role of having a CMC on the association between depressive symptoms and cannabis use either. As noted in an earlier section, mental health difficulties are some of the most commonly reported reasons for using of medical marijuana (Walsh et al., 2013; Walsh et al., 2017), despite the insufficient evidence to support a therapeutic effect of medical marijuana for mental health symptoms (Hill, 2015; National Academies of Sciences Engineering and Medicine, 2017; Cousijn et al., 2018; (Whiting et al., 2015) and data suggesting that cannabis use coping motives are associated with poorer outcomes, including problematic cannabis use (Cooper, 1994; Otto et al., 2004; Stewart et al., 1997; Zvolensky et al., 2005). The current study will examine the moderating role of CMC status on the relations between depressive symptoms and cannabis vaping among young adults.

Current Study

The current study has three aims to enhance our understanding of the associations between depressive symptoms, CMC status, and cannabis vaping (i.e., current use of

cannabis vaporizers; current use of electronic nicotine devices to use THC) among college students. The first aim is to identify if depressive symptoms are associated with past month use of cannabis vaporizers and/or past month use of nicotine delivery devices to use cannabis. Consistent with the self-medication hypothesis (Wilkinson et al., 2016; Womack et al., 2016; Weinberger et al., 2020; Bolanis et al., 2020; Hooshmand et al., 2012; Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012), it is hypothesized that experiencing greater depressive symptoms will be associated with an increased likelihood of vaping cannabis. The second aim is to identify if CMC status is associated with current cannabis vaping. Given the prior literature showing that adults with CMCs are more likely to use cannabis (Dai & Richter, 2019), it is hypothesized that college students with CMCs will be more likely to vape cannabis compared to college students without CMCs. The third and final aim is to identify the moderating role of CMC status on the association between depressive symptoms and cannabis vaping (i.e., current use of cannabis vaporizers; current use of electronic nicotine devices to use THC). It is hypothesized that the association between depressive symptoms and cannabis vaping will be stronger among college students with a CMC compared to those without a CMC. Though no existing research has examined if the association between depressive symptoms and cannabis use is stronger for young adults with CMCS relative to those without CMCs, this hypothesis is proffered because of the increased stressors and demands that young adults with CMCs experience (Brougham et al., 2009; Compas et al., 1986; Dusselier et al., 2005; Eddington et al., 2010; Ferro et al., 2015; Egede; 2007; Katon, 2011). These findings will inform the development of psychosocial screening efforts and interventions aimed at reducing cannabis use and promoting alternative (i.e.

healthy) ways of coping among individuals experiencing depressive symptoms, especially those with CMCs.

CHAPTER III

METHODOLOGY

Participants and Procedures

Participants (N= 3, 742) in the present study were college students from a large midwestern university who completed a broader study of psychosocial functioning among college students. Participants were recruited through an online survey system, consented to the study, and then filled out questionnaires online. Consistent with many universities, many undergraduate psychology courses require a research component; students who completed this study were compensated with course credit. Data collection for the larger study is ongoing; data for the current study includes data from every semester from Fall 2017 until Spring 2021. Sample size varied across analyses due to missing data on the dependent variables; however, missing data rates were minimal (frequency of cannabis vaping: data available = 3, 674, missing = 68 (1.8%); frequency of using e-cigarette to vape cannabis: data available = 3, 677, missing = 65 (1.7%)).

Measures

Demographic Information. Participants self-reported on demographic information such as race, ethnicity, age, gender, socioeconomic status (SES), first generation college student status, first generation college student status, and education level. 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) Education level was dichotomized: Lower-classmen (Freshmen/ Sophomores; coded as 0) and upper-classmen (Juniors/ Seniors; coded as 1). The date of survey completion was used to create a pandemic onset variable: Data collected prior to Spring 2020 was coded as pre-pandemic (0) and data collected during or after Spring 2020 was coded as collected during the pandemic (1).

