# EXAMINATION OF CANNABIS USE PATTERNS, HEAVY USER CHARACTERISTICS, AND CANNABIS-RELATED HARMS: RESULTS FROM 2012–2013 US NATIONAL CROSS-SECTIONAL SURVEY DATA

by

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**Abstract**

This thesis aimed to examine cannabis use patterns by quantity in the United States, identify key characteristics of the heaviest cannabis users, and conduct an initial assessment of whether the prevention paradox may hold for cannabis use in the United States. Using data from the National Epidemiologic Survey on Alcohol and Related Conditions – III, findings suggest that a small portion of the cannabis-using population consumes the majority of the yearly cannabis supply in the United States. Characteristics that affect the odds of being a heavy cannabis user include age, sex, personal income, education level, age of initiation, and the presence of a cannabis use or nicotine use disorder. A larger absolute number of cases experience cannabis-related harms in the low-to-moderate-using group compared to the heaviest-using group. However, a higher percentage of heavy cannabis users experience cannabis-related harms. Therefore, a dual-pronged approach of both targeted and population-based strategies may be appropriate.

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# Chapter 1

## Introduction

Public health–directed cannabis policies not only require a detailed understanding of the distribution of cannabis use and related harms within the population, but also a comprehensive understanding of the cannabis users most at risk for cannabis-related harms. The strongest evidence supporting harms associated with cannabis use include motor-vehicle accidents, negative impacts on brain development, psychosis, acute cognitive and psychomotor impairments, and pulmonary issues (Broyd et al., 2016; Gunn et al., 2016; Marconi et al., 2016; National Academies of Sciences, Engineering, and Medicine, 2017; Rogeberg & Elvik, 2016). Cannabis use in adolescents has been shown to impair brain development, which negatively affects IQ and cognitive functioning (Camchong et al., 2017), and increases behavioural impulsivity (Gruber et al., 2014) and psychiatric disturbances (Schlossarek et al., 2016; Semple et al., 2005). Additionally, early-onset dependent users have been shown to have poorer attention, memory, and executive functioning (Fontes et al., 2011; Solowij et al., 2011).

Systematic reviews have suggested that there is an association between frequency or intensity of cannabis use and adverse health outcomes, including mental health and cardiovascular adverse health outcomes (Gibbs et al., 2015; Hall & Degenhardt, 2009; Marconi et al., 2016; Reece, 2009; Wang et al., 2013). In 2015, it was reported that 8.3% of the American population 12 years and older had used cannabis in the past month, with an increase since 2002 in past-month cannabis use in all age categories except 12-to-17-year-olds (Central for Behavioral Health Statistics and Quality [CBHSQ], 2016a). In addition, the heaviest-using group (daily or nearly daily use) has grown from 1 in 9 in 1992 to 1 in 3 in

2014, indicating an increase in intensity of use among existing users (National Academies of Sciences, Engineering, and Medicine, 2017). Given that the heaviest-using group in the population is expanding, it is crucial to understand what individual characteristics may predict heavy cannabis use to effectively develop targeted reduction and prevention strategies.

Understanding the general distribution of cannabis use within a population is essential for developing high-risk-focused and population-based reduction and prevention strategies and may provide insights into where cannabis-related harms may be positioned within the population. For example, if cannabis use patterns reveal that a small number of individuals consumed the majority of the cannabis per year, then developing targeted policies toward this small heavy-using group may be required. Distribution data may also demonstrate that the majority of cannabis-related harms fall in the low-to-moderate-using groups due to large absolute numbers, a phenomenon known as the prevention paradox. In this case, population-based policies may also be required.

This study used data from the National Epidemiologic Survey on Alcohol and Related Conditions-III (NESARC-III) and quantitative methods to (a) examine cannabis use patterns by quantity in the United States, (b) identify key characteristics of individuals in the heaviest-using group, and (c) conduct an initial assessment on whether the prevention paradox may hold in the context of cannabis use in the United States.

This thesis is composed of eight chapters beginning with an introduction and a literature review. Chapter 3 will describe the overall study methodology, while chapters 4 – 6 will describe the methodology, results, and interpretation of each study individually. Chapter 7 will discuss study implication, while Chapter 8 will highlight study strengths.

# Chapter 2

# Literature Review

## Lessons From Alcohol Use Distribution Patterns and Policy Development

The previous knowledge attained regarding alcohol consumption trends, use patterns, health outcomes, and policy development approaches may inform cannabis harm reduction and prevention strategies. Thus, it is important to have an understanding of historical alcohol-related literature and early public discourses in relation to alcoholism, alcoholism-related harms, and a phenomenon called the prevention paradox.

In the United States, the top 2.5% of drinkers drink 25%–27% of the total alcohol consumed by volume per year, and the top 5% drink on average 39%–42% of the total alcohol consumed per year (Greenfield & Rogers, 1999). In Brazil, it appears that the distribution of alcohol consumption may be slightly less concentrated in the top 2.5% of drinkers, with the top 2.5% of consumers drinking 14.9% of total alcohol consumed by volume per year, and the top 5% of consumers drinking 27.4% of total alcohol consumed by volume per year (Caetano et al., 2012). In addition, it has been demonstrated that as consumption increases in a population, so does consumption in the heaviest-drinking group (Skog, 1985). This increase in consumption leads to an increase in alcohol-related harms (Skog, 1985). When reflecting on alcohol consumption research, does the distribution of cannabis use within the population follow a similar pattern to alcohol? What population is best to focus on in terms of reduction and prevention policy development, the small heaviest-using group or the large light-to-moderate-using group? Similar questions have been asked throughout the history of alcohol policy development, and thus may provide insights and learning opportunities for cannabis policy approaches. Alcohol use policies have focused on

both the heaviest-using and the low-to-moderate-using groups with continuous debate on best approaches and whether the prevention paradox holds true.

In the infancy of addiction studies, the primary focus was on harms associated with alcoholism, and more specifically individuals with alcohol use disorders. Consequentially, the public's perception grew to perceive that a population's alcohol-related negative impacts were primarily within this subpopulation of heavy users, including the harms present from alcohol use in the general population (Brunn et al., 1975; Kreitman, 1986; Stockwell & Giesbrecht, 2013). Even in the 1950s, as rates of alcoholism rose, the issue was dealt with at an individual level with treatment, rather than being considered a public health concern (Thom & Berridge, 1995). In the 1980s, a U.K. Government published a document called "Drinking Sensibly" and stated that alcohol was harmless for the majority of drinkers. It was the minority of "misusers" that could cause harm to themselves and to the public (Department of Health and Social Security, 1981; Kreitman, 1986). The "misusers" were often identified by focusing on individuals at risk of alcohol-related harms on account of high consumption (Kreitman, 1986). The "Drinking Sensibly" report focused on self-governance and encouraged individuals to be responsible, drink sensibly, and manage their own risks associated with drinking. Consequentially, this placed increased responsibility on dealing with harms and ill-health on the individual rather than the government or the healthcare system (Department of Health and Social Security, 1981).

In the mid-1970s and early-1980s, researchers began to focus more broadly on alcohol-related harms and examine whether alcohol-related harms may occur in other groups of the population. Research found that alcohol-related harms were experienced in the low-to-moderate alcohol users. A more surprising finding was that most of the alcohol-related

burden on the population was, in fact, due to alcohol-related harms experienced by the low-to-moderate group as opposed to the high-risk individuals living in marginalized environments (Kreitman, 1986). This observation was termed a "paradox" because of the historical early alcohol literature, which focused primarily on the small subpopulation of marginalized individuals living with alcohol use disorders. Following the findings that a large burden of alcohol-related harms might occur in low-to-moderate drinkers, researchers began to investigate how targeted and population-based strategies may address, reduce, or prevent alcohol-related harms in society.

In 1975, the "purple book" was published advocating for a public health approach to control alcohol consumption and harms (Brunn et al., 1975). This report stated that population changes in alcohol consumption have an impact on the health of individuals in that community and therefore alcohol availability and control measures are a public health issue (Brunn et al., 1975). Six years later, Rose (1981) provided further evidence supporting a public health approach for the management of certain diseases. Rose argued that most disease (or harms) is experienced by individuals in the low-risk group as opposed to the high-risk group simply because there are greater numbers if individuals within the low-risk group. Therefore, it is necessary to target the whole population in order to prevent disease (or harms), not just the high-risk group (Rose, 1981). This study demonstrated that reducing cholesterol levels in the entire population as opposed to only in members in the high-risk group would be a more effective strategy in reducing the overall incidence of coronary heart disease. A population-based strategy would be more effective because the low-to-moderate risk group had higher absolute numbers than the high-risk group alone. Therefore, a reduction in the low-to-moderate group had a greater impact in reducing overall coronary

heart disease incidence rate (Rose, 1981). This phenomenon was termed the prevention paradox.

This population-based approach was later demonstrated in the context of alcohol by Kreitman (1986). Kreitman examined the results of three surveys reporting on alcohol consumption and alcohol-related harms and demonstrated that there was a greater frequency in absolute numbers of alcohol-related harms in people categorized as low-risk drinkers (Kreitman, 1986). Kreitman believed there was evidence that the prevention paradox may apply to alcohol and suggested an alternative approach towards preventative strategies. Kreitman argued for the consideration of developing programs that target small reductions in alcohol consumption for the whole population (Kreitman, 1986). Two contrasting strategies emerged: high-risk strategies targeting high-risk drinkers, and population-based strategies targeting the entire population's consumption level. High-risk strategies include policies that target (a) drinking and driving, (b) promoting behaviour change through education, and (c) increased access to intervention and treatment programs (Stockwell & Giesbrecht, 2013). Population-level strategies include policies that target: (a) alcohol marketing, (b) alcohol pricing, (c) purchasing availability via drinking age limit-setting and retail store hours of operation, and (d) alcohol control system regulation and monitoring (Stockwell & Giesbrecht, 2013).

## Criticisms of the Prevention Paradox

### *Prevention Paradox May Not Hold in All Scenarios*

In 1996, Stockwell et al. argued that the prevention paradox is not an ideal platform from which to base, create, and recommend policies. Stockwell et al. (1996) compared Kreitman's (1986) data with data from an Australian survey to demonstrate that the

prevention paradox disappears for binge-drinking if taking into account the amount of alcohol consumed on either (a) the heaviest drinking day in the past 4 days, or (b) when alcohol-related harms occurred (Stockwell et al., 1996). The study found that though participants with low average consumption experienced only 60% of the alcohol-related harms, 84% of those participants were considered high-risk when examining intake on heaviest-drinking days (Stockwell et al., 1996). Subsequently, Skog (1999a) would describe this as a second-order prevention paradox, meaning that the majority of high-risk binge drinkers fall under the low-to-moderate average consumption groups and also account for the majority of alcohol-related problems among binge drinkers.

### *Survey Bias May Affect the Validity of the Prevention Paradox*

Skog (1999b) explored the possibility that survey data may bias estimates and that the influence or role attributed to the heaviest drinkers may be underestimated. Skog highlighted that survey data typically suffered from limitations that may bias estimates. First, severity of a harm is positively correlated with consumption, but the severity of an accident, event, or symptom is often not recorded in the survey, which potentially exaggerates the representational strength of light-to-moderate drinkers and underestimates the degree of harms among heavy drinkers (Skog, 1999b). Second, surveys typically do not document how often the participant has experienced the alcohol-related problem in question nor collect data related to lifetime experience harms, which further exaggerates the representational strength of light-to-moderate drinkers. Third, the response rate is disproportionate among user types, with the heaviest users typically participating less often, making them underrepresented (Skog, 1999b).

Using linear and convex risk function calculations, Skog (1999b) demonstrated that

the prevention paradox was a real phenomenon, but only in alcohol-related harms with reduced curved risk functions, meaning the risk grew slowly at low and high consumption levels. Skog demonstrated that the majority of cases that had alcohol-related harms with strongly curved risk functions were within the heaviest drinkers. Therefore, the prevention paradox could not apply because the heavy drinkers, not low-to-moderate drinkers, contributed the majority of cases. Skog concluded that though there are some alcohol-related harms in which the risk functions are minimally curved and the prevention paradox may apply, the relative importance of these scenarios is unknown. Therefore, prevention efforts should not focus primarily on alcohol-related harms related to drunkenness as it is unclear whether most alcohol-related harms are due to drunkenness (Skog, 1999b).

***Prevention Paradox May Not Inform Direction of Population-Based Reduction Strategies***

To further explore the findings of Kreitman (1986), Stockwell et al. (1996), and Skog (1999b), Gmel et al. (2001) examined why low-risk drinkers, both in average consumption and binge-drinking patterns, report high numbers of alcohol-related harms. The study surveyed 1,256 drinkers using the 1998 baseline survey conducted by the Swiss Institute for the Prevention of Alcohol and other Drug Problems (Gmel et al., 2001). Daily average cut-off points were calculated and set to 20 g (two standard drinks) for women and 30 g (three standard drinks) for men. Additionally, binge drinking limits were defined as consuming four or more drinks on one occasion for women and five or more drinks on one occasion for men. The study grouped participants into three main categories: (a) moderate with no binge drinking, (b) hazardous with no binge drinking, and (c) hazardous with binge drinking (Gmel et al., 2001). Six alcohol-related consequences (work problems, accidents, problems with police, friends, partners, and family members) were selected to construct a severity scale

using structural equation modelling. Additionally, motivational stages of changes were assigned to drinkers using exploratory factor analysis. The researchers hypothesized that most reported problems of low-risk drinkers occurred during the motivational (pre-contemplative) stage, meaning the stage when they were not concerned about their drinking habits (Gmel et al., 2001).

Gmel et al.'s (2001) three main findings coincided with Kreitman (1986), Stockwell et al. (1996), and Skog (1999b). Gmel et al.'s study found that volume-based moderate drinkers reported more problems than did hazardous drinkers, confirming Kreitman's (1986) findings (Gmel et al., 2001). Second, binge drinkers reported more problems compared to non-binge drinkers, suggesting that binge drinking is a better predictor for alcohol-related harm than volume-based consumption, aligning with findings by Stockwell et al. (1996) (Gmel et al., 2001). Third, there was a higher frequency of binge drinkers in the moderate group when examining their annual alcohol intake, confirming findings by Skog (1999b) (Gmel et al., 2001). The study concluded that the main target for harm prevention programs should continue to be population-based because most of the binge-drinkers fall within the moderate group; however, it is unclear whether a population-based strategy should be directed at mean consumption or binge drinking patterns (Gmel et al., 2001).

### *Frequency of Intoxication May Affect Validity of the Prevention Paradox*

Following Gmel et al.'s (2001) publication, Rossow and Romelsjo (2006) attempted to assess the degree of impact that high-risk drinking criteria and subpopulations with different drinking patterns have on the prevention paradox. Using one dataset from two combined national surveys and a dataset from inpatient hospital data, the study assessed the prevention paradox's validity by examining harms typically related to acute intoxication

(Rossow & Romelsjo, 2006). High-risk groups were defined as the upper 10% of drinkers in terms of annual alcohol volume consumption or by the number of intoxications annually. These two high-risk groups were combined, and three risk subgroups were identified: (a) high risk by volume and low risk by intoxication frequency, (b) low risk by volume and high risk by intoxication, and (c) high risk by volume and high risk by intoxication. Acute alcohol-related harms examined included fights, hospital admissions for attempted suicide, and hospital admissions for violent injuries (Rossow & Romelsjo, 2006).

Rossow and Romelsjo (2006) confirmed that the majority of acute alcohol-related problems are found in the low-to-moderate risk groups. However, if using frequency of intoxication rather than annual drinking volume as the determinant for high-risk grouping, a larger proportion of acute alcohol-related problems were found in the high-risk group, and the number of alcohol-related harms was more evenly distributed. The study concluded that the prevention paradox may have stronger validity in subpopulations or cultures where intoxication is common (Rossow & Romelsjo, 2006).

