2019

A Longitudinal Investigation of Interpersonal Trauma Exposure, Posttraumatic Stress Disorder, and Cannabis Use Phenotypes among College Students

Terrell A. Hicks

A Longitudinal Investigation of Interpersonal Trauma Exposure, Posttraumatic Stress Disorder, and Cannabis Use Phenotypes among College Students

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University

By: Terrell Alexander Hicks

Bachelor of Science, University of North Carolina at Chapel Hill, 2014

Direction: Ananda B. Amstadter, Ph.D.

Associate Professor

Departments of Psychiatry, Psychology, and Human and Molecular Genetics

Virginia Commonwealth University

Richmond, VA

Thursday, November 21, 2019

Table of Contents

Abstract

College students have an increased risk for cannabis use, trauma exposure, and posttraumatic stress disorder (PTSD). Cannabis use disorder (CUD) and PTSD comorbidity is high, and given the negative consequences of the comorbidity (e.g., poor academic outcomes), there is a need to understand comorbid CUD-PTSD etiology. Two primary etiologic models exist: self-medication (i.e., PTSD → CUD) and high-risk (i.e., CUD → PTSD) hypotheses. This study 1) examined the prevalence and predictors of cannabis use and interpersonal trauma (IPT) exposure; 2) investigated the relationship between cannabis use and IPT; and 3) examined cannabis use, IPT, and PTSD through mediational self-medication and high-risk hypotheses lenses in a large (n = 9,889) longitudinal study of college students. Aim 1 found the prevalence of lifetime problematic (i.e., use ≥ 6 times) and experimental (i.e., use 1-5 times) cannabis use was 28.3% and 17.4%, respectively. Aim 1 results also estimated that the prevalence of lifetime IPT exposure was 35.9%. Aim 2 results supported the self-medication hypothesis, but not the high-risk hypothesis. Overall model fit from Aim 3 was poor. Nonetheless, Aim 3 results did not support the self-medication or high-risk hypotheses. Given the poor model fit of Aim 3, results should be interpreted with caution. However, as a whole, these findings provide preliminary support for the self-medication hypothesis, indicating that those reporting IPT exposure and probable PTSD may be at risk for cannabis use. Implications of these findings, in light of study limitations, are discussed.

Keywords: cannabis, substance use, trauma, interpersonal trauma, posttraumatic stress disorder

Statement of the Problem

Public support for the legalization of cannabis is increasing (Kilmer & MacCoun, 2017), which may be contributing to the high prevalence of use. Indeed, cannabis is the currently most widely used illicit substance in the United States (U.S.) (Substance Abuse and Mental Health Services Administration, 2016). Cannabis use and cannabis use disorder (CUD) are common in the general population, and among college students (Hasin et al., 2016; Johnston, O'Malley, Bachman, Schulenberg, & Miech, 2016). Of concern, cannabis use is higher among college students than their same-age, non-college peers (Johnston et al., 2016). Most long-term adverse effects of cannabis use are more likely among heavy or chronic users, but short-term adverse effects can affect anyone regardless of frequency of use (Hall & Degenhardt, 2009; Kalant, 2004). Functional short-term consequences of cannabis use include neurocognitive impairment (i.e., problems with psychomotor function, attention, memory, and learning), which can negatively affect the large number of individuals who use cannabis occasionally or moderately. Thus, the identification of etiological factors associated with cannabis use and CUD, particularly among high-risk populations such as college students, are needed to inform prevention and intervention programming.

Two key potential factors associated with cannabis use that warrant increased study are trauma exposure and posttraumatic stress disorder (PTSD), both of which are common among college students (Netto et al., 2013; Read, Ouimette, White, Colder, & Farrow, 2011; Scarpa et al., 2002; Vrana & Lauterbach, 1994). In addition, college students are also at higher risk for certain types of traumatic events that have a high likelihood of leading to PTSD, such as interpersonal trauma (IPT) (Anders, Frazier, & Shallcross, 2012; Anders, Shallcross, & Frazier, 2012; Edwards, Catling, & Parry, 2016). Epidemiological and acute trauma studies suggest that

trauma exposure and PTSD are associated with cannabis use and CUD and that PTSD and CUD frequently co-occur (Cougle, Bonn-Miller, Vujanovic, Zvolensky, & Hawkins, 2011; Kevorkian et al., 2015; Vlahov et al., 2002).

There are numerous phenotypic models posited to explain comorbid PTSD and CUD. Co-occurrence of these two conditions may begin when a person attempts to self-medicate their PTSD symptoms (Chilcoat & Breslau, 1998), or CUD could lead to PTSD if the person experiences trauma caused by their cannabis use (Chilcoat & Breslau, 1998), like a car accident or physical violence. There is a need for empirical investigation of these models explaining comorbid PTSD and CUD particularly as public support for the legalization of cannabis is increasing (Kilmer & MacCoun, 2017), which may further increase cannabis use.

The increasing prevalence of cannabis use and its adverse health effects combined with an increased risk for trauma exposure among college students makes the intersection of CUD and PTSD an area in need of future research. Indeed, etiologic models of CUD and PTSD have not been fully elucidated. Limited epidemiological studies are available on the association between CUD and PTSD specifically, as most studies have examined the co-occurrence of PTSD and other substance use disorders such as alcohol use disorder or tobacco use disorder (Debell et al., 2014; Fu et al., 2007). Even fewer have examined the association between cannabis use and post-trauma phenotypes longitudinally which will allow for testing of direction of causation between these conditions.

Literature Review

Prevalence of Cannabis Use Phenotypes

Cannabis has been the most commonly used illicit substance in the U.S. for several decades (Johnston, O'Malley, Bachman, & Schulenberg, 2006; Rouse, Sanderson, & Feldmann,

2002). According to the U.S. National Survey on Drug Use and Health (NSDUH) 2015 annual report, the lifetime prevalence of cannabis use was 44% (approximately 117.9 million people) and cannabis use in the past month increased from 6.2% in 2002 to 8.3% (approximately 22.2 million people) in 2015 among people aged 12 or older (Substance Abuse and Mental Health Services Administration, 2016). Research suggests that about 10% of those who ever use cannabis become daily users, and about 20% to 30% become weekly users (Hall & Pacula, 2003). Individuals who use cannabis weekly or more have an increased risk for developing a substance use disorder (SUD) than experimental users (Swift, Coffey, Carlin, Degenhardt, & Patton, 2008).

While the majority of cannabis use remains recreational, a notable number of individuals go on to develop CUD, a disorder characterized by the harmful consequences of repeated cannabis use, a pattern of compulsive cannabis use, and in some cases physiological dependence on cannabis (i.e., tolerance and/or symptoms of withdrawal) (American Psychiatric Association, 2013). CUD is only diagnosed when cannabis use becomes persistent and causes significant academic, occupational or social impairment. CUD in Diagnostic and Statistical Manual of Mental Disorders (DSM-5) combines the DSM-IV categories of cannabis abuse and dependence into a single disorder measured on a continuum from mild to severe. In addition to the DSM-IV abuse and dependence diagnoses being combined into a singular diagnosis for DSM-5 CUD, the symptom of recurrent legal problems has been removed, and the symptom of craving or a desire or urge to use cannabis has been added. Given the numerous changes in criteria, comparing prevalence of CUD to the prior abuse and dependence diagnoses is difficult. For example, whereas a diagnosis of DSM-IV cannabis abuse previously required only one symptom, mild cannabis use in DSM-5 requires two to three symptoms from a list of 11. Therefore, it is

currently more difficult to reach the threshold for DSM-5 CUD than DSM-IV. A study published using the National Epidemiological Survey on Alcohol and Related Conditions (NESARC) data in 2011 estimated an 8.9% cumulative probability of developing lifetime cannabis dependence based on DSM-IV criteria for substance dependence among individuals who reported any history of cannabis use (Lopez-Quintero et al., 2011). In an epidemiological study estimating the prevalence of DSM-IV cannabis abuse and dependence among a large nationally representative sample of U.S. adults, Stinson and colleagues (2006) found the prevalence of lifetime (8.5%) and 12-month (1.5%) CUD (i.e., abuse or dependence). More specifically, the prevalence of 12-month (1.1%) and lifetime (7.2%) DSM-IV cannabis abuse surpassed the rates of 12-month (0.3%) and lifetime (1.3%) cannabis dependence (Stinson et al., 2006).

Multiple lines of evidence support the conclusion that cannabis use is on the rise. One study analyzed Veteran Administration medical record data and found an increase of about 50% in CUD with co-occurring SUDs from 2002 to 2009 and an increase of 115% in CUD without other SUDs during the same time period (Bonn-Miller, Harris, & Trafton, 2012). Using data on illicit substances involved with fatally injured motor vehicle accidents in U.S. emergency hospital visits from 2004 to 2011, researchers found a 62% increase in cannabis use (Brady & Li, 2014). Additionally, another study analyzing cannabis metabolites of individuals with the Fatality Analysis Reporting System from 1999 to 2010 reported a 200% increase in cannabis use (Drug Abuse Warning Network, 2011). Analyzing data collected from three cross-sectional adult surveys (e.g., the 1991-1992 National Longitudinal Alcohol Epidemiologic Survey, the 2001-2002 NESARC, 2012-2013 NESARC–III), Hasin and colleagues (2017) concluded that states that allow medicinal cannabis use have an increased risk for cannabis use and CUD. Additionally, rates of cannabis use and CUD are increasing at a significantly greater rate in states

that allow medicinal cannabis use than in states that do not (Hasin et al., 2017). Given the high prevalence of cannabis use in the U.S. population, it is critical to examine factors that are related to use and the transition from use to problematic use (e.g., daily, weekly, or heavy use; CUD) in order to inform effective prevention and intervention programming.

Sex and Cannabis Use Phenotypes

Generally, extant studies suggest that men are more likely to use cannabis than women, and the differences tend to be most stark at higher frequency levels. Based on a longitudinal nationally representative sample of high school graduates in the U.S. from 1975 to 2015, the sex gap has averaged about 5 to 9 percentage points for 19- to 30-year olds since 1995 (Johnston et al., 2016). Additionally, daily cannabis use levels were more than twice as high for men than women (8.1% versus 3.8%) in 2015 (Johnston et al., 2016). The NSDUH found that the prevalence of past-year cannabis use increased for both men (+4.0%) and women (+2.7%) from 2002 to 2014 (Carliner et al., 2017). Increases were greater for men (+4.4%) than women (+2.7%) between 2007 and 2014, leading to a widening of the sex gap over time (Carliner et al., 2017). Both the growing positive public perception and increasing rates of cannabis use likely play a role in cannabis being the drug with the highest rate of problematic use regardless of sex in the U.S. (Substance Abuse and Mental Health Services Administration, 2016).

Similar to cannabis use, patterns of CUD mirror those of past-year and daily cannabis use in terms of sex. Based on results from the 2001-2002 NESARC, the prevalence of lifetime CUD was higher in men (11%) than women (5%) (Khan et al., 2013). Additionally, men were using at higher quantities per day compared to women (3.38 versus 2.54 joints per day) and the average duration of the longest episode of CUD was higher in men compared to women (40.43 versus 31.01 weeks) (Khan et al., 2013). Findings from the 2012-2013 NESARC-III were comparable

to results from the 2001-2002 NESARC, which suggests that the sex gap is not widening in terms of CUD as it is with past-year cannabis use (Hasin et al., 2016). Men were 2.2 times more likely than women to meet DSM-5 criteria for any severity of past 12-month CUD. Additionally, men were 2.8 times more likely to meet DSM-5 criteria for past 12-month severe CUD than were women, 1.8 times more likely for moderate CUD, and 2.2 times more likely for mild CUD (Hasin et al., 2016). Men were 2.1 times more likely than women to meet DSM-5 criteria for lifetime CUD. Additionally, men were 2.4 times more likely to meet DSM-5 criteria for lifetime severe CUD than were women, 2.1 time more likely for moderate CUD, and 1.9 times more likely for mild CUD (Hasin et al., 2016). Collectively, these findings suggest that there may be sex-specific pathways that influence the initiation of cannabis use and the development of CUD. Thus, it is important to consider sex-specific patterns of cannabis use and CUD in future research. Similar to sex, race and ethnicity are other un-modifiable factors that contribute to an individual's risk for cannabis use and CUD.

Race, Ethnicity, and Cannabis Use Phenotypes

Generally, research shows that African-American and Hispanic individuals are more likely to use cannabis than other racial/ethnic groups (Pacek, Malcolm, & Martins, 2012; Warner, 2016). All racial/ethnic groups saw an increase in cannabis use across the 2001-2002 NESARC and 2012-2013 NESARC-III, but the difference was higher for certain groups (Hasin et al., 2015). Specifically, significant increases in cannabis use were seen among Caucasian (4.1% versus 9.4%), African-American (4.7% versus 12.7%), Native American (7.0% versus 17.1%), and Hispanic (3.3% versus 8.4%) individuals (Hasin et al., 2015). Trends in cannabis use from 1999-2013 among a national sample of U.S. high school students mirror national prevalence estimates for adults (Johnson et al., 2015). By 2013, four of the seven racial/ethnic

groups had a prevalence of current cannabis use that exceeded 25%: African-American (29%), Hispanic (28%), American-Indian (36%) and Multi-Racial individuals (29%), whereas the prevalence of use was lower among Caucasian individuals (22%) and Asian-American Individuals (11%) (Johnson et al., 2015). Similar to cannabis use, the rates of past 12-month DSM-IV CUDs increased among African-American (1.8% versus 4.6%) and Hispanic (1.2% versus 2.8%) individuals (Hasin et al., 2015). Higher levels of cannabis use among African-American, Hispanic, and American-Indian individuals deserve public health attention because these groups are more likely than Caucasian individuals to experience negative consequences of cannabis use, including CUD and negative psychosocial outcomes (Edwards, Bunting, & Garcia, 2015). Thus, it is important to consider both racial- and ethnic-specific patterns of cannabis use and CUD in future research.

Age and Cannabis Use Phenotypes

Generally, research shows that individuals between the ages of 18- and 25-years old are more likely to use cannabis compared to older adults (Suerken et al., 2014). Based on results from the 2012-2013 NESARC, the prevalence of past-year cannabis use was highest among 18- to 29-year olds (21%) and decreased with age (30- to 34-year olds (10%), 45- to 64-year olds (6%), 65-year olds and older (1%) (Hasin et al., 2015). Similarly, according to the 2015 NSDUH, cannabis use is most prevalent among young individuals ages 18- to 25-years old, with an estimated 19.8% using in the past month (Center for Behavioral Health Statistics and Quality, 2014). Not surprisingly, estimated prevalence of CUD among age groups follows a similar pattern as cannabis use. Based on results from the 2012-2013 NESARC, the prevalence of DSM-IV past-year CUDs (e.g., abuse or dependence) was highest among 18- to 29-year olds (7.5%) and decreased with age (30- to 34-year olds (2.9%), 45- to 64-year olds (1.3%), 65-year olds and

older (0.3%)) (Hasin et al., 2015). Despite DSM-5 no longer distinguishing between DSM-IV cannabis abuse and dependence, the list of DSM-5 CUD symptoms are nearly identical to DSM-IV cannabis abuse and dependence. Therefore, rates of CUD remain relatively similar across the two diagnostic rubrics. According to the 2012-2013 NESARC adjusted for DSM-5 criteria, 6.9% and 11% of 18- to 29-year olds, 2.5% and 7.4% of 30- to 44-year olds, 0.8% and 3.7% of 45-year olds and older met DSM-5 criteria for 12-month CUDs (mild, moderate, or severe) and lifetime CUD, respectively (Hasin et al., 2016). In summary, recent epidemiologic studies show that young adults were found to be at highest risk for cannabis use and CUD when examined by age, and also suggest that the average age of onset is around the same timeframe.

Based on two epidemiological studies (Hasin et al., 2016; Stinson et al., 2006), the average age of onset for CUD appears to be during young adulthood. The average ages of onset for DSM-IV cannabis abuse and dependence were 19.3-years old and 19.0-years old, respectively (Stinson et al., 2006). Based on the 2012-2013 NESARC, the average age at onset of DSM-5 CUD was 21.7 years-old (Hasin et al., 2016). Thus, the estimated average age of onset of CUDs overlaps with an important developmental period for most individuals—college. College students have become an important population to study in order to prevent public health problems, especially drug use, because of its size (estimated 20.4 million students in American colleges and universities in Fall 2017) and critical age range (average age range of 18- to 24-years old) (National Center for Education Statistics & US Department of Education, 2016). Approximately one-third of young adults between the ages of 18- and 24-years old are enrolled in post-secondary education (National Center for Education Statistics & US Department of Education, 2016). The college years represent a particularly important developmental phase. Most students are away from home for the first time without parental supervision and are trying

to adjust, socialize, and fit in. In addition to adjusting to being away from home, students are attending parties with alcohol and other illegal substances, which makes college a potentially dangerous period. Therefore, college students are more vulnerable to new, sometimes prohibited or illicit, experiences (Leibsohn, 1994; Walsh, 1992). A number of epidemiologic studies suggest that the prevalence of CUD is highest among young adults (Center for Behavioral Health Statistics and Quality, 2014; Hasin et al., 2016; Hasin et al., 2015; Suerken et al., 2014), and also suggest that the age of onset of CUD is in young adulthood (Hasin et al., 2016). Thus, it is critical to consider age-specific patterns of cannabis use and CUD in future research as well as study cannabis use and CUD among college students and how changes in their environment influence use.

Cannabis Use Phenotypes among College Students. Postsecondary education has become all but required for a well-paying career in today's economy and, as a result, college enrollment rates are skyrocketing. Between 2000 and 2015, the 18- to 24-year-old population rose from approximately 27.3 million to nearly 31.2 million (National Center for Education Statistics & US Department of Education, 2016). Likewise, the estimated number of 18- to 24-year olds enrolled in college also rose from approximately 15.3 million to nearly 19.9 million between 2000 and 2015 (National Center for Education Statistics & US Department of Education, 2016). In a sample of 3,146 college students from 11 colleges and universities in North Carolina and Virginia, nearly 30% of students reported using cannabis prior to enrolling in college (Suerken et al., 2014). Suerken and colleagues (2014) also found that 8.5% of college students who did not use cannabis prior to starting college initiated use during freshman year. As of 2016, the Monitoring the Future survey results revealed that 1 in 5 college students will become first-time users of cannabis during their time in college (Johnston et al., 2016). Although

students who attend college are less likely to use cannabis prior to graduating from high school than their peers who do not attend college, the prevalence of cannabis use among young adults attending college is increasing at a higher rate than the prevalence of cannabis use among their counterparts who do not attend college (Johnston et al., 2016; White, Labouvie, & Papadaratsakis, 2005). Past-year cannabis use was 51% higher among college students than their same-age, non-college peers in 2015, 41% in 2014, and 31% in 2013 (Johnston et al., 2016). The National Survey Results on Drug Use from 1975-2015 reported that perceived availability of cannabis is higher among 12th graders through 27- to 30-year-olds versus 35- to 55-year-olds (81-87% versus 69-80%), which could play a role in why cannabis is currently the most commonly used illicit drug among college students (Blavos et al., 2017; Johnston et al., 2016; Suerken et al., 2014).

Trends in cannabis use among college students mirror trends in the general population. The National Survey Results on Drug Use from 1975-2015 also found that cannabis use is higher among college males than females (40% versus 33%) and college males are three times as likely to report daily cannabis use compared to females (8.7% versus 3.9%) (Johnston et al., 2016). Among a random sample of first-year college students from two large public universities, 65.1% of students who reported cannabis use in the past month also reported alcohol use during that time period and 23.2% of males and 8.5% of females reported using both substances on the same day (Whitehill, Rivara, & Moreno, 2014). Concurrent use of cannabis and alcohol is one of the most common forms of polydrug mix among college students and one of the best predictors of both substances use is peer use (Windle, Haardorfer, Lloyd, Foster, & Berg, 2017). Since cannabis use phenotypes are often comorbid with other substance use phenotypes (e.g., nicotine and alcohol; i.e., polysubstance use) those are key variables to control for in future cannabis use

research. The strong association between peer use and cannabis use among college students may be due to greater personal autonomy, different living circumstances, a new and larger socialization network, increasing legalization in some states, and perceived easier access to substances (Windle & Zucker, 2010). Thus, it is important to examine potentially modifiable variables (i.e., other substance use, peer substance use, social network, coping strategies) associated with increased risk for cannabis use. College may be a period of increased risk for exposure to problematic cannabis use, but it is also a time of increased risk to trauma exposure, which both can contribute to the development of cannabis use phenotypes among college students.

Summary: Correlates of Cannabis Use Phenotypes

In summary, cannabis is the most commonly used illicit drug (Johnston et al., 2006; Rouse et al., 2002). Those in the general population between the ages of 18- and 29-years old have been shown to be at high risk for this type of substance misuse, with usage rates of 21% (Hasin et al., 2015). Race and ethnicity, sex, and year-in-school have often been cited as covariates in cannabis use and CUD literature. However, there continues to be a lack of consensus on rates and motivations based on these demographics. Thus, it is important to consider age-, sex-, racial-, and ethnic-specific patterns of cannabis use and CUD in future cannabis research in order to give clarity to these discrepancies. It is also important to control for other substance use phenotypes (e.g., nicotine and alcohol) that are commonly used with cannabis in further cannabis research. In addition to age, sex, race, and ethnicity as established risk factors for cannabis use, there are also associations between trauma-related factors (i.e., trauma exposure and PTSD) and cannabis phenotypes (i.e., cannabis use and CUD).

Prevalence and Correlates of Trauma Exposure and PTSD

According to the American Psychiatric Association's (APA) DSM-5 (2013), a traumatic event is defined as "exposure to actual or threatened death, serious injury, or sexual violence," which includes, but is not limited to, sexual abuse, physical abuse, domestic violence, community and school violence, suicides, and other traumatic losses. Trauma exposure is universally common among all populations. Twenty-four countries across six continents assessed trauma exposure with a list of 29 types of traumatic events among a sample of 68,894 adults and over 70% of respondents reported exposure to at least one traumatic event and 30.5% reported exposure to four or more traumatic events (Benjet et al., 2016). The U.S. had the third highest prevalence of trauma exposure (82.7%) of all countries included in the study (Benjet et al., 2016). Consistently, in a representative sample of U.S. adults, most respondents (89.7%) reported exposure to at least one DSM-5 PTSD Criterion A traumatic event (Kilpatrick et al., 2013).

Sociodemographic predictors of trauma exposure include sex, race, ethnicity, and age. Women are more likely than men to be exposed to intimate partner or sexual violence, but men are more likely than women to experience all other types of traumatic events such as interpersonal violence (i.e., human-perpetrated violence) or being mugged with a weapon (Benjet et al., 2016). Similar to sex, racial/ethnic group differences in risk for exposure to traumatic events has been shown to vary by type of event. Based on a large, representative sample of U.S. adults, Roberts and colleagues (2011) found that Caucasian individuals were more likely than other racial/ethnic groups to be exposed to any traumatic event, but African-American and Hispanic individuals were more likely than Caucasian individuals to be exposed to childhood trauma and witnessing domestic violence, and African-American, Hispanic, and Asian-American individuals had a higher risk of war-related trauma exposure than Caucasian individuals.

Regarding cohort effects, individuals below the age of 65-years old are more likely to experience interpersonal violence, sexual violence, accidents, injuries, unexpected death of a loved one, and being mugged, but this increased risk decreases with age (Benjet et al., 2016). Being a college student was specifically associated with an increased risk for most types of trauma exposure unrelated to collective violence, having a life-threatening illness, and having a child with a serious illness suggesting something unique about the developmental period of college (Benjet et al., 2016).