Depressive Symptoms. Depressive symptoms were measured using the 20-item Center for Epidemiologic Studies Depression (CESD) scale (Radloff, 1977). Participants used a 4-point Likert scale (0 = never, 3 = most of the time) to identify how often they experienced depressive symptoms over the past week. Total scores were created by summing item responses, after rescaling necessary items. 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). The Cronbach's alpha for the current sample was .83, indicating good internal consistency.

Chronic Medical Conditions (CMC). To measure CMC status, participants answered the question "Do you have a chronic illness?". Participants who endorsed a CMC identified their diagnosis from a list of common diagnoses, including asthma, type 1 diabetes, type 2 diabetes, sickle cell disease, cystic fibrosis, obesity, fibromyalgia,

juvenile Rheumatic disease, epilepsy, celiac disease, inflammatory bowel disease, irritable bowel disease, allergies, cancer, disorder of sexual development, chronic migraines, polycystic ovarian syndrome, endometriosis, postural orthostatic tachycardia syndrome, thyroid disease, mental health conditions, other medical conditions. Participants who chose "other" had the option to write in their diagnosis if it was not listed. An overall CMC status was created for analyses. Participants in the Healthy group did not endorse a CMC (coded as 0); participants who did not endorse a CMC but endorsed a mental health diagnosis were included in the Healthy group. 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

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?"). Response options included: Never tried, not even once; tried it before; use yearly (less than monthly); use monthly; use weekly; use daily. This question was used to create two variables: a lifetime history of use variable and a current use variable.

This question, and the question used to assess the frequency of using electronic nicotine devices to use cannabis, were modeled after questions from standardized assessments of cannabis use used in the NIH-funded PATH Study (Hyland et al., 2017). Prior research has demonstrated that similar, brief assessments of young adults' reports of the frequency of cannabis use are reliable based on their associations with other more

intensive, validated measures of self-reported cannabis use (i.e., the Timeline Followback) (Ramo, Hall, et al., 2012). Prior research also supports the construct validity and concurrent criterion validity of brief self-reported cannabis use frequency measures (as used in this study) (Ramo, Hall, et al., 2012; Shiplo et al., 2016). Existing research also supports the use of self-reported frequency of use when specifically assessing use of cannabis vaporizers (Jones et al., 2016; Shiplo et al., 2016).

Data from the above question were recoded to create a lifetime history of cannabis vaporizer use. Participants who reported that they have never tried, not even once were coded as not having a history of using cannabis vapes (coded as '0'). Participants who endorsed any level of use (including having tried cannabis vaporizers) were coded as having a lifetime history of cannabis vaporizing (coded as '1').

Data from the original frequency question was recoded to create a current use of cannabis vaporizer variable (Schulenberg et al., 2021). Participants with a lifetime history of using cannabis vaporizers were coded as current users if they endorsed monthly, weekly, or daily use (1). Participants who endorsed that they had tried cannabis vaporizers, used cannabis vaporizers only yearly, or had never tried cannabis were coded as non-current users (0).

Use of Electronic Nicotine Devices to use Cannabis

Participants also self-reported on their frequency of using electronic nicotine devices (e.g., e-cigarettes, e-hookah, etc.) to deliver cannabis ("How often do you use cannabis electronic vaporizers to deliver THC?"). This question was modeled after prior research that assessed use of electronic nicotine devices to use cannabis (Morean et al.,

2018). Response options were identical to those used for the measure of frequency of cannabis vaporizer use; additionally, the same coding scheme 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