During the same year, Skog (2006) submitted an editorial presenting three issues that needed further investigation: (a) the validity of empirical observations from previous studies, (b) implications for prevention; and (c) the effect that drinking cultures may have on results. Skog proposed a dual-pronged approach, applying both targeted and population strategies for prevention. In addition, Skog argued for the need to apply measures that target drinking patterns as well as consumption level (intake per year) and drinking contexts (Skog, 2006).

### *Self-Reported Data Versus Hospitalization Data*

Poikolainen et al. (2007) attempted to address the limitations of studies using self-reported harms by examining harm indicators from hospital admissions and alcohol-related

death data. The study pooled data from four surveys that examined alcohol-related hospital admissions, alcohol-related deaths, and self-reported problems. The highest risk group was determined using annual average alcohol consumption (Poikolainen et al., 2007). The distribution of various alcohol-related harms between light-to-moderate drinkers and heavy drinkers was examined.

Similar to previous studies, Poikolainen et al. (2007) found that the majority of alcohol-related problems were found among the low-to-moderate risk group. This low-to-moderate risk group was responsible for 70% of self-reported alcohol-related problems, 70% of alcohol-related hospitalizations, 64% of premature life-years lost before age 65 years old, and 64% of alcohol-related deaths for men, and 64%, 60%, 98%, and 93% respectively for women (Poikolainen et al., 2007). The study demonstrated that the prevention paradox could apply to both self-reported data as well as hospitalization and death data. Therefore, findings could not be dismissed as response bias (Poikolainen et al., 2007). The authors concluded that drinking patterns should be an important consideration when discussing prevention strategies, posing a question similar to Skog's (2006): How does one change a drinking culture that favors binge drinking (Poikolainen et al., 2007; Skog, 2006)?

### *Drinking Culture's Impact on the Prevention Paradox*

In alignment with the question posed above, a Brazilian study (Caetano et al., 2012) examined prevention paradox validity in a nation with a different drinking culture than North America. The authors described the Brazilian drinking culture as having a high abstention rate in addition to having a high rate of binge drinking. Using the Brazilian National Alcohol Survey (BNAS) and multi-stage sampling, the study measured the average number of drinks per year, frequency of binge drinking in past year, alcohol-related problems in the previous

year, and drinker classification (low-risk, moderate-risk, and high-risk drinking patterns) (Caetano et al., 2012). The study found that the top 2.5% of drinkers consumed 14.9% by volume of annual alcohol, while the top 5% of drinkers consumed 27.4%. When categorized by weekly volumetric intake, low-to-moderate individuals accounted for 45%–47% of all alcohol-related problems (Caetano et al., 2012). Additionally, binge drinkers with the lowest annual volumes consumed accounted for 35% of all social alcohol-related problems.

Using multiple logistic regression, the study found that both binge drinking (*OR* = 3.3; 95% CI = 1.4, 7.4) and volume consumed (*OR* = 1.07; 95% CI = 1.05, 1.08) were independently associated with social alcohol-related problems (Caetano et al., 2012). The study findings were consistent with findings among other cultures, suggesting that culture may not play a strong role in the prevention paradox. The study concluded that Brazilian policies should target the entire population, focusing on low-to-moderate drinkers in addition to binge drinkers (Caetano et al., 2012).

***Prevention Paradox and Youth***

A final publication contributing to alcohol policy development history and the prevention paradox literature is a study by Romelsjo and Danielsson (2012), which attempted to determine the validity of the prevention paradox in relation to annual alcohol consumption, binge-drinking, and alcohol-related problems in youth. The study included 7,288 adolescents, 13–17 years of age using data from the annual school-based nation Swedish survey (Romelsjo & Danielsson, 2012). Two measurements were taken of alcohol use: (a) annual alcohol intake, and (b) frequency of drinking over the last 12 months.

Similar to other studies, the study found that the majority of participants with alcohol-related problems belonged to the bottom 90% of annual-intake consumers (Romelsjo &

Danielsson, 2012). However, the study reported that participants who were (a) in the 17-year-old age group, (b) reported monthly binge-drinking, and (c) fell within the bottom 90% of annual-intake consumption accounted for greater than 50% of alcohol-related problems. Romelsjo and Danielsson (2012) concluded that the prevention paradox applies to adolescents greater than 15 years old.

**Distribution of Cannabis Use**

To reduce cannabis-related harms in a population, understanding the distribution of cannabis use within the population is crucial. A recent publication by Callaghan et al. (2019) examined the distribution of cannabis consumption to evaluate whether population-level consumption patterns were similar to distribution patterns reported in the alcohol literature. Using pooled data from wave 1–3 of the National Cannabis Survey in Canada, the study assessed cannabis consumption from all product types, including edibles. Using the self-reported quantity values, the study created conversion metrics to convert non-flower cannabis products into a standard joint equivalent. The study's findings aligned with previous alcohol literature, with the top 10% of cannabis users consuming approximately 65.5% of cannabis consumed in the country. In addition, they found that males self-reported consuming more than females (60% vs. 40%), and the 15–34 years of age group consumed a greater volume (roughly 55%) than all other ages (Callaghan et al., 2019).

**Current Gaps in Cannabis Research**

From the history of alcohol policy development and the prevention paradox literature, it can be concluded that, though it appears that the prevention paradox may exist and population-based policies may be effective at reducing alcohol consumption and alcohol-related harms, consideration should be given to targeted policy development for high-risk

drinking patterns, such as binge drinking (Caetano et al., 2012; Gmel et al., 2001; & Poikolainen et al., 2007). Applying this knowledge to cannabis, there are still many unanswered questions.

### *Evaluation of Cannabis-Related Harms*

Where do the majority of cannabis-related harms lie within the population? What indicators are best to evaluate cannabis-related harms? Alcohol-related mortality and morbidity indicators can be applied in alcohol-related harms research, such as alcoholic liver cirrhosis. However, there are no established cannabis-related mortality and morbidity indicators, making it difficult to standardize the evaluation of cannabis-related harms (Hall & Swift, 2000).

### *Measures to Examine Cannabis Use*

What is the best way to measure cannabis use: frequency, volume, or potency? Currently, the majority of literature related to the distribution of cannabis use evaluates frequency as opposed to volume or potency (Casajuana et al., 2016). In addition, consistency is lacking with regard to terminology and what is considered a heavy user versus moderate or light user. Standard definitions are lacking for the terminology "risky/hazardous" user and "problematic/harmful" user.

A systematic review by Casajuana et al. (2016) highlighted the need for standardized terminology when considering frequency, pattern, duration, potency, and volume. Of 1,582 publications, 46 were included in their search. Twenty-one articles used frequency to define risky/hazardous and problematic use, while only six articles combined a time frame with frequency. No article included in the review had information on the dose or quantity of cannabis consumed. The systematic review found that the majority of studies defined risky /

high risk as daily or almost every day, while problematic/harmful use was less clearly defined. Casajuana et al. (2016) made the following recommendations:

1. Provide a quantitative definition for risky/hazardous cannabis use. This definition should include a daily to weekly dose threshold, the timeframe of use, and special population recommendations, such as for pregnant women.
2. Provide a qualitative definition for problematic/harmful cannabis use. This definition should include cannabis-related consequences and timeframe of use.
3. Describe cannabis use patterns according to frequency and quantity. More specifically, potency should be included.

***Public Policies Approaches***

What would be the best approach for cannabis public policies: risk-based or population-based? If low-to-moderate users were the main target for reduction and prevention strategies, what negative impact might that have on heavy cannabis users? Strictly targeting low-to-moderate users may exclude a proportion of users that, though they may be fewer in absolute numbers, may have greater health risks and may present stronger negative impacts on the health care system. Ultimately, should cannabis reduction strategies have a dual-pronged approach similar to the one described by Skog (2006)?

To address the knowledge gaps listed above and to inform best approaches for cannabis public health policy development, it is crucial to (a) understand the distribution of cannabis use within the population, (b) understand the characteristics of different user groups, and (c) determine if the prevention paradox holds.

# Chapter 3

# Data Source and Methodology

## Data Source

This study used the National Epidemiologic Survey on Alcohol and Related Conditions-III (NESARC-III). The NESARC-III is a cross-sectional survey that collected information on alcohol and drug use, associated risk variables, and physical and mental health information from 2012 to 2013. The final sample size of this survey was 36,309 (Grant et al., 2014). The sample included U.S. civilians aged 18 years or older, but excluded individuals who were institutionalized or homeless at the time of the survey, and individuals who lived in remote locations in Alaska and Hawaii (Grant et al., 2014).

Primary sampling units selected included individual counties or groups of neighboring counties, while secondary sampling units consisted of groups of U.S. Census-defined blocks and tertiary sampling units consisted of households within the secondary sampling units (Grant et al., 2014). The final step of sample selection included random sampling of adults within sampled households. Two respondents per household were selected when households had at least four eligible individuals who were of ethnic or racial minority. Hispanic, Black, and Asian respondents were oversampled. The total response rate was 60.1%, with a screener and person-level response rate of 72.0% and 84.0%, respectively (Grant et al., 2014).

NESARC-III data were adjusted for oversampling and nonresponse, and weighted through post-stratification analysis. The first step in weighting was to assign weights within each dwelling unit (DU). This DU weight was equal to the inverse of the overall probability of selection, and was an intermediate weight used to calculate the individual-level weights.

Individual-level weights were calculated from a set of nonresponse-adjusted DU weights. Final individual-level weights included the following: (a) assigning initial individual weight to reflect the probability of selecting the individual for the study; (b) adjusting initial individual-level weight to compensate for nonresponse to the AUDADIS-5 interview; and (c) post-stratification of nonresponse-adjusted individual weights to population counts using 2012 American Community Survey data (Grant et al., 2014).

NESARC-III data were partially collected prior to the legalization of recreational marijuana in some states. Prior to 2012, medical marijuana was legal in a minority of states, but recreational marijuana was illegal. In 2012, both Colorado and Washington legalized recreational marijuana. As of 2020, 11 additional states had legalized recreational marijuana: Oregon, California, Nevada, Alaska, Arizona, Montana, South Dakota, Illinois, Michigan, Vermont, Massachusetts, and Maine (ProCon, 2020).

The NESARC-III survey was chosen as this study's dataset instead of a Canadian survey for the following reasons:

1. NESARC-III data provided information on the quantity of cannabis use, as well as frequency of use. Only a limited number of population-based studies currently examine cannabis use in terms of quantity.
2. NESARC-III contained questions about DSM-5 psychiatric diagnoses and allowed examination of relationships between psychiatric disorders and cannabis use. This is an important consideration as research has shown that the population of cannabis users with a psychiatric disorder consumes a large majority of the yearly cannabis supply (Lev-Ran, et al., 2013).
3. To provide an initial assessment of the potential validity of the prevention paradox, it

was necessary to examine cannabis-related harms. NESARC-III contained questions on a range of cannabis-related harms, such as driving under the influence of cannabis.

**Methodology**

Descriptive analytics, cross-tabulation analysis, and logistic regression were conducted to answer the three studies. R-studio version 1.1.463 was used for statistical analysis (RStudio Team, 2020). The following three chapters will provide additional detailed information on each research study. Each chapter will include an introduction, methodology, results, and interpretation section for each study.

# Chapter 4

## Study 1

### Introduction

Limited literature exists on the distribution of cannabis use in terms of quantity (Casajuana et al., 2016). A Canadian study (Callaghan et al., 2019) evaluated whether population-level cannabis consumption patterns aligned with the alcohol literature. They found that, similarly to alcohol use, the top 10% of cannabis users consumed approximately 65.5% of the Canadian cannabis supply (Callaghan et al., 2019).

Study 1 attempted to replicate and extend components of Greenfield and Rogers' (1999) study on the distribution of alcohol consumption in the context of cannabis by asking the question: What are the distribution patterns of cannabis consumption in the United States?

### Methodology

#### *Data Source*

This study used the National Epidemiologic Survey on Alcohol and Related Conditions-III (NESARC-III). Please see Chapter 3 (p. 15) for a detailed description of the data source.

#### *Sample*

The sample cohort consisted of all NESARC-III survey participants who used cannabis in the past 12 months. Individuals who had not used cannabis in the past 12 months were excluded from the study. The final sample size was 3,586.

#### *Primary Outcome Variables*

Using the NESARC-III survey questions N3BQ3 and N3BD3Q2C, this study

examined cannabis use patterns and categorized participants into user groups by quantity (number of joints smoked per year - weighted). Variable N3BQ3 corresponded to the question: "On the days that you used marijuana in the last 12 months, about how many joints did you usually smoke in a single day?" Variable N3BD3Q2C corresponded to the question: "How often did you use marijuana in the last 12 months?" The number of joints smoked in a day over the past 12 months (N3BQ3) ranged from 1 to 30 joints per day, with 2137 (59.6%) participants smoking on average one joint per day and 297 (8.3%) participants smoking 5+ joints per day. The frequency of marijuana use in the last 12 months (N3BD3Q2C) ranged from once in the last year to every day, with 516 (14.4%) participants smoking two times per year or less and 712 (19.9%) participants smoking daily.

In addition to the primary outcome variable, the study defined a heaviest-using group and a low-to-moderate-using group. The heaviest-using group was defined as the top 10% of users. The top 10% of users was selected as the heaviest-using group to align with previous alcohol-distribution literature. Both Greenfield and Rogers (1999) and Caetano et al. (2012) described the distribution of alcohol consumption in the top 2.5%, top 5%, and top 10%. Greenfield and Rogers (1999) described policy implications in relation to health risks, which they determined should focus on the top 5%. Caetano et al. (2012) took a different approach and defined drinkers by risk, with "high-risk" drinkers drinking above the threshold of the NIAAA risky drinking guidelines and falling within the top 10% volume distribution. Kerr and Greenfield (2007) examined alcohol use distributions and alcohol expenditures to observe the degree to which heavy users may avoid spending to attain their alcohol. Their study found that the top 10% consumed 55.3% of the total alcohol per year and accounted for 33% of the expenditures. The top 5% consumed 40% of the total alcohol per year and spent

24% of the total expenditures (Kerr & Greenfield, 2007). This study did not explicitly categorize what should be considered in the heavy user group, but concluded that the top 10% use different strategies to spend less. As such, taxes and minimum price restrictions may be effective strategies for this group (Kerr & Greenfield, 2007).

***Analytical Plan***

The following steps were conducted to answer Study 1:

1. Identify/select the participants who have used recreational and/or medicinal cannabis in the past 12 months. Individuals who have not used cannabis in the past 12 months were excluded from the study.
2. Categorize participants by the number of joints smoked in the last 12 months (N3BQ3), then multiply by how often they used marijuana in the last 12 months (N3BD3Q2C).
3. N3BD3Q2C responses corresponded to the following categories for multiplication:

    a) "1" = every day → x 365
    b) "2" = almost every day → x 312 (6*52)
    c) "3" = 3 to 4/week → x 182 (3.5*52)
    d) "4" = 1 to 2/week → (1.5*52)
    e) "5" = 2 to 3/month → (2.5*12)
    f) "6" = 1/month → x12
    g) "7" = 7 to 11/year → x9
    h) "8" = 3 to 6/year → x4.5
    i) "9"= 2/year → x2
    j) "10"= 1/year → 1

*Six participants had a response of "99" (unknown) and were removed.

4. Multiply the unweighted number of joints smoked per year from the previous calculation (N3BQ3*N3BD3Q2C) by the survey weight variable called AUDWEIGHT.
5. Rank participants from the least to most number of joints smoked per year (weighted)

6. Generate prevalence data by categorizing into top 2.5%, top 5%, top 10% etc.,

### *Research Ethics Board (REB) and Data Access*

The NESARC-III dataset was obtained through the NESARC application process. After applying to UNBC REB, it was deemed that the application did not need REB approval. See Appendix A for a copy of the NESARC application and UNBC REB submission.