Exposure to a traumatic event is a criterion for a diagnosis of PTSD. PTSD is a disorder characterized by the following primary symptom areas: exposure to a traumatic event, intrusion or re-experiencing (i.e., recurrent recollections of the event), fear or avoidance behaviors, changes in mood and cognition (i.e., negative alterations in emotions or thoughts), arousal and hyper-reactivity (i.e., agitation, state of constant wakefulness and alertness) (American Psychiatric Association, 2013). PTSD is only diagnosed when the symptoms last more than a month, seriously affect an individual's ability to function, and are not due to substance use, medical illness, or anything except the event itself. According to a systematic review of 35 studies investigating PTSD prevalence and trajectories in trauma exposed populations, an estimated 25.4% of those exposed to a traumatic event go on to meet DSM-5 criteria for PTSD one month post-trauma (Santiago et al., 2013). PTSD prevalence rates decrease to 18.8% three months post-trauma and remain steady at twelve months post-trauma (17.7%) (Santiago et al., 2013). The National Comorbidity Survey – Replication (NCS-R) estimated the prevalence rate of lifetime PTSD based on the DSM-IV diagnostic criteria to be about 6.8% among a nationally representative sample of U.S. adults (Kessler, Berglund, et al., 2005). The National Epidemiologic Survey on Alcohol and Related Conditions documented similar estimates of

DSM-IV lifetime PTSD (6.4%) among a representative sample of U.S. adults (Pietrzak, Goldstein, Southwick, & Grant, 2011). PTSD in DSM-5 differs significantly from DSM-IV. The stressor criterion is more explicit with regard to what classifies as a traumatic event. Also, the subjective reaction of needing to feel intense fear, helplessness, or horror during the traumatic event has been removed. The three major symptom clusters in DSM-IV (e.g., reexperiencing, avoidance/numbing, and arousal) are now four symptom clusters in DSM-5. The DSM-IV avoidance/numbing cluster is divided into two distinct clusters in the DSM-5: avoidance and negative alterations in cognitions and mood. Negative alterations in cognitions and mood retained most of the DSM-IV numbing symptoms, but also includes new symptoms, such as persistent negative emotional states. Lastly, alterations in arousal and hyper-reactivity retains most of the DSM-IV arousal symptoms, but also includes irritable or aggressive behavior and reckless or self-destructive behavior. Despite these major revisions to what qualifies for a diagnosis of PTSD, the prevalence rates remain relatively similar across the DSM-IV and DSM-5. More recently, results from the National Stressful Events Survey documented similar estimates of DSM-IV lifetime PTSD (10.6%) and DSM-5 lifetime PTSD (9.4%), which sampled a demographically and geographically representative group of U.S. adults (Kilpatrick et al., 2013).

Many factors play a part in whether an individual will develop PTSD after experiencing a traumatic event. In a meta-analysis across 77 studies examining risk factors for PTSD in trauma-exposed adults, Brewin and colleagues (2000) found pre-trauma (e.g., sex, race, low socioeconomic status), peri-trauma (e.g., trauma severity), and post-trauma (e.g., low social support, subsequent life stress) factors that were associated with a greater likelihood of developing PTSD. Although women are less likely than men to be exposed to a traumatic event,

women have a two to three times higher risk of developing PTSD compared to men (Olff, 2017). The lifetime prevalence of PTSD ranges from 10–12% in women and 5–6% in men (Olff, 2017). Racial/ethnic differences in PTSD have been investigated and Roberts and colleagues (2011) found that the lifetime prevalence of PTSD was highest among African-American individuals (8.7%), intermediate among Caucasian and Hispanic individuals (7.4% and 7.0%), and lowest among Asian-American Individuals (4.0%). Regarding age as a pre-trauma vulnerability factor for PTSD, the NCS-R found that individuals aged 18- to 29-years old had the highest odds of a lifetime risk for PTSD compared to 30- to 44-year olds and 45- to 59-year olds (Kessler, Berglund, et al., 2005). College students are in that critical age range for an increased risk for PTSD and constitute a sizeable cohort of the U.S. population. These pre-trauma characteristic differences are attributed to a variety of cultural, socioeconomic, and cohort phenomena.

Psychosocial factors, in addition to demographic variables, contribute to PTSD risk. A meta-analysis across 68 studies examining predictors of PTSD and symptoms in adults found that risk factors for developing PTSD besides low social support had a stronger effect if the index trauma was noncombat interpersonal violence (Ozer, Best, Lipsey, & Weiss, 2003). Similarly, Frans and colleagues (2005) examined the lifetime prevalence of traumatic experiences and PTSD and found that the highest risk for developing PTSD was associated with IPT (i.e., sexual and physical assault), robbery, and multiple trauma experiences. Recently, Kilpatrick and colleagues (2013) also found that the prevalence of PTSD was highest among victims of IPT and combat. Consistent evidence supports IPT being more likely to lead to PTSD than accidental trauma. Ozer and colleagues (2003) also found that low perceived social support following a traumatic event was associated with greater development of PTSD. According to Brewin and colleagues (2000), lack of social support and more subsequent life stress were two of

the three peri- and post-trauma factors that convey the strongest risk of PTSD. Given the knowledge on pre- peri- and post-trauma risk factors, it is important to investigate trauma exposure and PTSD in high risk subpopulations (i.e., college students) in order to better understand the negative effects both acutely and in the longer-term.

Trauma Exposure and PTSD among College Students. Trauma exposure is common among young adults, and exposure in young adults in a college environment is of particular concern. Estimates of the prevalence of exposure to traumatic events among college students have been as high as 84% (Scarpa et al., 2002; Vrana & Lauterbach, 1994). More recently, preliminary results from Spit for Science, an ongoing representative study of college students used for the current study, found a similarly high prevalence rate of exposure to traumatic events (82%) (Overstreet, Berenz, Kendler, Dick, & Amstadter, 2017). Additionally, 39% of college students reported a lifetime prevalence of experiencing an interpersonal traumatic event, which is more likely to lead to PTSD than accidental trauma. Using a more conservative definition of a traumatic event, Read and colleagues (2011) found the prevalence of DSM-IV criterion A trauma exposure among newly matriculated college students to be slightly lower (66%) than exposure to traumatic events. More specifically, 23% reported exposure to one traumatic event, 20% reported two events, and 25% reported three or more events. In a sample of college students, 67% of participants reported experiencing at least one traumatic event based on DSM-5 PTSD's criteria and 59% of participants met criteria for DSM-5 PTSD (Elhai et al., 2012). Notably, rates of occurrence of trauma exposure have been shown to peak sharply between ages 16- to 20-years old, which overlaps with the ages of the average college population (Breslau et al., 1998). Therefore, college students are at an increased risk for trauma exposure and PTSD than the general population across the lifespan.

Lifetime estimates of DSM-IV and DSM-5 PTSD in the general population are as high as 10% (Kilpatrick et al., 2013). Similar to how college students have an increased risk for trauma exposure compared to other age groups, they also have an increased risk for developing PTSD. A limited number of recent studies have examined the prevalence of trauma exposure and PTSD in college students, estimating rates of PTSD to be in the range of 8%–15% (Frazier et al., 2009; Netto et al., 2013; Read et al., 2011; Smyth, Hockemeyer, Heron, Wonderlich, & Pennebaker, 2008; Watson & Haynes, 2007). Studies suggest that college students are at an increased risk for developing PTSD, but these studies have been limited by a focus on PTSD in only women (Watson & Haynes, 2007), small sample sizes (Smyth et al., 2008), or a cross-sectional study design (Frazier et al., 2009; Netto et al., 2013), and so onset or causality cannot be determined.

PTSD and SUD Comorbidity

Although trauma is most closely associated with PTSD, trauma is a transdiagnostic risk factor for a variety of conditions, including SUDs. PTSD and SUD comorbidity is common with estimated prevalence rates of PTSD among individuals with SUD ranging from 25% to 45% or almost three to five times more likely than in the general population (Dore, Mills, Murray, Teesson, & Farrugia, 2012; Dragan & Lis-Turlejska, 2007; Gielen, Havermans, Tekelenburg, & Jansen, 2012; Reynolds, Hinchliffe, Asamoah, & Kouimtsidis, 2011). Individuals with comorbid PTSD and SUD have an increased risk for more severe symptoms (Peirce, Kindbom, Waesche, Yuscavage, & Brooner, 2008), other psychiatric problems (i.e., depression, anxiety) (Pietrzak et al., 2011), suicidality (Pietrzak et al., 2011), morbidity and mortality (Bohnert et al., 2013; Possemato, Wade, Andersen, & Ouimette, 2010), unemployment (Najavits & Hien, 2013), and social impairment (Najavits & Hien, 2013). Additionally, the comorbidity is economically burdensome on the healthcare system, as it results in increased service use (Bowe & Rosenheck,

2015) and worse treatment prognosis (Mills, Lynskey, Teesson, Ross, & Darke, 2005). A majority of comorbid PTSD and SUD studies have focused on alcohol, the most commonly co-occurring SUD comorbid with PTSD (Debell et al., 2014), and nicotine (Fu et al., 2007). However, the literature is much more limited in studies on PTSD and SUD comorbidity that have focused on cannabis use and CUD specifically.

Trauma Exposure, PTSD, and Cannabis Use Phenotypes

Although the literature on trauma, PTSD, cannabis, and CUD comorbidity is smaller than that of other substances, there is evidence of associations between these phenotypes found across multiple study designs: acute increases post-trauma (Vlahov et al., 2002), community (Buckner, Joiner, Schmidt, & Zvolensky, 2012), clinical (Bonn-Miller et al., 2012; Compton, Simmons, Weiss, & West, 2011), and epidemiologic (Agosti, Nunes, & Levin, 2002; Kilpatrick et al., 2000).

In a study examining the acute effects of the September 11, 2001 terrorist attacks among Manhattan, New York residents, Vlahov and colleagues (2002) saw a 29% increase in substance use (i.e., alcohol, nicotine, cannabis) 5-8 weeks after the attack. Specifically, 3.2% of local residents reported an increase in cannabis use during the acute post-disaster period (Vlahov et al., 2002). Additionally, an increase in cannabis use was associated with an increased likelihood of developing PTSD compared to no use or no increase (36.0% versus 6.6%) (Vlahov et al., 2002). Results suggest that cannabis use increases after acute trauma exposure, but research in a more representative sample is required to investigate the relationship between trauma exposure and cannabis use more broadly.

The NCS-R is one of the few epidemiologic studies that examined co-occurring trauma and substance use phenotypes (Kessler, Chiu, Demler, Merikangas, & Walters, 2005). However,

one limitation of the NCS-R is that the results were not specific to cannabis use phenotypes, and were instead focused on substance use broadly in relation to PTSD. This study found that a diagnosis of DSM-IV PTSD was significantly related to a diagnosis of a DSM-IV substance use disorder (e.g., alcohol or drug) (Kessler, Chiu, et al., 2005). In another epidemiologic study, Kevorkian and colleagues (2015) examined the relationship between trauma exposure, PTSD, and cannabis use phenotypes and found that a lifetime history trauma exposure was associated with a 1.2 increased likelihood of lifetime cannabis use. Additionally, among those endorsing lifetime trauma exposure and cannabis use lifetime PTSD was associated with a 1.2 increased likelihood of CUD. In a large representative sample of U.S. adults who reported data on current and lifetime psychiatric diagnoses and answered questions related to lifetime and current cannabis use from the NCS-R, Cougle and colleagues (2011) found that lifetime PTSD was associated with greater odds of lifetime, past-year, and daily cannabis use above and beyond demographic and psychiatric correlates, such as sex, ethnicity, age, and trauma load. Specifically, individuals with a lifetime and past-year PTSD were 3.3 and 3.4 times more likely to have lifetime cannabis use, respectively (Cougle et al., 2011). Interestingly, Cougle and colleagues (2011) also found that 50.4% of individuals with both a lifetime PTSD diagnosis and lifetime cannabis use reported that their PTSD onset preceded or occurred at the same time as the first time they used cannabis. These results suggest a potentially causal relationship between trauma and cannabis phenotypes. However, this relationship has primarily been studied in cross-sectional epidemiological studies. Given the greater than chance relationship between post-trauma psychopathology and cannabis use phenotypes, smaller clinical samples have been studied to examine the co-occurrence more closely.

In a sample of veterans receiving care in the Veterans Affairs Health Care System, Bonn-Miller and colleagues (2012) found that the prevalence of CUD diagnoses have increased from 0.66% to 1.05% between 2002 and 2009, which is more than a 50% increase over 7 years. Additionally, the prevalence of patients with a CUD diagnosis but no other illicit SUD diagnosis increased from 0.27% to 0.58% between 2002 and 2009, which is more than a 115.41% increase during the same time period. Of those individuals with a CUD, but no other illicit SUD diagnosis, 23%, 27%, and 29% also met diagnostic criteria for PTSD in 2002, 2008, and 2009, respectively. Results indicate that the rate of PTSD and CUD comorbidity is increasing. It remains unclear if PTSD comorbidity among individuals with CUD are causes, consequences, or correlates of CUD, but further investigation of the association is necessary.

Trauma exposure and PTSD are highly related to substance use phenotypes (Jacobsen, Southwick, & Kosten, 2001), and cannabis use phenotypes are increasing among individuals with PTSD (Bonn-Miller et al., 2012; Cougle et al., 2011). Given the associations between PTSD and cannabis use phenotypes, there have been numerous theories that have attempted to address the high rates of co-occurrence. Co-occurrence of these two conditions may begin when a person attempts to self-medicate their PTSD symptoms, or cannabis use could lead to PTSD if the person experiences trauma caused by their cannabis use, like a car accident or physical violence (Chilcoat & Breslau, 1998). Although cannabis is being considered as a potential mental health treatment to ease distressing symptoms in individuals with PTSD, the drug may enhance some symptoms associated with PTSD, making the condition worse (Shishko, Oliveira, Moore, & Almeida, 2018).

The Self-Medication Hypothesis

The self-medication hypothesis is the most prominent and widely accepted phenotypic model of comorbidity that is thought to explain the development of comorbid PTSD and SUD (Khantzian, 1985). The self-medication hypothesis purports that individuals with trauma exposure and/or PTSD engage in substance use in an effort to alleviate negative symptoms of the disorder and consequently develop a SUD (i.e., PTSD to SUD). Longitudinal research has found that PTSD symptoms often have an earlier onset than SUD symptoms (Bremner, Southwick, Darnell, & Charney, 1996), lending support to the purported order of onset of the self-medication hypothesis. Another prominent example of the dynamic relationship between PTSD and SUD was found over a 26-week period where increases in PTSD symptoms were positively associated with increases in SUD symptoms (Ouimette, Read, Wade, & Tirone, 2010). Ouimette and colleagues' (2010) research suggests that individuals' substance use symptoms are tied to their PTSD symptoms and that they could be showing signs of using substances in response to their increase in distressing PTSD symptoms. A majority of the PTSD and SUD studies that have attempted to test the tenants of the self-medication hypothesis have been conducted on drug use broadly (Reed, Anthony, & Breslau, 2007), alcohol (Breslau, Davis, & Schultz, 2003; Jacobsen et al., 2001), nicotine (Breslau et al., 2003; Cook, Jakupcak, Rosenheck, Fontana, & McFall, 2009), or cocaine (Jacobsen et al., 2001), but fewer studies have examined the relationship between PTSD and cannabis use phenotypes.

Those exposed to trauma are at a higher risk of using cannabis than individuals without a history of exposure to trauma (Kevorkian et al., 2015). Additionally, individuals with PTSD are at an increased risk for CUD (Cornelius et al., 2010). Cornelius and colleagues (2010) found that the average age of onset of PTSD was 15.4 +/- 5.6 years and the average age of onset of CUD was 16.7 +/- 2.3 years among trauma exposed adolescents. Cornelius and colleagues' (2010)

results suggest that PTSD contributes to the etiology of CUD. Further supporting the self-medication hypothesis for PTSD and CUD, individuals report using cannabis to regulate negative emotions, or help cope with intrusive PTSD symptoms (Bonn-Miller, Vujanovic, Boden, & Gross, 2011). Research suggests that individuals could be using cannabis to self-medicate their PTSD symptoms, but more research is still needed to provide a more comprehensive evaluation of the unique associations between trauma exposure, PTSD, and cannabis use phenotypes.

Not all studies have results that are consistent with the self-medication hypothesis in relation to PTSD and SUD. Breslau and colleagues (2003) did not find supporting evidence for self-medicating relationship between PTSD and alcohol use. Specifically, exposure to trauma in individuals with and without a diagnosis of PTSD did not predict alcohol abuse or dependence in a longitudinal study of young adults (Breslau et al., 2003). In a study examining the relationship between specific PTSD symptom clusters and substance use, Tull and colleagues (2010) found contradicting evidence against the self-medication hypothesis. Specifically, no evidence was found for a specific relationship between any of the PTSD symptom clusters and cocaine or alcohol (Jakupcak et al., 2010). Although the self-medication hypothesis is the most prominent phenotypic model of comorbid PTSD and SUD, it is possible for the relationship to be in the opposite direction.

The High-Risk and Susceptibility Hypotheses

The high-risk and susceptibility hypotheses are explanations for how comorbid PTSD and SUD develop that are based on the opposite causal direction for the relationship compared to the self-medication hypothesis (i.e., SUD to PTSD). The high-risk hypothesis states substance use behaviors are assumed to increase an individual's risk of exposure to potentially traumatic

events and consequentially increases their risk of developing PTSD. Substance use may increase risk for exposure to a traumatic event by placing individuals in high-risk situations or by impairing recognition of danger cues in the environment (Davis, Stoner, Norris, George, & Masters, 2009; Windle, 1994). The susceptibility hypothesis states that substance use increases the likelihood of developing PTSD after being exposed to a traumatic event (Chilcoat & Breslau, 1998). Individuals who use substances may be less able to manage peri- or post-trauma negative emotions because the substance use is likely to interfere with their ability to effectively manage increased anxiety and arousal levels or be a method of avoidance and lack of processing (Kaysen et al., 2011; Stewart, Pihl, Conrod, & Dongier, 1998). For example, individuals with a SUD were more likely to meet criteria for PTSD than individuals without a SUD following the Oklahoma City bombing (North et al., 1999). More recently, individuals with a history of problematic alcohol use were more likely to have more severe PTSD symptoms following an assault compared to those without a history of problematic alcohol use (Kaysen et al., 2006). Research has shown that age of onset of substance abuse precedes PTSD in cocaine abusing individuals and that the trauma is likely to be associated with the procurement and use of the drug opposed to childhood trauma (Brady, Dansky, Sonne, & Saladin, 1998). In a study investigating patients with SUD and the association with development of PTSD, cannabis use was the third most commonly reported drug of concern with 36% of the total sample reporting problematic use and 40.9% of those with co-occurring PTSD reported cannabis as their principal drug of concern (Dore et al., 2012). A majority of the supporting studies are cross-sectional and focus on other substances (i.e., alcohol, cocaine) besides cannabis, which limits the generalizability of their findings, and thus, longitudinal studies are needed for examining the natural course of associations between trauma and cannabis phenotypes.

Shared Risk Model

Research also suggests that the comorbidity of PTSD and CUD may represent a shared vulnerability. The shared risk model hypothesizes that individuals with greater common liability for PTSD and CUD are more likely to develop both disorders (Krueger & Markon, 2006). Both PTSD and SUDs are genetically influenced. Lyons and colleagues (1993) found that heritability estimates ranged from 35% to 47% for combat exposure among a large sample of Vietnam male-twin veterans. In civilian twin study, Stein and colleagues (2002) also found modest heritability for IPT (e.g., robbery, sexual assault), whereas exposure to accidental trauma (e.g., motor vehicle accident, natural disaster) was best explained by environmental influences. Beyond genetic influences on trauma exposure itself, PTSD is also moderately heritable with estimates ranging from 30% (Stein et al., 2002) to 72% (Sartor et al., 2011) for PTSD. Cannabis use phenotypes are also moderately influenced by genetic factors (31% for cannabis use; (Ystrom, Reichborn-Kjennerud, Neale, & Kendler, 2014), and range from 45-79% for CUD (Agrawal & Lynskey, 2006; Ystrom et al., 2014). Beyond the individual genetic influences on each phenotype, twin studies also suggest that some of the genes that account for risk may overlap. Wolf and colleagues (2010) examined the factor structure of PTSD and SUDs in a large study of over 3,000 twin pairs and found that common genetic liability exists between PTSD and SUDs. Xian and colleagues (2000) also investigated whether and to what degree genetic and environmental contributions overlap among PTSD, alcohol use disorders (AUD) and SUDs in a large study of over 3,000 veteran twin pairs and found that about 15% of genetic risk for PTSD was shared among AUDs and SUDs. Although not specific to cannabis use phenotypes, Xian and colleague's (2000) results suggest that PTSD and CUD share common risk. This shared genetic influence may in part account for PTSD and CUD comorbidity. However, further research is

necessary in order to understand shared risk factors for trauma and cannabis phenotypes, specifically.

Summary

Cannabis use and its associations marks an interesting area of research as legal restrictions become less stringent (Hall, 1994, 2006). Based on cross-sectional and longitudinal evidence in other populations, trauma and PTSD seem to be well established as risk factors at least for initiation of cannabis use and the use of other illicit substances (i.e., alcohol, nicotine, cocaine). Most PTSD and SUD comorbidity research has been done on other drugs warranting more research focused specifically on PTSD and CUD comorbidity. Given the vast public health implication of CUD and PTSD, there is a clinical and research imperative for a better understanding of the etiology of these co-occurring conditions. Given the inconsistencies within the literature, continued examination is necessary to clarify our understanding of cannabis use and its correlates. The majority of research on PTSD and CUD among young adults has been limited by cross-sectional study design that do not allow a detailed analysis of the dynamic relationship between trauma exposure, PTSD, cannabis use, and CUD. Given the limitations of cross-sectional studies with regard to testing the potential causal relations (i.e., self-medication and high-risk hypotheses) between these phenotypes, longitudinal studies are needed. To date, no longitudinal studies have simultaneously examined the role of trauma exposure and PTSD for using cannabis and for developing CUD in young adults and vice versa. This study addresses this gap in the literature by examining the onset and testing the directional relationship of trauma exposure and cannabis use phenotypes.

Current Study

The current study aimed to 1) determine the prevalence and baseline correlates of lifetime any (i.e., yes/no), experimental (i.e., use 1-5 times), and problematic (i.e., use ≥ 6 times) cannabis use and lifetime IPT exposure in relation to each other among college students prior to college enrollment; 2) to examine the self-medication and high-risk hypotheses by investigating the bidirectional relationship between IPT exposure and cannabis use among college students over time; 3) further investigate the self-medication and high-risk hypotheses by examining probable PTSD as a potential mediator in the relationship between IPT exposure and cannabis use as well as examining IPT exposure as a potential mediator in the relationship between cannabis use and probable PTSD. It was hypothesized that: (1a) there will be significant differences in lifetime cannabis use between sexes (i.e., men will be more likely to use compared to women) and racial groups, (i.e., racial minorities will be more likely to use compared to White individuals); and (1b) there will be significant differences in lifetime IPT exposure between sexes (i.e., women will be more likely to experience IPT than men) and racial groups (i.e., racial minorities will be more likely to experience IPT than White individuals); (2a) lifetime IPT exposure assessed at year 1 Fall will be positively associated with new onset cannabis use threshold assessed at year 1 Spring; (2b) lifetime cannabis use threshold assessed at year 1 Fall will be positively associated with new onset IPT exposure count assessed at year 1 Spring; (3a) probable PTSD assessed at year 1 Spring will mediate the relationship between IPT exposure count assessed at year 1 Fall and cannabis use threshold assessed at year 2 Spring; and (3b) IPT exposure count assessed at year 1 Spring will mediate the relationship between cannabis use threshold assessed at year 1 Fall and probable PTSD assessed at year 2 Spring.

