# Cannabis Use Problems: Who is at Risk and Why? The Identification of Markers

by

Brittany Skelding

B.A. (Honours) Psychology, (*University of New Brunswick, 2018)*

A Thesis Submitted in Partial Fulfillment

of the Requirements for the Degree of

## Master of Arts

in the Graduate Academic Unit of Psychology

Supervisor: Caroline Brunelle, Ph.D., Psychology
Examining Board: Mary Ann Campbell, Ph.D., Psychology
Jonathan Wilbiks, Ph.D., Psychology
Greg Marquis, Ph.D., History and Politics

This thesis is accepted by the

Dean of Graduate Studies

THE UNIVERSITY OF NEW BRUNSWICK

July 2020

© Brittany Skelding, 2020

## ABSTRACT

Cannabis is the second most used substance in the world after alcohol but has been researched less extensively than other substances. The aims of the current study were twofold. First, the current study examined the contribution of quantity and frequency of cannabis use on the likelihood of experiencing cannabis-related problems. Second, clusters of cannabis users were formed using polysubstance use, mental health (i.e., externalizing and internalizing symptoms), and cannabis use (including quantity and frequency of use) variables. A total of 372 past-year cannabis users participated in the study online or in person. Overall, cannabis use-related negative consequences were best accounted for by the DSM-5 cannabis use disorder criteria; however, measures of both quantity and frequency contributed to these negative outcomes. Furthermore, three distinct cannabis using clusters emerged: low frequency non-problematic, moderate frequency, and high frequency problematic cannabis users. The current findings have significant implications for prevention and intervention practices.



*Keywords*: cannabis, use-related problems, quantity, frequency, clusters, internalizing symptoms, externalizing symptoms

## ACKNOWLEDGEMENTS

First and foremost, I would like to thank my wonderful supervisor, Dr. Caroline Brunelle, who encouraged, pushed, and believed in me for the past three years. You have taught me a lot about myself and have made me a better researcher in the process. I thank you for that, and for never slowing my roll when I had a self-imposed deadline to meet.

I would like to thank my committee members, Dr. Jonathan Wilbiks and Dr. Mary Ann Campbell, who provided me with thoughtful comments and invaluable insight throughout the completion of this project. Dr. Greg Marquis, for your time and expertise. My lab mate, Lillian, who has always looked out for me and encouraged me to be the best I can be. My fellow classmates, without our lengthy discussions and many laughs, being a student would have been much more overwhelming. And to Caitlin for always saving me a seat and for making sure I never took myself too seriously.

Finally, I would like to thank my family. Emily, I wouldn't have gotten though these presentations and exams had you not been my practice audience for hours on end. I appreciate you and you comforting words more than you know. To my parents, Rob and Tammy, and my little brother, Zac, I know you are looking forward to dinners that do not revolve around my thesis progress. This one is for you.

Thank you.

Table of Contents

**ABSTRACT** ..... ii

**ACKNOWLEDGEMENTS** ..... iii

**List of Tables** ..... vi

**List of Abbreviations** ..... vii

**Introduction** ..... 1

**Cannabis** ..... 2

**Prevalence of Cannabis Use** ..... 4

**Cannabis Use Disorder** ..... 6

**Quantity and Frequency of Substance Use** ..... 7

**Quantity and Frequency of Cannabis Use** ..... 9

Frequency of cannabis use ..... 10

Quantity of cannabis use ..... 12

**Risk Factors for the Development of Cannabis Use and Misuse** ..... 18

Gender ..... 18

Age ..... 20

Internalizing symptoms ..... 23

Externalizing symptoms ..... 27

Polysubstance use ..... 29

**Cannabis Use Clusters** ..... 32

**The Current Study** ..... 37

**Method** ..... 39

**Participants** ..... 39

**Measures** ..... 41

Demographics Questionnaire ..... 41

Depression Anxiety Stress Scale-21 ..... 41

Urgency, Premeditation, Perseverance, Sensation Seeking, Positive Urgency, Impulsive Behaviour Scale-Short-Form ..... 42

Alcohol, Smoking, and Substance Involvement Screening Test-Adapted ..... 43

Cannabis Use Questionnaire ..... 44

Addiction Severity Index-Adapted ..... 44

DSM-5 Cannabis Use Disorder Criteria Questionnaire ..... 45

**Procedure** ..... 48

**Results** ..... 50

**Data Cleaning and Conditioning** ..... 50

**Substance Use Practices** ..... 53

**Cannabis-Related Problems** ..... 55

**Internalizing and Externalizing Symptoms** ..... 56

**Correlations** ..... 57

**Role of Quantity and Frequency on Cannabis-Related Negative Consequences** ..... 58

ASSIST-A as a measure of negative cannabis-related consequences. ..... 58

CUDIT-R as a measure of negative cannabis-related consequences. ..... 60

**Clusters of Cannabis Users and Their Associated Consequences** ..... 61

Forming clusters of cannabis users. ..... 62

Describing cluster characteristics. ..... 64

Comparisons of clusters on relevant outcomes. ..... 67
**Goal 1: Quantity and Frequency as Indicators of Cannabis-Related Problems..... 69**
**Goal 2: Cannabis Use Clusters and Their Associated Characteristics and Consequences.... 80**
**Implications ..... 88**
**Limitations..... 90**
**Table 1..... 93**
**Table 2..... 94**
**Table 3..... 95**
**Table 4..... 96**
**Table 5..... 97**
**Table 6..... 98**
**Table 7..... 99**
**References..... 100**
**Appendix A ..... 133**
**Appendix B ..... 135**
**Appendix C ..... 136**
**Appendix D..... 137**
**Appendix E ..... 138**
**Appendix F ..... 143**
**Appendix G..... 144**
**Appendix H..... 145**
**Appendix I ..... 147**
**Appendix J..... 149**
**Appendix K ..... 151**
**Appendix L..... 153**
**Curriculum Vitae..... 155**

**List of Tables**

Table 1 – Demographic Descriptive Variables

Table 2 – Descriptive Data for Study Measures

Table 3 – Correlations Between Study Variables

Table 4 – Hierarchical Regressions Assessing the Predictive Ability of Quantity and Frequency on ASSIST-A and CUDIT-R scores

Table 5 – Latent Class Cluster Analysis Summary

Table 6 – Games-Howell Post-Hoc Multiple Comparisons for Cluster Descriptives

Table 7 – Games-Howell Post-Hoc Multiple Comparisons for Cluster Outcome Variables

**List of Abbreviations**

ADHD – Attention Deficit Hyperactivity Disorder

AIC – Akaike Information Criteria

ASI – Addiction Severity Index

ASSIST-A –Alcohol, Smoking and Substance Involvement Screening Test-Adapted

BIC – Bayesian Information Criteria

CBD – Cannabidiol

CUD – Cannabis Use Disorder

CUDIT-R – Cannabis Use Disorder Identification Test-Revised

DASS-21 – Depression Anxiety Stress Scale-21

DSM – Diagnostic and Statistical Manual

MLE – Maximum-Likelihood Estimation

SUPPS-P – Urgency, Premeditation, Perseverance, Sensation Seeking, Positive Urgency, Impulsive Behaviour Scale Short-Form

THC – Tetrahydrocannabinol

TLFB – Timeline Follow Back

Cannabis Use Problems: Who is at Risk and Why? The Identification of Markers

## Introduction

Cannabis, often referred to as marijuana, has been consumed in its various forms across the world for thousands of years (Murray, Morrison, Henquet, & Di Forti, 2007). However, its long-term effects, potential benefits, and associated risks remain relatively poorly understood (Hayatbakhsh, Najman, Bor, O'Callaghan, & Williams, 2009; Sachs, McGlade, & Yurgelun-Todd, 2015). In recent years, novel ways of identifying individuals with possible substance use disorders have been explored, such as using indices of quantity and frequency of use (Rehm et al., 2013). However, the literature on quantity and frequency of substance use as indicators of a diagnosable disorder has rarely emphasized cannabis, as there are a variety of obstacles (i.e., variable potencies, alternative modes of administration) that have complicated the relationship between cannabis use problems and measures of quantity (e.g., Fischer et al., 2017; Newmeyer, Swortwood, Abulseoud, & Huestis, 2017). This literature review will delve into quantity and frequency of cannabis use as measures of cannabis use-related problems, emphasizing the possible complications associated with using measures of quantity of use in the context of cannabis, specifically. Furthermore, studies that have explored alternative measures of quantity and frequency of cannabis use will be highlighted to demonstrate a potential alternative screening option for cannabis misuse than what is available in current practice. This will support the motivation driving the first goal of the current thesis, which is to understand the roles of quantity and frequency of cannabis use when identifying individuals who may be consuming cannabis problematically.

The following literature review will then go on to explore the existing empirically supported risk factors that have been associated with cannabis use and misuse. Given that some cannabis users may be at higher risk for developing cannabis use-related problems than others (e.g., Fischer et al., 2017), the current thesis will explore the wealth of research on cannabis use risk factors, particularly focusing on demographic factors, cannabis use patterns, and mental health symptoms. Importantly, previously established typologies of cannabis users will be examined, and gaps in existing clustering studies will be noted. This will lead to the second goal of the current thesis, which is to identify clusters of cannabis users and to subsequently describe their distinct characteristics and risks. As a whole, the following literature review aims to contextualize the goals driving the current study and will provide a rationale for the hypotheses, methodologies and statistical analyses that were used.

**Cannabis**

Cannabis has two primary active ingredients: Delta-9-tetrahydrocannabinol (THC) and cannabidiol (CBD; Morgan et al., 2018; Solowij et al., 2019). THC is the primary psychoactive ingredient in cannabis and produces the effects that individuals typically associate with cannabis intoxication (i.e., feeling "stoned"; Hart et al., 2002; Solowij et al., 2019). THC is also the ingredient in cannabis that has been most consistently linked to the negative outcomes that can sometimes be associated with cannabis use (e.g., Arkell et al., 2019; Fischer et al., 2017; Hall, 2014; Morgan et al., 2018). More specifically, high potency cannabis (i.e., cannabis with a high THC concentration) has been linked to psychosis and psychotic-like symptoms, which may present similarly to symptoms of schizophrenia (Morgan et al., 2018; Morrison et al.,

2009). Other negative cannabis-related outcomes associated with THC are impaired acute and chronic memory and attention disturbance, psychomotor function, cognitive disorganization, and dissociation (Broyd, Van Hell, Beale, Yücel, & Solowij, 2016; Curran et al., 2016; Morgan et al., 2018; Solowij et al., 2019).

In contrast to THC, CBD is known as the "protective" ingredient in cannabis when it is consumed in conjunction with THC. Despite its capacity to be psychoactive, CBD is generally regarded as non-intoxicating and has the potential to guard against the harmful effects of THC; most notably, THC-induced memory impairment and psychosis (Englund, Freeman, Murray, & McGuire, 2017; Morgan et al., 2018; Osborne, Solowij, & Weston-Green, 2017). Individual strains of cannabis contain variable amounts of THC and CBD (e.g., low THC and high CBD vs. high THC and low CBD) and therefore can cause highly variable subjective experiences upon consumption (Fischer et al., 2017; Morgan et al., 2018; Solowij et al., 2019).

Another factor that can cause variability in subjective cannabis use experiences is an individual's chosen method of administration. Cannabis is most often consumed via inhalation (i.e., joints, pipes, bongs, vaporizers, lungs) or oral methods (i.e., candies, oils, pills, teas, baked goods, etc.; Cuttler, Mischley, & Sexton, 2016; Hall, 2015; Hazekamp, Ware, Muller-Vahl, Abrams, & Grotenhermen, 2013; Johnston et al., 2019; McDonald & Brunelle, 2018). Inhaled cannabis products and orally ingested cannabis products are metabolized differently and result in distinct cannabis-related effects (Newmeyer et al., 2017). Inhaled cannabis is fast acting and its effects are acute, providing optimal THC-induced psychoactive effects (Hall, 2014). In contrast, when consuming edible forms of cannabis, effects are delayed and tend to persist for longer

periods of time relative to inhalation methods (Allen et al., 2017; Giombi, Kosa, Rains, & Cates, 2017). Both inhaled and ingested cannabis consumption have risks; most notably, pulmonary/respiratory effects for inhalation and the risk of taking greater amounts than intended with edibles (Martinasek, McGrogan, & Maysonet, 2016; Sachs et al., 2015; Vandrey et al., 2015).

**Prevalence of Cannabis Use**

Other than alcohol, cannabis is by far the most widely used psychoactive substance in the world, totalling approximately 192.2 million users annually (United Nations Office on Drugs and Crime Estimates, 2016). Canada, where cannabis has recently been legalized, is no exception (Government of Canada, 2019). According to the National Cannabis Survey of Canada (Statistics Canada, 2019), 17.5% of Canadians aged 15 and over have consumed cannabis within the last three months. With the legalization of recreational cannabis use, the number of first time cannabis users is also increasing, nearly doubling the estimate of 327,000 first time users in 2018 to 646,000 in 2019 (Statistics Canada, 2019). Not only are first time cannabis users on the rise, but the proportion of current, active cannabis users is also increasing (Canadian Centre on Substance Use and Addiction, 2017; Statistics Canada, 2004; Statistics Canada, 2019). Since 1989, Statistics Canada has highlighted a steady increase in past-year cannabis users, noting a sharp increase in prevalence in the 21$^{st}$ century (i.e., 6.5% in 1989, 7.4% in 1994, 12.2% in 2012, 22% in 2018), mirroring the slow movement of cannabis decriminalization in both Canada and the United States (Health Canada, 2018; Statistics Canada, 2004; Statistics Canada, 2015).

In Canada, the use of cannabis for medical purposes is also legal and has been on the rise alongside recreational cannabis use. This has been exemplified by Statistics Canada data, in which substantial increases in medical cannabis use from 2015 (i.e., 24% of cannabis users) to 2017 (i.e., 37% of cannabis users; Canadian Centre on Substance Use and Addiction, 2017; Statistics Canada, 2018) have been reported. Cannabis use is particularly prevalent among young Canadians; youth and young adults consistently report higher frequency of use than older Canadians (Canadian Centre on Substance Use and Addiction, 2017; Padovano & Miranda, 2018; Pearson, Liese, Dvorak, & Marijuana Outcomes Study Team, 2017; Statistics Canada, 2018; Statistics Canada, 2019).

Although all Canadian provinces report higher levels of cannabis use than the international average of approximately 4%, provinces do differ significantly in their level of cannabis use (Statistics Canada, 2019; United Nations Office on Drugs and Crime Estimates, 2016). Quebec and Manitoba fall significantly below the national average of cannabis use (i.e., 17.5%); 11% and 13% of residents aged 15 or older in these two provinces, respectively, report cannabis use within a three-month period. In contrast, Ontario and Alberta report significantly greater prevalence rates than the national average, with 20% and 21.5% of residents aged 15 or older reporting cannabis use within the last three months, respectively (Statistics Canada, 2019)**.** The prevalence of past 3-month cannabis use in New Brunswick, however, is closer to the national average at 18.2% (Statistics Canada, 2019). Given these rates of cannabis use, it is important to investigate what proportion of the population may experience significant negative consequences as a result of their cannabis consumption.

**Cannabis Use Disorder**

Although most cannabis users have a recreational pattern of consumption – which is less likely to be associated with significant negative consequences – cannabis use may evolve into a cannabis use disorder (CUD) for a small portion of users (Fischer et al., 2017; Kosty, Seeley, Farmer, Stevens, & Lewinsohn, 2016). The American Psychiatric Association (APA, 2013) has described CUD in the Diagnostic and Statistical Manual of Mental Disorders: fifth edition (DSM-5) as a problematic pattern of use which is associated with negative health, social, and occupational consequences. Such problematic practices are tied to clinically significant impairment or distress, and an individual must demonstrate at least two of the following 11 criteria (APA, 2013) within the last year to meet the clinical threshold for CUD: 1. cannabis is often taken in larger amounts or over a longer period than was intended; 2. there is persistent desire or unsuccessful efforts to cut down on or control cannabis use; 3. a great deal of time is spent in activities to obtain cannabis, use cannabis, or recover from its effects; 4. the individual experiences craving, or urges to use cannabis; 5. recurrent cannabis use results in a failure to fulfill major role obligations at work, school, or home; 6. there is continued cannabis use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of cannabis; 7. important social, occupational, or recreational activities are given up or reduced because of cannabis use; 8. there is recurrent cannabis use in situations in which it is physically hazardous; 9. cannabis use is continued despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by cannabis; 10. tolerance is experienced, defined by either (a) a need for markedly increased

amounts of cannabis to achieve intoxication or desired effect or (b) markedly diminished effect with continued use of the same amount of cannabis; and/or 11. withdrawal is experienced, manifested by either (a) the characteristic withdrawal syndrome for cannabis or (b) cannabis (or a closely related substance) being taken to relieve or avoid withdrawal symptoms (APA, 2013).

In addition to the identification of the individual's relevant symptoms, CUD is further qualified as being either mild, moderate, or severe depending on the number of diagnostic criteria the individual has met. Mild CUD is present when two to three criteria have been met, moderate requires four criteria to be met, and severe CUD is diagnosed when five or more criteria are met (APA, 2013). The majority of cannabis users do not progress into problematic cannabis use; the 12-month prevalence of CUD in adults (i.e., aged 18 and older) is approximately 2.5% (Hasin et al., 2016). Among younger adults, CUD is more prevalent, with nearly 7% of 18 to 29 year olds experiencing a range of problematic cannabis use symptoms severe enough to warrant a diagnosis of CUD (Butterworth, Slade, & Degenhardt, 2014; Hasin et al., 2016).

**Quantity and Frequency of Substance Use**

Some substance use researchers have debated whether or not diagnostic criteria for substance use disorders, most often specified by previous or current versions of the DSM, is necessary (Rehm et al., 2013; Saha, Stinson, & Grant, 2007). More specifically, it has been suggested that individuals who use substances problematically may benefit from more efficiently delivered healthcare experiences by bypassing the necessary step of first being formally diagnosed with an official substance use disorder to access these

services; instead, a health care provider could identify an inherent problem based on their heavy use over time (Rehm et al., 2013).

Rehm and colleagues (2013) presented compelling arguments in an opinion paper concerning the use of quantity and frequency as indicators of problematic substance use rather than the assignment of the traditional DSM diagnosis of substance use disorder. Importantly, within their argument is the idea that heavy use over time accounts for the majority of the symptoms included in the DSM substance use disorder criteria (Rehm et al., 2013). To illustrate, these authors argued that heavy use over time is responsible for the biological changes (e.g., long and short-term effects on the brain), social consequences (e.g., performance at place of employment), substance-related mortality, and the tolerance, withdrawal, and intoxication symptoms that are associated with the use of a particular substance (Rehm et al., 2013). In a separate review article, Rehm and Roerecke (2013) demonstrated the validity of these arguments by presenting aggregated data from three studies on alcohol users that found that a reduction in alcohol intake in heavy users significantly decreased mortality rates. Therefore, the extensive DSM criteria for substance use disorder may be unnecessary for capturing disordered use and may be more complicated than required to guide care. Having a simpler method available for clinicians and researchers to identify potentially at-risk substance users may be beneficial, as health care professionals would have the skillset to assess the level of risk for a given individual, even if diagnosis is outside of their scope of practice. This flexibility in assessment would allow for more efficient screening and, in turn, could lead to expedited access to treatments and interventions for substance misusing individuals. The lack of a clinical label, such as alcohol use disorder, may also reduce

the stigma that is associated with the diagnosis of a substance use disorder (Rehm et al., 2013). However, one concern with abandoning the DSM diagnosis of substance use disorder is the complications that may arise when deciding which services and treatment plans may be best suited for each individual (Saunders, 2013). Nevertheless, in the context of research, a diagnosis is often used as an outcome variable, but the delivery of services and treatments are generally not offered at this point of contact. Therefore, this potential obstacle may not be as relevant to researchers. Additionally, adopting a screening method to identify problematic substance use more efficiently would not necessarily eliminate the need to obtain a formal diagnosis altogether, but would rather accelerate the process of service accessibility, from which point those who require further diagnostic services may be subsequently referred to such resources.

Although there is disagreement regarding which approach to identifying problematic substance use is best (e.g., Dierker et al., 2007; Mcbride, Strong, & Kahler, 2010; Mcbride, Teesson, Baillie, & Slade, 2011), assessing quantity and frequency of use has the potential to be useful for health care practitioners as well as researchers.

**Quantity and Frequency of Cannabis Use**

Both quantity and frequency variables have proven to be reliable indicators of problematic substance use, particularly with alcohol and tobacco (Rehm et al., 2013). Studies also have demonstrated that both quantity and frequency of cannabis use may serve as strong markers of cannabis-related negative consequences and that these two measures could be sufficient in identifying problematic, high risk cannabis use (Norberg, Mackenzie, & Copeland, 2012; Tomko et al., 2018; Walden & Earleywine, 2008; Zeisser et al., 2012). Although both cannabis use measures (i.e., quantity and

frequency) may have value, it has been argued that frequency of use may be the strongest indicator of risky cannabis use and associated problems, with or without an additional indicator for quantity of use (Chen, Kandel, & Davies, 1997; Cuttler & Spradlin, 2017; Tomko et al., 2018; Zeisser et al., 2012). However, as discussed below, there are methodological challenges associated with assessing quantity of cannabis that may have masked its true relationship with cannabis-related problems.

**Frequency of cannabis use.** The assessment of frequency of cannabis use has closely resembled the measurements of frequency of use of other licit and illicit substances, as additional factors (i.e., potency, method of administration) do not confound this variable. For instance, simply querying how often an individual consumes cannabis products within a given period of time appears to be a reliable indicator of on how many occasions the individual uses cannabis, regardless of the quantity they consume. For this reason, frequency of use measures for cannabis tend to be similar across studies, posing questions such as "How many times did you use cannabis?" or "On about how many of these days did you use marijuana, cannabis, or hashish?" (e.g., Monshouwer et al., 2006; Zeisser et al., 2012). Occasionally, this question may be accompanied by an aid, such as a calendar, to facilitate recall (e.g., Tomko et al., 2018).

What is less clear, however, is the range of time that these questions should assess. Oftentimes, studies address lifetime use, past-year use, past 6-month use, and/or past-month use (e.g., Crane, Schuster, & Gonzalez, 2013; Leadbeater, Ames, & Linden-Carmichael, 2018; Zeisser et al., 2018). In accordance with Rehm's (2013) position regarding quantity and frequency of use measures as indicators of problematic cannabis use, recent research by Chavez, Bradley, Lapham, Wickizer, and Chisolm (2019)

attempted to determine the optimal cutoff point of frequency of cannabis use in screening for CUD in adolescents. They found that, depending on cannabis users' age, there may be a differential risk for the development of CUD when considering how frequently cannabis is consumed. Notably, they found that youth aged 12-15 years should be flagged as potential problematic users if they report having consumed cannabis on three or more occasions in the past 12 months, whereas later adolescents (i.e., 16 years or older) may require a higher threshold with a cutoff point of 12 or more occasions of cannabis use in the past 12 months. One other study (Kelly et al., 2014) examined past-year cannabis use as a potential screening tool for cannabis use problems in a sample of 525 adolescents aged 12 to 17 years, and found that using on two or more days in the past 12 months could be used as a threshold for potential negative consequences, although they did not consider age as a potential confounding variable.

Overall, frequency of cannabis use indicators are important predictors of specific problems, such as reduced gray matter volume in areas that are integral to motivational, emotional, and affective processing (Battistella et al., 2014). A linear relationship also exists between frequency of cannabis use and externalizing symptoms, as well as with symptoms of psychosis, depression, and anxiety (Leadbeater et al., 2018; Monshouwer et al., 2006). In addition, cognitive problems, such as having trouble thinking clearly, have been tied to higher frequency of cannabis use (Monshouwer et al., 2006). Problems external to the individual also may arise due to higher frequency of cannabis use, such as legal, financial, and social problems (Tomko et al., 2018; Zeisser et al., 2018). These correlating factors support the assessment of frequency of cannabis use as an indicator of possible negative cannabis-related consequences.

**Quantity of cannabis use.** Frequency of cannabis use as a metric appears to be easier to assess than quantity of cannabis use as there are unique challenges in assessing quantity, specifically in relation to cannabis use. Most importantly, there is a lack of standardized measures of cannabis consumption (Freeman et al., 2014; Tomko et al., 2018). For many other substances, standardized dosing exists, which allow individuals as well as researchers to more accurately measure the quantity of the substance that has been, or will be, consumed (Kalinowski & Humphreys, 2016; Turner, 1990). For example, a standard serving of alcohol in North America is defined as 14 grams of pure ethanol (or approximately 12 ounces of 5% beer, 5 ounces of 12% wine, or 1.5 ounces of 40% distilled spirits; Centre for Addiction and Mental Health, 2012; Kalinowski & Humphreys, 2016). The true quantity of cannabis an individual has consumed, however, cannot be easily measured with such precision due to its wide variability in composition (i.e., CBD, THC potencies), consistency of joint/edible size and potency, and the route of administration an individual chooses to consume cannabis, and therefore may be easily misjudged, causing inaccuracies in self-reported intake.

To remedy these measurement inaccuracies for quantity, some researchers have suggested using a pseudo-cannabis substance to represent the physical quantity of cannabis that an individual believes they have consumed (Mariani, Brooks, Haney, & Levin, 2011; Norberg et al., 2012; Tomko et al. 2018). The surrogate substance (e.g., oregano) is given to the participant, who then partitions amounts of the substance for the researcher, which is weighed and quantified (in grams). For example, Norberg, Mackenzie, and Copeland (2012) assessed the effectiveness of this approach when used in conjunction with the timeline follow back (TLFB) approach. The TLFB method

involves using a physical calendar to report whether a substance has been used, the quantity that has been used (in grams or joints), and how many times the substance was consumed on each day (Sobell & Sobell, 1992). In their study, 98 Australians who self-identified as cannabis users completed a TLFB interview alongside a trained researcher to report their cannabis use for the same 90-day period on two separate occasions. Participants were asked to report their cannabis use on each morning, afternoon, and evening with the help of a surrogate substance (i.e., "marijuanilla") and relevant drug paraphernalia (i.e., rolling paper, pipes) and to estimate, in grams, the quantity of the surrogate substance it contained. Results demonstrated that participants were unable to correctly gauge by verbalization the proportion of the pseudo-cannabis substance that they had partitioned (in grams), but that the partitioning method of measurement was reliable nonetheless, as demonstrated by nearly perfect test-retest reliability on time one and time two TLFB sessions (i.e., participants portioned the surrogate substance similarly). These researchers also found that assessing quantity of use using this method was predictive of cannabis-related problems and dependence severity over and above frequency of use.

More recently, Tomko and her colleagues (2018) conducted a similar study to that of Norberg and colleagues but with a clinical sample of 302 participants who tested positive for recent cannabis use, as determined by a urine cannabinoid test. Again, the TLFB method was used in combination with a surrogate substance (i.e., dried motherwort) and relevant drug paraphernalia. However, in this case, participants were asked to report on past 30-day use rather than past 90-day use. Participants were also instructed to estimate the amount, in grams, of the surrogate substance they had

indicated using on each day. The study concluded that the measures used to estimate cannabis quantity (i.e., the surrogate substance and TLFB) were predictive of urine cannabinoid levels (i.e., a biological marker of cannabis use), but were not helpful in predicting cannabis-related problems, in contrast to Norberg et al.'s (2012) findings. Hence, the visual representation of cannabis may allow the participant to more reliably report on the quantity of cannabis they have consumed, but it is unclear whether it adds to the predictability of cannabis-related consequences.

In addition to accuracy concerns, assessing quantity using physical representations in conjunction with the TLFB method has a significant drawback in that it takes notably more time and resources to deliver than do self-report questionnaires (Tomko et al., 2018). Other considerations in assessing quantity include how many individuals have shared each dose of cannabis (i.e., whether or not the dose was consumed alone or passed between individuals in a group setting), the variable potencies of joints, the variable strength of edibles, and the different modes of administration (i.e., joints, bongs, edibles, oils, etc.; Stockburger, 2016; Tomko et al, 2018; Walden & Earleywine, 2008), which are not addressed with the use of a pseudo-cannabis measure. Despite promising results from studies that have paired the TLFB method with the partitioning of surrogate substances, the inability to take into consideration these other factors (e.g., potency, mode of administration) negatively affects the utility of this method and measurement.

Other options for measuring quantity have been considered. Researchers have tried measuring quantity with direct questions pertaining explicitly to the amount of cannabis consumed, which can be reported in grams or in amounts of joints/hits

consumed (e.g., Zeisser et al., 2012). However, as individuals often roll their own joints, joint size is not a consistent measure. Zeisser (2012) outlined guidelines for quantity of cannabis measurement within their study, in which quantity was measured in joints that corresponded to particular amounts of cannabis (i.e., 1 joint = 0.5 grams of cannabis, or 5 bong/pipe hits, or 10 puffs of a joint). These authors concluded that their method for measuring cannabis quantity was valid within their sample. In addition, they suggested guidelines for consumption similar to those associated with alcohol in that they proposed, based on their findings, that one joint per day (as defined above) may not be harmful, but more than one joint per day may lead to increased odds of experiencing cannabis-related problems. These authors also found that cannabis quantity was predictive of cannabis-related problems, but to a lesser extent than was frequency of use. This method – outlining explicit guidelines for quantity – only has been tested on a single sample; therefore, it is unclear whether or not this method is reliable. In addition, it remains difficult to assess the effects associated with a given quantity of cannabis, as a standard physical quantity does not address other concerns with the accurate measurement of cannabis quantity, such as the variability in the types, compositions, potencies, and modes of administration of cannabis products (Tomko et al., 2018; Walden & Earleywine, 2008).