## Results

### *Descriptive Characteristics*

Table 1 below presents the descriptive characteristics and demographic profile of past-year cannabis users. The sample consisted of 2,130 (59.4%) males and 1,456 (40.6%) females. Ages ranged from 18 to 81 years, with an average age of 35.1 years old. Grouped by ethnic categories, the sample included 1,861 (52.0%) non-Hispanic white, 943 (26.3%) Black/African American; 594 (16.6%) Hispanic; 96 (2.7%) Asian/ Native Hawaii/Pacific Islander; and 92 (2.6%) American Indian/ Alaska Native. Completion of high school was reported by 3,046 (84.9%) respondents. Approximately 2,070 (57.7%) respondents made less than $20,000 per year in personal income, while only 744 (20.7%) respondents made greater than $35,000 per year in personal income. Within the top 10% of users, there were 247 (69.0%) males and 111 females (31.0%). The majority of heavy users were 18–29 years of age (58.1%), white (52.8%), and made less than $20,000 per year in personal income (77.1%). The heavy-using group had fewer proportionally who reported an educational level of “some college or higher” than the total sample at 39.7% and 57.0%, respectively.

**Table 1**

*Demographic Profile of Total Sample and Heavy-Using Group (Top 10%)*

| Characteristic | Value | Heavy user, top 10% | Total sample |
|---|---|---|---|
| Sex | Male | 247 (69.0%) | 2,130 (59.4%) |
| | Female | 111 (31.0%) | 1,456 (40.6%) |
| Age | 18–29 years | 208 (58.1%) | 1,591 (44.4%) |
| | 30–44 years | 92 (25.7%) | 1,060 (29.6%) |
| | 45+ years | 58 (16.2%) | 935 (26.1%) |
| Ethnicity | White | 190 (52.8%) | 1,861 (52.0%) |
| | Black/African American | 104 (29.0%) | 943 (26.3%) |
| | American Indian/Alaska Native | 11 (3.1%) | 92 (2.6%) |
| | Asian/Native Hawaiian/Pacific Islander | 8 (2.3%) | 96 (2.7%) |
| | Hispanic | 45 (12.8%) | 594 (16.6%) |
| Education | Less than high school | 83 (23.2%) | 540 (15.1%) |
| | Completed high school | 133 (37.2%) | 1,001 (27.9%) |
| | Some college or higher | 142 (39.7%) | 2,045 (57.0%) |
| Personal Income | $ 0–19,999 | 276 (77.1%) | 2,070 (57.7%) |
| | $ 20,000–34,999 | 56 (15.6%) | 772 (21.5%) |
| | $ >35,000 | 26 (7.3%) | 744 (20.7%) |
| Psychiatric Disorder | Not present | 50 (14.0%) | 911 (25.4%) |
| | Present | 308 (86.0%) | 2,675 (74.6%) |
| N | | 358 | 3,586 |

### *Distribution of Cannabis Use*

This section describes the distribution of cannabis use within the sample, as well as application of post-stratification weights (AUDWEIGHT) to attain population estimates. Table 2 below presents the mean and cumulative proportions of cannabis consumption for the number of joints smoked per year. Regarding the distribution of cannabis use on a

sample-level, 90 respondents fell within the top 2.5% of users, smoking between 2 to 30 joints per day or 730–10,950 (unweighted) joints per year. When applying population weights, this is equivalent to 995,720 individuals who consumed 31.4% (95% CI = 28.2%, 35.5%) of the total joint supply within the population. This is followed by the top 5% of users consuming 45.1% (95% CI = 41.5%, 49.6%) of the total volume, and the top 10% of users accounting for 62.2% (95% CI = 58.3%, 67.2%) of the yearly joints consumed in the population.

**Table 2**

*Means and Cumulative Proportions of 12-month Cannabis Consumption Joints Smoked)*

| Number of joints smoked in past year at individual level (weighted) | Cumulative % of Users | Population | Mean number of joints consumed in 12 months at individual level (weighted) | Cumulative % consumption | 95% Confidence interval | % Subjects |
|---|---|---|---|---|---|---|
| 0.1–1.1 | 100% | 1 442 419 | 0.6 | 99.9% | 95.2%–100% | 10.0% |
| 1.1–2.7 | 90% | 2 241 984 | 1.8 | 99.8% | 95.2%–100% | 10.0% |
| 2.7–6.1 | 80% | 2 110 335 | 4.2 | 99.7% | 95.1%–100% | 10.0% |
| 6.1–14.1 | 70% | 2 390 928 | 9.4 | 99.5% | 94.9%–100% | 10.0% |
| 14.2–38.2 | 60% | 2 337 279 | 24.1 | 99.1% | 94.5%–100% | 10.0% |
| 38.3–84.9 | 50% | 1 893 612 | 59.6 | 98.1% | 93.5%–100% | 10.0% |
| 85.3–160.6 | 40% | 1 781 831 | 121.4 | 95.5% | 90.9%–100% | 10.0% |
| 161.0–289.0 | 30% | 1 890 673 | 218.4 | 90.2% | 85.7%–95.6% | 10.0% |
| 289.3–417.2 | 20% | 1 157 791 | 344.3 | 80.7% | 76.4%–85.9% | 5.0% |
| 417.4–598.2 | 15% | 1 269 582 | 501.3 | 73.1% | 69.0%–78.2% | 5.0% |
| 598.7–1037.5 | 10% | 1 345 165 | 788.7 | 62.2% | 58.3%–67.2% | 5.0% |
| 1038.9–1595.7 | 5% | 911 948 | 1264.7 | 45.1% | 41.5%–49.6% | 2.5% |
| 1614.8–8656 | 2.5% | 995 720 | 2886.5 | 31.4% | 28.2%–35.5% | 2.5% |

Figure 1 below presents the mean number of joints smoked per year across cumulative percentage of users, while Figure 2 displays the same information, but with population weights applied to demonstrate consumption volumes within the population. The top 10% of users consumed on average 788.7 joints per year at a sample level, or 7,887,279 joints per year on a population level.

**Figure 1**

*Cumulative Distribution: Mean Number of Joints Smoked per Year Across Cannabis-Using Groups at the Sample Level, From Heaviest-Using (far left) to Lightest-Using (far right).*

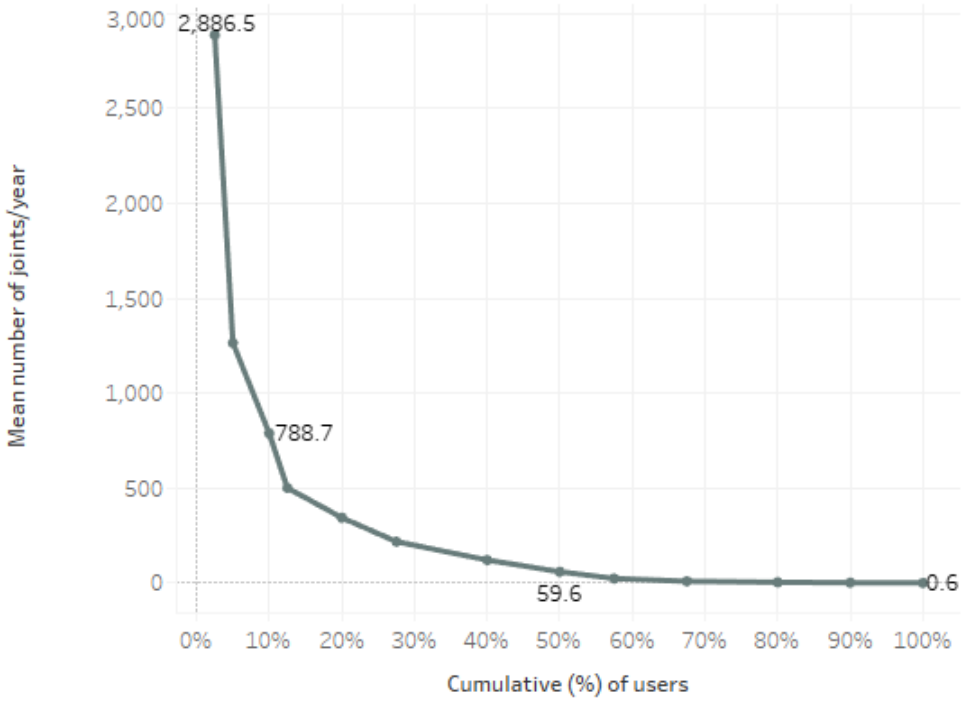
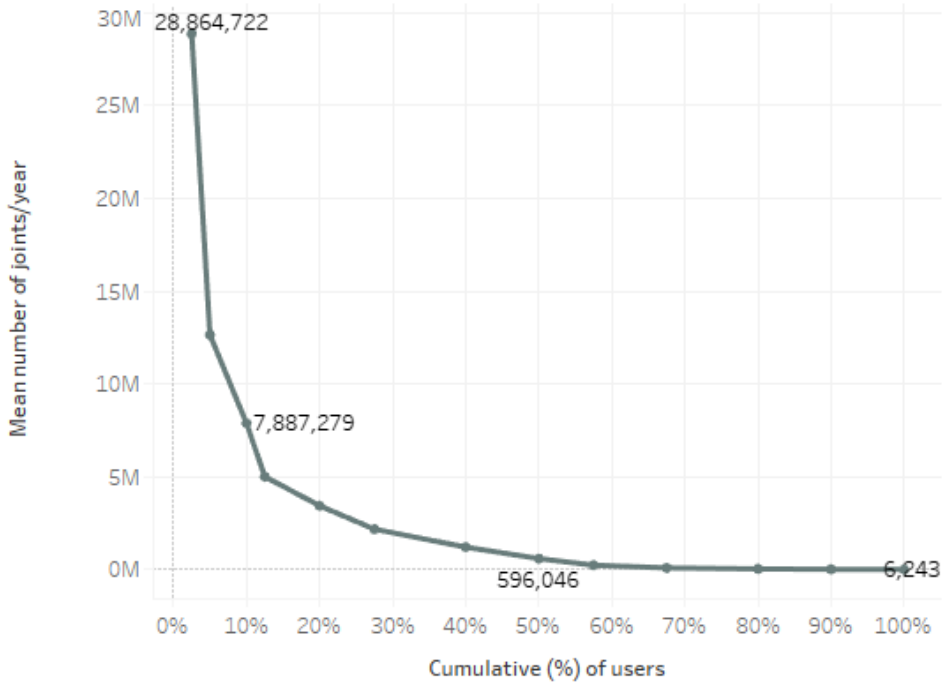


**Figure 2**

*Cumulative Distribution: Mean Number of Joints Smoked per Year Across Cannabis-Using Groups at the Population Level, From Heaviest-Using (far left) to Lightest-Using (far right).*




Figures 3 to 5 below display the cumulative percentage of cannabis consumption, stratified by sex, age, and psychiatric disorder status. Figure 3 demonstrates that males consumed a greater number of joints annually, with males accounting for approximately 67.7% of the self-reported yearly joints smoked in NESARC-III. Figure 4 demonstrates that the 18–34 age group had the highest consumption, accounting for approximately 65.7% of the total yearly consumption, while Figure 5 demonstrates that respondents with psychiatric disorders accounted for approximately 84.4% of the self-reported yearly joints smoked. Psychiatric disorders included were cannabis use disorder, alcohol use disorder, all other substance use disorders (excluding nicotine use disorder), and all mood, personality, and anxiety disorders included within the NESARC-III survey. Please note that this psychiatric disorder status categorization differs for research Study 2, which will be explained in the

appropriate section below. Please refer to Appendix B for the list of DSM-5 diagnosis criteria applied in NESARC-III (American Psychiatric Association, 2013).

**Figure 3**

*Percentage of Total Self-Reported Cannabis Consumption by Sex in the US, 2012–2013.*

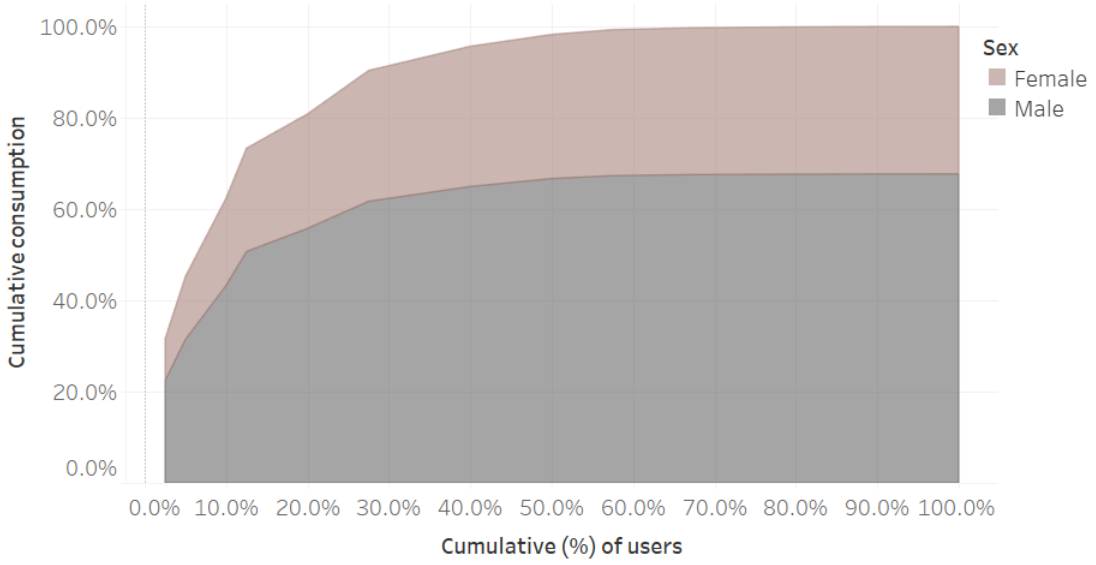



**Figure 4**

*Percentage of Total Self-Reported Cannabis Consumption by Age Groups in the US, 2012–2013.*

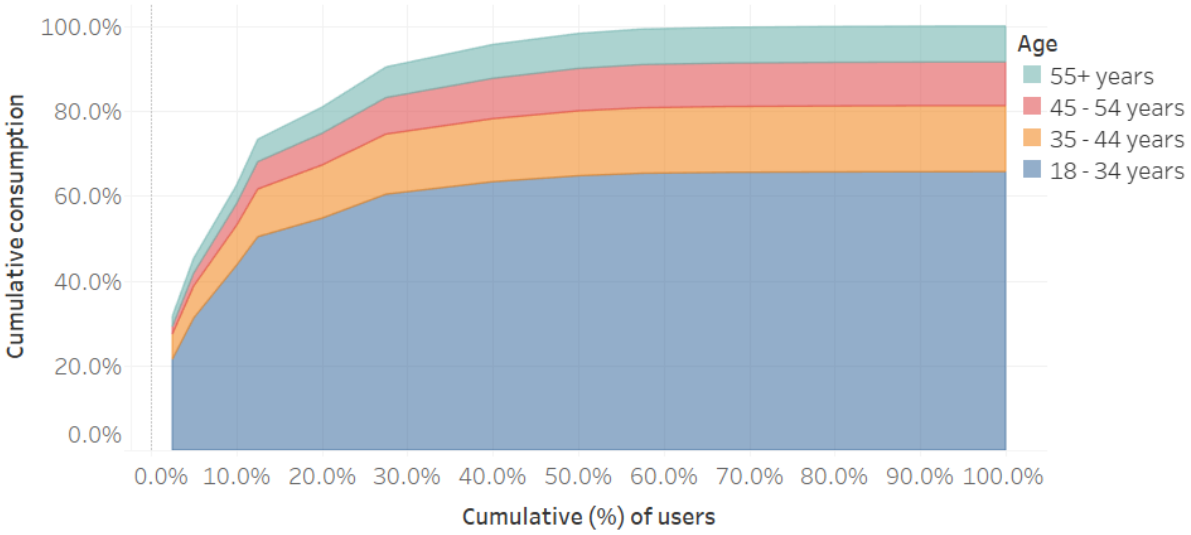
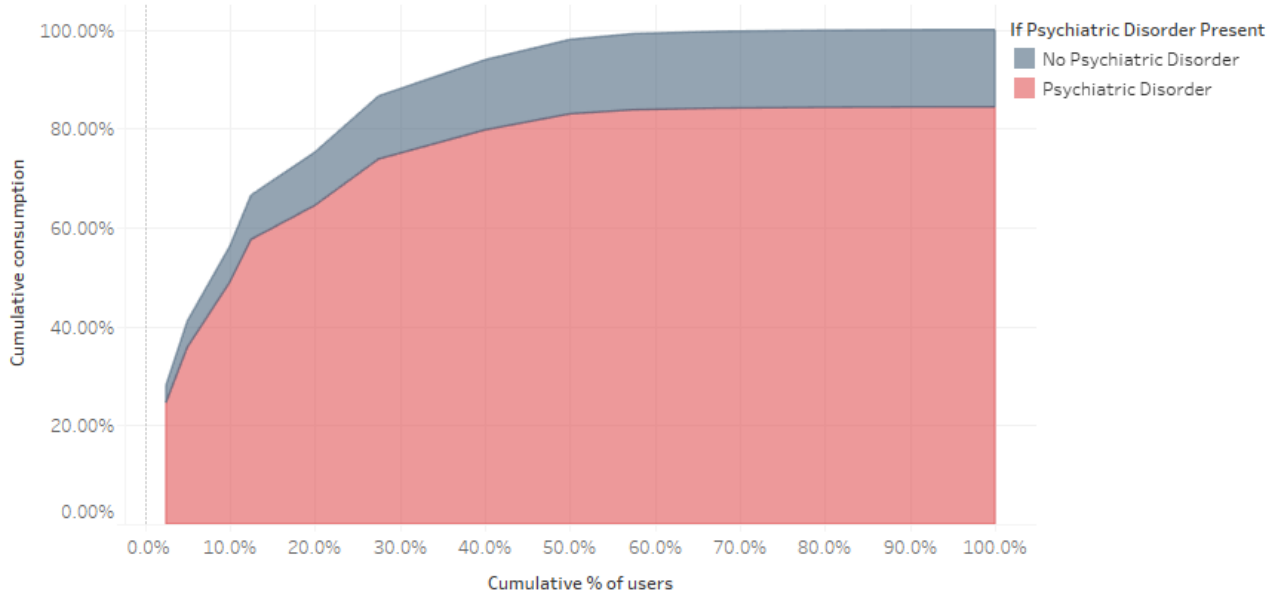


