Steering Clear of Cannabis: An Epidemiological Study of Traffic Violations among Emerging Adults who Engage in Regular or Occasional Use of Cannabis

by

Tiana M. Ciccarelli

A thesis

presented to the University of Waterloo

in fulfillment of the

thesis requirement for the degree of

Master of Science

in

Public Health and Health Systems

Waterloo, Ontario, Canada, 2020

AUTHOR'S DECLARATION

ABSTRACT

Background: A drug-impaired traffic violation is observed every three hours in Canada. Yet, there is conflicting evidence to suggest an increased risk of traffic violations in individuals who engage in cannabis use.

Objectives: This thesis studied the association between past-year traffic violations and regular or occasional use of cannabis among emerging adults (EA). Specifically, the objectives are to: (1) estimate the overall, sex-specific, and age-specific prevalence of past-year traffic violations, (2) model the association between cannabis use frequency and traffic violations, adjusting for potential confounding factors; and, (3) test whether sex, age, regular use of alcohol or other drugs, and mood and anxiety disorders moderate the association.

Methods: Data come from the 2012 Canadian Community Health Survey–Mental Health, a cross-sectional epidemiological survey. The analytical sample was comprised of 5,630 weighted participants categorized as: early EAs (15-19 y), middle EAs (20-24 y), and late EAs (25-29 y). Traffic violations were measured using self-report and regular and occasional use of cannabis were measured using the CCHS-MH/WHO-CIDI screening method. Weighted logistic regression was used to determine adjusted estimates and ensure representativeness.

Results: The prevalence of traffic violations in the analytical sample was 14.7%, was higher for males (19.2%), and higher for middle (16.2%) and late (19.4%) EAs. The odds of reporting traffic violations were higher for EAs who engaged in regular [OR=1.93 (1.28-2.92)] or occasional [OR=1.93 (1.35-2.4)] use of cannabis when compared to EAs who were non-users of cannabis. Higher odds of traffic violations were reported in early EAs who engaged in occasional use [OR=3.65 (1.96-6.80)] of cannabis and middle EAs who engaged in regular [OR=2.42 (1.37-4.29)] and occasional [OR=1.70 1.28-3.04)] use of cannabis when compared to their counterparts. Moreover, higher odds of traffic violations were reported in EAs who did not engage in regular use of other drugs but, who engaged in both regular [OR=1.70 (1.08-2.67)] and occasional [OR=1.97 (1.38-2.82)] use of cannabis when compared to their counterparts.

Conclusion: EAs who engage in regular or occasional use of cannabis were shown to have increased risk of traffic violations and this finding was augmented across age groups and use of other drugs. These findings call for population-based preventative interventions as recreational cannabis has been decriminalized in Canada.

ACKNOWLEDGEMENTS

I would like to start off by thanking my supervisor, Dr. Mark Ferro, for taking me on as a student while entering my last year of my master's. I am especially grateful for all your patience, guidance, and support over these past few months. Your tremendous encouragement has allowed me to regain confidence and strive to reach my full potential as both an academic and an individual. It has been an absolute pleasure working together on this thesis project.

I wish to thank my committee members, Dr. Scott Leatherdale and Dr. Chris Perlman. Your expertise, positive feedback, and encouragement were monumental towards the success of this project.

To my colleagues and friends in the School of Public Health and Health Systems, I am whole-heartedly appreciative of the inspiration, motivation, and kindness that you have shown me over the last two years.

Though no amount of "Thank-Yous" will suffice, I would like to express my sincerest gratitude to my family. Dad, Mom, Matteo and Giuliano, thank you for your unparalleled love, endless support and constant encouragement. This journey would not have been possible without you guys, and for that reason, I dedicate this milestone to you.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DSM-5	Diagnostic and Statistical Manual of Mental Disorders – 5th Edition
CCHS-MH	Canadian Community Health Survey – Mental Health
WHO-CIDI	World Health Organization – Composite International Diagnostic Interview
ICD-10	International Statistical Classification of Diseases and Related Health Problems – 10th Edition
SE	Standard Error
OR	Odds Ratio
CI	Confidence Interval

BACKGROUND

1.1. Emerging Adulthood

1.1.1. Theoretical Background

Emerging adulthood has been proposed as a new period of development for late teens through their twenties, specifically ages 18-29 (Arnett, Žukauskienė, & Sugimura, 2014). Emerging adults are distinct from children, adolescents, and adults demographically, subjectively, and regarding identity explorations (Arnett, 2000). In recent decades, there has been a demographic shift in the timing of marriage and adulthood which now take place in the late twenties and early thirties (Arnett, 2000). This shift has led emerging adults to explore different aspects of their lives. For example, about one third of emerging adults attend a post-secondary institute and become semiautonomous, about 40% move out of their parents' home for full-time work, and some emerging adults experience a combination between living at home, going to school, and working (Goldschieder & Davanzo, 1986; Goldschieder & Goldschieder 1994). Additionally, about two thirds of emerging adults cohabit with a romantic partner (Michael, Gagnon, Laumann, & Kolata, 1995). Regarding subjectivity, emerging adults believe they have left adolescence but have not yet entered adulthood (Arnett, 2000). For example, when emerging adults were asked if they feel they have reached adulthood, the majority answered *in some respects yes, in some respects no*, when compared to just answering *yes* or *no* (Arnett, 2001). Concerning identity explorations, emerging adults explore emotional and physical intimacy, different occupancies and post-secondary majors, and changes in worldviews (Arnett, 2000). Moreover, other significant findings in emerging adulthood include increased mental health outcomes and risk-taking behaviours.

1.1.2. Mental Health Outcomes

Emerging adulthood is a period of self-exploration and experimentation which can be overwhelming for an individual. This can often lead to the development of mental health disorders, specifically anxiety and mood disorders (Arnett, Žukauskienė, & Sugimura, 2014). For example, in the Clark University Poll of Emerging Adults, 72% of respondents answered *this time of my life is stressful*, 56% of respondents answered *I often feel anxious*, 32% of respondents answered *I often feel depressed*, and 30% of respondents answered *I often feel that my life is not going well*, when asked how they feel about themselves (Arnett, Žukauskienė, & Sugimura, 2014). Another study determined that perceived adults met the criteria of adulthood, believed they had achieved the criteria of adulthood, had better awareness of their identity and romantic aspirations, were less depressed, and engaged in fewer risk behaviours than their emerging adult peers (Nelson & Barry, 2005). Substance use disorders are also associated with the instability and uncertainty of emerging adulthood (Arnett, 2001). For example, substance use peaks during emerging adulthood and declines following marriage and parenthood (Arnett, 2001). A more recent epidemiological study of substance use disorders among emerging and young adults determined that the odds of reporting alcohol or drug abuse/dependence were higher for both early emerging adults (15-22 years old) and late emerging adults (23-29 years old) when compared with young adults (30-39 years old) (Qadeer, Georgiades, Boyle, & Ferro, 2019).

1.1.3. Risky Driving Behaviour

As previously mentioned, there has been a demographic shift in terms of marriage and adulthood, such as having children and a stable job, which leaves a period of ambiguity between adolescence and adulthood. During this period, emerging adults experience high rates of risky behavior owing to their identity explorations (Arnett, 2001). Specifically, sensation seeking is more prevalent in emerging adults because they have become semiautonomous, are less likely to be watched by their parents, and are not yet constrained by the responsibilities of adulthood (Arnett, 2001). Risky driving behaviours, such as driving at high speeds or while impaired, are common among the emerging adult population (Schulenberg, O'Malley, Bachman, Wadsworth, & Johnson, 1996). Another study predicting recklessness via four psychosocial predictors (i.e., impulsivity, peer pressure, perceived risk, and perceived benefits) in emerging adults found that all four psychosocial predictors were associated with reckless driving (Teese & Bradley, 2008).

1.2. Cannabis Use

1.2.1. Trends

In North America, cannabis is the most frequently used illicit drug (UNODC, 2015). In Canada, the prevalence of past-year cannabis use increased from 3.6 million users in 2015 (12%) to 4.4 million users in 2017 (15%). Higher use is found among males compared to females (19% vs. 11%) and younger people (youth 15-19 years, 19%; young adults 20-24 years, 33%; adults 25 years or older, 13%) (Government of Canada, 2019). These findings are consistent with previous reports (Degenhardt & Hall, 2012). While the prevalence of past-year cannabis use for adults aged 25 years or older increased from 2015 to 2017, it remained unchanged for youth and young adults (Government of Canada, 2019). With recent legalization in Canada and some U.S. states, the prevalence of past-year cannabis use is expected to continue trending upward. In Colorado, past-year cannabis use in users aged 18-25 has increased from 39% (pre-legalization) to 48% (post-legalization) (Substance Abuse and Mental Health Services Administration, 2016). The increase in prevalence of past-year cannabis use may be attributable to the decrease in perceived risk of cannabis and normalization (Spackman et al., 2017; Hathaway, Mostaghim, Erickson, Kolar, & Oborne, 2018; Brochu, Duff, Asbridge, & Erickson, 2011).

1.2.2. Perceptions and Motivations

The 'normalization thesis' is a theoretical framework used to explain the cultural and societal shifts associated with illicit substance use, including cannabis (Parker, Measham, & Aldridge, 1995). Moreover, recent research suggests that cannabis use, previously condemned as deviant behaviour, has become more tolerable across society (Measham, Newcombe & Parker, 1994; Duff, 2005; Cheung & Cheung, 2006). Parker and colleagues discovered six indicators of substance normalization, they include: (1) better accessibility and availability of the substance, (2) higher prevalence rates of the substance, (3) an increasingly positive outlook regarding substance use among both users and non-users, (4) substance use expectations among abstainers, (5) media influence on substance use, and (6) liberal policy shifts towards legalization (Parker, 2005). Normalization studies have primarily focussed on youth and adolescents, however recent findings reveal homogeneity in cannabis consumption and perceptions about use into young adulthood (Duff et al., 2011; Aldridge, Measham, & Williams, 2011). Consequently, cannabis normalization has been shown to offset the harms associated with cannabis use based on personal experience. For example, participants described health risks (i.e., mood disorders, respiratory problems, pregnancy) as less meaningful than the health risks associated with alcohol or tobacco and that these risks can be lowered by decreasing the frequency and quantity of cannabis consumption (Duff & Erickson, 2014).

1.3. Harms Associated with Cannabis Use

The harms associated with cannabis use are dependent upon dosage, route of administration, previous experience, current attitudes and mood, and social setting (Hall & Pacula, 2003; WHO, 2016).

1.3.1. Acute Harms

Acute harms of cannabis, or short-term effects, occur when the associated harm is immediately preceded by cannabis exposure (WHO, 2016). Short term effects include impaired cognition and coordination (i.e., reduced information processing, perceptual-motor coordination, motor performance, attention, and tracking behavior) anxiety and psychotic symptoms (i.e., panic attacks and hallucinations), cardiovascular effects (i.e., increased heart rate and blood pressure), and traffic injuries and fatalities (Hall & Degenhardt, 2009; Crean, Crane, & Mason, 2011; Smith, 1968; Pacher & Kunos, 2013; Asbridge, Hayden, & Cartwright, 2012).