Preliminary Analyses

SPSS version 24 was used for all data analyses. Descriptive statistics were used to generate means/standard deviations and frequencies (percentages) of variables of interest. Prior literature and results from bivariate correlations (or chi-squares) between the demographic variables (e.g., age, race/ethnicity, college level, socioeconomic status, sex) and lifetime and current cannabis vaporizing and use of electronic nicotine devices to use cannabis were executed to identify covariates for primary analyses. Covariates that were associated with a lifetime history of cannabis vaporizing at $p<.1$ included: data collected during the pandemic ($x^2(1, N= 3,674)= 87.295$, $p <.001$) and age ($r= .041$, $p =.013$); only data collected during the pandemic ($x^2(1, N= 3,677)= 69.030$, $p <.001$) and income ($r= .032$, $p =.052$) were associated with a lifetime history of electronic nicotine devices to deliver cannabis. Covariates that were associated with current cannabis vaporizing and/or current use of electronic nicotine devices to deliver THC at $p<.1$ included: data collected during the pandemic (Cannabis vaporizing: $x^2(1, N= 3,674)= 44.77$, $p <.001$; Using electronic nicotine devices to use THC: $x^2(1, N= 3,677)=17.955$, $p <.001$) and sex (Cannabis vaporizing: $x^2(1, N= 3,674)= 6.051$, $p = .014$; Using electronic nicotine devices to use THC: $x^2(1, N= 3,677)= 6.758$, $p = .009$). Based on these results, data collection during the pandemic, age, sex, and income were included as covariates in the

primary analyses; race/ethnicity was also included as covariates based on its association with cannabis vaping in prior literature. Initial analyses for Aims 1 and 2 also identified the unadjusted, bivariate associations between: 1) depressive symptoms and dependent variables (Aim 1; correlations), and 2) CMC status with dependent variables (Aim 2; chi-square analyses).

Primary Analyses

Eight separate logistic regressions were to execute the primary analyses. 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 electronic nicotine devices to use cannabis, and current use of electronic nicotine devices to use cannabis). To examine Aim 3, four models were run 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 (a SPSS macro) was used to estimate the logistic regression models and to probe any significant two-way interactions (Hayes & Matthes, 2009). 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).

CHAPTER IV

FINDINGS

Participant demographics and descriptive statistics on variables of interest are presented in Table 1. The associations between depressive symptoms and dependent variables were as follows: lifetime cannabis vaporizing (r=0.138, p<.001), current cannabis vaporizing (r=0.109, p<.001), lifetime use of electronic nicotine devices to use cannabis (r=0.110, p<.001), and current use of electronic nicotine devices to use cannabis (r=0.060, p<.001). The associations between CMC status and dependent variables were as follows: lifetime cannabis vaporizing (x^2(1, N=3,486)=3.276, p=.070), current cannabis vaporizing (x^2(1, N=3,486)=1.116, p=.291), lifetime use of electronic nicotine devices to use cannabis (x^2(1, N=3,488)=.037, p=.846) and current use of electronic nicotine devices to use cannabis (x^2(1, N=3,488)=.176, p=.675).

Main Effects Only Models

Lifetime History of Cannabis Vaporizing

The overall model examining the main effects of depressive symptoms and CMC status on lifetime cannabis vaporizing was significant (x^2(12, N =3433) = 152.23, p<.001). See

Table 2. Greater depressive symptoms were related to an increased likelihood of having a lifetime history of cannabis vaporizing (OR= 1.026, CI: 1.020-1.033). Having a CMC was not a significant predictor of lifetime cannabis vaporizing. In addition, individuals who completed the survey during the pandemic were more likely to have vaped cannabis in their lifetime compared to those who completed the survey before the pandemic (OR= 2.075, CI: 1.725 – 2.497); greater income was also associated with an increased likelihood of having a history of vaping cannabis (OR= 1.041, CI: 1.010 – 1.073).

Current Cannabis Vaporizing

The overall model examining the main effects of depressive symptoms and CMC status on current cannabis vaporizing was significant ($X^2(12, N= 3{,}433) = 81.71$, $p<.001$). See Table 2. Greater depressive symptoms were associated with an increased likelihood of current cannabis vaporizing (OR= 1.035, CI: 1.024 – 1.046). CMC status was not a significant predictor of current cannabis vaporizing. Several covariates were also significantly related to current cannabis vaporizing. Participants who completed the survey during the pandemic were more likely to use cannabis vapes compared to those who took the survey before the pandemic (OR= 2.144, CI: 1.591 – 2.888). Females were less likely to use cannabis vapes compared to males (OR= 0.689, CI: 0.509 - 0.933).