**Figure 5**

*Percentage of Total Self-Reported Cannabis Consumption by Psychiatric Disorder Status*




## Interpretation

### *Summary of Findings*

According to Study 1's findings, the top 10% of cannabis users consumed roughly 62.2% of all cannabis consumed within the population. This group consisted of 69.0% males, with 58.1% 18–29 years old, 52.8% white, 60.4% having only high school education or less, and 77.1% making <$20,000 per year in personal income. Males consumed roughly 67.7% of the self-reported yearly joints smoked, while 18–34-year-olds consumed roughly 65.7% of the self-reported yearly joints smoked. Respondents with a psychiatric disorder (mood, anxiety, personality, and substance use) consumed roughly 84.4% of the self-reported yearly joints smoked.

### *Explanation of Findings*

Findings are consistent with previous alcohol and cannabis use literature, demonstrating that a small subset of the cannabis-using population consumes a large proportion of the cannabis supply. Comparing these results to Greenfield and Rogers' (1999) findings, the top 10% of drinkers accounted for 61.1% of adult drinkers' total consumption, while males accounted for 76% of overall alcohol consumption. Callaghan et al. (2019) reported similar findings when examining cannabis use patterns in Canada. The top 10% of users consumed 65.5% of the yearly joints consumed in the population, with males accounting for 60% of the cannabis consumed by volume (Callaghan et al., 2019). However, Callaghan et al. (2019) reported that ages 15-34 years old accounted for approximately 55% of the cannabis consumed, while in Study 1, ages 18-34 years old accounted for approximately 65.7% of yearly joints consumed. One potential reason for this difference in findings could be that Callaghan et al.'s (2019) study design included all types of cannabis products, including edibles, which in their study accounted for 14% of the total cannabis market share in Canada. Given that Study 1 only included joint use, it may have excluded users in age brackets >34 years old who used other forms of cannabis, ultimately affecting cumulative consumption distribution patterns by age.

In addition, Study 1 had similar findings as previous research in terms of psychiatric disorder status and cannabis use patterns. A study by Lev Ran et al. (2013), further described in Study 2, examined the prevalence of cannabis use and cannabis use disorder in individuals with mental health and/or substance use illnesses. Using NESARC-I data, Lev Ran et al. included any psychiatric disorder in the last 12 months that fell in DSM-IV Axis I, II, or substance use disorder (SUD). This included mood, anxiety, personality disorders, and

substance use. Substance use disorder included any alcohol or drug use disorder but excluded cannabis and nicotine use disorders. The study reported that individuals with mental illness in the past 12 months represented 72% of all cannabis users and consumed 83% of all cannabis consumed nationally (Lev-Ran et al., 2013). These results are consistent with findings from Study 1 that 74.6% of cannabis users had a psychiatric disorder and consumed 84.4% of self-reported yearly joints consumed. Though Study 1 demonstrated that many cannabis consumers had psychiatric disorders, this study cannot provide insights in to the relationship between cannabis use and psychiatric disorder severity, or whether cannabis use may help or aggravate the disorder.

***Limitations***

One limitation of Study 1 in understanding cannabis use patterns is that the study does not include all types of cannabis products. Examining only joint use may have potentially excluded other types of cannabis users who solely use non-joint products. Callaghan et al.'s (2019) study found that dried cannabis leaf/flower accounted for roughly 60% of the total market share in Canada, while concentrates, edibles, and "other" accounted for 23%, 14%, and 3%, respectively, and thus there may be a significant subgroup of the population not included in our study.

Similar to the majority of studies using survey data, limitations to this study include the use of self-reported data. This may cause an overrepresentation of low-to-moderate users because many individuals often underestimate their use (Skog, 1999b). Additionally, the question used to calculate the number of joints per year may lead moderate users to underestimate as individuals who do not smoke daily may have difficulty averaging their daily joint use for 12 months. An overrepresentation of low-to-moderate users, and an

underrepresentation of heavy users, may have an impact on the distribution patterns of cannabis use.

### *Conclusion*

In conclusion, the patterns of cannabis use by quantity demonstrated that a small percentage of the cannabis-using population consumes a significant portion of the yearly cannabis supply, consistent with previous research. These findings suggest that cannabis use patterns are similar to alcohol consumption patterns. Therefore, future research and policy development may be able to draw upon learnings from alcohol reduction and prevention research and policy development.

# Chapter 5

# Study 2

## Introduction

Understanding what characteristics may predict group membership within the heaviest-using group is important for prevention and reduction strategy development, particularly for strategies that target individuals and high-risk behaviours. Study 2 attempted to answer the question: What characteristics predict group membership in the heaviest-using group?

## Methodology

### *Data Source*

This study used the National Epidemiologic Survey on Alcohol and Related Conditions-III (NESARC-III). Please see Chapter 3 (p. 15) for a detailed description of the data source.

### *Sample*

The sample consisted of all NESARC-III survey participants derived from research Study 1. Heavy users were identified based on the top 10% cumulative distribution results from Study 1. The final sample size was 3,578. The sample size for research Study 2 was ultimately reduced in size, from 3,586 to 3,578, as eight participants answered "not applicable" to potential predictor variables included in the logistic regression model.

### *Primary Outcome Variable and Predictor Variables*

The primary outcome variable was whether a respondent was a heavy cannabis user or a low-to-moderate user. Predictor variables (12 in total) included in the logistic regression model were as follows: (a) sex [NSEX]; (b) ethnicity [NETHRACE]; (c) 12-month personal

income [N1Q18BR]; (d) 12-month household income [N1Q20BR]; (e) highest education level [NEDUC]; (f) current age [NAGE]; (g) age first used marijuana [N3BD3Q2A]; (h) psychiatric disorder present; substance use disorder present; general health rating [N1Q25]; (i) cannabis use disorder present [maud5]; (j) nicotine use disorder present [nicdep5]; (k) alcohol use disorder present [pyaud5]; and (l) past 4-week pain interference [N1Q35].

Initially, the following additional potential predictor variables (six in total) were considered: (a) blood/natural father/mother had problems with drugs [N3EQ1/N3EQ2]; (b) age first used cigarettes [N3AQ2A1]; (c) age first started drinking [N2AQ12A]; (d) number of separate times staying in hospital overnight [N14Q1]; (e) number of times received treatment in the Emergency room [N14Q3]; and (f) medical marijuana use in past 12 months [N14Q16D]. However, these were eliminated because groupings were too small in *n*-value or there were too many "not applicable" responses to be included in the logistic regression model.

Having a psychiatric disorder present was grouped differently than in Study 1. In Study 2, psychiatric disorders only included anxiety, mood, and personality disorders, because alcohol use, nicotine use, cannabis use, and all other substance use disorders were their own separate predictor variables within the logistic regression model. For substance use disorder, participants were assigned as "1" if they met the criteria for a DSM-5 diagnosis of any of the illicit drugs listed: cocaine, heroin, sedative, stimulant, hallucinogen, inhalant, club, or other.

NESARC-III does make a distinction between DSM-5 clinical mood disorders (hierarchical) and substance-induced or illness-induced mood disorders (non-hierarchical). Typically, for clinical diagnosis of mood disorders, substance and illness-induced causes are

ruled out (hierarchical); however, non-hierarchical variables were used when possible for the purpose of this study to create the "psychiatric disorder present" predictor variable. Non-hierarchical variables were used because an objective of this study was to predict the characteristics of the heaviest cannabis users. These characteristics may be complex and multifactorial, including psychiatric conditions that may be caused by substance or illness. Two psychiatric disorders that could not be examined with a non-hierarchical (inclusive and substance and illness-induced causes) variable were Major Depressive Disorder and Bipolar 1; thus, the hierarchical variables were used.

Another distinction NESARC-III makes is the categorization of personality disorders and whether they have met the requirements for distress/social-occupational dysfunction criterion. To be as inclusive as possible, this study used variables that met the lowest criterion for the distress/social-occupational dysfunction criterion. Please refer to Appendix B for the list of DSM-5 diagnosis criteria applied in NESARC-III (American Psychiatric Association, 2013).

***Analytical Plan***

Cross-tabulation was used to examine bivariate relationships between the outcome variable (heavy user) and all potential predictor variables as all variables were categorical. This allowed for the examination of the number of cases in each group and results of the chi-square test of association to establish whether a statistically significant association between two variables existed. Following this, logistic regression was used to predict the likelihood of an outcome occurring as the outcome variable was dichotomous (yes or no to being a heavy user). Logistic regression modelled group membership probability by assessing the relationship among predictor variables and the probability of the outcome (heavy user) based

on individual characteristics (Knapp, 2017). Backwards stepwise selection was used to establish a final "best" model and prevent overfitting and the inclusion of unnecessary variables that did not contribute to the model (Hosmer & Lemeshow, 2000, Chapter 4). Assumptions of our logistic regression model included (Knapp, 2017):

1. The outcome variable was dichotomous, with a score coded as 1 or 0.
2. The outcome variable scores were statistically independent of each other and observations were not derived from repeated measurements.
3. The two categories of the outcome variable (1 or 0) were exhaustive and mutually exclusive, meaning that participants belong to one group or the other, not both.
4. Little or no multicollinearity is present among the predictor variables, meaning the predictor variables are not highly correlated.

The following seven steps were conducted to answer Study 2:

1. Identify the heaviest users versus low-to-moderate users by assigning participants who fell into the top 10% cumulative distribution with a "1" and all other participants with a "0" for the heavy-using variable.
2. Remove participants who had answered "unknown" or "not applicable" in potential predictor variables included in the logistic regression analysis. The final sample size was 3,578.
3. Conduct univariate analysis using contingency tables and chi-square testing between the outcome variable (heavy user) and potential predictor variables to determine if any potential predictor variables should be excluded from the logistic regression model. Variables with univariable tests that have a $p$ value of $<0.25$ can be candidates for multivariable modelling (Hosmer & Lemeshow, 2000,

Chapter 4). In addition, outliers are examined, but not removed through the use of *Z*-scores and Mahalanobis distance. Testing for multicollinearity was also conducted using chi-square testing.

4. Divide *n*-value of heavy-using group by 10 to ensure the number of potential predictor variables does not exceed this number. The heavy-using group had an *n*-value of 358, which led to 36 potential predictor variables allowed when dividing 358 by 10 (Knapp, 2017).
5. Re-categorize potential predictor variables to have only two or three categories because *n*-values of some initial groupings were small.
6. Use backwards stepwise model and Wald's test to determine which potential predictor variables to retain in best model. Potential predictor variables were eliminated one-by-one based on the predictor with the highest/least significant *p* value. Predictors variables were not removed if the *p* value was less than 0.20 to prevent the removal of influential predictors (Hosmer & Lemeshow, 2000, Chapter 4).
7. Examine whether interactions were present using the Wald test (Hosmer & Lemeshow, 2000, Chapter 4).
8. Assess the fit of the model using diagnostic testing.

***Research Ethics Board (REB) and Data Access***

The NESARC-III dataset was obtained through the NESARC application process. After applying to UNBC REB, it was deemed that the application did not need REB approval. See Appendix A for a copy of the NESARC application and UNBC REB submission.

## Justification of Predictor Variable Selection

### *12-month DSM-5 Diagnosis of Cannabis Use Disorder*

It was important to examine cannabis use disorder in the analysis as it was expected to be strongly associated with heavy cannabis users. Research on cannabis dependence suggests that approximately 9% of the population who have reported ever using cannabis will develop dependence (Anthony et al., 1994; Lopez-Quintero et al., 2011). Gender, changes in mother's marital status, maternal smoking, adolescent school performance, childhood sexual abuse history, adolescent aggression/delinquency history, and adolescent smoking and alcohol consumption have been found to be strongly associated with developing a cannabis use disorder (Hayatbakhsh et al., 2009).

### *12-month DSM-5 Substance Use Disorder*

Many studies have shown a relationship between cannabis use and the use of other illicit drugs (Degenhardt et al., 2009; Khan et al., 2013; Mayet et al., 2012), including relationships with cannabis use frequency (Mayet et al., 2012) and early onset of cannabis use (Fergusson et al., 2006; Van Gundy & Rebellon, 2010). In addition, dependency use risk has been shown to increase from 1 in 10 to 1 in 6 if use started before age 18 years old (Anthony, 2006).

Secades-Villa et al. (2015) used NESARC-1 data to examine the probability of progression to using illicit drugs. The study found that 44.7% of people who have used cannabis in their lifetime progress to using illicit drugs (Secades-Villa et al., 2015). The study also found that individuals with cannabis use disorder were more likely to use illicit drugs in comparison to individuals who did not have cannabis use disorder (HR = 2.33; 95% CI = 2.06, 2.62), and early onset of cannabis use was found to have a weaker relationship in

predicting progression to illicit drug use (HR = 0.94; 95% CI = 0.92, 0.97) (Secades-Villa et al., 2015).

***12-month DSM-5 Diagnosis of Mood, Anxiety, and Personality Disorders***

Lev-Ran et al. (2013) studied the association between mental illness and cannabis use by analyzing rates of cannabis use and cannabis use disorder (CUD) in individuals with primary psychiatric disorders. Using NESARC wave 1 data, the study categorized cannabis users into "at least weekly" and "less than weekly." Cannabis dose was also examined by the average daily number of joints consumed within the last 12 months. Sociodemographic information was examined in participants with any 12-month psychiatric disorder (Lev-Ran et al., 2013). Mood disorders included major depressive disorder, bipolar I, bipolar II, dysthymia, panic disorder, social anxiety disorder, specific phobias, and generalized anxiety disorder, while personality disorders included paranoid-schizoid, histrionic, antisocial, obsessive-compulsive, dependent, and avoidant personality disorders (Lev-Ran et al., 2013). Prevalence of cannabis use and CUDs in participants with and without past 12-month primary psychiatric disorder was calculated with cross-tabulations. Logistic regression was used to calculate the odds of having any 12-month psychiatric illness in each demographic group and to calculate the odds for cannabis use and CUDs in participants with 12-month psychiatric disorders. The study used the *t*-test to compare daily cannabis use dose in participants with and without 12-month psychiatric disorders and the Mantel-Haenszel $x^2$ test to compare trends and rates of cannabis use according to 12-month psychiatric disorder frequency (Lev-Ran et al., 2013).