1.3.2. Chronic Harms

Chronic harms of cannabis, or long-term effects, occur when the associated harm arises from regular cannabis exposure, especially daily use, over prolonged periods of time (WHO, 2016). Long term effects include impaired cognitive function (i.e., lower IQ scores and structural changes in the brain), psychosocial consequences (i.e., lack of educational attainment and additional substance use), comorbid mental disorders (i.e., schizophrenia, depression, anxiety, and bipolar), comorbid physical disorders (i.e., cancer, respiratory, and cardiovascular diseases) and dependence (i.e., cannabis use disorder) (Auer et al., 2016; Solowij et al., 2013; Fergusson, Boden, & Horwood, 2015; Di Forti et al., 2015; Lai & Sitharthan, 2012; Swift, Hall, Tesson, 2001; Hall & Pacula, 2010).

1.4. Cannabis Use and Driving

1.4.1. Current Legislature

The legal age to purchase and consume recreational cannabis is 19 years in most provinces, with the exception of Alberta and Quebec, in which the legal age is 18 years (Bill C-45, 2018).

In most provinces, an individual can obtain a driver's license (learner's permit) if they are 16 years old and accompanied by someone with a full valid driver's license. However, the following are notable exceptions: Alberta, Manitoba and Saskatchewan. In Alberta, an individual can obtain a learner's permit if they are 14 years old and accompanied by someone over the age of 18 who is a non-probationary licensed driver (Government of Alberta, 2019). In Manitoba, an individual can obtain a learner's permit if they are 15.5 years old, entered in a driver's education program, and supervised by a driver who has held a full valid driver's license for 3 or more years (Manitoba Public Insurance, 2019). In Saskatchewan, an individual can obtain a learner's permit if they are 15 years old, have parental approval, and are enrolled in a driver's education program (SGI, 2019).

There are three federal offences in the Criminal Code of Canada for driving under the influence of cannabis, they include: (1) driving with at least 2 nanograms (ng) but less than 5 ng of tetrahydrocannabinol (THC) per millilitre (ml) of blood, (2) driving with 5 or more ng of THC per ml of blood, and (3) driving with a combination of 50 or more mg of alcohol plus 2.5 or more ng of THC per 1 ml of blood (Bill C-46, 2018). Driving with at least 2 ng but less than 5 ng of THC per ml of blood will result in a maximum $1,000 fine. Driving with more than 5 ng of

THC per ml of blood or driving with a combination of 50 or more mg of alcohol plus 2.5 or more ng of THC per 1 ml of blood will result in a mandatory minimum fine of $1,000 on the first offence with increasing severity of penalties for subsequent offences. There is also a zero-tolerance policy for both young drivers and commercial drivers (Bill C-46, 2018). Both young and commercial drivers who violate zero tolerance will be required to pay a $250 fine and have their license suspended for 3 days on their first offense (Ministry of Transportation, 2013). If convicted in court on the first offense, both young and commercial drivers will be required to pay an additional fine up to $500, have their license suspended for a minimum of one year, attend an education or treatment program, use an ignition interlock device for a minimum of one year, and undergo a mandatory medical evaluation to determine fitness to drive (Ministry of Transportation, 2013). The penalties for drug impaired driving and court conviction increase in severity for any subsequent offences within 10 years (Ministry of Transportation, 2013).

1.4.2. Screening and Detection

Currently, there are four universal methods used to determine cannabis impairment, they include: standardized field sobriety tests, drug recognition experts, blood/serum testing, and oral fluid testing.

Standardized field sobriety tests were originally created to detect impairment by alcohol and are comprised of three different tests (i.e., Horizontal Gaze Nystagmus Test, Walk and Turn Test, and the One-Leg Stand Test) (Stuster & Burns, 1998). However, research remains mixed on whether standardized field sobriety tests can detect cannabis impairment (Bosker et al., 2012a). For example, dose-dependent dronabinol (synthetic THC) impairment was observed in occasional cannabis users and regular cannabis users when compared to a placebo however, the results of the standardized field sobriety tests did not reveal cannabis impairment in any of the three conditions (Bosker et al., 2012b). In contrast, other studies found that chronic cannabis users had higher failure rates on standardized field sobriety tests when compared to a control group (Doroudgar et al., 2018; Porath-Waller & Beirness, 2013; Bosker et al., 2012a). Drug recognition experts are certified police officers trained to distinguish drug impairment by conducting an evaluation of the physical, mental and medical state of a person (Talpins & Hayes, 2004). A study of 302 cannabis drug recognition expert cases determined that the most common predictors of cannabis impairment included increased heart rate, lack of convergence, dilated pupils, rebound dilation, and failure to successfully complete 2 of 4 psychological tasks (Hartman, Richman, Hayes, & Huetis, 2016). However, both standardized field sobriety tests and drug recognition expert examinations fail to meet sensitivity or specificity standards for cannabis impairment (Capler, Bilsker, Van Pelt, & MacPherson, 2017) and have not been empirically validated for drugs other than alcohol (Bosker et al., 2012a).

The biological testing of blood/serum and oral fluid may serve to confirm observations from standardized field sobriety tests and drug recognition experts in detecting cannabis impairment. However, researchers argue that cannabis impairment cannot be determined by specific THC concentrations because: (1) THC concentrations in blood may be considerably less at the time of collection since concentration levels drop significantly within the first two hours of use (Schwope, Karschner, Gorelick, & Huestis, 2011), (2) THC may be detected in oral fluid by passive contamination (Lee & Huestis, 2014), (3) tolerance results in less impairment among high frequency cannabis users than low frequency cannabis users at the same dose of THC (Reisfield, Goldberger, Gold, & DuPont, 2012), and (4) THC may be present in the blood for several days following use (Papafotiou, Carter, Stough, 2005).

1.4.3. Perceived Risk

According to the Canadian Alcohol and Drug Use Monitoring Survey, approximately 20% of cannabis users with a valid driver's license self-reported driving within two hours of cannabis consumption in the past year (Health Canada, 2013). Recent studies indicate low perceived risk of consequences when driving under the influence of cannabis which may help to explain this trend (Goodman, Leos-Toro, & Hammond, 2019; Wickens, Watson, Mann, & Brands, 2019; Malhorta, Starkey, & Charlton, 2017; Swift, Jones, & Donnelly, 2010). In a Canadian sample of young people (i.e., 16-30 years old), 28% of respondents reported 'not at all' or 'a little' when asked if they believe cannabis increased the risk of a motor vehicle accident and 38% of respondents believed that an individual driving under the influence of cannabis would be unlikely to be stopped by law enforcement (Goodman, Leos-Toro, & Hammond, 2019). Moreover, respondents believed that individuals driving under the influence of cannabis would be less likely to be charged with an offence and a respondent would be less likely to intervene if a friend had used cannabis and was going to drive, when compared to individuals driving under the influence of alcohol (Goodman, Leos-Toro, & Hammond, 2019). Another factor that leads to decreased perceived risk of driving under the influence of cannabis is the absence of social activism and mass-media campaigns related to driving under the influence of cannabis compared to driving under the influence of alcohol (i.e., Mothers Against Drunk Driving) (McGuire, Dawe, Shield, Rehm, Fischer, 2011).

1.4.4. Perceived Driving Behaviours

An individual's perceived driving behaviour has also been associated with driving under the influence of cannabis (Watson, Mann, Wickens, & Brands, 2019; Macdonald et al., 2008; Terry & Wright, 2005). For example, a study of cannabis users in a remedial program for convicted or suspended drivers found that respondents believed driving under the influence of cannabis was ordinary and part of their daily routine (Watson, Mann, Wickens, & Brands, 2019). Moreover, most respondents reported that they did not have to adjust their driving behaviours to offset impairment (Watson, Mann, Wickens, & Brands, 2019). In a similar study, individuals in a treatment program for regular use of cannabis who reported no negative effects of cannabis (i.e., nervousness, alertness, feeling disoriented, etc.) believed they drove more cautiously, or their driving was unaffected while under the influence of cannabis (Macdonald et al., 2008). Conversely, reporting negative effects of cannabis was associated with a lower frequency of driving under the influence of cannabis (Macdonald et al., 2008).

1.4.5. Driving Performance

While individuals feel as though their driving behaviours remain unaffected or improve after using cannabis, the literature on cannabis consumption and impaired driving for both simulated and actual driving performance remains mixed (Micallef et al., 2018; Doroudgar et al., 2018; Hartman et al., 2015). For example, a study of moderate (i.e., less than 8 cannabis cigarettes per day) and occasional (i.e., smoking THC less than once a month) cannabis smokers determined that THC was associated with drowsiness, inappropriate line crossings, and deviation of the lateral position of a vehicle in both simulated and actual driving performance (Micallef et al., 2018). A study of regular cannabis use and simulated driving performance determined that individuals who engage in regular use of cannabis (i.e., using cannabis 4+ days per week) were more likely to fail standardized field sobriety tests, had slower reaction times, less standard deviation of speed, and decreased ability to match the lead vehicles speed when compared to abstainers (Doroudgar et al., 2018). Comparable effects on driving performance were shown for both oral (Bosker et al., 2012b) and vaporized (Arkell et al., 2019; Hartman et al., 2015) cannabis consumption. Conversely, a study of individuals who engage in regular use of cannabis (i.e., smoking 1 or 2 cannabis cigarettes per day) and occasional use of cannabis (i.e., smoking 1 or 2 cannabis cigarettes per week) found that occasional use was associated with driving with less caution, having poorer driving performance, and having effects of impairment lasting longer when compared to regular use, despite individuals who partake in regular use having higher blood concentrations of THC (Hartley et al., 2019). Lower levels of impairment in individuals who engage in regular use of cannabis despite high blood concentrations of THC when compared to individuals who engage in occasional use of cannabis may be attributed to (1) tolerance; namely the reduced responsiveness of the reward circuitry to cannabis intoxication responsible for the subjective high and ability to sustain an attention task in a chronic cannabis user (Mason et al., 2019) and higher baseline levels of THC in the blood from previous use (Papafotiou, Carter, Stough, 2005), ability to compensate for impairment in more experienced cannabis users by slowing down and reducing risk-taking behaviours (Smiley, 1986; Kalant & Porath-Waller, 2019), and (3) differences in smoking and inhalation techniques between regular use and occasional use (Fabritius et al., 2013). Studies of biological impairment and driving performance have habitually focussed on acute consumption with impairment present when there is ≥ 2 ng of THC per mL of blood however, future research is warranted on the biological impairment of individuals who engage in regular use of cannabis (Hartman & Huestis, 2013).