Lifetime History of Using Electronic Nicotine Devices to Use Cannabis

The overall model examining the main effects of depressive symptoms and CMC status on lifetime history of using electronic nicotine devices to use cannabis was significant ($X^2(12, N= 3{,}435) = 104.90$, $p<.001$). See Table 3. Greater depressive symptoms were associated with an increased likelihood of a having a lifetime history of using electronic nicotine devices to deliver cannabis (OR= 1.023, CI: 1.016 – 1.030).

CMC status was not a significant predictor. In addition, completing the survey during the pandemic (OR= 1.976, CI: 1.618 – 2.413) and having greater income (OR= 1.051, CI: 1.017 -1.087) were associated with a greater likelihood of having a lifetime history of using an electronic nicotine device to deliver THC.

Current Use of Electronic Nicotine Devices to Use Cannabis

The overall model was significant ($X^2(12, N=3,435 = 38.65, p< .001$). See Table 3. Greater depressive symptoms were related to an increased likelihood of currently using an electronic nicotine device to deliver THC (OR= 1.024, CI: 1.011 – 1.037). CMC status was not a significant predictor. Additionally, individuals who completed the survey during the pandemic were more likely to use electronic nicotine devices to deliver THC (OR= 1.599, CI: 1.122 – 2.279). Individuals who identified as American Indian were less likely than non-Hispanic, White to use electronic nicotine devices to deliver THC (OR= 0.35, CI: 0.128 - 0.962).

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 ($x^2(1, N =3433) = 8.38, p = .003$). See 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 healthy individuals, 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 depressive symptom and CMC status 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. See Table 4. The interaction was not significant. The depressive symptom main effect was significant: greater depressive symptoms were associated with an increased likelihood of having a history 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.

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. See Table 5. The interaction was not significant. 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 ($x^2(1, N= 3,435) =.276$, $p<.001$. See Table 5. The interaction and CMC main effect were not significant. Greater depressive symptoms were associated with an increased likelihood of having a history of cannabis vaping (B =0.025, $p <.001$, CI: 0.011 - 0.039). Having data collected during the pandemic was a risk factor; individuals who identified as American Indian were less likely to use electronic nicotine devices to use cannabis.

CHAPTER V

CONCLUSIONS

This study extended the limited available research on predictors of cannabis vaping among college students, an important contribution given the greater substance use among college students (Schulenberg et al., 2021) and because these findings can help to inform prevention and intervention programming. Specifically, the current study examined the associations between depressive symptoms and CMC status and current and lifetime cannabis vaping; the moderating role of CMC status on these associations was also examined. Across analyses, the most consistent predictors of an increased likelihood of cannabis vaping were having greater depressive symptoms and having data collected during the pandemic. Greater depressive symptoms were related to an increased likelihood of cannabis vaping across all outcomes: namely, lifetime and current use for both cannabis vaporizing and using electronic nicotine devices to deliver cannabis. On the other hand, having a CMC was only related to one outcome: Having a lifetime history of cannabis vaporizing, such that those with CMC were more likely to have a vaporizing history. Furthermore, 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 healthy young adults but not those with a CMC.

Greater depressive symptoms were related to an increased likelihood of lifetime and current cannabis vaporizing and use of electronic nicotine devices to deliver THC. 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) (Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012). However, the association between depressive symptoms and cannabis vaping in particular was yet to be explored. Most closely related, Jones et al., 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 are in contrast to 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). In considering the findings of these two studies 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. Thus, it is important to continue exploring depression as a risk factor for cannabis vaping to ultimately inform prevention and intervention efforts focused on decreasing cannabis use among young adults.

The link between depression and cannabis vaping found in the present study is consistent with the self-medication hypothesis (Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012; Weinberger et al., 2020; Bottorff et al., 2009). As discussed, the self-medication hypothesis posits that individuals with depressive symptoms use cannabis to reduce depressive symptoms (Khantzian, 1985; Khantzian, 1997), and this has been supported for adolescents and young adults when examining overall cannabis use (Wilkinson et al., 2016; Womack et al., 2016). The

current finding that depression robustly 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 means of managing their depression 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). With further research, these findings may help to extend the self-medication hypothesis from general cannabis use to cannabis vaping in particular.