Data will be drawn from The Spit for Science: A Virginia Commonwealth University Student Survey (Dick et al., 2014), a large, representative longitudinal study, to accomplish these aims.

Methods

Participants

The current study included baseline (i.e., year 1 Fall) and follow-up (i.e., year 1 Spring and year 2 Spring) data from the first four cohorts of Spit for Science (N=9,889). Data from the parent study was collected from 2011-2014 when all incoming students aged ≥ 18 years were invited to participate in a university-wide research study on college behavioral health. Approximately 2 weeks before arriving on campus, information was mailed to all incoming students and (separately) to their parents. The week before Welcome Week all eligible students (age 18 or older) received an e-mail through their university e-mail account inviting them to participate in the project. Participants were representative of the broader student population attending Virginia Commonwealth University (VCU), in terms of both sex and race. The VCU Institutional Review Board (IRB) approved all study procedures and informed consent was obtained from all study participants. Study data were collected and managed using REDCap (Research Electronic Data Capture), hosted at VCU. REDCap is a secure, web-based application designed to support data capture for research studies, providing 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to statistical packages; and 4) procedures for importing data from external sources. Participants completed an online survey during the Fall of their freshman year in REDCap assessing a variety of factors including childhood experiences, personality, relationships, and behavior, receiving $10 and a t-shirt as

compensation. Detailed information concerning recruitment can be found in (Dick et al., 2014).

Measures

Given the large-scale nature of the parent Spit for Science study, measures were abbreviated to reduce participant burden. Item response theory modeling was used to justify all scale modifications using data from the first wave of the study. Specifically, by investigating the item characteristic and information curves, items that resembled the calibrating information for estimating subjects' location on the latent factor were removed. If an item was distinct enough compared with the other items included as indicators of the factor and items that optimally functioned on the latent continuum, then they were included in the measures. Therefore, items that provided good discrimination at various locations along the range of the latent factor scale were utilized to make test administration both practical and feasible. Unless otherwise stated, given the longitudinal nature of the dataset, each variable described below was calculated the same way for each time point.

Demographics. Data regarding demographics were drawn from the baseline (year 1 Fall) survey. These questions included self-reported sex, race, cohort, and age. For sex, men were coded as 0 and women were coded as 1 in order to compare men to women. For race, 3 dummy coded variables were created for White, Black, Asian, and Other (i.e., American Indian/Alaska Native, Hispanic/Latino, Native Hawaiian/Other Pacific, more than one race, unknown, and I choose not to answer) with White as the reference group in order to make the following comparisons: White versus Black, White versus Asian, and White versus Other. For cohort, 3 dummy coded variables were created for cohorts one through four with one as the reference group in order to make the following comparisons: one versus two, one versus three, and one versus four.

Cannabis Use. Lifetime use and total times used was measured using items adapted from the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA) (Bucholz et al., 1994). Recent cannabis use was assessed using items adapted from Substance Abuse and Mental Health Service Administration (Substance Abuse and Mental Health Service Administration, 2013). In baseline surveys, participants were asked if they had ever used (yes/no response options) and, if so, how many times (free response). Use 1-5 times was classified as "experimental" use and use 6 or more times was classified as "problematic" use, which will be referred to as the "cannabis use threshold" variable. During their follow-up Spring survey the first year, participants were asked the same questions about use "since VCU," roughly corresponding to past 6 months use. In all other Spring follow-up surveys, participants were asked the same questions about past 12-months use and number of times used.

Interpersonal Trauma Exposure (IPT). Traumatic event (TE) exposure was assessed at baseline (e.g., year 1 Fall) using an abbreviated version of the Life Events Checklist (Gray, Litz, Hsu, & Lombardo, 2004). Participants were asked to report on the occurrence of five different stressful events: natural disasters, physical assaults, sexual assaults, other unwanted or uncomfortable sexual experiences, and transportation accidents. Response options were "yes" or "no" to items regarding whether each stressful event occurred "before the past 12 months", "during the past 12 months", or "never happened to me". If a participant endorsed that the event occurred either "before the past 12 months", or "during the past 12 months", it was considered a positive endorsement of TE exposure prior to college. If a participant did not endorse any of the aforementioned options or reported that the events "never happened to me", it was considered a negative endorsement of TE history. Categories were further clustered by interpersonal TEs (i.e., physical assaults, sexual assaults, other unwanted or uncomfortable sexual experiences). The

clustering created two IPT variables, which were utilized in this study: An IPT endorsement variable (i.e., yes/no) and an IPT count variable ranging from 0-3 for each type of IPT event. The same items were utilized during year 1 Spring and yearly Spring follow-ups, however, the timeframe of reference was altered to appropriately capture events occurring "since VCU" and "in the past 12 months", respectively.

Probable PTSD. If a participant endorsed a TE on the Life Events Checklist (Gray et al., 2004) or the single item derived from stressful events measure (Kendler, Karkowski, & Prescott, 1999) they were prompted to respond to four PTSD screener items (four items; $\alpha = .93$). The PTSD screener items were derived from the Primary Care PTSD Screen (PC-PTSD), previously used in screening PTSD symptoms in primary care settings (Prins et al., 2016). The four items ask whether the participant has ever experienced: nightmares, attempts to avoid thoughts or reminders of the potentially traumatic experience, hypervigilance, and feelings of detachment. The total symptom count (ranging from 0-4) was used as the primary PTSD variable in analyses, and based on standardized scoring for this measure; endorsement of three or more items was used as indication of a positive lifetime history of probable PTSD. Cohort 4 is the only cohort that received the four-item measure of probable PTSD. Cohorts 1 through 3 received a version of probable PTSD assessment where all four items were asked in one question and endorsement of any item (e.g., nightmares, attempts to avoid thoughts or reminders of the potentially traumatic experience, hypervigilance, and feelings of detachment) was used as indication of a positive lifetime history of probable PTSD. Assessments for cohorts one through four were combined to create an endorsement of probable PTSD variable (i.e., yes/no), where a score greater than 0 classified as probable PTSD. Response options were coded as 0 and 1, where 0 was indicative of no probable PTSD and 1 was indicative of probable PTSD.

Alcohol Use Frequency. Average frequency of alcohol use during the past year was assessed using the frequency items from the Alcohol Use Disorder Identification Test (AUDIT; (Bohn, Babor, & Kranzler, 1995). Response options for frequency ("How often do you have a drink containing alcohol?") were "never", "monthly or less", "2 to 4 times a month", "2 to 3 times a week", or "4 or more times a week." Response options were coded from 0 to 4, where higher responses were indicative of more frequent alcohol use.

Nicotine Use Frequency. Nicotine use was assessed across 4 categories: cigarettes, cigars, smokeless tobacco, and hookah. Lifetime use and total quantity consumed was assessed using items adapted from the SSAGA (Bucholz et al., 1994). Recent (past 30 days) frequency of use was measured using items adapted from SAMSHA (Substance Abuse and Mental Health Service Administration, 2013). For each nicotine category, participants were asked how frequently they used the product in the last 30 days. Answer options were "I did not use," "Once or twice," "A few days (3 to 4 days a month)," "A couple of days a week (5 to 11 days a month)," "3 times a week (12 to 14 days a month)," "most days of the week (15 to 25 days a month)," and "daily or almost daily (26 to 30 days a month)." Response options specifically for cigarette use were coded from 0 to 6, where higher responses were indicative of more frequent nicotine use.

Data Analytic Plan

Multiple Imputation. Missing data was imputed using the R package "missForest" (Stekhoven & Buhlmann, 2012). A non-parametric multiple imputation method was applied to estimate missing data in five binary variables of cannabis use from year 1 Fall, year 1 Spring, and year 2 Spring. Eight iterations of the imputation process were performed until reaching an optimal stopping point. The imputation was based on six binary (3 cannabis, 3 alcohol) and nine

categorical (3 cannabis, 3 nicotine, and 3 alcohol) variables from years 1 to 2. The overall estimate of imputation error was 0.1459 based on the proportion of falsely classified (PFC) entries, with the PFC of the six binary variables of cannabis use ranging between 0.00 and 0.0002. It is expected that good performance results of imputation with "missForest" will give a value close to 0, in contrast with inadequate results returning values close to 1 (Stekhoven & Buhlmann, 2012). The imputed dataset was used for all analyses.

Overview of Data Analytic Plan. Detailed descriptions of the data analytic plan are presented prior to the results of each aim. In brief, Aim 1 utilized a multinomial logistic regression framework in order to test predictors of (1a) experimental and problematic cannabis use and (1b) lifetime IPT exposure. Aim 2 and Aim 3 utilized cross-lagged path analyses in order to test the relations among cannabis use, IPT exposure, and probable PTSD. Additionally, Aim 3's path analyses utilized a mediational framework.

Determination of Statistical Significance. Due to the large number of participants (n = 9889) and research suggesting that *p*-values become less meaningful with very large samples (Sullivan & Feinn, 2012), a more stringent significance level (i.e., $p < .001$) was set to determine statistical significance.

Aim 1 Analyses. Analyses for Aim 1 examined cross-sectional predictors of (1a) lifetime experimental and problematic cannabis use and (1b) lifetime IPT exposure assessed at the beginning of college at year 1 Fall. Specifically, two sets of multinomial logistic regressions were employed using a model building approach in order to test the hypotheses that (1a) lifetime IPT exposure is a significant predictor of lifetime experimental and problematic cannabis use above and beyond covariates and (1b) lifetime cannabis use is a significant predictor of lifetime IPT exposure above and beyond covariates. Covariates included sex, race, cohort, lifetime IPT

exposure (in the model predicting experimental and problematic cannabis use), lifetime cannabis use (in the model predicting IPT exposure), alcohol use frequency, and nicotine use frequency. Data were analyzed using SPSS Version 24 (IBM Corporation, 2016).

Results

Aim 1 Participant Characteristics

Descriptive statistics are presented in Table 1. The majority of participants in the present sample reported that they were White (n = 4959, 50.1%) and female (n = 6083, 61.5%). Participation across all four cohorts was about equal. Prevalence of lifetime IPT and probable PTSD upon college entry was 35.9% (n = 3549) and 32.2% (n=3186), respectively.

Table 1. *Demographic and Clinical Characteristics of Substance Users and Non-Users at Year 1 Fall*

	Full Sample N = 9889	No Cannabis, Alcohol, or Nicotine N = 1948 (19.7%)*	Cannabis Only N = 276 (2.8%)*	Alcohol Only N = 2290 (23.2%)*	Nicotine Only N = 213 (2.2%)*	Cannabis and Alcohol N = 1811 (18.3%)*	Cannabis and Nicotine N = 467 (4.7%)*	Alcohol and Nicotine N = 772 (7.8%)*	Cannabis, Alcohol, and Nicotine N = 2112 (21.4%)*
Characteristic	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Race									
White	4959 (50.1%)	677 (34.8%)	153 (55.4%)	1065 (46.5%)	110 (51.6%)	931 (51.4%)	118 (25.3%)	483 (62.6%)	1422 (67.3%)
Black	1900 (19.2%)	527 (27.1%)	39 (14.1%)	486 (21.2%)	32 (15.0%)	362 (20.0%)	177 (37.9%)	70 (9.1%)	207 (9.8%)
Asian	1640 (16.6%)	501 (25.7%)	45 (16.3%)	462 (20.2%)	65 (30.5%)	262 (14.5%)	7 (1.5%)	143 (18.5%)	155 (7.3%)
Other	1390 (14.1%)	243 (12.5%)	39 (14.1%)	277 (12.1%)	6 (2.8%)	256 (14.1%)	165 (35.3%)	76 (9.8%)	328 (15.5%)
Cohort									
1	2707 (27.4%)	524 (26.9%)	106 (38.4%)	731 (31.9%)	23 (10.8%)	421 (23.2%)	169 (36.2%)	196 (25.4%)	537 (25.4%)
2	2481 (25.1%)	560 (28.7%)	86 (31.2%)	588 (25.7%)	46 (21.6%)	417 (23.0%)	40 (8.6%)	201 (26.0%)	543 (25.7%)
3	2391 (24.2%)	462 (23.7%)	33 (12.0%)	505 (22.1%)	48 (22.5%)	479 (26.4%)	121 (25.9%)	210 (27.2%)	533 (25.2%)
4	2310 (23.4%)	402 (20.6%)	51 (18.5%)	466 (20.3%)	96 (45.1%)	494 (27.3%)	137 (29.3%)	165 (21.4%)	499 (23.6%)

Table 1 (cont.). *Demographic and Clinical Characteristics of Substance Users and Non-Users at Year 1 Fall*

	Full Sample N = 9889	No Cannabis, Alcohol, or Nicotine N = 1948 (19.7%)*	Cannabis Only N = 276 (2.8%)*	Alcohol Only N = 2290 (23.2%)*	Nicotine Only N = 213 (2.2%)*	Cannabis and Alcohol N = 1811 (18.3%)*	Cannabis and Nicotine N = 467 (4.7%)*	Alcohol and Nicotine N = 772 (7.8%)*	Cannabis, Alcohol, and Nicotine N = 2112 (21.4%)*
Characteristic	n (%)/M (SD)	n (%)/M (SD)	n (%)/M (SD)	n (%)/M (SD)	n (%)/M (SD)	n (%)/M (SD)	n (%)/M (SD)	n (%)/M (SD)	n (%)/M (SD)
Sex									
Men	3806 (38.5%)	646 (33.2%)	78 (28.3%)	986 (43.1%)	81 (38.0%)	638 (35.2%)	232 (49.7%)	243 (31.5%)	902 (42.7%)
Women	6083 (61.5%)	1302 (66.8%)	198 (71.7%)	1304 (56.9%)	132 (62.0%)	1173 (64.8%)	235 (50.3%)	529 (68.5%)	1210 (57.3%)
Lifetime IPT									
No	6340 (64.1%)	1378 (70.7%)	177 (64.1%)	1647 (71.9%)	129 (60.6%)	1145 (63.2%)	246 (52.7%)	544 (70.5%)	1074 (50.9%)
Yes	3549 (35.9%)	570 (29.3%)	99 (35.9%)	643 (28.1%)	84 (39.4%)	666 (36.8%)	221 (47.3%)	228 (29.5%)	1038 (49.1%)
Probable PTSD									
No	6703 (67.8%)	1371 (70.4%)	167 (60.5%)	1648 (72.0%)	150 (70.4%)	1157 (63.9%)	384 (82.2%)	537 (69.6%)	1289 (61.0%)
Yes	3186 (32.2%)	577 (29.6%)	109 (39.5%)	642 (28.0%)	63 (29.6%)	654 (36.1%)	83 (17.8%)	235 (30.4%)	823 (39.0%)

Note: * = percent of full sample; IPT = Interpersonal trauma; PTSD = Posttraumatic stress disorder

Aim 1a(i): Prevalence Estimates of Lifetime Cannabis, Nicotine, and Alcohol Use

Among those who reported lifetime cannabis use at year 1 Fall (n = 4498, 45.5%), a majority reported problematic use (i.e., use ≥ 6 times) opposed to experimental use (i.e., use 1-5 times). Specifically, 2788 participants (28.3%) reported problematic cannabis use and 1718 participants (17.4%) reported experimental cannabis use. Among those who reported lifetime cannabis, nicotine, and/or alcohol use at year 1 Fall (n = 7941, 80.3%), alcohol use only and polysubstance use (i.e., cannabis, nicotine, and alcohol) were the most common. Specifically, 2290 participants (23.2%) reported only lifetime alcohol use and 2112 participants (21.4%) reported lifetime cannabis, alcohol, and nicotine use. 772 participants (7.8%) reported both lifetime alcohol and nicotine use. 467 participants (4.7%) reported both lifetime cannabis and nicotine use. 1811 participants (18.3%) reported both lifetime cannabis and alcohol use. 213 participants (2.2%) reported only lifetime nicotine use. 276 participants (2.8%) reported only lifetime cannabis use. 1948 participants (19.7%) reported no lifetime cannabis, nicotine, or alcohol use.

Aim 1a(ii): Predictors of Lifetime Experimental and Problematic Cannabis Use

Model Building Approach: Multivariate Analyses Predicting Lifetime Problematic Cannabis Use

Multinomial logistic regression was used to examine whether demographics, lifetime IPT exposure, alcohol use, and nicotine use predicts lifetime experimental and problematic cannabis use assessed at year 1 Fall, compared to never having used. All effect sizes are reported as odds ratios, which can be interpreted as the relative odds (compared to the reference group of no lifetime use) of reporting experimental (i.e., 1-5 times) and problematic (i.e., ≥ 6 times) cannabis use.

Model 1 (see Table 2) tested sex, race, and cohort as predictors of lifetime experimental and problematic cannabis use. Sex and cohort were not significant predictors of experimental cannabis use. Race was a significant predictor of experimental cannabis use. Specifically, White individuals were more likely to report experimental cannabis use compared to Black and Asian individuals. Sex, race, and cohort were all significant predictors of problematic cannabis use. Specifically, men were more likely to report problematic cannabis use compared to women; White individuals were more likely to report problematic cannabis use compared to Black and Asian individuals; and individuals from cohort three were more likely to report problematic cannabis use compared to individuals from cohort one.

Table 2. *Model 1: Demographics Predicting Lifetime Experimental and Problematic Cannabis Use*

	R^2	Lifetime Cannabis Use	Predictor	β	Std. Error	Wald's χ2	df	*p*	OR	95% CI
Model 1 (Demographics)	.07	Experimental[a]	Sex (M vs. W)	.03	.06	.34	1	.56	1.04	.92-1.16
			Race (W vs. B)	**.36**	**.07**	**24.38**	**1**	**<.001**	**1.44***	**1.24-1.66**
			Race (W vs. A)	**1.12**	**.09**	**152.52**	**1**	**<.001**	**3.08***	**2.57-3.68**
			Race (W vs. O)	.25	.09	8.44	1	.004	1.28	1.08-1.51
			Cohort (1 vs. 2)	.06	.08	.49	1	.49	1.06	.91-1.23
			Cohort (1 vs. 3)	.03	.08	.11	1	.75	1.03	.88-1.20
			Cohort (1 vs. 4)	-.24	.08	9.91	1	.002	.78	.67-.91
		Problematic[b]	**Sex (M vs. W)**	**.39**	**.05**	**62.84**	**1**	**<.001**	**1.47***	**1.34-1.62**
			Race (W vs. B)	**.76**	**.07**	**131.28**	**1**	**<.001**	**2.14***	**1.88-2.44**
			Race (W vs. A)	**1.44**	**.08**	**332.44**	**1**	**<.001**	**4.20***	**3.60-4.90**
			Race (W vs. O)	.21	.07	8.99	1	.003	1.23	1.07-1.41
			Cohort (1 vs. 2)	-.13	.07	3.59	1	.06	.88	.78-1.00
			Cohort (1 vs. 3)	**-.26**	**.07**	**15.11**	**1**	**<.001**	**.77***	**.68-.88**
			Cohort (1 vs. 4)	-.13	.07	3.44	1	.06	.88	.77-1.01

Note: No lifetime cannabis use is the reference group for lifetime experimental and problematic cannabis use comparisons; * = $p <$ .001; [a] = use 1-5 times, [b] = use ≥ 6 times; Coding: M = men = 0, W = women = 1; W = White = 0, B = Black = 1, A = Asian = 1, O = Other = 1; cohort 1 = 0, cohort 2 = 1, cohort 3 = 1, cohort 4 = 1

Model 2 (see Table 3) expanded the demographic variables in the initial model to include the effects of lifetime IPT exposure in the prediction of lifetime experimental and problematic cannabis use. For both experimental and problematic cannabis use, sex and race effects remained consistent with Model 1 results. Cohort was a significant predictor of experimental cannabis use. Specifically, individuals from cohort four were more likely to report experimental cannabis use compared to individuals from cohort one. Lastly, individuals with a history of IPT exposure were more likely to endorse both cannabis use outcomes.

Model 3 (see Table 4) added the effect of past 30-day nicotine and past year alcohol use frequency in addition to the variables described in Model 2 in the prediction of lifetime experimental and problematic cannabis use. Sex, race, cohort, and lifetime IPT exposure were consistent with Model 2 regarding experimental cannabis use. Alcohol was not a significant predictor of experimental cannabis use. Nicotine use was a significant predictor of experimental cannabis use. Specifically, individuals who reported smoking more frequently during the past month were more likely to report experimental cannabis use. Sex, race, cohort, and lifetime IPT exposure were consistent with Model 2 regarding problematic cannabis use. Nicotine and alcohol use were both significant predictors of problematic cannabis use. Specifically, individuals who reported smoking more frequently during the past month were more likely to report problematic cannabis use; individuals who reported more frequent alcohol consumption during the past month were more likely to report problematic cannabis use.