1.4.6. Traffic Violations

A traffic violation occurs when a driver disobeys legislation that regulates the operation of vehicles on streets and highways (FindLaw, n.d.). There are two types of traffic violations: moving violations and non-moving violations. A moving violation occurs when a driver violates laws while the vehicle is in motion, such as failure to stop at a stop sign or a red light, speeding, impaired driving, driving with no headlights, and reckless driving (FindLaw, n.d.). A non-moving violation occurs when a driver violates laws while the vehicle is not in motion, such as parking in front of a fire hydrant, in a no parking-zone, in front of an expired meter, and having unnecessary muffler noise (FindLaw, n.d.).

In Canada, a drug-impaired traffic violation is observed every three hours (Statistics Canada, 2015). Among drivers arrested for impairment, cannabis is the most frequently detected substance succeeding alcohol (Kalant & Porath-Waller, 2019). Moreover, a Canadian study of fatal traffic accidents determined that approximately 17% of individuals tested positive for cannabis and 40% of the fatalities were in emerging adults aged 16-24 who consumed cannabis prior to the crash (Kalant & Porath-Waller, 2019; Beirness, Beasley, & Boase, 2013). However, study limitations cannot prove that these fatalities were a result of cannabis impairment (Kalant & Porath-Waller, 2019). Little research exists on traffic violations in emerging adults who engage in regular or occasional use of cannabis. A study of collisions and traffic violations for individuals in treatment for regular substance use (i.e., alcohol, cocaine, and cannabis) found that all three treatment groups were more likely to get a traffic violation when compared to matched controls (Macdonald, Mann, Chipman, & Anglin-Bodrug, 2004). Similarly, engaging in regular cannabis use prior to treatment was significantly associated with “at fault” crashes (Chipman, Macdonald, Mann, 2003). Most of the literature highlights the association between acute cannabis consumption and risk of a traffic accident, with heterogenous results. A case-crossover study of Canadian drivers determined that the odds of a traffic accident were 4 times higher for individuals reporting cannabis use prior to the accident than individuals not reporting cannabis use prior to the accident (Asbridge et al., 2014). These findings were similar to other research on acute cannabis impairment and risk of a traffic accident (Li et al., 2012). In contrast, a meta-analysis of acute cannabis impairment and risk of a traffic accident determined that inadequate attempt to control for confounding has led to an overestimation of reported associations in the literature and that the risk of a traffic accident is not of similar magnitude as seen in alcohol impairment (Rogeberg & Elvik, 2016). However, the additive effect of cannabis and alcohol increases the risk of a traffic accident substantially (Hartman & Huestis, 2013).

1.5 Theory of Planned Behaviour

The Theory of Planned Behaviour is a model that was created to help predict when and where an individual will engage in a behaviour (Ajzen, 1985). More recently, health psychologists have used the Theory of Planned Behaviour to help understand how likely an individual will engage in a healthy or unhealthy behaviour based on their perceptions and beliefs about the behaviour (LaMorte, 2019). There are three factors which influence an individual's intention to engage in a health behaviour, they are: (1) attitude toward the behaviour, (2) subjective norm, and (3) perceived behavioural control. A person's attitude toward the behaviour is influenced by their behavioural beliefs, or what they believe will be the outcome of engaging in the behaviour. As previously mentioned, young people in Canada believe that cannabis does not increase the risk of a motor vehicle accident and that individuals who drive under the influence of cannabis are not likely to be stopped by police (Goodman, Leos-Toro, & Hannmond, 2019), thus leading to a positive attitude toward driving under the influence of cannabis. Subjective norms are motivated by normative beliefs, or what others think about engaging in the behaviour. For example, a study of college students discovered that lower perceived risk of penalties and greater perceived acceptance by peers was associated with increased likelihood of driving under the influence of cannabis (McCarthy, Lynch, & Pederson, 2007). An individual's perceived behavioural control is partial to their control beliefs, or how confident an individual feels about engaging in the behaviour, despite barriers which may hinder performance. As cited in the literature review, Canadian drivers in a remedial program believed that driving under the influence of cannabis was normal and that they did not have to make any adjustments to compensate for impairment (Watson, Mann, Wickens, & Brands, 2019). Thus, a positive attitude towards the behaviour, favourable subjective norms, and increased perceived behavioural control form an intention, which is then succeeded by engagement in the behaviour. Moreover, the Theory of Planned Behaviour can be used as a framework to implement population-based interventions to reduce driving under the influence of cannabis.

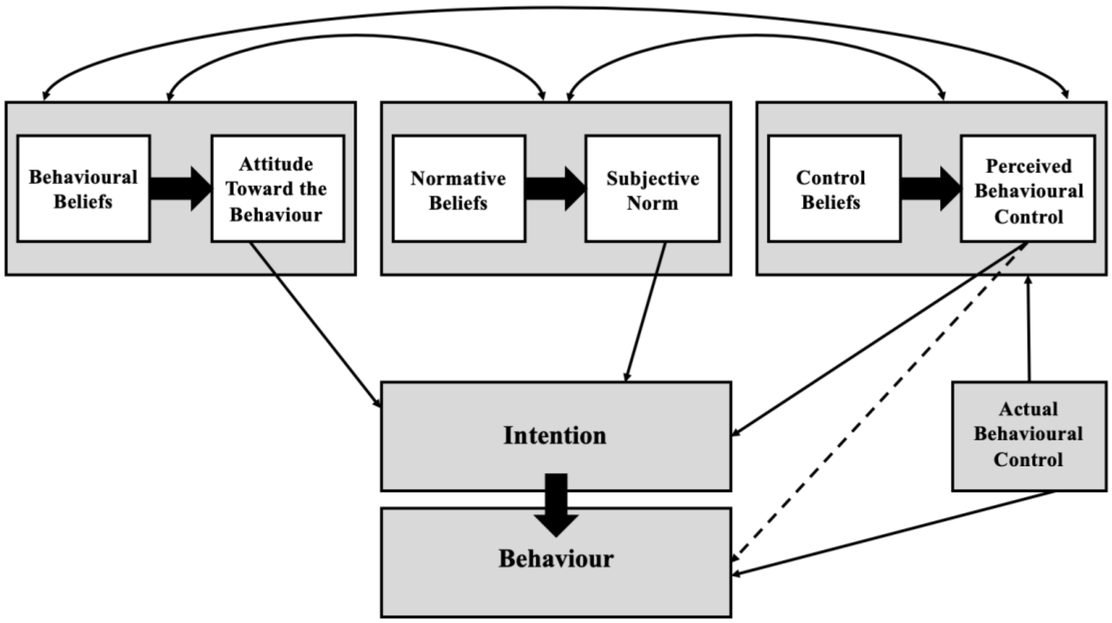


Figure 1. The Theory of Planned Behaviour Model (LaMorte, 2019).

STUDY RATIONALE & RESEARCH OBJECTIVES

2.1. Study Rationale

2.1.1. Addressing the Knowledge Gaps and Problems in Current Research

The purpose of the current study was to investigate the association between both regular and occasional use of cannabis and traffic violations among emerging adults in a Canadian sample. As presented in the literature review, prior research on this topic is limited. The present study aimed to address the following knowledge gaps and limitations within the field:

1. *Limited research exists on regular use of cannabis and traffic violations*. Currently, most research is focused on acute impairment and is conducted in laboratory or treatment group settings. Some research on regular cannabis use exists, however researchers define 'regular use' differently. Addressing this limitation is vital because individuals who engage in regular use of cannabis may have lower levels of impairment despite higher blood concentrations of THC when compared to occasional users (Hartley et al., 2019) which may be owing to the strategies used by more experienced users to compensate for impairment (Smiley 1986; Kalant & Porath-Waller, 2019). This can lead to the unfair criminalization of individuals who engage in regular use of cannabis because the current policy on cannabis impairment is determined by blood concentrations of THC in addition to field sobriety testing. This study can help to understand the association between cannabis use frequency and traffic violations from a policy standpoint, to ensure both safety and justice for cannabis consumers.

2. *Research on regular cannabis use and risk of a traffic violation is mixed.* Currently, some research demonstrates an association between regular cannabis consumption and traffic violations, while other studies show no association. Moreover, research suggests that null findings may be owing to tolerance and greater ability to compensate for impairment in chronic users when compared to occasional users (Watson, Mann, Wickens, & Brands, 2019). Addressing this limitation is important because researchers, health care professionals, and policy makers are concerned that legalization may be associated with an increase in cannabis consumption and thus, an increase in traffic violations. Given that the Canadian Community Health Survey – Mental Health (CCHS-MH) data is from 2012, this study can serve as a framework for future research on cannabis consumption and traffic violations when data after legalization becomes available.

3. *Adequate controls for known confounders are not included.* Currently, studies showing associations between cannabis use and traffic violations may be overestimations of findings because most do not adequately control for known confounders (Rogeberg & Elvik, 2016). Addressing this limitation is imperative to ensure that appropriate findings are represented in the literature. The current study aims to address this issue by controlling for known confounders as outlined by Rogeberg & Elvic (2016).

4. *No research has been conducted within the emerging adult population.* Currently, studies on the association between cannabis use and traffic violations are conducted in the adolescent and adult populations. However, emerging adults are more likely to engage in risk behaviours such as increased substance use and impaired driving because they are less likely to be monitored by their parents than youth and are not yet obliged by the

responsibilities of adulthood. It is important to address this problem because the leading cause of injury deaths among young people is unintentional motor vehicle traffic accidents (Centers for Disease Control and Prevention, 2019). The current study can help to understand if either regular or occasional cannabis use plays a role in this relationship.

2.2. Objectives and Hypotheses

The current study explored the association between regular or occasional use of cannabis and past-year traffic violations among emerging adults (15 to 29 years) using quantitative analyses of the CCHS-MH. The objectives of the study and subsequent hypotheses are listed below:

2.2.1. Objective 1

To estimate the (i) general, (ii) sex-specific, and (iii) age-specific prevalence of past-year traffic violations in emerging adults who engaged in regular or occasional use of cannabis when compared to emerging adults who were non-users of cannabis. Based on previous research, it was hypothesized that the prevalence of past-year traffic violations would be higher among (i) emerging adults who engaged in regular or occasional use of cannabis, (ii) male emerging adults, and (iii) middle and late emerging adults.

2.2.2. Objective 2

To model the association between lifetime cannabis use frequency and past-year traffic violations among emerging adults, adjusting for potential confounding factors. Given that the current research on the association between traffic violations and regular cannabis use is mixed, it was hypothesized that the odds of reporting past-year traffic violations would be higher for emerging adults who engaged in regular and occasional use of cannabis when compared to emerging adults who were non-users of cannabis.