The self-medication hypothesis would also predict that CMC status is associated with cannabis vaping; this hypothesis was partially supported. CMC status was only related to having a lifetime history of cannabis vaporizing, with those with CMC being more likely to have a history. As we have mentioned, substance use, including cannabis use, is more common among individuals with CMCs compared to those without CMCs during adolescence and adulthood (Dai & Richter, 2019; Wisk & Weitzman, 2016). More specifically, cross-sectional research shows that individuals with CMCs (compared to those without a CMC) are more likely to be current and daily marijuana users across young adulthood and into older adulthood (e.g., from 18-> 65 years of age) (Dai & Richter, 2019). In addition, one longitudinal study found a pattern where lifetime cannabis use was higher in individuals with a CMC than peers across multiple points from pre-adolescence (less than or equal to 14 years of age) to early adulthood (greater than or equal to 24 years of age) (Wisk & Weitzman, 2016). Similarly, our study observed greater lifetime cannabis vaporizing in individuals with versus without CMCs; however, this association was only identified in one model. Several potential factors may have contributed to CMC status only being related to cannabis vaporizing. For example, greater access and ease of using cannabis vaporizers relative to using electronic nicotine devices to deliver cannabis may have supported greater use of cannabis vaporizers over other modalities; additionally, the publicized EVALI outbreak may have deterred use of electronic nicotine devices to use cannabis, given their association with EVALI, but not use of cannabis vaporizers. Overall, cannabis use among individuals with CMCs,

especially adolescents and young adults, is a public health problem and prevention and intervention efforts are needed to address this modifiable risk for this group of medically vulnerable young people. Though prior longitudinal research supports that CMC status and depressive symptoms are associated with increased risk for cannabis use (Rhew et al., 2017; Crane et al., 2015; Lazareck et al., 2012), to our knowledge, no existing research has yet examined if the association between depressive symptoms and cannabis vaping differs between young adults with CMCs relative to those without CMCs.

Regarding our final aim, CMC status only moderated the associations between depressive symptoms and cannabis vaping when examining lifetime cannabis vaporizing. Results indicated that depressive symptoms were only a risk factor for cannabis vaporizing among healthy young adults; however, depressive symptoms were unrelated to lifetime cannabis vaporizing for young adults with a CMC. Consistent with the self-medication hypothesis, we 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 use of cannabis for coping; this hypothesis was unsupported. To our knowledge, this is the first study to focus on the moderating effects of CMC status on the association between depressive symptoms and cannabis use. The finding that depressive symptoms were only associated with cannabis vaping in healthy young adults, but not young adults with CMCs, was unexpected. This finding could be explained by other factors such as: 1) Electronic cigarettes and other modes of electronic delivery devices have gained popularity; thus, healthy young adults may have become curious about the product rather than just using the product to self-medicate; 2) There are other motives for cannabis use among college students such as social enhancement, relaxation, experimenting, and enjoyment/fun that may be influencing cannabis use (Lee et al., 2007); and 3) Cannabis use has significantly increased across

time among college students, which could impact patterns of young adult cannabis use observed (Odani et al., 2019; National Institute on Drug Abuse, 2020). Taken together, this suggests that the current study's use of substance use behaviors and not substance use motives (coping or social enhancement, relaxation, experimenting, and enjoyment/fun) as outcomes reduced the ability to draw firm conclusions regarding reasons for cannabis use among those with and without CMCs. Nevertheless, one of the primary motives for cannabis use is the relief of negative mood (Simons et al., 1998). Further, among young adults with a CMC, it is possible that there are more influential predictors of cannabis vaping over and beyond depressive symptoms that were not examined in the present study and warrant additional attention. For example, important medically-related predictors may be general distress/stress associated with medical conditions and/or management of physical symptoms of medical conditions. Future research should assess cannabis use motives and these other potential factors to further elucidate risk factors for cannabis vaping among young adults with and without CMCs.