Table 3. *Model 2: Demographics and IPT Predicting Lifetime Experimental and Problematic Cannabis Use*

	R^2	Lifetime Cannabis Use	Predictor	β	Std. Error	Wald's χ2	df	*p*	OR	95% CI
Model 2 (IPT)	.10	Experimental[a]	Sex (M vs. W)	.09	.06	2.07	1	.15	1.09	.97-1.23
			Race (W vs. B)	**.36**	**.07**	**24.23**	**1**	**<.001**	**1.44***	**1.24-1.66**
			Race (W vs. A)	**1.10**	**.09**	**146.08**	**1**	**<.001**	**3.02***	**2.52-3.61**
			Race (W vs. O)	.27	.09	9.81	1	.002	1.31	1.11-1.55
			Cohort (1 vs. 2)	.03	.08	.11	1	.74	1.03	.86-1.20
			Cohort (1 vs. 3)	.00	.08	.00	1	.97	1.00	.85-1.17
			Cohort (1 vs. 4)	**-.28**	**.08**	**12.64**	**1**	**<.001**	**.76***	**.65-.88**
			IPT (No vs. Yes)	**-.53**	**.06**	**84.44**	**1**	**<.001**	**.59***	**.53-.66**
		Problematic[b]	**Sex (M vs. W)**	**.46**	**.05**	**86.98**	**1**	**<.001**	**1.59***	**1.44-1.75**
			Race (W vs. B)	**.76**	**.07**	**129.06**	**1**	**<.001**	**2.14***	**1.88-2.45**
			Race (W vs. A)	**1.41**	**.08**	**313.84**	**1**	**<.001**	**4.09***	**3.50-4.78**
			Race (W vs. O)	.24	.07	11.46	1	.001	1.27	1.10-1.45
			Cohort (1 vs. 2)	-.17	.07	6.12	1	.01	.85	.74-.97
			Cohort (1 vs. 3)	**-.30**	**.07**	**20.09**	**1**	**<.001**	**.74***	**.65-.84**
			Cohort (1 vs. 4)	-.18	.07	6.62	1	.01	.84	.73-.96
			IPT (No vs. Yes)	**-.74**	**.05**	**230.16**	**1**	**<.001**	**.48***	**.43-.52**

Note: No lifetime cannabis use is the reference group for lifetime experimental and problematic cannabis use comparisons; * = $p <$ .001; [a] = use 1-5 times, [b] = use ≥ 6 times; Coding: M = men = 0, W = women = 1; W = White = 0, B = Black = 1, A = Asian = 1, O = Other = 1; cohort 1 = 0, cohort 2 = 1, cohort 3 = 1, cohort 4 = 1; IPT = interpersonal trauma, no = 0, yes = 1

Table 4. *Model 3: Demographics, IPT, and Polysubstance Use Predicting Lifetime Experimental and Problematic Cannabis Use*

	R^2	Lifetime Cannabis Use	Predictor	β	Std. Error	Wald's χ2	df	*p*	OR	95% CI
Model 3 (Substance Use)	.20	Experimental[a]	**Nicotine**	**.08**	**.02**	**20.82**	**1**	**<.001**	**1.08***	**1.05-1.12**
			Alcohol	.10	.03	9.76	1	.002	1.11	1.04-1.18
			Sex (M vs. W)	.07	.06	1.19	1	.28	1.07	.95-1.20
			Race (W vs. B)	**.31**	**.08**	**16.74**	**1**	**<.001**	**1.36***	**1.17-1.57**
			Race (W vs. A)	**1.06**	**.09**	**134.51**	**1**	**<.001**	**2.90***	**2.42-3.47**
			Race (W vs. O)	.25	.09	8.30	1	.004	1.28	1.08-1.51
			Cohort (1 vs. 2)	.02	.08	.07	1	.80	1.02	.87-1.19
			Cohort (1 vs. 3)	-.02	.08	.06	1	.81	.98	.84-1.15
			Cohort (1 vs. 4)	**-.28**	**.08**	**13.19**	**1**	**<.001**	**.75***	**.65-.88**
			IPT (No vs. Yes)	**-.51**	**.06**	**76.95**	**1**	**<.001**	**.60***	**.54-.68**
		Problematic[b]	**Nicotine**	**.22**	**.01**	**247.17**	**1**	**<.001**	**1.24***	**1.21-1.27**
			Alcohol	**.66**	**.03**	**517.02**	**1**	**<.001**	**1.93***	**1.82-2.04**
			Sex (M vs. W)	**.36**	**.05**	**47.14**	**1**	**<.001**	**1.44***	**1.30-1.59**
			Race (W vs. B)	**.47**	**.07**	**43.80**	**1**	**<.001**	**1.60***	**1.39-1.84**
			Race (W vs. A)	**1.19**	**.08**	**205.47**	**1**	**<.001**	**3.29***	**2.79-3.87**
			Race (W vs. O)	.12	.07	2.55	1	.11	1.13	.97-1.30
			Cohort (1 vs. 2)	-.10	.07	2.07	1	.15	.90	.79-1.04
			Cohort (1 vs. 3)	**-.28**	**.07**	**15.80**	**1**	**<.001**	**.75***	**.66-.87**
			Cohort (1 vs. 4)	-.12	.07	2.86	1	.09	.88	.76-1.02
			IPT (No vs. Yes)	**-.64**	**.05**	**152.22**	**1**	**<.001**	**.53***	**.47-.58**

Note: No lifetime cannabis use is the reference group for lifetime experimental and problematic cannabis use comparisons; * = $p <$ .001; [a] = use 1-5 times, [b] = use ≥ 6 times; Coding: M = men = 0, W = women = 1; W = White = 0, B = Black = 1, A = Asian = 1, O = Other = 1; cohort 1 = 0, cohort 2 = 1, cohort 3 = 1, cohort 4 = 1; IPT = interpersonal trauma, no = 0, yes = 1

Post-Hoc Analyses

In an attempt to tease apart the individual effects of nicotine and alcohol regarding polysubstance use, two additional multinomial logistic regressions were employed. Specifically, one model examined nicotine use frequency as a predictor of lifetime cannabis use threshold without alcohol use frequency, and the other model examined alcohol use frequency as a predictor of lifetime cannabis use threshold without nicotine use frequency.

Model 4 (see Table 5) tested sex, race, cohort, lifetime IPT exposure, and past 30-day nicotine use frequency as predictors of lifetime experimental and problematic cannabis use. Findings were consistent with Model 3 such that past 30-day nicotine use frequency remained a significant predictor of both lifetime experimental and problematic cannabis use. Model 5 (see Table 6) tested sex, race, cohort, lifetime IPT exposure, and past year alcohol use frequency as predictors of lifetime experimental and problematic cannabis use. Findings differed from Model 3 such that past year alcohol use frequency became a significant predictor of both lifetime experimental and problematic cannabis use opposed to only lifetime problematic cannabis use. In summary, results suggest that past 30-day nicotine use frequency was accounting for a unique variance when both nicotine and alcohol use frequency were included as predictors of lifetime experimental cannabis use in Model 3, but alcohol use frequency only accounted for a significant amount of variance when it was included as a predictor without nicotine use frequency.

Table 5. *Post-Hoc Model 4: Demographics, IPT, and Nicotine Use Predicting Lifetime Experimental and Problematic Cannabis Use*

	R^2	Lifetime Cannabis Use	Predictor	β	Std. Error	Wald's χ2	df	*p*	OR	95% CI
Model 4 (Nicotine Only)	.15	Experimental[a]	**Nicotine**	**.09**	**.02**	**25.40**	**1**	**<.001**	**1.09***	**1.05-1.13**
			Sex (M vs. W)	.07	.06	1.18	1	.28	1.07	.95-1.20
			Race (W vs. B)	**.32**	**.07**	**18.59**	**1**	**<.001**	**1.38***	**1.19-1.59**
			Race (W vs. A)	**1.08**	**.09**	**139.11**	**1**	**<.001**	**2.94***	**2.46-3.52**
			Race (W vs. O)	.26	.09	9.10	1	.003	1.29	**1.10-1.53**
			Cohort (1 vs. 2)	.02	.08	.09	1	.76	1.02	.88-1.20
			Cohort (1 vs. 3)	-.02	.08	.05	1	.82	.98	.84-1.15
			Cohort (1 vs. 4)	**-.29**	**.08**	**13.44**	**1**	**<.001**	**.75***	**.65-.88**
			IPT (No vs. Yes)	**-.51**	**.06**	**78.44**	**1**	**<.001**	**.60***	**.54-.67**
		Problematic[b]	**Nicotine**	**.26**	**.01**	**406.21**	**1**	**<.001**	**1.30***	**1.27-1.34**
			Sex (M vs. W)	**.38**	**.05**	**54.47**	**1**	**<.001**	**1.46***	**1.32-1.61**
			Race (W vs. B)	**.59**	**.07**	**73.26**	**1**	**<.001**	**1.80***	**1.57-2.06**
			Race (W vs. A)	**1.32**	**.08**	**263.07**	**1**	**<.001**	**3.73***	**3.18-4.37**
			Race (W vs. O)	.20	.07	8.03	1	.005	1.23	1.06-1.41
			Cohort (1 vs. 2)	-.18	.07	6.93	1	.008	.83	.73-.96
			Cohort (1 vs. 3)	**-.36**	**.07**	**27.40**	**1**	**<.001**	**.70***	**.61-.80**
			Cohort (1 vs. 4)	-.21	.07	9.04	1	.003	.81	.70-.93
			IPT (No vs. Yes)	**-.67**	**.05**	**179.37**	**1**	**<.001**	**.51***	**.46-.56**

Note: No lifetime cannabis use is the reference group for lifetime experimental and problematic cannabis use comparisons; * = $p <$ .001; [a] = use 1-5 times, [b] = use ≥ 6 times; Coding: M = men = 0, W = women = 1; W = White = 0, B = Black = 1, A = Asian = 1, O = Other = 1; cohort 1 = 0, cohort 2 = 1, cohort 3 = 1, cohort 4 = 1; IPT = interpersonal trauma, no = 0, yes = 1

Table 6. *Post-Hoc Model 5: Demographics, IPT, and Alcohol Use Predicting Lifetime Experimental and Problematic Cannabis Use*

	R^2	Lifetime Cannabis Use	Predictor	β	Std. Error	Wald's χ2	df	*p*	OR	95% CI
Model 5 (Alcohol Only)	.18	Experimental[a]	**Alcohol**	**.12**	**.03**	**14.11**	**1**	**<.001**	**1.13***	**1.06-1.20**
			Sex (M vs. W)	.08	.06	1.98	1	.16	1.09	.97-1.22
			Race (W vs. B)	**.34**	**.07**	**20.99**	**1**	**<.001**	**1.40***	**1.21-1.62**
			Race (W vs. A)	**1.08**	**.09**	**139.25**	**1**	**<.001**	**2.95***	**2.46-3.53**
			Race (W vs. O)	.25	.09	8.79	1	.003	1.29	1.09-1.52
			Cohort (1 vs. 2)	.03	.08	.10	1	.76	1.03	.88-1.20
			Cohort (1 vs. 3)	.00	.08	.00	1	.97	1.00	.85-1.17
			Cohort (1 vs. 4)	-.27	.08	12.11	1	.001	.76	.66-.89
			IPT (No vs. Yes)	**-.52**	**.06**	**81.73**	**1**	**<.001**	**.60***	**.53-.67**
		Problematic[b]	**Alcohol**	**.73**	**.03**	**660.87**	**1**	**<.001**	**2.07***	**1.96-2.19**
			Sex (M vs. W)	**.43**	**.05**	**68.51**	**1**	**<.001**	**1.54***	**1.39-1.70**
			Race (W vs. B)	**.60**	**.07**	**72.70**	**1**	**<.001**	**1.81***	**1.58-2.08**
			Race (W vs. A)	**1.25**	**.08**	**232.77**	**1**	**<.001**	**3.50***	**2.98-4.11**
			Race (W vs. O)	.14	.07	3.54	1	.06	1.15	.99-1.32
			Cohort (1 vs. 2)	-.08	.07	1.41	1	.23	.92	.80-1.06
			Cohort (1 vs. 3)	-.23	.07	10.39	1	.001	.80	.70-.92
			Cohort (1 vs. 4)	-.09	.07	1.52	1	.22	.92	.80-1.05
			IPT (No vs. Yes)	**-.69**	**.05**	**182.94**	**1**	**<.001**	**.50***	**.45-.55**

Note: No lifetime cannabis use is the reference group for lifetime experimental and problematic cannabis use comparisons; * = $p <$ .001; [a] = use 1-5 times, [b] = use ≥ 6 times; Coding: M = men = 0, W = women = 1; W = White = 0, B = Black = 1, A = Asian = 1, O = Other = 1; cohort 1 = 0, cohort 2 = 1, cohort 3 = 1, cohort 4 = 1; IPT = interpersonal trauma, no = 0, yes = 1

Aim 1b(i): Prevalence Estimates of Lifetime Interpersonal Trauma Exposure

Among those who reported lifetime IPT exposure at year 1 Fall (n = 3549, 35.9%), exposure to only one of the three experiences (i.e., physical assault, sexual assault, or other) of IPT was the most common. Specifically, 2378 participants (67.0%) reported a history of experiencing one of the three types of IPT. 789 participants (22.2.0%) reported a history of experiencing two types of IPT. 382 participants (10.8%) reported a history of experiencing all three types of IPT.

Aim 1b(ii): Predictors of Lifetime Interpersonal Trauma Exposure

Model Building Approach: Multivariate Analyses Predicting Lifetime Interpersonal Trauma Exposure

Logistic regression was used to examine whether demographics, alcohol use, nicotine use, and cannabis use predict lifetime IPT exposure assessed at year 1 Fall. All effect sizes are reported as odds ratios, which can be interpreted as the relative odds (compared to the reference group of no lifetime IPT exposure) of reporting lifetime IPT exposure.

Model 1 (see Table 7) tested sex, race, and cohort as predictors of lifetime IPT exposure. Sex, race, and cohort were all significant predictors of lifetime IPT exposure. Specifically, women were more likely to report a history of IPT exposure compared to men; White individuals were more likely to report a history of IPT exposure compared to Asian individuals; and cohorts two, three, and four were less likely to report a history of IPT compared to cohort one.

Model 2 (see Table 8) expanded the demographic variables in the initial model to include the effects of lifetime cannabis use in the prediction of lifetime IPT exposure. Sex and cohort were consistent with Model 1 regarding lifetime IPT exposure. Race was no longer a significant

predictor of lifetime IPT exposure. Individuals who did not report a history of cannabis use were less likely to report a history of IPT compared to individuals who reported lifetime cannabis use.

Model 3 (see Table 9) added the effect of past 30-day nicotine and past year alcohol use frequency in addition to the variables described in Model 2 in the prediction of lifetime IPT exposure. Sex, race, cohort, and lifetime cannabis use were consistent with Model 2 regarding lifetime IPT exposure. Alcohol was not a significant predictor of lifetime IPT exposure. Nicotine was a significant predictor of lifetime IPT exposure. Specifically, individuals who reported smoking more cigarettes during the past month were more likely to report lifetime IPT exposure.

Table 7. *Model 1: Demographics Predicting Lifetime Interpersonal Trauma Exposure*

	R^2	Predictor	β	Std. Error	Wald's χ2	df	*p*	OR	95% CI
Model 1 (Demographics)	.02	**Sex (M vs. W)**	**-.35**	**.04**	**68.88**	**1**	**<.001**	**.71***	**.65-.77**
		Race (W vs. B)	.10	.05	3.10	1	.08	1.10	.99-1.22
		Race (W vs. A)	**.36**	**.06**	**38.08**	**1**	**<.001**	**1.43***	**1.28-1.60**
		Race (W vs. O)	-.12	.06	4.08	1	.04	.88	.78-1.00
		Cohort (1 vs. 2)	**.21**	**.06**	**14.07**	**1**	**<.001**	**1.23***	**1.11-1.38**
		Cohort (1 vs. 3)	**.21**	**.06**	**13.31**	**1**	**<.001**	**1.23***	**1.10-1.37**
		Cohort (1 vs. 4)	**.24**	**.06**	**17.08**	**1**	**<.001**	**1.27***	**1.13-1.42**

Note: * = $p < .001$; Coding: M = men = 0, W = women = 1; W = White = 0, B = Black = 1, A = Asian = 1, O = Other = 1; cohort 1 = 0, cohort 2 = 1, cohort 3 = 1, cohort 4 = 1

Table 8. *Model 2: Demographics and Cannabis Use Predicting Lifetime Interpersonal Trauma Exposure*

	R^2	Predictor	β	Std. Error	Wald's χ2	df	*p*	OR	95% CI
Model 2 (Cannabis Use)	.05	**Sex (M vs. W)**	**-.40**	**.04**	**86.79**	**1**	**<.001**	**.67***	**.62-.73**
		Race (W vs. B)	.00	.06	0.00	1	.99	1.00	.90-1.11
		Race (W vs. A)	.16	.06	7.54	1	.006	1.18	1.05-1.33
		Race (W vs. O)	-.16	.06	6.92	1	.009	.85	.75-.96
		Cohort (1 vs. 2)	**.22**	**.06**	**15.61**	**1**	**<.001**	**1.25***	**1.12-1.40**
		Cohort (1 vs. 3)	**.24**	**.06**	**16.91**	**1**	**<.001**	**1.27***	**1.13-1.42**
		Cohort (1 vs. 4)	**.27**	**.06**	**21.65**	**1**	**<.001**	**1.31***	**1.17-1.47**
		Cannabis (No vs. Yes)	**-.66**	**.04**	**241.49**	**1**	**<.001**	**.52***	**.48-.56**

Note: * = $p < .001$; Coding: M = men = 0, W = women = 1; W = White = 0, B = Black = 1, A = Asian = 1, O = Other = 1; cohort 1 = 0, cohort 2 = 1, cohort 3 = 1, cohort 4 = 1; cannabis = lifetime cannabis use, no = 0, yes = 1

Table 9. *Model 3: Demographics and Polysubstance Use Predicting Lifetime Interpersonal Trauma Exposure*

	R^2	Predictor	β	Std. Error	Wald's χ2	df	*p*	OR	95% CI
Model 3 (Substance Use)	.06	**Nicotine**	**.07**	**.01**	**39.75**	**1**	**<.001**	**1.08***	**1.05-1.10**
		Alcohol	.07	.02	10.27	1	.001	1.08	1.03-1.13
		Sex (M vs. W)	**-.43**	**.04**	**98.19**	**1**	**<.001**	**.65***	**.60-.71**
		Race (W vs. B)	-.06	.06	1.22	1	.27	.94	.84-1.05
		Race (W vs. A)	.12	.06	4.21	1	.04	1.13	1.01-1.27
		Race (W vs. O)	-.18	.06	8.48	1	.004	.83	.74-.94
		Cohort (1 vs. 2)	**.23**	**.06**	**15.91**	**1**	**<.001**	**1.26***	**1.12-1.40**
		Cohort (1 vs. 3)	**.23**	**.06**	**15.77**	**1**	**<.001**	**1.26***	**1.12-1.41**
		Cohort (1 vs. 4)	**.27**	**.06**	**20.78**	**1**	**<.001**	**1.30***	**1.16-1.46**
		Cannabis (No vs. Yes)	**-.58**	**.04**	**174.63**	**1**	**<.001**	**.56***	**.51-.61**

Note: * = $p < .001$; Coding: M = men = 0, W = women = 1; W = White = 0, B = Black = 1, A = Asian = 1, O = Other = 1; cohort 1 = 0, cohort 2 = 1, cohort 3 = 1, cohort 4 = 1; cannabis = lifetime cannabis use, no = 0, yes = 1

Data Analytic Plan: Aims 2 and 3

Aims 2 and 3 Analyses. Analyses for Aims 2 and 3 used continuous (e.g., cannabis use threshold and IPT exposure count) predictors and outcomes as well as continuous (e.g., age) covariates that were mean-centered in order to reduce non-essential multicollinearity and increase interpretability of the findings (Cohen, Cohen, West, & Aiken, 2003). The cannabis use threshold variable is an ordered categorical variable (i.e., 0 = no use, 1 = experimental use, 2 = problematic use) with higher values indicating greater use, however it was treated as continuous for the purposes of these analyses. Analyses for Aims 2 and 3 also used categorical (e.g., sex) covariates. Tests for univariate and multivariate outliers in the predictor variables were performed. Specifically, DFBETAS and studentized deleted residuals were utilized to determine whether there were any outlying cases (Neter, Wasserman, & Kutner, 1989). Distributional properties of all continuous variables were analyzed to ensure normal distribution of variables. Skewness and kurtosis values were examined for continuous variables to ensure that they fell within acceptable ranges (+/-2, +/-7, respectively; (Byrne, 2013; George & Mallery, 2016)). Main effects of covariates on the outcome variables (e.g., cannabis use threshold and IPT exposure count) were analyzed; when main effects of covariates were significant ($p < .001$) they were retained in the model. Interactions between covariates and covariates (e.g., sex and age), covariates and predictors (e.g., sex and cannabis use threshold) for Aims 2 and 3, and predictors and predictors (e.g., cannabis use threshold and IPT exposure count) specifically for Aim 3 were tested. Only significant interactions ($p < .001$) were retained in the model. All models testing Aims 2 and 3 were estimated in Mplus Version 8 (Muthen & Muthen, 2017), with mediation within Aim 3 being tested using the *Model Indirect* function.

Aim 2 tested the longitudinal associations between cannabis use threshold and IPT exposure count, over and above covariates. To test Aim 2, cross-lagged path analyses were conducted to test the hypotheses that (2a) year 1 Fall IPT exposure count is prospectively and positively associated with year 1 Spring cannabis use threshold and (2b) year 1 Fall cannabis use threshold is prospectively and positively associated with year 1 Spring IPT exposure count. Broadly, year 1 Fall cannabis use threshold and IPT exposure count were entered as a priori predictors of year 1 Spring IPT exposure count and cannabis use threshold, respectively. The covariates were age, sex, race, cohort, alcohol use frequency, and nicotine use frequency. Specifically, to test Aim 2a (i.e., longitudinal associations between IPT exposure count and cannabis use threshold, over and above covariates), significant covariates were entered into the model, followed by IPT exposure count, in order to test if IPT exposure count predicted cannabis use threshold over and above covariates. Specifically, to test Aim 2b (i.e., longitudinal associations between cannabis use threshold and IPT exposure count, over and above covariates), significant covariates were entered into the model, followed by cannabis use threshold, in order to test if cannabis use threshold significantly predicted IPT exposure count over and above covariates.

Aim 3 proposed to model the longitudinal, and indirect, associations among IPT exposure count, probable PTSD, and cannabis use threshold to test the hypotheses that (3a) probable PTSD will mediate the relation between IPT exposure count and cannabis use threshold and (3b) IPT exposure count will mediate the relation between cannabis use threshold and probable PTSD. Specifically, a model building approach was employed, in which two different mediation analyses (i.e., one for both parts of Aim 3) were run simultaneously and tested (3a) whether IPT exposure count is associated with probable PTSD, and in turn increased cannabis use threshold

(i.e., self-medication hypothesis), as well as (3b) whether cannabis use threshold is associated with new IPT exposure count, and in term probable PTSD (i.e., high-risk hypothesis). The covariates were age, sex, race, alcohol use frequency, and nicotine use frequency. Covariates significantly associated with the outcomes ($p < .001$) were retained in the final model. In order to test study hypotheses, mediation analyses investigated whether the indirect effects of IPT exposure count on cannabis use threshold through probable PTSD as well as cannabis use threshold on probable PTSD through IPT exposure count were significant.

Determination of Model Fit. Path analyses rely on several statistical tests in order to determine the adequacy of model fit to the data. The Root Mean Square Error of Approximation (RMSEA) is related to residual in the model. RMSEA values range from 0 to 1 with a smaller RMSEA value indicating better model fit. Acceptable model fit is indicated by an RMSEA value of 0.06 or less (Hu & Bentler, 1999). The Comparative Fit Index (CFI) compares the fit of a target model to the fit of a null model. CFI ranges from 0 to 1 with a larger value indicating better model fit. Acceptable model fit is indicated by a CFI value of 0.90 or greater (Hu & Bentler, 1999). The Tucker-Lewis Index (TLI) is an incremental fit index preferable for smaller sample sizes. TLI ranges from 0 to 1 with a larger value indicating better model fit.

Aims 2 and 3 Participant Characteristics

Descriptive statistics are presented in Table 10. Prevalence of experimental and problematic cannabis use upon college entry (i.e., Year 1 Fall) was 17.4% (n = 1718) and 28.1% (n = 2780), respectively. Prevalence of lifetime IPT exposure count upon college entry for 1, 2, and 3 types was 29.2% (n = 2890 for 1 type), 12.5% (n = 1240 for 2 types), and 6.5% (n = 642 for 3 types), respectively. Prevalence of probable PTSD upon college entry was 32.2% (n = 3186). Prevalence of experimental and problematic cannabis use during approximately the past

six months assessed at Year 1 Spring was 19.1% (n = 1888) and 22.6% (n = 2240), respectively. Prevalence of new onset IPT exposure count during approximately the past six months assessed at Year 1 Spring for 1, 2, and 3 types was 16.6% (n = 1645), 4.4% (n = 438), and 1.6% (n = 161), respectively. Prevalence of probable PTSD assessed at Year 1 Spring was 29.2% (n = 2887). Prevalence of experimental and problematic cannabis use during approximately the past year assessed at Year 2 Spring was 17.6% (n = 1744) and 26.9% (n = 2657), respectively. Prevalence of new onset IPT exposure count during approximately the past year assessed at Year 2 Spring for 1, 2, and 3 types was 13.9% (n = 1370), 2.4% (n = 234), and 0.6% (n = 62), respectively. Prevalence of probable PTSD assessed at Year 2 Spring was 30.7% (n = 3035).