2.2.3. Objective 3

To estimate the degree to which (i) sex, (ii) age, (iii) regular use of alcohol, (iv) regular use of other drugs, (v) co-morbid mood disorder, and (vi) co-morbid generalized anxiety disorder moderate the association between lifetime cannabis frequency (i.e., regular use and occasional use) and past-year traffic violations among emerging adults. Based on previous research, it was hypothesized that in the presence of each moderator (i.e., male sex, middle and late emerging adulthood, regular use of alcohol, regular use of other drugs, co-morbid mood disorder, and co-morbid generalized anxiety disorder) emerging adults who engaged in regular or occasional use of cannabis would have higher odds of reporting traffic violations when compared to emerging adults who were non-users of cannabis.

METHODS

3.1. Study Design

The CCHS-MH was a national study with a cross-sectional design developed by Statistics Canada and stakeholders from Health Canada, the Public Health Agency of Canada, the Provincial Health Ministries, the Mental Health Commission of Canada, and academic experts (Statistics Canada, 2013a). The CCHS-MH was created to understand the mental well-being, daily functioning, and access to mental health services and supports of Canadian residents (Statistics Canada, 2013a). A three-stage design was used to select the respondents for the study. Clusters were selected first, followed by households within each cluster, and finally one respondent $\geq$ 15 years-old was randomly selected (Statistics Canada, 2013a). Geographical clusters were selected using the Canadian Labour Force Survey whereby independent samples are drawn from homogeneous strata and households are then selected from the corresponding household lists for each stratum (Statistics Canada, 2013a). Respondents aged 15 or older were randomly selected via a selection probability method. In each household, those $\geq$ 15 years-old were assigned a selection probability factor to help achieve the target population (Statistics Canada, 2013a). The selection probabilities assigned to each respondent were as follows: multiplicative factor of seven for respondents aged 15-24 and a multiplicative factor of one for respondents aged 25-44, 45-64, and 65+ (Statistics Canada, 2013a). After each household member was assigned a selection probability, one member of the household was randomly selected via a computer program which incorporated the selection probabilities (Statistics Canada, 2013a).

3.2. Study Sample

The CCHS-MH consisted of 25,113 respondents aged 15 years of age or older living in the ten provinces (Statistics Canada, 2013a). Approximately 3% of the target population was excluded from this study and included persons living on reserves and in other Indigenous communities, full-time members of the Canadian Forces, and the institutionalized population (Statistics Canada, 2013a).

3.3. Data Collection

The data for the CCHS-MH was collected voluntarily from respondents from January 2012 to December 2012 (Statistics Canada, 2013a). Prior to interviewing, introductory letters and brochures were mailed to the households of the individuals chosen to participate, outlining the purpose, importance, and implications of the study (Statistics Canada, 2013a). Following introductory letters, interviewers initiated contact with respondents via telephone to arrange an in-person interview (Statistics Canada, 2013a). Most interviews (87%) were conducted in the respondents' homes and the remaining interviews were conducted via telephone (Statistics Canada, 2013a). Interviews were conducted using computer assisted personal interviewing (CAPI), which is an interviewing technique that uses a computer to administer a survey and collect responses (Statistics Canada, 2013a, 2017). The computer program also takes an audio recording of the respondent while the interviewer inputs the answers to the survey, which can be referred to after study completion should any issues arise (Statistics Canada, 2017). The interviews were conducted by regional office project managers and senior interviewers for the CCHS-MH (Statistics Canada, 2013a).

3.3.1. Weighting

To ensure that the survey data is nationally represented, a survey weight was given to each respondent which corresponds to the number of individuals nationally represented by that respondent (Statistics Canada, 2013b). This process was used to control for non-response, removal of out-of-scope households, and extreme weight outliers (Statistics Canada, 2013b).

3.3.2. Analytical Sample

The analytical sample obtained from the CCHS-MH for the purpose of this study comprised 5,630 weighted respondents aged 15 to 29 years old.

3.4. Study Measures and Variables

3.4.1. WHO-CIDI

The World Health Organization version of the Composite Diagnostic Interview (WHO-CIDI) was a comprehensive interview used to assess mental disorders and conditions according to the definitions and criteria presented in the DSM-IV and ICD-10 (International Statistical Classification of Diseases and Related Health Problems – 10th Revision) (Statistics Canada, 2013b). The criteria for lifetime cannabis dependence, lifetime alcohol abuse or dependence, lifetime drug abuse or dependence (excluding cannabis), and lifetime mood disorder as defined in the CCHS-MH are comparably enumerated to the DSM-IV however, everyday language was used to improve response rate and interpretation of results (Statistics Canada, 2014). Due to the minor differences between the CCHS-MH and DSM-IV, it is incorrect to assume an association between the two (Statistics Canada, 2014). It is important to note that the sections on lifetime cannabis dependence, lifetime alcohol abuse or dependence, lifetime drug abuse or dependence, and lifetime mood disorder were measured using the CCHS-MH/WHO-CIDI and not self-report.

For the purpose of this thesis, the respondents who answered *"don't know/refusal"* or did not answer the question were excluded from the analyses because they were coded into a single variable and thus, cannot be explored independently.

3.4.2. Outcome

The outcome, or dependent variable, in this study was self-reported, past-year traffic violations. Respondents were asked the following question in a section about contact with police, *"In the past 12 months, did you come into contact with police for a traffic violation?"* proceeded by the following answers, *"Yes, no, don't know/refusal"* (Statistics Canada, 2011).

3.4.3. Exposure

The exposure, or independent variable, in this study was lifetime cannabis use frequency. The lifetime cannabis use frequency variable was mutually exclusive and consists of three different categories of cannabis users, they include, emerging adults who engaged in regular use of cannabis, emerging adults who engaged in occasional use of cannabis, and emerging adults who have not currently engaged in cannabis use. These categories were derived from the following CCHS-MH variables: *lifetime cannabis dependence, lifetime cannabis abuse, lifetime cannabis use including one-time use, lifetime cannabis use excluding one-time use, and lifetime cannabis abstinence* (Appendix A – Tables 1-3). The classification of each variable is described below.

Lifetime cannabis dependence was classified as a categorical variable and was used to create a new category, regular use, in the cannabis use frequency variable. The section relating to lifetime cannabis dependence was measured using the CCHS-MH/WHO-CIDI screening method. To reduce respondent burden, the section related to cannabis dependence was introduced if respondents reported using marijuana more than 50 times in their lifetime. For example, *"Have you used marijuana or hashish more than 50 times in your lifetime?"* proceeded by the following answers, *"Yes, no, don't know/refusal"* or *"In your lifetime, how many times have you used marijuana or hashish?"* proceeded by the interviewer entering a number between 2 and 995 (Statistics Canada, 2011). The following was the criteria for the CCHS-MH/WHO-CIDI that needed to be met to be categorized as having lifetime cannabis dependence:

I. at least three symptoms of cannabis dependence (i.e., tolerance, withdrawal, increased consumption, attempts to quit, time lost, reduced activities);

and

II. a maladaptive pattern of cannabis use demonstrated by three or more symptoms occurring at the same time, in the same 12-month period (Statistics Canada, 2014).

Lifetime cannabis abuse was classified as a categorical variable and was used to create a new category, regular use, in the cannabis use frequency variable. Lifetime cannabis abuse was measured using the CCHS-MH/WHO-CIDI screening method. The section related to cannabis abuse was initiated if respondents reported using marijuana or hashish more than once in their lifetime. For example, *"Have you ever used or tried marijuana or hashish?"* proceeded by the following answers, *"Yes (just once), yes (more than once), no, don't know/refusal"* (Statistics Canada, 2011). The following was the criteria for the CCHS-MH/WHO-CIDI that needed to be met to be categorized as having lifetime cannabis abuse:

I. the respondent didn't meet the criteria for cannabis dependence;

and

II. experienced at least one of the four symptoms of cannabis abuse (i.e., interfering with responsibilities, social problems, continued use despite problems, risk of injury) (Statistics Canada, 2014).

Lifetime cannabis use excluding one-time use (more than once) was classified as a categorical variable and was used to create a new category, occasional use, in the cannabis use frequency variable. 'More than once use' was measured using the CCHS-MH/WHO-CIDI screening method. Respondents were asked the following question about their use of cannabis, *"Have you ever used or tried marijuana or hashish?"* proceeded by the following answers, *"Yes (just once), yes (more than once), no, don't know/refusal"* (Statistics Canada, 2014). If respondents reported using cannabis more than once, they were categorized into the variable which did not include one-time use of cannabis.

Lifetime cannabis use including one-time use (ever use) was classified as a categorical variable and was used to create a new category, non-use, in the cannabis use frequency variable.

‘Ever use’ was measured using the CCHS-MH/WHO-CIDI screening method. Respondents were asked the following question about their use of cannabis, *“Have you ever used or tried marijuana or hashish?”* proceeded by the following answers, *“Yes (just once), yes (more than once), no, don’t know/refusal”* (Statistics Canada, 2014). If respondents reported ever using cannabis (i.e., just once or more than once), they were categorized into the variable which included one-time use of cannabis.

Lifetime cannabis abstinence (never use) is classified as a categorical variable and was used to create a new category, non-use, in the cannabis use frequency variable. ‘Never use’ was measured using the CCHS-MH/WHO-CIDI screening method. Respondents were asked the following question about their use of cannabis, *“Have you ever used or tried marijuana or hashish?”* proceeded by the following answers, *“Yes (just once), yes (more than once), no, don’t know/refusal”* (Statistics Canada, 2014). If respondents reported never using cannabis, they were categorized into the abstinence variable.

3.4.4. Covariates

Sex was classified as a dichotomous categorical predictor and was measured by asking respondents whether they were male or female (Statistics Canada, 2011).

Age was classified as a categorical predictor and was measured by asking respondents how old they were. Respondents were categorized by the CCHS-MH into three age groups: 15-19, 20-24, 25-29 (Statistics Canada, 2011). For the purpose of this thesis, the respondents who were categorized in the group of 15-19 year-olds were referred to as early emerging adults, the respondents who were categorized into the group of 20-24 year-olds were referred to as middle emerging adults, and the respondents who were categorized into the 25-29 year-olds were referred to as late emerging adults.

Province of residence was classified as a categorical predictor and was measured by asking the respondents what province they are from (Statistics Canada, 2011). For statistical analyses, the provinces were grouped by legal driving age. Group one consisted of Alberta, Manitoba and Saskatchewan (i.e., legal driving age less than 16 years) and group two consisted of British Columbia, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador (i.e., legal driving age of 16 years).

Census metropolitan area (CMA) was classified as a dichotomous categorical predictor and was measured by asking the respondents if they lived in a CMA vs. if they did not live in a CMA (Statistics Canada, 2011).