Lev-Ran et al. (2013) found that 4.1% of the population used cannabis within the past 12 months, with 2.4% using less than weekly, 1.7% using at least weekly, and 1.5% having a

CUD. Among individuals who used cannabis in the last 12 months, 72.2% had a 12-month psychiatric disorder. Among the individuals who had a 12-month psychiatric disorder, 81.8% had a CUD (Lev-Ran et al., 2013). Prevalence of 12-month psychiatric disorder was statistically significantly higher in participants who used cannabis at least weekly compared to participants who used less than weekly (77.2%; 68.7%; $p<0.01$) (Lev-Ran et al., 2013). The study also found that among participants with a 12-month psychiatric disorder, the mean number of joints was 1.4 joints per day in the "less than weekly" group and 3.1 joints per day in the "at least weekly" group ($p<.0001$) (Lev-Ran et al., 2013). Cannabis use frequency and cannabis use disorder were higher in individuals with bipolar 1, antisocial, and histrionic disorders. Once controlled for substance use disorders, odds of cannabis use for participants with psychiatric disorders remained elevated ($OR = 2.5$; 95% CI = 2.1, 3.0) (Lev-Ran et al., 2013). The study calculated that participants with a 12-month psychiatric disorder consumed 83% of the total yearly supply of cannabis in the United States (Lev-Ran et al., 2013).

***Sociodemographic Information***

Cannabis use varies among different demographics, such as ethnicity and age. According to 2015 national survey data available from the Substance Abuse and Mental Health Services Administration (SAMHSA) publicly accessible data system, African Americans had the highest rates of past-month use (10.7%), followed by Caucasians (8.4%) (Center for Behavioral Health Statistics and Quality [CBHSQ], 2016b; National Academies of Sciences, Engineering, and Medicine, 2017). When comparing age groups, the age category 18–25 had the highest rates of past-month use (20.1%), followed by age 26–34 years old (13%), while youth 12–17 years old had a past-month use rate of 7.1% (CBHSQ, 2016b; National Academies of Sciences, Engineering, and Medicine, 2017).

### *Age of Initial Cannabis Use*

Research has demonstrated that using cannabis in adolescence has short-term and long-term consequences, including impulsivity, academic underachievement, mental illness, brain development changes, and employment instability (Lisdahl et al., 2013; Washburn & Capaldi, 2015). Research suggests that early cannabis use has an impact on neural connectivity long-term, including decreased connectivity of the fimbria and the precuneus region, which play major roles in memory formation, self-reflection and awareness, and some components of consciousness (Zalesky et al., 2012).

Roughly 6% of American 12th graders report daily or almost daily cannabis use (Johnston et al., 2017). Additionally, there may be a trend towards earlier age of first use among cannabis users, as shown by an Australian study that found that 21% of users born between 1940 and 1949 started cannabis before age 18 years old compared to 78% of those born in 1970 to 1979 (Hall & Swift, 2000).

### *12-month DSM-5 Diagnosis of Tobacco Use Disorder*

Both cross-sectional and longitudinal studies have demonstrated a relationship between cannabis use and tobacco cigarette smoking (Kapusta et al., 2007; Ramo et al., 2013), including decreased likelihood of quitting cannabis smoking (Haney et al., 2013) and increased risk of relapse (Weinberger et al., 2017).

Dierker et al. (2018) set out to examine whether cigarette smoking and/or nicotine dependence predicted cannabis use disorder and whether the frequency of cannabis use affected the relationship. Using data from the National Survey on Drug Use and Health (NSDUH), the study found that 54.7% of participants smoked cigarettes within the past 30 days. Participants who smoked cigarettes used cannabis more frequently, started using

cannabis at a younger age, and reported CUD symptoms more frequently than did participants who did not smoke cigarettes (Dierker et al., 2018). In addition, nicotine dependence, but not cigarette smoking frequency, was found to be associated with cannabis use disorder symptoms. Dierker et al. concluded that cigarette smokers are vulnerable to cannabis use disorders and that prevention and treatment programs should consider cigarette smoking comorbidities.

### *12-month DMS-5 Diagnosis of Alcohol-use Disorder*

Previous studies have shown significant associations between cannabis use and alcohol use, including a higher degree of alcohol consumption and alcohol-related consequences in those using both, compared to those using alcohol alone (Butterworth et al., 2014; Subbaraman & Kerr, 2015).

Weinberger et al. (2016) used longitudinal data from respondents who completed both wave 1 and wave 2 of NESARC and who started using cannabis prior to the age reported having an alcohol use disorder (AUD). The purpose of this study was to examine the relationship between cannabis use and AUD. Two subsamples were created for statistical analysis: (a) one group was restricted to only respondents with no lifetime AUD diagnosis prior to wave 1, to examine AUD incidence, and (b) the second group was restricted to respondents with an AUD lifetime diagnosis prior to wave 1, to examine AUD persistence (Weinberger et al., 2016).

Using a series of logistic regression models, unadjusted and adjusted to control for sociodemographic covariates, lifetime history of psychiatric disorders, lifetime nicotine dependence, and other illicit drug use disorders, the study found that cannabis use was associated with both an increased likelihood of AUD onset (*OR* = 5.43; 95% CI = 4.54, 6.49)

and an increased likelihood of AUD persistence (*OR* = 1.74; 95% CI = 1.56, 1.95) within 3 years relative to respondents who did not use cannabis (Weinberger et al., 2016). Statistically significant relationships in AUD onset (*OR* = 2.12; 95% CI= 1.70, 2.64) and AUD persistence (*OR*= 1.32; 95% CI = 1.17, 1.50) likelihood in cannabis users compared to non-cannabis users remained after controlling for sociodemographics, other substance use disorders, and psychiatric disorders (Weinberger et al., 2016).

***General Health, Pain Status, and Hospitalization***

Self-rating questions on general health, past 4-week pain interference, and emergency and inpatient hospitalization were included in the logistic regression analysis. These predictor variables were included to examine the relationship between cannabis use and perceived health, pain status, and degree of hospitalization. Reports between 2006 and 2011 have shown that hospitalization due to cannabis use has increased significantly (Young & Jesseman, 2014). Cannabis-related hospital stays have increased by 44%, while the length of stay due to cannabis-related disorders has increased by 40% (Young & Jesseman, 2014). This is believed to be due to increased cannabis use and complications among youth 15–24 years of age (Young & Jesseman, 2014). Consequently, hospital-associated costs have increased by 52%, with a total cost increase from 9 million to 14 million in Canadian dollars (Young & Jesseman, 2014).

**Results**

Table 3 below summarizes the frequencies for each predictor variable present in the final logistic regression model for the total sample and the heavy-using group. Sociodemographic variable frequencies were described within Study 1, and thus will not be discussed in this section. In terms of age of initial cannabis use, a higher proportion of

individuals in the heavy-using group started before age 15 years old compared to the total sample at 49.4% versus 29.0%, respectively. In the heavy-using group, 251 (70.1%) individuals had nicotine dependence, 233 (65.1%) had a psychiatric disorder present (anxiety, mood, and/or personality disorders only), and 201 (56.1%) had a cannabis use disorder. (See Table 3 for respective percentages for the total sample.)

**Table 3**

*Demographic Profile of Total Sample and Heavy-Using Group (Top 10%)*

| Characteristic | Value | Heavy user, top 10% | Total sample |
|---|---|---|---|
| Sex | Male | 247 (69.0%) | 2,125 (59.4%) |
| | Female | 111 (31.0%) | 1,453 (40.6%) |
| Age | 18–29 years | 208 (58.1%) | 1,589 (44.4%) |
| | 30–44 years | 92 (25.7%) | 1,059 (29.6%) |
| | 45+ years | 58 (16.2%) | 930 (26.0%) |
| Ethnicity | non-Hispanic white | 190 (53.1%) | 1,859 (52.0%) |
| | Non-white | 168 (46.9%) | 1,719 (48.0%) |
| Education | Less than high school | 83 (23.2%) | 538 (15.0%) |
| | Completed high school | 133 (37.2%) | 999 (27.9%) |
| | Some college or higher | 142 (39.7%) | 2,041 (57.0%) |
| Personal income | $ 0–19,999 | 276 (77.1%) | 2,063 (57.7%) |
| | $ 20,000–34,999 | 56 (15.6%) | 771 (21.5%) |
| | $ >35,000 | 26 (7.3%) | 744 (20.8%) |
| Age of initial cannabis use | <15 years | 177 (49.4%) | 1,037 (29.0%) |
| | 15–17 years | 128 (35.8%) | 1,380 (38.6%) |
| | 18+ years | 53 (14.8%) | 1,161 (32.4%) |
| DSM-5 nicotine use disorder | Not present | 107 (29.9%) | 1,824 (51.0%) |
| | Present | 251 (70.1%) | 1,754 (49.0%) |
| DSM-5 psychiatric disorder (anxiety, mood, personality only) | Not present | 125 (34.9%) | 1,748 (48.9%) |
| | Present | 233 (65.1%) | 1,830 (51.1%) |
| DSM-5 cannabis use disorder | Not present | 157 (43.9%) | 2,624 (73.3%) |
| | Present | 201 (56.1%) | 954 (26.7%) |
| N | | 358 | 3,578 |

Table 4 below provides a summary of cross-tabulation results. During the examination of cross-tabulation results, recommendations by Hosmer and Lemeshow (2000)

were followed. The elimination of potential predictor variables with a *p* value of >0.25, rather than 0.05, were applied to minimize the elimination of important variables (Hosmer & Lemeshow, 2000, Chapter 4). Ethnicity was the only variable that did not have a *p* value of <0.25 ($p = 0.60$). This variable remained included as research has shown that ethnicity plays a role in substance use (CBHSQ, 2016b; National Academies of Sciences, Engineering, and Medicine, 2017).

**Table 4**

*Cross-Tabulation Results of Potential Predictor Variables*

| Predictor | Response | *n*-value | $\chi 2$ |
|---|---|---|---|
| Sex | Male | 2,125 (59.4%) | 7.086*** |
| | Female | 1,453 (40.6%) | |
| Age | 18–29 years | 1,589 (44.4%) | 8.914**** |
| | 30–44 years | 1,059 (29.6%) | |
| | 45+ years | 930 (26.0%) | |
| Ethnicity | non-Hispanic white | 1,859 (52.0%) | 0.282 |
| | Non-white | 1,719 (48.0%) | |
| Education | Less than high school | 538 (15.0%) | 22.093**** |
| | Completed high school | 999 (27.9%) | |
| | Some college or higher | 2,041 (57.0%) | |
| Personal income | $ 0–19,999 | 2,063 (57.7%) | 20.653 **** |
| | $ 20,000–34,999 | 771 (21.5%) | |
| | $ >35,000 | 744 (20.8%) | |
| Age of initial cannabis use | <15 years | 1,037 (29.0%) | 55.813**** |
| | 15–17 years | 1,380 (38.6%) | |
| | 18+ years | 1,161 (32.4%) | |
| DSM-5 nicotine use disorder | Not present | 1,824 (51.0%) | 75.953**** |

| Predictor | Response | *n*-value | χ2 |
|---|---|---|---|
| DSM-5 psychiatric disorder (anxiety, mood, personality only) | Present | 1,754 (49.0%) | 22.121**** |
| | Not present | 1,748 (48.9%) | |
| DSM-5 cannabis use disorder | Present | 1,830 (51.1%) | 143.51**** |
| | Not present | 2,624 (73.3%) | |
| DSM-5 alcohol use disorder | Present | 954 (26.7%) | 4.665** |
| | Not present | 1,931 (54.0%) | |
| DSM-5 substance use disorder (excluding maud5, pyaud5, nicdep5) | Present | 1,647 (46.0%) | 19.864**** |
| | Not present | 3,239 (90.5%) | |
| General health rating | Present | 339 (9.5%) | 6.451** |
| | Excellent | 697 (19.5%) | |
| | Very good/good | 2,156 (60.3%) | |
| | Fair/poor | 725 (20.3%) | |
| Past 4 week pain score interference | Not at all | 2,011 (56.2%) | 3.190* |
| | A little bit to extremely | 1,567 (43.8%) | |
| Household income | $ 0–19,999 | 1,349 (37.7%) | 11.265**** |
| | $ 20,000–34,999 | 750 (21.0%) | |
| | $ >35,000 | 1,479 (41.3%) | |
| N-total | | 3,578 | |

****$p$<0.001, ***$p$<0.01, **$p$<0.05, *$p$<0.25

Table 5 below presents a model comparison between the full model and the best model. Backwards stepwise selection was used to eliminate non-essential predictor variables from the full model and minimize over-fitting. Ultimately, five potential predictor variables were eliminated because their *p* values were not significant, and a reduction in the Akaike information criterion (AIC) was observed when the predictor variable was eliminated. In addition, the Wald test between each model confirmed that removing the predictor variable did not harm the model. Log-likelihood ratio test could not be performed in the analysis because survey data were used and the svyglm function in R was applied, which is not fitted

by maximum likelihood. As an alternative, the Wald test was used (Hosmer & Lemeshow, 2000, Chapter 6).

When comparing the full model to the best model, it can be observed that the AIC was reduced from 2,580.2 to 2,570.1, suggesting that the second model is better fitted. The Wald test comparing the two models had a $p$ value >0.5, suggesting that removing the predictor variables from the full model would not substantially harm the fit of the model.

Potential interactions were also examined after stepwise selection was performed; however, none were shown to be significant and therefore were not included in the final model. These interactions included (a) NSEX and cannabis use disorder, (b) current age and cannabis use disorder, (c) NSEX and psychiatric disorder present, (d) education and personal income, (e) education and ethnicity, (f) age of initial cannabis use and cannabis use disorder, (g) NSEX and personal income, and (h) ethnicity and personal income.

When examining the best model, predictor variables with significant $p$ values at an $\alpha = 0.05$ were age, personal income, cannabis use disorder, sex, education, age of initial cannabis use, and nicotine use disorder. Significant predictor variables with the highest OR included personal income, cannabis use disorder, and age of initial cannabis use. Having a personal income of $0–19,999 had 2.54 the odds of being a heavy user compared to individuals who made greater than $35,000 in personal income per year, $p = .003$, 95% CI [1.39, 4.61]. Having CUD had 3.17 odds of being a heavy user compared to members who did not have CUD, $p = <0.001$, 95% CI [2.42, 4.14], while an age of initial cannabis use of <15 years old had 2.89 odds of being a heavy user compared to starting cannabis at 18 years or older, $p = <0.001$, 95% CI [2.00, 4.19].