As an alternative measure, assessing the potency of cannabis to estimate risk of adverse effects may be more appropriate than measuring the absolute physical quantity of cannabis used. To illustrate, when an individual consumes the same amount of low potency cannabis (e.g., 3% THC) as another individual who consumes high potency cannabis (e.g., 17% THC), the physical quantity may be of lesser interest, as the

individual who has consumed the higher potency cannabis may suffer more intense side effects than their lower potency consuming counterpart (Fischer et al., 2017; Potter, Clark, & Brown, 2008). Moreover, different combinations of THC and CBD may produce significantly varying effects from one strain of cannabis to another (Fischer et al., 2017). Although both THC and CBD are thought to have psychoactive effects, CBD does not cause intoxicating effects (Solowij et al., 2019). In fact, CBD helps to attenuate the intoxicating effects of cannabis products that are high in THC (Solowij et al., 2019). Hence, it has been suggested that research investigating quantity and frequency of cannabis use should query potency (i.e., % concentration of THC and CBD; Hindocha, Norberg, & Tomko, 2018).

Freeman and colleagues (2014) investigated potency within a sample of 247 cannabis users. Participants were instructed to first describe the cannabis they were going to smoke in terms of its type (i.e., “skunk”, “herbal”, “resin”, or “other”) and potency, which was rated on a 10-point Likert scale, where 1 corresponded to “negligible effect” and 10 to “incredibly strong”. Participants were then instructed to smoke their cannabis in the presence of the researcher. The researcher recorded the amount of cannabis the participant consumed, in grams, by weighing the joint prior to the participants’ consumption. The researcher also collected a sample of the cannabis to test for THC and CBD concentrations. Participants subsequently rated their subjective high from 1 (“not stoned”) to 10 (“extremely stoned”). The major conclusions drawn by Freeman et al. were that individuals who consumed cannabis more frequently (i.e., daily users) were better able to estimate the true potency of their cannabis relative to recreational users (i.e., used on average 10 days per month), and that THC

concentrations were negatively associated with joint sizes, irrespective of frequency of use. In other words, participants tailored the amount of cannabis they smoked to the potency of the product, suggesting that potency is more important than objective quantity. Finally, participants' subjective ratings of intoxication correlated with estimated potency but not THC concentrations. However, as could be expected, increased CBD concentrations were associated with a matched decrease in estimated potency. These authors suggested that the lack of association between subjective high ratings and THC potency may be linked to the titration of high potency cannabis, in which cannabis users adjust their dose to attain optimal levels of intoxication. Hence, these findings provide further evidence that a physical amount of cannabis alone may not be a reliable measure of cannabis quantity, as individuals adjust their level of intoxication based on potency rather than physical quantity.

In addition to direct measures, indirect methods of assessing quantity also have been employed by querying subjective levels of intoxication. For instance, Walden and Earleywine (2008) questioned cannabis users on "approximately how 'high,' 'buzzed,' 'stoned,' or intoxicated do you usually get when you use marijuana?" (Walden & Earleywine, 2008). This question, although not assessing quantity directly, may still extract pertinent information based on the strength of the effects that the individual has experienced as a result of their cannabis consumption. Walden and Earleywine used one direct measure of quantity (i.e., self-reported quarter ounces consumed per month) alongside two indirect measures of quantity: usual intensity of intoxication and maximum intensity of intoxication. Their results revealed that the indirect measures of cannabis quantity were both significantly associated with cannabis-related problems and

dependency over and above the effect of frequency. Additionally, these authors noted that both direct and indirect measures of cannabis quantity were predictive of cannabis-related outcomes and argued that subjective levels of intoxication should be assessed when examining the impact of cannabis quantity.

Due to the challenges with assessing quantity of cannabis use in existing research and its potential to predict negative consequences related to use, future research should focus on novel ways of assessing cannabis quantity (e.g., THC/CBD concentrations, subjective ratings of effects). One of the objectives of the current thesis is to assess the contribution of quantity and frequency of cannabis use estimates on the likelihood of experiencing negative cannabis-related consequences. In addition, the current research examined broader aspects of an individuals' experience that may predispose them to using cannabis problematically, which is the focus of the following section.

**Risk Factors for the Development of Cannabis Use and Misuse**

It is important to examine which factors predict cannabis-related problems and cannabis misuse over and above measures of quantity and frequency. Specifically, gender, age, internalizing and externalizing symptoms, and polysubstance use each have been identified as possible risk factors for the development of problematic cannabis use and subsequent cannabis-related consequences. Available research on these risk factors will be reviewed below.

**Gender.** An individual's gender serves as a risk factor for the development of various cannabis-related consequences (Cooper & Haney, 2016; Fogel, Kelly, Westgate, & Lile, 2017; Hayatbakhsh et al., 2009; Swift, Coffey, Carlin, Degenhardt, & Patton,

2008). According to the National Cannabis Survey of Canada (Statistics Canada, 2019), males are significantly more likely than females to have recently consumed cannabis or cannabis products, with 22.3% of males (in contrast to 12.7% of females) reporting having consumed cannabis in the last three months. Males are also more likely than females to report past-year cannabis use, as well as lifetime cannabis use (Butterworth et al., 2014; Government of Canada, 2018; Substance Abuse and Mental Health Services Administration, 2014). Unsurprisingly, CUD rates are higher among males as well (Butterworth et al., 2014; Hasin et al., 2016; Hayatbakhsh et al., 2009; Wagner & Anthony, 2007). For instance, Hasin (2017) found that 8.4% of males from a large, representative American sample reported lifetime CUD relative to only 4.3% of females from the same population.

Although males experience a higher risk of both consuming cannabis in general and developing CUD, females also exhibit unique cannabis-related risks. For example, there is strong evidence linking female users to an increased likelihood of telescoping (Ehlers et al., 2010; Hernandez-Avila, Rounsaville, & Kranzler, 2004; Khan et al., 2013). Telescoping can be defined as a cannabis use trajectory characterized by the rapid onset of misuse following initial cannabis use (Fogel et al., 2017). This unique cannabis use trajectory implies that women develop problematic cannabis use at a faster pace than men (Khan et al., 2013). Additionally, despite women's increased likelihood of seeking treatment quickly, they also tend to experience greater withdrawal symptoms, which have been linked to relapse (Copersino et al., 2010; Hall, 2014; Hernandez-Avila et al., 2004). Women also have higher rates of comorbidity, particularly with mood and

anxiety disorders, which may lead to an increased risk of relapse (Kahn et al., 2013; Wright, Scerpella, & Lisdahl, 2016).

Relative to women, men may be more susceptible to the analgesic effects of cannabis and tend to experience more prolonged and severe CUD (Cooper & Haney, 2016; Khan et al., 2013). However, relative to men, women tend to report greater positive cannabis-induced effects (Cooper & Haney, 2014). These positive subjective cannabis-related experiences have been tied to increased cannabis use, and have the potential to lead to cannabis-related problems, such as CUD (De Wit & Phillips, 2012; Le Strat et al., 2009). Moreover, when consuming cannabis, men and women respond differently to varying levels of THC (Cooper & Haney, 2014; Fogel et al., 2017; Lundahl & Greenwald, 2015). For example, Fogel et al. (2017) found that women reported greater sensitivity (e.g., self-rated "high") to low levels of orally administered THC in comparison to men. However, when higher levels of THC were administered, men reported greater sensitivity than women (Fogel et al., 2017). Other studies have found differences in the subjective effects of THC between males and females as well, using various modes of administration and potencies of cannabis products (e.g., Cooper & Haney, 2014; Lundahl & Greenwald, 2015). More research is needed on the specific gender differences with respect to cannabis use before a clear understanding of this relationship can be established (Cuttler et al., 2016).

**Age.** Adolescents and emerging adults are far more likely to consume cannabis than any other age group (Canadian Centre on Substance Abuse and Addiction, 2018; Cuttler et al., 2016; Government of Canada, 2018; Statistics Canada, 2019). In fact, in 2019, 30% of Canadians aged 15 to 24 reported recent (i.e., past 3-month) cannabis use,

in contrast to much lower reports of use (16%) by their older peers (Statistics Canada, 2019). Although these variations in cannabis use populations are striking, they may actually reflect underestimates of the true prevalence of cannabis use among young Canadians. This underestimate may be due to the wide age bracket that is used in Canadian population surveys (e.g., 15 to 24 years). For example, a large Ontario-based study with high school students found a steady increase in cannabis use prevalence throughout adolescence (Centre for Addiction and Mental Health, 2017). Senior students, who are roughly 17 years old had a striking 36.9% lifetime prevalence of cannabis use – a large jump from the observed lifetime prevalence rates in freshmen (9.3%), who are roughly 14 years old (Centre for Addiction and Mental Health, 2017). Similarly, the Canadian Cannabis Survey (Government of Canada, 2019) presented cannabis use prevalence within more restricted age ranges of 16 to 19 and 20 to 24 years old, and again, found higher estimates of past-year cannabis use in the older age group (i.e., 36% vs. 44%). Although the highest rates of cannabis use are found among older adolescents and emerging adults, the proportion of young adolescents (i.e., younger than 16 years) consuming cannabis remains high, with estimates ranging from 3% to 15% (Centre for Addiction and Mental Health, 2017; Health Canada, 2014; Rodríguez, 2015). These high rates of cannabis use in Canadian youth are important to note, as early initiation of cannabis use has been associated with a myriad of cannabis-related negative consequences, spanning from adolescence to adulthood (Fischer et al., 2017; Lisdahl & Price, 2012; Lisdahl, Wright, Kirchner-Medina, Maple, & Shollenbarger, 2014; Meier et al., 2012; Richmond-Rakerd et al., 2016). For example, individuals who consume cannabis early in life are at a significantly greater risk for the development of

CUD (Butterworth et al., 2014; Fischer et al., 2017; Hasin et al., 2016; Schlossarek, Kempkensteffen, Reimer, & Verthein, 2015; Swift et al., 2008).

Adolescence and young adulthood are periods of critical brain development during which cannabis use can be detrimental (Fischer et al., 2017; Lisdahl & Tapert, 2012). Specifically, consuming cannabis throughout this period of brain growth (i.e., adolescence and emerging adulthood) may lead to altered volume and structure of grey and white matter (Demirakca et al., 2010; Gruber, Dahlgren, Sagar, Gönenç, & Lukas, 2013; Lisdahl & Price, 2012). This increased susceptibility to cannabis use in young users has been thought to lead to a multitude of adverse consequences (e.g., driving while under the influence of cannabis, doing or saying embarrassing things, etc.; Pearson et al., 2017). Additionally, cannabis use has been associated with unemployment and risky sexual behaviour in youth (Fergusson, Boden, & Horwood, 2015; Schuster, Crane, Mermelstein, & Gonzalez, 2012).

Mental health concerns may also arise in young cannabis users, particularly with regard to psychosis/psychotic-like experiences (Furgusson, Boden, & Horwood, 2015; Hasin, 2017; Spriggens, & Hides, 2015). Furgusson and colleagues (2015) examined a large cohort of New Zealanders who had been followed since birth and found that, between the ages 18 and 25 years, there was a significant association between cannabis use and subsequent onset of psychotic symptoms. However, the converse was not true, suggesting that cannabis use may indeed precede psychotic-like experiences in emerging adults. Furthermore, chronic cannabis use throughout adolescence has been linked to reductions in intelligence quotient (IQ) scores (Camchong, Lim, & Kumra, 2017; Meier et al., 2012). A large longitudinal study by Meier and her colleagues (2012) revealed

that individuals who consumed cannabis weekly prior to the age of 18 experienced an average reduction of 6 IQ points from childhood to adulthood. Moreover, these decreases in IQ persisted regardless of whether or not the individual continued their cannabis use into adulthood. However, adults who reported continued frequent use of cannabis saw greater reductions in IQ than individuals who had abstained or reported infrequent adult cannabis use (Meier et al., 2012). Thus, there are cognitive implications of cannabis use in youth.

Other cognitive factors are also impacted by early cannabis use in both cross-sectional and longitudinal studies, including impaired memory function (Crane, Schuster, Fusar-Poli, & Gonzalez, 2012; Hanson et al., 2010; Meier et al., 2012; Solowij et al., 2011). Attentional deficits and poor executive function also have been observed in adolescent cannabis users (Camchong et al., 2017; Gruber et al., 2013; Hanson et al., 2010; Lisdahl & Price, 2012; Meier et al., 2012). Furthermore, a cross-sectional study by Lisdahl and Price (2012) concluded that psychomotor function was impaired as a result of adolescent cannabis use, particularly in young male participants. Hence, age of first use is a notable predictor of cannabis-related problems for psychosis, cognitive domains, and psychomotor functioning.

**Internalizing symptoms.** Mental health symptoms are relevant in the context of cannabis use risk factors beyond increased risk of psychosis. Mental health disorders can be categorized into overarching categories of disorders based on shared symptomatology (Achenbach, 1978; Krueger, 1999). Specifically, Krueger, Caspi, Moffitt, and Silva (1998) examined various DSM mental health disorders (e.g., anxiety disorders, substance use disorders, etc.) and found a two-factor model in which groups

of diagnoses shared common variance. These two overarching factors were termed as internalizing (e.g., anxiety disorders, depressive disorders) and externalizing factors (e.g., antisocial personality disorder, CUD, alcohol use disorder), which outline the higher-order symptoms that are associated with various mental illnesses (Krueger et al., 1998). Personality traits also have been associated with these broad mental health factors. For instance, individuals with anxiety and affective disorders often score high on measures of neuroticism, whereas those with externalizing disorders display lower levels of conscientiousness (Krueger et al., 1998; Krueger, 1999; Krueger, Mcgue, & Iacono, 2001).

Studies examining the relationship between internalizing features and cannabis use have been inconsistent in their results. For example, Rodríguez (2015) found that neuroticism as a measure of trait emotionality was associated with cannabis use in a younger group of participants (i.e., 12-14 years), but not in an older group (i.e., 15-18 years), whereas another study found cannabis users did not differ significantly from controls on measures of neuroticism (Fridberg, Vollmer, O'Donnell, & Skosnik, 2011). However, a twin study by Vink, Nawijn, Boomsma, and Willemsen (2007) concluded that twins who were discordant for cannabis use differed significantly on indices of neuroticism; specifically, the sibling who reported consuming cannabis had higher neuroticism scores. Thus, given that the literature is mixed, it is unclear whether neuroticism is meaningfully linked to cannabis use.

Self-reported anxiety symptoms and anxiety sensitivity are also subsumed under internalizing factors. Evidence for a link between this subset of internalizing symptoms and cannabis use is more substantial than neuroticism as an emotionality construct,

particularly with regard to social interaction anxiety (Buckner et al., 2008; Schlossarek et al., 2015). A variety of studies have identified an individual's likelihood of experiencing anxiety symptoms as a risk factor for both the initiation of cannabis use as well as for the development of a CUD (Bierhoff et al., 2019; Hayatbakhsh et al., 2009; Pol et al., 2013; Schlossarek et al., 2015). These findings are also supported in Kedzior and Laeber's (2014) review on anxiety and cannabis use in non-clinical populations. Notably, social interaction anxiety seems to persist as a risk factor for problematic cannabis use, even when controlling for other anxiety disorders, suggesting that it plays a unique role in the development of cannabis-related consequences (Buckner et al., 2008). In fact, individuals with a diagnosis of social anxiety disorder have 6.5 times greater odds of developing CUD relative to participants without this anxiety diagnosis, according to a 14-year long longitudinal study (Buckner et al., 2008). This association persisted after accounting for variance that may be attributable to other internalizing and externalizing constructs, gender, and past CUD and alcohol use disorder (Buckner et al., 2008).

Similarly to neuroticism, depressive symptoms also have been associated with cannabis use within the literature (Hayatbakhsh et al., 2009; Patrick, Yeomans-Maldonado, & Griffin, 2015); however, results from these studies are discordant on whether or not depressive symptoms meaningfully influence cannabis use and cannabis-related outcomes (Buckner et al., 2008; Chabrol, Chauchard, Goutaudier, & Leeuwen, 2012; Hall, 2014). Some researchers claim that individuals with depressive symptoms are at increased risk of consuming cannabis and/or developing cannabis dependence/CUD (Chabrol et al., 2012; Kedzior & Laeber, 2014; Korn, Haynie, Luk,

Simons-Morton, 2018). For example, depressive symptoms were associated with frequent cannabis use (i.e., on more than 20 occasions in the past-year) in an American sample of emerging adults (Korn et al., 2018). In contrast to such findings, other research has found no significant relationship between depressive symptoms and CUD (Buckner et al., 2008; Manrique-Garcia, Zammit, Dalman, Hemmingsson, & Allebeck, 2012). A recent review on cannabis use risk factors (Hall, 2014) suggests that this contrast in findings may be explained by the level of control over confounding variables within each individual study. By way of illustration, Hall (2014) provided multiple examples of studies that have initially found a relationship between measures of depression and cannabis use, but fail to find a lasting effect when additional confounding variables (e.g., use of tobacco or risky use of alcohol, IQ) are included in their models (e.g., Fergusson & Horwood, 1997; Hall, 2014; Manrique-Garcia et al., 2012). Therefore, it remains unclear whether or not depressive symptoms have a significant impact on cannabis use.

If one accepts that at least some elements of internalizing symptoms are associated with cannabis use, then the most established theory accounting for this association has been the self-medication hypothesis. This theory posits that individuals use substances to alleviate the symptoms that are associated with their mental health problems, which may in turn lead to problematic use (Khantzian, 1987). The self-medication hypothesis may also explain the differential influence of each internalizing symptom on cannabis use (Buckner et al., 2008). For instance, generalized anxiety disorder and panic disorder are typically characterized by a fear of health-related problems and increased arousal (APA, 2013). These symptoms may act as a protective

factor against the initiation or use of substances such as cannabis (which may induce the sensations they fear) in comparison to individuals with social interaction anxiety, who may find relief from their symptoms by consuming cannabis (Ali et al, 2016; Buckner et al., 2008). An alternate plausible explanation for the association between internalizing disorders and cannabis use is that there may be a biological susceptibility that is linked to both substance misuse and mental health disorders (Hasin, 2017); however, the specific genetic mechanisms behind this potential association remain unclear (e.g., Carey et al., 2016; Hodgson et al., 2017; Otten, Huizink, Monshouwer, Creemers, & Onrust, 2017). In either case, these factors may act alone or interact with externalizing factors.

**Externalizing symptoms.** In contrast to internalizing symptoms, externalizing symptoms are those that contribute to disruptive behaviours, such as impulsivity, risk taking, and delinquency (Farmer, Seeley, Kosty, Olino, & Lewinsohn, 2013; Liu, 2004). Externalizing constructs consistently have been associated with cannabis use (Boyle et al., 1992; Chabrol et al., 2012; Khan et al., 2013; Schlossarek et al., 2015; Monshouwer et al., 2006), particularly in adolescents and young adults (Farmer et al., 2015; Griffith-Lendering, Huijbregts, Mooijaart, Vollebergh, & Swaab, 2011; Hayatbakhsh et al., 2008; Hayatbakhsh et al., 2009; Schlossarek et al., 2015). Similar to internalizing symptoms, the association between externalizing symptoms and cannabis use also may be attributable to the self-medication hypothesis (Griffith-Lendering et al., 2011), although the shared causes hypothesis (i.e., shared genetic and/or environmental vulnerability) has been explored and may too play a role with externalizing symptoms and cannabis use vulnerability (Hayatbakhsh et al., 2008; Wei, Loeber, & White, 2004).

When externalizing symptoms have been measured as an aggregate score (i.e., symptoms associated with many disorders on a single "externalizing" scale"), a linear relationship has been found between the proportion of externalizing disorder symptoms an individual displays and cannabis use problems (Foster, Arterberry, Iacono, McGue, & Hicks, 2017; Meier, Hill, Small, & Luthar, 2015; Tarter, Kirisci, Ridenour, & Vanyukov, 2008). For instance, Hayatbakhsh and colleagues (2008) found that externalizing behaviours emerging in childhood and adolescence were strong predictors of CUD in early adulthood. A more recent longitudinal study (Foster et al., 2017) found a link between externalizing symptoms and cannabis-related problems as well, with a dose dependent relationship (i.e., non-users, users without CUD, users with CUD) found between cannabis-related problems and participants' levels of externalizing symptoms.

Specific externalizing symptoms have been examined in relation to cannabis use; particularly, impulsivity. Impulsivity is the most well known and most researched externalizing risk factor (VanderVeen, Hershberger, & Cyders, 2016). However, despite this clear link, findings from the body of impulsivity research has been somewhat inconsistent (VanderVeen et al., 2016). In their meta-analytic review, VanderVeen and colleagues (2016) argued that these discrepancies may emerge due to the measurement of different facets of impulsivity. Although sometimes viewed as a unidimensional construct, contemporary research is starting to view impulsivity as a multidimensional construct. For example, one model argues there are five facets of impulsivity, labelled positive urgency (i.e., acting rashly when experiencing unusually positive emotions), negative urgency (i.e., acting rashly when experiencing unusually negative emotions), lack of planning, lack of perseverance, and sensation seeking (Cyders, Littlefield,

Coffey, & Karyadi, 2015; Cyders & Smith, 2008). These sub-dimensions of impulsivity share some variance but are independent of one another nonetheless (Cyders & Smith, 2007; Cyders et al., 2015). VanderVeen et al.'s (2016) meta-analysis reviewed studies that examined these five dimensions of impulsivity separately. Results revealed that, as expected, sensation seeking received considerably more attention within the cannabis research field ($k = 52$) than did the remaining facets of impulsivity, noting a stark lack of research on lack of perseverance ($k = 2$). Importantly, based on the available research on impulsivity and cannabis use, VanderVeen and colleagues (2016) suggested that one source of the discrepancies in impulsivity findings may rest in variability in choices of cannabis outcome measures. Specifically, it was noted that sub-facets of impulsivity generally tended to have a small effect size for cannabis use initiation, but a larger effect size (i.e., medium relationship) for cannabis use-related consequences. Moreover, VanderVeen et al. highlighted the parity of effect sizes across all dimensions of impulsivity, with the exception of lack of perseverance; although this later discrepancy should be considered in light of the paucity of research on this particular sub-dimension of impulsivity. Consequently, externalizing symptoms appear to pose a noteworthy risk for the development of CUD, particularly in adolescents and young adults.

**Polysubstance use.** Another risk factor consistently linked to cannabis-related problems and CUD is the use of other substances (Connor et al., 2013; Peters, Budney, & Carroll, 2012; Ramo, Liu, & Prochaska, 2012). According to the Canadian Tobacco Alcohol and Drugs survey (Statistics Canada, 2018), Canadians who consume cannabis products are more likely than Canadians who abstain from cannabis to have consumed other substances within the past year. More specifically, Canadians who self-reported

having used cannabis in the past 12 months were more likely to have consumed alcohol (i.e., 92% of users versus 76% of non-users), be cigarette smokers (i.e., 38% of users versus 11% of non-users), and have consumed at least one other illicit drug (i.e., 20% of users versus 0.4% of non-users) in comparison to their peers who had not consumed cannabis (Statistics Canada, 2018).

The substance examined most extensively in regard to its relationship with cannabis is tobacco. Although there is ample support for the link between increased cannabis use and increased cigarette smoking, the sequential order of use onset between these substances remains unclear (Dierker, Braymiller, Rose, Goodwin, & Selya, 2018). Frequently, the relationship between cannabis and tobacco use is described in terms of the "gateway theory", which posits that tobacco use commonly precedes the use of cannabis (Moss, Chen, & Yi, 2014; Peters et al., 2012; Ramo et al., 2012). This theory was supported in a review article by Ramo et al. (2012), who found that 90% of cross-sectional studies ($k = 87$) and 80% of longitudinal studies ($k = 40$) found a positive relationship between past tobacco use and future cannabis use. However, the reverse has been found as well, with past cannabis use predicting future tobacco use (Peters et al., 2012; Ramo et al., 2012).

Despite the uncertainty of which substance precedes the other, it is common, particularly in adolescents and young adults, to consume cannabis and tobacco products jointly (Moss et al., 2014; Ramo, Delucchi, Hall, Lui, & Prochaska, 2013; Tzilos, Reddy, Caviness, Anderson, & Stein, 2014). Co-occurring cannabis and tobacco use has been associated with a reduced likelihood of successful cannabis use cessation (Haney et al., 2013; Peters et al., 2012), an increased likelihood of relapse to the use of other illicit

substances (Weinberger et al., 2017), using cannabis at a younger age (Dierker et al., 2018; Hayatbakhsh et al., 2009), and experiencing substance use-related problems (Ramo et al., 2012). Finally, the use of both cannabis and tobacco has been linked to greater incidences of CUD (Hayatbakhsh et al., 2009; Peters et al., 2012; Ramo et al., 2012; Schlossarek et al., 2015; Timberlake, 2009).

Although nicotine and cannabis are known to have a strong influence on each other, there are other substances (e.g., alcohol) that also may be associated with cannabis-related problems. Similar to tobacco, alcohol and cannabis are often used in conjunction (Connor et al., 2013; Erevik, Torsheim, Andreassen, Vedaa, & Pallesen, 2017; Moss et al., 2014). For example, a large cross-sectional study on Norwegian students found that participants who self-identified as cannabis users were also more likely to experience problematic alcohol use in comparison to individuals who seldom used or never used cannabis (Erevik et al., 2017). Likewise, a large longitudinal study found that individuals who had consumed alcohol by the age of 14 years were at an increased risk for using cannabis as well as for developing a CUD (Hayatbakhsh et al., 2009).

The combined use of alcohol and cannabis has been suggested to arise, at least in part, due to the enhanced effects of both substances that occurs as a result of co-use (Pape, Rossow, & Storvoll, 2009; Tzilos et al., 2014). Alternatively, it has been proposed that combined use may occur due to shared risk factors for substance use, or that individuals who consume illicit drugs may have greater opportunity to consume other illicit substances as they may be available through the same sources (i.e., the "black market"; Erevik et al., 2017; Hall, 2014). Indeed, there is a link between cannabis

use frequency and the use of a variety of other illicit drugs, including cocaine, stimulants, opiates, and hallucinogens (Erevik et al., 2017; Hall, 2015; Tzilos et al., 2014). Cannabis users who also use other substances have an increased likelihood of experiencing substance use-related problems, and tend to be at greater risk for the development of one or more substance use disorders (Connor et al., 2013; Connor, Gullo, White, & Kelly, 2014; Moss et al., 2014; Schlossarek et al., 2015). Despite the significance of research of cannabis use risk factors, the available research is limited in that it does not allow consideration of the impact of a combination of risk factors as additive factors, nor how these factors might interact with one another to influence cannabis use patterns and outcomes. One way to consider the nuances amongst risk factors more comprehensively is through identifying clusters of individuals who have shown increased vulnerability to risks.

**Cannabis Use Clusters**

Substance use clusters allow researchers to group individuals based on common variability across measured characteristics and to subsequently investigate how each cluster of users differentially relate to the likelihood of chosen substance use outcomes (Lavery, 2011). Although this approach has been used regularly in the substance use literature (e.g., Cohn et al., 2017; Lannoy, Billieux, Poncin, & Maurage, 2015; Mun, Eye, Bates, & Vaschillo, 2008; Perrot, Hardouin, Gall-Bronnec, & Challet-Bouju, 2018), substance use clusters rarely have been examined in relation to cannabis specifically. Notably, to our knowledge, only four such studies exist and explored cannabis use clusters using cannabis use patterns and mental health variables.

One of the first cannabis use cluster studies (Korf et al., 2007) examined 388 Dutch participants who self-identified as past-month cannabis users. These researchers included various cannabis use variables (i.e., quantity and frequency of use, age of initiation, preferred potency), in addition to DSM-IV cannabis dependency criteria and combined use of tobacco products. From their data, Korf and colleagues identified three cannabis use clusters: "strongest high", "consistent high", and "steady quantity". The first cluster, "strongest high", had the youngest mean age, and consisted of those who consumed the most cannabis in terms of both quantity and frequency. This group tended to prefer higher potency cannabis and inhaled these products more deeply than other groups. However, this cluster also tended to have been using cannabis for the shortest amount of time. The second cluster, "consistent high", could be considered the least problematic users of the three groups. Despite being relatively young (i.e., emerging adults), they initiated cannabis at an older age than the "strongest high" cluster and consumed lower potency cannabis. When they consumed higher potency cannabis, they titrated their cannabis dosage (i.e., smoked less, inhaled less deeply) and overall, consumed the least amount of cannabis. The third cluster, "steady quantity" was the oldest group of users and preferred to smoke cannabis alone. These users also had been consuming cannabis for the longest amount of time relative to the other groups. However, in contrast to the "consistent high" group, they did not titrate their cannabis according to potency. Korf et al. suggested that these clusters may actually represent the evolution of cannabis use, whereby individuals may begin using cannabis seeking a strong high and later morph into a pattern of habitual use. Although Korf et al. included cannabis use variables when forming their clusters, they did not consider how mental

health variables may contribute to the formation of cannabis using groups or variations between these clusters. Additionally, their findings may not be representative of the cannabis using population as a whole, as participants were exclusively sampled from cannabis coffee shops where it is legal to sell and consume cannabis products in the Netherlands.

Miller and Plant (2002) filled in some of the gaps in the existing literature by examining cannabis use clusters on the basis of psychopathology (i.e., mood and delinquency/aggression measures), polysubstance use, relationships with family and friends, and leisure time activities (e.g., "riding around on motor-cycles or mopeds just for fun"). Their study included 201 students between the ages of 15 and 16 who had identified as heavy cannabis users, defined as having consumed cannabis on a minimum of 40 occasions throughout their lifetime. Three typologies were produced from their data: One group was marked primarily by their increased aggressive and delinquent tendencies, particularly stealing and destruction of property, and were termed the "antisocial" cluster. A group labeled as the "unhappy" cluster stood apart from their peers due to their low self-esteem and depressed mood in the last seven days. Finally, an "ordinary" group identified individuals who were generally found to have more positive outcomes on all measures. They were the least likely to use other illicit drugs, or to engage in criminal acts, and reported quality family relationships and friendships in addition to living in a stable environment. Despite the inclusion of mental health variables, Miller and Plant's study also had limited generalizability in that it included only high school students who were heavy users.