Importantly, other predictors of cannabis vaping were also identified. The most consistent covariate that was related to cannabis vaping was whether the data were collected during the pandemic. This is consistent with literature suggesting that cannabis use has increased during the pandemic (Bartel et al., 2020; Sznitman et al., 2021), highlighting the need for additional research on substance use changes during the pandemic. On the other hand, this finding may be related to other contextual factors that somewhat coincided with the onset of the pandemic such as increased cannabis legalization across the United States (Borodovosky et al., 2017) and the increase in vape shops since the following medical legalization of cannabis in Oklahoma in 2018, where the current study's population is located.

Additionally, the social construct of race and ethnicity also seem to be important in understanding cannabis vaping. The current study found that individuals who identified as

American Indian were less likely than non-Hispanic, White individuals to currently use electronic nicotine devices to deliver cannabis and to have a lifetime history of cannabis vaporizing. Additionally, individuals who identified as Asian were less likely to have a lifetime history of cannabis vaporizing compared to individuals who identify as non-Hispanic, White. This is in line 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) and suggests that future research should examine promotive factors that may be supporting this reduced risk among American Indian and Asian students. The present study expanded on the Jones et al. study and the extant literature on cannabis vaping by utilizing a sample with more representation of American Indian young adults (6.5% of the sample) and by identifying that American Indian individuals were less likely to vape cannabis. Lastly, consistent with prior research, having a higher income and being male were associated with cannabis vaping among college students (Jones et al., 2016).

Clinical Implications

With the observed associations between having a CMC and/or depressive symptoms and cannabis vaping, intervention and prevention efforts are needed to provide supports for individuals with these conditions. Greater 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). Taken together, 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 mechanisms and reduce cannabis use. Evidence-based interventions for individuals with comorbid cannabis use disorder and depressive symptoms include Cognitive Behavioral Therapy (CBT), Motivational Interviewing, Motivational Enhancement Therapy, and Contingency Management (Lees et al., 2021; Satre et al., 2018). Unfortunately, there is

inadequate access to treatment for college students with substance use or mental health difficulties (Sun, 2020).

Cannabis use screening and intervention is important for medically vulnerable young adults to maximize physical and mental health outcomes across the lifespan (Wisk & Weitzman, 2016). This is critical because 1) current findings and prior research document greater cannabis use among those with a CMC (Dai & Richter, 2019), 2) earlier initiation of cannabis use is associated with increased risk for developing cannabis use disorder (DeWit et al., 2000; Swift et al., 2008; Borodovsky et al., 2017), 3) long-term, heavy cannabis use is associated numerous negative consequences (Fergusson, Horwood, & Swain-Campbell, 2002; Hall et al., 2016; National Academies of Sciences Engineering and Medicine, 2017), and 4) the health effects of vaping cannabis are not well understood (Jones et al., 2016). To date, there is a paucity of research focused on addressing cannabis use specifically among young adults with CMCs; however, integrating cannabis use screening and brief interventions into medical settings has the potential to reduce cannabis use among young adults with and without CMCs (Kansagara et al., 2019; Haller et al., 2009). Cannabis use among young adults and 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 (Kansagara et al., 2019; Halladay et al., 2019; Montemayor et al., 2022). Examples of evidence-based brief interventions for cannabis use among college students and young adults include Screening, Brief Intervention, and Referral to Treatment (SBIRT) protocols (Turner et al., 2020) and Motivational Interviewing-based interventions (Kansagara et al., 2019; Halladay et al., 2019; Montemayor et al., 2022; Gates et al., 2016; Buckner et al., 2021). Further, these interventions could integrate young adult's values surrounding their health to support cannabis use reductions, a technique which may be particularly motivating for those with a CMC.