Lifetime alcohol abuse or dependence was classified as a dichotomous categorical predictor and was measured using the CCHS-MH/WHO-CIDI screening method. The CCHS-MH/WHO-CIDI defined “one drink” as: (i) having one bottle, can, or glass of beer or cooler or (ii) one cocktail with 1 ½ ounces of liquor (Statistics Canada, 2011). The section related to alcohol abuse was initiated if respondents reported (i) drinking 12 or more drinks in a year (i.e., *“Have you ever had 12 or more drinks in a year?”* proceeded by the following answers, “*Yes, no, don’t know/refusal”*) and (ii) drinking at least once a week (i.e., *“Think about the years in your life when you drank most. During those years, how often did you usually have at least one* *drink?"* proceeded by the following answers, *Less than once a month*, *once a month*, *2 to 3 times a month, once a week, 2 to 3 times a week, 4 to 6 times a week, every day"*) or drinking 3 or more drinks per occasion for less frequent use (i.e., *"On the days you drank during those years, about how many drinks did you usually have per day"* proceeded by the interviewer entering a number between 1 and 95) in the year which they drank the most (Statistics Canada, 2011). To reduce respondent burden, the section related to alcohol dependence was initiated if respondents reported (i) drinking 12 or more drinks in a year and (ii) having 4 or more drinks per week or having 5 or more drinks per occasion for less frequent use in the year which they drank the most (Statistics Canada, 2011). The following was the criteria for the CCHS-MH/WHO-CIDI that needed to be met to be categorized as having lifetime alcohol abuse or dependence:

I. the respondent met the criteria for alcohol abuse:
   a. didn't meet the criteria for alcohol dependence;

      and

   b. experienced at least one of the four symptoms of alcohol abuse (i.e., interfering with responsibilities, social problems, continued use despite problems, risk of injury);

or

II. the respondent met the criteria for alcohol dependence:
   c. at least three symptoms of alcohol dependence (i.e., tolerance, withdrawal, increased consumption, attempts to quit, time lost, reduced activities);

      and

   d. a maladaptive pattern of alcohol use demonstrated by three or more symptoms occurring within a 12-month period (Statistics Canada, 2014).

Lifetime other drug abuse or dependence (excluding cannabis) was classified as a dichotomous categorical predictor and was measured using the CCHS-MH/WHO-CIDI screening method. The section related to other drug abuse or dependence (excluding cannabis) was initiated if the respondent reported using a drug and/or using a prescription drug non-medically more than once in their lifetime (Statistics Canada, 2011). The CCHS-MH/WHO-CIDI defined "non-medical drug use" as using a prescription drug without medical advice, using a prescription drug more than the recommended dose, or using a prescription drug for any other reason than what was suggested by a healthcare professional (Statistics Canada, 2011). The drugs groups (not including cannabis) analyzed in the CCHS-MH were sedatives or tranquilizers, stimulants, pain killers, cocaine, club drugs, hallucinogens, heroin or opium, and inhalants or solvents. The following are the criteria for the CCHS-MH/WHO-CIDI that needed to be met to be categorized as having lifetime other drug abuse or dependence:

I. the respondent met the criteria for other drug abuse (excluding cannabis):
   a. didn't meet the criteria for other drug (excluding cannabis) dependence;

and

b. experienced at least one of the four symptoms of drug abuse (i.e., interfering with responsibilities, social problems, continued use despite problems, risk of injury);

II. the respondent met the criteria for other drug dependence (excluding cannabis):
   a. at least three symptoms of drug dependence (i.e., tolerance, withdrawal, increased consumption, attempts to quit, time lost, reduced activities);

   and

   b. a maladaptive pattern of drug use demonstrated by three or more symptoms occurring within a 12-month period (Statistics Canada, 2014).

Any mood disorder (Lifetime) was classified as a dichotomous categorical predictor and was measured using the CCHS-MH/WHO-CIDI screening method for major depressive episode, bipolar I, bipolar II, and hypomania. A respondent was categorized as having a mood disorder if they met the criteria for at least one of the four disorders listed above (Statistics Canada, 2014).

Generalized anxiety disorder (Lifetime) was classified as a dichotomous categorical predictor and was measured using the CCHS-MH/WHO-CIDI screening method. A respondent was categorized as having generalized anxiety disorder if they reported:

I. excessive anxiety and worry and anxiety about at least two different events or activities that lasted at least six months;
II. finding it difficult to control the worry;
III. the anxiety and the worry were associated with three or more symptoms associated with anxiety;
IV. the focus of the anxiety and worry was not confined to features of an Axis 1 disorder; and
V. the anxiety, worry, or physical symptoms caused clinically significant distress or significant impairment in social, occupational, or other important areas of functioning (Statistics Canada, 2014).

3.5. Justification for Grouping 'Regular Use' in Cannabis Frequency Variable

In the CCHS-MH dataset, respondents were originally categorized as having cannabis dependence and abuse. Respondents for both 'dependence' and 'abuse' were classified as engaging in cannabis use more than 50 times in their lifetime and only differed by the symptoms which each group experienced. Moreover, this data was collected in 2012 using the DSM-IV and the diagnostic criteria has since changed with the new edition. In the DSM-5, cannabis abuse and dependence have been merged into one group and the diagnostic criteria for regular cannabis use has been reworked (Qadeer, Georgiades, Boyle & Ferro, 2019; American Psychiatric Association, 2013). Moreover, both 'dependence' and 'abuse' do not contribute to stigma-reducing language. Therefore, a binary logistic regression analysis was conducted to determine if the respondents who were categorized as having cannabis dependence and cannabis abuse had statistically different odds of reporting a past-year traffic violations. The results of this analysis determined that there was no evidence to support significant difference between groups, as shown by the overlapping confidence interval estimates (Appendix B - Table 1). Grouping respondents into emerging adults who engage in regular use of cannabis both increases statistical power and reduces stigma by incorporating person-first language. Thus, all analyses will be conducted using the following three levels of the cannabis use frequency variable: regular use, occasional use, non-use.

3.6. Justification for Selected Covariates

According to a replication of two published meta-analyses, higher estimates were reported on cannabis use and crash risk due to inadequate adjustment of known confounders (Rogeberg & Elvik, 2016). A confounder is a variable that causes a spurious association by influencing both the independent and dependent variable. Rogeberg & Elvik (2016) determined nine confounding variables that should be controlled for when researching cannabis and crash risk, they include: age, sex, kilometers driven, drug use history, drug dosage, use of other drugs, use of alcohol, health comorbidity, and place of residence (Rogeberg & Elvik, 2016). In the current study, all the confounders above have been selected except for kilometers driven and drug dosage because these variables were not included in the CCHS-MH. Moreover, age was controlled for by looking at early (15-19), middle (20-24), and late (25-39) emerging adults and categorizing provinces by driving age, sex was controlled for by including it in the model, drug use history was controlled by cannabis use frequency (i.e., emerging adults who engaged in both regular and occasional cannabis use), place of residence was assessed by asking the respondents if they live in a census metropolitan area, and health comorbidity was assessed by presence of comorbid mood disorder and comorbid generalized anxiety disorder. Both mood disorder and comorbid generalized anxiety disorder will be used to assess health comorbidity because they are known risk factors of traffic violations. For example, a population study of anxiety and mood disorders on self-reported traffic violations determined that probable anxiety or mood disorder was associated with an increased risk of accident involvement (Wickens et al., 2013).

3.7. Analysis Plan

All analyses were conducted using Statistical Analysis System (SAS) (SAS Institute, 1985) and with a significance level of $\alpha = 0.05$. The SURVEY procedure was used to ensure that the appropriate variance estimators and sampling weights were used when analyzing the CCHS-MH survey data.

3.7.1. Weighting

A new sampling weight variable, called WTS_N, was created using the following equation:

$$WTS\_N = \frac{WTS\_M}{\bar{x}_{WTS\_M}}$$

where
WTS_N was the new sampling weight,
WTS_M was the master sampling weight, and
$\bar{x}_{WTS\_M}$ was the average of the master sampling weight ($\bar{x}_{WTS\_M} = 1202.194655$)

The WTS_N sampling weight was applied to each statistical procedure, so results were nationally representative.

3.7.2. Creating a Mutually Exclusive Variable for Cannabis Use Frequency

A new variable for cannabis use frequency was created to ensure each dummy variable for cannabis frequency (i.e. emerging adults who engaged in regular use of cannabis, emerging adults who engaged in occasional use of cannabis, and emerging adults who have not currently engaged in the use of cannabis) was mutually exclusive. The new variables were created from the following variables in the CCHS-MH: *lifetime cannabis dependence, lifetime cannabis abuse, lifetime cannabis use including one-time use, lifetime cannabis use excluding one-time use, and lifetime cannabis abstinence* (Appendix A – Tables 1-3). With reference to the previous variable categories, *lifetime cannabis dependence* and *lifetime cannabis abuse* were mutually exclusive (i.e., a person who was dependent on drugs could not be a person who also abused drugs). However, *lifetime cannabis abuse* and *lifetime cannabis use (including one-time use)* and *lifetime cannabis use (excluding one-time use)* were not mutually exclusive (i.e., an abuser can also be a user). Thus, in order to obtain three mutually exclusive categories for cannabis frequency, a four-way cross tabulation analysis using the SURVEYFREQ procedure was used to tease out the three cannabis variables listed above (Appendix A – Tables 1-3).

3.7.3. Dummy Variables for Cannabis Use Frequency

A dummy variable is a numerical variable that uses values (0,1) to identify categorical groups in regression analyses. Two dummy variables were created for cannabis use frequency (Appendix C - Table 1).

3.7.4. Reference Categories

For *lifetime cannabis use frequency*, emerging adults who have not currently engaged in cannabis use were chosen as the reference category because the current study aims to explore the relationship between emerging adults who engaged in regular use of cannabis and traffic violations. Thus, in order to determine the impact of the risk factor (i.e., regular use of cannabis) and traffic violations, emerging adults who have not currently engaged in cannabis use must be set as the reference category because they are not part of the target population represented in the research question.

For *sex*, females were chosen as the reference category because traffic violations are more prevalent in males. Thus, in order to determine the impact of the risk factor (i.e., male sex) and traffic violations, females must be set as the reference category because they are not part of the target population represented in the research question.

For *age*, respondents aged 15-19 years-old were chosen as the reference category because there are respondents in this age category who would be classified as a young driver and would be accompanied by a more experienced driver. Thus, in order to determine the impact of the risk factor (i.e., age) and traffic violations, respondents aged 15-19 years-old must be set as the reference category because they are not part of the target population represented in the research question.

For *province of residence,* group 2 was selected as the reference category because the current study aims to determine if a younger legal driving age is associated with an increase in self-reporting traffic violations. Thus, in order to determine the impact of the risk factor (i.e., legal driving age less than 16 years-old) and traffic violations, provinces that have a legal driving age of 16 must be set as the reference category because they are not part of the target population represented in the research question.

For *census metropolitan area*, respondents living in a metropolitan area were chosen as the reference category because it is assumed that there would be an increased risk of a traffic violation (i.e., more roads, increased police presence, more individuals driving, etc.). Thus, in order to determine the impact of the risk factor (i.e., living in a rural area) and traffic violations, individuals living in an urban area must be set as the reference category because they are not part of the target population represented in the research question.