The most recent study available on cannabis use clusters (Chabrol et al., 2012) used Miller and Plants' (2002) study as a framework, and aimed to expand on their findings regarding the psychopathological indicators associated with cannabis use by including additional mental health variables in their study (i.e., depressive, social anxiety, and psychopathic symptoms). Chabrol and colleagues (2012) conducted a hierarchical cluster analysis with the data of 199 French adolescents who reported current cannabis use (i.e., at least monthly for the last six months), with three clusters emerging. An "ordinary" cluster emerged, in line with Miller and Plant (2012), who reported below average scores on all mental health symptomatology; a "borderline" cluster, which is akin to Miler & Plants' "unhappy" cluster, with high levels of borderline personality, depression, and social anxiety symptoms; and an "impulsive" cluster, linked to Miller and Plant's "antisocial" cluster as this group reported high levels of impulsivity and callous traits. Additionally, clusters who reported mental health problems (i.e., borderline and impulsive clusters) consumed cannabis more frequently than their peers. Hence, Chabrol et al.'s (2012) results suggest that both internalizing and externalizing symptoms are associated with more severe cannabis use problems. One limitation of the previously described study (Chabrol et al., 2012) was the absence of polysubstance use in their cluster variables, as it has been associated with poorer outcomes in cannabis users (Schlossarek et al., 2015). Additionally, the likelihood of experiencing cannabis-related negative consequences were not explored for each cluster of users (Chabrol et al., 2012). Furthermore, their study retained the same generalizability issues as Miller and Plant's (2012) original study by limiting their sample to high school students.

Finally, Fischer et al. (2010) conducted the most comprehensive cluster study to date. These authors were interested in assessing cannabis use practices (i.e., age of onset, days used in last 30 days, frequency of use in last 3 months, quantity consumed in last year, medical and recreational use) and physical/mental health, as well as cannabis use outcomes. Four cannabis use typologies emerged from this sample of 1303 Canadian cannabis users, ranging in age from 15 to 84 years. Cluster 1 were occasional (i.e., 7 times or less in the last month) social cannabis users who initiated use at or before the age of 21. Cluster 1 was the least likely to use other illicit substances and have co-occurring mental health problems, and used cannabis in smaller quantities than other clusters. However, this cluster consumed the most alcohol. Cluster 2 reported earlier cannabis use onset than cluster 1 (i.e., at or before age 17), but were also occasional, social users. Cluster 3 reported greater baseline use of cannabis (1-14 days within the last month) and experienced the most mental health problems of the four clusters. Additionally, unlike clusters 1 and 2, cluster 3 was composed of both social and medical cannabis users. Finally, cluster 4 initiated cannabis use at the youngest age (i.e., at or before age 15), were the most likely to use other illicit drugs, and reported daily or near daily use of cannabis. Although Fischer and colleagues assessed mental health symptoms, these were measured very generally (i.e., binary response of whether the individual experienced "15 or more days with mental health problems in the past 30 days") and they were not incorporated in the cluster analysis itself, but rather as an outcome variable. Additionally, as this is the first cannabis use cluster study conducted within a Canadian context, these results must be replicated.

Despite inconsistencies in identifying the number of clusters, much of the research that has been performed has identified similar trends among users. Major subgroups of users typically include individuals who generally do not misuse cannabis, individuals who are persistently at a high risk for developing mental health problems in conjunction with their cannabis use, and individuals who engage in a range of risky cannabis use behaviours such as early initiation, frequent heavy use and polysubstance use (Chabrol et al., 2012; Fischer et al., 2010; Korf et al., 2007; Miller & Plant, 2002). Taken together, findings from these studies provide insight into cannabis risk factors. However, these studies have been limited by the nature of the variables included and by generalizability concerns (e.g., paucity of Canadian data, limited age range). The current study aims to bridge these gaps by assessing the impact of the empirically supported risk factors (i.e., cannabis use patterns, mental health variables, polysubstance use) and associated cluster profiles within a broad population of cannabis users.

**The Current Study**

Despite some understanding of factors contributing to cannabis misuse, there is much less research focusing on cannabis in contrast to other substances (i.e., alcohol or opioids). In the context of Canadian cannabis legalization and an increased necessity of developing efficient methods of assessing cannabis misuse, it is timely to examine whether quantity and frequency estimates are sufficient to identify risky cannabis use relative to the comprehensive assessment of CUD. Furthermore, given that only a handful of studies have examined types of cannabis users, and did so mostly outside of the North American context and/or within a framework where cannabis was considered an illicit substance, it is necessary to identify Canadian clusters of cannabis users to

replicate the one study (Fischer et al., 2010) that has been conducted in Canada. Furthermore, this work needs to include mental health risk factors in conjunction with substance use variables.

Based on the identified research needs, the first goal of the proposed study was to examine the validity of Rehm and colleagues' (2013) theory that quantity and frequency estimates are sufficient indicators of problematic cannabis-related consequences on their own to capture risk of negative cannabis use outcomes. Quantity indicators included the assessment of potency as well as ratings of subjective high, whereas frequency measures assessed both the typical frequency of use in the past-year as well as past 30-day cannabis use. The following hypotheses were addressed in relation to goal one of the current study:

- Frequency of cannabis use (i.e., "how often did you typically consume cannabis in the past year; how many days in the past 30 days did you consume cannabis") will be the strongest predictor of cannabis-related problems (i.e., health, social, legal, and/or financial; e.g., Cuttler & Spradlin, 2017; Tomko et al., 2018).
- Cannabis quantity indicators (i.e., cannabis potency and subjective intoxication) will not be correlated with one another, but will contribute to cannabis-related problems, albeit accounting for less variance than frequency of use (Freeman et al., 2014).
- CUD, as assessed by the DSM-5 CUD criteria, will not contribute any additional variance to cannabis-related problems over and above quantity and frequency estimates (Rehm et al., 2013).

The second goal of the proposed study was to assess whether cannabis use variables (i.e., age of first use, quantity and frequency of use, and cannabis use practices), polysubstance use, and mental health symptoms (i.e., internalizing and externalizing symptoms) could be used to identify clusters of cannabis users and, if so, whether these potential clusters were associated with different levels of CUD and/or cannabis-related problems. Based on the few existing typologies for cannabis users, it was hypothesized that at least three clusters of cannabis users would emerge. One would consist of polysubstance users with a combination of high internalizing (i.e., stress, anxiety, depressive symptoms) and externalizing symptoms (i.e., impulsivity, sensation seeking), and would use cannabis the most (i.e., quantity and frequency, and problematically; e.g., Chabrol et al., 2012; Fischer et al., 2010; Miller & Plant, 2002). Another proposed cluster would include individuals who used cannabis for medical reasons. These individuals would have lower levels of externalizing symptoms but be high in internalizing symptoms and use cannabis frequently but less problematically (Fischer et al., 2010). A third group would include infrequent cannabis users which would have the lowest levels of both internalizing and externalizing symptoms, and exhibit less negative cannabis use consequences (e.g., Chabrol et al., 2012; Miller & Plant, 2002).

## Method

### Participants

Participants were recruited from the University of New Brunswick as well as from social media platforms that extended beyond the University population (e.g., cannabis user chatrooms, Reddit, etc.). Additionally, efforts were made to recruit

participants from substance using populations, such as at the Centre for Research, Education, and Clinical Care of At-Risk Populations (RECAP) and Avenue B Harm Reduction in the Greater Saint John area in New Brunswick in order to obtain a diverse sample with respect to cannabis use patterns. Based on Dziak, Lenza, and Tan's (2014) latent class cluster power analyses, a sample of 250 individuals was estimated to be sufficient to achieve a power of .80 with a medium effect size and a proposed three class model. However, given that the number of individuals in each use category was likely to vary and that unequal class size can decrease power, a larger data set was sought. Specifically, stratified sampling was employed in order to ensure that the sample size was both sufficient and representative. Approximately 187 students from the University of New Brunswick, 292 individuals from the community at large, and 54 individuals from sites servicing individuals who use substances in the greater Saint John area were recruited for the current study, resulting in a sample size of 533. Inclusion criteria consisted of being over the age of 19, living in Canada, and currently using cannabis, as defined by past-year use. As most participants completed the study online, some participants ($n$ = 118) were excluded based on their responses to screening questions (e.g., "have you consumed cannabis at least once in the last year?"), unrealistic completion times (i.e., 5 minutes or less), or impossible combinations of responses ($n$ = 3). Additionally, some participants ($n$ = 39) were excluded due to significant missing data (i.e., 20% of the survey or above). Thus, the final sample size for the current study was $N$= 373. Participants were primarily Caucasian (92.8%) and female (75.5%) and had a mean age of 27.6 years ($SD$ = 10.60; see Table 1 for descriptive demographics).

## Measures

**Demographics Questionnaire** (Internally generated; see Appendix A). The self-developed demographics questionnaire collected basic demographic information from each participant, including age, gender, ethnicity, marital status, employment status, and level of education.

**Depression Anxiety Stress Scale-21** (DASS-21; Crawford & Henry, 2003; see Appendix B). Adapted from the original DASS-41 (Antony, Bieling, Cox, Enns, & Swinson, 1998), the DAAS-21 is a well validated, shortened version that addresses depressive, anxiety, and stress symptoms in three distinct subscales. Items from each subscale are evenly distributed (i.e., 7 items per subscale). Questions within the depressive symptom subscale (e.g., "I couldn't seem to experience any positive feelings at all") address symptoms such as hopelessness and low positive affect. Questions pertaining to anxiety (e.g., "I felt I was close to panic") assess physical manifestations of anxiety (e.g., rapid heartrate) as well as feelings of uneasiness. Finally, items that query irritability and general tension and arousal (e.g., "I found it difficult to relax") make up the stress symptom subscale. The 21-item questionnaire uses a Likert-type scale to assess the degree to which participants have experienced each symptom in the past week on a scale ranging from never to almost always (i.e., 0 = Never, 1 = Sometimes, 2 = Often, 3 = Almost always).

Internal reliability for all DASS-21 subscales have been excellent (Crawford & Henry, 2003), with Cronbach's alpha values of $\alpha = .90$ (anxiety subscale), $\alpha = .93$ (stress subscale), and $\alpha = .95$ (depression subscale). The same was true in the current study, where Cronbach's alphas ranged from .81 to .92. The internal reliability of the

questionnaire overall ($\alpha$ = .97) has been exceptional and was excellent in the context of the current study as well ($\alpha$ = .95). The DASS-21 has been validated in several languages and subpopulations around the world, demonstrating validity across languages and cultures (e.g., Tran, Tran, & Fisher, 2013).

**Urgency, Premeditation, Perseverance, Sensation Seeking, Positive Urgency, Impulsive Behaviour Scale-Short-Form** (SUPPS-P; Cyders et al., 2015; see Appendix C). The SUPPS-P measured various dimensions of impulsivity with 20 items. Five subscales, each containing four items, assessed emotion-based rash actions, deficits in conscientiousness, and sensation seeking. Specifically, negative urgency and positive urgency subscales measured emotion-based rash actions in response to negative and positive events, respectively (e.g., "When I am upset I often act without thinking" and "I tend to lose control when I am in a great mood"), whereas the lack of premeditation and lack of perseverance subscales measured deficits in conscientiousness and follow-through (e.g., "I like to stop and think things over before I do them" and "I finish what I start", reverse coded). Sensation seeking was measured as a single subscale of four items (e.g., "I quite enjoy taking risks"). All items were answered generally (i.e., no specific timeframe) using a 4-point scale (i.e., disagree strongly to agree strongly), where higher values indicated greater endorsement of impulsive symptoms.

The SUPPS-P exhibits strong correlations (*r*'s ranging from .64 to .83) between all subscales when compared to the original UPPS-P subscales, which contained 59 items. Predictive validity for the measure is satisfactory, as the SUPPS-P subscales have had the ability to accurately predict specific behaviours previously linked to each impulsive construct (Cyders et al., 2015). For example, higher scores on sensation

seeking have been associated with increased alcohol and drug use, gambling, and risky sexual behaviour. Finally, the internal consistency for the SUPPS-P has been acceptable, with Cronbach's alpha scores of .74 for the sensation seeking subscale, .78 for the negative urgency subscale, .79 for the lack of perseverance subscale, and .85 for both the lack of premeditation and positive urgency subscales (Cyders et al., 2015). In the current study, Cronbach's alphas ranged from acceptable ($\alpha$ = .66) to good ($\alpha$ = .80) for the subscale scores, and the scale had an overall alpha of $\alpha$ = .81.

**Alcohol, Smoking, and Substance Involvement Screening Test-Adapted** (ASSIST-A; World Health Organization [WHO] ASSIST Working Group, 2002; see Appendix D). An adapted version of the original ASSIST screening instrument was used to measure participants' cannabis-related negative consequences. A total of 4-items queried cannabis users' frequency of health, social, legal, and financial problems within the past 12 months. Items were answered using a 7-point Likert-type scale (i.e., Never = 0; Once or Twice = 4; Monthly = 5; Weekly = 6; Daily or Almost Daily = 7). Therefore, total scores range from 0 to 28. Each item was posed in the context of cannabis use (e.g., "During the last year, how often has your cannabis use led to health problems?") to ensure relevant cannabis-related consequences were captured. The original ASSIST interview has demonstrated low inter-rater and high internal reliability (i.e., $k$ = .64, and $\alpha$ = .85, respectively; WHO ASSIST Working Group, 2002). However, self-reported versions of the ASSIST (e.g., Barreto, Christoff, & Boerngen-Lacerda, 2014) have demonstrated good internal reliability on sections which pertain to cannabis (i.e., $\alpha$ = .86). In the current study, the scale demonstrated borderline internal consistency ($\alpha$ = .64).

**Cannabis Use Questionnaire** (Internally generated; see Appendix E). The self-developed 21-item cannabis use questionnaire was created to assess participant's cannabis use patterns. The questionnaire focused on frequency of cannabis use (e.g., "how many days have you used cannabis in the last 30 days?"; "how often did you use cannabis in the last year?"), and quantity of cannabis use by querying their most commonly consumed cannabis product potencies (e.g., "Please indicate the percentage of THC in the cannabis you purchase most frequently") as well as their preferred method of administration and subjective ratings of their cannabis-induced "high" (e.g., "When I consume cannabis, I generally get [not high at all to extremely high]). In addition, personal risk factors (i.e., family history of substance use disorders or psychosis, age of first use) were also captured. As participants must have been past-year cannabis users in order to participate in the current study, the questionnaire focused on both past-year use and recent use (i.e., past 30-day use) in order to obtain a comprehensive representation of each participant's cannabis use patterns.

**Addiction Severity Index-Adapted** (ASI-A; McLellan, Luborsky, Woody, & O'Brien, 1980; see Appendix F). The original ASI was adapted to assess participant's use of various substances, including tobacco, opiates, barbiturates, sedatives, heroin, amphetamines, alcohol, cocaine, and hallucinogens in the last three months. This section of the ASI questionnaire presented each type of substance and provided a list of names (e.g., "Sedatives/ Hypnotics/ Tranquilizers [Benzodiazepines, Valium, Xanax, Librium, Ativan, Quaaludes]") in an attempt to facilitate the identification of a particular substance of interest that the participant may have been using. Participants were asked to indicate their frequency of consumption for each category of substances on a six-point

scale, ranging from 1 (Never use) to 6 (Once a day or more). The questions were posed in a manner that assessed only non-prescription use of each substance. Total scores for this subscale were calculated by assigning one point to each substance used and subsequently summing the total amount of substances used in the past three months in order to assess polysubstance use. In addition, to distinguish licit from illicit substance use, participants were assigned to a binary (i.e., used or not used) category for both licit and illicit substances (i.e., a score of 0 on all illicit substances was classified as having not used illicit substances whereas scores above 1 were assigned to the "used" category).

**DSM-5 Cannabis Use Disorder Criteria Questionnaire** (APA, 2013; see Appendix G). To assess CUD diagnosis and severity in the past year, participants were asked to identify which, if any, of the 11 DSM-5 CUD criteria applied to them. Items were formulated to reflect the DSM-5 criteria wording as close as possible (e.g., "I give up or reduce my involvement in important social, work-related, or recreational activities because of cannabis") and presented in a yes or no checklist format. Although there are 11 DSM-5 criteria for cannabis use, the questionnaire contained 12 items. Items 11 and 12 were separated criteria items that focused on the withdrawal criteria. These two items separated the physical and psychological/emotional dimensions of withdrawal (i.e., "after stopping cannabis use following heavy use for at least a few months, I have experienced 3 or more of the following [psychological/emotional symptoms]" and "after stopping cannabis use following heavy use for at least a few months, I have experienced 1 or more of the following [physical symptoms]"). All questions answered "yes" were given a score of 1 with the exception of items 11 and 12, which were given a score of 0 if none of the two items were checked "yes" and a score of 1 if one or both items were

endorsed (the DSM-5 requires only one of two [psychological or physical] symptoms to meet withdrawal criteria). Scores range from 0 to 11; diagnostically, endorsing 2-3 symptoms is considered a mild substance use disorder, endorsing 4-5 symptoms is indicative of a moderate substance use disorder, and endorsing 6 symptoms or more suggests the existence of a severe substance use disorder (APA, 2013).

Similar questionnaires have been developed based on DSM criteria for mental health disorders and have proven to be reliable and valid. For example, Davis, Hoffmann, Morse, and Luehr (1992) developed the Substance Use Disorder Diagnostic Schedule-IV according to DSM-IV criteria for substance abuse and dependence to assess for potential substance use problems. Such scales typically have excellent reliability as they are based on established diagnostic criteria. In the case of the current study, internal reliability was excellent ($\alpha$ = .86).

**Cannabis Use Disorders Identification Test-Revised** (CUDIT-R; Adamson et al., 2010; see Appendix H). The CUDIT-R measured problematic cannabis use with eight items. These questions focused on the participant's cannabis use and related cannabis problems in the last six months by inquiring about the participant's frequency of use, how often they felt their cannabis use was out of control (e.g., "How often during the past 6 months did you find that you were not able to stop using cannabis once you had started?"), how often cannabis interfered with their typical day-to-day functioning (e.g., "How often in the past 6 months have you had a problem with your memory or concentration after using cannabis?"), and risky cannabis use practices (e.g., "How often do you use cannabis in situations that could be physically hazardous, such as driving, operating machinery, or caring for children?"). Items were answered based on frequency

of use or occurrence (e.g., never, less than monthly, 2-4 times per month, 2-3 times per week, 4 times or more per week) with the exception of the final question (i.e., "Have you ever thought about cutting down, or stopping, your use of cannabis?"), designed in a yes or no format. Scores have the potential to range from 0 to 32, where higher scores are indicative of increased hazardous cannabis use. However, to clearly separate cannabis problems as measured by the CUDIT-R from measures of quantity and frequency of cannabis, both of the items pertaining to cannabis use frequency were excluded from the total score. Thus, the possible range of scores within the current research was from 0 to 24.

The CUDIT-R demonstrates strong convergent validity when compared to other well validated substance misuse instruments which assess similar constructs (Adamson et al., 2010). For example, the Cannabis-modified version of the Readiness to Change Questionnaire-treatment version measures an individual's stages of readiness for change in regards to their substance use patterns, and is associated with CUDIT-R scores (*rs* = .59, $p < .001$), as well as with the Daily Sessions, Frequency, Age of Onset, and Quantity of Cannabis Use Inventory (*r*'s ranging from .20 to .73; a measure of cannabis use behaviours; Cuttler & Spradlin, 2017). Frequency of use was the most strongly correlated ($r = .73$) and quantity of cannabis use was the least associated ($r = .20$) variable with the CUDIT-R. The internal consistency for the CUDIT-R ($\alpha = .91$) is nearly identical to the full-length version ($\alpha = .91$) of the CUDIT, which are both excellent (Adamson et al., 2010). In the current study, the Cronbach's alpha was .73.

**Procedure**

Ethical approval for the current study was obtained from both the University of New Brunswick's (Saint John campus) and the Horizon Health Network's Research Ethics Boards. Additionally, Horizon Health's Mental Health and Addictions manager granted access to all Horizon Health affiliated data collection sites. Both the university and community samples participated in the study online. Participants either accessed the study via SONA (i.e., a registration system used by the university to award bonus points in exchange for participation in research), by manually entering the link provided on the recruitment posters in an internet search engine, or by clicking on a direct link to the study provided through social media advertisements. Students from the Saint John campus of the University of New Brunswick were informed about the study primarily though classroom announcements and posters that were on display throughout the campus (see Appendix I). The posters and/or announcements informed potential participants that the study would query their cannabis use as well as various aspects of their mental health in exchange for one-half of a bonus point. In contrast, the community sample was accessed through social media (e.g., Facebook, Cannabis use forums) as well as through snowballing (i.e., word of mouth). Clicking or entering the direct link in a search engine took participants to the survey, hosted by Qualtrics. Upon accessing the survey, an informed consent form was automatically displayed (see Appendix J), outlining the goals of the study, expectations, and the individual's right to withdraw any time without penalty. By virtually signing the consent form (i.e., clicking a mandatory consent box), participants proceeded to a short questionnaire that gathered basic demographic information. When the demographic questionnaire was complete, gated

questions verified that the participant has used cannabis in the last year, that they currently resided in Canada, and were over the age of 19. If they had not met these eligibility criteria, then the survey automatically terminated, and participants were redirected to a separate Qualtrics survey thanking them for their time. If the participant qualified for participation in the study, then the DASS-21, ASI-A and ASSIST-A, SUPPS-P, Cannabis Use Disorder Criteria Questionnaire, CUDIT-R and the DSM-5 CUD criteria questionnaires were presented in a random order, with an average completion time of approximately 14.8 minutes. Upon completion of the study, participants were redirected to a second, unaffiliated Qualtrics survey to provide contact information if they wished to enter a draw for one of three $25 Amazon gift cards.

Finally, the clinical population was informed about the study though posters (see Appendix K), which were placed in areas where potential cannabis users accessed services (e.g., waiting areas of Avenue B Harm Reduction), by word of mouth from their health care providers and/or peers (i.e., pharmacist, receptionists, nurse practitioners), and/or by the primary researcher, who visited clinical sites regularly. These sites included RECAP, Avenue B Harm Reduction, and the Opiate Replacement Therapy Program (ORTP) at Saint Joseph's Community Health Centre. At the recruitment stage, potential clinical participants were verbally provided with the same information regarding their role in the study as all other participants (i.e., the information they would be asked to provide, compensation, etc.) The primary researcher was present in a confidential area on site for interested participants to complete the survey. Those who chose to participate in the study were given a physical copy of the informed consent form (see Appendix L) outlining confidentiality safeguards and their

ability to withdraw from the study at any time without penalty. If informed consent was provided, then participants were given a randomized package of questionnaires to be completed in the presence of the primary researcher (excluding the CUDIT-R). Upon completion of the survey, participants each received a $5 Tim Horton's gift card in exchange for their participation.

## Results

Data analyses were conducted using SPSS 26 and Mplus. Relevant statistical analyses were conducted prior to the cleaning and conditioning of the dataset to eliminate participants who did not meet eligibility criteria and to ensure that all statistical assumptions were met. These procedures (e.g., addressing outliers) aligned with the recommendations of Tabachnick and Fidell (2019). All data analyses were evaluated using an alpha level of $p < .05$, unless otherwise specified.

### Data Cleaning and Conditioning

The data was first screened for out of range values. Two out of range values (i.e., age of first use of "1", and one extremely large value for money spent on cannabis in the last 30 days) were identified, removed, and subsequently treated as missing values. Additionally, participants who responded with a range of scores were assigned an average value (e.g., a score of "between 6 and 8" on the subjective high scale was entered as 7). Written responses corresponding to "other" options were also analyzed and moved to the correct response option when appropriate (e.g., "CBD oil" changed from "other" [6] to "Oils" [5]).

Univariate outliers were then examined using standardized scores (i.e., Z scores). Z scores which exceeded the cut-off of 3 were noted and assessed for plausibility and

continuity with the remainder of the data. Variables that contained outliers included age ($n$ = 3), money spent on cannabis in the past 30 days ($n$ = 13), age at first use ($n$ = 10), total ASI-A scores ($n$ = 8), DASS-21 subscale ($n$ = 5) and total scores ($n$ = 3), SUPPS-P subscale ($n$ = 7) and total scores ($n$ = 1) as well as total ASSIST-A ($n$ = 7), DSM-5 CUD ($n$ = 7), and CUDIT-R ($n$ = 8) scores. Due to the nature of the questionnaires used in the current study (e.g., the ASI-A), some outliers were expected to arise as a result of engaging at greater frequency in low base rate activities, such as high frequencies of polysubstance use and substance use-related problems. Therefore, the majority of the outliers that were observed were retained, as values were generally continuous with the remainder of the dataset and consisted of plausible scores or responses. Three exceptions can be noted, all of which fell under one variable which assessed the amount of money individuals spent on cannabis in the past 30 days. The top three scores (i.e., $900, $640, and 480$) were modified using the winsorizing method as recommended by Tabachnick and Fidell (2019). This technique involved replacing the data points in question by a value which corresponded to one unit larger than the most extreme (but not out of range) score, resulting of new scores of $403, $402, and $401, respectively.

Finally, multivariate outliers were detected using Mahalanobis distances. First, Mahalanobis distances were calculated for variables that were included in the regression analysis. One multivariate outlier was detected, which resulted in the removal of the case. No additional multivariate outliers were identified. Mahalanobis distances were then computed for variables included in the latent class cluster analysis and its follow-up analyses, however no multivariate outliers were identified. Therefore, after taking the

removal of multivariate outliers into account, the final sample size in the current study was $N = 372$.

P-P plots were then examined for all variables, which suggested potential normality issues for some variables. Thus, this initial observation was followed by an inspection of the values of skew and kurtosis. Overall, the majority of variables fell within a normal range (i.e., under 1 and under 5, respectively). Of the variables whose skew and kurtosis values fell above the normal range, the majority only showed slight deviations. Specifically, the demographic variables of age (skew = 1.27; *SE* = .13) and gender (skew = -1.14, *SE* = .13) as well as total scores on the DSM-5 CUD criteria (skew = 1.94, *SE* = .13) were slightly skewed. Only age at first use (skew = 3.00, *SE* = .13; kurtosis = 11.88, *SE* = .25), total ASSIST-A scores (skew = 2.24, *SE* = .13; kurtosis = 5.18, *SE* = .25) and the ASI-A total scores (skew = 2.43, *SE* = .13; kurtosis = 7.97, *SE* = .25) deviated more remarkably from normality. However, these measures were expected to emerge with slight deviations due to their nature and their relatively low prevalence in the overall population. Given that Tabachnick and Fidell (2019) suggested that a large sample size (i.e., greater than 200) may act as a protective measure against deviations of normality, as well as the fact that regression and MANOVA can accommodate for some lack of normality, analyses moved forward with unaltered data. Homogeneity of variance was examined upon running the MANOVA analyses and *p* values were adjusted when homogeneity of variance was not demonstrated. Finally, multicollinearity was preliminarily assessed using correlations. However, VIF and Tolerance values were also computed in conjunction with the regression analyses. All VIF values were exceptional, as values ranged from 1.04 to

1.56. Similarly, Tolerance values were high. The lowest Tolerance value observed was .64 and the remaining values ranged from .73 to .96. Hence, there were no problems pertaining to multicollinearity.

**Substance Use Practices**

All participants identified as having used cannabis within the past 12 months. Current use was prevalent, with 71.5% of the sample ($n$ = 266) reporting having consumed cannabis at least once in the past 30 days. Furthermore, 21.2% ($n$ = 79) reported using cannabis on all past 30 days. Participants who consumed cannabis within the last month spent between 0 and $403 on cannabis products, with the majority of users spending $0 ($n$ = 173), a median past-month allowance of $10 and a mean past-month spending of $52.78 ($SD$ = $93.03). The large proportion of participants reporting having spent $0 on cannabis products may be a result of a number of factors, such as not having used cannabis within the past 30-days ($n$ = 106), sharing cannabis products with friends/family, or growing their own cannabis plants. The majority (81.4%) of participants began using cannabis as adolescents (i.e., prior to the age of 20 years; $n$ = 302), resulting in an overall mean age of first use of 17.52 years ($SD$ = 5.80). However, a wide range of ages of onset were reported (minimum = 8 years, maximum = 49 years).

The sample was predominantly composed of recreational cannabis users (87.9%) with only 45 participants self-identifying as medicinal users (12.1%). In order to define participants as medical users, participants who indicated at least one physiological condition that has been validated by research (i.e., epilepsy, cancer symptoms, Parkinson's disease, and multiple sclerosis) or one condition that has other plausible medical implications for cannabis (e.g., migraines, chronic pain, fibromyalgia; see

review articles such as Amar, 2006; Hill, 2015; Reis, Almeida, Lopes, Mendes, & Bor-Seng-Shu, 2020) were retained as self-identified medical cannabis users ($n$ = 45). In contrast, individuals who reported conditions that may be worsened by the use of cannabis (e.g., anxiety; Bierhoff et al., 2019; Buckner et al., 2008) or were unlikely to be prescribed cannabis as a treatment method by a doctor (e.g., ADHD) were defined as recreational users ($n$ = 27) despite self-identifying as medical users. Pain, multiple sclerosis, cancer symptoms, Fibromyalgia, and arthritis were among the most common conditions that were reported by medical users for their cannabis use. All users who identified as recreational users were coded as such.

Overall, participants were generally unaware of the levels of THC and CBD in the cannabis products that they consume. Less than half of the participants were confident in their knowledge of the concentration of THC in their cannabis (48.6%), and just over one third were confident in their knowledge of the proportion of CBD (34.4%). Despite not being confident in the exact concentrations of THC and CBD in their cannabis products, participants were able to identify whether they preferred cannabis that was high in both THC and CBD (17.1%), high in THC and low in CBD (30.6%), low in THC and high in CBD (19.2%), or low in THC and CBD (3.5%). About 29% of cases identified not having a preference of THC or CBD levels (i.e., responding "I don't care about THC and CBD concentrations" when asked their preferred combination of THC and CBD).

In the current sample, the average reported subjective high was 5.36 ($SD$ = 2.31) on a 10-point scale, with the most frequent response ($n$ = 77) consisting of ranking their subjective intoxication as a 6. Most often, the preferred form of cannabis was the

cannabis flower (55.9%), followed by edibles (27.4%). Finally, joints (39.5%), edibles such as oils (24.7%), and bongs (10.5%) were most commonly identified as the preferred methods of consumption.