**Table 5**

*Logistic Regression Models Predicting Heaviest Cannabis User Group Membership*

| | Best model | | | | | | Full model | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable (referent) | β | *SE* | *t* value | *p* | OR | *95% CI* | β | *SE* | *t* value | *p* | OR | *95% CI* |
| Intercept | -4.90 | 0.39 | -12.5 | <0.001** | 0.01 | 0.00–0.02 | -4.79 | 0.46 | -10.4 | <0.001** | 0.01 | 0.00–0.02 |
| Age 18–29 (≥45) | 0.46 | 0.18 | 2.58 | 0.01* | 1.58 | 1.12–2.23 | 0.56 | 0.20 | 2.78 | 0.007* | 1.75 | 1.18-2.59 |
| Age 30–44 (≥45) | 0.30 | 0.22 | 1.34 | 0.18 | 1.35 | 0.87–2.10 | 0.36 | 0.24 | 1.51 | 0.13 | 1.43 | 0.90–2.27 |
| Personal income 0–19,999 (>35k) | 0.93 | 0.31 | 3.04 | 0.003* | 2.54 | 1.39–4.61 | 0.85 | 0.35 | 2.41 | 0.02* | 2.34 | 1.17–4.65 |
| Personal income –20,000-34,999 (>35k) | 0.39 | 0.35 | 1.12 | 0.27 | 1.47 | 0.75–2.91 | 0.41 | .35 | 1.18 | 0.24 | 1.51 | 0.76–3.00 |
| Cannabis use disorder present (not present) | 1.15 | 0.14 | 8.42 | <0.001** | 3.17 | 2.42–4.14 | 1.16 | 0.14 | 8.21 | <0.001** | 3.20 | 2.43–4.23 |
| Male (Female) | 0.44 | 0.15 | 2.84 | 0.005* | 1.55 | 1.14–2.09 | 0.45 | 0.16 | 2.84 | 0.006* | 1.56 | 1.15–2.12 |
| Less than high school education (some college or higher) | 0.39 | 0.19 | 2.09 | 0.04* | 1.47 | 1.02–2.12 | 0.34 | 0.19 | 1.75 | 0.084 | 1.40 | 0.96–2.06 |
| Completed high school (some college or higher) | 0.51 | 0.17 | 3.10 | .003* | 1.67 | 1.21–2.30 | 0.51 | 0.16 | 3.13 | 0.002* | 1.66 | 1.21–2.28 |
| non-Hispanic white (non-white) | 0.14 | .014 | 1.00 | 0.34 | 1.14 | 0.88–1.49 | 0.14 | 0.14 | 0.99 | 0.32 | 1.15 | 0.88–1.50 |
| Initial cannabis use age <15 (age 18+) | 1.06 | 0.19 | 5.59 | <0.001** | 2.89 | 2.00–4.19 | 1.05 | 0.19 | 5.52 | <0.001** | 2.85 | 1.97–4.14 |
| Initial cannabis use age 15-17 (age 18+) | 0.49 | 0.16 | 3.08 | 0.003* | 1.64 | 1.20–2.42 | 0.50 | 0.16 | 3.09 | 0.003* | 1.65 | 1.20–2.27 |

| | Best model | | | | | | Full Model | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable (Referent) | β | *SE* | *t* value | *p* | OR | *95% CI* | β | *SE* | *t* value | *p* | OR | *95% CI* |
| Intercept | -4.90 | 0.39 | -12.5 | <0.001** | 0.01 | 0.00–0.02 | -4.79 | 0.46 | -10.4 | <0.001** | 0.01 | 0.00–0.02 |
| Nicotine use disorder present (not present) | 0.69 | 0.15 | 4.74 | <0.001** | 1.99 | 1.50–2.64 | 0.69 | 0.15 | 4.55 | <0.001** | 1.99 | 1.48–2.67 |
| Having anxiety, mood, or personality disorder (no psychiatric disorder) | 0.18 | 0.15 | 1.23 | 0.22 | 1.20 | 0.90–1.60 | 0.17 | 0.15 | 1.14 | 0.26 | 1.18 | 0.89–1.58 |
| Alcohol use disorder present (not present) | | | | | | | -0.12 | 0.13 | -0.81 | 0.42 | 0.90 | 0.70–1.16 |
| General health rating very good/good (excellent) | | | | | | | -0.09 | 0.19 | -0.49 | 0.63 | 0.91 | 0.63–1.32 |
| General health rating fair/poor (excellent) | | | | | | | 0.08 | 0.29 | 0.30 | 0.77 | 1.09 | 0.62–1.91 |
| Past 4 week pain interference (not at all) | | | | | | | 0.07 | 0.19 | 0.35 | 0.73 | 1.07 | 0.74–1.53 |
| Substance use disorder present (not present) | | | | | | | 0.08 | 0.19 | 0.39 | 0.70 | 1.08 | 0.74–1.57 |
| Household income 20,000-34,999 (0-19,999) | | | | | | | -0.18 | 0.20 | -0.91 | 0.37 | 0.84 | 0.57–1.23 |
| Household income >35 (0-19,999) | | | | | | | -0.09 | 0.20 | -0.44 | 0.66 | 0.91 | 0.61–1.37 |
| | Best model | | | | | | Full model | | | | | |
| Wald Test – comparing full model to best model | | F = 0.45 | df: *p*= 0.87 | | | | | | | | | |
| AIC | 2,570 | | | | | | 2,581 | | | | | |

** $p < 0.001$, * $p < 0.05$

## Interpretation

### *Summary of Results*

Study 2 findings demonstrate that age, personal income, sex, education, age of initial cannabis use, having a CUD, and having nicotine dependence are statistically significant predictors of heavy cannabis use group membership.

### *Explanation of Findings*

Currently, no known literature predicts group membership for heavy cannabis use to allow for comparisons. However, the study findings are not surprising based on previous literature, including the literature described in the justifications section above. For example, previous research has found that ages 15–34 years old account for higher consumption volumes of cannabis use (Callaghan et al., 2019). Therefore, it is not surprising that a younger user has an increased risk of being a heavy user. Research has shown that adolescents are initiating marijuana earlier than in the mid-1900s and that daily or near-daily use has increased (Hall & Swift, 2000; National Academies of Sciences, Engineering, and Medicine, 2017). As described in the justification of predictor variables section, Dierker et al. (2018) reported that individuals who smoked cigarettes used cannabis more often, started at a younger age, and experienced CUD symptoms more often than did individuals who did not smoke cigarettes. Dierker et al. also reported that nicotine dependence was associated with CUD, consistent with Study 2 findings.

Though literature on predicting heavy cannabis use group membership could not be found, Feingold et al. (2020) examined the probability of transitioning from cannabis use to having a CUD and what characteristics may be associated with that transition. This study used NESARC-III data and univariate and multivariate discrete-time survival analysis to

examine the association between cannabis dependence predictors and the risk of transitioning to CUD. Cannabis use was determined by past-year and prior-to-past-year use and aggregated to form a lifetime use variable. Age of first use for cannabis was transformed into a three-level categorical variable: <15 years, 16–19 years, and 20 + years. Other predictor variables (13 in total) included the following: (a) gender, (b) ethnicity, (c) age, (d) marital status, (e) education, (f) 12-month household income, (g) urbanicity and region, (h) mood, anxiety, and personality disorders, (i) emotional and physical abuse in childhood, (j) exposure to domestic violence, (k) neglect and endangerment, (l) sexual abuse, and (m) parental dysfunction (Feingold et al., 2020).

Feingold et al. (2020) found that lifetime cannabis users (n = 11,272) comprised 32.3% (SE = 0.54) of the NESARC-III sample, with 57% of lifetime users being male, 73% white, 39% 45–64 years old, 65% college-educated, and 54% married or living with someone as if married. The average age of marijuana start was 17.6 years old (SE = 0.06). The study reported that the cumulative probability of transitioning from cannabis use to having CUD 1, 3, 5, 10, and 20 years after age of initial marijuana use was 3.9%, 8.4%, 11.5%, 13%, and 15.5%, respectively (Feingold et al, 2020). The lifetime cumulative probability of developing CUD since age of marijuana initiation was 27% (Feingold et al., 2020). Gender, current age, education level, marital status,12-month household income, and having a psychiatric or substance use disorder were significantly associated with increased risk of transitioning to CUD. In addition, cannabis users who reported childhood adverse events were at increased risk of transitioning to CUD. Characteristics with the highest probabilities of transitioning to CUD were being male, belonging to an ethnic minority, early age of initial marijuana use, and individuals who experienced three or more childhood adverse events (Feingold et al.,

2020).

Feingold et al.'s (2020) findings are consistent with Study 2 results, particularly sex, age of initial cannabis use, education, and income. However, Study 2 did not find a strong relationship with ethnicity. Potential reasons for this difference may be that Study 2 only examined current 12-month cannabis users, and the sample size was significantly smaller, potentially affecting regression results. In addition, Study 2 examined characteristics that may predict heavy use, not CUD in a population that already uses. Thus, perhaps ethnicity does not play a strong role in heavy use, but may play a role in CUD development.

One interesting perspective to consider is the DSM-5 diagnosis process, such as CUD, and an individual's perception of harm. A study by Santaella-Tenorio et al. (2019) examined whether a trend toward decreasing prevalence of CUD was observable in individuals who reported daily or almost daily cannabis use. Using data from the 2002–2016 National Survey on Drug Use (NSDUH) surveys, the study found that the frequency of CUD among daily or almost daily users decreased from 2002 to 2016 by 26.8% for ages 12–17, 29.7% for ages 18–25, and 37.5% for age 26+ (Santaella-Tenorio et al., 2019).

Santaella-Tenorio et al. suggested the following reasons for decreases in frequency of CUD among daily or almost daily users: (a) increased legalization of medical and recreational use may have reduced stigma and perceptions of risks associated; (b) this, in turn, could have an impact on social attitudes towards cannabis use, potentially reducing or minimizing conflicts, such as conflicts with relatives and friends regarding cannabis use; (c) increased legalization may also have reduced legal problems and arrests, and (d) increased legalization and reduced stigma could potentially motivate a cohort of the population that is healthier overall to start using cannabis more frequently. The authors believe this new group

of daily or near-daily users have the potential to dilute the prevalence of CUD over time if these users are less likely to suffer negative impacts and cannabis-related harms from their daily or near-daily use. Nevertheless, this study suggests a decrease in CUD prevalence overtime, and ultimately a change in behaviour among daily or near-daily users (Santaella-Tenorio et al., 2019).

Though Santaella-Tenorio et al.'s (2019) study provides an interesting perspective on how group membership may change over time and how social attitudes may affect one's perception and experience regarding cannabis-related harms and ultimately diagnosis of CUD, study 2 findings suggest that having a CUD is a strong predictor for becoming a heavy cannabis user. However, this finding is not self-evident as literature has shown that the general public, particularly cannabis users, do not perceive cannabis use as harmful. In addition, within the public discourse, there is the perception that cannabis use has few negative consequences on health (Gali et al., 2021; Leos-Toro et al, 2020). For example, Leos-Toro et al. (2020) reported that *never* and *ever* users were more likely to report cannabis-related physical concerns than *current* users (*AOR* = 1.89, 95% CI [1.26,2.85], $p$ = 0.002; *AOR* = 1.57, 95% CI [1.07,2.31], $p$ = 0.002, respectively). In addition, the study found that *ever* and *current* users were less likely to report that using cannabis may harm their mental health compared to *never* users (*AOR* = 0.48, 95% CI [0.31,0.74], $p$ = 0.001; *AOR* = 0.35, 95% CI [0.22,0.56], $p$ <0.001, respectively). Study 2 findings suggest that individuals who consume large amounts of cannabis experience cannabis-related harms and compulsive use (CUD), which is similar to findings in alcohol literature. It is important to note that the DSM-5 cannabis use disorder diagnosis requires at least two of the 11 criteria listed in Appendix D within a 12-month period (American Psychiatric Association, 2013).

### *Limitations*

One limitation of Study 2 is the exclusion of predictor variables related to childhood adversity, which has been shown to play a role in cannabis use (Feingold et al., 2020). Future studies may want to replicate Study 2 with the inclusion of childhood adversity to gain better insight into childhood experiences and their impact on cannabis use.

Similar to the majority of studies using survey data, limitations to this study include the use of self-reported data. This may cause an overrepresentation of low-to-moderate users as many individuals often underestimate their use (Skog, 1999b). Additionally, the question used to calculate the number of joints per year may lead moderate users to underestimate as individuals who do not smoke daily may have difficulty averaging their daily joint use for 12 months. Having an overrepresentation of low-to-moderate users, and an underrepresentation of heavy users may have an impact on the logistic regression analysis and group membership predictions.

One interesting perspective that could not be addressed in Study 2 is the concept of positive mental health attributes and the role they may play in preventing light-to-moderate users from becoming heavy users. A study by Butler et al. (2019) used data from the Mental Health Module of the COMPASS study to examine the relationship between mental health and cannabis use among adolescents who use. Students ($n$ = 6,550) from 10 high schools in British Columbia and Ontario answered questionnaires to assess depression and anxiety symptoms, in addition to flourishing and cannabis use frequency (Butler et al., 2019). Flourishing was measured using Diener's Flourishing Scale, which assessed how participants viewed their life purpose and satisfaction, self-esteem, relationships, optimism, and interest in daily activities. Using logistic regression, the study found that anxiety ($OR$ = 1.30, CI =

1.1–1.51, $p = 0.001$) and depression (OR = 1.40, CI = 1.20–1.63, $p < 0.001$) were associated with cannabis use (Butler et al., 2019). However, once flourishing was included as a covariate, the relationship between anxiety, depression, and cannabis disappeared (Butler et al., 2019).

Butler et al. (2019) demonstrated that flourishing strongly affected variance when examining how depression and anxiety predict cannabis use, a finding that has not been demonstrated in previous literature. The study suggested that future research and surveillance tools should control for positive mental health attributes as they may have confounding effects (Butler et al., 2019). Highly influential determinants of heaviest-using group membership are perhaps not attributable to possessing specific characteristics, but rather may involve missing a trait that ultimately contributes to resilience. The concept of including positive mental health attributes as covariates is an important consideration that cannot be addressed in this study because the survey does not ask questions that could examine this relationship.

### *Conclusion*

In conclusion, characteristics that increase the odds of being a heavy cannabis user include being younger in age, initiating cannabis use at a younger age, being male, having a lower education level, having a low personal income, having a nicotine dependency disorder, and having a cannabis use disorder. These findings highlight both the importance of cannabis use reduction and prevention strategies targeted towards youth, in addition to the importance of continued nicotine and cigarette reduction and prevention strategies.

# Chapter 6

# Study 3

## Introduction

The relationships between cannabis consumption trends, use patterns, health outcomes, and policy development approaches may be similar to those of alcohol use. Alcohol reduction and prevention policies have focused on both the heaviest-using and the low-to-moderate-using groups with continuous debate on best approaches and whether a phenomenon called the prevention paradox holds true. This phenomenon suggests that a population-based strategy for harm reduction would be more effective because the low-to-moderate risk group has higher absolute numbers than the high-risk group alone. Therefore, a reduction in harms within the low-to-moderate group would have a greater impact.

Understanding the distribution of cannabis-related harms within a population is critical for public health and safety policy development. This study attempted to answer the question: Does the prevention paradox hold for cannabis use in the United States?

## Methodology

### *Data Source*

This study used the National Epidemiologic Survey on Alcohol and Related Conditions-III (NESARC-III). Please see Chapter 3 (p. 15) for a detailed description of the data source.

### *Sample*

Using the same dataset as Study 2, the final sample size was 3578. For further description of the sample, please see page 32 (Chapter 5, Study 2).

### *Primary Outcome Variables*

The primary outcome variable was whether a respondent experienced at least one of the cannabis-related harms listed in Appendix C.

### *Analytical Plan*

A cannabis-related harm variable was created, with survey respondents receiving a "1" if they answered "yes" to at least one of the cannabis-related harms listed in Appendix C. The study determined the number of individuals in both the heaviest-using group and the low-to-moderate-using group who had experienced at least one cannabis-related harm and survey weights (AUDWEIGHT) were applied to determine population size representation.

### *Research Ethics Board (REB) and Data Access*

The NESARC-III dataset was obtained through the NESARC application process. After applying to UNBC REB, it was deemed that the application did not need REB approval. See Appendix A for a copy of the NESARC application and UNBC REB submission.