For *lifetime alcohol abuse/dependence,* respondents who were not categorized as an alcohol abuser/dependent were chosen as the reference category because they are less likely to drive impaired and receive a traffic violation than respondents categorized as an alcohol abuser/dependent. Thus, in order to determine the impact of the risk factor (i.e., alcohol abuse/dependence) and traffic violations, respondents who have not been categorized as an alcohol abuser/dependent must be set as the reference category because they are not part of the target population represented in the research question.

For *lifetime drug abuse/dependence,* respondents who have not been categorized as a drug abuser/dependent were chosen as the reference category because they are less likely to drive impaired and receive a traffic violation than respondents categorized as a drug abuser/dependent. Thus, in order to determine the impact of the risk factor (i.e., drug abuse/dependence) and traffic violations, respondents who have not been categorized as a drug abuser/dependent must be set as the reference category because they are not part of the target population represented in the research question.

For *lifetime mood disorder,* respondents who reported not having a mood disorder were chosen as the reference category because they are less likely to receive a traffic violation compared to respondents diagnosed as having a mood disorder. Thus, in order to determine the impact of the risk factor (i.e., presence of a mood disorder) and traffic violations, respondents who do not have a mood disorder must be set as the reference category because they are not part of the target population represented in the research question.

For *lifetime generalized anxiety disorder,* respondents who reported not having generalized anxiety disorder were chosen as the reference category because they are less likely to receive a traffic violation compared to respondents diagnosed as having generalized anxiety disorder. Thus, in order to determine the impact of the risk factor (i.e., presence of generalized anxiety disorder) and traffic violations, respondents who do not have generalized anxiety disorder must be set as the reference category because they are not part of the target population represented in the research question. A summary of the reference categories can be found in the appendix (Appendix D - Table 1).

3.7.5. Cross Tabulation Analyses

Cross tabulation analyses were conducted to gain an understanding of the analytical sample’s descriptive statistics using the weighted frequencies reported from the frequency tables in SURVEYFREQ procedure. Frequency tables were reported for univariate exploratory data analyses of the outcome, exposure, and covariates (Table 1) and bivariate exploratory data analyses between each covariate and the outcome (Table 2).

3.7.6. Objective 1

The (i) general, (ii) sex-specific, and (iii) age-specific period prevalence of past-year traffic violations in emerging adults who engaged in regular or occasional use of cannabis when compared to emerging adults who are non-users of cannabis was estimated using the number of weighted respondents found in the frequency tables from the SURVEYFREQ procedure (Tables 1 & 2). The weighted frequencies provided in the previous step were applied to the probability tree-diagrams outlined in Figures 1, 2, and 3 (Appendix E). The probability tree diagrams were used in the prevalence equations to determine the prevalence (Appendix F). To determine the significance between the reported proportions, the Rao-Scott Chi-Square test was used.

3.7.7. Objective 2

Hierarchical, binary logistic regression was used to model the association between cannabis use frequency and traffic violations among emerging adults, where lifetime cannabis use frequency is the categorical variable for exposure and past-year traffic violations is the dichotomous categorical variable for the outcome. When conducting analyses, the two dummy variables (i.e., emerging adults who engaged in regular or occasional use of cannabis) were used in the models. The SURVEYLOGISIC procedure was used to obtain regression estimates and odds ratios. Four main effects regression models were used in effort to control for the potential effects of covariates by adding covariates into the model sequentially (Appendix G). The confounders were added to the unadjusted model in the following blocks: (1) demographic characteristics (i.e., sex, age, living in an urban vs. rural area, and province of residence), (2) regular substance use (i.e., alcohol and other drugs), and (3) presence of co-morbid mental disorder (i.e., mood disorder and generalized anxiety disorder). The hierarchical model compared c-statistic values (i.e., estimated area under the ROC curve), odds ratios and 95% confidence intervals.

3.7.8. Objective 3

The SURVEYLOGISIC procedure was used to estimate the degree to which (i) sex, (ii)age, (iii) regular alcohol use, (iv) regular drug use, (v) co-morbid mood disorder, and (vi) co-morbid generalized anxiety disorder moderate the association between emerging adults who engaged in regular or occasional use of cannabis and past-year traffic violations. Specifically, the hypothesized model containing all the covariates (Model 4 in Appendix G) with the addition of interaction terms was used to test for two-way interactions between (i) cannabis use frequency and sex, (ii) cannabis use frequency and age, (iii) cannabis use frequency and regular alcohol use, (iv) cannabis use frequency and regular drug use, (v) cannabis use frequency and co-morbid mood disorder, and (vi) cannabis use frequency and co-morbid generalized anxiety disorder (Appendix H). The joint tests were used to determine if any of the two-way interactions were statistically significant (i.e., $p < 0.05$). If any of the two-way interactions were statistically significant, the optimal model was stratified by the effect modifier.

RESULTS

4.1. Study Sample Characteristics

4.1.1. Univariate Analyses

Both the sex distribution (i.e., 52.7% male vs. 47.3% female) and age distribution (i.e., 32.9% early emerging adults vs. 32.0% middle emerging adults vs. 34.1% late emerging adults) were similar (Table 1). Respondents were more likely to report non-use of cannabis (58.9%) and engaging in occasional use of cannabis (30.2%) when compared to those who reported engaging in regular use of cannabis (10.9%). Most respondents reported living in a province with a driving age of 16 years old (81.6%) and living in an urban area (77.1%). Engaging in regular use of alcohol and drugs other than cannabis was reported for 17.7% and 4.7% of the sample, respectively. Additionally, 12.6% of the sample reported having a mood disorder and 6.9% of the sample reported having generalized anxiety disorder.

Table 1. Univariate Exploratory Data Analyses: descriptive statistics for the analytical sample (n=5,630).

	n (%)
Outcome	
Traffic Violations	830 (14.8)
Exposure	
Cannabis Use Frequency	
Regular Use	607 (10.9)
Occasional Use	1683 (30.2)
Demographic Characteristics	
Male	2969 (52.7)
Middle EA (20-24 y)	1799(32.0)
Late EA (25-29 y)	1922 (34.1)
Province	1035 (18.4)
Rural	1290 (22.9)
Substance Use	
Regular Alcohol Use	989 (17.7)
Regular Drug Use	263 (4.7)
Mental Disorder	
Mood Disorder	707 (12.6)
Generalized Anxiety Disorder	387 (6.9)

Province refers to province group 1 which consists of Alberta, Saskatchewan and Manitoba. All three provinces have a legal driving age that is less than 16 years old. Reported frequencies (n/%) were determined for the outcome, exposure, and each covariate.

4.1.2. Bivariate Analyses

Reporting a past-year traffic violation was higher among: males (68.5%), emerging adults engaging in occasional use of cannabis (42.5%), late emerging adults (44.7%), living in a province with a driving age of 16 years old (77.3%), living in an urban area (78.6%), not engaging in regular use of alcohol (72.2%) or other drugs (92.3%), and emerging adults without a mood disorder (86.6%) or generalized anxiety disorder (93.0%) (Table 2).

Table 2. Bivariate Exploratory Data Analysis: descriptive statistics for the analytical sample (n=5,630).

	n (%)
Exposure	
Cannabis Use Frequency	
Regular Use	143 (17.3)
Occasional Use	351 (42.5)
Demographic Characteristics	
Male	569 (68.5)
Middle EA (20-24 y)	291 (35.1)
Late EA (25-29 y)	371 (44.7)
Province	188 (22.7)
Rural	178 (21.4)
Substance Use	
Regular Alcohol Use	230 (27.8)
Regular Drug Use	63 (7.7)
Mental Disorder	
Mood Disorder	111 (13.4)
Generalized Anxiety Disorder	58 (7.0)

Province refers to province group 1 which consists of Alberta, Saskatchewan and Manitoba. All three provinces have a legal driving age that is less than 16 years old. Reported frequencies (n/%) were determined between (i) the exposure and outcome and (ii) each covariate and outcome.

4.2. Objective 1

4.2.1. General Prevalence

The prevalence of past-year traffic violations in the total sample was 14.7% and was 23.8%, 20.8%, and 10.1% for engaging in regular, occasional, and non-use, respectively (Table 3).

Table 3. General prevalence of past-year traffic violations for the analytical sample (n=5,630).

Cannabis Use Frequency	Traffic Violations	χ^2 (P-Value)
Regular Use	143 (23.8)	30.0 (<.001)
Occasional Use	351 (20.9)	30.1 (<.001)
Non-Use	331 (10.1)	38.7 (<.001)

Reported prevalence is presented as n (%). Regular and occasional use of cannabis was compared to non-use. Non-use was compared to aggregated regular and occasional use. Numbers may not add up to sample because of missing data.

4.2.2. Sex-Specific Prevalence

Overall, the prevalence of past-year traffic violations was highest among male emerging adults when compared to female emerging adults (19.2% vs. 9.9%) (Table 4). Males who engaged in regular and occasional use of cannabis were more likely to report a traffic violation when compared to their female counterparts. Female non-users of cannabis use were more likely to report a traffic violation than their male counterparts, however, this finding was not statistically significant (p=0.229). Post-hoc comparisons in both males and females revealed significant differences between (i) regular and non-use (p=0.001 males; p=0.005 females), (ii) occasional and non-use (p=0.001 males; p<0.001 females), and (iii) non-use and aggregated regular and occasional use (p<0.001 males; p<0.001 females).

Table 4. Sex-specific prevalence of past-year traffic violations for the analytical sample (n=5,630).

	Traffic Violations		**Between Sex**
	Male	**Female**	**χ^2 (P-Value)**
Cannabis Use Frequency			
Regular Use	116 (35.0)	26 (18.1)	6.9 (0.008)
Occasional Use	237 (52.5)	114 (49.1)	0.2 (0.657)
Non-Use	214 (37.8)	117 (45.3)	1.5 (0.229)
Within Sex χ^2 (P-Value)			
Regular Use	14.9 (0.001)	8.1 (0.005)	
Occasional Use	13.0 (0.001)	20.0 (<0.001)	
Non-Use	17.3 (<0.001)	21.4 (<0.001)	

Reported prevalence is presented as n (%). Regular and occasional use of cannabis was compared to non-use use. Non-use was compared to aggregated regular and occasional use. Post-hoc comparisons were made between regular vs. non-use, occasional vs. non-use, and non-use vs. aggregated regular and occasional use for males and females. Numbers may not add up to sample because of missing data.