The average score on the ASI-A was 1.73 out of 10 (*SD* = 1.50). The overwhelming majority (90.9%) reported using three substances or less in the past three months, with just under half (48.9%) of participants using only one other substance other than cannabis and 8.6% reporting none. Most frequently, participants disclosed the use of alcohol (*n* = 314) and tobacco (*n* = 136). Illicit substance use in the current sample was generally low, with approximately 25% of the sample reporting having used one or more illicit substance in the last three months. Among the illicit drugs that were measured, cocaine (*n* = 43), opiates (*n* = 41), and hallucinogens (*n* = 40) were reported most frequently (See Table 2).

**Cannabis-Related Problems**

The average score on the ASSIST-A was remarkably low, averaging 2.08 out of 28 (*SD* = 3.85). More than two thirds of the sample (69.4%) scored a 0 on this measure, and only 10.5% scored above a 7 (i.e., indicated more than one type of cannabis-related problem). The range of scores for this measure was restricted, as the highest score (*n* = 1) was 21 out of 28 and only 1.1% of the sample scored in the top half of the possible scores (i.e., above 14). In contrast, the CUDIT-R had a more acceptable range of scores despite a low overall mean. Specifically, values ranged from the lowest (i.e., 0; *n* = 107) to the highest (i.e., 24, *n* = 1) possible scores, resulting in a mean of 3.67 (*SD* = 4.36).

Similarly, the DSM-5 CUD criteria also revealed a good range, with all possible scores being present (i.e., 0 to 11). Nearly half (46.8%) of respondents scored a 0 on this

measure. However, as this instrument serves to identify disordered use and seeing that even low scores are considered problematic diagnostically, this should be expected. Just under a quarter of participants (24.2%) self-reported experiencing at least 2 diagnostic criteria (i.e., mild CUD), 11.8% reported experiencing at least 4 diagnostic criteria (i.e., moderate CUD), and 6.5% reported experiencing at least 6 diagnostic symptoms (i.e., severe CUD). Overall, the mean DSM-5 CUD score was 1.64 (*SD* = 2.40).

**Internalizing and Externalizing Symptoms**

The mean score on the DASS-21, which measured internalizing symptoms, was 15.09 (*SD* = 12.26) and total scores ranged from 0 to 63 (i.e., the full range of possible scores). Clinical cut-off score guidelines state that scores above 16 should be flagged, as respondents with scores greater than 16 have a higher likelihood of having diagnosable anxiety or depression disorders. Participants scoring under 16 may still be at risk but are much less likely (30%) to receive a follow-up diagnosis of anxiety or depression (Chin, Buchanan, Ebesutani, & Young, 2018). In the current sample, 36.7% of participants yielded scores above 16, which is significantly higher than the national estimates of past-year prevalence of anxiety and depression (i.e., 2.6% and 4.7%, respectively; Statistics Canada, 2012). The means on the DASS-21 subscales of depression, anxiety and stress were 4.82 (*SD* = 4.97), 4.64 (*SD* = 4.05) and 5.63 (*SD* = 4.42), respectively. For all subscales, the range of possible scores (i.e., 0 to 21) were observed.

The measure for externalizing symptoms, the SUPPS-P, could range in scores from 20 to 80. However, the lowest observed score was 22 (*n* = 4) and the highest was 73 (*n* = 1). The average total score on the SUPPS-P was 39.90 (*SD* = 8.14). The majority of the sample (*n* = 190) had total scores that fell between 35 and 45. Of the five SUPPS-

P subscales, sensation seeking had the highest mean score ($M$ = 9.60, $SD$ = 2.83), followed closely by negative urgency ($M$ = 9.29, $SD$ = 2.94) and subsequently by positive urgency ($M$ = 7.35, $SD$ = 2.80). The subscales with the lowest means were lack of premeditation ($M$ = 6.77, $SD$ = 2.16) and lack of perseverance ($M$ = 6.90, $SD$ = 2.20). Scores were similar to those that have been observed in other studies on substance using populations (e.g., Ramakrishnan et al., 2019). See Table 2 for descriptives of all measures.

**Correlations**

Some relevant variables displayed moderate to strong correlations with one another (see Table 3). Specifically, variables that were used to measure mental health factors (i.e., DASS-21 and SUPPS-P scores) were significantly correlated with one another (e.g., DASS-21 total score and SUPPS-P negative urgency subscale; $r$ = .47, $p$ < .001), as well as with many of the variables that were used to measure cannabis use problems ($r$'s ranging from .14 to .40). Interestingly, many of the correlations were stronger between select mental health variables and cannabis use problem measures than they were for cannabis use variables and cannabis use problem measures.

Some variables emerged with strong correlations, which are important to note in the case of regression, as high correlation values may be indicative of multicollinearity. Most notably, two correlations between SUPPS-P subscales were flagged. First, a strong positive relationship emerged between positive and negative urgency, with an $r$ value of .62, $p$ < .001. The second correlation, between the lack of premeditation and lack of perseverance subscales, was slightly weaker, where $r$ = .53, $p$ < .001. However, the original validation of this scale noted similar strong correlations between subscales and

some overlap is to be expected when measuring similar constructs (Cyders et al., 2014). Three additional correlations between measures of cannabis use-related negative consequences were particularly striking. The DSM-5 CUD criteria strongly correlated with both the ASSIST-A total scores, $r = .68$, $p < .001$, and CUDIT-R total scores, $r = .78$, $p < .001$, and the ASSIST-A total scores correlated strongly with the CUDIT-R, $r = .59$, $p < .001$. Thus, these measures share some overlap in the construct (i.e., cannabis problems) they are measuring and these high correlation values should be expected.

**Role of Quantity and Frequency on Cannabis-Related Negative Consequences**

Two hierarchical regressions were conducted to assess whether DSM-5 CUD criteria accounted for any variance in cannabis use problems over and above what was already accounted for by demographic variables and measures of quantity and frequency of cannabis use (see Table 4). It was hypothesized that frequency of cannabis use would be the strongest contributor of poorer cannabis use-related outcomes; that indices of quantity would also account for negative cannabis use-related outcomes, but to a lesser extent than frequency; and that the DSM-5 CUD criteria would not account for any additional variance over and above quantity and frequency variables.

**ASSIST-A as a measure of negative cannabis-related consequences.** The first regression analysis was conducted to investigate the role of quantity and frequency on the likelihood of reporting negative cannabis-related consequences as assessed by the ASSIST. In block one, relevant demographic factors were entered (i.e., age, gender). Block two contained measures of cannabis quantity, as measured by subjective high, and frequency by the number of days cannabis was used in the past 30 days, as well as how often individuals consumed cannabis in the past 12 months. Potency estimates were not

included in the analysis as an index of cannabis use quantity as participants rated confidence in their estimates at less than chance level (i.e., 34% for CBD concentration and 48.6% for THC concentration). Finally, to assess whether the DSM-5 diagnostic criteria of CUD accounted for any remaining variance in cannabis use negative consequences over and above the variance accounted for by quantity and frequency measures, the self-reported diagnostic criteria checklist (i.e., DSM-5 CUD questionnaire total score) was entered in block three. Overall, the model was significant, $F(6, 361) = 58.21$, $p < .001$, and accounted for 49.2% of the variance in cannabis-related negative consequences when measured by the ASSIST-A.

The demographic information that was controlled for in block one (i.e., age and gender) contributed significantly to the model, albeit only accounting for 2.1% of the variance in cannabis-related negative outcomes. However, only male gender emerged as a significant predictor in this block, $\beta = -.15$, $p = .005$ (see Table 4). As such, these results suggest that male participants were more likely to experience cannabis-related problems.

The second block accounted for an additional 7.8% of the variance in the ASSIST-A scores, with only the measure of cannabis use quantity (i.e., subjective high), $\beta = .18$, $p < .001$, emerging as significant. In contrast, both measures of frequency did not emerge as significant predictors of cannabis-related problems; past 30-day use yielded a beta value of .13, $p = .155$, and past 12-month use yielded a beta value of .09, $p = .347$. Thus, individuals who achieve greater subjective intoxication from cannabis are more inclined to experience cannabis-related negative consequences as measured by the ASSIST-A in the current sample.

Finally, the third block consisting only of self-reported CUD criteria, β = .74, $p < .001$, accounted for the greatest proportion of variance in the model, at 39.2%. This finding indicates that increased endorsement of DSM-5 CUD criteria is associated with a matched increase in cannabis-use related problems.

**CUDIT-R as a measure of negative cannabis-related consequences.** As the total scores on the ASSIST-A were low and lacked variability ($M = 2.08$, $SD = 3.85$), a second hierarchical regression was conducted to assess the role of quantity and frequency on the likelihood of reporting negative cannabis-related consequences, as measured by the CUDIT-R (see Table 4 for a comparison of both regression outcomes). As in the original hierarchical regression, block one controlled for relevant demographic information (i.e., age and gender), block two consisted of measures of quantity and frequency (i.e., subjective high, number of days cannabis was used in the past 30 days, how often cannabis was consumed in the past 12 months), and self-reported diagnostic criteria checklist (i.e., DSM-5 CUD questionnaire total score) was entered in block three. Overall, the model was significant, $F(6, 323) = 92.16$, $p < .001$, and accounted for 63.1% of the variance in CUDIT-R scores.

Block one significantly contributed to the model, with only one of the two control variables (i.e., age) emerging as a significant predictor of cannabis use-related problems, β = -.14, $p = .014$, suggesting that younger cannabis users are more likely to experience cannabis use-related negative consequences. As a whole, block one accounted for 2.3% of the variance in CUDIT-R scores.

Block two accounted for more of the variance in CUDIT-R scores (i.e., 22.5%) in the current model in contrast to the regression using ASSIST-A scores as the outcome

(i.e., 7.8%). Notably, all predictors in this block emerged as significant: both quantity (i.e., subjective high), β = .13, $p$ = .012, and frequency (i.e., past 30 day use, β = .24, $p$ = .007; past 12 month use, β = .26, $p$ = .003) contributed to the model, indicating that individuals who both consume more cannabis (i.e., based on subjective high achieved) and those who consume cannabis more frequently may experience greater cannabis-related negative consequences.

Consistent with the regression which used the ASSIST-A as the dependent variable, block three accounted for the largest proportion of the variance in CUDIT-R total scores (38.4%). As the only predictor in block three, DSM-5 CUD scores emerged as an important contributor of negative cannabis use outcomes, with β = .74 ($p$ < .001). Hence, higher endorsement of DSM-5 CUD criteria contributes to negative cannabis use-related problems as measured by the CUDIT-R.

**Clusters of Cannabis Users and Their Associated Consequences**

The second goal of the current study was to assess whether cannabis use variables, polysubstance use, and mental health symptoms could identify distinct clusters of cannabis users. A subsequent goal was to assess whether these potential clusters were associated with different levels of CUD and/or cannabis-related problems. The current study hypothesized that at least three clusters of cannabis users would emerge: One would consist of polysubstance users who exhibited elevated mental health symptoms overall and who would use cannabis the most in terms of both quantity and frequency; another would consist of individuals who used cannabis frequently for medical reasons and had lower levels of externalizing symptoms and cannabis use problems but higher levels of internalizing symptoms; and a third which would include

infrequent cannabis users who had the lowest levels of mental health symptoms overall and who would exhibit low negative cannabis use-related consequences.

**Forming clusters of cannabis users.** As latent class cluster analysis cannot be conducted using SPSS 26, the cluster formation procedure was performed using Mplus, a similar statistical software program. Mplus does not tolerate empty cells (i.e., missing data); therefore, participants with missing values on relevant outcomes ($n$ = 9) were removed from the dataset for the formation of clusters as well as for follow-up analyses (i.e., a complete case analysis). Cannabis use practice variables (i.e., age of first use, quantity and frequency of use, and medical versus recreational use), mental health symptoms (i.e., DASS-21 and SUPPS-P total scores), and polysubstance use (i.e., ASI-A) were included in the latent class analysis to determine whether meaningful groups of cannabis users would emerge based on these variables. Follow-up analyses (i.e., chi-squared tests and MANOVA) were conducted using SPSS to assess the relevant differences between clusters, including cluster variables, demographic variables (i.e., age, gender, employment status, level of education) and negative cannabis-related consequences (ASSIST-A and DSM-5 CUD scores).

Latent class analysis is a probabilistic statistical procedure which groups cases into clusters based on similarities in the predictors which have been added to the model. Latent class analysis does not adhere to traditional statistical assumptions (i.e., normality, linearity, or homoscedasticity; Magidson & Vermunt, 2002). Therefore, this procedure was ideal as it allowed for a robust analysis of the data. This analysis typically outperforms other models of cluster analysis in terms of its ability to assign

weights to mixed variable types (i.e., continuous and categorical; Bacher, Wenzig, & Volger, 2004).

In the current study, parameter estimates, which establish the weights assigned to each variable, were extracted using the maximum-likelihood estimation method as this method allows for the greatest distinction between clusters (Vermunt & Magidson, 2002). Various statistics were examined to determine the most reliable cluster solution, including the chi-square goodness of fit value, the Lo-Mendell-Rubin adjusted likelihood ratio statistic, and information criteria.

Both the chi-square goodness of fit and the Lo-Mendell-Rubin adjusted likelihood ratio statistic provide an indication of how well each solution fits the dataset (Lavery, 2011; Vermunt & Magidson, 2002). In other words, these statistics inform the absolute fit of each model. Similarly, the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) provide a measure of model fit while striking a balance between the explanatory power of the model and the complexity of the model, thereby including the effect of parsimony in the statistic as well (Kuha, 2004; Lavery, 2011). Larger values are indicative of a better fit for the chi-square goodness of fit statistic and for the Lo-Mendell-Rubin adjusted likelihood ratio statistic, whereas lower values for both information criteria (i.e., AIC and BIC) are favored. Finally, entropy values indicate the level of uniqueness between clusters. Higher entropy values are indicative of increased separation between clusters. Values can range between 0 and 1, with a value of 1 representing absolute independence between clusters.

The results of the latent class analysis are presented in Table 5. Two, three, and four class models were assessed for best fit. However, as degrees of freedom could not

be calculated for any model solution due to limited sample size, *p*-values were not computed to support the chi-square goodness of fit values and were therefore assessed purely upon their values. The four class solution did not have a significant Lo-Mendell-Rubin adjusted likelihood ratio statistic and displayed a slight reduction in the entropy statistic. For this reason, the four cluster solution was excluded despite smaller AIC/BIC values than for two and three cluster solutions. Furthermore, the chi-square goodness of fit and AIC and BIC values pointed toward a three cluster solution as a better fit in comparison to a two cluster solution. Entropy was indistinguishable between two and three class solutions and Lo-Mendell-Rubin adjusted likelihood ratio statistics were significant across both two and three class solutions. Therefore, the three cluster solution was selected. The three clusters consisted of one group of 178 cases (49.31%), a second cluster of 74 cases (20.50%) and a third of 109 cases (30.19%). These clusters had an estimated membership likelihood of 99.5% (class 1), 97.2% (class 2), and 99.2% (class 3).

**Describing cluster characteristics.** Follow up analyses for categorical variables revealed that cluster one was characterized by recreational cannabis users, $z = 4.50$, $p < .001$, who prefer to consume cannabis that is low in THC, $z = 4.05$, $p < .001$, and are less likely to develop CUD, $z = 7.57$, $p < .001$. Cluster one was less likely to engage in polysubstance use involving illegal substances, $z = 2.99$, $p = .003$. Cluster two participants were notable only for their preference for cannabis that is high in THC, $z = 2.96$, $p = .003$. In contrast, cluster three not only preferred high potency (i.e., high THC concentration) cannabis, $z = 6.30$, $p < .001$, but qualified for CUD more frequently, $z = 7.14$, $p < .001$. Cluster three contained more medical cannabis users, $z = 4.05$, $p < .001$,

and engaged in illegal substance use more frequently than cluster one and two, $z = 2.16$, $p = .031$. Additionally, all three clusters differed in terms of past-year cannabis use, as cluster one used less than monthly, $z = 13.03$, $p < .001$, cluster two consumed cannabis at least monthly, $z = 8.92$, $p < .001$, but less than daily/nearly daily, and cluster three consumed the most frequently, reporting daily/near daily use, $z = 16.04$, $p < .001$.

More specifically, the overwhelming majority of cluster one participants self-reported using cannabis recreationally (96.1%) and 22% of users in cluster three identified as medical users. Similarly, only 15.2% of cluster one met the diagnostic criteria for CUD and a mere 18.5% reported using illicit substances in the last 3 months in comparison to 61.5% of cluster three meeting DSM-5 CUD criteria and one third (i.e., 33.0%) using illicit substances. Clusters two and three also differed from cluster one in their preference for high potency cannabis (i.e., high THC concentrations; 63.5% and 73.4%, respectively), whereas cluster one preferred low potency cannabis (31.5%) or did not have a preference for THC concentrations (42.1%). Interestingly, notable differences emerged between the three clusters on measures of frequency of past-year cannabis use. There were no instances (i.e., 0.0%) of daily/nearly daily use of cannabis in cluster one, and no instances (i.e., 0.0%) of less than monthly use of cannabis in cluster two, and only one instance (0.9%) of less than monthly use in cluster three. Thus, past-year frequency of use had clear classifications within each cluster given that 64.6% of cluster one used less than monthly, 81.1% of cluster two used more than monthly but less than daily, and 90.8% of cluster three used daily/nearly daily.

Additional $\chi^2$ analyses were conducted to broaden the scope of understanding of each cluster's distinct characteristics. Analyses involving each cluster's preferred

method of cannabis consumption and employment status underwent Bonferroni corrections, as recommended by Armstrong (2014) given that over 10 tests were run within the $\chi^2$ analyses. First, cannabis use variables of preferred form (e.g., cannabis flower, concentrates) and preferred method of consumption of cannabis (e.g., joints, edibles) revealed differences between clusters one and three. Cluster one preferred ingested forms of cannabis (50.0%; $z = 5.78$, $p < .001$ and 47.8%; $z = 5.90$, $p < .001$, respectively). Cluster three favoured the cannabis flower (75.2%), $z = 4.89$, $p < .001$, and were the most likely to consume their cannabis through joints (53.2%), $z = 3.40$, $p = .001$. Demographic variables were noted for each cluster as well. Cluster one was the most likely to identify as female (83.7%), $z = 3.31$, $p = 001$, as students, $z = 5.52$, $p < .001$, and were the most highly educated cluster (i.e., completed at least some university; 69.7%), $z = 3.96$, $p < .001$, whereas cluster three was the least educated (i.e., had a high school education or less, or attended trade school; 57.8%), $z = 4.34$, $p < .001$, and were most likely to identify as male (33%), $z = 2.70$, $p = .007$.

Continuous cluster variables were then analysed using a Games-Howell corrected multiple comparison post-hoc test, as cluster sizes were unequal and the assumption of homogeneity of variance was violated, as assessed by Levene's tests. Results from this analysis are presented in Table 6. Clusters differed on measures of cannabis use frequency (past 30-day use) and age. Cluster one used the least frequently ($M = 1.15$, $SD = 0.20$) and were the youngest ($M = 23.93$ years, $SD = 0.63$), whereas cluster three used cannabis the most frequently ($M = 28.19$, $SD = 0.31$) and were the oldest ($M = 33.15$ years, $SD = 1.10$). Cluster two significantly differed from both cluster one and cluster three, indicating a moderate frequency of cannabis use ($M = 8.55$, $SD =$

0.62) and a mean age that was in between that of cluster 1 and cluster 3 ($M$ = 27.68, $SD$ = 1.18). Interestingly, no significant differences emerged between clusters on DASS-21 or SUPPS-P total scores. Additionally, clusters did not differ significantly in terms of age of first cannabis use or ratings of subjective high.

Finally, an additional ANOVA analysis was conducted to determine whether clusters differed in terms of how long they had been consuming cannabis. Overall, the model was significant, $F(2, 369) = 29.40$, $p < .001$); however, upon inspection of Games-Howell post-hoc analyses, clusters one ($M$ = 6.65 years) and two ($M$ = 8.97 years) did not differ significantly from one another ($M_{diff} = 2.32$, $p = .30$). Cluster three ($M$ = 16.06 years) did differ significantly from cluster one ($M_{diff} = 9.41$, $p < .001$) and from cluster two ($M_{diff} = 7.09$, $p < .001$), having used cannabis for a significantly longer period of time than the other clusters. Due to these differences, cluster 1 was labelled low frequency non-problematic cannabis users, cluster 2 was labelled moderate frequency users and cluster 3 was coined high frequency problematic users.

**Comparisons of clusters on relevant outcomes.** A MANOVA analysis was conducted to assess relevant differences between clusters on measures of negative cannabis-related outcomes. Specifically, the resulting clusters from the latent class analysis were inserted as the grouping variable, and DSM-5 CUD criteria and ASSIST-A scores were entered as dependent variables. Homogeneity of variance was assessed using a Levene's test of equality of variances and revealed violations of this assumption. Therefore, Pillai's Trace significance statistics were used as they are more robust to these violations. Overall, the model was significant, $F(4, 716) = 21.27$, $p < .001$; $\eta^2 = .12$. However, as the MANOVA analysis can only reveal that there are significant

differences, but not where those differences lie, Games-Howell post-hoc analyses were conducted to identify significant differences between specific clusters (see Table 7). Post-hoc tests revealed that DSM-5 CUD total scores meaningfully increased in clusters one, two and three, respectively ($M_{diff}$ ranging from 1.20 to 2.42, $p$'s < .001). However, an additional $\chi^2$ analysis using a binary measure of DSM-5 CUD criteria (i.e., qualifies or does not qualify for CUD diagnosis) indicated that only clusters one and three differed in clinical terms, with cluster 1 being least likely, $z$ = -7.17, $p$ < .001, and cluster 3 being most likely, $z$ = 7.14, $p$ < .001, to meet criteria for a diagnosis of CUD. Similarly, the Games-Howell post-hoc test suggested that cluster three exhibited higher scores on the ASSIST-A than did cluster one ($M_{diff}$ = 1.78, $p$ = .001); however, all clusters maintained very low scores on this measure (i.e., means ranging from 1.36 to 3.14 on a scale of 28).

## Discussion

The current study was multifaceted in its desired goals. Past research (e.g., Norberg, Mackenzie, & Copeland, 2012; Tomko et al., 2018; Walden & Earleywine, 2008; Zeisser et al., 2012) has suggested that both quantity and frequency of cannabis use may be reliable predictors of cannabis-related problems and could serve as simple screening tools to identify problematic cannabis use. Thus, the first goal of the current study was to examine the role of quantity and frequency of cannabis use as potential markers of negative cannabis-related consequences. The current study sought to expand on the available research focusing on cannabis use typologies. Specifically, the current research aimed to integrate various cannabis use-related variables, measures of internalizing and externalizing symptoms, and an index of polysubstance use in the

formation of cannabis use clusters. Furthermore, the resulting clusters were compared on cannabis use outcome variables to determine the relationship between each emerging cluster and cannabis use-related negative consequences.

**Goal 1: Quantity and Frequency as Indicators of Cannabis-Related Problems**

Goal one of the current study sought to explore the relationship between measures of quantity and frequency of cannabis use and associated cannabis-related problems. Specifically, the current study investigated whether measures of cannabis frequency and quantity would account for variation in cannabis-related problems. Cannabis use frequency was defined by how often participants consumed cannabis within the past 30 days as well as by past-year frequency of use and cannabis use quantity was operationalized using ratings of subjective high. If these frequency and quantity indicators were to account for cannabis-related problems, then undergoing a formal diagnostic assessment of CUD may not be necessary to screen for problematic cannabis use. In contrast to expectations, when cannabis use-related problems were measured using the ASSIST-A total scores, frequency of cannabis use did not emerge as an important predictor of these problems. However, cannabis use quantity did emerge as a small contributor to cannabis use-related negative consequences. Given that ASSIST-A scores lacked variability in the current sample, which may have masked the effects of cannabis use frequency, cannabis use-related problems were also examined using total CUDIT-R scores to operationalize this construct. As anticipated, both past 30-day cannabis use and frequency of cannabis consumption within the last 12 months emerged as important predictors of CUDIT-R measured cannabis-related problems, alongside ratings of subjective high. Nevertheless, both ratings of quantity and frequency

accounted for significantly less of the variance in cannabis related-negative consequences (i.e., 22.5%) than total scores on the DSM-5 CUD measure (i.e., an additional 38.4%).

In summary, the first hypothesis for goal one stated that measures of cannabis use frequency (i.e., past 30-day and past year use) would be the strongest predictors of cannabis-related problems. This hypothesis was partially supported in that frequency was the most important use-related predictor of cannabis problems (measured by the CUDIT-R; i.e., β's = .24 and .26) as compared to cannabis use quantity (i.e., β = .14); however, DSM-5 CUD diagnostic criteria accounted for additional variance over and above the variance which was accounted for by both quantity and frequency indicators combined regardless of how cannabis-use problems was measured. In addition, both frequency and quantity measures emerged together only after changing the outcome variable from the ASSIST-A to CUDIT-R total scores.

Although it remains unclear as to why the ASSIST-A had a restricted range in scores, and therefore was not an optimal measure of cannabis problems in the current study, a number of possibilities should be considered. It is plausible that the wording of the questionnaire, which refers to the difficulties that were being measured as "*problems* that have been caused by cannabis", may be leading to skewed interpretation within the sample. Specifically, participants may not consider their difficulties to be problematic, as the term "problem" inherently implies that the respondent has insight into the consequences of their substance use to define it as a problem and/or of the need for change and potential intervention. Furthermore, when considering models such as Prochaska and Norcross's (2001) stages of change, individuals who are in the

precontemplation stage of readiness for change are not likely to think about the consequences that may arise due to their troublesome behaviours, such as consuming cannabis problematically (Prochaska, Redding, & Evers, 2015). Thus, some participants could have experienced higher incidences of these problems (e.g., financial, health, etc.) than they reported on this questionnaire, but may be attributing these concerns to other personal or environmental factors, such as the use of illicit drugs or other difficulties in their day-to-day life.

Another factor that may explain the lack of variability in ASSIST-A scores is the participant's views of cannabis. Interestingly, perceptions of cannabis as a potentially dangerous substance have decreased over time (Carliner, Brown, Sarvet, & Hasin, 2017; Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2015), despite growing evidence that cannabis consumption can pose significant health and well-being challenges to users (e.g., Meier et al., 2012). A review by Carliner, and colleagues (2017) revealed a marked decrease in the perceived risk that is associated with the regular use of cannabis (i.e., once or twice a week") among adolescents and young adults in the United States from 1991 to 2015. Consequently, respondents who view cannabis as a safe substance, a natural or medicinal product, may be less inclined to report and/or attribute problems to their cannabis use. In fact, Simons, Clark, Simons, and Spelman (2016) found that individuals who perceive cannabis as a useful tool were less likely to recognize the problems that may be associated with its use.

As the ASSIST-A was problematic in the current study, the CUDIT-R was used as an alternative instrument to measure cannabis use-related negative consequences. Although the ASSIST-A measured some of the important consequences cannabis use

can have on an individual, the CUDIT-R assesses more specific impairments, such as memory/concentration problems and risky behaviours (e.g., impaired driving), in addition to some of the ASSIST-A domains (i.e., health and social problems). Furthermore, questions on the CUDIT-R are posed more descriptively than questions on the ASSIST-A (e.g., "How often during the past 6 months did you fail to do what was normally expected from you because of using cannabis?" on the CUDIT-R versus "How often has your cannabis use caused you legal problems" on the ASSIST-A), leaving less room for interpretation by participants. Therefore, the use of the CUDIT-R (in addition to the ASSIST-A) to assess cannabis-related consequences allowed this researcher to better assess the impact of quantity and frequency of use on cannabis problems.

It was expected that DSM CUD would not add any predictive variance in cannabis problems over and above quantity and frequency indicators, but this predictor accounted for more variance than quantity and frequency indicators combined. Frequency of cannabis use was nevertheless predictive of cannabis-related problems, accounting for a significant proportion of the variance. Hence, frequency of cannabis use remains an important and substantial predictor of cannabis use-related problems. To substantiate this finding, an additional post-hoc *t*-test was conducted, which revealed significant differences in past 30-day cannabis use frequency between individuals who qualified for a diagnosis of CUD (i.e., had a score of two or above on the DSM-5 CUD questionnaire) and those who did not meet criteria for a diagnosis of CUD. On average, individuals who qualified for a diagnosis of at least mild CUD consumed cannabis on 11 additional days ($M = 17.98$, $SD = 12.34$) when compared to individuals who did not disclose experiencing symptoms of CUD ($M = 7.09$, $SD = 10.50$). Thus, although

receiving the formal diagnosis of CUD adds to the prediction of negative cannabis use consequences, these findings further support the hypothesis that frequency of cannabis use is an indicator of increased risk of experiencing poorer outcomes.

In 2017, Fischer and colleagues comprehensively examined research on cannabis use-related negative consequences and subsequently published a list of 10 lower risk cannabis use guidelines. Within these guidelines, Fisher and colleagues recommended avoiding "frequent or intensive" cannabis use and suggest using occasionally, at most, if an individual does not wish to abstain from use altogether. Despite these general guidelines, they are less clear as to what qualifies as frequent or intensive use. However, the guideline developers do cite the research of Zeisser (2012), who found that daily or near daily use of cannabis was associated with the greatest risk for developing cannabis use-related problems as measured by the ASSIST-A. Such findings are consistent with the results of the current study, as both measures of cannabis use frequency (i.e., use in the past 30 days and frequency of use in the past 12 months) were predictive of cannabis use-related problems. Moreover, the results of the current study highlighted that on average, individuals who qualified for a diagnosis of CUD used cannabis on approximately 18 days (in the past 30 days) as compared to approximately 7 days in individuals who did not meet criteria for a diagnosis of CUD, offering specific support for the claim that daily and/or near daily cannabis use may be more problematic than occasional use. Problems that have been associated with cannabis use (e.g., physical health, mental health, social problems, societal harm, etc.) also have been frequently and consistently linked to frequency of use (e.g., Di Forti et al., 2013; Manning et al., 2019; Quattrone et al., 2020; Weinberger et al., 2019). Therefore, although measures of

cannabis use frequency may not eliminate the need for clinicians to assess for a formal diagnosis of CUD to inform treatment needs, it may be a useful screening tool to identify potentially problematic users of cannabis.