Table 10. *Clinical Characteristics at Year 1 Fall, Year 1 Spring, and Year 2 Spring*

	Year 1 Fall		Year 1 Spring		Year 2 Spring	
Variable	Category	n (%)	Category	n (%)	Category	n (%)
Cannabis Use Threshold	None	5393 (54.5%)	None	5763 (58.3%)	None	5490 (55.5%)
	Experimental	1718 (17.4%)	Experimental	1888 (19.1%)	Experimental	1744 (17.6%)
	Problematic	2780 (28.1%)	Problematic	2240 (22.6%)	Problematic	2657 (26.9%)
IPT Exposure Count	0	5119 (51.8%)	0	7647 (77.3%)	0	8225 (83.2%)
	1	2890 (29.2%)	1	1645 (16.6%)	1	1370 (13.9%)
	2	1240 (12.5%)	2	438 (4.4%)	2	234 (2.4%)
	3	642 (6.5%)	3	161 (1.6%)	3	62 (0.6%)
Probable PTSD	No	6703 (67.8%)	No	7004 (70.8%)	No	6856 (69.3%)
	Yes	3186 (32.2%)	Yes	2887 (29.2%)	Yes	3035 (30.7%)

Note: IPT = Interpersonal Trauma, PTSD = Posttraumatic Stress Disorder

Aim 2 Model Fit

The path analysis, with covariates such as sex, race, age, cohort, and alcohol and nicotine use, produced a decent to good fitting model χ^2 (8) = 530.05, $p < .001$; RMSEA = 0.08, CFI = 0.92, and TLI = 0.43. To improve model fit, modification indices were considered. However, paths that were recommended to improve model fit were theoretically irrational (i.e., year 1 Fall cannabis on year 1 Spring cannabis, year 1 Fall IPT with year 1 Spring cannabis) and were thus not incorporated into the model. The path coefficients of this model are presented in Table 11.

Aim 2 Outlier Analyses

There were no univariate outliers based on DFBETAS or multivariate outliers based on studentized deleted residuals (SDRs) (Cohen et al., 2003). The cut-off value for DFBETAS is 2/sqrt(*n*), where *n* is the number of observations (*n* = 9889). No cases exceeded a DFBETAS cut-off value of 0.02, but we removed the top three cases with the largest values of DFBETAS. Since SDRs have a t-distribution, an SDR of magnitude 3 or more in absolute value will be considered an outlier. No cases exceed a SDR cut-off value of 3 in absolute value, but we removed the top three cases with the largest values of SDRs. The model results did not change after the most influential cases were removed. Thus, the confidence in the findings not being driven by single cases was increased. Results of the path analysis are presented in Table 11 and detailed below.

Cross-Lagged Panel Model Examining Cannabis Use and IPT Count

Aim 2a: Association between Year 1 Fall IPT and Year 1 Spring cannabis use (Self-Medication Hypothesis)

Age was not a significant predictor of year 1 Fall cannabis use. Sex was a significant predictor of year 1 Fall cannabis use, such that women were less likely to report a greater number of times using cannabis compared to men. Race was a significant predictor of year 1 Fall

cannabis use, such that Black and Asian individuals were less likely to report a greater number of times using cannabis at year 1 Fall compared to White individuals. Cohort three was more likely to report a greater number of times using cannabis at year 1 Fall compared to cohort one. Both alcohol and nicotine use were significant predictors of year 1 Fall cannabis use, such that individuals who reported more frequent alcohol and nicotine use were more likely to report a greater number of times using cannabis at year 1 Fall.

Year 1 Spring cannabis use was predicted by year 1 Fall IPT above and beyond year 1 Fall cannabis use and covariates. Specifically, individuals who reported experiencing more types of IPT at year 1 Fall were more likely to report a greater number of times using cannabis at year 1 Spring. Race and age were not significant predictors of year 1 Spring cannabis use. Year 1 Fall cannabis use was a significant predictor of year 1 Spring cannabis use, such that individuals who reported a greater number of times using cannabis at year 1 Fall were more likely to report a greater number of times using cannabis at year 1 Spring. Sex was a significant predictor of year 1 Spring cannabis use, such that women were less likely to report a greater number of times using cannabis compared to men. Cohort three was more likely to report a greater number of times using cannabis at year 1 Spring compared to cohort one. Alcohol and nicotine use were significant predictors of cannabis use at year 1 Spring. Specifically, individuals who reported more frequent alcohol and nicotine use at year 1 Spring were more likely to report a greater number of times using cannabis at year 1 Spring.

Aim 2b: Association between Year 1 Fall cannabis use and Year 1 Spring IPT (High-Risk Hypothesis)

Race, cohort, and age were not significant predictors of year 1 Fall IPT count. Sex was a significant predictor of year 1 Fall IPT count, such that women were more likely to report

experiencing more types of IPT compared to men. Both alcohol and nicotine use were significant predictors of year 1 Fall IPT count, such that individuals who reported more frequent alcohol and nicotine use were more likely to report experiencing more types of IPT at year 1 Fall.

Year 1 Spring IPT count was not predicted by year 1 Fall cannabis use above and beyond year 1 Fall IPT count and covariates. Sex, race, cohort, age, and alcohol use were not significant predictors of year 1 Spring IPT count. Year 1 Fall IPT count was a significant predictor of year 1 Spring IPT count, such that individuals who reported experiencing more types of IPT at year 1 Fall were more likely to report experiencing more types of IPT at year 1 Spring. Nicotine use was a significant predictor of IPT count at year 1 Spring. Specifically, individuals who reported more frequent nicotine use at year 1 Spring were more likely to report experiencing more types of IPT at year 1 Spring.

Table 11. *IPT Predicting Cannabis Use (Self-Medication Hypothesis) and Cannabis Use Predicting IPT (High-Risk Hypothesis) Path Analysis Results*

Predictors	Cannabis Use Threshold						IPT Count					
	Y1F			Y1S			Y1F			Y1S		
	β	S.E.	*p*	β	S.E.	*p*	β	S.E.	*p*	β	S.E.	*p*
Sex (Women)	**-.05**	**.01**	**< .001***	**-.05**	**.01**	**< .001***	**.15**	**.01**	**< .001***	.01	.01	.41
Race (Black)	**-.07**	**.01**	**< .001***	.02	.01	.07	.01	.01	.79	.01	.01	.14
Race (Asian)	**-.17**	**.01**	**< .001***	-.02	.01	.03	-.03	.01	.001	.01	.01	.45
Race (Other)	-.02	.01	.08	.02	.01	.02	.03	.01	.02	-.01	.01	.25
Age	.00	.01	.67	-.02	.01	.01	.01	.01	.31	-.01	.01	.25
Cohort (2)	.01	.01	.22	.01	.01	.42	-.04	.01	.001	.01	.01	.13
Cohort (3)	**.04**	**.01**	**< .001***	**.05**	**.01**	**< .001***	-.04	.01	.003	-.01	.01	.75
Cohort (4)	.02	.01	.06	.04	.01	.001	-.04	.01	.001	.01	.01	.15
Alcohol (Y1F)	**.23**	**.01**	**< .001***	-	-	-	**.07**	**.01**	**< .001***	-	-	-
Alcohol (Y1S)	-	-	-	**.15**	**.01**	**< .001***	-	-	-	.02	.01	.05
Nicotine (Y1F)	**.17**	**.01**	**< .001***	-	-	-	**.11**	**.01**	**< .001***	-	-	-
Nicotine (Y1S)	-	-	-	**.07**	**.01**	**< .001***	-	-	-	**.03**	**.01**	**< .001***
Cannabis (Y1F)	-	-	-	**.43**	**.01**	**< .001***	-	-	-	.02	.01	.04
IPT (Y1F)	-	-	-	**.03**	**.01**	**< .001***	-	-	-	**.62**	**.01**	**< .001***

Note: IPT = Interpersonal Trauma, Sex (Reference: Male), Race (Reference: White), Cohort (Reference: 1), Y1F = Year 1 Fall, Y1S = Year 1 Spring, * significant at p < .001

Aim 3 Model Fit

The path analysis, with covariates such as sex, race, age, cohort, and alcohol and nicotine use, produced a poor fitting model χ^2 (33) = 6470.76, $p < .001$; RMSEA = 0.14, CFI = 0.14, and TLI = -1.07. To improve model fit, modification indices were considered. However, paths that were recommended to improve model fit were theoretically irrational (i.e., year 1 Fall probable PTSD on year 2 Spring probable PTSD, year 1 Spring IPT count with year 1 Spring probable PTSD) and thus were not added to the model. The path coefficients of this model are presented in Table 12.

Aim 3 Outlier Analyses

There were no univariate outliers based on DFBETAS or multivariate outliers based on studentized deleted residuals (SDRs) (Cohen et al., 2003). No cases exceeded a DFBETAS cut-off value of 0.02, but we removed the top three cases with the largest values of DFBETAS. No cases exceed a DFBETAS cut-off value of 3 in absolute value, but we removed the top three cases with the largest values of SDRs. The model results did not change after the most influential cases were removed one at a time. Thus, the confidence in the findings not being driven by single cases was increased. Results of the path analysis are presented in Table 12 and detailed below.

Cross-Lagged Panel Model Examining Cannabis Use, IPT Count, and Probable PTSD

Aim 3a: Mediational association between Year 1 Fall IPT count, Year 1 Spring probable PTSD, and Year 2 Spring cannabis use threshold (High-Risk Hypothesis)

Sex was a significant predictor of year 1 Spring probable PTSD, such that women were more likely to meet criteria for probable PTSD compared to men. Race was a significant predictor of year 1 Spring probable PTSD, such that Black and Asian individuals were less likely

to meet criteria for probable PTSD compared to White individuals. Cohorts two, three, and four were more likely to meet criteria for probable PTSD at year 1 Spring compared to cohort one. Age was a significant predictor of year 1 Spring probable PTSD, such that older individuals were more likely to meet criteria for probable PTSD at year 1 Spring. Nicotine use was a significant predictor of year 1 Spring probable PTSD, such that individuals who reported more frequent nicotine use were more likely to meet criteria for probable PTSD at year 1 Spring. Alcohol use was not significant a predictor of probable PTSD at year 1 Spring. IPT count was a significant predictor of year 1 Spring probable PTSD, such that individuals who reported experiencing more types of IPT exposure at year 1 Fall were more likely to meet criteria for probable PTSD at year 1 Spring.

Sex, cohort, and age were not significant predictors of year 2 Spring cannabis use. Race was a significant predictor of year 2 Spring cannabis use, such that Asian individuals were less likely to report a greater number of times using cannabis compared to White individuals. Both nicotine and alcohol use were significant predictors of year 2 Spring cannabis use, such that individuals who reported more frequent nicotine use were more likely to report experimental or problematic cannabis use at year 2 Spring. IPT count was a significant predictor of year 2 Spring cannabis use, such that individuals who reported more types of IPT exposure at year 1 Fall were more likely to report a greater number of times using cannabis at year 2 Spring. Probable PTSD was not a significant predictor of year 2 Spring cannabis use.

In examining whether year 1 Spring probable PTSD mediated the effect of year 1 Fall IPT count on year 2 Spring cannabis use, we found that the indirect effect was non-significant (β = -.01, 95% CI: -.020 - -.002, p = .01). Therefore, year 1 Spring probable PTSD did not mediate the effect of year 1 Fall IPT count on year 2 Spring cannabis use.

Aim 3b: Mediational association between Year 1 Fall cannabis use threshold, Year 1 Spring IPT count, and Year 2 Spring probable PTSD (High-Risk Hypothesis)

Sex, race, cohort, age, nicotine use, and cannabis use were not significant predictors of year 1 Spring IPT count. Alcohol was a significant predictor of year 1 Spring IPT count, such that individuals who reported more frequent alcohol use were more likely to report experiencing more IPT at year 1 Spring.

Alcohol and cannabis use were not significant predictors of probable PTSD at year 2 Spring. Sex was a significant predictor of year 2 Spring probable PTSD, such that women were more likely to meet criteria for probable PTSD compared to men. Race was a significant predictor of year 2 Spring probable PTSD, such that Other individuals were more likely to meet criteria for probable PTSD at year 2 Spring compared to White individuals. Cohorts two, three, and four were more likely to meet criteria for probable PTSD at year 2 Spring compared to cohort one. Age was a significant predictor of year 2 Spring probable PTSD, such that older individuals were more likely to meet criteria for probable PTSD at year 2 Spring. Nicotine use was a significant predictor of year 2 Spring probable PTSD, such that individuals who reported more frequent nicotine use were less likely to meet criteria for probable PTSD at year 2 Spring. IPT count was a significant predictor of year 2 Spring probable PTSD, such that individuals who reported experiencing more types of new onset IPT exposure between year 1 Fall and year 1 Spring were more likely to meet criteria for probable PTSD at year 2 Spring.

In examining whether year 1 Spring IPT count mediated the effect of year 1 Fall cannabis use on year 2 Spring probable PTSD, we found that the indirect effect was non-significant (β = .00, 95% CI: -.001 - .003, p = .19). Therefore, year 1 Spring IPT count did not mediate the effect of year 1 Fall cannabis use on year 2 Spring probable PTSD.

Table 12. *Probable PTSD as a Mediator Between IPT and Cannabis Use (Self-Medication Hypothesis) and IPT as a Mediator Between Cannabis Use and Probable PTSD (High-Risk Hypothesis) Path Analysis Results*

Predictors	Self-Medication Hypothesis						High-Risk Hypothesis					
	PTSD (Y1S)			Cannabis (Y2S)			IPT (Y1S)			PTSD (Y2S)		
	β	S.E.	*p*	β	S.E.	*p*	β	S.E.	*p*	β	S.E.	*p*
Sex (Women)	**.17**	**.01**	**< .001***	-.02	.01	.02	.01	.01	.43	**.17**	**.01**	**< .001***
Race (Black)	**-.06**	**.01**	**< .001***	-.02	.01	.05	.02	.01	.10	.00	.01	.76
Race (Asian)	**-.06**	**.01**	**< .001***	**-.05**	**.01**	**< .001***	.01	.01	.38	.04	.01	.006
Race (Other)	.01	.01	.66	.00	.01	.95	-.01	.01	.28	**.06**	**.01**	**< .001***
Cohort (2)	**.06**	**.02**	**< .001***	.01	.01	.59	.02	.01	.17	**.06**	**.02**	**< .001***
Cohort (3)	**.14**	**.02**	**< .001***	.00	.01	.80	-.01	.01	.65	**.09**	**.02**	**< .001***
Cohort (4)	**.15**	**.02**	**< .001***	.01	.01	.68	.02	.01	.18	**.13**	**.02**	**< .001***
Age	**.09**	**.01**	**< .001***	.01	.01	.64	-.01	.01	.30	**.05**	**.01**	**< .001***
Nicotine (Y1F)	**.08**	**.02**	**< .001***	-	-	-	.00	.01	.95	-	-	-
Nicotine (Y1S)	-	-	-	**.10**	**.01**	**< .001***	-	-	-	**-.10**	**.02**	**< .001***
IPT (Y1F)	**.29**	**.01**	**< .001***	**.06**	**.01**	**< .001***	-	-	-	-	-	-
IPT (Y1S)	-	-	-	-	-	-	-	-	-	**.08**	**.01**	**< .001***
PTSD (Y1F)	-	-	-	-	-	-	-	-	-	-	-	-
PTSD (Y1S)	-	-	-	-.04	.02	.01	-	-	-	-	-	-

Note: IPT = Interpersonal Trauma, PTSD = Posttraumatic Stress Disorder, Sex (Reference: Male), Race (Reference: White), Cohort (Reference: 1), Y1F = Year 1 Fall, Y1S = Year 1 Spring, Y2S = Year 2 Spring, * significant at p < .001

Table 12 (cont.). *Probable PTSD as a Mediator Between IPT and Cannabis Use (Self-Medication Hypothesis) and IPT as a Mediator Between Cannabis Use and Probable PTSD (High-Risk Hypothesis) Path Analysis Results*

Predictors	Self-Medication Hypothesis						High-Risk Hypothesis					
	PTSD (Y1S)			Cannabis (Y2S)			IPT (Y1S)			PTSD (Y2S)		
	β	S.E.	*p*	β	S.E.	*p*	β	S.E.	*p*	β	S.E.	*p*
Cannabis (Y1F)	-	-	-	-	-	-	.01	.01	.18	.00	.01	.99
Alcohol (Y1F)	.01	.01	.45	-	-	-	**.04**	**.01**	**<.001*** **	-	-	-
Alcohol (Y1S)	-	-	-	**.10**	**.01**	**< .001*** **	-	-	-	.00	.01	.97

Note: IPT = Interpersonal Trauma, PTSD = Posttraumatic Stress Disorder, Sex (Reference: Male), Race (Reference: White), Cohort (Reference: 1), Y1F = Year 1 Fall, Y1S = Year 1 Spring, Y2S = Year 2 Spring, * significant at p < .001

Discussion

The aims of the present study were threefold. First, the present study examined the prevalence and predictors of lifetime cannabis use and lifetime IPT exposure. Second, the self-medication and high-risk hypotheses were explored by investigating the bidirectional relationship between IPT count and cannabis use threshold over time. Third, the self-medication and high-risk hypotheses were further studied using a mediational framework. Specifically, the self-medication hypothesis was investigated by testing the indirect effect of IPT count onto cannabis use threshold via probable PTSD. Likewise, the high-risk hypothesis was investigated by testing the indirect effect of cannabis use threshold onto probable PTSD via IPT count. Findings from each aim are discussed in turn.

Aim 1a: Prevalence and Predictors of Lifetime Cannabis Use

Overall Summary of Findings

This study estimated the prevalence of lifetime cannabis use and investigated demographic and clinical characteristics as predictors of lifetime cannabis use, which produced four main findings. First, results showed that individuals who reported a history of IPT exposure prior to college were more likely to report lifetime experimental and problematic cannabis use. Second, results showed evidence for sex differences with respect to lifetime cannabis use, such that men were more likely to report a history of problematic cannabis use compared to women, but not experimental cannabis use. Third, results showed evidence for racial differences with respect to lifetime cannabis use, such that White individuals were more likely to report a history of experimental and problematic cannabis use compared to Black and Asian individuals. Fourth, results showed evidence for lifetime alcohol and nicotine use as predictors of lifetime cannabis use.

Prevalence of Lifetime Cannabis Use

The present study assessed the prevalence of lifetime experimental and problematic cannabis use among a large sample of college students at an urban college campus in the southeastern part of the United States. Overall, 17.4% and 28.3% of participants reported lifetime experimental and problematic cannabis use, respectively. These findings were consistent with previous prevalence estimates, which suggested that almost half (45%) of incoming college students report lifetime cannabis use (Arria et al., 2017). Our study separated lifetime cannabis use into categories based on total number of times used (i.e., experimental = use 1-5 times, problematic = use ≥ 6 times), but combined, almost half (45.7%) of study participants reported a history of either category of cannabis use upon college entry.

Predictors of Lifetime Cannabis Use

The present study also examined predictors of lifetime experimental and problematic cannabis use. Lifetime IPT exposure was hypothesized to predict lifetime cannabis use above and beyond demographic and substance use covariates. Consistent with previous research (Kevorkian et al., 2015; Konkoly Thege et al., 2017; Werner et al., 2016), results show that individuals who reported lifetime IPT exposure were more likely to report lifetime experimental and problematic cannabis use. IPT is a stronger predictor of psychopathology compared to accidental trauma (Frans et al., 2005; Kilpatrick et al., 2013). Although previous research supports trauma exposure broadly predicting cannabis use (Kevorkian et al., 2015), results from this study support IPT exposure as a category of trauma exposure that is a predictor of increased risk for cannabis use. Similar to Kevorkian and colleagues (2015), alcohol, but not nicotine, was included as a predictor of cannabis use along with trauma exposure. However, a recent study investigating the co- and tri-use of cannabis, cigarettes, and alcohol without trauma as a predictor

found that the use of cannabis, cigarettes, or alcohol independently increased the probability of subsequent, simultaneous co-use of one of the two remaining substances (Roche et al., 2019). Therefore, our study expanded the literature by including both alcohol and nicotine as predictors of cannabis use in order to help demonstrate that IPT is associated with increased risk over other established correlates.

As hypothesized, demographic factors were associated with risk of reporting lifetime cannabis use. Regarding sex, it was hypothesized that men would be more likely to report a history of cannabis use compared to women. Results show that men were more likely to report lifetime problematic cannabis use compared to women, but men and women were equally likely to report lifetime experimental cannabis use. Results align with previous research, which suggests that men are more likely to use cannabis than women, and the differences tend to be most severe at higher frequency levels (Carliner et al., 2017; Johnston et al., 2016; Substance Abuse and Mental Health Services Administration, 2016). This sex gap regarding cannabis use could be due to both biological and sociological differences, such as how cannabis use affects the body, addiction stigma, and societal expectations about emotional expression. Results also mirrored similar epidemiologic research that examined sex differences in prevalence of CUDs (Kerridge, Pickering, Chou, Saha, & Hasin, 2018). Therefore, results expanded the literature by demonstrating the level of use (i.e., experimental versus problematic) where sex differences are more likely to be detected among college students.

While there were racial differences among those who were more likely to report lifetime cannabis use, the racial differences were not in the hypothesized direction. Specifically, it was hypothesized that individuals belonging to racial minority groups would be more likely to report cannabis use compared to White individuals. Results show that White individuals were more

likely to report both experimental and problematic cannabis use compared to Black, Asian, and Other individuals. Regarding race as a predictor of cannabis use, previous research shows that racial and ethnic minority individuals are more likely to report using cannabis compared to White individuals (Pacek et al., 2012; Warner, 2016). Therefore, the race results of this study are inconsistent with previous research suggesting that racial minority individuals are less likely to use cannabis compared to White individuals. Among adolescents on the trajectory to college, recent epidemiological study results show a trend that cannabis use is increasing in the United States among non-White adolescents in the 10th through 12th grades (Keyes, Wall, Feng, Cerda, & Hasin, 2017). These self-report survey procedures have been shown to enhance valid reporting by collecting data via non-school-associated university personnel. While Spit for Science is also collected via self-report, it is subject to potentially more bias and error due to its affiliation with the university, which provides a possible explanation for the inconsistent findings. However, consistent with previous research (Johnson et al., 2015), results showed that Asian individuals were the racial group least likely to report cannabis use. Regardless of the levels of cannabis use among racial and ethnic minorities, these individuals are still more likely than White individuals to experience negative consequences of cannabis use, including CUD, negative psychosocial outcomes, and academic difficulties (Blavos et al., 2017; Edwards et al., 2015).

Additional covariates were explored as predictors of lifetime cannabis use. Cohorts 3 and 4 were more likely to report lifetime problematic and experimental cannabis use, respectively, compared to cohort 1. These results are consistent with previous research suggesting that the overall prevalence of lifetime cannabis use is increasing among individuals 12 years and older and that younger generations are more likely to use cannabis compared to older generations due to increasing acceptance and legalization rates (Kilmer & MacCoun, 2017; Substance Abuse and

Mental Health Services Administration, 2016). In a related study investigating alcohol consumption and drinking to cope with trauma-related distress in the same sample, latter cohorts were overall more risky regarding their alcohol use (Bountress et al., 2019). Results from this study extended their overall more risky behavior to include cannabis use.