4.2.3. Age-Specific Prevalence

The overall prevalence of past-year traffic violations was higher among middle (16.2%) and late (19.4 %) emerging adults when compared to early emerging adults (8.8%) (Table 5). Middle and late emerging adults who engaged in regular or occasional use of cannabis were more likely to report a traffic violation when compared to early emerging adults who engaged in regular or occasional use of cannabis. Moreover, early emerging adults were more likely to report non-use (50.0%) when compared to middle (36.2%) and late (38.5%) emerging adults. However, there was no significant difference between age groups for both occasional (p=0.673) and non- (p=0.261) use. Post-hoc comparisons in early emerging adults revealed significant differences between: (i) occasional use and non-use (p<0.001) and (ii) non-use and aggregated regular and occasional use (p<0.001). However, there was no significant difference observed between regular use and non-use. Post-hoc comparisons in middle emerging adults revealed significant differences between: (i) regular use and non-use (p<0.001), (ii) occasional use and non-use (p=0.001), and (iii) non-use vs. aggregated regular and occasional use (p<0.001). Post-hoc comparisons in late emerging adults revealed only a significant difference between regular and non-use (p=0.010).

Table 5. Age-specific prevalence of past-year traffic violations for the analytical sample (n=5,630).

	Traffic Violations			Between Age
	15-19 Years	**20-24 Years**	**25-29 Years**	**χ^2 (P-Value)**
Cannabis Use Frequency				
Regular Use	13 (13.4)	66 (38.8)	64 (31.1)	8.3 (0.016)
Occasional Use	71 (45.8)	116 (52.5)	164 (53.4)	0.8 (0.673)
Non-Use	84 (50.0)	104 (36.2)	143 (38.5)	2.7 (0.261)
Within Age χ^2 (P-Value)				
Regular Use	1.3 (0.246)	22.2 (<0.001)	6.5 (0.010)	
Occasional Use	32.2 (<0.001)	12.2 (0.001)	1.9 (0.163)	
Non-Use	24.7 (<0.001)	22.0 (<0.001)	3.5 (0.060)	

Prevalence is presented as n (%). Regular and occasional use of cannabis was compared to non-use use. Non-use was compared to aggregated regular and occasional use. Post-hoc comparisons were made between regular vs. non-use, occasional vs. non-use, and non-use vs. aggregated regular and occasional use for early, middle, and late emerging adults. Numbers may not add up to sample because of missing data.

4.3. Objective 2

The hierarchical logistic regression model is shown below in Table 6. In the unadjusted model, both regular and occasional use of cannabis were significantly associated with a past-year traffic violation. However, the odds of reporting a past-year traffic violation were higher for emerging adults who engaged in regular use of cannabis when compared to emerging adults who engaged in occasional use of cannabis. Model two contained the adjusted model with the addition of four demographic characteristics (i.e., sex, age, residing in an urban or rural area, and province of residence). In model two, male sex, middle emerging adulthood (i.e., 20-24), late emerging adulthood (i.e., 25-29), and living in a province with a driving age < 16 years-old significantly increased the odds of reporting a past-year traffic violation. Similar to model one, the odds of reporting a traffic violation were higher for emerging adults who engaged in regular use of cannabis when compared to emerging adults who engaged in occasional use of cannabis. In model three, co-morbid substance use was added to the model and neither regular use of alcohol and/or drugs were associated with increased odds of a traffic violation. The effect of regular cannabis use seen in models one and two was reduced in model three such that the odds of reporting a traffic violation in emerging adults who engaged in regular use of cannabis were slightly less than emerging adults who engaged in occasional use of cannabis. In the final model, co-morbid mental disorders (i.e., mood disorder and generalized anxiety disorder) were added and were not significantly associated with reporting a past-year traffic violation. However, the odds of reporting a past-year traffic violation still remained significant for regular and occasional use of cannabis. The effect of reporting a traffic violation was the same for emerging adults who engaged in both regular and occasional use of cannabis. The overall c-statistic for the final model was 0.67, suggesting that the model was a satisfactory fit to the data.

Table 6. Hierarchical logistic regression of cannabis use frequency and traffic violations.

	Unadjusted	Model 2	Model 3	Model 4
C-Statistic	0.61	0.67	0.67	0.67
Cannabis Use				
Regular	2.77 (1.91-4.02)	2.24 (1.53-3.27)	1.92 (1.28-2.89)	1.93 (1.23-2.92)
Occasional	2.36 (1.73-3.22)	1.99 (1.42-2.79)	1.93 (1.36-2.74)	1.93 (1.35-2.74)
Demographics				
Male		2.03 (1.56-2.65)	2.02 (1.54-2.65)	2.03 (1.55-2.65)
Age 20-24		1.68 (1.23-2.29)	1.64 (1.20-2.25)	1.64 (1.20-2.25)
Age 25-29		2.03 (1.38-2.99)	2.00 (1.35-2.96)	1.99 (1.35-2.95)
Rural		0.90 (0.70-1.17)	0.88 (0.68-1.14)	0.88 (0.68-1.15)
Province		1.36 (1.04-1.77)	1.34 (1.03-1.75)	1.34 (1.03-1.76)
Substance Use				
Alcohol			1.18 (0.86-1.61)	1.19 (0.87-1.64)
Drugs			1.25 (0.79-1.99)	1.27 (0.78-2.04)
Mental Disorder				
Mood				0.96 (0.65-1.41)
Anxiety				1.00 (0.57-1.75)

Province refers to province group 1 which consists of Alberta, Saskatchewan and Manitoba. All three provinces have a legal driving age that is less than 16 years old. Values denote Odds Ratio (95% Confidence Interval).

4.4. Objective 3

The two-way interactions model (Appendix H), which consists of model four, in addition to the six interaction terms (i.e., Cannabis Frequency*Sex, Cannabis Frequency*Age, Cannabis Frequency*Regular Alcohol Use, Cannabis Frequency*Regular Drug Use, Cannabis Frequency*Mood Disorder, and Cannabis Frequency*Generalized Anxiety Disorder), was used to determine interaction effects. The results indicated a significant interaction between cannabis use frequency and age and a significant interaction between cannabis use frequency and engaging in regular use of drugs other than cannabis. The overall c-statistic for the two-way interactions model was 0.67, suggesting that the model was a satisfactory fit to the data. Pertaining to the observation of two significant interactions, stratified analyses were conducted to determine strata-specific logistic regression estimates (Table 7).

Table 7. Adjusted two-way interactions model of past-year traffic violations.

Effect	**β (SE)**
Intercept	-1.72 (0.16)
Regular Use	0.13 (0.19)
Occasional Use	0.26 (0.19)
Male	0.36 (0.07)
Age 20-24	0.14 (0.09)
Age 25-29	0.33 (0.10)
Rural	-0.06 (0.07)
Province	0.14 (0.07)
Regular Use of Alcohol	0.12 (0.09)
Regular Use of Drugs	-0.08 (0.14)
Mood Disorder	-0.05 (0.10)
Generalized Anxiety Disorder	0.01 (0.13)
Sex Interactions	
Regular Use*Male	0.02 (0.11)
Occasional Use*Male	-0.03 (0.09)
Age Interactions	
Regular Use*Age 20-24	0.24 (0.15)
Occasional Use*Age 20-24	-0.18 (0.12)
Regular Use*Age 25-29	0.17 (0.16)
Occasional Use*Age 25-29	-0.31 (0.13)
Substance Use Interactions	
Regular Use*Regular Alcohol Use	-0.10 (0.13)
Occasional Use*Regular Alcohol Use	-0.07 (0.11)
Regular Use*Regular Drug Use	0.43 (0.17)
Occasional Use*Regular Drug Use	-0.11 (0.18)
Mental Disorder Interactions	
Regular Use*Mood Disorder	-0.14 (0.15)
Occasional Use*Mood Disorder	0.20 (0.13)
Regular Use*Generalized Anxiety Disorder	-0.22 (0.18)
Occasional Use*Generalized Anxiety Disorder	-0.12 (0.16)
	C-Statistic = 0.67

Province refers to province group 1 which consists of Alberta, Saskatchewan and Manitoba. All three provinces have a legal driving age that is less than 16 years old. Values denote β Coefficient (Standard Error).

4.4.1. Stratified Analyses by Age

I. Early emerging adults (i.e., 15-19)

There was an association observed between cannabis use frequency and past-year traffic violations in early emerging adults. Specifically, the odds of reporting past-year traffic violations were higher among early emerging adults who engaged in occasional use of cannabis when compared to early emerging adults who were non-users of cannabis [OR=3.65 (1.96-6.80)] (Table 8). The overall c-statistic for the binary logistic regression model stratified by age was 0.69, suggesting that the model was a satisfactory fit to the data.

Table 8. Unadjusted and adjusted models of past-year traffic violations stratified by early emerging adults.

Effect	OR (95% CI)	
Unadjusted		
Regular Use	1.48 (0.76-2.90)	
Occasional Use	4.18 (2.45-7.13)	
		C-Statistic = 0.62
Adjusted		
Regular Use	1.24 (0.55-2.77)	
Occasional Use	3.65 (1.96-6.80)	
Male	2.04 (1.25-3.31)	
Rural	1.21 (0.74-2.00)	
Province	1.70 (1.01-2.87)	
Regular Use of Alcohol	2.08 (1.01-4.26)	
Regular Use of Drugs	0.35 (0.10-1.27)	
Mood Disorder	0.93 (0.44-2.00)	
Generalized Anxiety Disorder	1.16 (0.26-5.12)	
		C-Statistic = 0.69

Province refers to province group 1 which consists of Alberta, Saskatchewan and Manitoba. All three provinces have a legal driving age that is less than 16 years old. OR is the odds ratio estimate and CI is the confidence interval.

II. Middle emerging adults (i.e., 20-24)

There was an association observed between cannabis use frequency and past-year traffic violations in middle emerging adults. The odds of reporting past-year traffic violations were higher for middle emerging adults who engaged in regular [OR=2.42 (1.37-4.29)] and occasional [OR=1.70 (1.28-3.04)] use of cannabis when compared to middle emerging adults who were non-users of cannabis (Table 9). The overall c-statistic for the binary logistic regression model stratified by age was 0.64, suggesting that the model was a satisfactory fit to the data.

Table 9. Unadjusted and adjusted models of past-year traffic violations stratified by middle emerging adults.

Effect	OR (95% CI)	
Unadjusted		
Regular Use	2.93 (1.85-4.64)	
Occasional use	2.03 (1.34-3.03)	
		C-Statistic = 0.59
Adjusted		
Regular Use	2.43 (1.37-4.29)	
Occasional Use	2.00 (1.28-3.04)	
Male	1.60 (1.06-2.31)	
Rural	0.95 (0.65-1.37)	
Province	1.53 (1.05-2.22)	
Regular Use of Alcohol	1.08 (0.67-1.76)	
Regular Use of Drugs	1.19 (0.61-2.33)	
Mood Disorder	1.09 (0.63-1.89)	
Generalized Anxiety Disorder	0.86 (0.45-1.66)	
		C-Statistic = 0.64

Province refers to province group 1 which consists of Alberta, Saskatchewan and Manitoba. All three provinces have a legal driving age that is less than 16 years old. OR is the odds ratio estimate and CI is the confidence interval.