The second hypothesis of goal one was that the cannabis quantity measures of subjective high and THC potency would not be correlated with one another, but would both contribute to cannabis-related problems. Furthermore, based on previous research (e.g., Freeman et al., 2014), it was expected that cannabis use quantity would account for less variance in cannabis use-related problems than frequency. However, the current study revealed that there were low levels of awareness of exact cannabis potency among participants; therefore, a direct measure of potency levels could not be incorporated into the regression analyses. Cannabis quantity may be represented with greater validity by ratings of subjective high, as suggested by the research of Walden and Earleywine (2008) and Freeman and colleagues (2014). In addition to its predictive utility and its ability to combine many of the variables which make measuring cannabis use quantity difficult, ratings of subjective high are very simple to comprehend, as they are similar to other commonly used measures such as the pain index (i.e., rating pain on a scale from 1 to 10). The second hypothesis was nevertheless in part supported as it was found that cannabis quantity, as measured by subjective ratings of intoxication, was predictive of cannabis problems, albeit less so than frequency indicators. Beta values, which provide an index of the relative importance of each predictor in a given block of the model, were larger for both measures of frequency (i.e., $\beta = .24$ and .26) than for the measure of quantity (i.e., $\beta = .14$). This finding is not surprising, as any substance that is used regularly and continuously has the potential to impair one's life (Rehm et al., 2013). For

example, the continued use of inhaled products, such as smoking cannabis, may affect one's health by increasing the likelihood of contracting diseases of the lungs or leading to cardiovascular problems (Borges, Bagge, & Orozco, 2016; Martinasek et al., 2016; Rehm et al., 2013). Furthermore, consistent use of products that have the ability to cause intoxication may alter relationships with friends and family as these behaviours can be a source of conflict between loved ones and substance using individuals (APA, 2013). Occupational duties and responsibilities also may be impacted when individuals spend great amounts of time seeking, using, or recovering from the use of psychoactive substances, which may ultimately impact performance and/or the ability to begin or complete tasks (APA, 2013).

In terms of the predictive ability of cannabis use quantity, past research has identified significant problems with the operationalization of this variable in particular, which may ultimately reduce the capacity to accurately measure and identify relationships between cannabis use quantity and other associated outcomes. More specifically, cannabis use quantity as a whole is comprised of many underlying factors which come together to create a complex variable. These components include absolute quantity, THC potency, CBD potency, and route of administration variations (e.g., combined substance use, method of administration; Gray, Watson, & Christie, 2009; Tomko et al., 2018). When individuals consume cannabis of varying potencies (i.e., different concentrations of THC and CBD), effects can vary greatly (Fischer et al., 2017). An added confounding variable, physical quantity, can alter these effects as well. In the current study, cannabis use quantity was measured by querying an individual's average subjective high. Ratings of subjective high theoretically encompass measures of

potency as well as physical quantity by directly measuring the effects that were caused by the cannabis consumed. Measures of subjective high also account for the effect of tolerance, which occurs when individuals consume cannabis for extended periods of time and experience reduced effects from the same proportion of their chosen product as a result of consistent exposure (Gorelick et al., 2012; Jones, Benowitz, & Bachman, 1976).

In spite of the fact that that self-reported estimates of THC potency were unreliable and thus not further used in the current study, it is important to highlight the lack of awareness of cannabis potency in the sample, especially given the fact that there is a proportional increase in adverse consequences when THC concentrations rise (Fischer, 2017; Stuyt, 2018). As the current study was conducted in the wake of cannabis legalization, a measure of THC potency could become increasingly more reliable in the coming years with the increased use of legal dispensaries. In the current study, participants may have been acquiring their products from the black market prior to cannabis legalization and continued to do so despite legal options that were newly available. This could be a potential by-product of the price differential between cannabis that can be purchased though illegal channels (e.g., street dealers) and the more costly alternative of obtaining legal cannabis form a dispensary (Statistics Canada, 2018). Consequently, it is difficult, if not impossible, for these participants to have access to an accurate measure of the THC concentrations in the off-market products that they purchase. Additionally, participants who acquire their cannabis illegally and do not consume cannabis regularly may not have the ability to accurately gauge the potency of their cannabis when they are not given this information explicitly (Freeman et al., 2014).

In contrast, when individuals purchase their cannabis from legal dispensaries, they are more likely to encounter accurate information regarding their cannabis products, including the proportions of both THC and CBD in their products and the effects that these compounds have when they are consumed. This information can be found on cannabis product packaging or infographics promoting public health campaigns that have been hung in stores, or could be shared by the individuals who sell cannabis products to customers (Government of Canada, 2019; Haug et al., 2016) Therefore, as the legal purchasing of cannabis increases (i.e., moves from illegal to legal sources), it follows that THC awareness could mirror this trend. In fact, the National Cannabis Survey revealed that more Canadians were purchasing from legal sources than they had been in previous versions of the survey, moving from 10% of Canadians shopping for cannabis products exclusively from legal sources in 2018 to 28% in 2019 and 23% of Canadians obtaining cannabis legally at least once in 2018 to 53% in 2019 (Statistics Canada, 2019).

The widespread lack of knowledge about the THC potency in the products consumed by cannabis users is also significant because cannabis use guidelines, such as those developed by Fischer (2017), reference THC concentrations as an important consideration when choosing cannabis products in order to consume cannabis more safely. Furthermore, as higher THC concentrations have been associated with higher incidences of cannabis use-related consequences (e.g., psychosis and cognitive impairments), it is important that individuals be mindful of the THC concentrations that are in the products that they consume (Curran et al., 2016; Morgan et al., 2018; Prini et al., 2020). Thus, the lack of awareness of THC concentrations suggests that future

public health campaigns and/or substance use education programs should promote increased knowledge regarding THC potency for cannabis users and awareness of the associated outcomes.

The third and final hypothesis of goal one stated that the DSM-5 CUD criteria would not contribute any additional variance to cannabis-related negative consequences over and above what was already accounted for by quantity and frequency estimates. This hypothesis was not supported, as the DSM-5 CUD criteria contributed a significant amount of additional variance to cannabis-related problems (regardless of measurement instrument), even after accounting for the effects of quantity and frequency (i.e., $\Delta R^2$ = .38 for the CUDIT-R and $\Delta R^2$ = .39 for the ASSIST-A). In fact, the DSM-5 CUD criteria accounted for a larger proportion of the variance than what was already accounted for by both the control variables as well as the measures of quantity and frequency of cannabis use combined (i.e., $\Delta R^2$ = .02 and .23 for the CUDIT-R and $\Delta R^2$ = .02 and .08 for the ASSIST-A).

The current study's hypotheses were drawn from the work of Rehm and colleagues (2013), who suggested that quantity and frequency measures may be sufficient predictors of substance use-related problems potentially eliminating the need for a formal diagnosis of substance use disorder to be made in order to access treatments and services. However, Rehm et al. (2013) primarily focused on substances that have been licit for many years, particularly alcohol and tobacco. Substances that are legalized have the benefit of receiving increased empirical attention. For example, there are clear cut guidelines that exist for alcohol consumption (Butt, Beirness, Stockwell, Gilksman, & Paradis, 2011) and individuals are generally aware of how to self-monitor their

intake. In contrast, both researchers and the general public alike are not yet aware of how much cannabis use should be considered "excessive" and potentially harmful as no specific guidelines exist for cannabis products (Fischer et al., 2017; Volkow, Baler, Compton, & Weiss, 2014). Thus, a widespread lack of awareness and standardization of cannabis use practices may contribute to why measures of quantity and frequency are insufficient to fully capture problematic cannabis use.

Another potential source of discrepancy between what has been observed in the current study and what has been proposed by Rehm and colleagues (2013) in the context of other licit substances is the differences in the effects that are caused by consuming each substance. Generally, individuals who consume alcohol experience more intense levels of impairment, such as on psychomotor performance and aggression, than individuals who consume cannabis (De Sousa, Theunissen, Kuypers, Toennes, & Ramaekers, 2016; Sewell, Poling, & Sofuoglu, 2009). Moreover, cannabis intoxication can lead to highly variable effects depending on the type and amount of cannabis that has been consumed, such as experiencing sedation when consuming strains of cannabis such as indica (i.e., high CBD) versus experiencing euphoria and/or psychoactive effects when consuming cannabis sativa (i.e., high THC strain; Pearce, Mitsouras, & Irizarry, 2014). Therefore, individuals who consume cannabis regularly or in larger quantities may experience overall less legal, familial or work impairments than alcohol users (Sewell et al., 2009, Yurasek, Aston, & Matrik, 2017). Furthermore, alcohol and tobacco have well-known long-term health consequences which have been profusely scientifically supported, such as cancers, organ failure, and stroke (Butt et al., 2011). In contrast, the long-term effects of cannabis are not as clear and have been less researched

(Bergamaschi, Queiroz, Zuardi, & Crippa, 2011; Volkow et al., 2014). Consequently, the argument presented by Rehm and colleagues (2013) which posit that quantity and frequency of use can be directly linked to long-term negative health outcomes may apply to a lesser extent for cannabis users. For example, it could be argued that THC concentrations are more related to the onset of psychosis in adolescents than the absolute quantity of the product consumed, as research has not yet fully teased apart the intricacies of cannabis products and their associated consequences (Arseneault, Cannon, Witton, & Murray, 2004; Di Forti et al., 2019). Hence although quantity and frequency indicators may be useful tools for clinicians to rapidly assess risk of negative consequences, a formal assessment of DSM CUD in individuals flagged at high risk based on these cannabis use patterns, remains necessary.

**Goal 2: Cannabis Use Clusters and Their Associated Characteristics and Consequences**

Goal two of the current study was to determine if classes of cannabis users could be formed using a relevant and novel combination of predictor variables. More specifically, the current study aimed to expand on the existing cannabis use typology literature by classifying past-year cannabis users into clusters using cannabis use practices (i.e., age of first use, quantity and frequency of use, preferred form and administration methods of cannabis products), polysubstance use of licit and illicit substances, and mental health symptomatology (i.e., internalizing and externalizing symptoms) variables. Furthermore, the current study sought to examine the relationship between the emerging clusters and their associated risk of experiencing cannabis-related negative consequences. Negative cannabis-related outcomes were measured by both the

ASSIST-A and the DSM-5 CUD questionnaire to gauge each cluster's experience of overall cannabis use consequences (i.e., financial, social, legal, and health problems) as well as their levels of clinical symptoms of CUD, respectively. This combination of variables adds to the current cannabis use cluster research as existing studies have not examined these variables in conjunction with one another, or have done so using measures with substantial limitations (e.g., using a binary measure of mental health problems; Fischer et al., 2010). Additionally, the current study strove to be more inclusive of cannabis users by including a range of age groups and types of users. Past research had overwhelmingly focused on adolescent users (i.e., Chabrol et al., 2012; Korf et al., 2007; Miller & Plant, 2002) and past 30-day users (i.e., Fischer et al., 2010; Miller & Plant, 2002); thus, the current study actively recruited users above the age of majority and included past-year users (i.e., infrequent as well as frequent users) in the sample. Finally, clinical, community and university participants were recruited in order to fully capture the cannabis using population.

The results of the current study's latent class analysis revealed a three-cluster solution, in which a low frequency cannabis using cluster, a moderate frequency cannabis cluster, and a high frequency problematic cluster emerged. Overall, low frequency cannabis users were the least problematic in terms of all measures of interest, including frequency of use and the level of cannabis-related negative outcomes. In contrast, high frequency problematic users were the most likely to experience cannabis-related problems, use potent cannabis, and engage in polysubstance use. Moderate frequency cannabis users fell between these extremes on all measures, with the

exception of their preference for products containing high THC concentrations, which was in line with the preferences of high frequency problematic users.

The hypothesis for goal two stated that three clusters would emerge, representing one group of problematic, frequent users who would engage in polysubstance use and experience high levels of internalizing and externalizing symptoms, another who would use frequently for medical purposes, exhibit high levels of internalizing symptoms but would not experience negative outcomes, and a final group who would use infrequently and experience the least amount of negative consequences. This hypothesis was partially supported, as one cluster of problematic users and another cluster of infrequent cannabis users emerged. However, mental health variables and measures of subjective high (i.e., quantity) were not found to differentiate these three clusters. In addition, a cluster comprised predominantly of medicinal cannabis users did not emerge. Rather, medicinal users were largely represented under the frequent problematic cannabis using cluster.

Generally, the frequent cannabis using cluster exhibited the most problematic aspects of cannabis use. Fischer and colleagues (2017) described 10 ways in which users can consume cannabis more safely. These guidelines included recommendations regarding the use of cannabis which contained low concentrations of THC, choosing ingestible forms of cannabis rather than methods which require combustion, and avoiding frequent (i.e., daily or near daily) use of cannabis products. Frequent problematic cannabis users in the current study, however, engaged in all of the riskier alternatives: This cluster indicated a preference for cannabis products with high THC concentrations, consumed cannabis on an average of 28 of the past 30 days, and reported consuming their cannabis in the form of joints. In addition to their overall riskier use,

this cluster of users was also the most likely to experience problems due to their cannabis use. This pattern occurred not only in terms of social, financial, health, and/or legal problems as measured by the ASSIST-A, but also in terms of their likelihood of experiencing CUD symptoms.

Given that the current study was cross-sectional in design, the directionality of the relationship between frequent cannabis and CUD symptomatology cannot be determined. Many studies have established an association between frequency of use and disordered use (e.g., Cuttler & Spradlin, 2017; Gunn, Aston, Sokolovsky, White, & Jackson, 2020; Tomko et al., 2018; Volkow et al., 2014), but this hypothesized causal path has not yet been examined in the context of a longitudinal study. Thus, it is possible that participants who consume cannabis at very high frequencies (i.e., daily or near daily) may experience the emergence of CUD symptoms as a result of their frequent use. Alternatively, it is also possible that individuals who currently qualify for CUD use more cannabis *because of* their disorder. For example, individuals could be using cannabis more frequently to avoid symptoms of withdrawal (Budney & Hughes, 2006; Budney, Vandrey, Huges, Moore, & Bahrenburg, 2007). It is also possible that individuals who experience tolerance may consume more cannabis to achieve their desired high (APA, 2013; Jones et al., 1976). Despite the ambiguous directionality between daily cannabis use and CUD, it is clear that daily use is linked with increasingly negative outcomes.

Interestingly, a relationship emerged between level of education and cluster membership, where cluster one was the most educated and cluster three was the least educated; however, once again, the direction of this relationship cannot be determined

by the present study. Therefore, it is both possible that cannabis use leads to lower levels of educational achievement or that lower levels of education leads to greater cannabis consumption. Meier and colleagues' (2012) study appears to support the former hypothesis as individuals who consumed cannabis heavily in their adolescence saw a six-point reduction in their IQ in early adulthood. Thus, individuals who consume cannabis may be more likely to drop out of school or less likely to continue on to post-secondary education on account of the difficulty they may experience in a learning setting.

In contrast to the frequent problematic cannabis using cluster, the low frequency cannabis using cluster experienced very low levels of CUD symptomatology and tended to follow many of the guidelines which were outlined by Fischer and colleagues in 2017 (i.e., they preferred ingestible forms of cannabis with low concentrations of THC and consumed cannabis occasionally). Another distinguishing feature of this cluster was their lower age: Low frequency cannabis users had an average age of 24 years, which was nearly 10 years younger than the frequent problematic cannabis using cluster (i.e., 33 years old). Interestingly, the central cluster of moderate frequency cannabis user's age differed significantly from both groups as well, with a mean age of 28 years. To better understand this progression, an ANOVA analysis was conducted to determine the period of time participants had been consuming cannabis and whether this variable would differ in terms of each of the three clusters. The analysis revealed that, on average, low frequency cannabis users had been consuming cannabis for 7 years, moderate frequency cannabis users had been using for 9 years, and frequent problematic cannabis users had been using for 16 years. Although low and moderate frequency users

did not differ significantly from one another in duration of use, a sharp increase in time used distinguished these two clusters from the frequent problematic cannabis using cluster.

The observed difference in the length of time each cluster has been consuming cannabis raises the question of whether younger individuals experience less cannabis-related problems due to having consumed cannabis for a shorter period of time than their older counterparts who have been consuming cannabis for many years. Thus, this finding suggests that there is a possibility that the clusters which emerged in the current study depict the progression of chronic cannabis use. Some studies that have examined the associations between cannabis and negative outcomes support this possibility. Studies have found a positive relationship between the length of an individual's cannabis using career and negative physical and mental health, social, and cognitive effects (Feeney & Kampman, 2016; Fibey et al., 2014; Han, Gfroerer, & Colliver, 2010; Solowij & Grenyer, 2002; Winward, Hanson, Tapert, & Brown, 2014). Consequently, it is plausible that the three clusters that emerged in the current study reflect the evolution of cannabis use over time, from low potency, non-problematic and infrequent use to regular use of higher potency products and more problematic consumption. Although no current longitudinal research exists to support this claim, future longitudinal studies should focus on this possibility to examine this hypothesis.

Although, overall, the cluster hypothesis of the current study was largely supported, one typology which did not emerge as expected was the group of predominantly medical cannabis users. However, despite framing the question querying medicinal use only within the context of recognized conditions (i.e., "Cannabis may be

used to treat medical conditions, such as epilepsy, cancer symptoms, Parkinson's disease, and multiple sclerosis. Do you consider yourself primarily a…" followed by answer choices of "recreational cannabis user" or "medical cannabis user [please specify]"), many participants reported reasons which were not included in the desired list of responses (e.g., anxiety, migraines, HIV). As a result, only a small portion of participants ($n$ = 42) endorsing medicinal use were coded as medicinal users. Additionally, participants were forced to choose whether they were recreational or medicinal users when in fact, they might have a medical condition but also use recreationally. Survey data appears to suggest that individuals may be more likely to refer to themselves as medicinal users despite not having a cannabis prescription for an endorsed medical condition. This is exemplified in Statistics Canada data that indicates that 37% of Canadian users label their cannabis use as medicinal (Statistics Canada, 2018). Thus, the absence of a medical cannabis using cluster may be due to the challenges in measuring this variable.

It was also expected that mental health variables would contribute to the formation of the clusters and that differences in mental health variables would emerge across clusters. Previous studies, such as the cluster formation studies conducted by Miller and Plant (2002), Chabrol and colleagues (2012) and Fischer and colleagues (2010), did demonstrate differences in mental health symptoms amongst the cannabis using their derived clusters. These studies measured mental health outcomes either by querying specific mental health diagnoses or behaviours (e.g., depression, aggression) or by asking a highly generic screening question (i.e., "have you experienced mental health problems"). In contrast, the current study measured whether participants experienced

symptoms of higher order traits that have been integrated into recent conceptualizations of mental health disorders: internalizing and externalizing symptoms. Mental health disorders can be categorized in terms of the types of symptoms (i.e., internalizing vs externalizing) that are considered to be overarching these clinical disorders (Krueger et al., 1998). For this reason, multiple internalizing disorders (e.g., anxiety, depression) could display some of the same internalizing symptoms (e.g., anxiety sensitivity; the same is true for externalizing disorder/symptoms). In other words, participants were not asked whether or not they received specific diagnoses, but rather, they self-reported on broad internalizing and externalizing behavioural tendencies (i.e., impulsivity, sensation-seeking, etc.), which may have obscured relationships between mental health symptoms and cannabis use.

In spite of the fact that the current measures of internalizing and externalizing symptoms (i.e., the DASS-21 and the SUPPS-P, respectively) did not measure specific mental health disorders directly, they have been observed to have satisfactory convergent and predictive validity with other, more specific measures of mental disorders (Crawford & Henry, 2003; Cyders et al., 2015). For example, the DASS-21 has exhibited satisfactory convergent validity, demonstrated by its strong correlations with other validated measures of mental health symptoms, such as the Personal Disturbance Scale's anxiety subscale, $r = .72$ and the depression subscale of the Hospital Anxiety and Depression questionnaire, $r = .66$. In addition, studies have consistently established a relationship between cannabis use and internalizing symptoms as well as externalizing symptoms, such as sensation seeking (Bierhoff et al., 2019; Gillespie, Lubke, Gardner, Neale, & Kendler, 2012; Kedzior & Laeber, 2014; VanderVeen et al.,

2016). It is possible that, regardless of cluster formation, all cannabis users experience at least moderate levels of these symptoms, making differences in these broad mental health symptoms indistinguishable across groups. Although none of the clusters as a whole met the clinical cut-off scores recommended for the DASS-21 (i.e., 16), all three groups were on the cusp of meeting this threshold (i.e., means of 14.90, 15.38, and 15.35, respectively). Furthermore, 41% of participants (38.8% of cluster one, 43.2% of cluster two, and 43.1% of cluster three) scored 16 or above on the DASS-21. Hence, general levels of internalizing symptoms were high across all clusters. Additionally, small to moderate correlations emerged between various cannabis use variables and measures of mental health problems. For example, subjective high ratings had a positive correlation with both the DASS-21 ($r = .24$, $p < .001$) and with various subscales of the SUPPS-P, such as positive, $r = .25$, $p < .001$, and negative, $r = .47$, $p < .001$, urgency. Taken together, these correlations suggest that there is a relationship between cannabis use and mental health, despite the lack of emergence of differential specificity between cannabis use clusters. Future studies should include both diagnoses of mental health disorders, as well as the broader categories of internalizing and externalizing symptoms, when exploring the relationship between cannabis use and mental health.

**Implications**

Millions of Canadians consume cannabis every year and cannabis use prevalence is rising with the recent legalization of cannabis in Canada (Statistics Canada, 2019). Cannabis use, particularly heavy use, is associated with a number of negative consequences (e.g., risky sexual behaviour, psychosis, and cognitive dysfunction; Meier et al., 2012; Schuster et al., 2012). For this reason, it is important to identify individuals

who may be at greater risk of experiencing negative consequences from their cannabis use. As such, the current thesis determined whether self-reported quantity and frequency estimates of cannabis use could be used to assess individual risk of negative cannabis-related consequences. Measures of quantity and frequency were not sufficient as stand-alone predictors of cannabis use consequences (i.e., to replace a full assessment of CUD). However, they did provide valuable information which have relevant clinical implications (e.g., for their use as a screening tool), as both quantity (self-reported subjective high) and frequency (i.e., past 30-day and past-year use) of cannabis use were found to be predictive of worsened cannabis-related outcomes.

The second goal of the current study was to expand upon previously existing research regarding cannabis use typologies. Mental health, as well as cannabis use variables were used to determine whether distinct groups of cannabis users would emerge and examine each group's propensity to develop cannabis use-related problems and/or CUD. Overall, increased frequency of use and use of cannabis with higher THC concentrations were associated with increasingly negative outcomes. These findings, in combination with the findings from goal one, provide support for the recently published lower risk cannabis use guidelines (Fischer et al., 2017). Moreover, problematic cannabis users were more likely to be less educated, of the male gender, report joints as their preferred method of consumption, and to have used cannabis for an extended period of time (i.e., older adults). Taken together, these findings could ultimately inform how problematic cannabis users are identified and targeted for interventions. For example, assessments of CUD could begin with a two-step process in which individuals are asked about their quantity and frequency of cannabis use, including their ratings of

subjective high, to gauge their risk of being or becoming a problematic user (i.e., if high levels are reported on either of these aspects). Following this brief assessment, a more thorough assessment may be conducted with individuals who report high quantity/frequency of use and/or subjective high, which may include a diagnostic assessment (e.g., DSM-5 diagnostic criteria).

In addition to how problematic cannabis use is identified, the results of the current study could inform CUD prevention. Currently, quality research is lacking in effective cannabis use prevention strategies (Norberg, Kezelman, & Lim-Howe, 2013). However, the results of the current study provide evidence that increased education regarding the components of cannabis (i.e., THC, CBD potency) and their acute and longer-term effects and/or consequences is needed. Addressing the widespread lack of awareness about the composition of cannabis products individuals consume is essential to help them to make informed decisions regarding cannabis use. In consequence, such knowledge could help to circumvent some escalation into problematic cannabis use and further aid in choosing safer cannabis product options.

**Limitations**

The conclusions of the current study should be considered in light of its limitations. First, the ASSIST-A was limited in range of scores and performed sub optimally when assessing negative cannabis use consequences. Fortunately, an additional measure (i.e., the CUDIT-R) could be used in several of the analyses as an alternative to measure cannabis problems. However, the CUDIT-R was only distributed to participants who completed the study online. Due to time constraints, individuals who were recruited from clinical sites did not complete the CUDIT-R, making it impossible

to use the CUDIT-R as an outcome variable in the MANOVA examining differences between clusters. Furthermore, as the study had a cross sectional design, causal inferences could not be made when examining the relationship between frequency/quantity of cannabis use and cannabis problems. Given the financial and time constraints which are inherent to a longitudinal study, a cross sectional design was the only option possible in the context of a graduate thesis. However, to expand on the current findings and to form conclusions on directionality, a longitudinal design should also be implemented.

The operationalization of medical cannabis users was also a limitation in the current study. It would have been ideal to label medical users by utilizing medical records rather than relying on self-reported use, as individuals may be unreliable in reporting whether they are medical or recreational users. Finally, a limitation of cannabis research as a whole is the accurate measurement of cannabis quantity. Researchers have used several strategies for measuring cannabis quantity (i.e., absolute quantity, number of grams, etc.) but these have been plagued by limitations (i.e., variations in potency, strains, mode of administration). In the current study, it was proposed that quantity could be assessed via potency estimates, but most participants are unaware of the THC/CBD potency of the products they are consuming. Fortunately, cannabis quantity was also assessed using a rating of subjective high, which was predictive of negative cannabis-related outcomes. The current study's finding demonstrating lack of awareness regarding the cannabis products individuals are using should be considered a strength of this study, as such a finding could help inform future research as well as future prevention strategies.

In spite of the noted limitations in the current study, the current work provided further insight into the various predictors of cannabis-related negative consequences and contributed to Rehm and colleagues (2013) theory that quantity and frequency of use could account in part for the negative consequences associated with substance use, specifically in the context of cannabis. Cannabis clusters were also defined, outlining three distinct cannabis using groups within a more representative, Canadian cannabis using sample. These clusters informed which groups were at higher risk for the development of negative cannabis-related outcomes and which types of cannabis users should be considered as low-risk users. In the context of recent legalization of cannabis, the current research expands our knowledge about cannabis and helps to address the lack of empirical research regarding the potential risks of cannabis use that have been noted previously (Gorce, 2018).

Table 1

*Demographic Descriptive Variables*

| Variable | *M* | *SD* | Min | Max | % | *n* |
|---|---|---|---|---|---|---|
| Age (in years) | 27.55 | 10.60 | 18 | 62 | | |
| Gender | | | | | | |
| Male | | | | | 23.9 | 89 |
| Female | | | | | 75.8 | 282 |
| Other | | | | | .3 | 1 |
| Ethnicity | | | | | | |
| White/Caucasian | | | | | 93 | 346 |
| Non-white | | | | | 7 | 26 |
| Employment status | | | | | | |
| Employed | | | | | 36.6 | 136 |
| Unemployed | | | | | 5.9 | 22 |
| Student | | | | | 46 | 171 |
| Other | | | | | 11.5 | 43 |
| Education | | | | | | |
| Less than high school | | | | | 4 | 15 |
| High school or GED | | | | | 23.7 | 88 |
| Trade/ technical/ vocational school | | | | | 14 | 52 |
| Some university | | | | | 43.5 | 162 |
| Bachelor's degree | | | | | 12.1 | 45 |
| Graduate degree | | | | | 2.7 | 10 |
| Marital Status | | | | | | |
| Single/never married | | | | | 67.7 | 252 |
| Married/common law | | | | | 27.4 | 102 |
| Other | | | | | 4.9 | 18 |

*Note*. $N = 372$.

Table 2

Descriptive Data for Study Measures

| Variable | *M* | *SD* | Min | Max | % | *n* |
|---|---|---|---|---|---|---|
| DASS-21 total score | 15.09 | 12.26 | 0 | 63 | | |
| Depression subscale | 4.82 | 4.97 | 0 | 21 | | |
| Anxiety subscale | 4.64 | 4.05 | 0 | 21 | | |
| Stress subscale | 5.63 | 4.42 | 0 | 21 | | |
| SUPPS-P total score | 39.90 | 8.14 | 22 | 73 | | |
| Lack of premeditation | 6.77 | 2.16 | 4 | 16 | | |
| Lack of perseverance | 6.90 | 2.20 | 4 | 16 | | |
| Positive urgency | 7.35 | 2.80 | 4 | 16 | | |
| Negative urgency | 9.29 | 2.94 | 4 | 16 | | |
| Sensation seeking | 9.60 | 2.83 | 4 | 16 | | |
| ASSIST total score | 2.08 | 3.85 | 0 | 21 | | |
| Cannabis use Questionnaire | | | | | | |
| Age of first use | 17.52 | 5.80 | 8 | 49 | | |
| Past 30-day spending | 52.78 | 93.03 | 0 | 403 | | |
| Subjective high | 5.36 | 2.31 | 0 | 10 | | |
| Type of user | | | | | | |
| Recreational | | | | | 87.6 | 326 |
| Medical | | | | | 12.1 | 45 |
| ASI-A total score | 1.73 | 1.50 | 0 | 10 | | |
| DSM-5 CUD total score | 1.64 | 2.40 | 0 | 11 | | |
| CUDIT-R total score | 3.67 | 4.36 | 0 | 24 | | |
| Frequency of cannabis use | | | | | | |
| Past 30-day use | 10.83 | 12.30 | 0 | 30 | | |
| Past year use | | | | | | |
| Daily/almost daily | | | | | 31.3 | 113 |
| Weekly | | | | | 14.1 | 51 |
| Bi-weekly | | | | | 6.1 | 22 |
| Monthly | | | | | 16.3 | 59 |
| Once or twice | | | | | 32.1 | 116 |

*Note*. $N = 372$. Some totals do not sum to $N = 372$ due to missing values: DASS-21 and subscales ($n = 1$), SUPPS-P and subscales ($n = 1$), age of first use ($n = 1$), past 30-day allowance ($n = 1$), subjective high ($n = 3$), type of user ($n = 1$), and CUDIT-R ($n = 39$). DASS-21 = Depression Anxiety Stress Scale-21; SUPPS-P = Urgency, Premeditation, Perseverance, Sensation Seeking, Positive Urgency, Impulsive Behaviour Scale Short-Form; ASSIST = Adapted Alcohol, Smoking, and Substance Involvement Screening Test; ASI-A = Adapted Addiction Severity Index; DSM-5 CUD = Diagnostic and Statistical Manual of Mental Disorders 5th edition Cannabis Use Disorder Criteria; CUDIT-R = Cannabis Use Disorders Identification Test-Revised.