Legal substances, such as nicotine and alcohol, were explored as predictors of lifetime cannabis use. Individuals who reported more frequent nicotine use during the past month were more likely to report lifetime experimental cannabis use. Additionally, individuals who reported more frequent nicotine use during the past month and more frequent alcohol use during the past year were more likely to report lifetime problematic cannabis use. Post-hoc analyses revealed that individuals who reported more frequent alcohol use during the past year were more likely to report both lifetime experimental and problematic cannabis use when past 30-day nicotine use frequency was not included as a predictor. These results are consistent with previous epidemiological research suggesting that cannabis use is more common among people who smoke cigarettes than among those who do not (Goodwin et al., 2018). However, results extend the literature by showing more frequent nicotine use is a better predictor of lifetime cannabis use among individuals with both frequent nicotine and alcohol use, which could be due to the similar route of administration (i.e., inhalation). Although a majority of previous research supports the association between more severe phenotypes such as lifetime nicotine use, alcohol use, and cannabis use disorders (Grant et al., 2016; Kevorkian et al., 2015), these results are still consistent such that a history of alcohol and nicotine are predictors of increased risk for lifetime cannabis use.

Aim 1b: Prevalence and Predictors of Lifetime IPT Exposure

Overall Summary of Findings

This study estimated the prevalence of lifetime IPT exposure and investigated demographic and clinical characteristics as predictors of lifetime IPT exposure, which produced four main findings. First, results showed cross-sectional support for the high-risk hypothesis, such that individuals who reported a history of cannabis use were more likely to report lifetime IPT exposure. Second, results showed evidence for sex differences with respect to lifetime IPT exposure, such that women were more likely to report a history of IPT exposure compared to men. Third, results showed that all racial groups were equally likely to report a history of lifetime IPT exposure. Fourth, results showed evidence for nicotine use as a predictor of lifetime IPT exposure.

Prevalence of Lifetime IPT Exposure

The present study assessed the prevalence of lifetime IPT exposure among college students. Overall, 35.9% of participants reported lifetime IPT exposure. This study's findings were inconsistent with previous prevalence estimates, which suggested that about 50.6% of college students reported a history of IPT exposure (Read, Griffin, Wardell, & Ouimette, 2014). This inconsistency is likely due to the different ways trauma exposure was assessed. Read and colleagues (2014) used the Traumatic Life Events Questionnaire (TLEQ) to assess trauma exposure compared to Spit for Science's Life Events Checklist (LEC). In contrast, 11 out of the 21 items of the TLEQ map onto the definition of IPT opposed to 3 out of the 5 items of the modified LEC used in the present study. This lower prevalence estimate based on this study were likely due to lack of inclusion of other categories of IPT that are included in other measures, such as the TLEQ.

Predictors of Lifetime IPT Exposure

The present study also assessed predictors of lifetime IPT exposure. Lifetime cannabis use was hypothesized to predict lifetime IPT exposure above and beyond demographic and clinical covariates. Consistent with previous research investigating the association between lifetime cannabis use and lifetime trauma exposure (Kevorkian et al., 2015), results show that individuals with a history of cannabis use were more likely to report lifetime IPT exposure.

As hypothesized, there were demographic differences among those who were more likely to report lifetime IPT exposure. Results were consistent with the hypothesis that women would be more likely to report a history of IPT compared to men. Results align with previous research, which suggests that women are more likely to experience IPT than men in both college (Fedina, Holmes, & Backes, 2018; Read et al., 2011) and non-college (Benjet et al., 2016; Lilly & Valdez, 2012) samples. Results add to the substantial evidence that sex differences are universal regarding IPT exposure and that the college environment is no exception.

It was hypothesized that individuals belonging to racial minority groups would be more likely to report a history of IPT exposure compared to White individuals. Contrary to hypotheses, results indicate that there were no racial differences among those who reported lifetime IPT exposure. Although previous research has shown significant differences in IPT exposure across different racial and ethnic groups (Roberts et al., 2011), this study's results show that all college students, regardless of race, are equally likely to report lifetime IPT exposure prior to college enrollment. This inconsistency is likely due to the different ways trauma exposure was assessed. Roberts and colleagues (2011) used data from structured diagnostic interviews of the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) to assess lifetime trauma exposure compared to Spit for Science's LEC. In contrast, at least 6 out of the 27 items of the NESARC map onto the definition of IPT opposed to 3 out of the 5 items of the LEC. The equal

likelihood of individuals of different racial backgrounds having a history of IPT exposure based on this study could be due to having less specific and a lower variety of potential IPT events for participants to choose from during self-reported assessment of lifetime trauma exposure. Another possible explanation for the inconsistencies is that there may not be racial differences in IPT exposure among those seeking higher education compared to the general population. In a study examining trauma exposure of newly matriculated college students, Read and colleagues (2011) found that individuals from a non-White racial background were at higher risk for IPT exposure compared to White individuals. However, individuals who reported identifying as Black, Asian, Hispanic/Latino, American-Indian/Alaskan, Hawaiian/Pacific Islander, and Multiracial were grouped together for statistical analyses due to not ideal percentages of representation in most groups (i.e., < 10%). It is possible that racial differences may not have been found if analyses were conducted separately by larger racial groups.

Additional covariates were explored as predictors of lifetime IPT exposure. Cohorts 2, 3, and 4 were less likely to report a history of IPT exposure compared to cohort 1. Additionally, individuals who reported more frequent nicotine use during the past 30 days were more likely to report lifetime IPT exposure. These results are consistent with previous research, which indicate that current- and ever-smokers have increased odds of reporting experiencing traumatic events compared to never-smokers (Hapke et al., 2005). (Jamal et al., 2014), those who continue to smoke cigarettes could be classified as more risky individuals, and perhaps this may partially account for the increased risk for IPT exposure. Additionally, these analyses are cross-sectional, and thus order of onset cannot be determined. Thus, it could be that smoking behavior occurred subsequent to IPT exposure. There is a wealth of literature on increased smoking behaviors

among trauma and PTSD populations (Gabert-Quillen, Selya, & Delahanty, 2015; Kearns et al., 2018; Pericot-Valverde, Elliott, Miller, Tidey, & Gaalema, 2018).

Aim 2: Longitudinal Investigation of the Self-Medication and High-Risk Hypotheses

Overall Summary of Findings

The associations between lifetime cannabis use and lifetime IPT exposure speaks to the self-medication (Boden, Babson, Vujanovic, Short, & Bonn-Miller, 2013) and high-risk (Ramaekers, Berghaus, van Laar, & Drummer, 2004) hypotheses. According to the self-medication hypothesis, cannabis use may serve as an avoidance function for those with an IPT history and could be coping with trauma-related symptoms. Conversely, the high-risk hypothesis purports that using cannabis may lead to higher risk for experiencing trauma exposure. The self-medication and high-risk hypotheses can be used as a lens to try to understand the associations among cannabis use, trauma exposure, and PTSD, with longitudinal analyses allowing for methods by which one could examine links in these pathways. This study used these etiologic models of comorbid cannabis use and trauma-related phenotypes to investigate the relationships between lifetime IPT exposure and new onset cannabis use and lifetime cannabis use and new onset IPT exposure during the first year of college. Results supported the direction of effect from IPT to cannabis use, supporting the self-medication hypothesis, but not from IPT to cannabis use, not lending support to the high-risk hypothesis.

Self-Medication Hypothesis

Path analyses suggest that IPT exposure is a significant predictor of cannabis use above and beyond race, age, nicotine, alcohol, and previous cannabis use. These results are consistent with previous research, which suggests that trauma exposure tends to precede, rather than follow, the development of lifetime cannabis use and cannabis use problems (Kevorkian et al., 2015),

specifically IPT (Browne, Dolan, Simpson, Fortney, & Lehavot, 2018; Werner et al., 2016).

Results from the current study expanded the trauma-related and cannabis use phenotypes self-medication literature with the use of longitudinal data and a college sample. Kevorkian and colleagues (2015) used a nationally-representative sample of adults in the U.S. to examine the association between lifetime trauma exposure, PTSD, cannabis use, and CUD and found that individuals exposed to trauma are at a higher risk of using cannabis or developing cannabis use problems compared to individuals without a history of trauma exposure. Although the direction of effect cannot be determined due to the cross-sectional nature of the study, results suggest that because trauma-exposed individuals had higher odds of reporting cannabis use than non-trauma exposed individuals, there is a unique association between trauma exposure and cannabis use (2015). Werner and colleagues (2016) utilized data from a longitudinal study investigating alcohol-related problems and associated psychopathology in order to examine the direction of effect between trauma exposure and cannabis use. Specifically, Werner and colleagues (2016) examined the contribution of first reported age of onset given for trauma exposures to cannabis initiation in an all-female emerging adult twin sample. Results suggest that trauma exposure is an important contributor to cannabis initiation and provide support for the self-medication hypothesis posited to explain the development of comorbid PTSD-CUD. However, Werner and colleagues' (2016) results are limited by their use of an all-female sample and their reliance on retrospective self-report for the longitudinal nature of their study. In another all-female sample, Browne and colleagues (2018) examined the independent contributions of sexual trauma on past-year cannabis use including alcohol and tobacco use as covariates. Cross-sectional results revealed that regular cannabis use is common among individuals who had experienced sexual trauma, individuals with higher PTSD symptoms, and individuals reporting alcohol or tobacco

use. However, Browne and colleagues' (2018) results are limited by their use of an all-female and veteran sample. The current study combined previously supported associations and covariates to investigate patterns between trauma exposure and cannabis use. Overall, the current study results reveal that trauma exposure, specifically IPT, may be an important contributor to cannabis use, but suggest the importance of considering sex and polysubstance use when developing etiologic models of trauma-related phenotypes predicting cannabis use phenotypes.

High-Risk Hypothesis

Path analyses did not suggest that cannabis use is a significant predictor of IPT exposure. A majority of previous research on the functional relationship between substance use and trauma exposure has focused on substances besides cannabis (i.e., alcohol, cocaine) (Brady et al., 1998; Kaysen et al., 2006), but limited evidence on the longitudinal relationship between substance use and IPT exposure suggests that the misuse of cocaine may be associated with subsequent trauma exposure and post-trauma psychopathology (Brady et al., 1998). While the directionality of our results from Aim 1 cannot be determined, they demonstrated an association between lifetime cannabis use and lifetime IPT exposure similar to other studies examining the functional relationship between cocaine use and trauma-related psychopathology (Brady et al., 1998). However, our results do not show support for the prospective association between lifetime cannabis use potentially influencing new onset IPT exposure.

Previous studies examining trauma-related and substance use phenotypes from a high-risk hypothesis framework found a functional relationship between substance use and trauma exposure. For example, Davis and colleagues (2009) examined the effects of alcohol on women's sexual assault risk perception and found that alcohol may increase women's sexual

victimization likelihood through reduced sexual assault risk perception. Studies comparing behavioral effects of alcohol and cannabis use found that alcohol use caused more impairment than cannabis use at higher doses (Heishman, Arasteh, & Stitzer, 1997; Heishman, Stitzer, & Bigelow, 1988). One possible explanation the current study did not find a significant association between cannabis use and new onset IPT exposure could be that other substances, such as cocaine and alcohol, have more behavioral effects on the body than cannabis use at higher usage levels. Another possible explanation the current study did not find a significant association between cannabis use and new onset IPT exposure could be due to measurement error. It is possible that greater amounts or more frequent cannabis use is associated with a greater likelihood of new onset IPT exposure and the way cannabis use was measured in S4S cannot differentiate between low and high levels of use. There is a need for both more research on the effects of cannabis use on behavior effects and longitudinal studies investigating the effects of cannabis use on future trauma exposure.

Aim 3: Mediational Investigation of the Self-Medication and High-Risk Hypotheses

Overall Summary of Findings

A high rate of comorbidity clearly exists between PTSD and CUD (Bonn-Miller et al., 2012; Cougle et al., 2011; Kevorkian et al., 2015; Vlahov et al., 2002). Trauma exposure, specifically IPT, is highly likely to lead to PTSD; likewise, individuals who engage in substance use behaviors have been shown to have a higher likelihood of developing PTSD potentially due to an increase in risky behavior compared to individuals who do not engage in substance use behaviors (Brady et al., 1998; Chilcoat & Breslau, 1998; Davis et al., 2009). The self-medicating relationship between IPT and cannabis use could be mediated by a diagnosis of PTSD and the high-risk relationship between cannabis use and PTSD could be mediated by IPT. This study

used these etiologic models of comorbid cannabis use and trauma-related phenotypes to investigate the mediational relationships between lifetime IPT exposure, probable PTSD, and new onset cannabis use, as well as lifetime cannabis use, new onset IPT exposure, and probable PTSD during the first two years of college. Although the overall limitations of this study are detailed below, two critical limitations relevant to this aim warrant mention prior to interpretation of the results. First, a major caveat in the interpretation of these results is that the overall model fit was quite poor, which leads to a lack of confidence in the overall model and findings. Second, the probable-PTSD assessment is quite poor – consisting of a single item. Thus, results should be interpreted with caution. Results of these models did not find significant mediation in support of either self-medication or high-risk hypothesis.

Self-Medication Hypothesis

Path analyses suggest a functional relationship between lifetime IPT exposure and cannabis use during the first 2 years of college, but that it may not be due to the development of PTSD. These results are inconsistent with limited previous research, which suggests that individuals who have experienced IPT and developed PTSD may use cannabis to self-medicate their distress (Bonn-Miller et al., 2011). Potential reasons for these inconsistent results could be due to varying ways of measuring cannabis use and PTSD, as well as mechanisms that better explain self-medicating cannabis use. For example, the dichotomous measure of possible PTSD used in this study is eliminating the variance that has been shown to exist in other samples assessing continuous symptoms of PTSD among cannabis users (Bonn-Miller et al., 2011; Bonn-Miller, Vujanovic, Feldner, Bernstein, & Zvolensky, 2007). Another reason that our hypothesis may have not been supported could be due to the use of an epidemiological sample versus a clinical sample. For example, Bonn-Miller and colleagues (2007) used a clinical sample of

individuals who all reported meeting DSM-IV-TR PTSD Criteria A1 and A2 for at least one lifetime traumatic event and cannabis use in the past 30 days versus S4S's sample, which is representative of the entire VCU student body (Institutional Research and Decision Support, 2018), which is comparable to the national average of young adults regarding overall diversity (i.e., sex, racial/ethnic distribution) (Pew Research Center, 2010). If previous studies have documented cannabis use as a self-medicating behavior for PTSD in clinical samples, then it is possible that a sample consisting of a majority healthy, some subclinical, and even fewer clinical cases would yield different results. Additionally, Bonn-Miller and colleagues (2011) used a measure of cannabis use motives in their mediational model in which participants indicated the degree to which they used cannabis for a variety of possible reasons (e.g., coping). Although there has been an overall push towards the legalization of medical and recreational cannabis use in the past decade (Kilmer & MacCoun, 2017), recent research has shown that self-medication of mood and anxiety disorders with cannabis is higher in states with medical cannabis use laws compared to those without, such as Virginia (Sarvet et al., 2018). It is worth noting that medicinal cannabis use was legalized in Vermont in 2004, which could be a confounding factor influencing Bonn-Miller and colleagues' (2011; 2007) results. Given the limited number of studies examining cannabis use and PTSD through a self-medication lens, there is a need for more longitudinal research on cannabis use as a self-medicating behavior for PTSD in order to see if the relationship is specific to clinical populations or if it also applies to the general young adult population.

High-Risk Hypothesis

Path analyses do not suggest a functional relationship between lifetime cannabis use, new onset IPT exposure, and probable PTSD. Although results did show that more frequent alcohol

use was associated with subsequent IPT exposure, results specific to cannabis use as the main substance use behavior are inconsistent with previous substance use (i.e., alcohol, cocaine) literature that shows individuals who engage in problematic substance use behaviors are more likely to experience IPT and develop PTSD (Brady et al., 1998; Davis et al., 2009). One of the few studies that longitudinally examined cannabis use as a risk factor for future IPT exposure found that cannabis use predicted subsequent sexual victimization and physical assault victimization (Martino, Collins, & Ellickson, 2004). However, individuals who experienced IPT following cannabis use were also more likely to be involved in other risky behaviors, such as the sales of drugs, which could be confounding variables. One of the more recent longitudinal studies that investigated cannabis use as a risk factor for prospective IPT exposure combined cannabis use with other substance use (i.e., heroin, opiates, cocaine, alcohol) and found a positive relationship between substance use and interpersonal violence (Barrett, Teesson, & Mills, 2014). Potential explanations for the current study's inconsistent results could be due to measurement differences. For example, the current study did not separate IPT outcomes into physical and sexual assault similar to Martino and colleagues (2004) when examining the relationship between cannabis use, IPT exposure, and PTSD. Likewise, the current study examined cannabis, alcohol, and nicotine use as separate predictors of IPT exposure and PTSD unlike Barrett and colleagues (2014). Barrett and colleagues (2014) also used the Clinician Administered PTSD Scale (CAPS) to measure PTSD symptoms, which is the gold standard for assessing PTSD (Weathers et al., 2018), opposed to a one-item PTSD screener. Interestingly, results from this study are more similar to an older study, which found that cannabis users were at lower risk for developing PTSD compared to other substance users (i.e., cocaine, hallucinogens, alcohol), but at an increased risk for experiencing trauma exposure similar to

other substance users (Cottler, Compton, Mager, Spitznagel, & Janca, 1992). Given these conflicting results, more research is needed to understand individual-level varying factors that influence the complex relationship between cannabis use, IPT exposure, and the development of PTSD.

Limitations

Results must be viewed in the context of a number of limitations. First, although college students are at a high risk for trauma exposure (Elhai et al., 2012; Overstreet et al., 2017; Scarpa et al., 2002; Vrana & Lauterbach, 1994) and cannabis use (Blavos et al., 2017; Johnston et al., 2016; Suerken et al., 2014), they are a selected population, which may limit the generalizability of certain findings. Second, self-reported answers may be subjected to "social desirability" bias (i.e., people respond in ways that they think will be viewed favorably), which could influence data collection in the areas of illicit and/or illegal substance use (i.e., cannabis, underage drinking). Third, the measure used to assess PTSD was a one-item screener tool opposed to a diagnostic tool used to verify a clinical diagnosis and thus, rates of diagnosed PTSD are not as accurate as they could be. Using a one-item PTSD screener creates a situation where individuals who are subclinical and clinical cases are grouped together, which has negative implications in the data analysis process. For example, if the relationship between IPT exposure and problematic cannabis use is mediated by PTSD for more severe cases, then a PTSD screener would not be capable of detecting an effect. A similar limitation also applies to the study's assessment of IPT count, where all IPT exposures are weighted equally in terms of how they could lead to increased risk for negative consequences. However, research shows that some forms of IPT are more likely to lead to PTSD than others, such as childhood IPT (Hyland et al., 2017), which is not specifically measured in the current study. Fourth, while scales assessing coping-related motives

behind using licit substances (i.e., alcohol, nicotine) exist [i.e., Drinking Motives Questionnaire-Revised (Cooper, Russell, Skinner, & Windle, 1992)], no scale exists that measures trauma-specific coping-related cannabis use motives. A more specific scale will likely enrich the research on cannabis use and its impact on the effects of cannabis in humans, specifically using a self-medication framework. In order to attain more meaningful results, a standardized assessment tool for measuring cannabis use should be created, validated, and utilized in future studies. Currently, assessing cannabis use history can be difficult, especially for recreational cannabis use due to the lack of a standardized dose, varying levels of THC, and its effect on the body regarding the multiple routes of administration (Schauer, King, Bunnell, Promoff, & McAfee, 2016). Fifth, assessing whether a specified model fits the data is one of the most important steps in structural equation modelling (Yuan, 2005). Results from Aim 3 should be interpreted with caution due to poor model fit. Lastly, while the longitudinal nature of the Spit for Science data is a strength, the current study used the first, second, and third time points, where the second timepoint is relatively close to the first (i.e., 6 months). Therefore, there may not be enough time between assessments for the development of psychopathology to be detected using the brief assessment tools that were a part of Spit for Science, which could be heavily influencing study results. Further, only using three of the five time points limits the ability to examine trajectories. Future research should utilize more than three time points to further investigate these hypotheses and findings.

Implications and Future Directions

The current study identified both risk factors and consequences of cannabis use and IPT exposure among college students. Additionally, the current results can serve as a platform for future longitudinal studies examining the association between trauma-related and cannabis use

phenotypes to build upon. The cross-sectional and longitudinal association between IPT exposure and cannabis use remained consistent throughout all aims of the current study, but the mediational results regarding the self-medication and high-risk hypotheses may not have been supportive of the hypotheses due to confounding effects of individual-level factors that were not included in this study (i.e., socioeconomic status, parental income, peer substance use) or this study's broad measurement of clinical characteristics (i.e., problematic cannabis use, PTSD) may not be accurate enough to detect significant effects. However, these findings still have clinical implications. For example, the association between IPT exposure and subsequent cannabis use suggests the importance of trying to create safer college environments, particularly in the early stages of college, in prevention efforts aimed at reducing IPT exposure and cannabis use on college campuses. Existing work has shown the efficacy of brief interventions (i.e., initiating bystander intervention programs, safety escorts) aimed at reducing trauma exposure (Coker et al., 2015; Ponsford, 2016); future work should investigate whether such interventions lead to decreased cannabis use. Future research should also examine other factors that appear to be important in the relationship between IPT exposure and cannabis use, such as polysubstance use (Dierker, Braymiller, Rose, Goodwin, & Selya, 2018; Yurasek, Aston, & Metrik, 2017). Future investigations into predictors of cannabis use, IPT exposure, and PTSD will assist efforts to identify, prevent, and treat students at a greater risk for psychopathology. Previous research has convincingly demonstrated that the more students report using cannabis, the more they skip classes, have lower GPAs, have enrollment gaps, and do not graduate on time, which are all relatively short-term consequences of cannabis use that can have negative long-term effects on life trajectory (Arria et al., 2017; Suerken et al., 2016). Regarding short-term risks, any efforts made to prevent cannabis use could help improve academic outcomes among college students.

Given that results of the current study demonstrate that alcohol and nicotine use frequency is positively associated with cannabis use, the more established health risks of alcohol and nicotine use (Rehm, 2011; Trofor et al., 2018) could be used as a gateway to build rapport and start the conversation about potential health risks of cannabis use using a motivational interviewing approach. The general public currently minimizes potential risks of cannabis use (Keyhani et al., 2018), so by taking a motivational interviewing approach, individuals may begin to realize that they may be underestimating potential short- and long-term risks associated with cannabis use. The gaps in our understanding of the health effects and safety of regular cannabis use are extensive due to the irregularity of the drug and a lack of longitudinal studies. There is a need for the continued investment in cannabis use research not only to identify risk and protective factors for cannabis use, but to better understand short- and long-term consequences and health effects of cannabis use and how to communicate potential risks to the general public, similar to alcohol and nicotine use.

Conclusion

Overall, findings support an immediate, small effect of IPT exposure on cannabis use, which is preliminary evidence for the self-medication hypothesis. Although evidence for the high-risk hypothesis was not found, both etiologic models of comorbid PTSD-CUD should continue to be evaluated in other representative samples in order to investigate if and how these associations form in other populations. Additionally, findings suggest that measurement error could have an impact on the association between IPT exposure and cannabis use given this study's conflicting results with previous studies. The use of more specific assessment tools for cannabis use as well as PTSD should be used in future studies in order to investigate the etiologic models of comorbid PTSD-CUD. Although current study results should be interpreted

with caution due to poor model fit, college mental health centers could screen regularly for trauma exposure, PTSD, and behaviors such as substance and alcohol use, which could serve as crucial prevention efforts and treatment targets. This preliminary evidence of an association between IPT exposure and cannabis use provides an exciting direction for future research, which is warranted as cannabis use continues to gain public and legislature support for legalization with little longitudinal research to support how it could potentially affect individuals.