Importantly, in the current study, when CMC and depressive symptoms were observed together, *healthy* young adults with depressive symptoms (and not young adults with depression and a CMC) were more likely to report lifetime use of cannabis vaporizing. Thus, all individuals that use cannabis, regardless of CMC status, may benefit from the aforementioned evidence-based treatments for comorbid depression and cannabis use; this finding also supports the potential for more universal programs to prevent cannabis use and/or reduce cannabis use among college students by addressing depressive symptoms and healthy coping. Overall, while these clinical implications are important, current findings also suggest it is also critical to tailor clinical interventions to be culturally sensitive and to consider other external factors such as the pandemic when discussing intervention and prevention efforts.

Limitations

Despite its strengths, the present study also has several limitations. First, because data were collected from a predominately female college sample from a midwestern university with inadequate representation of diverse populations (i.e., 75% white), the generalizability of findings to other young adult populations (e.g., non-college students, more diverse young adults) may be limited. While the current study had greater representation of American Indian college students relative to the only other study investigating college student cannabis vaping (Jones et al., 2016), future research should utilize samples with more representation of racially minoritized college students. It is important to note that 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.

In addition, the current study's use of self-reported cannabis use may have led to underreporting of cannabis vaping (Harrison et al., 2007); however, prior research has documented the convergent, concurrent criterion validity, 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). Nevertheless, future research should consider using cannabis use biomarkers to reduce the possibility of underestimating current cannabis use. Notably, it is likely that the current results would be even more pronounced among a sample where cannabis vaping was not potentially underestimated. Moreover, the cross-sectional design limits the ability to draw causal conclusions, including conclusions about support for the self-medication hypothesis; however, given the current paucity of available data on cannabis vaping among college students, the present cross-sectional data provides important preliminary data on the associations between depressive symptoms, CMCs, and cannabis vaping. Future studies should build upon our findings with longitudinal data to explore how these constructs relate to each other over time.

Finally, the present study investigated support for the self-medication hypothesis by assessing associations between depressive symptoms and cannabis vaping, and CMC and cannabis vaping, hypothesizing that positive associations provided support for self-medication; this methodology is supported in the extant literature (Wilkinson et al., 2016; Womack et al., 2016; Hooshmand et al., 2012; Bolanis et al., 2020). However, this study did not directly measure participant motives for cannabis use (i.e., coping motives versus other motives such as socializing) or if participants used cannabis recreationally or medicinally (and if medicinally, for

what diagnosis); the omission of these variables limits conclusions that can be drawn about if participants were using cannabis to ameliorate depressive symptoms or distress associated with having a CMC.

Although the current study did not assess whether cannabis use was recreational or medicinal, it is important to consider because medicinal use is legal in Oklahoma (where data were collected) and there is not a list of qualifying medical conditions to be prescribed medical marijuana (The Oklahoman, 2018). Thus, 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) though mental health difficulties are some of the most commonly reported reasons for using of medical marijuana (Walsh et al., 2013; Walsh et al., 2017), there is insufficient evidence to support a therapeutic effect for mental health symptoms (Hill, 2015; National Academies of Sciences Engineering and Medicine, 2017; Cousijn et al., 2018; Whiting et al., 2015). Overall, 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. Future research should directly assess cannabis use motives and examine if the use of medical versus recreational cannabis impacts findings, including examinations of how having medical cannabis prescribed for depression may impact findings.

Conclusions

Overall, the present 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 supporting young adults' use of cannabis to reduce depressive

symptoms (Khantzian, 1985; Khantzian, 1997;Wilkinson et al., 2016; Womack et al., 2016; Hooshmand et al., 2012; Bolanis et al., 2020); that having a CMC was only associated with cannabis vaping in one model; and that depressive symptoms may only be a risk factor for cannabis vaporizing among healthy young adults. Taken together**,** these findings suggest the need for prevention and intervention efforts 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 young adults and 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 (Kansagara et al., 2019; Halladay et al., 2019; Montemayor et al., 2022).

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APPENDICES

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)
Race/Ethnicity	
Caucasian	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%)

Notes: N's ranged due to missing data

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 Status	-.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

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.

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.

VITA

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