Table 3

Correlations Between Study Variables

| | Cannabis use Questionnaire | | | | SUPPS-P | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Days | Age | High | DASS | NU | LPER | LPM | SS | PU | CUD | ASSIST | AS | CUDIT |
| Days | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Age | -.03 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| High | .09 | -.23*** | 1 | - | - | - | - | - | - | - | - | - | - |
| DASS | .01 | .16** | .24*** | 1 | - | - | - | - | - | - | - | - | - |
| NU | .00 | -.16** | .19*** | .47*** | 1 | - | - | - | - | - | - | - | - |
| LPER | .03 | .05 | -.03 | .12* | .08 | 1 | - | - | - | - | - | - | - |
| LPM | .03 | -.08 | .10 | .23*** | .30*** | .53*** | 1 | - | - | - | - | - | - |
| SS | -.06 | -.19*** | .14** | .03 | .17** | .11* | .06 | 1 | - | - | - | - | - |
| PU | -.02 | -.12*** | .25*** | .32*** | .63*** | .02 | .31*** | .37*** | 1 | - | - | - | - |
| CUD | .44*** | -.20*** | .25*** | .32*** | .23*** | .14** | .28*** | .05 | .30*** | 1 | - | - | - |
| ASSIST | .19*** | -.18*** | .23*** | .40*** | .23*** | .18** | .32*** | .07 | .29*** | .68*** | 1 | - | - |
| ASI | .17** | -.25*** | .17*** | .17** | .13* | -.01 | .13* | .18*** | .20*** | .23*** | .24*** | 1 | - |
| CUDIT | .35*** | -.15** | .24*** | .33*** | .26*** | .08 | .23*** | .11* | .25*** | .78*** | .59*** | .13* | 1 |

*Note*. *$p$ <.05; **$p$ < .01; ***$p$ < .001. Days = past 30-day use; Age = age at first use; High = subjective high; DASS-21 = Depression Anxiety Stress Scale-21; NU = negative urgency; LPER = lack of perseverance; LPM = lack of premeditation; SS = sensation seeking; PU = positive urgency; CUD = Cannabis Use Disorder; ASSIST = Adapted Alcohol, Smoking, and Substance Involvement Screening Test; ASI-A = Adapted Addiction Severity Index; CUDIT-R = Cannabis Use Disorders Identification Test-Revised.

Table 4

*Hierarchical Regressions Assessing the Predictive Ability of Quantity and Frequency on ASSIST-A and CUDIT-R Scores*

| | ASSIST-A | | CUDIT-R | |
|---|---|---|---|---|
| Predictors | $\Delta R^2$ | β | $\Delta R^2$ | β |
| Step 1 | .021 | | .023 | |
| Age | | -.062 | | -.137** |
| Gender | | -.152** | | -.087 |
| Step 2 | .078 | | .225 | |
| Past 30-day cannabis use | | .133 | | .235** |
| Past 12-month cannabis use | | .087 | | .257** |
| Subjective high ratings | | .183*** | | .128* |
| Step 3 | .392 | | .384 | |
| DSM-5 CUD total score | | .742*** | | .742*** |
| Total $R^2$ | .492 | | .631 | |
| *N* | 368 | | 330 | |

*Note.* *$p < .05$. **$p < .01$. ***$p < .001$.

Table 5

*Latent Class Cluster Analysis Summary*

| Class size | 1 vs 2 | 2 vs 3 | 3 vs 4 |
|---|---|---|---|
| Maximum Loglikelihood | -7695.82 | -7492.71 | -7382.22 |
| Likelihood Ratio Chi-Squared Value | 30.04 | 32.72 | 25.84 |
| AIC | 15455.63 | 15075.42 | 14880.45 |
| BIC | 15580.07 | 15250.42 | 15106.00 |
| ADJ BIC | 15478.55 | 15107.66 | 14921.99 |
| Entropy | 0.98 | 0.98 | 0.97 |
| Lo-Mendell-Rubin ADJ Likelihood Ratio Value | 755.79 | 400.97 | 217.62 |
| Bootstrap Likelihood Ratio *p* Value | $p < .001$ | $p = .002$ | $p = .206$ |
| Breakdown of Participants per Cluster (*n*) | 235/126 | 178/74/109 | 105/13/178/65 |

*Note.* AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; ADJ BIC = Sample size adjusted Bayesian Information Criterion.

Table 6

*Games-Howell Post-Hoc Multiple Comparisons for Cluster Descriptives*

| Variable | (I) Latent Class Cluster | (J) Latent Class Cluster | Mean Difference (I-J) | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Age | 1 | 2 | -3.75* | 1.35 | -6.92 | -0.58 |
| | | 3 | -9.22*** | 1.27 | -11.8 | -2.71 |
| | 2 | 3 | -5.47** | 1.61 | -9.29 | -1.65 |
| Past 30-day use | 1 | 2 | -7.41*** | 0.65 | -8.96 | -5.86 |
| | | 3 | -27.05*** | 0.37 | -27.93 | -26.17 |
| | 2 | 3 | -19.64*** | 0.70 | -21.29 | -17.99 |

*Note.* *$p < .05$, **$p < .01$, ***$p < .001$.

Table 7

*Games-Howell Post-Hoc Multiple Comparisons for Cluster Outcome Variables*

| Variable | (I) Latent Class Cluster | (J) Latent Class Cluster | Mean Difference (I-J) | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| ASSIST-A | 1 | 2 | -1.07 | 0.57 | -2.42 | .28 |
| | | 3 | -1.78** | 0.49 | -2.93 | -.63 |
| | 2 | 3 | -0.71 | 0.68 | -2.31 | .90 |
| DSM-5 CUD | 1 | 2 | -1.22*** | 0.29 | -1.93 | -.52 |
| | | 3 | -2.42*** | 0.30 | -3.14 | -1.71 |
| | 2 | 3 | -1.20** | 0.40 | -2.14 | -.26 |

*Note.* $^{**}p < .01$, $^{***}p < .001$. ASSIST = Adapted Alcohol, Smoking, and Substance Involvement Screening Test; DSM-5 CUD = Diagnostic and Statistical Manual of Mental Disorders 5th edition Cannabis Use Disorder Criteria.

## References


Achenbach, T. M. (1978). The child behavior profile: I. Boys aged 6-11. *Journal of Consulting and Clinical Psychology, 46*(3), 478-488. doi:10.1037//0022-006x.46.3.478

Adamson, S. J., Kay-Lambkin, F. J., Baker, A. L., Lewin, T. J., Thornton, L., Kelly, B. J., & Sellman, J. D. (2010). An improved brief measure of cannabis misuse: The Cannabis Use Disorders Identification Test-Revised (CUDIT-R). *Drug and Alcohol Dependence*, *110*(1-2), 137–143. doi: 10.1016/j.drugalcdep.2010.02.017

Ali, A., Carré, A., Hassler, C., Spilka, S., Vanier, A., Barry, C., & Berthoz, S. (2016). Risk factors for substances use and misuse among young people in France: What can we learn from the Substance Use Risk Profile Scale? *Drug and Alcohol Dependence, 163*, 84-91. doi:10.1016/j.drugalcdep.2016.03.027

Allen, J. A., Davis, K. C., Duke, J. C., Nonnemaker, J. M., Bradfield, B. R., & Farrelly, M. C. (2017). New product trial, use of edibles, and unexpected highs among marijuana and hashish users in Colorado. *Drug and Alcohol Dependence, 176*, 44-47. doi:10.1016/j.drugalcdep.2017.03.006

Amar, M. B. (2006). Cannabinoids in medicine: A review of their therapeutic potential. *Journal of Ethnopharmacology, 105*(1-2), 1-25. doi:10.1016/j.jep.2006.02.001

American Psychiatric Association (2013). *The diagnostic and statistical manual of mental disorders: Fifth edition*. Arlington, VA: American Psychiatric Publishing.

Antony, M. M., Bieling, P. J., Cox, B. J., Enns, M. W., & Swinson, R. P. (1998). Psychometric properties of the 42-item and 21-item versions of the Depression

Anxiety Stress Scales in clinical groups and a community sample. *Psychological Assessment, 10,* 176-181. doi:10.1037/1040-3590.10.2.176

Arkell, T. R., Lintzeris, N., Kevin, R. C., Ramaekers, J. G., Vandrey, R., Irwin, C., . . . Mcgregor, I. S. (2019). Cannabidiol (CBD) content in vaporized cannabis does not prevent tetrahydrocannabinol (THC)-induced impairment of driving and cognition. *Psychopharmacology, 236*(9), 2713-2734. doi:10.1007/s00213-019-05246-8

Armstrong, R. A. (2014). When to use the Bonferroni correction. *Ophthalmic and Physiological Optics*, *34*(5), 502–508. doi:10.1111/opo.12131

Arseneault, L., Cannon, M., Witton, J., & Murray, R. M. (2004). Causal association between cannabis and psychosis: Examination of the evidence. *British Journal of Psychiatry, 184*(2), 110-117. doi:10.1192/bjp.184.2.110

Bacher, J., Wenzig, K., & Volger, M. (2004). *SPSS twostep cluster: A first evaluation*. Paper presented at the RC33 sixth International Conference on Social Science Methodology, Amsterdam, Netherlands.

Barreto, H. A. G., Christoff, A. D. O., & Boerngen-Lacerda, R. (2014). Development of a self-report format of ASSIST with university students. *Addictive Behaviors*, *39*(7), 1152–1158. doi: 10.1016/j.addbeh.2014.03.014

Battistella, G., Fornari, E., Annoni, J., Chtioui, H., Dao, K., Fabritius, M., . . . Giroud, C. (2014). Long-term effects of cannabis on brain structure. *Neuropsychopharmacology, 39*(9), 2041-2048. doi:10.1038/npp.2014.67

Bergamaschi, M. M., Queiroz, R. H., Zuardi, A. W., & Crippa, J. A. (2011). Safety and side effects of cannabidiol, a cannabis sativa constituent. *Current Drug Safety, 6*(4), 237-249. doi:10.2174/157488611798280924

Bierhoff, J., Haardörfer, R., Windle, M., & Berg, C. J. (2019). Psychological risk factors for alcohol, cannabis, and various tobacco use among young adults: A longitudinal analysis. *Substance Use & Misuse, 54*(8), 1365-1375. doi:10.1080/10826084.2019.1581220

Borges, G., Bagge, C. L., & Orozco, R. (2016). A literature review and meta-analyses of cannabis use and suicidality. *Journal of Affective Disorders, 195*, 63-74. doi:10.1016/j.jad.2016.02.007

Boyle, M. H., Offord, D. R., Racine, Y. A., Szatmari, P., Fleming, J. E., & Links, P. S. (1992). Predicting substance use in late adolescence: Results from the Ontario Child Health Study follow-up. *American Journal of Psychiatry, 149*(6), 761-767. doi:10.1176/ajp.149.6.761

Broyd, S. J., Van Hell, H. H., Beale, C., Yücel, M., & Solowij, N. (2016). Acute and chronic effects of cannabinoids on human cognition—A systematic review. *Biological Psychiatry, 79*(7), 557-567. doi:10.1016/j.biopsych.2015.12.002

Buckner, J. D., Schmidt, N. B., Lang, A. R., Small, J. W., Schlauch, R. C., & Lewinsohn, P. M. (2008). Specificity of social anxiety disorder as a risk factor for alcohol and cannabis dependence. *Journal of Psychiatric Research,42*(3), 230-239. doi:10.1016/j.jpsychires.2007.01.002

Budney, A. J., & Hughes, J. R. (2006). The cannabis withdrawal syndrome. *Current Opinion in Psychiatry, 19*(3), 233-238. doi:10.1097/01.yco.0000218592.00689.e5

Budney, A. J., Vandrey, R. G., Hughes, J. R., Moore, B. A., & Bahrenburg, B. (2007). Oral delta-9-tetrahydrocannabinol suppresses cannabis withdrawal symptoms. *Drug and Alcohol Dependence, 86*(1), 22-29. doi:10.1016/j.drugalcdep.2006.04.014

Butt, P., Beirness, D., Stockwell, T., Gliksman, L., & Paradis, C. (2011). *Alcohol and health in Canada: A summary of evidence and guidelines for low-risk drinking*. Ottawa, ON: Canadian Centre on Substance Abuse.

Butterworth, P., Slade, T., & Degenhardt, L. (2014). Factors associated with the timing and onset of cannabis use and cannabis use disorder: Results from the 2007 Australian National Survey of Mental Health and Well-Being. *Drug and Alcohol Review, 33*(5), 555-564. doi:10.1111/dar.12183

Camchong, J., Lim, K. O., & Kumra, S. (2017). Adverse effects of cannabis on adolescent brain development: A longitudinal study. *Cerebral Cortex, 27*(3), 1922-1930. doi:10.1093/cercor/bhw015

Canadian Centre on Substance Abuse and Addiction (2017). *Canadian drug summary: Cannabis*. Retrieved online: https://www.cpha.ca/sites/default/files/uploads/resources/cannabis/ccsa-canadian-drug-summary-cannabis-2017-en.pdf

Canadian Centre on Substance Abuse and Addiction (2018). *Canadian drug summary: Cannabis*. Retrieved online: https://www.ccsa.ca/sites/default/files/2019-04/CCSA-Canadian-Drug-Summary-Cannabis-2018-en.pdf

Carey, C. E., Agrawal, A., Bucholz, K. K., Hartz, S. M., Lynskey, M. T., Nelson, E. C., . . . Bogdan, R. (2016). Associations between polygenic risk for psychiatric

disorders and substance involvement. *Frontiers in Genetics, 7*. doi:10.3389/fgene.2016.00149

Carliner, H., Brown, Q. L., Sarvet, A. L., & Hasin, D. S. (2017). Cannabis use, attitudes, and legal status in the U.S.: A review. *Preventative Medicine, 104*, 13-23. doi.org/10.1016/j.ypmed.2017.07.008

Centre for Addiction and Mental Health (2012). *Do you know… Alcohol*. Retrieved online: https://www.camh.ca/-/media/files/guides-and-publications/dyk-alcohol.pdf?la=en&hash=7E6F38BC94FB9A7D2C689F0DE7257B2D88A35C0E

Centre for Addiction and Mental Health (2017). *The 2017 Ontario Student Drug Use and Health Survey drug use report – Summary.* Retrieved online: https://www.camh.ca/-/media/files/pdf---osduhs/summary-drug-use-report---2017-osduhs.pdf?la=en&hash=CE004A289552A7889929450F68EE075F5FB73EAF

Chabrol, H., Chauchard, E., Goutaudier, N., & Leeuwen, N. V. (2012). Exploratory study of the psychopathological profiles of adolescent cannabis users. *Addictive Behaviors, 37*(10), 1109-1113. doi:10.1016/j.addbeh.2012.05.005

Chavez, L. J., Bradley, K. A., Lapham, G. T., Wickizer, T. M., & Chisolm, D. J. (2019). Identifying problematic substance use in a national sample of adolescents using frequency questions. *The Journal of the American Board of Family Medicine, 32*(4), 550-558. doi:10.3122/jabfm.2019.04.180284

Chen, K., Kandel, D. B., & Davies, M. (1997). Relationships between frequency and quantity of marijuana use and last year proxy dependence among adolescents and adults in the United States. *Drug and Alcohol Dependence, 46*(1-2), 53-67. doi:10.1016/s0376-8716(97)00047-1

Chin, E. G., Buchanan, E. M., Ebesutani, C., & Young, J. (2018). Depression, anxiety, and stress: How should clinicians interpret the total and subscale scores of the 21-item depression, anxiety, and stress scales? *Psychological Reports*, *122*(4), 1550–1575. doi: 10.1177/0033294118783508

Cohn, A., Johnson, A., Pearson, J., Rose, S., Ehlke, S., Ganz, O., & Niaura, R. (2017). Determining non-cigarette tobacco, alcohol, and substance use typologies across menthol and non-menthol smokers using latent class analysis. *Tobacco Induced Diseases, 15*(1). doi:10.1186/s12971-017-0111-5

Connor, J. P., Gullo, M. J., Chan, G., Young, R. M., Hall, W. D., & Feeney, G. F. (2013). Polysubstance use in cannabis users referred for treatment: Drug use profiles, psychiatric comorbidity and cannabis-related beliefs. *Frontiers in Psychiatry, 4*. doi:10.3389/fpsyt.2013.00079

Connor, J. P., Gullo, M. J., White, A., & Kelly, A. B. (2014). Polysubstance use: Diagnostic challenges, patterns of use and health. *Current Opinion in Psychiatry, 27*(4), 269-275. doi:10.1097/yco.0000000000000069

Cooper, Z. D., & Haney, M. (2014). Investigation of sex-dependent effects of cannabis in daily cannabis smokers. *Drug and Alcohol Dependence, 136*, 85-91. doi:10.1016/j.drugalcdep.2013.12.013

Cooper, Z. D., & Haney, M. (2016). Sex-dependent effects of cannabis-induced analgesia. *Drug and Alcohol Dependence, 167*, 112-120. doi:10.1016/j.drugalcdep.2016.08.001

Copersino, M. L., Boyd, S. J., Tashkin, D. P., Huestis, M. A., Heishman, S. J., Dermand, J. C., . . . Gorelick, D. A. (2010). Sociodemographic characteristics of

cannabis smokers and the experience of cannabis withdrawal. *The American Journal of Drug and Alcohol Abuse, 36*(6), 311-319. doi:10.3109/00952990.2010.503825

Crane, N. A., Schuster, R. M., Fusar-Poli, P., & Gonzalez, R. (2012). Effects of cannabis on neurocognitive functioning: Recent advances, neurodevelopmental influences, and sex differences. *Neuropsychology Review, 23*(2), 117-137. doi:10.1007/s11065-012-9222-1

Crane, N. A., Schuster, R. M., & Gonzalez, R. (2013). Preliminary evidence for a sex-specific relationship between amount of cannabis use and neurocognitive performance in young adult cannabis users. *Journal of the International Neuropsychological Society, 19*(9), 1009-1015. doi:10.1017/s135561771300088x

Crawford, J. R., & Henry, J. D. (2003). The Depression Anxiety Stress Scales (DASS): Normative data and latent structure in a large non-clinical sample. *British Journal of Clinical Psychology, 42*(2), 111-131. doi:10.1348/014466503321903544

Curran, H. V., Freeman, T. P., Mokrysz, C., Lewis, D. A., Morgan, C. J., & Parsons, L. H. (2016). Keep off the grass? Cannabis, cognition and addiction. *Nature Reviews Neuroscience, 17*(5), 293-306. doi:10.1038/nrn.2016.28

Cuttler, C., Mischley, L. K., & Sexton, M. (2016). Sex differences in cannabis use and effects: A cross-sectional survey of cannabis users. *Cannabis and Cannabinoid Research, 1*(1), 166-175. doi:10.1089/can.2016.0010

Cuttler, C., & Spradlin, A. (2017). Measuring cannabis consumption: Psychometric properties of the Daily Sessions, Frequency, Age of Onset, and Quantity of Cannabis Use Inventory (DFAQ-CU). *Plos One,12*(5). doi:10.1371/journal.pone.0178194

Cyders, M. A., Littlefield, A. K., Coffey, S., & Karyadi, K. A. (2015). A short version of the UPPS-P impulsive behavior scale has been developed. *PsycEXTRA Dataset, 39*(9), 1372-1376. doi:10.1037/e521652015-012

Cyders, M. A., & Smith, G. T. (2007). Mood-based rash action and its components: Positive and negative urgency. *Personality and Individual Differences, 43*(4), 839-850. doi:10.1016/j.paid.2007.02.008

Cyders, M. A., & Smith, G. T. (2008). Emotion-based dispositions to rash action: Positive and negative urgency. *Psychological Bulletin, 134*(6), 807–828. doi: 10.1037/a0013341

Davis, L.J., Hoffmann, N.G., Morse, R.M. & Luehr, J.G. (1992). Substance Use Disorder Diagnostic Schedule (SUDDS): The equivalence and validation of a computer administered and an interviewer-administered form. *Alcoholism: Clinical and Experimental Research, 16(2)*, 250-254.

Demirakca, T., Sartorius, A., Ende, G., Meyer, N., Welzel, H., Skopp, G., . . . Hermann, D. (2010). Diminished gray matter in the hippocampus of cannabis users: Possible protective effects of cannabidiol. *Drug and Alcohol Dependence, 114*(2-3), 242-245. doi:10.1016/j.drugalcdep.2010.09.020

De Sousa, E. B., Theunissen, E. L., Kuypers, K. P., Toennes, S. W., & Ramaekers, J. G. (2016). Subjective aggression during alcohol and cannabis intoxication before and after aggression exposure. *Psychopharmacology, 233*(18), 3331-3340. doi:10.1007/s00213-016-4371-1

De Wit, H., & Phillips, T. J. (2012). Do initial responses to drugs predict future use or abuse? *Neuroscience & Biobehavioral Reviews, 36*(6), 1565-1576. doi:10.1016/j.neubiorev.2012.04.005

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

Dierker, L. C., Donny, E., Tiffany, S., Colby, S. M., Perrine, N., & Clayton, R. R. (2007). The association between cigarette smoking and DSM-IV nicotine dependence among first year college students. *Drug and Alcohol Dependence, 86*(2-3), 106-114. doi:10.1016/j.drugalcdep.2006.05.025

Di Forti, M., Quattrone, D., Freeman, T. P., Tripoli, G., Gayer-Anderson, C., Quigley, H., . . . Ven, E. V. (2019). The contribution of cannabis use to variation in the incidence of psychotic disorder across Europe (EU-GEI): A multicentre case-control study. *The Lancet Psychiatry, 6*(5), 427-436. doi:10.1016/s2215-0366(19)30048-3

Di Forti, M., Sallis, H., Allegri, F., Trotta, A., Ferraro, L., Stilo, S. A., . . . Murray, R. M. (2013). Daily use, especially of high-potency cannabis, drives the earlier onset of psychosis in cannabis users. *Schizophrenia Bulletin, 40*(6), 1509-1517. doi:10.1093/schbul/sbt181

Dziak, J. J., Lanza, S. T., & Tan, X. (2014). Effect size, statistical power, and sample size requirements for the bootstrap likelihood ratio test in latent class analysis. *Structural Equation Modeling: A Multidisciplinary Journal, 21*(4), 534-552. doi:10.1080/10705511.2014.919819

Ehlers, C. L., Gizer, I. R., Vieten, C., Gilder, D. A., Stouffer, G. M., Lau, P., & Wilhelmsen, K. C. (2010). Cannabis dependence in the San Francisco Family Study: Age of onset of use, DSM-IV symptoms, withdrawal, and heritability. *Addictive Behaviors, 35*(2), 102-110. doi:10.1016/j.addbeh.2009.09.009

Englund, A., Freeman, T. P., Murray, R. M., & Mcguire, P. (2017). Can we make cannabis safer? *The Lancet Psychiatry, 4*(8), 643-648. doi:10.1016/s2215-0366(17)30075-5

Erevik, E. K., Torsheim, T., Andreassen, C. S., Vedaa, Ø, & Pallesen, S. (2017). Recurrent cannabis use among Norwegian students. *Nordic Studies on Alcohol and Drugs, 34*(6), 497-510. doi:10.1177/1455072517743427

Farmer, R. F., Seeley, J. R., Kosty, D. B., Gau, J. M., Duncan, S. C., Lynskey, M. T., & Lewinsohn, P. M. (2015). Internalizing and externalizing psychopathology as predictors of cannabis use disorder onset during adolescence and early adulthood. *Psychology of Addictive Behaviors, 29*(3), 541-551. doi:10.1037/adb0000059

Farmer, R. F., Seeley, J. R., Kosty, D. B., Olino, T. M., & Lewinsohn, P. M. (2013). Hierarchical organization of axis I psychiatric disorder comorbidity through age 30. *Comprehensive Psychiatry,54*(5), 523-532. doi:10.1016/j.comppsych.2012.12.007

Feeney, K. E., & Kampman, K. M. (2016). Adverse Effects of Marijuana Use. *The Linacre Quarterly, 83*(2), 174-178. doi:10.1080/00243639.2016.1175707

Fergusson, D. M., Boden, J. M., & Horwood, L. J. (2015). Psychosocial sequelae of cannabis use and implications for policy: Findings from the Christchurch Health and

Development Study. *Social Psychiatry and Psychiatric Epidemiology, 50*(9), 1317-1326. doi:10.1007/s00127-015-1070-x

Fergusson, D. M., & Horwood, L. J. (1997). Early onset cannabis use and psychosocial adjustment in young adults. *Addiction, 92*(3), 279-296. doi:10.1111/j.1360-0443.1997.tb03198.x

Fischer, B., Rehm, J., Irving, H., Ialomiteanu, A., Fallu, J., & Patra, J. (2010). Typologies of cannabis users and associated characteristics relevant for public health: A latent class analysis of data from a nationally representative Canadian adult survey. *International Journal of Methods in Psychiatric Research*. doi:10.1002/mpr.307

Fischer, B., Russell, C., Sabioni, P., Brink, W. V., Foll, B. L., Hall, W., . . . Room, R. (2017). Lower-risk cannabis use guidelines: A comprehensive update of evidence and recommendations. *American Journal of Public Health, 107*(8), 1277-1277. doi:10.2105/ajph.2017.303818a

Fogel, J. S., Kelly, T. H., Westgate, P. M., & Lile, J. A. (2017). Sex differences in the subjective effects of oral Δ9-THC in cannabis users. *Pharmacology, Biochemistry, and Behavior, 152*, 44-51. doi:10.1016/j.pbb.2016.01.007

Foster, K. T., Arterberry, B. J., Iacono, W. G., Mcgue, M., & Hicks, B. M. (2017). Psychosocial functioning among regular cannabis users with and without cannabis use disorder. *Psychological Medicine, 48*(11), 1853-1861. doi:10.1017/s0033291717003361

Freeman, T. P., Morgan, C. J., Hindocha, C., Schafer, G., Das, R. K., & Curran, H. V. (2014). Just say 'know': How do cannabinoid concentrations influence users

estimates of cannabis potency and the amount they roll in joints? *Addiction, 109*(10), 1686-1694. doi:10.1111/add.12634

Fridberg, D. J., Vollmer, J. M., Odonnell, B. F., & Skosnik, P. D. (2011). Cannabis users differ from non-users on measures of personality and schizotypy. *Psychiatry Research, 186*(1), 46-52. doi:10.1016/j.psychres.2010.07.035

Gillespie, N. A., Lubke, G. H., Gardner, C. O., Neale, M. C., & Kendler, K. S. (2012). Two-part random effects growth modeling to identify risks associated with alcohol and cannabis initiation, initial average use and changes in drug consumption in a sample of adult, male twins. *Drug and Alcohol Dependence, 123*(1-3), 220-228. doi:10.1016/j.drugalcdep.2011.11.015

Giombi, K. C., Kosa, K. M., Rains, C., & Cates, S. C. (2017). Consumers perceptions of edible marijuana products for recreational use: Likes, dislikes, and reasons for use. *Substance Use & Misuse, 53*(4), 541-547. doi:10.1080/10826084.2017.1343353

Groce, E. (2018). The health effects of cannabis and cannabinoids: The current state of evidence and recommendations for research. *Journal of Medical Regulation, 104*(4), 32-32. doi:10.30770/2572-1852-104.4.32

Gorelick, D. A., Goodwin, R. S., Schwilke, E., Schwope, D. M., Darwin, W. D., Kelly, D. L., . . . Huestis, M. A. (2012). Tolerance to effects of high-dose oral Δ9-Tetrahydrocannabinol and plasma cannabinoid concentrations in male daily cannabis smokers. *Journal of Analytical Toxicology, 37*(1), 11-16. doi:10.1093/jat/bks081

Government of Canada (2018). *Canadian Cannabis Survey 2017 - Summary.* Retrieved online: https://www.canada.ca/en/health-canada/services/publications/drugs-health-products/canadian-cannabis-survey-2017-summary.html

Government of Canada (2019). *Canadian Cannabis Survey 2018 Summary.* Retrieved online: https://www.canada.ca/en/services/health/publications/drugs-health-products/canadian-cannabis-survey-2018-summary.html#_Theme_2

Gray, K. M., Watson, N. L., & Christie, D. K. (2009). Challenges in quantifying marijuana use. *American Journal on Addictions, 18*(2), 178-179. doi:10.1080/10550490902772579

Griffith-Lendering, M., Huijbregts, S., Mooijaart, A., Vollebergh, W., & Swaab, H. (2011). Cannabis use and development of externalizing and internalizing behaviour problems in early adolescence: A TRAILS study. *Drug and Alcohol Dependence, 116*(1-3), 11-17. doi:10.1016/j.drugalcdep.2010.11.024

Gruber, S. A., Dahlgren, M. K., Sagar, K. A., Gönenç, A., & Lukas, S. E. (2013). Worth the wait: Effects of age of onset of marijuana use on white matter and impulsivity. *Psychopharmacology, 231*(8), 1455-1465. doi:10.1007/s00213-013-3326-z

Gunn, R. L., Aston, E. R., Sokolovsky, A. W., White, H. R., & Jackson, K. M. (2020). Complex cannabis use patterns: Associations with cannabis consequences and cannabis use disorder symptomatology. *Addictive Behaviors, 105*, 106329. doi:10.1016/j.addbeh.2020.106329

Hall, W. (2014). What has research over the past two decades revealed about the adverse health effects of recreational cannabis use? *Addiction, 110*(1), 19-35. doi:10.1111/add.12703