## Results

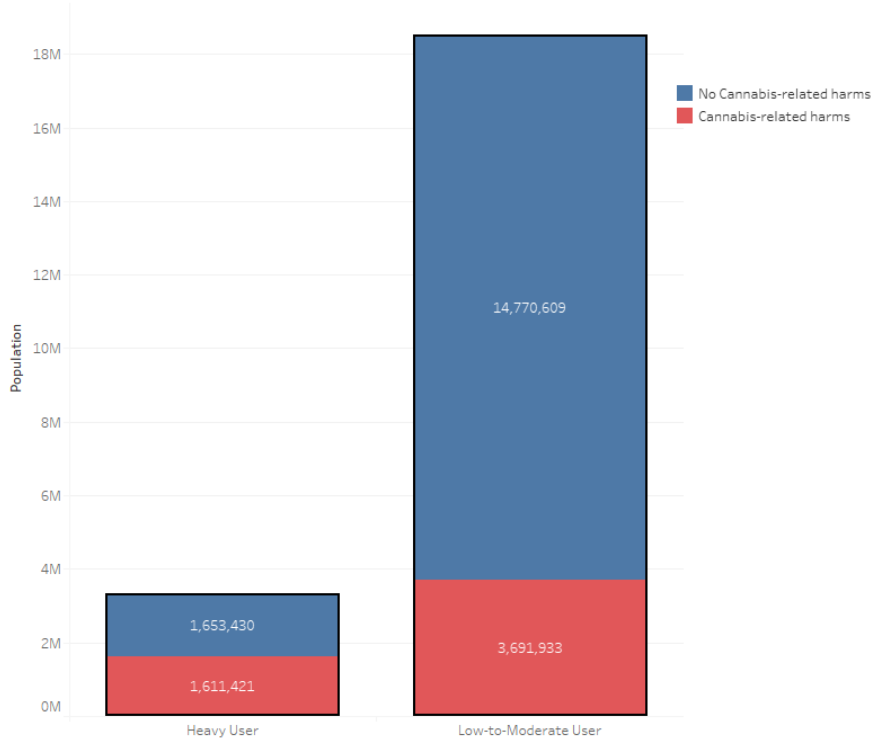
Similar to findings in alcohol prevention paradox research, the study found a larger absolute number of cases that experienced cannabis-related harms in the low-to-moderate-using group.

Figure 6 below displays the population estimates of cannabis-related harms experienced by the heavy-using and low-to-moderate-using groups. Between April 2012 and June 2013, a total of 1,611,421 individuals in the United States experienced cannabis-related harms in the heavy-using group in contrast to 3,691,933 in the low-to-moderate-using group. However, a higher proportion of heavy users (49.4%) experienced cannabis-related harms

compared low-to-moderate users (20.0%). When examining in detail the cannabis-related harms questions included, the main contributing cannabis-related harm was "driving a vehicle when under the influence of marijuana more than once in the past 12 months (N3CD3Q1C47)". Driving under the influence as a cannabis-related harm was experienced in 1,557,943 (47.7%) cases involving heavy users and 3,511,004 (19.1%) cases involving low-to-moderate users when applying population weights.

**Figure 6**

*Population Estimates of Cannabis-Related Harms Experienced by Using Group*




## Interpretation

### *Summary of Results*

Population estimates show that between April 2012 and June 2013, a total of 1,611,421 individuals in the United States experienced cannabis-related harms in the heavy-

using group compared to 3,691,933 in the low-to-moderate-using group.

***Explanation of Findings***

Study 3 findings suggest that the majority of cannabis-related harms in terms of absolute numbers do fall within the low-to-moderate users, which is consistent with previous alcohol prevention paradox literature (e.g., Kreitman, 1986). As such, one might argue that a population-based reduction strategy, rather than a targeted approach, may be more effective in reducing the frequency of cannabis-related harms. However, when reflecting on criticisms made towards the prevention paradox in the context of alcohol, one might apply the same logic to cannabis. One applicable argument is the impact that survey bias may have on the validity of the prevention paradox. Skog (1999b) described survey limitations, including the inability to record the severity of a harm, the frequency with which an individual experiences this harm, and the disproportionate response rate among users, with heavy users typically responding less often. These three factors can exaggerate the representational strength of light-to-moderate users and underestimate the impact of harms among the heaviest users (Skog, 1999b).

Another factor to consider is the impact of culture and stigma around marijuana use on harm perceptions. Reflecting on the study by Santaella-Tenorio et al. (2019) described in Chapter 5, one might ask: As the stigma of marijuana use diminishes, will some types of cannabis-related harms diminish? Will there be a difference in perception of harms between the heaviest and low-to-moderate users? How might this affect the prevention paradox and whether reduction strategies should be population or individual focused? As mentioned previously, Skog (2006) proposed a dual-pronged approach in the context of alcohol, suggesting that prevention policies should contain both targeted and population strategies, in

addition to addressing use patterns, consumption level, and drinking contexts while maintaining flexibility within different drinking cultures. This vision could be applied in the context of cannabis as Study 3 has demonstrated a need for both individual and population prevention strategies.

***Limitations***

Study limitations are consistent with the limitations addressed in Skog's study (1999b) and include (a) the inability to examine the severity of a harm, (b) the inability to examine the frequency of a harm, and (c) potentially disproportionate response rate among users, with heavy users typically responding less often. These three limitations can exaggerate the representational strength of light-to-moderate users and underestimate the impact of harms among the heaviest users. In addition, the study was limited in the types of cannabis-related harms examined as the survey only asked a limited set of questions on cannabis-related harms.

An additional limitation is the subjectivity when answering cannabis-related harms questions. What one individual may consider a harm, another individual may not. An example is the impact that age may have on one's perception of experiencing a cannabis-related harm. The heaviest-using group's average and median ages were 31 and 26 years old, respectively, while the low-to-moderate group's average and median ages were 35 and 32 years old. Given that the heaviest-using group is slightly younger, they may not have had enough time to experience the same harms as the low-to-moderate group, and their perception of experienced harm may be different due to immaturity or limited life experience.

### *Conclusion*

In conclusion, low-to-moderate users experience the highest numbers of cannabis-related harms in terms of absolute numbers. However, a higher proportion of heavy cannabis users experience cannabis-related harms. Therefore, a dual-pronged approach in high-risk and population-based reduction and prevention strategies may be appropriate.

# Chapter 7

## Implications for Policy, Practice, and Research

Overall study findings contribute to the literature by providing further insights into the distribution of cannabis use and cannabis-related harms within the American population, and further understanding of the characteristics of the heaviest-using group. A small percentage of the cannabis-using population (top 10%) consumes a significant portion of the yearly cannabis supply (62%). Characteristics that may increase the odds of belonging to this small group of heavy cannabis users include (a) being male, (b) being younger in age, (c) initiating cannabis use at an early age, (d) having lower socioeconomic standing, (e) having a CUD, (f) and having a nicotine dependency disorder. Consistent with the prevention paradox theory for alcohol, findings demonstrate that a greater number of individuals experience cannabis-related harms in the low-to-moderate group. However, the heaviest users proportionally experience more cannabis-related harms. These findings support the need for a dual-pronged approach, as proposed by Skog (2006).

### Implications for Youth

One implication of the study findings is the negative impacts that initiating cannabis use at an early age may have on consumption patterns. Study 2 found that the past 12-months cannabis users' average age of cannabis initiation was 16.7 years old. In addition, individuals who began using cannabis before age 15 years old were 189% (*OR* = 2.89; CI = 2.00, 4.19) more likely to become a heavy user.

Adolescents cannot legally purchase cannabis products and may put themselves at greater social and health harms. These harms include interactions with adults who conduct illegal activity frequently; exposure to unwanted illegal substances, such as fentanyl-laced

cannabis; and negative impacts to brain/cognitive development (Haines-Saah et al., 2019; Leung et al., 2020; Plunk et al., 2019; Scott et al., 2018).

Given that the NESARC-III survey limits respondents to age 18 years or older, the average age of cannabis initiation might have been found to be lower if adolescents had been allowed to respond to the survey, since the literature has demonstrated that the age of initiation may be decreasing (Hall & Swift, 2000). Future research should further explore cannabis use and harms associated with accessing marijuana by individuals aged 10 to 17 years old. Public policy development should continue to focus on reducing the exposure of youth to cannabis, similar to approaches used with tobacco (Steinberg et al., 2020).

**Implications for Mental Health and Substance Use**

Study findings demonstrated that a significant number of individuals who used cannabis had a psychiatric disorder, potentially informing mental health and substance use policy, practice, and research development. Though Study 2 found that having an anxiety, mood, or personality psychiatric disorder did not significantly increase the risk of being a heavy user (*OR* = 1.20; *p* = 0.22; 95% CI = 0.90, 1.60), it is important to acknowledge the prevalence of having a psychiatric disorder in the cannabis-using community. Factors, such as socioeconomic standing and age first used may have more significant impacts in determining group membership. Given that this study used data from the United States where health care is privatized, future research may want to explore whether these individuals have access to mental health and substance use health care services and whether they are self-medicating.

The Canadian Centre on Substance Use and Addiction (2019) suggests that most cannabis users do not develop a psychiatric disorder, such as depression or anxiety, from

their cannabis use, but rather live with a psychiatric disorder related to other substance use, external chronic life stressors, childhood adversity, and/or living with low socioeconomic status. Thus, it is important to differentiate between population-level risk and individual risk, such as the socioeconomic position of a population or childhood trauma. Understanding what types of risks an individual faces, while considering population-level risks, further supports the concept of a dual-pronged approach for prevention and reduction.

**Implications for Harm Reduction Measures**

As cannabis use is accepted more widely globally and legalization grows, cannabis-related harm reduction measures may evolve similarly to alcohol and tobacco reduction measures. This study highlighted the relationship between nicotine dependency and heavy cannabis use. This finding is consistent with previous research, such as Dierker et al.'s (2018) finding that participants who smoked cigarettes used cannabis more frequently, started using cannabis at a younger age, and reported CUD symptoms more frequently. This finding is important to consider because of the potential for cannabis use to have an impact on tobacco use and vice versa.

Similar to tobacco use, allowing cannabis smoking and vaping in public settings may expose non-users to second-hand smoke and normalize cannabis smoking behaviours in youth (Tobacco Control Network, 2016). A publication by Steinberg et al. (2020) described the experiences and challenges of maintaining smoke-free laws in the seven states that allow recreational cannabis sale: Alaska, California, Colorado, Massachusetts, Nevada, Oregon, and Washington. Within these states, components of a tobacco control framework were applied to identify best practices in cannabis regulation. The authors described how, as legalization grows in the United States, local jurisdictions have been experiencing challenges

with finding acceptable locations for cannabis users to consume legally without violating the smoke-free air laws and ultimately compromising the health of the public (Steinberg et al., 2020).

To add to the complexity, recreational cannabis use is illegal at the federal level in the United States, and thus cannabis users who rent or stay in government housing that bans federally designated illegal substances may incur fines or evictions if cannabis is used on the property, causing a social equity issue (Steinberg et al., 2020). These individuals often belong to the low-income communities that have already been negatively affected by "the war on drugs" and United States drug laws. To address these challenges, some states have or will be developing indoor cannabis consumption lounges (Steinberg et al., 2020). However, these lounges are not without liabilities and disadvantages. For example, they may violate employee safety and protection regarding smoking in the workplace.

Steinberg et al. (2020) concluded by recommending that indoor use continue to be prohibited, but they suggested an alteration in the language surrounding outdoor use. They also noted that stand-alone buildings could be developed to allow use outside where employees and other patrons could avoid exposure to second-hand smoke. Developing these stand-alone buildings might also allow for control of exposure to youth (Steinberg et al., 2020). The authors emphasized that the education of law enforcement members would be critical to prevent discriminatory enforcement (Steinberg et al., 2020).

Steinberg et al.'s (2020) publication demonstrates the need for access to safe locations to use cannabis, particularly for members who rent and live in government housing. Often this population varies in ethnicity, is of lower socioeconomic standing, and may not have access to mental health and substance use services, and thus may self-medicate more

frequently with drugs, such as cannabis.

Study 2 findings indirectly support Steinberg et al.'s (2020) recommendations in terms of demonstrating that the individuals who consume the majority of cannabis are of low socioeconomic standing and that a large majority of users have one or multiple psychiatric disorders. This population of users need access to safe locations for cannabis use and law enforcement training requirements to prevent discrimination. Study 2 findings also suggest a relationship between heavy use and early use, as well as between heavy use and nicotine dependency, supporting the need to control measures that limit exposure to youth, similar to cigarette smoking public policies and control measures.

**Implications for Health Care**

A consideration when discussing future research needs is the impact of widespread cannabis use on the health care system. Shelton et al. (2020) examined why patients come to the Emergency Department (ED) after using cannabis. This study performed a retrospective chart review on patients seen at the Colorado UCHealth Hospital between 2012 and 2016 with ICD-9 and 10-CM diagnosis codes related to cannabis use. Descriptive statistics, chi-square, and t-tests were applied. A total of 449,031 patients were seen between 2012 and 2016, with 9,973 patients presenting with ICD-9 or 10 codes related to cannabis. Upon further evaluation, 2,567 (25.7%) of these diagnoses were at least partially related to cannabis.

Shelton et al. (2020) found that over 65% of the cannabis-attributable cases were male compared to 43.5% of the overall ED visits ($p<.0001$). Patients with cannabis-attributable diagnoses were more frequently admitted to hospital, with 31.6% of cases admitted versus only 15.9% admitted in the overall ED visits ($p<.0001$) (Shelton et al.,

2020). In terms of chief complaints, the most common chief complaint categories for the cannabis-attributable visits were gastrointestinal (GI), intoxication, and psychiatric-related (Shelton et al., 2020). The study reported that 75% of the psychiatric-related visits had chief complaints related to acute complaints, particularly suicidal ideation and anxiety. A large majority of the GI complaints were related to cannabinoid hyperemesis syndrome (repeated and severe vomiting) (85%).

In conjunction with Shelton et al.'s (2020) findings, reports between 2006 and 2011 have shown that hospitalization due to cannabis has increased significantly (Young & Jesseman, 2014). Cannabis-related hospital stays have increased by 44%, while the length of stay due to cannabis-related disorders has increased by 40% (Young & Jesseman, 2014). This is believed to be due to increased cannabis use and complications among youth15–24 years old. Consequently, hospital-associated costs have increased by 52%, with a total cost increase from 9 million to 14 million in Canadian dollars (Young & Jesseman, 2014).

Future research needs include examining health care impacts in terms of cost to the health care system, and utilization of beds in a system that is already at over-capacity (Shelton et al., 2020). One limitation of Study 3 is the inability to examine the impact of cannabis use on the health care system. Though the NESARC-III survey contained questions related to hospitalization, drug rehabilitation, and ED visits due to cannabis use, this information did not provide any insight in to the impact on the health care system. Responses to health care-related cannabis harms questions (Appendix C) were "yes" or "no" and thus did not allow for examination of how long the survey respondents stayed in hospital, the resources utilized during their stay, and the costs incurred during their stay.

# Chapter 8

## Study Strengths

Though survey data studies have limitations, a significant strength of this study is the use of the NESARC-III survey itself. The NESARC-III has a robust methodology for sampling, surveying, weighting, and post-stratification of the data. In addition, the survey allows for a large sample size and uses DSM-5 criteria for analysis of psychiatric and substance use disorders.

An additional strength of this study is the ability to examine quantity-based cannabis use by calculating the number of joints smoked per year. Previous literature suggests that the dosage/potency of cannabis consumed has independent effects from cannabis-use frequency in predicting cannabis-related problems and dependency (Chen et al., 1997; Grant & Pickering, 1998; Walden & Earleywine, 2008). However, national surveys often do not include quantity indicators. Creating a standardized measure, or unit for consumption, is difficult because cannabis can be consumed in many ways, the type of cannabis and THC potency consumed can vary, and many individuals do not know how much THC they are ingesting. Zeisser et al. (2012) standardized a measurement and included quantity as a predictor for problematic cannabis use by defining a "standard joint" as 0.5 g, 5 pipe hits, or 10 puffs. The quantity consumed had an independent and positive effect on the likelihood of experiencing cannabis-related harms (Zeisser et al., 2012). Future research should explore the use of potency and standardized measures when possible. Though this study could not include potency, it did examine quantity according to the number of joints smoked per year, which is an improvement from the majority of previous studies that examined only frequency by day, week, and month.

A final strength is the ability to examine the relationship between psychiatric disorders and heavy cannabis use. This bidirectional relationship between mental health and substance use is complex and multifactorial, but essential to consider when examining characteristics of users.