References

Agosti, V., Nunes, E., & Levin, F. (2002). Rates of psychiatric comorbidity among U.S. residents with lifetime cannabis dependence. *Am J Drug Alcohol Abuse, 28*(4), 643-652.

Agrawal, A., & Lynskey, M. T. (2006). The genetic epidemiology of cannabis use, abuse and dependence. *Addiction, 101*(6), 801-812. doi:10.1111/j.1360-0443.2006.01399.x

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5®)*. Washington, DC: American Psychiatric Pub.

Anders, S. L., Frazier, P. A., & Shallcross, S. L. (2012). Prevalence and effects of life event exposure among undergraduate and community college students. *J Couns Psychol, 59*(3), 449-457. doi:10.1037/a0027753

Anders, S. L., Shallcross, S. L., & Frazier, P. A. (2012). Beyond Criterion A1: the effects of relational and non-relational traumatic events. *J Trauma Dissociation, 13*(2), 134-151. doi:10.1080/15299732.2012.642744

Arria, A. M., Caldeira, K. M., Allen, H. K., Bugbee, B. A., Vincent, K. B., & O'Grady, K. E. (2017). Prevalence and incidence of drug use among college students: an 8-year longitudinal analysis. *Am J Drug Alcohol Abuse, 43*(6), 711-718. doi:10.1080/00952990.2017.1310219

Barrett, E. L., Teesson, M., & Mills, K. L. (2014). Associations between substance use, post-traumatic stress disorder and the perpetration of violence: A longitudinal investigation. *Addict Behav, 39*(6), 1075-1080. doi:10.1016/j.addbeh.2014.03.003

Benjet, C., Bromet, E., Karam, E. G., Kessler, R. C., McLaughlin, K. A., Ruscio, A. M., . . . Koenen, K. C. (2016). The epidemiology of traumatic event exposure worldwide: results

from the World Mental Health Survey Consortium. *Psychol Med, 46*(2), 327-343. doi:10.1017/S0033291715001981

Blavos, A. A., Glassman, T. J., Sheu, J. J., Thompson, A., DeNardo, F., & Diehr, A. J. (2017). Marijuana and college students: A critical review of the literature. *American Journal of Health Education, 48*(3), 167-184. doi:10.1080/19325037.2017.1292878

Boden, M. T., Babson, K. A., Vujanovic, A. A., Short, N. A., & Bonn-Miller, M. O. (2013). Posttraumatic stress disorder and cannabis use characteristics among military veterans with cannabis dependence. *Am J Addict, 22*(3), 277-284. doi:10.1111/j.1521-0391.2012.12018.x

Bohn, M. J., Babor, T. F., & Kranzler, H. R. (1995). The Alcohol Use Disorders Identification Test (AUDIT): validation of a screening instrument for use in medical settings. *J Stud Alcohol, 56*(4), 423-432.

Bohnert, K. M., Ilgen, M. A., Rosen, C. S., Desai, R. A., Austin, K., & Blow, F. C. (2013). The association between substance use disorders and mortality among a cohort of Veterans with posttraumatic stress disorder: variation by age cohort and mortality type. *Drug Alcohol Depend, 128*(1-2), 98-103. doi:10.1016/j.drugalcdep.2012.08.015

Bonn-Miller, M. O., Harris, A. H., & Trafton, J. A. (2012). Prevalence of cannabis use disorder diagnoses among veterans in 2002, 2008, and 2009. *Psychol Serv, 9*(4), 404-416. doi:10.1037/a0027622

Bonn-Miller, M. O., Vujanovic, A. A., Boden, M. T., & Gross, J. J. (2011). Posttraumatic stress, difficulties in emotion regulation, and coping-oriented marijuana use. *Cogn Behav Ther, 40*(1), 34-44. doi:10.1080/16506073.2010.525253

Bonn-Miller, M. O., Vujanovic, A. A., Feldner, M. T., Bernstein, A., & Zvolensky, M. J. (2007). Posttraumatic stress symptom severity predicts marijuana use coping motives among traumatic event-exposed marijuana users. *J Trauma Stress, 20*(4), 577-586. doi:10.1002/jts.20243

Bountress, K. E., Cusack, S. E., Sheerin, C. M., Hawn, S., Dick, D. M., Kendler, K. S., & Amstadter, A. B. (2019). Alcohol consumption, interpersonal trauma, and drinking to cope with trauma-related distress: An auto-regressive, cross-lagged model. *Psychol Addict Behav, 33*(3), 221-231. doi:10.1037/adb0000457

Bowe, A., & Rosenheck, R. (2015). PTSD and substance use disorder among veterans: characteristics, service utilization and pharmacotherapy. *J Dual Diagn, 11*(1), 22-32. doi:10.1080/15504263.2014.989653

Brady, J. E., & Li, G. (2014). Trends in alcohol and other drugs detected in fatally injured drivers in the United States, 1999-2010. *Am J Epidemiol, 179*(6), 692-699. doi:10.1093/aje/kwt327

Brady, K. T., Dansky, B. S., Sonne, S. C., & Saladin, M. E. (1998). Posttraumatic stress disorder and cocaine dependence. Order of onset. *Am J Addict, 7*(2), 128-135.

Bremner, J. D., Southwick, S. M., Darnell, A., & Charney, D. S. (1996). Chronic PTSD in Vietnam combat veterans: course of illness and substance abuse. *Am J Psychiatry, 153*(3), 369-375. doi:10.1176/ajp.153.3.369

Breslau, N., Davis, G. C., & Schultz, L. R. (2003). Posttraumatic stress disorder and the incidence of nicotine, alcohol, and other drug disorders in persons who have experienced trauma. *Arch Gen Psychiatry, 60*(3), 289-294.

Breslau, N., Kessler, R. C., Chilcoat, H. D., Schultz, L. R., Davis, G. C., & Andreski, P. (1998). Trauma and posttraumatic stress disorder in the community: the 1996 Detroit Area Survey of Trauma. *Arch Gen Psychiatry, 55*(7), 626-632.

Brewin, C. R., Andrews, B., & Valentine, J. D. (2000). Meta-analysis of risk factors for posttraumatic stress disorder in trauma-exposed adults. *J Consult Clin Psychol, 68*(5), 748-766.

Browne, K. C., Dolan, M., Simpson, T. L., Fortney, J. C., & Lehavot, K. (2018). Regular past year cannabis use in women veterans and associations with sexual trauma. *Addict Behav, 84*, 144-150. doi:10.1016/j.addbeh.2018.04.007

Bucholz, K. K., Cadoret, R., Cloninger, C. R., Dinwiddie, S. H., Hesselbrock, V. M., Nurnberger, J. I., Jr., . . . Schuckit, M. A. (1994). A new, semi-structured psychiatric interview for use in genetic linkage studies: a report on the reliability of the SSAGA. *J Stud Alcohol, 55*(2), 149-158.

Buckner, J. D., Joiner, T. E., Jr., Schmidt, N. B., & Zvolensky, M. J. (2012). Daily marijuana use and suicidality: the unique impact of social anxiety. *Addict Behav, 37*(4), 387-392. doi:10.1016/j.addbeh.2011.11.019

Byrne, B. M. (2013). *Structural equation modeling with EQS: Basic concepts, applications, and programming*: Routledge.

Carliner, H., Mauro, P. M., Brown, Q. L., Shmulewitz, D., Rahim-Juwel, R., Sarvet, A. L., . . . Hasin, D. S. (2017). The widening gender gap in marijuana use prevalence in the U.S. during a period of economic change, 2002-2014. *Drug Alcohol Depend, 170*, 51-58. doi:10.1016/j.drugalcdep.2016.10.042

Center for Behavioral Health Statistics and Quality. (2014). *National Survey on Drug Use and Health (NSDUH): Summary of Methodological Studies, 1971–2014. Substance Abuse and Mental Health Services Administration*. Retrieved from Rockville, MD: https://www.samhsa.gov/data/sites/default/files/NSDUHmethodsSummary2013/NSDUHmethodsSummary2013.pdf

Chilcoat, H. D., & Breslau, N. (1998). Investigations of causal pathways between PTSD and drug use disorders. *Addict Behav, 23*(6), 827-840.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple correlation/regression analysis for the behavioral sciences*: Routledge.

Coker, A. L., Fisher, B. S., Bush, H. M., Swan, S. C., Williams, C. M., Clear, E. R., & DeGue, S. (2015). Evaluation of the Green Dot Bystander Intervention to Reduce Interpersonal Violence Among College Students Across Three Campuses. *Violence Against Women, 21*(12), 1507-1527. doi:10.1177/1077801214545284

Compton, M. T., Simmons, C. M., Weiss, P. S., & West, J. C. (2011). Axis IV psychosocial problems among patients with psychotic or mood disorders with a cannabis use disorder comorbidity. *Am J Addict, 20*(6), 563-567. doi:10.1111/j.1521-0391.2011.00184.x

Cook, J., Jakupcak, M., Rosenheck, R., Fontana, A., & McFall, M. (2009). Influence of PTSD symptom clusters on smoking status among help-seeking Iraq and Afghanistan veterans. *Nicotine Tob Res, 11*(10), 1189-1195. doi:10.1093/ntr/ntp123

Cooper, M. L., Russell, M., Skinner, J. B., & Windle, M. (1992). Development and validation of a three-dimensional measure of drinking motives. *Psychological assessment, 4*(2), 123.

Cornelius, J. R., Kirisci, L., Reynolds, M., Clark, D. B., Hayes, J., & Tarter, R. (2010). PTSD contributes to teen and young adult cannabis use disorders. *Addict Behav, 35*(2), 91-94. doi:10.1016/j.addbeh.2009.09.007

Cottler, L. B., Compton, W. M., 3rd, Mager, D., Spitznagel, E. L., & Janca, A. (1992). Posttraumatic stress disorder among substance users from the general population. *Am J Psychiatry, 149*(5), 664-670. doi:10.1176/ajp.149.5.664

Cougle, J. R., Bonn-Miller, M. O., Vujanovic, A. A., Zvolensky, M. J., & Hawkins, K. A. (2011). Posttraumatic stress disorder and cannabis use in a nationally representative sample. *Psychol Addict Behav, 25*(3), 554-558. doi:10.1037/a0023076

Davis, K. C., Stoner, S. A., Norris, J., George, W. H., & Masters, N. T. (2009). Women's awareness of and discomfort with sexual assault cues: effects of alcohol consumption and relationship type. *Violence Against Women, 15*(9), 1106-1125. doi:10.1177/1077801209340759

Debell, F., Fear, N. T., Head, M., Batt-Rawden, S., Greenberg, N., Wessely, S., & Goodwin, L. (2014). A systematic review of the comorbidity between PTSD and alcohol misuse. *Soc Psychiatry Psychiatr Epidemiol, 49*(9), 1401-1425. doi:10.1007/s00127-014-0855-7

Dick, D. M., Nasim, A., Edwards, A. C., Salvatore, J. E., Cho, S. B., Adkins, A., . . . Kendler, K. S. (2014). Spit for Science: launching a longitudinal study of genetic and environmental influences on substance use and emotional health at a large US university. *Front Genet, 5*, 47. doi:10.3389/fgene.2014.00047

Dierker, L., Braymiller, J., Rose, J., Goodwin, R., & Selya, A. (2018). Nicotine dependence predicts cannabis use disorder symptoms among adolescents and young adults. *Drug Alcohol Depend, 187*, 212-220. doi:10.1016/j.drugalcdep.2018.02.037

Dore, G., Mills, K., Murray, R., Teesson, M., & Farrugia, P. (2012). Post-traumatic stress disorder, depression and suicidality in inpatients with substance use disorders. *Drug Alcohol Rev, 31*(3), 294-302. doi:10.1111/j.1465-3362.2011.00314.x

Dragan, M., & Lis-Turlejska, M. (2007). Prevalence of posttraumatic stress disorder in alcohol dependent patients in Poland. *Addict Behav, 32*(5), 902-911. doi:10.1016/j.addbeh.2006.06.025

Drug Abuse Warning Network. (2011). National Estimates of Drug-Related Emergency Department Visits: HHS Publication No. (SMA) 13-4760 (Table 9): DAWN Series D-39.

Edwards, E., Bunting, W., & Garcia, L. (2015). *The war on marijuana in black and white*. Retrieved from

Edwards, T., Catling, J. C., & Parry, E. (2016). Identifying predictors of resilience in students. *Psychology Teaching Review, 22*(1), 26-34.

Elhai, J. D., Miller, M. E., Ford, J. D., Biehn, T. L., Palmieri, P. A., & Frueh, B. C. (2012). Posttraumatic stress disorder in DSM-5: estimates of prevalence and symptom structure in a nonclinical sample of college students. *J Anxiety Disord, 26*(1), 58-64. doi:10.1016/j.janxdis.2011.08.013

Fedina, L., Holmes, J. L., & Backes, B. L. (2018). Campus Sexual Assault: A Systematic Review of Prevalence Research From 2000 to 2015. *Trauma Violence Abuse, 19*(1), 76-93. doi:10.1177/1524838016631129

Frans, O., Rimmo, P. A., Aberg, L., & Fredrikson, M. (2005). Trauma exposure and post-traumatic stress disorder in the general population. *Acta Psychiatr Scand, 111*(4), 291-299. doi:10.1111/j.1600-0447.2004.00463.x

Frazier, P., Anders, S., Perera, S., Tomich, P., Tennen, H., Park, C., & Tashiro, T. (2009). Traumatic events among undergraduate students: Prevalence and associated symptoms. *Journal of Counseling Psychology, 56*(3), 450.

Fu, S. S., McFall, M., Saxon, A. J., Beckham, J. C., Carmody, T. P., Baker, D. G., & Joseph, A. M. (2007). Post-traumatic stress disorder and smoking: a systematic review. *Nicotine Tob Res, 9*(11), 1071-1084. doi:10.1080/14622200701488418

Gabert-Quillen, C. A., Selya, A., & Delahanty, D. L. (2015). Post-traumatic stress disorder symptoms mediate the relationship between trauma exposure and smoking status in college students. *Stress Health, 31*(1), 78-82. doi:10.1002/smi.2543

George, D., & Mallery, P. (2016). *IBM SPSS Statistics 23 step by step: A simple guide and reference*: Routledge.

Gielen, N., Havermans, R. C., Tekelenburg, M., & Jansen, A. (2012). Prevalence of post-traumatic stress disorder among patients with substance use disorder: it is higher than clinicians think it is. *Eur J Psychotraumatol, 3*. doi:10.3402/ejpt.v3i0.17734

Goodwin, R. D., Pacek, L. R., Copeland, J., Moeller, S. J., Dierker, L., Weinberger, A., . . . Hasin, D. S. (2018). Trends in Daily Cannabis Use Among Cigarette Smokers: United States, 2002-2014. *Am J Public Health, 108*(1), 137-142. doi:10.2105/AJPH.2017.304050

Grant, B. F., Saha, T. D., Ruan, W. J., Goldstein, R. B., Chou, S. P., Jung, J., . . . Hasin, D. S. (2016). Epidemiology of DSM-5 Drug Use Disorder: Results From the National Epidemiologic Survey on Alcohol and Related Conditions-III. *JAMA Psychiatry, 73*(1), 39-47. doi:10.1001/jamapsychiatry.2015.2132

Gray, M. J., Litz, B. T., Hsu, J. L., & Lombardo, T. W. (2004). Psychometric properties of the life events checklist. *Assessment, 11*(4), 330-341. doi:10.1177/1073191104269954

Hall, W. D. (1994). The health and psychological effects of cannabis use. *Current Issues Crim. Just., 6*, 208.

Hall, W. D. (2006). Cannabis use and the mental health of young people. *Aust N Z J Psychiatry, 40*(2), 105-113. doi:10.1080/j.1440-1614.2006.01756.x

Hall, W. D., & Degenhardt, L. (2009). Adverse health effects of non-medical cannabis use. *Lancet, 374*(9698), 1383-1391. doi:10.1016/S0140-6736(09)61037-0

Hall, W. D., & Pacula, R. L. (2003). *Cannabis use and dependence: public health and public policy*: Cambridge university press.

Hapke, U., Schumann, A., Rumpf, H. J., John, U., Konerding, U., & Meyer, C. (2005). Association of smoking and nicotine dependence with trauma and posttraumatic stress disorder in a general population sample. *J Nerv Ment Dis, 193*(12), 843-846. doi:10.1097/01.nmd.0000188964.83476.e0

Hasin, D. S., Kerridge, B. T., Saha, T. D., Huang, B., Pickering, R., Smith, S. M., . . . Grant, B. F. (2016). Prevalence and Correlates of DSM-5 Cannabis Use Disorder, 2012-2013: Findings from the National Epidemiologic Survey on Alcohol and Related Conditions-III. *Am J Psychiatry, 173*(6), 588-599. doi:10.1176/appi.ajp.2015.15070907

Hasin, D. S., Saha, T. D., Kerridge, B. T., Goldstein, R. B., Chou, S. P., Zhang, H., . . . Grant, B. F. (2015). Prevalence of Marijuana Use Disorders in the United States Between 2001-2002 and 2012-2013. *JAMA Psychiatry, 72*(12), 1235-1242. doi:10.1001/jamapsychiatry.2015.1858

Hasin, D. S., Sarvet, A. L., Cerda, M., Keyes, K. M., Stohl, M., Galea, S., & Wall, M. M. (2017). US Adult Illicit Cannabis Use, Cannabis Use Disorder, and Medical Marijuana Laws: 1991-1992 to 2012-2013. *JAMA Psychiatry, 74*(6), 579-588. doi:10.1001/jamapsychiatry.2017.0724

Heishman, S. J., Arasteh, K., & Stitzer, M. L. (1997). Comparative effects of alcohol and marijuana on mood, memory, and performance. *Pharmacol Biochem Behav, 58*(1), 93-101. doi:10.1016/s0091-3057(96)00456-x

Heishman, S. J., Stitzer, M. L., & Bigelow, G. E. (1988). Alcohol and marijuana: comparative dose effect profiles in humans. *Pharmacol Biochem Behav, 31*(3), 649-655. doi:10.1016/0091-3057(88)90244-4

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1-55.

Hyland, P., Murphy, J., Shevlin, M., Vallieres, F., McElroy, E., Elklit, A., . . . Cloitre, M. (2017). Variation in post-traumatic response: the role of trauma type in predicting ICD-11 PTSD and CPTSD symptoms. *Soc Psychiatry Psychiatr Epidemiol, 52*(6), 727-736. doi:10.1007/s00127-017-1350-8

IBM Corporation. (2016). SPSS for Mac, version 24.

Institutional Research and Decision Support. (2018). *Statistical Summary (2017-18): Enrollment (Fall 2018)*. Retrieved from https://opds.vcu.edu/eaar/facts-and-figures/

Jacobsen, L. K., Southwick, S. M., & Kosten, T. R. (2001). Substance use disorders in patients with posttraumatic stress disorder: a review of the literature. *Am J Psychiatry, 158*(8), 1184-1190. doi:10.1176/appi.ajp.158.8.1184

Jakupcak, M., Tull, M. T., McDermott, M. J., Kaysen, D. L., Hunt, S., & Simpson, T. (2010). PTSD symptom clusters in relationship to alcohol misuse among Iraq and Afghanistan war veterans seeking post-deployment VA health care. *Addict Behav, 35*(9), 840-843. doi:10.1016/j.addbeh.2010.03.023

Jamal, A., Agaku, I. T., O'Connor, E., King, B. A., Kenemer, J. B., & Neff, L. (2014). Current cigarette smoking among adults--United States, 2005-2013. *MMWR Morb Mortal Wkly Rep, 63*(47), 1108-1112.

Johnson, R. M., Fairman, B., Gilreath, T., Xuan, Z., Rothman, E. F., Parnham, T., & Furr-Holden, C. D. (2015). Past 15-year trends in adolescent marijuana use: Differences by race/ethnicity and sex. *Drug Alcohol Depend, 155*, 8-15. doi:10.1016/j.drugalcdep.2015.08.025

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2006). *Monitoring the future national survey results on drug use 1975–2005. Volume I: Secondary school students*. Retrieved from https://files.eric.ed.gov/fulltext/ED495780.pdf

Johnston, L. D., O'Malley, P. M., Bachman, J. G., Schulenberg, J. E., & Miech, R. A. (2016). *Monitoring the future national survey results on drug use, 1975-2015: Volume II, college students and adults ages 19-55*. Retrieved from https://deepblue.lib.umich.edu/bitstream/handle/2027.42/137906/mtf-vol2_2015.pdf?sequence=1&isAllowed=y

Kalant, H. (2004). Adverse effects of cannabis on health: an update of the literature since 1996. *Prog Neuropsychopharmacol Biol Psychiatry, 28*(5), 849-863. doi:10.1016/j.pnpbp.2004.05.027

Kaysen, D., Atkins, D. C., Moore, S. A., Lindgren, K. P., Dillworth, T., & Simpson, T. (2011). Alcohol Use, Problems, and the Course of Posttraumatic Stress Disorder: A Prospective Study of Female Crime Victims. *J Dual Diagn, 7*(4), 262-279. doi:10.1080/15504263.2011.620449

Kaysen, D. L., Simpson, T., Dillworth, T., Larimer, M. E., Gutner, C., & Resick, P. A. (2006). Alcohol problems and posttraumatic stress disorder in female crime victims. *J Trauma Stress, 19*(3), 399-403. doi:10.1002/jts.20122

Kearns, N. T., Carl, E., Stein, A. T., Vujanovic, A. A., Zvolensky, M. J., Smits, J. A. J., & Powers, M. B. (2018). Posttraumatic stress disorder and cigarette smoking: A systematic review. *Depress Anxiety, 35*(11), 1056-1072. doi:10.1002/da.22828

Kendler, K. S., Karkowski, L. M., & Prescott, C. A. (1999). The assessment of dependence in the study of stressful life events: validation using a twin design. *Psychol Med, 29*(6), 1455-1460.

Kerridge, B. T., Pickering, R., Chou, P., Saha, T. D., & Hasin, D. S. (2018). DSM-5 cannabis use disorder in the national epidemiologic survey on alcohol and related conditions-III: gender-specific profiles. *Addictive Behaviors, 76*, 52-60.

Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry, 62*(6), 593-602. doi:10.1001/archpsyc.62.6.593

Kessler, R. C., Chiu, W. T., Demler, O., Merikangas, K. R., & Walters, E. E. (2005). Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry, 62*(6), 617-627. doi:10.1001/archpsyc.62.6.617

Kevorkian, S., Bonn-Miller, M. O., Belendiuk, K., Carney, D. M., Roberson-Nay, R., & Berenz, E. C. (2015). Associations among trauma, posttraumatic stress disorder, cannabis use, and cannabis use disorder in a nationally representative epidemiologic sample. *Psychol Addict Behav, 29*(3), 633-638. doi:10.1037/adb0000110

Keyes, K. M., Wall, M., Feng, T., Cerda, M., & Hasin, D. S. (2017). Race/ethnicity and marijuana use in the United States: Diminishing differences in the prevalence of use, 2006-2015. *Drug Alcohol Depend, 179*, 379-386. doi:10.1016/j.drugalcdep.2017.07.027

Keyhani, S., Steigerwald, S., Ishida, J., Vali, M., Cerda, M., Hasin, D., . . . Cohen, B. E. (2018). Risks and Benefits of Marijuana Use: A National Survey of U.S. Adults. *Ann Intern Med, 169*(5), 282-290. doi:10.7326/M18-0810

Khan, S. S., Secades-Villa, R., Okuda, M., Wang, S., Perez-Fuentes, G., Kerridge, B. T., & Blanco, C. (2013). Gender differences in cannabis use disorders: results from the National Epidemiologic Survey of Alcohol and Related Conditions. *Drug Alcohol Depend, 130*(1-3), 101-108. doi:10.1016/j.drugalcdep.2012.10.015

Khantzian, E. J. (1985). The self-medication hypothesis of addictive disorders: focus on heroin and cocaine dependence. *Am J Psychiatry, 142*(11), 1259-1264. doi:10.1176/ajp.142.11.1259

Kilmer, B., & MacCoun, R. J. (2017). How medical marijuana smoothed the transition to marijuana legalization in the United States. *Annu. Rev. Law Soc. Sci., 13*, 181-202. doi:10.1146/annurev-lawsocsci-110615-084851

Kilpatrick, D. G., Acierno, R., Saunders, B., Resnick, H. S., Best, C. L., & Schnurr, P. P. (2000). Risk factors for adolescent substance abuse and dependence: data from a national sample. *J Consult Clin Psychol, 68*(1), 19-30.

Kilpatrick, D. G., Resnick, H. S., Milanak, M. E., Miller, M. W., Keyes, K. M., & Friedman, M. J. (2013). National estimates of exposure to traumatic events and PTSD prevalence using DSM-IV and DSM-5 criteria. *J Trauma Stress, 26*(5), 537-547. doi:10.1002/jts.21848

Konkoly Thege, B., Horwood, L., Slater, L., Tan, M. C., Hodgins, D. C., & Wild, T. C. (2017). Relationship between interpersonal trauma exposure and addictive behaviors: a systematic review. *BMC Psychiatry, 17*(1), 164. doi:10.1186/s12888-017-1323-1

Krueger, R. F., & Markon, K. E. (2006). Reinterpreting comorbidity: a model-based approach to understanding and classifying psychopathology. *Annu Rev Clin Psychol, 2*, 111-133. doi:10.1146/annurev.clinpsy.2.022305.095213

Leibsohn, J. (1994). The relationship between drug and alcohol use and peer group associations of college freshmen as they transition from high school. *J Drug Educ, 24*(3), 177-192. doi:10.2190/DVYX-PUX7-KA7T-1X4R

Lilly, M. M., & Valdez, C. E. (2012). Interpersonal trauma and PTSD: The roles of gender and a lifespan perspective in predicting risk. *Psychological Trauma: Theory, Research, Practice, and Policy, 4*(1), 140. doi:10.1037/a0022947

Lopez-Quintero, C., Perez de los Cobos, J., Hasin, D. S., Okuda, M., Wang, S., Grant, B. F., & Blanco, C. (2011). Probability and predictors of transition from first use to dependence on nicotine, alcohol, cannabis, and cocaine: results of the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). *Drug Alcohol Depend, 115*(1-2), 120-130. doi:10.1016/j.drugalcdep.2010.11.004

Lyons, M. J., Goldberg, J., Eisen, S. A., True, W., Tsuang, M. T., Meyer, J. M., & Henderson, W. G. (1993). Do genes influence exposure to trauma? A twin study of combat. *Am J Med Genet, 48*(1), 22-27. doi:10.1002/ajmg.1320480107

Martino, S. C., Collins, R. L., & Ellickson, P. L. (2004). Substance use and vulnerability to sexual and physical aggression: a longitudinal study of young adults. *Violence Vict, 19*(5), 521-540.

Mills, K. L., Lynskey, M., Teesson, M., Ross, J., & Darke, S. (2005). Post-traumatic stress disorder among people with heroin dependence in the Australian treatment outcome study (ATOS): prevalence and correlates. *Drug Alcohol Depend, 77*(3), 243-249. doi:10.1016/j.drugalcdep.2004.08.016

Muthen, L. K., & Muthen, B. O. (2017). *Mplus*. Los Angeles: Muthen & Muthen.

Najavits, L. M., & Hien, D. (2013). Helping vulnerable populations: a comprehensive review of the treatment outcome literature on substance use disorder and PTSD. *J Clin Psychol, 69*(5), 433-479. doi:10.1002/jclp.21980

National Center for Education Statistics, & US Department of Education. (2016). Fast facts: Back to school statistics. Retrieved from https://nces.ed.gov/fastfacts/display.asp?id=372

Neter, J., Wasserman, W., & Kutner, M. G. (1989). Applied linear regression analysis. *Homewood, IL: Irwin*.

Netto, L. R., Cavalcanti-Ribeiro, P., Pereira, J. L., Nogueira, J. F., Santos, L. L., Lira, S. B., . . . Quarantini, L. C. (2013). Clinical and socio-demographic characteristics of college students exposed to traumatic experiences: a census of seven college institutions in Northeastern Brazil. *PLoS One, 8*(11), e78677. doi:10.1371/journal.pone.0078677

North, C. S., Nixon, S. J., Shariat, S., Mallonee, S., McMillen, J. C., Spitznagel, E. L., & Smith, E. M. (1999). Psychiatric disorders among survivors of the Oklahoma City bombing. *JAMA, 282*(8), 755-762.

Olff, M. (2017). Sex and gender differences in post-traumatic stress disorder: an update. *European Journal of Psychotraumatology, 8*((sup4)), 1351204.

Ouimette, P., Read, J. P., Wade, M., & Tirone, V. (2010). Modeling associations between posttraumatic stress symptoms and substance use. *Addict Behav, 35*(1), 64-67. doi:10.1016/j.addbeh.2009.08.009

Overstreet, C., Berenz, E. C., Kendler, K. S., Dick, D. M., & Amstadter, A. B. (2017). Predictors and mental health outcomes of potentially traumatic event exposure. *Psychiatry Res, 247*, 296-304. doi:10.1016/j.psychres.2016.10.047

Ozer, E. J., Best, S. R., Lipsey, T. L., & Weiss, D. S. (2003). Predictors of posttraumatic stress disorder and symptoms in adults: a meta-analysis. *Psychol Bull, 129*(1), 52-73.

Pacek, L. R., Malcolm, R. J., & Martins, S. S. (2012). Race/ethnicity differences between alcohol, marijuana, and co-occurring alcohol and marijuana use disorders and their association with public health and social problems using a national sample. *Am J Addict, 21*(5), 435-444. doi:10.1111/j.1521-0391.2012.00249.x

Peirce, J. M., Kindbom, K. A., Waesche, M. C., Yuscavage, A. S., & Brooner, R. K. (2008). Posttraumatic stress disorder, gender, and problem profiles in substance dependent patients. *Subst Use Misuse, 43*(5), 596-611. doi:10.1080/10826080701204623

Pericot-Valverde, I., Elliott, R. J., Miller, M. E., Tidey, J. W., & Gaalema, D. E. (2018). Posttraumatic stress disorder and tobacco use: A systematic review and meta-analysis. *Addict Behav, 84*, 238-247. doi:10.1016/j.addbeh.2018.04.024

Pew Research Center. (2010). Millennials: A Portrait of Generation Next. Retrieved from https://www.pewresearch.org/wp-content/uploads/sites/3/2010/10/millennials-confident-connected-open-to-change.pdf

Pietrzak, R. H., Goldstein, R. B., Southwick, S. M., & Grant, B. F. (2011). Prevalence and Axis I comorbidity of full and partial posttraumatic stress disorder in the United States: results from Wave 2 of the National Epidemiologic Survey on Alcohol and Related Conditions. *J Anxiety Disord, 25*(3), 456-465. doi:10.1016/j.janxdis.2010.11.010

Ponsford, L. R. (2016). Assessing mental health and violence on college campuses using the vulnerability model. *J Am Assoc Nurse Pract, 28*(4), 212-217. doi:10.1002/2327-6924.12351

Possemato, K., Wade, M., Andersen, J., & Ouimette, P. (2010). The impact of PTSD, depression, and substance use disorders on disease burden and health care utilization among OEF/OIF veterans. *Psychological Trauma: Theory, Research, Practice, and Policy, 2*(3), 218.

Prins, A., Bovin, M. J., Smolenski, D. J., Marx, B. P., Kimerling, R., Jenkins-Guarnieri, M. A., . . . Tiet, Q. Q. (2016). The Primary Care PTSD Screen for DSM-5 (PC-PTSD-5): Development and Evaluation Within a Veteran Primary Care Sample. *J Gen Intern Med, 31*(10), 1206-1211. doi:10.1007/s11606-016-3703-5

Ramaekers, J. G., Berghaus, G., van Laar, M., & Drummer, O. H. (2004). Dose related risk of motor vehicle crashes after cannabis use. *Drug Alcohol Depend, 73*(2), 109-119.

Read, J. P., Griffin, M. J., Wardell, J. D., & Ouimette, P. (2014). Coping, PTSD symptoms, and alcohol involvement in trauma-exposed college students in the first three years of college. *Psychol Addict Behav, 28*(4), 1052-1064. doi:10.1037/a0038348

Read, J. P., Ouimette, P., White, J., Colder, C., & Farrow, S. (2011). Rates of DSM-IV-TR Trauma Exposure and Posttraumatic Stress Disorder Among Newly Matriculated College Students. *Psychol Trauma, 3*(2), 148-156. doi:10.1037/a0021260

Reed, P. L., Anthony, J. C., & Breslau, N. (2007). Incidence of drug problems in young adults exposed to trauma and posttraumatic stress disorder: do early life experiences and predispositions matter? *Arch Gen Psychiatry, 64*(12), 1435-1442. doi:10.1001/archpsyc.64.12.1435

Rehm, J. (2011). The risks associated with alcohol use and alcoholism. *Alcohol Res Health, 34*(2), 135-143.

Reynolds, M., Hinchliffe, K., Asamoah, V., & Kouimtsidis, C. (2011). Trauma and post-traumatic stress disorder in a drug treatment community service. *The Psychiatrist, 35*(7), 256-260.

Roberts, A. L., Gilman, S. E., Breslau, J., Breslau, N., & Koenen, K. C. (2011). Race/ethnic differences in exposure to traumatic events, development of post-traumatic stress disorder, and treatment-seeking for post-traumatic stress disorder in the United States. *Psychol Med, 41*(1), 71-83. doi:10.1017/S0033291710000401

Roche, D. J. O., Bujarski, S., Green, R., Hartwell, E. E., Leventhal, A. M., & Ray, L. A. (2019). Alcohol, tobacco, and marijuana consumption is associated with increased odds of same-day substance co- and tri-use. *Drug Alcohol Depend, 200*, 40-49. doi:10.1016/j.drugalcdep.2019.02.035

Rouse, B., Sanderson, C., & Feldmann, J. (2002). Results from the 2001 national household survey on drug abuse: Volume I. Summary of national findings. *Rockville: Substance Abuse and Mental Health Services Administration, Office of Applied Studies*.

Santiago, P. N., Ursano, R. J., Gray, C. L., Pynoos, R. S., Spiegel, D., Lewis-Fernandez, R., . . . Fullerton, C. S. (2013). A systematic review of PTSD prevalence and trajectories in

DSM-5 defined trauma exposed populations: intentional and non-intentional traumatic events. *PLoS One, 8*(4), e59236. doi:10.1371/journal.pone.0059236

Sartor, C. E., McCutcheon, V. V., Pommer, N. E., Nelson, E. C., Grant, J. D., Duncan, A. E., . . . Heath, A. C. (2011). Common genetic and environmental contributions to post-traumatic stress disorder and alcohol dependence in young women. *Psychol Med, 41*(7), 1497-1505. doi:10.1017/S0033291710002072

Sarvet, A. L., Wall, M. M., Keyes, K. M., Olfson, M., Cerda, M., & Hasin, D. S. (2018). Self-medication of mood and anxiety disorders with marijuana: Higher in states with medical marijuana laws. *Drug Alcohol Depend, 186*, 10-15. doi:10.1016/j.drugalcdep.2018.01.009

Scarpa, A., Fikretoglu, D., Bowser, F., Hurley, J. D., Pappert, C. A., Romero, N., & Van Voorhees, E. (2002). Community violence exposure in university students: A replication and extension. *Journal of Interpersonal Violence, 17*(3), 253-272.

Schauer, G. L., King, B. A., Bunnell, R. E., Promoff, G., & McAfee, T. A. (2016). Toking, Vaping, and Eating for Health or Fun: Marijuana Use Patterns in Adults, U.S., 2014. *Am J Prev Med, 50*(1), 1-8. doi:10.1016/j.amepre.2015.05.027

Shishko, I., Oliveira, R., Moore, T. A., & Almeida, K. (2018). A review of medical marijuana for the treatment of posttraumatic stress disorder: Real symptom re-leaf or just high hopes? *Mental Health Clinician, 8*(2), 86-94.

Smyth, J. M., Hockemeyer, J. R., Heron, K. E., Wonderlich, S. A., & Pennebaker, J. W. (2008). Prevalence, type, disclosure, and severity of adverse life events in college students. *J Am Coll Health, 57*(1), 69-76. doi:10.3200/JACH.57.1.69-76

Stein, M. B., Jang, K. L., Taylor, S., Vernon, P. A., & Livesley, W. J. (2002). Genetic and environmental influences on trauma exposure and posttraumatic stress disorder symptoms: a twin study. *Am J Psychiatry, 159*(10), 1675-1681. doi:10.1176/appi.ajp.159.10.1675

Stekhoven, D. J., & Buhlmann, P. (2012). MissForest--non-parametric missing value imputation for mixed-type data. *Bioinformatics, 28*(1), 112-118. doi:10.1093/bioinformatics/btr597

Stewart, S. H., Pihl, R. O., Conrod, P. J., & Dongier, M. (1998). Functional associations among trauma, PTSD, and substance-related disorders. *Addict Behav, 23*(6), 797-812.

Stinson, F. S., Ruan, W. J., Pickering, R., & Grant, B. F. (2006). Cannabis use disorders in the USA: prevalence, correlates and co-morbidity. *Psychol Med, 36*(10), 1447-1460. doi:10.1017/S0033291706008361

Substance Abuse and Mental Health Service Administration. (2013). *Results from the 2013 National Survey on Drug Use and Health: Summary of National Findings*. Retrieved from Rockville, MD: https://www.samhsa.gov/data/sites/default/files/NSDUHresultsPDFWHTML2013/Web/NSDUHresults2013.pdf

Substance Abuse and Mental Health Services Administration. (2016). Key substance use and mental health indicators in the United States: Results from the 2015 National Survey on Drug Use and Health. *Substance Abuse and Mental Health Services Administration website. https://www. samhsa.gov/data/sites/default/files/NSDUH-FFR1-2015/NSDUH-FFR1-2015/NSDUH-FFR1-2015.pdf.*

Suerken, C. K., Reboussin, B. A., Egan, K. L., Sutfin, E. L., Wagoner, K. G., Spangler, J., & Wolfson, M. (2016). Marijuana use trajectories and academic outcomes among college students. *Drug Alcohol Depend, 162*, 137-145. doi:10.1016/j.drugalcdep.2016.02.041

Suerken, C. K., Reboussin, B. A., Sutfin, E. L., Wagoner, K. G., Spangler, J., & Wolfson, M. (2014). Prevalence of marijuana use at college entry and risk factors for initiation during freshman year. *Addict Behav, 39*(1), 302-307.

Sullivan, G. M., & Feinn, R. (2012). Using Effect Size-or Why the P Value Is Not Enough. *J Grad Med Educ, 4*(3), 279-282. doi:10.4300/JGME-D-12-00156.1

Swift, W., Coffey, C., Carlin, J. B., Degenhardt, L., & Patton, G. C. (2008). Adolescent cannabis users at 24 years: trajectories to regular weekly use and dependence in young adulthood. *Addiction, 103*(8), 1361-1370. doi:10.1111/j.1360-0443.2008.02246.x

Trofor, A. C., Papadakis, S., Lotrean, L. M., Radu-Loghin, C., Eremia, M., Mihaltan, F., . . . consortium, E.-P. (2018). Knowledge of the health risks of smoking and impact of cigarette warning labels among tobacco users in six European countries: Findings from the EUREST-PLUS ITC Europe Surveys. *Tob Induc Dis, 16*, A10. doi:10.18332/tid/99542

Vlahov, D., Galea, S., Resnick, H., Ahern, J., Boscarino, J. A., Bucuvalas, M., . . . Kilpatrick, D. (2002). Increased use of cigarettes, alcohol, and marijuana among Manhattan, New York, residents after the September 11th terrorist attacks. *Am J Epidemiol, 155*(11), 988-996.

Vrana, S., & Lauterbach, D. (1994). Prevalence of traumatic events and post-traumatic psychological symptoms in a nonclinical sample of college students. *J Trauma Stress, 7*(2), 289-302.

Walsh, A. (1992). Drug use and sexual behavior: users, experimenters, and abstainers. *J Soc Psychol, 132*(5), 691-693. doi:10.1080/00224545.1992.9713911

Warner, T. D. (2016). Up in Smoke: Neighborhood Contexts of Marijuana Use from Adolescence Through Young Adulthood. *J Youth Adolesc, 45*(1), 35-53. doi:10.1007/s10964-015-0370-5

Watson, S. B., & Haynes, S. N. (2007). Brief screening for traumatic life events in female university health service patients. *International Journal of Clinical and Health Psychology, 7*(2).

Weathers, F. W., Bovin, M. J., Lee, D. J., Sloan, D. M., Schnurr, P. P., Kaloupek, D. G., . . . Marx, B. P. (2018). The Clinician-Administered PTSD Scale for DSM-5 (CAPS-5): Development and initial psychometric evaluation in military veterans. *Psychol Assess, 30*(3), 383-395. doi:10.1037/pas0000486

Werner, K. B., McCutcheon, V. V., Agrawal, A., Sartor, C. E., Nelson, E. C., Heath, A. C., & Bucholz, K. K. (2016). The association of specific traumatic experiences with cannabis initiation and transition to problem use: Differences between African-American and European-American women. *Drug Alcohol Depend, 162*, 162-169. doi:10.1016/j.drugalcdep.2016.03.003

White, H. R., Labouvie, E. W., & Papadaratsakis, V. (2005). Changes in substance use during the transition to adulthood a comparison of college students and their noncollege age peers. *Journal of Drug Issues, 35*(2), 281-305.

Whitehill, J. M., Rivara, F. P., & Moreno, M. A. (2014). Marijuana-using drivers, alcohol-using drivers, and their passengers: prevalence and risk factors among underage college students. *JAMA Pediatr, 168*(7), 618-624. doi:10.1001/jamapediatrics.2013.5300

Windle, M. (1994). Substance use, risky behaviors, and victimization among a US national adolescent sample. *Addiction, 89*(2), 175-182.

Windle, M., Haardorfer, R., Lloyd, S. A., Foster, B., & Berg, C. J. (2017). Social Influences on College Student Use of Tobacco Products, Alcohol, and Marijuana. *Subst Use Misuse, 52*(9), 1111-1119. doi:10.1080/10826084.2017.1290116

Windle, M., & Zucker, R. A. (2010). Reducing underage and young adult drinking: how to address critical drinking problems during this developmental period. *Alcohol Res Health, 33*(1-2), 29-44.

Wolf, E. J., Miller, M. W., Krueger, R. F., Lyons, M. J., Tsuang, M. T., & Koenen, K. C. (2010). Posttraumatic stress disorder and the genetic structure of comorbidity. *J Abnorm Psychol, 119*(2), 320-330. doi:10.1037/a0019035

Xian, H., Chantarujikapong, S. I., Scherrer, J. F., Eisen, S. A., Lyons, M. J., Goldberg, J., . . . True, W. R. (2000). Genetic and environmental influences on posttraumatic stress disorder, alcohol and drug dependence in twin pairs. *Drug Alcohol Depend, 61*(1), 95-102.

Ystrom, E., Reichborn-Kjennerud, T., Neale, M. C., & Kendler, K. S. (2014). Genetic and environmental risk factors for illicit substance use and use disorders: Joint analysis of self and co-twin ratings. *Behav Genet, 44*(1), 1-13. doi:10.1007/s10519-013-9626-6

Yuan, K. H. (2005). Fit Indices Versus Test Statistics. *Multivariate Behav Res, 40*(1), 115-148. doi:10.1207/s15327906mbr4001_5

Yurasek, A. M., Aston, E. R., & Metrik, J. (2017). Co-use of alcohol and cannabis: A review. *Current Addiction Reports, 4*(2), 184-193.

Appendix

Below are the variable names and their corresponding questions from VCU's Spit for Science student survey:

Alcohol use frequency:

How often do you have a drink containing alcohol?			
		Y1F	Y
1	Never	611	
2	Monthly or less	1861	2
3	2 to 4 times a month	1237	2
4	2 to 3 times a week	564	
5	4 or more times a week	95	
-9	Skip	1374	1
-99	I choose not to answer	164	

Cannabis use threshold:

drug_1_b	Have you used 6 or more times in your life: Cannabis: marijuana, hashish, THC, ganja, other?
drug_1_c	How many times have used cannabis over the last 12 months?

Nicotine use frequency:

How frequently did you smoke cigarettes in the last 30 days?				
		Y1F	Y1S	Y2S
1	I didn't smoke any cigarettes in the la	1218	1513	1167
2	Once or twice	570	617	352
3	A few days (3 to 4 days a month)	268	262	155
4	A couple of days a week (5 to 11 day	180	169	86
5	Three times a week (12 to 14 days a	113	96	50
6	Most days of the week (15 to 25 days	133	154	70
7	Daily or almost daily (26 to 30 days a	389	402	227
-9	Skip	4986	4257	2892
-99	I choose not to answer	101	132	74

Sex:

Sex	
1	Male
2	Female
-9	Skip
-99	I choose not to answer

Race:

Which one of these groups best describes you? (please choose only one)						
		Y1F	Y1S	Y2S	Y3S	
1	American Indian/Alaska Native	51				
2	Asian	1614				
3	Black/African American	1873				
4	Hispanic/Latino	594				
5	More than one race	617				
6	Native Hawaiian/Other Pacific	67				
7	Unknown	39				
8	White	4881				
-9	Skip	13				
-99	I choose not to answer	128				

Interpersonal trauma:

_1b_before	Physical assault (for example, being attacked, hit, slapped, kicked, beaten up, shot, stabbed) • Yes
str_1b_neve	Physical assault (for example, being attacked, hit, slapped, kicked, beaten up, shot, stabbed) • Never happened to me
str_1b.d	Physical assault (for example, being attacked, hit, slapped, kicked, beaten up, shot, stabbed) • I choose not to answer

_1c_before	Sexual assault (rape, attempted rape, made to perform any type of sexual act through force or threat of harm) • Yes
str_1c_neve	Sexual assault (rape, attempted rape, made to perform any type of sexual act through force or threat of harm) • Never happened to me
str_1c.d	Sexual assault (rape, attempted rape, made to perform any type of sexual act through force or threat of harm) • I choose not to answer

_1d_before	Other unwanted or uncomfortable sexual experience • Yes
str_1d_neve	Other unwanted or uncomfortable sexual experience • Never happened to me
str_1d.d	Other unwanted or uncomfortable sexual experience • I choose not to answer

Probable PTSD:

str_3	Have any of these experiences resulted in any of the following symptoms: Nightmares about it, tried hard not to think about it or went out of your way to avoid situations that reminded you of it, constantly on guard, watchful, or easily startled, or felt numb or detached from others, activities, or your surroundings?