Han, B., Gfroerer, J. C., & Colliver, J. D. (2010). Associations between duration of illicit drug use and health conditions: Results from the 2005–2007 National Surveys

on Drug Use and Health. *Annals of Epidemiology, 20*(4), 289-297. doi:10.1016/j.annepidem.2010.01.003

Haney, M., Bedi, G., Cooper, Z. D., Glass, A., Vosburg, S. K., Comer, S. D., & Foltin, R. W. (2013). Predictors of marijuana relapse in the human laboratory: Robust impact of tobacco cigarette smoking status. *Biological Psychiatry, 73*(3), 242-248. doi:10.1016/j.biopsych.2012.07.028

Hanson, K. L., Winward, J. L., Schweinsburg, A. D., Medina, K. L., Brown, S. A., & Tapert, S. F. (2010). Longitudinal study of cognition among adolescent marijuana users over three weeks of abstinence. *Addictive Behaviors, 35*(11), 970-976. doi:10.1016/j.addbeh.2010.06.012

Hart, C., Ward, A., Haney, M., Comer, S., Foltin, R., & Fischman, M. (2002). Comparison of smoked marijuana and oral Δ 9 -tetrahydrocannabinol in humans. *Psychopharmacology, 164*(4), 407-415. doi:10.1007/s00213-002-1231-y

Hasin, D. S. (2017). US Epidemiology of Cannabis Use and Associated Problems. *Neuropsychopharmacology, 43*(1), 195-212. doi:10.1038/npp.2017.198

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. *American Journal of Psychiatry, 173*(6), 588-599. doi:10.1176/appi.ajp.2015.15070907

Hayatbakhsh, M. R., Mcgee, T. R., Bor, W., Najman, J. M., Jamrozik, K., & Mamun, A. A. (2008). Child and adolescent externalizing behavior and cannabis use disorders in

early adulthood: An Australian prospective birth cohort study. *Addictive Behaviors, 33*(3), 422-438. doi:10.1016/j.addbeh.2007.10.004

Hayatbakhsh, M. R., Najman, J. M., Bor, W., Ocallaghan, M. J., & Williams, G. M. (2009). Multiple risk factor model predicting cannabis use and use disorders: A longitudinal study. *The American Journal of Drug and Alcohol Abuse, 35*(6), 399-407. doi:10.3109/00952990903353415

Hazekamp, A., Ware, M. A., Muller-Vahl, K. R., Abrams, D., & Grotenhermen, F. (2013). The medicinal use of cannabis and cannabinoids—An international cross-sectional survey on administration forms. *Journal of Psychoactive Drugs, 45*(3), 199-210. doi:10.1080/02791072.2013.805976

Health Canada (2014). S*upplementary Tables, Youth Smoking Survey 2012-2013.* Retrieved online https://www.canada.ca/en/health-canada/services/publications/healthy-living/youth-smoking-survey-2012-2013-supplementary-tables.html#t1

Health Canada (2018). *Canadian Tobacco, Alcohol and Drugs Survey (CTADS): summary of results for 2017.* Retrieved online: https://www.canada.ca/en/health-canada/services/canadian-tobacco-alcohol-drugs-survey/2017-summary.html#n3

Hernandez-Avila, C. A., Rounsaville, B. J., & Kranzler, H. R. (2004). Opioid-, cannabis- and alcohol-dependent women show more rapid progression to substance abuse treatment. *Drug and Alcohol Dependence, 74*(3), 265-272. doi:10.1016/j.drugalcdep.2004.02.001

Hill, K. P. (2015). Medical marijuana for treatment of chronic pain and other medical and psychiatric problems. *JAMA, 313*(24), 2474. doi:10.1001/jama.2015.6199

Hindocha, C., Norberg, M. M., & Tomko, R. L. (2018). Solving the problem of cannabis quantification. *The Lancet Psychiatry*, *5*(4). doi: 10.1016/s2215-0366(18)30088-9

Hodgson, K., Almasy, L., Knowles, E. E., Kent, J. W., Curran, J. E., Dyer, T. D., . . . Glahn, D. C. (2017). The genetic basis of the comorbidity between cannabis use and major depression. *Addiction, 112*(1), 113-123. doi:10.1111/add.13558

Johnston, L. D., Miech, R. A., O'Malley, P. M., Bachman, J. G., Schulenberg, J. E., & Patrick, M. E. (2019). *Monitoring the Future national survey results on drug use 1975-2018: Overview, key findings on adolescent drug use.* Retrieved from: http://www.monitoringthefuture.org/pubs/monographs/mtf-overview2018.pdf

Johnston, L.D., O'Malley, P.M., Miech, R.A., Bachman, J.G., & Schulenberg, J.E. (2015). Monitoring the future: National survey results on drug use, 1975–2015: Overview, key findings on adolescent drug use. Ann Arbor, MI: Institute for Social Research, the University of Michigan.

Jones, R. T., Benowitz, N., & Bachman, J. (1976). Clinical studies of cannabis tolerance and dependence. *Annals of the New York Academy of Sciences, 282* (1 Chronic Canna), 221-239. doi:10.1111/j.1749-6632.1976.tb49901.x

Kalinowski, A., & Humphreys, K. (2016). Governmental standard drink definitions and low-risk alcohol consumption guidelines in 37 countries. *Addiction, 111*(7), 1293-1298. doi:10.1111/add.13341

Kedzior, K. K., & Laeber, L. T. (2014). A positive association between anxiety disorders and cannabis use or cannabis use disorders in the general population- a meta-analysis of 31 studies. *BMC Psychiatry, 14*(1). doi:10.1186/1471-244x-14-136

Kelly, S. M., Gryczynski, J., Mitchell, S. G., Kirk, A., O'Grady, K. E., & Schwartz, R. P. (2014). Validity of brief screening instrument for adolescent tobacco, alcohol, and drug use. *Pediatrics, 133*(5). doi:10.1542/peds.2013-2346d

Khan, S. S., Secades-Villa, R., Okuda, M., Wang, S., Pérez-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 and Alcohol Dependence, 130*(1-3), 101-108. doi:10.1016/j.drugalcdep.2012.10.015

Khantzian, E. J. (1987). The self-medication hypothesis of addictive disorders: Focus on heroin and cocaine dependence. *The Cocaine Crisis,*65-74. doi:10.1007/978-1-4613-1837-8_7

Korf, D. J., Benschop, A., & Wouters, M. (2007). Differential responses to cannabis potency: A typology of users based on self-reported consumption behaviour. *International Journal of Drug Policy, 18*(3), 168-176. doi:10.1016/j.drugpo.2006.08.002

Korn, L., Haynie, D. L., Luk, J. W., & Simons-Morton, B. G. (2018). Prospective associations between cannabis use and negative and positive health and social measures among emerging adults. *International Journal of Drug Policy, 58*, 55-63. doi:10.1016/j.drugpo.2018.05.003

Kosty, D. B., Seeley, J. R., Farmer, R. F., Stevens, J. J., & Lewinsohn, P. M. (2016). Trajectories of cannabis use disorder: Risk factors, clinical characteristics and outcomes. *Addiction, 112*(2), 279-287. doi:10.1111/add.13557

Krueger, R. F. (1999). The Structure of Common Mental Disorders. *Archives of General Psychiatry, 56*(10), 921. doi:10.1001/archpsyc.56.10.921

Krueger, R. F., Caspi, A., Moffitt, T. E., & Silva, P. A. (1998). The structure and stability of common mental disorders (DSM-III-R): A longitudinal-epidemiological study. *Journal of Abnormal Psychology, 107*(2), 216-227. doi:10.1037//0021-843x.107.2.216

Krueger, R. F., McGue, M., & Iacono, W. G. (2001). The higher-order structure of common DSM mental disorders: Internalization, externalization, and their connections to personality. *Personality and Individual Differences, 30*(7), 1245-1259. doi:10.1016/s0191-8869(00)00106-9

Kuha, J. (2004). AIC and BIC. *Sociological Methods & Research*, *33*(2), 188–229. doi: 10.1177/0049124103262065

Lannoy, S., Billieux, J., Poncin, M., & Maurage, P. (2015). Foc6-2 interactions between drinking motives and impulsivity in binge drinking: A cluster analysis. *Alcohol and Alcoholism, 50*(Suppl 1). doi:10.1093/alcalc/agv079.21

Lavery, R. (2011, September). *An animated guide: An introduction to latent class clustering in SAS*. Paper presented at the 23rd Annual Northeast SAS Users Group Conferences, Portland, ME.

Leadbeater, B. J., Ames, M. E., & Linden-Carmichael, A. N. (2018). Age-varying effects of cannabis use frequency and disorder on symptoms of psychosis, depression and anxiety in adolescents and adults. *Addiction,114*(2), 278-293. doi:10.1111/add.14459

Le Strat, Y., Ramoz, N., Horwood, J., Falissard, B., Hassler, C., Romo, L., . . . Gorwood, P. (2009). First positive reactions to cannabis constitute a priority risk

factor for cannabis dependence. *Addiction,104*(10), 1710-1717. doi:10.1111/j.1360-0443.2009.02680.x

Lisdahl, K. M., & Price, J. S. (2012). Increased marijuana use and gender predict poorer cognitive functioning in adolescents and emerging adults. *Journal of the International Neuropsychological Society, 18*(4), 678-688. doi:10.1017/s1355617712000276

Lisdahl, K. M., & Tapert, S. (2012). Chronic effects of heavy alcohol and marijuana use on the brain and cognition in adolescents and young adults. In H. R. White & D. L. Rabiner (Eds.), *College drinking and drug use* (pp. 63-83). New York, NY: The Guilford Press.

Lisdahl, K. M., Wright, N. E., Medina-Kirchner, C., Maple, K. E., & Shollenbarger, S. (2014). Considering cannabis: The effects of regular cannabis use on neurocognition in adolescents and young adults. *Current Addiction Reports, 1*(2), 144-156. doi:10.1007/s40429-014-0019-6

Liu, J. (2004). Childhood externalizing behavior: Theory and implications. *Journal of Child and Adolescent Psychiatric Nursing, 17*(3), 93-103. doi:10.1111/j.1744-6171.2004.tb00003.x

Lundahl, L. H., & Greenwald, M. K. (2015). Effect of oral THC pretreatment on marijuana cue-induced responses in cannabis dependent volunteers. *Drug and Alcohol Dependence, 149*, 187-193. doi:10.1016/j.drugalcdep.2015.01.046

Magidson, J., & Vermunt, J. K. (2002). Latent class models for clustering: A comparison with K-means. *Canadian Journal of Marketing Research, 20*(1), 37-44.

Manning, K., Garey, L., Paulus, D. J., Buckner, J. D., Hogan, J. B., Schmidt, N. B., & Zvolensky, M. J. (2019). Typology of cannabis use among adults: A latent class approach to risk and protective factors. *Addictive Behaviors, 92*, 6-13. doi:10.1016/j.addbeh.2018.12.008

Manrique-Garcia, E., Zammit, S., Dalman, C., Hemmingsson, T., & Allebeck, P. (2012). Cannabis use and depression: A longitudinal study of a national cohort of Swedish conscripts. *BMC Psychiatry, 12*(1). doi:10.1186/1471-244x-12-112.

Mariani, J. J., Brooks, D., Haney, M., & Levin, F. R. (2011). Quantification and comparison of marijuana smoking practices: Blunts, joints, and pipes. *Drug and Alcohol Dependence, 113*(2-3), 249-251. doi:10.1016/j.drugalcdep.2010.08.008

Martinasek, M. P., McGrogan, J. B., & Maysonet, A. (2016). A systematic review of the respiratory effects of inhalational marijuana. *Respiratory Care, 61*(11), 1543-1551. doi:10.4187/respcare.04846

Mcbride, O., Strong, D. R., & Kahler, C. W. (2010). Exploring the role of a nicotine quantity–frequency use criterion in the classification of nicotine dependence and the stability of a nicotine dependence continuum over time. *Nicotine & Tobacco Research, 12*(3), 207-216. doi:10.1093/ntr/ntp196

Mcbride, O., Teesson, M., Baillie, A., & Slade, T. (2011). Assessing the dimensionality of lifetime DSM-IV alcohol use disorders and a quantity-frequency alcohol use criterion in the Australian population: A factor mixture modelling approach. *Alcohol and Alcoholism, 46*(3), 333-341. doi:10.1093/alcalc/agr008

McDonald, C., & Brunelle, C. (2018, June). *Addressing the change in cannabis legislation: What does the evidence say?* Talk presented at the 29th Annual Atlantic Crime Prevention Conference, Saint John, New Brunswick.

McLellan, A., Luborsky, L., O'Brien, C., & Woody, G. (1980). An improved diagnostic instrument for substance abuse patients: The Addiction Severity Index. *Journal of Nervous and Mental Disorders, 168,* 26-33. doi:10.1097/00005053-198001000-00006

Meier, M. H., Caspi, A., Ambler, A., Harrington, H., Houts, R., Keefe, R. S., . . . Moffitt, T. E. (2012). Persistent cannabis users show neuropsychological decline from childhood to midlife. *Proceedings of the National Academy of Sciences, 109*(40). doi:10.1073/pnas.1206820109

Meier, M. H., Hill, M. L., Small, P. J., & Luthar, S. S. (2015). Associations of adolescent cannabis use with academic performance and mental health: A longitudinal study of upper middle class youth. *Drug and Alcohol Dependence, 156*, 207-212. doi:10.1016/j.drugalcdep.2015.09.010

Miller, P., & Plant, M. (2002). Heavy cannabis use among UK teenagers: An exploration. *Drug and Alcohol Dependence, 65*(3), 235-242. doi:10.1016/s0376-8716(01)00165-x

Monshouwer, K., Dorsselaer, S. V., Verdurmen, J., Bogt, T. T., Graaf, R. D., & Vollebergh, W. (2006). Cannabis use and mental health in secondary school children. *British Journal of Psychiatry, 188*(2), 148-153. doi:10.1192/bjp.188.2.148

Morgan, C. J., Freeman, T. P., Hindocha, C., Schafer, G., Gardner, C., & Curran, H. V. (2018). Individual and combined effects of acute delta-9-tetrahydrocannabinol and

cannabidiol on psychotomimetic symptoms and memory function. *Translational Psychiatry, 8*(1). doi:10.1038/s41398-018-0191-x

Morrison, P. D., Zois, V., Mckeown, D. A., Lee, T. D., Holt, D. W., Powell, J. F., . . . Murray, R. M. (2009). The acute effects of synthetic intravenous Δ9-tetrahydrocannabinol on psychosis, mood and cognitive functioning. *Psychological Medicine, 39*(10), 1607. doi:10.1017/s0033291709005522

Moss, H. B., Chen, C. M., & Yi, H. (2014). Early adolescent patterns of alcohol, cigarettes, and marijuana polysubstance use and young adult substance use outcomes in a nationally representative sample. *Drug and Alcohol Dependence, 136*, 51-62. doi:10.1016/j.drugalcdep.2013.12.011

Mun, E. Y., Eye, A. V., Bates, M. E., & Vaschillo, E. G. (2008). Finding groups using model-based cluster analysis: Heterogeneous emotional self-regulatory processes and heavy alcohol use risk. *Developmental Psychology, 44*(2), 481-495. doi:10.1037/0012-1649.44.2.481

Murray, R. M., Morrison, P. D., Henquet, C., & Di Forti, M. (2007). Cannabis, the mind and society: The hash realities. *Nature Reviews Neuroscience, 8*(11), 885-895. doi:10.1038/nrn2253

Newmeyer, M. N., Swortwood, M. J., Abulseoud, O. A., & Huestis, M. A. (2017). Subjective and physiological effects, and expired carbon monoxide concentrations in frequent and occasional cannabis smokers following smoked, vaporized, and oral cannabis administration. *Drug and Alcohol Dependence,175*, 67-76. doi:10.1016/j.drugalcdep.2017.02.003

Norberg, M. M., Kezelman, S., & Lim-Howe, N. (2013). Primary prevention of cannabis use: A systematic review of randomized controlled trials. *PLoS ONE, 8*(1). doi:10.1371/journal.pone.0053187

Norberg, M. M., Mackenzie, J., & Copeland, J. (2012). Quantifying cannabis use with the Timeline Followback approach: A psychometric evaluation. *Drug and Alcohol Dependence, 121*(3), 247-252. doi:10.1016/j.drugalcdep.2011.09.007

Osborne, A. L., Solowij, N., & Weston-Green, K. (2017). A systematic review of the effect of cannabidiol on cognitive function: Relevance to schizophrenia. *Neuroscience & Biobehavioral Reviews, 72*, 310-324. doi:10.1016/j.neubiorev.2016.11.012

Otten, R., Huizink, A. C., Monshouwer, K., Creemers, H. E., & Onrust, S. (2017). Cannabis use and symptoms of anxiety in adolescence and the moderating effect of the serotonin transporter gene. *Addiction Biology, 22*(4), 1081-1089. doi:10.1111/adb.12372

Padovano, H. T., & Miranda, R. (2018). Supplemental material for subjective cannabis effects as part of a developing disorder in adolescents and emerging adults. *Journal of Abnormal Psychology, 127*(3), 282-293. doi:10.1037/abn0000342.supp

Pape, H., Rossow, I., & Storvoll, E. E. (2009). Under double influence: Assessment of simultaneous alcohol and cannabis use in general youth populations. *Drug and Alcohol Dependence, 101*(1-2), 69-73. doi:10.1016/j.drugalcdep.2008.11.002

Patrick, M. E., Yeomans-Maldonado, G., & Griffin, J. (2015). Daily reports of positive and negative affect and alcohol and marijuana use among college student and

nonstudent young adults. *Substance Use & Misuse, 51*(1), 54-61. doi:10.3109/10826084.2015.1074694

Pearce, D. D., Mitsouras, K., & Irizarry, K. J. (2014). Discriminating the effects of cannabis sativa and cannabis indica: A web survey of medical cannabis users. *The Journal of Alternative and Complementary Medicine, 20*(10), 787-791. doi:10.1089/acm.2013.0190

Pearson, M. R., Liese, B. S., Dvorak, R. D., & Marijuana Outcomes Study Team. (2017). College student marijuana involvement: Perceptions, use, and consequences across 11 college campuses. *Addictive Behaviors, 66*, 83-89. doi:10.1016/j.addbeh.2016.10.019

Perrot, B., Hardouin, J., Grall-Bronnec, M., & Challet-Bouju, G. (2018). Typology of online lotteries and scratch games gamblers behaviours: A multilevel latent class cluster analysis applied to player account-based gambling data. *International Journal of Methods in Psychiatric Research, 27*(4). doi:10.1002/mpr.1746

Peters, E. N., Budney, A. J., & Carroll, K. M. (2012). Clinical correlates of co-occurring cannabis and tobacco use: A systematic review. *Addiction, 107*(8), 1404-1417. doi:10.1111/j.1360-0443.2012.03843.x

Pol, P. V., Liebregts, N., Graaf, R. D., Have, M. T., Korf, D. J., Brink, W. V., & Laar, M. V. (2013). Mental health differences between frequent cannabis users with and without dependence and the general population. *Addiction,108*(8), 1459-1469. doi:10.1111/add.12196

Potter, D. J., Clark, P., & Brown, M. B. (2008). Potency of Δ9–THC and other cannabinoids in cannabis in England in 2005: Implications for psychoactivity and

pharmacology. *Journal of Forensic Sciences, 53*(1), 90-94. doi:10.1111/j.1556-4029.2007.00603.x

Prini, P., Zamberletti, E., Manenti, C., Gabaglio, M., Parolaro, D., & Rubino, T. (2020). Neurobiological mechanisms underlying cannabis-induced memory impairment. *European Neuropsychopharmacology,* 1-10. doi:10.1016/j.euroneuro.2020.02.002

Prochaska, J. O., & Norcross, J. C. (2001). Stages of change. *Psychotherapy: Theory, Research, Practice, Training, 38*(4), 443-448. doi:10.1037/0033-3204.38.4.443

Prochaska, J. O., Redding, C. A., & Evers, K. E. (2015). The transtheoretical model and stages of change. In *Health behaviour: Theory, research and practice* (5th ed., pp. 125-142). San Francisco, CA: Jossey-Bass.

Quattrone, D., Ferraro, L., Tripoli, G., Cascia, C. L., Quigley, H., Quattrone, A., . . . Forti, M. D. (2020). Daily use of high-potency cannabis is associated with more positive symptoms in first-episode psychosis patients: The EU-GEI case–control study. *Psychological Medicine,* 1-9. doi:10.1017/s0033291720000082

Ramakrishnan, N., Mcphee, M., Sosnowski, A., Rajasingaam, V., & Erb, S. (2019). Positive urgency partially mediates the relationship between childhood adversity and problems associated with substance use in an undergraduate population. *Addictive Behaviors Reports*, *10*, 100230. doi:10.1016/j.abrep.2019.100230

Ramo, D. E., Delucchi, K. L., Hall, S. M., Liu, H., & Prochaska, J. J. (2013). Marijuana and tobacco co-use in young adults: Patterns and thoughts about use. *Journal of Studies on Alcohol and Drugs, 74*(2), 301-310. doi:10.15288/jsad.2013.74.30

Ramo, D. E., Liu, H., & Prochaska, J. J. (2012). Tobacco and marijuana use among adolescents and young adults: A systematic review of their co-use. *Clinical Psychology Review, 32*(2), 105-121. doi:10.1016/j.cpr.2011.12.002

Rehm, J., Marmet, S., Anderson, P., Gual, A., Kraus, L., Nutt, D. J., . . . Gmel, G. (2013). Defining substance use disorders: Do we really need more than heavy use? *Alcohol and Alcoholism, 48*(6), 633-640. doi: 10.1093/alcalc/agt127

Rehm, J., & Roerecke, M. (2013). Reduction of drinking in problem drinkers and all-cause mortality. *Alcohol and Alcoholism, 48*(4), 509-513. doi:10.1093/alcalc/agt021

Reis, R. D., Almeida, K. J., Lopes, L. D., Mendes, C. M., & Bor-Seng-Shu, E. (2020). Efficacy and adverse event profile of cannabidiol and medicinal cannabis for treatment-resistant epilepsy: Systematic review and meta-analysis. *Epilepsy & Behavior, 102*, 106635. doi:10.1016/j.yebeh.2019.106635

Richmond-Rakerd, L. S., Slutske, W. S., Lynskey, M. T., Agrawal, A., Madden, P. A., Bucholz, K. K., . . . Martin, N. G. (2016). Age at first use and later substance use disorder: Shared genetic and environmental pathways for nicotine, alcohol, and cannabis. *Journal of Abnormal Psychology,125*(7), 946-959. doi:10.1037/abn0000191

Rodríguez, A. M. (2015). Age, sex and personality in early cannabis use. *European Psychiatry, 30*(4), 469-473. doi:10.1016/j.eurpsy.2015.02.008

Sachs, J., Mcglade, E., & Yurgelun-Todd, D. (2015). Safety and toxicology of cannabinoids. *Neurotherapeutics, 12*(4), 735-746. doi:10.1007/s13311-015-0380-8

Saha, T. D., Stinson, F. S., & Grant, B. F. (2007). The role of alcohol consumption in future classifications of alcohol use disorders. *Drug and Alcohol Dependence, 89*(1), 82-92. doi:10.1016/j.drugalcdep.2006.12.003

Saunders, J. B. (2013). The concept of substance use disorders: A commentary on 'Defining substance use disorders: Do we really need more than heavy use' by Rehm et al. *Alcohol and Alcoholism, 48*(6), 644-645. doi:10.1093/alcalc/agt146

Schlossarek, S., Kempkensteffen, J., Reimer, J., & Verthein, U. (2015). Psychosocial determinants of cannabis dependence: A systematic review of the literature. *European Addiction Research, 22*(3), 131-144. doi:10.1159/000441777

Schuster, R. M., Crane, N. A., Mermelstein, R., & Gonzalez, R. (2012). The influence of inhibitory control and episodic memory on the risky sexual behavior of young adult cannabis users. *Journal of the International Neuropsychological Society, 18*(5), 827-833. doi:10.1017/s1355617712000586

Sewell, R. A., Poling, J., & Sofuoglu, M. (2009). The effect of cannabis compared with alcohol on driving. *American Journal on Addictions, 18*(3), 185-193. doi:10.1080/10550490902786934

Simons, J. S., Clarke, C. J., Simons, R. M., & Spelman, P. J. (2016). Marijuana consequences in a motivational context: Goal congruence reduces likelihood of taking steps toward change. *Addictive Behaviors, 52,* 83-90. doi:10.1016/j.addbeh.2015.08.010

Sobell, L., & Sobell, M. (1992). Timeline Follow-Back for alcohol consumption. *PsycTESTS Dataset*. doi:10.1037/t06202-000

Solowij, N., Broyd, S., Greenwood, L., Hell, H. V., Martelozzo, D., Rueb, K., . . . Croft, R. (2019). A randomised controlled trial of vaporised Δ9-tetrahydrocannabinol and cannabidiol alone and in combination in frequent and infrequent cannabis users: Acute intoxication effects. *European Archives of Psychiatry and Clinical Neuroscience, 269*(1), 17-35. doi:10.1007/s00406-019-00978-2

Solowij, N., & Grenyer, B. F. (2002). Are the adverse consequences of cannabis use age-dependent? *Addiction, 97*(9), 1083-1086. doi:10.1046/j.1360-0443.2002.00243.x

Spriggens, L., & Hides, L. (2015). Patterns of cannabis use, psychotic-like experiences and personality styles in young cannabis users. *Schizophrenia Research, 165*(1), 3-8. doi:10.1016/j.schres.2015.03.023

Statistics Canada. (2004). *Mental and substance use disorders in Canada* (Component of Statistics Canada catalogue No. 82-624-X). Retrieved from https://www150.statcan.gc.ca/n1/pub/82-624-x/2013001/article/11855-eng.htm

Statistics Canada. (2012). *Use of cannabis and other illicit drugs* (Component of Statistics Canada catalogue No. 82-003). Retrieved from https://www150.statcan.gc.ca/n1/en/pub/82-003-x/2003004/article/6976-eng.pdf?st=t-ehcljV

Statistics Canada. (2015). *Prevalence and correlates of marijuana use in Canada, 2012* (Component of Statistics Canada catalogue No. 82-003-X). Retrieved from https://www150.statcan.gc.ca/n1/en/pub/82-003-x/2015004/article/14158-eng.pdf?st=wPk_Rv1l

Statistics Canada. (2019). *Average quarterly price of cannabis* (Component of Statistics Canada catalogue No. 13-610-X). Retrieved from https://www150.statcan.gc.ca/n1/daily-quotidien/200123/t001c-eng.htm

Statistics Canada. (2018). *Canadian Tobacco, Alcohol and Drugs Survey (CTADS): summary of results for 2017* (Component of Statistics Canada catalogue No. 11-001-X). Retrieved from https://www150.statcan.gc.ca/n1/en/daily-quotidien/181030/dq181030b-eng.pdf?st=VIdzOScc

Statistics Canada. (2018). *National Cannabis Survey: First quarter 2018* (Component of Statistics Canada catalogue No. 11-627-M). Retrieved from https://www150.statcan.gc.ca/n1/daily-quotidien/180418/dq180418b-eng.htm

Statistics Canada. (2019). *National Cannabis Survey: Detailed information for second quarter 2019* (Component of Statistics Canada catalogue No. 11-627-M). Retrieved from https://www150.statcan.gc.ca/n1/daily-quotidien/190502/dq190502a-eng.htm

Statistics Canada. (2019). *National Cannabis Survey, first quarter 2019* (Component of Statistics Canada catalogue No. 11-627-M). Retrieved from https://www150.statcan.gc.ca/n1/daily-quotidien/190502/dq190502a-eng.htm

Statistics Canada. (2019). *National Cannabis Survey: Third quarter 2019* (Component of Statistics Canada catalogue No. 11-001-X). Retrieved from https://www150.statcan.gc.ca/n1/daily-quotidien/191030/dq191030a-eng.pdf

Stuyt, E. (2018). The problem with the current high potency THC marijuana from the perspective of an addiction psychiatrist. *Missouri Medicine, 115*(6), 482-486.

Stockburger, S. (2016). Forms of administration of cannabis and their efficacy. *Journal of Pain Management*, *9*(4), 381-386.

Substance Abuse and Mental Health Services Administration. (2014). *Results from the 2013 National Survey on Drug Use and Health: Summary of National Findings.* Retrieved from https://www.samhsa.gov/data/sites/default/files/NSDUHresultsPDFWHTML2013/Web/NSDUHresults2013.pdf

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

Tabachnick, B. G., & Fidell, L. S. 2019. Using multivariate statistics (7th ed.). Boston, MA: Pearson Education Incorporated.