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# Appendix A

## Copy of the National Institute on Alcohol Abuse and Alcoholism Data Use Agreement and Associated UNBC REB

UNBC UNIVERSITY OF NORTHERN BRITISH COLUMBIA

**RESEARCH ETHICS BOARD**

MEMORANDUM

**To:** Russ Callaghan

**From:** Henry Harder, Chair
Research Ethics Board

**Date:** June 8, 2018

**Re:** Assessment of consumption patterns of cannabis, alcohol and other drugs in the National Epidemiologic Survey on Alcohol and Related Condidtions – III (NESARC 3)

Thank you for submitting the above-noted study to the UNBC Research Ethics Board. Your study has been reviewed and it has been determined that, as presented to us, REB approval is not required.

If you have any questions, or require further clarification, please feel free to contact Isobel Hartley in the Office of Research (reb@unbc.ca or 250-960-6735).

Sincerely,

Dr. Henry Harder
Chair, Research Ethics Board

3333 University Way, Prince George, BC, V2N 4Z9, Telephone (250) 960-6735

National Institute on Alcohol Abuse and Alcoholism
Data Use Agreement

**NIAAA NESARC – III Data Use Agreement**

Date June 5, 2018

Type of Application: New

Date Requested: July 1, 2018: National Epidemiologic Survey on Alcohol and Related Conditions – III (NESARC- III)

**Project Director/Principal Investigator**

First Name: Russell Last Name: Callaghan

Degree: PhD Academic Position (or Title): Professor

Institution: University of Northern British Columbia Department: Northern Medical Program

Street Address: 3333 University Way

City: Prince George State/Province: British Columbia

Zip/Postal Code: V2N 4Z9 County: Canada

Telephone: 250.960.5668 Fax:

E-mail Address: russ.callaghan@unbc.ca

Research Project (title): Assessment of consumption patterns of cannabis, alcohol, and other drugs in the National Epidemiologic Survey on Alcohol and Related Conditions – III (NESARC 3)

By signing and dating this DUA as part of requesting access to NESARC –III data, my Institutional Officials and I certify that we will abide by the DUA and the NIH and NIAAA principles, policies and procedures for the use of the NIAAA NESARC-III. I further acknowledge that I have shared this document and the NIH and NIAAA policies and procedures with all research staff who will participate in the use of the NIAAA NESARC-III.

Signature: Russell Callaghan Date: June 5, 2018

*Authorized Institutional Business Official (as registered in the NIH eRA Commons: https://commons.era.nih.gov/commons/)*

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Name: Mr. Mark Barnes

FWA#:

Title: Director of Research

Signature: Date: June 8, 2018

**Inquiries about NESARC-III Data should be sent to:**
NESARC – III Data Access Committee
Laboratory of Epidemiology and Biometry
National Institute on Alcohol Abuse and Alcoholism
National Institutes of Health
5635 Fishers Ln., Room 3080,
Rockville, MD 20852
E-mail: NIAAA-NESARC-III@mail.nih.gov

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**Senior/KeyPerson Profile (Collaborating Investigator)**

10

First Name: Jordana Last Name: Archer

Degree: BSc Academic Position (or Title) Graduate Student

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Project Role Graduate student Other Project Role Category

**(Add pages if needed)**

## Appendix B

## DSM-5 Diagnosis Criteria Table

*DSM-5 Diagnosis Criteria and Exclusion Criteria (American Psychiatric Association, 2013)*

| Disorder | Diagnosis criteria | Exclusion criteria |
|---|---|---|
| | Mood disorders | |
| Major Depressive Disorder | Five or more of the following have been persistent during the same 2-week period and at least one of the symptoms is either depressed mood or loss of interest:<br><br>1- Depressive mood most of the day, nearly every day as indicated by respondent or observed by others<br>2- Loss of interest or joy in majority of activities indicated by respondent or observed by others<br>3- Significant (more than 5% /month) unintentional weight loss/gain or loss/increase in appetite<br>4- Sleep disturbance nearly every day<br>5- Psychomotor changes observable by others<br>6- Fatigue/low energy or decreased efficiency with routine tasks nearly every day<br>7- Feeling of worthlessness or excessive delusional guilt<br>8- Impaired ability in decision making or concentration indicated by respondent or observed by others<br>9- Recurrent suicidal ideation, or suicide attempt<br><br>Symptoms cause clinically significant deterioration in social, workplace, or other important areas of functioning | 1- Symptoms are not caused by direct physiological effects of substance or medical condition<br><br>2- Symptoms do not meet criteria for mixed episode<br><br>3- There has never been a manic or hypomanic episode<br><br>4- Diagnosis is not better explained by schizophrenia or other psychotic disorder<br><br>5- Symptoms are not better explained for by bereavement |
| Dysthemia | Depressed mood majority of the day, for more days than not indicated by respondent or observed by others for at least 2 years<br><br>Presence of two or more of the following when | 1- There has never been a manic, mixed , or hypomanic episode and criteria for cyclothymia has not |

| | | |
|---|---|---|
| | depressed:<br><br>1- Low appetite or overeating<br>2- Insomnia or oversleeping<br>3- Low energy or fatigue<br>4- Low self-esteem<br>5- Reduced ability to make decisions or concentrate<br>6- Feelings of hopelessness<br><br>During 2 year period, respondent has never been without two or more of the symptoms described above for more than 2 months at a time<br><br>Symptoms cause clinically significant deterioration in social, workplace, or other important areas of functioning | been met.<br><br>2- Diagnosis is not better explained by a psychotic disorder<br><br>3- Symptoms are not caused by direct physiological effects of substance or medical condition |
| Manic | Distinct period of abnormal and persistently elevated or irritable mood in addition to persistent goal-directed behaviour, lasting at least 1 week and present majority of the day, nearly every day.<br><br>-During period of increased energy and mood disturbance, three of the following symptoms are present significantly and cause noticeable change from typical behaviour:<br><br>1- Inflated self-esteem or grandiosity<br>2- Decreased need for sleep<br>3- More talkative than usual<br>4- Racing thoughts<br>5- Distractibility<br>6- Increase in goal-directed activity or psychomotor agitation<br>7- Increased involvement in risky activities<br><br>Mood disturbance is severe enough to impact social or occupational functioning or hospitalization is required to prevent harm. | 1- Symptoms are not caused by direct physiological effects of substance or medical condition |

| | | |
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| Hypomanic | Distinct period of abnormal and persistently elevated or irritable mood in addition to persistent increase activity or energy lasting at least 4 consecutive days present most of the day, nearly every day.<br><br>Three or more of the following symptoms have been persistent:<br><br>1- Inflated self-esteem or grandiosity<br>2- Decreased need for sleep<br>3- More talkative than usual<br>4- Racing thoughts<br>5- Distractibility<br>6- Increase in goal-directed activity or psychomotor agitation<br>7- Increased involvement in risky activities<br><br>Episode associated with change in functioning that is uncharacteristic of the person when not symptomatic<br><br>Disturbance is observable by others<br><br>Episode not severe enough to cause social or occupational impairment | 1- Symptoms are not caused by direct physiological effects of substance or medical condition |
| Bipolar 1 | Has met criteria for at least one manic episode. This may be followed by hypomanic or major depressive episode | 1- Occurrence of manic and major depressive episode is not better explained by schizophrenia spectrum or other psychotic disorders |
| | Anxiety disorders | |
| Specific phobia | Increased fear or anxiety about specific object or situation | 1- Disturbance is not better explained by another mental |

| | | |
|---|---|---|
| | Object or situation always provokes instant anxiety or fear<br><br>Fear or anxiety is exaggerated to actual danger posed<br><br>Object or situation is actively avoided or endured with increased anxiety or fear<br><br>Fear, avoidance, or anxiety causes clinically significant deterioration in social, workplace, or other important areas of functioning<br><br>Fear, avoidance, or anxiety lasts at least 6 months or more | health disorder or other incapacitating symptoms |
| Social phobia | Increased fear or anxiety about social situations in which the respondent may be exposed to possible scrutiny by others<br><br>The social situations almost always increase fear or anxiety<br><br>Person fears that they will act in a way or show anxiety symptoms that will be negatively evaluated<br><br>Fear or anxiety is exaggerated to actual threat posed<br><br>Social situations are actively avoided or endured with increased anxiety or fear<br><br>Fear, avoidance, or anxiety causes clinically significant deterioration in social, workplace, or other important<br><br>Fear, avoidance, or anxiety lasts at least 6 months or more | 1- Disturbance is not better explained by another mental health disorder<br><br>2- Symptoms are not caused by direct physiological effects of substance or medical condition |
| Panic disorder | Recurrent unexpected panic attacks<br><br>One or more panic attacks followed by 1 month or more of one or more of the following: | 1- Disturbance is not better explained by another mental health disorder |

| | | |
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| | 1- Persistent worry about having additional attacks and consequences<br>2- Significant change in behaviour in relation to attacks | 2- Symptoms are not caused by direct physiological effects of substance or medical condition |
| Agoraphobia | Increased fear or anxiety about two or more of the following:<br><br>1- Using public transportation<br>2- Being in open spaces<br>3- Being in enclosed public spaces<br>4- Being in a crowd or in a line up<br>5- Being outside of home alone<br><br>These situations are avoided or endured with increased anxiety or require a companion<br><br>These situations almost always cause anxiety or fear<br><br>The anxiety or fear is exaggerated in relation to the proportion of actual danger<br><br>Fear, avoidance, or anxiety lasts at least 6 months or more<br><br>Fear, avoidance, or anxiety causes clinically significant deterioration in important areas of functioning | 1- Disturbance is not better explained by another mental health disorder |
| General anxiety | Excessive worry or anxiety occurring majority of days for at least 6 months about a variety of events<br><br>Respondent has difficulty controlling worry<br><br>Worry and anxiety associated with three or more of the following:<br><br>1- Restlessness or on edge<br>2- Easily tired | 1- Disturbance is not better explained by another mental health disorder<br><br>2- Disturbance not caused by direct physiological effects of substance or medical condition |

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| | 3- Difficulty concentrating<br>4- Irritable<br>5- Muscle tension<br>6- Sleep disturbances<br><br>Anxiety causes clinically significant deterioration in social, workplace, or other important functioning | |
| Post-traumatic stress | Exposure to potential for death, serious injury, or sexual harm in one or more of the following:<br><br>1- Directly experiencing the traumatic event<br>2- Witnessing the traumatic event<br>3- Learning about traumatic event that impacted close family member of friend<br>4- Experiencing repeated or extreme exposure to highly traumatic details of an event<br><br>Presence of one or more of the following:<br><br>1- Reoccurring distressing memories of traumatic event<br>2- Reoccurring distressing dreams of traumatic event<br>3- Flashbacks as if event was reoccurring<br>4- Distress to internal or external cues of traumatic event<br>5- Increased psychological reactions to internal or external cues<br><br>Persistent avoidance of stimuli related to traumatic event<br><br>Negative changes in cognitions and mood related to traumatic event<br><br>Increased changes in arousal or reactivity related to traumatic event<br><br>Disturbances last 1 month or longer | 1- Disturbance not caused by direct physiological effects of substance or medical condition |

| | | |
|---|---|---|
| | Disturbances causes clinically significant deterioration in social, workplace, or other important areas of functioning | |
| | Personality disorders | |
| Schizotypal | Consistent pattern of social and interpersonal deficits demonstrated by discomfort with, and reduced ability for, close relationships as well as by cognitive or perceptual distortions starting in early adulthood, as indicated by 5 or more of the following:<br>1- Ideas of reference<br>2- Unusual beliefs or magical thinking that influences their behaviour and is not consistent with subcultural norms<br>3- Unusual perceptual experiences<br>4- Unusual thinking and speech<br>5- Inappropriate suspicious thinking or paranoid ideation<br>6-Inappropriate or misaligned emotions, behaviour, or demeanor<br>7- Bizarre behaviour<br>8- Inability to develop close relationships<br>9- Excessive social anxiety due to paranoid fears even in familiar situations | 1- Behaviours and personality trait expression not caused by direct physiological effects of substance or medical condition<br>2- Behaviour not exclusive present during course of schizophrenia or bipolar disorder |
| Borderline personality | Consistent pattern of instability of interpersonal relationships, self-image, behaviours, emotions, and demeanor, and increased impulsivity, starting in early adulthood and present in multiple contexts, as indicated by five or more of the following:<br>1- Excessive effort to avoid real or imagined abandonment<br>2- A pattern of unstable and intense relationships, alternating between idealization and devaluation of partner<br>3- Unstable self-image<br>4- Impulsivity in at least two areas that may be self-damaging<br>5- Recurrent suicidal ideation or behaviour<br>6- Increased reactivity of mood | 1- Behaviours and personality trait expression not caused by direct physiological effects of substance or medical condition |

| | | |
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| | 7- Chronic feelings of emptiness<br>8- Increase chronic anger or difficulty controlling anger<br>9- Paranoid ideation | |
| Conduct disorder | Persistent pattern of behaviours that violate the basic rights of others or age-appropriate societal rules with presence of three or more of the following in the past 12 months, with at least one criterion present within the past 6 months:<br><br>1- Aggression to people and animals<br>2- Destruction of property<br>3- Deceitfulness or theft<br>4- Serious violations of rules<br><br>Disturbances causes clinically significant deterioration in social, workplace, or other important functioning | 1- If age 18 or greater, criteria not met for Antisocial Personality Disorder |
| Antisocial personality disorder | A consistent pattern of disregard for and violation of the rights of others, occurring since at least age 15 years old, as indicated by 3 or more of the following:<br>1- Law breaking<br>2- Deceitfulness indicated by repeated lying and conning<br>3- Impulsivity and inability to plan ahead<br>4- Aggression and irritability indicated by repeated physical fights<br>5- Reckless disregard for the safety of others and self<br>6- Irresponsibility indicated by constant unemployment<br>7- Lack of remorse<br><br>Respondent at least age 18 years old<br>Evidence of conduct disorder with onset before age 15 years old | 1- Behaviours and personality trait expression not caused by direct physiological effects of substance or medical condition<br><br>2- Behaviour not exclusive present during course of schizophrenia or bipolar disorder |

## Appendix C

## Question 3 Harms Variables Table

*Question 3 Harms Variables Table*

| Variables examined | Inclusion responses | Exclusion responses |
|---|---|---|
| Within past 12 months, marijuana negatively impacting work or school (N3CD3Q1C44) | Yes, No | Unknown |
| Within past 12 months, marijuana interfered with taking care of family (N3CD3Q1C46) | Yes, No | Unknown |
| Within past 12 months, more than once drove a vehicle when under the influence of marijuana (N3CD3Q1C47) | Yes, No | Unknown |
| Within past 12 months, inpatient of a psychiatric or general hospital for marijuana (N3DD3Q2C4) | Yes, No | Unknown |
| Within past 12 months, drug or alcohol rehabilitation program for marijuana (N3DD3Q2C6) | Yes, No | Unknown |
| Within past 12 months, emergency room for any reason related to marijuana (N3DD3Q2C8) | Yes, No | Unknown |

## Appendix D

## Cannabis Use Disorder DSM-5 Criteria

1. Substance is often taken in larger amounts and/or over a longer period than the patient intended.
2. Persistent attempts or one or more unsuccessful efforts made to cut down or control substance use.
3. A great deal of time is spent in activities necessary to obtain the substance, use the substance, or recover from effects.
4. Craving or strong desire or urge to use the substance.
5. Recurrent substance use resulting in a failure to fulfill major role obligations at work, school, or home.
6. Continued substance use despite having persistent or recurrent social or interpersonal problem caused or exacerbated by the effects of the substance.
7. Important social, occupational or recreational activities given up or reduced because of substance use.
8. Recurrent substance use in situations in which it is physically hazardous.
9. Substance 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 the substance.
10. Tolerance, as defined by either the following:
    a. Markedly increased amounts of the substance in order to achieve intoxication or desired effect;
    b. Markedly diminished effect with continued use of the same amount;
11. Withdrawal, as manifested by either of the following:
    a. The characteristic withdrawal syndrome for the substance;
    b. The same (or closely related) substance is taken to relieve or avoid withdrawal symptoms.

American Psychiatric Association, 2013