Tarter, R. E., Kirisci, L., Ridenour, T., & Vanyukov, M. (2008). Prediction of cannabis use disorder between childhood and young adulthood using the child behavior checklist. *Journal of Psychopathology and Behavioral Assessment, 30*(4), 272-278. doi:10.1007/s10862-008-9083-3

Timberlake, D. S. (2009). A comparison of drug use and dependence between blunt smokers and other cannabis users. *Substance Use & Misuse, 44*(3), 401-415. doi:10.1080/10826080802347651

Tomko, R. L., Baker, N. L., Mcclure, E. A., Sonne, S. C., Mcrae-Clark, A. L., Sherman, B. J., & Gray, K. M. (2018). Incremental validity of estimated cannabis grams as a predictor of problems and cannabinoid biomarkers: Evidence from a clinical trial. *Drug and Alcohol Dependence, 182*, 1-7. doi:10.1016/j.drugalcdep.2017.09.035

Tran, T. D., Tran, T., & Fisher, J. (2013). Validation of the depression anxiety stress scales (DASS) 21 as a screening instrument for depression and anxiety in a rural community-based cohort of northern Vietnamese women. *BMC Psychiatry, 13*(1). doi:10.1186/1471-244x-13-24

Turner, C. (1990). How much alcohol is in a standard drink? An analysis of 125 studies. *Addiction, 85*(9), 1171-1175. doi:10.1111/j.1360-0443.1990.tb03442.x

Tzilos, G. K., Reddy, M. K., Caviness, C. M., Anderson, B. J., & Stein, M. D. (2014). Getting higher: Co-occurring drug use among marijuana-using emerging adults. *Journal of Addictive Diseases, 33*(3), 202-209. doi:10.1080/10550887.2014.950024

United Nations Office on Drugs and Crime Estimates. (2016). *Annual prevalence of the use of drugs by region and globally.* Retrieved from https://dataunodc.un.org/drugs/prevalence_regional

Vanderveen, J. D., Hershberger, A. R., & Cyders, M. A. (2016). UPPS-P model impulsivity and marijuana use behaviors in adolescents: A meta-analysis. *Drug and Alcohol Dependence, 168*, 181-190. doi:10.1016/j.drugalcdep.2016.09.016

Vandrey, R., Raber, J. C., Raber, M. E., Douglass, B., Miller, C., & Bonn-Miller, M. O. (2015). Cannabinoid dose and label accuracy in edible medical cannabis products. *JAMA, 313*(24), 2491. doi:10.1001/jama.2015.6613

Vermunt, J.K., & Magidson, J. (2002). Latent class cluster analysis. In J.A. Hagenaars, & A.L. McMutcheon (Eds.), *Applied latent class analysis* (pp. 89-106). New York: Cambridge University Press

Vink, J. M., Nawijn, L., Boomsma, D. I., & Willemsen, G. (2007). Personality differences in monozygotic twins discordant for cannabis use. *Addiction, 102*(12), 1942-1946. doi:10.1111/j.1360-0443.2007.02008.x

Volkow, N. D., Baler, R. D., Compton, W. M., & Weiss, S. R. (2014). Adverse health effects of marijuana use. *New England Journal of Medicine, 370*(23), 2219-2227. doi:10.1056/nejmra1402309

Wagner, F. A., & Anthony, J. C. (2007). Male–female differences in the risk of progression from first use to dependence upon cannabis, cocaine, and alcohol. *Drug and Alcohol Dependence, 86*(2-3), 191-198. doi:10.1016/j.drugalcdep.2006.06.003

Walden, N., & Earleywine, M. (2008). How high: Quantity as a predictor of cannabis-related problems. *Harm Reduction Journal, 5*(1), 20. doi:10.1186/1477-7517-5-20

Wei, E. H., Loeber, R., & White, H. R. (2004). Teasing apart the developmental associations between alcohol and marijuana use and violence. *Journal of Contemporary Criminal Justice,20*(2), 166-183. doi:10.1177/1043986204263777

Weinberger, A. H., Pacek, L. R., Sheffer, C. E., Budney, A. J., Lee, J., & Goodwin, R. D. (2019). Serious psychological distress and daily cannabis use, 2008 to 2016: Potential implications for mental health? *Drug and Alcohol Dependence, 197*, 134-140. doi:10.1016/j.drugalcdep.2019.01.010

Weinberger, A. H., Platt, J., Esan, H., Galea, S., Erlich, D., & Goodwin, R. D. (2017). Cigarette smoking is associated with increased risk of substance use disorder relapse. *The Journal of Clinical Psychiatry,78*(2). doi:10.4088/jcp.15m10062

WHO ASSIST Working Group (2002). The Alcohol, Smoking and Substance Involvement Screening Test (ASSIST): development, reliability and feasibility. *Addiction, 97*(9), 1183-1194.

Winward, J. L., Hanson, K. L., Tapert, S. F., & Brown, S. A. (2014). Heavy alcohol use, marijuana use, and concomitant use by adolescents are associated with unique and shared cognitive decrements. *Journal of the International Neuropsychological Society, 20*(8), 784-795. doi:10.1017/s1355617714000666

Wright, N. E., Scerpella, D., & Lisdahl, K. M. (2016). Marijuana use is associated with behavioral approach and depressive symptoms in adolescents and emerging adults. *Plos One, 11*(11). doi:10.1371/journal.pone.0166005

Yurasek, A. M., Aston, E. R., & Metrik, J. (2017). Co-use of alcohol and cannabis: A review. *Current Addiction Reports, 4*(2), 184-193. doi:10.1007/s40429-017-0149-8

Zeisser, C., Thompson, K., Stockwell, T., Duff, C., Chow, C., Vallance, K., . . . Lucas, P. (2012). A 'standard joint'? The role of quantity in predicting cannabis-related problems. *Addiction Research & Theory, 20*(1), 82-92. doi:10.3109/16066359.2011.569101

Appendix A

Demographics questionnaire (Internally generated)

**Demographics**

The following questionnaire is used to collect demographic information.

**What is your age?**

☐ Years

**What gender do you most identify with?**

☐ Male
☐ Female
☐ Other

**What is your ethnicity?**

☐ White/ Caucasian
☐ Hispanic/ Latino
☐ Black/ African Canadian or African American
☐ Middle Eastern
☐ Indigenous/ First Nations/ Metis
☐ Asian/ Pacific Islander
☐ Other

**What is your marital status?**

☐ Single, never married
☐ Married/ Common Law
☐ Widowed
☐ Divorced/ Separated

**What is your primary employment status?**

- [ ] Employed
- [ ] Unemployed
- [ ] Homemaker
- [ ] Student
- [ ] Social assistance
- [ ] Retired
- [ ] On leave (i.e., medical, parental)
- [ ] Other: Please specify _____

**What is the highest level of school you have completed?**

- [ ] Less than high school
- [ ] High school graduate or equivalent (e.g., GED)
- [ ] Some university
- [ ] Trade/technical/vocational training
- [ ] Bachelor's degree
- [ ] Graduate Degree
- [ ] Other: Please specify

Appendix B

Depression Anxiety Stress Scale (DASS-21; Crawford & Henry, 2003)

**DASS 21**

**Please read each statement and check a number (0, 1, 2 or 3) which indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much me on any statement.**

0= Never; 1= Sometimes; 2= Often; 3= Almost always

| | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| 1. I found it hard to wind down | | | | |
| 2. I was aware of dryness of my mouth | | | | |
| 3. I couldn't seem to experience any positive feeling at all | | | | |
| 4. I experienced breathing difficulty (e.g., excessively rapid breathing, breathlessness in the absence of physical exertion) | | | | |
| 5. I found it difficult to work up the initiative to do things | | | | |
| 6. I tended to over-react to situations | | | | |
| 7. I experienced trembling (e.g., in the hands) | | | | |
| 8. I felt that I was using a lot of nervous energy | | | | |
| 9. I was worried about situations in which I might panic and make a fool of myself | | | | |
| 10. I felt that I had nothing to look forward to | | | | |
| 11. I found myself getting agitated | | | | |
| 12. I found it difficult to relax | | | | |
| 13. I felt down-hearted and blue | | | | |
| 14. I was intolerant of anything that kept me from getting on with what I was doing | | | | |
| 15. I felt I was close to panic | | | | |
| 16. I was unable to become enthusiastic about anything | | | | |
| 1. I felt I wasn't worth much as a person | | | | |
| 2. I felt that I was rather touchy | | | | |
| 19. I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat) | | | | |
| 20. I felt scared without any good reason | | | | |
| 21. I felt that life was meaningless | | | | |

Appendix C

Urgency, Premeditation, Perseverance, Sensation Seeking, Positive Urgency, Impulsive Behaviour Scale Short-Form (SUPPS-P; Cyders, Littlefield, Coffey & Karyadi, 2015)

**SUPPS-P**

**Below are a number of statements that describe ways in which people act and think. For each statement, please indicate how much you agree or disagree with the statement. Be sure to indicate your agreement or disagreement for every statement below.**

1= Agree Strongly, 2= Agree Somewhat, 3=Disagree somewhat, 4= Disagree Strongly.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. I generally like to see things through to the end | | | | |
| 2. My thinking is usually careful and purposeful | | | | |
| 3. When I am in a great mood, I tend to get into situations that could cause me problems | | | | |
| 4. Unfinished tasks really bother me | | | | |
| 5. I like to stop and think things over before I do them | | | | |
| 6. When I feel bad, I will often do things I later regret in order to make myself feel better now | | | | |
| 7. Once I get going on something I hate to stop | | | | |
| 8. Sometimes when I feel bad, I can't seem to stop what I am doing even though it is making me feel worse | | | | |
| 9. I quite enjoy taking risks | | | | |
| 10. I tend to lose control when I am in a great mood | | | | |
| 11. I finish what I start | | | | |
| 12. I tend to value and follow a rational, "sensible" approach to things | | | | |
| 13. When I am upset I often act without thinking | | | | |
| 14. I welcome new and exciting experiences and sensations, even if they are a little frightening and unconventional | | | | |
| 15. When I feel rejected, I will often say thing that I later regret | | | | |
| 16. I would like to learn to fly an airplane | | | | |
| 17. Others are shocked or worried about the things I do when I am feeling very excited | | | | |
| 18. I would enjoy the sensation of skiing very fast down a high mountain slope | | | | |
| 19. I usually think carefully before doing anything | | | | |
| 20. I tend to act without thinking when I am really excited | | | | |

Appendix D

Adapted Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST-A;

WHO ASSIST Working Group, 2002)

**ASSIST-A**

Please answer the following questions by circling a number that corresponds to how often each statement applies to you **within the last year**.

| | Never | Once or Twice | Monthly | Weekly | Daily or Almost Daily |
|---|---|---|---|---|---|
| During the last year, how often has your cannabis use led to **health** problems? | 1 | 4 | 5 | 6 | 7 |
| During the last year, how often has your cannabis use led to **social** problems? | 1 | 4 | 5 | 6 | 7 |
| During the last year, how often has your cannabis use led to **legal** problems? | 1 | 4 | 5 | 6 | 7 |
| During the last year, how often has your cannabis use led to **financial** problems? | 1 | 4 | 5 | 6 | 7 |

Appendix E

Cannabis Use Questionnaire (Internally Generated)

**Cannabis Use Questionnaire**

Please answer the following questions regarding your past and current cannabis use.

1. **Have you used cannabis within the past 12 months?**
   - ☐ Yes
   - ☐ No
2. **In the last 12 months, I typically consumed cannabis:**
   - ☐ Daily/ Almost daily
   - ☐ Weekly
   - ☐ Bi-weekly
   - ☐ Monthly
   - ☐ Once or twice
3. **How often did you use cannabis to the point of intoxication in the last year?**
   - ☐ Rarely (once or twice)
   - ☐ Occasionally (monthly)
   - ☐ Regularly (weekly)
   - ☐ Frequently (daily)
4. **How many days in total have you used cannabis in the last 30 days? (e.g., every Friday and Saturday = 2 days x 4 weeks = 8 times in 30 days; write 0 if you have not consumed cannabis in the past 30 days)**

_____

5. **Generally, when you use cannabis, on how many times <u>per day</u> do you consume cannabis?**
   - ☐ Once per day
   - ☐ Twice per day
   - ☐ Three times per day
   - ☐ Four times per day
   - ☐ 5 or more times per day
6. **How much money would you say you spent on cannabis in the past 30 days?**

   _____
7. **At what age did you first use cannabis?**

   _____
8. **How aware are you of the THC levels in the cannabis you purchase?**
   - ☐ Very aware
   - ☐ Somewhat aware
   - ☐ Not at all aware

**9. Please indicate the percentage of THC in the cannabis you purchase most frequently.**
   - ☐ 1-5% THC
   - ☐ 6-14% THC
   - ☐ 15-30% THC
   - ☐ 31-49% THC
   - ☐ +50% THC
   - ☐ I am unaware of the level of THC in my cannabis products

**10. How aware are you of the CBD levels in the cannabis you purchase?**
   - ☐ Very aware
   - ☐ Somewhat aware
   - ☐ Not at all aware

**11. Please indicate the percentage of CBD in the cannabis you purchase most frequently.**
   - ☐ 1-15% CBD
   - ☐ 6-14% CBD

☐ 15-30% CBD

☐ 31-49% CBD

☐ +50% CBD

☐ I am unaware of the levels of CBD in my cannabis products

**12. When you purchase cannabis, you purchase strains that are…**

☐ Primarily THC

☐ Primarily CBD

☐ Approximately equivalent amounts of THC and CBD

**13. Do you prefer cannabis that is…**

☐ High in THC, High in CBD

☐ High in THC, Low in CBD

☐ Low in THC, High in CBD

☐ Low in THC, Low in CBD

☐ I don't care about THC and CBD concentrations

**14. When I consume cannabis, I generally get…**

| **Least High (Not high at all)** | | | | | | | | | | **Greatest High (Extremely high)** |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |

**15. What is your preferred form of cannabis?**

☐ Cannabis plant (cannabis indica, cannabis sativa, etc.)

☐ Cannabis concentrates (wax, shatter, honeycomb, etc.)

☐ Synthetic cannabinoids (Spice, K2)

☐ Edibles (baked goods, candies, teas)

☐ Cannabis oils

☐ Other - Please Specify: _____

**16. How do you prefer to consume cannabis? Select one option.**

- ☐ Joints
- ☐ Vaporizers
- ☐ Pipes
- ☐ Bongs
- ☐ Hot knives
- ☐ Lungs
- ☐ Buckets
- ☐ Edibles
- ☐ Pills
- ☐ Topical creams
- ☐ Oral spray
- ☐ Oils
- ☐ Other – Please specify: _____

**17. Cannabis may be used to treat medical conditions, such as epilepsy, cancer symptoms, Parkinson's disease, and multiple sclerosis. Do you consider yourself primarily a…**

- ☐ Recreational cannabis user
- ☐ Medical cannabis user – Please specify: _____

**18. Do you have a history of diagnosed substance use disorder (i.e., addiction)?**

- ☐ Yes
- ☐ No

**19. Does anyone in your family (sibling, parent, grandparent, aunt/uncle) have a family history of diagnosed substance use disorder (i.e., addiction)?**

- ☐ Yes
- ☐ No

**20. Do you have a history of psychosis (i.e., hallucinations, paranoia, disorganized speech and/or behaviour, etc.)?**

- ☐ Yes
- ☐ No

**21. Does anyone in your family (sibling, parent, grandparent, aunt/uncle) have a history of psychosis (i.e., hallucinations, paranoia, disorganized speech and/or behaviour, etc.).**

☐ Yes

☐ No

Appendix F

Adapted Addiction Severity Index (ASI; McLellan, Luborsky, Woody & O'Brien, 1980)

## ASI-A

Please circle how frequently you have used the following substances **in the last three months** (not including drugs taken as prescribed by your doctor).

| | |
|---|---|
| 1 = never use | 4 = once or twice a week |
| 2 = less than 6 times per year | 5 = nearly every day |
| 3 = about once a month | 6 = once a day or more |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. Tobacco (cigarettes, cigars, chew) | 1 | 2 | 3 | 4 | 5 | 6 |
| 2. Heroin | 1 | 2 | 3 | 4 | 5 | 6 |
| 3. Methadone | 1 | 2 | 3 | 4 | 5 | 6 |
| 4. Other opiates/narcotics (morphine; opium; Dilaudid; Demerol; Percocet; Vicodin; Oxycontin; Fentanyl; Codeine; Tylenol 2,3,4) | 1 | 2 | 3 | 4 | 5 | 6 |
| 5. Barbiturates (Nembutal, Seconol, Amytal, Secobarbital, Phenobarbital) | 1 | 2 | 3 | 4 | 5 | 6 |
| 6. Sedatives/Hypnotics/Tranquilizers (benzodiazepines, Valium, Xanax, Librium, Ativan, Quaaludes) | 1 | 2 | 3 | 4 | 5 | 6 |
| 7. Cocaine (free-base, crack cocaine) | 1 | 2 | 3 | 4 | 5 | 6 |
| 8. Amphetamines (Adderall, Methamphetamines, Dexedrine, Ritalin, speed, ice) | 1 | 2 | 3 | 4 | 5 | 6 |
| 9. Alcohol | 1 | 2 | 3 | 4 | 5 | 6 |
| 10. Hallucinogens (LSD [acid], mescaline, psilocybin [mushrooms], ecstasy, PCP [phencyclidine]) | 1 | 2 | 3 | 4 | 5 | 6 |

Appendix G

Diagnostic and Statistical Manual of Mental Disorders 5th edition Cannabis Use Disorder Criteria Questionnaire (DSM-5 CUD criteria; American Psychiatric Association, 2013)

**DSM-5 SUD criteria**

Please indicate whether the statements below apply to you **in the last year**.

| | YES | NO |
|---|---|---|
| I often consume larger amounts of cannabis or consume cannabis over a longer period of time than I had originally planned. | | |
| I have a persistent desire to engage in unsuccessful efforts to cut down or control my cannabis use. | | |
| A great deal of my time is spent engaging in activities necessary to get cannabis, use cannabis, or recover from using cannabis. | | |
| I crave cannabis. | | |
| I engage in repeated cannabis use, resulting in a failure to fulfill my major obligations at work, school, or home. | | |
| I engage in continued cannabis use despite having repeated social or interpersonal problems (e.g., loss of friendships, family conflicts) caused or made worse by the effects of cannabis on my life. | | |
| I give up or reduce my involvement in important social, work-related, or recreational activities because of cannabis. | | |
| I engage in repeated cannabis use in situations in which it is physically dangerous (e.g., operating machinery, driving a car). | | |
| I continue to use cannabis despite my knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or made worse by cannabis. | | |
| I experience a tolerance for cannabis (I need to consume more cannabis to get the desired effects OR I am using the same amount of cannabis but not feeling its effects as strongly) | | |
| After stopping cannabis use following heavy use for at least a few months, I have experienced 3 or more of the following: Irritability/anger/aggression, nervousness/anxiety, sleep difficulty, weight loss/eating less than usual, restlessness (i.e., unable to sit still and relax), depressed mood. | | |
| After stopping cannabis use following heavy use for at least a few months, I have experienced 1 or more of the following: Stomach pain, Shakiness/tremors, sweating, fever, chills, headache. | | |

Appendix H

Cannabis Use Disorders Identification Test-Revised (CUDIT-R; Adamson et al., 2010)

**CUDIT-R**

Please answer the following questions about your cannabis use. Select the response that is most correct for you in relation to your cannabis use over the last **six months.**

1. How many hours were you "stoned" on a typical day when you had been using cannabis?
   - ☐ less than 1
   - ☐ 1 or 2
   - ☐ 3 or 4
   - ☐ 5 or 6
   - ☐ 7+
   - ☐ I do not use cannabis

2. How often during the past 6 months did you find that you were not able to stop using cannabis once you had started?
   - ☐ Never
   - ☐ Monthly or less
   - ☐ 2-4 times per month
   - ☐ 2-3 times per week
   - ☐ 4 or more times per week

3. How often during the past 6 months did you fail to do what was normally expected from you because of using cannabis?
   - ☐ Never
   - ☐ Monthly or less
   - ☐ 2-4 times per month,
   - ☐ 2-3 times per week
   - ☐ 4 or more times per week

4. How often in the past 6 months have you had a problem with your memory or concentration after using cannabis?
   - ☐ Never
   - ☐ Monthly or less
   - ☐ 2-4 times per month
   - ☐ 2-3 times per week
   - ☐ 4 or more times per week

5. How often do you use cannabis in situations that could be physically hazardous, such as driving, operating machinery, or caring for children?
    - Never
    - Monthly or less
    - 2-4 times per month
    - 2-3 times per week
    - 4 or more times per week

6. Have you ever thought about cutting down, or stopping, your use of cannabis?
    - Never
    - Yes, but not in the past 6 months
    - Yes, during the past 6 months

Appendix I

Recruitment Poster

(Online Population)

# We want you to tell us about your cannabis use!

TITLE OF THE STUDY: Cannabis Use Problems: Who is at Risk and Why? The Identification of Markers

Investigator: Brittany Skelding (Masters student, Psychology);
Brittany.skelding@unb.ca
Supervisor: Dr. Caroline Brunelle (Psychology department);
cbrunell@unb.ca

**WHAT WILL I HAVE TO DO?** This study will take approximately 30 minutes of your time. You will be asked to complete an online survey focusing on your cannabis use and various aspects of your mental health. You will be awarded half of one bonus mark in exchange for your participation, or the chance to win a $25 Amazon gift card. Your responses will be kept confidential and anonymous.

**HOW DO I PARTICIPATE?** Sign up using the SONA registration system (https://unb-ss.sona-systems.com) or follow this link to the survey (xxxxxxxx).

# You MUST be a past-year cannabis user to participate!

Appendix J

Consent Form: Online Administration

## INFORMED CONSENT

**Title of the study:** Cannabis Use Problems: Who is at Risk and Why? The Identification of Markers

**Investigator:** Brittany Skelding (Masters Graduate Student), brittany.skelding@unb.ca

**Supervisor:** Dr. Caroline Brunelle, cbrunell@unb.ca

Please read the following information carefully before agreeing to participate in this research study.

This study is being conducted to examine the relationship between demographic factors, cannabis use practices, polysubstance use, and mental health problems and cannabis use-related outcomes. The goal of the current study is to determine if groups of cannabis users emerge based on these factors. Should you agree to participate in the study, you will be given short questionnaires to complete, which will measure cannabis use and practices, various mental health symptoms (e.g., anxiety, depression, impulsivity), and extent of use for various other substances.

Your participation in this study is voluntary. Should you wish to withdraw from the study at any point, you are free to do so. The study will take approximately 30 minutes to complete. Any information provided by you throughout the study will be strictly confidential. To ensure confidentiality, names and emails (given at the end of the study on a secure, separate website) will be anonymous and separate from the completed questionnaires. In addition, questionnaires will be identified by a number that will in no way be linked to any identifying information. The documents will be stored on an encrypted and password protected USB stick, locked in the primary researcher's office for seven years and will then be securely destroyed. Any information that you provide will only be used for the purpose of this study. No individuals will be singled out or identified in this study.

Psychology students at the University of New Brunswick will be awarded one half of a bonus point toward their final grade in a participating course. Other participants will be given the option to be entered in a draw for a $25 Amazon gift card upon completion of the study.

You are free not to answer question(s) on any questionnaire(s) that you feel is upsetting. You may discontinue your participation in the study at any time without penalty.

This study is being conducted by Brittany Skelding (brittany.skelding@unb.ca) under the supervision of Dr. Caroline Brunelle (506-648-5797, cbrunell@unb.ca), in the Psychology Department at the University of New Brunswick, Saint John.

By clicking "Continue," I confirm that I have read the information on the INFORMED CONSENT FORM and volunteer to participate in this study. I am aware that all records are entirely confidential, and that I may discontinue my participation at any point in the study without loss of compensation.

Note: If you wish to be notified of the results when the study is completed, please email the investigator of this study at cannabisunb@outlook.com at your convenience.

Participants who wish to discuss this study with someone who is not directly involved in the research can contact the research ethics chair, Beth Keyes, at (506) 648-5949, REB@unbsj.ca.

Appendix K

Recruitment poster

(Clinical Population)

# We want you to tell us about your cannabis use!

Investigator: Brittany Skelding (Masters student, Psychology);
Brittany.skelding@unb.ca
Supervisor: Dr. Caroline Brunelle (Psychology department); cbrunell@unb.ca

**WHAT WILL I HAVE TO DO?**
This study will take approximately 20 minutes of your time. You will be asked to complete a survey that will focus on your cannabis use and various aspects of your mental health.

**WHAT WILL I GET IN RETURN?**
As a thank you for participating in important research, each participant will receive a **$5 Tim Horton's gift card**! Your responses will be kept confidential and anonymous.

**HOW DO I PARTICIPATE?**
The researcher will be coming to this location weekly. Please ask your care provider or email cannabisunb@outlook.com for information about when you can participate!

## You MUST be a past-year cannabis user to participate!

Appendix L

Consent Form: Paper Copy

**INFORMED CONSENT**

**Title of the study:** Cannabis Use Problems: Who is at Risk and Why? The Identification of Markers

**Investigator:** Brittany Skelding (Masters Graduate Student), brittany.skelding@unb.ca

**Supervisor:** Dr. Caroline Brunelle, cbrunell@unb.ca

Please read the following information carefully before agreeing to participate in this research study.

This study is being conducted to examine the relationship between demographic factors, cannabis use practices, polysubstance use, and mental health problems and cannabis use-related outcomes. The goal of the current study is to determine if groups of cannabis users emerge based on these factors. Should you agree to participate in the study, you will be given short questionnaires to complete, which will measure cannabis use and practices, various mental health symptoms (e.g., anxiety, depression, impulsivity), and extent of use for various other substances.

Your participation in this study is voluntary. Should you wish to withdraw from the study at any point, you are free to do so. The study will take approximately 20 minutes to complete. Any information provided by you throughout the study will be strictly confidential. To ensure confidentiality, questionnaires will be identified by a number that will in no way be linked to any identifying information. The documents will be locked in the primary researcher's laboratory (restricted access) for seven years and will then be securely destroyed. Any information that you provide will be kept with the documents of other participants and will only be used for the purpose of this study. No individuals will be singled out or identified in this study.

Participants will be given a $5 Tim Hortons gift card upon completion of the study in exchange for their participation.

You are free not to answer question(s) on any questionnaire(s) that you feel is upsetting. You may discontinue your participation in the study at any time without penalty.

This study is being conducted by Brittany Skelding (brittany.skelding@unb.ca) under the supervision of Dr. Caroline Brunelle (506-648-5797, cbrunell@unb.ca), in the Psychology Department at the University of New Brunswick, Saint John.

I_____ (please print name), agree to participate in this study in exchange for class credit, and I give my consent to use the information I provide for the purpose of this study.

_____ (Signature) Date: _____

Note: If you wish to be notified of the results when the study is completed, please email the investigator of this study at cannabisunb@outlook.com at your convenience.

Participants who wish to discuss this study with someone who is not directly involved in the research can contact the chair of the ethics committee at the University of New Brunswick, Beth Keyes, at (506) 648-5949, REB@unbsj.ca

**Curriculum Vitae**

**Candidate's Full Name**: Brittany Skelding

**Universities Attended:** University of New Brunswick (Saint John), 2014-2018, BA(Hons)
University of New Brunswick (Saint John), 2018-2020, M.A. Candidate

**Conference Presentations:**
Lillian MacNeill, **Brittany Skelding,** Caroline Brunelle (November 20th 2018). *Client Characteristics and Outcomes in Methadone Maintenance Therapy (MMT) in Saint John, New Brunswick.* Poster presentation at the Canadian Research Initiative in Substance Misuse (CRISM) Atlantic Symposium, Moncton, NB.

**Brittany Skelding,** Caroline Brunelle (May 31st 2019). *The Impact of Early Life Experiences and Attachment on Alcohol Misuse in University Students.* Gimmie-5 at the 80th Canadian Psychological Association (CPA) National Convention, Halifax, NS.

**Brittany Skelding,** Caroline Brunelle, Lillian MacNeill (October 24th 2019)**.** *Cannabis and Harm Reduction: Knowledge of Lower Risk Cannabis Use Guidelines and Risky Cannabis Use Practices.* Poster presentation at the Canadian Society of Addiction Medicine Annual Meeting and Scientific Conference, Halifax, NS.

**Brittany Skelding**, Caroline Brunelle, Lillian MacNeill. (November 6th 2019). Cannabis and harm reduction: Beliefs regarding the lower risk cannabis use guidelines and risky cannabis use practices. Poster presentation at the Canadian Research Initiative in Substance Misuse (CRISM) Atlantic Symposium, Charlottetown, PEI.

**Brittany Skelding**, David Speed, Caroline Brunelle. (June 2020). *Understanding the link between trauma & problematic substance use: Does diagnosis trump experience?* Poster presentation at the Atlantic Health Exploration and Discovery Collaborative Health Research Week 2020 (virtual conference), Saint John, New Brunswick.

**Brittany Skelding**, David Speed. (June 2020). *Differences in sexual health between individuals who engage in non-heteronormative versus exclusively heterosexual sexual activity.* Poster presentation at the Atlantic Health Exploration and Discovery Collaborative Health Research Week 2020 (virtual conference), Saint John, New Brunswick.

Lillian MacNeill, Alison Luke, Shelley Doucet, **Brittany Skelding.** (June 2020). *Evaluating the implementation of a pediatric patient-navigation centre in Atlantic Canada: Preliminary results*. Poster presentation at the Atlantic Health

Exploration and Discovery Collaborative Health Research Week 2020 (virtual conference), Saint John, New Brunswick.

**Brittany Skelding**, David Speed, Caroline Brunelle. (2020, May 27-30). *Understanding the link between trauma & problematic substance use: Does diagnosis trump experience?* Gimmie-5 presentation at the 81st Canadian Psychological Association (CPA) National Convention, Montreal, Québec. (Conference cancelled due to Covid-19).

**Publications:**

MacNeill, L., Brunelle, C., DiTommaso, E., **Skelding, B.** (2019). Client Characteristics and Substance Use Patterns in Different Models of Methadone Maintenance Therapy (MMT). *Journal of Substance Use,* 1-5. doi:10.1080/14659891.2019.1704083.

MacNeill, L., Brunelle, C., **Skelding, B.,** DiTommaso, E. (2020). The experiences of clients in three types of methadone maintenance therapy in an Atlantic Canadian city: A qualitative study. *Canadian Journal of Nursing Research*, 1-11. doi:10.1177/0844562120924516.

**Academic Awards:**

School of Graduate Studies Travel Award (Two valued at $100 each; 2019)
New Brunswick Innovation Foundation Award ($7,000; 2018-2019)
Board of Governors Merit Awards for Graduate Studies ($3,000; 2018-2019)
Social Sciences and Humanities Research Council Award ($17,500; 2018-2019)
Knights Academic Bursary (Five valued at $300 each; 2015, 2016, 2017, 2018, 2019)
Bernice Alderman Memorial Prize in Psychology ($150; 2018)
Peter McGahan Memorial Scholarship ($2,750; 2017-2018)
Dr. Ann Gorman Condon Memorial Scholarship ($1,500; 2017-2018)
UNB Saint John Campus Scholarship ($1,750; 2017-2018)
PepsiCo Foundation ExCEL Award Program Scholarship ($2,500; 2017)
Dr. Collin B. Mackay Scholarship ($3,100; 2016-2017)
Alan B. McLean and Joyce E. McLean Scholarship ($900; 2016-2017)
Academic Bursary Saint-Francois-de-Sales (Two valued at $500 each; 2015, 2016)
Governor Thomas Carleton Scholarship ($1,000; 2014-2015)