III. Late emerging adults (i.e., 25-29)

There was no association observed between cannabis use frequency and past-year traffic violations in late emerging adults. The overall c-statistic for the binary logistic regression model stratified by age was 0.63, indicating the model was a satisfactory fit to the data (Table 10).

Table 10. Unadjusted and adjusted model of past-year traffic violations stratified by late emerging adults.

Effect	OR (95% CI)	
Unadjusted		
Regular Use	2.55 (1.24-5.26)	
Occasional Use	1.52 (0.84-2.74)	
		C-Statistic = 0.57
Adjusted		
Regular Use	1.66 (0.76-3.61)	
Occasional Use	1.39 (0.76-2.57)	
Male	2.50 (1.54-4.05)	
Rural	0.68 (0.42-1.09)	
Province	1.07 (0.66-1.74)	
Regular Use of Alcohol	1.08 (0.66-1.77)	
Regular Use of Drugs	1.94 (0.94-4.01)	
Mood Disorder	0.88 (0.42-1.83)	
Generalized Anxiety Disorder	1.12 (0.42-2.97)	
		C-Statistic = 0.63

Province refers to province group 1 which consists of Alberta, Saskatchewan and Manitoba. All three provinces have a legal driving age that is less than 16 years old. OR is the odds ratio estimate and CI is the confidence interval.

4.4.2. Stratified Analyses by Regular Use of Drugs (Excluding Cannabis)

I. *Emerging adults who engaged in regular use of drugs other than cannabis*

There was no association observed between cannabis use frequency and past-year traffic violations in emerging adults who engaged in regular use of drugs other than cannabis. The overall c-statistic for the binary logistic regression model stratified by regular use of drugs other than cannabis was 0.65, indicating the model was a satisfactory fit to the data (Table 11).

Table 11. Unadjusted and adjusted models of past-year traffic violations stratified by engaging in regular use of drugs other than cannabis.

Effect	OR (95% CI)	
Unadjusted		
Regular Use	6.04 (1.48-24.59)	
Occasional use	2.26 (0.54-9.50)	
		C-Statistic = 0.53
Adjusted		
Regular Use	4.68 (0.88-24.94)	
Occasional Use	1.92 (0.35-10.56)	
Age 20-24	2.42 (1.13-5.22)	
Age 25-29	5.91 (1.40-24.90)	
Male	9.04 (2.23-36.64)	
Rural	1.25 (0.56-2.75)	
Province	0.64 (0.26-1.58)	
Regular Use of Alcohol	0.93 (0.38-2.74)	
Mood Disorder	1.41 (0.51-3.91)	
Generalized Anxiety Disorder	0.39 (0.13-1.18)	
		C-Statistic = 0.65

Province refers to province group 1 which consists of Alberta, Saskatchewan and Manitoba. All three provinces have a legal driving age that is less than 16 years old. OR is the odds ratio estimate and CI is the confidence interval.

II. Emerging adults who did not engage in regular use of drugs other than cannabis

There was an association observed between cannabis use frequency and past-year traffic violations in emerging adults who did not engage in regular use of drugs other than cannabis. The odds of reporting past-year traffic violations were higher for emerging adults who did not engage in regular use of other drugs but, engaged in regular [OR=1.70 (1.08-2.67)] and occasional use [OR=1.97 (1.38-2.82)] of cannabis when compared to emerging adults who did not engage in regular use of drugs and were non-users of cannabis (Table 12). The overall c-statistic for the binary logistic model stratified by regular use of drugs other than cannabis was 0.67, suggesting the model was a satisfactory fit to the data.

Table 12. Unadjusted and adjusted models of past-year traffic violations stratified by not engaging in regular use of drugs other than cannabis.

Effect	OR (95% CI)	
Unadjusted		
Regular Use	2.34 (1.57-3.49)	
Occasional use	2.40 (1.74-3.29)	
		C-Statistic = 0.60
Adjusted		
Regular Use	1.70 (1.08-2.67)	
Occasional Use	1.97 (1.38-2.82)	
Age 20-24	2.00 (1.51-2.66)	
Age 25-29	1.57 (1.14-2.17)	
Male	1.85 (1.23-2.28)	
Rural	0.86 (0.65-1.13)	
Province	1.42 (1.07-1.88)	
Regular Use of Alcohol	1.21 (0.87-1.70)	
Mood Disorder	0.94 (0.62-1.41)	
Generalized Anxiety Disorder	1.21 (0.67-2.18)	
		C-Statistic = 0.67

Province refers to province group 1 which consists of Alberta, Saskatchewan and Manitoba. All three provinces have a legal driving age that is less than 16 years old. OR is the odds ratio estimate and CI is the confidence interval.

DISCUSSION

Given recent legalization in Canada, relevant stakeholders (i.e., researchers, clinicians, nurses, and public health professionals) are concerned about the possibility of rising trends in driving under the influence of cannabis. This study was the first to examine the association between past-year traffic violations and engaging in regular or occasional use of cannabis in the emerging adult population. Our findings indicate that regular and occasional use of cannabis increased the risk of reporting a traffic violation, and this association was moderated by age and use of other drugs.

5.1. Prevalence of Traffic Violations

The general prevalence of traffic violations reported in our sample was similar to findings in the literature for driving within two hours of consuming cannabis before (14.2%) and after (13.2%) legalization (Statistics Canada, 2020). In our study, the prevalence of traffic violations was higher for individuals who engaged in regular or occasional use of cannabis when compared to individuals who were non-users of cannabis. This finding is similar to other Canadian research (Statistics Canada, 2020; Fischer, Rodopoulos, Rehm & Ivsins, 2006; Mann et al., 2007).

Also comparable to existing data was higher prevalence of traffic violations in males. For example, a study analyzing post-legalization data has shown that males were more likely to report driving within two hours after using cannabis when compared to females (Statistics Canada, 2020). This was similar to the overall sex-specific prevalence of traffic violations found in our study. Significant sex-differences for reporting a past-year traffic violation were only observed for emerging adults who engaged in regular use of cannabis. Moreover, male emerging adults who engaged in regular use of cannabis were more likely to report a traffic violation than female emerging adults who engaged in regular use of cannabis. The sizable difference in prevalence between males and females may be attributed to the increased likelihood for males to engage in risky behaviors when compared to females. For example, males are more likely to report aggression, risky driving (Jafarpour & Rahimi-Movaghar, 2014), impulsivity, and regular substance use (Waldeck & Miller, 1997) when compared to females. Though not statistically significant, females were more likely to report non-use of cannabis compared to males. A reasonable explanation for this finding is the increase in proportion of females charged with impaired driving from 8% to 20% in 1986 and 2015, respectively (Statistics Canada, 2015).

With respect to age, the overall prevalence of traffic violations in this study was higher for middle and late emerging adults when compared to early emerging adults. Comparable to sex, significant age-differences in the prevalence of past-year traffic violations were only observed for emerging adults who engaged in regular use of cannabis. In accordance with our hypothesis, middle and late emerging adults who engaged in regular use of cannabis were more likely to report a traffic violation than early emerging adults who engaged in regular use of cannabis. Although no research in emerging adulthood currently exists, higher prevalence of traffic violations may be explained by more opportunity to engage in both cannabis use and driving throughout the lifetime of middle and late emerging adults. For example, individuals aged 20-29 years were more likely to report past-year use (26.1%) and past 3 months use (18.7%) when compared to individuals aged 15-19 years who reported past-year use (20.8%) and past 3 months use (14.0%) (Leos-Toro, Rynard, & Hammond, 2017). Early emerging adults who were non-users of cannabis use were more likely to report a traffic violation when compared to middle and late emerging adults who were non-users of cannabis use; however, this finding was not significant.

5.2. Association Between Traffic Violations and Regular or Occasional Use of Cannabis

After adjusting for known confounders, there was attenuation in the odds of reporting traffic violations such that emerging adults who engaged in regular or occasional use of cannabis had the same odds of reporting a past-year traffic violation. A plausible explanation for this observation is the development of tolerance in emerging adults who engage in regular use of cannabis. Moreover, research suggests that tolerance may explain why some studies fail to show clear effects of cannabis impairment in regular users (Ramaekers et al., 2011; Hart et al., 2010). For example, a systematic review showed that the acute cognitive effects of cannabis were less prominent in regular cannabis users when compared to non-regular users (Colizzi & Bhattacharyya, 2018). These less prominent effects can be explained by a reduction in the reward circuit pathway responsible for feelings of impairment and cognitive function (Mason et al., 2019). Regarding driving ability, some evidence suggests that individuals who engaged in more frequent use of cannabis revealed less impairment of driving ability when compared to individuals who engaged in occasional use of cannabis (Hartley et al., 2019; Newmeyer et al., 2017). However, other research suggests that engaging in regular use of cannabis is associated with driving impairment (Arkell et al., 2019; Doroudgar et al., 2018; Micallef et al., 2018; Bosker et al., 2012b)

5.3. Moderating Effects of Age and Other Drug Use

Significant moderating effects were observed for age and other drug use. Stratification by age revealed higher odds of reporting traffic violations in early emerging adults who engaged in occasional use of cannabis. However, non-significant findings were observed for early emerging adults who engaged in regular use of cannabis. Early emerging adults may have had less of an opportunity to engage in regular use of cannabis over their lifetime. Additionally, early emerging adults are still living at home and dependent on their parents leaving little time for experimentation (Arnett, 2001). In middle emerging adults, engaging in both regular and occasional use of cannabis was associated with increased odds of reporting a traffic violation. Increased odds may be related to semi-autonomy during this time. Most emerging adults aged 20-24 years will have left home for post-secondary education or work and will be experiencing living on their own for the first time (Goldschieder & Davanzo, 1986; Goldschieder & Goldschieder 1994). This period of self-exploration has been associated with an increase in sensation seeking and risky behaviour, such as increased substance use and impaired driving (Arnett, 2001). Canadian research has shown that the rate of drug-impaired driving in individuals who are 20-24 years old (17 per 100,000) is more than the rate of drug-impaired driving for individuals who are 16-19 years old (13 per 100,000) and 25-34 years old (15 per 100,000) (Statistics Canada, 2015). Our findings also indicate non-significant findings for late emerging adults who engaged in both regular and occasional use of cannabis. A plausible explanation for non-significant findings in late emerging adults may be a result of settling down and entering adulthood (Arnett, 2001). For example, some emerging adults aged 25-29 years may begin graduate or professional studies, become employed full-time, get married, or have children, leaving less time for experimentation/risk taking and more time for the obligations and responsibilities of adulthood.

Not supported by our hypothesis, stratification by other drug use revealed non-significant findings for emerging adults who engaged in regular use of drugs other than cannabis. The null finding may indicate that emerging adults who engage in regular use of drugs could have suspended licenses for impaired driving and declines in traffic violations might be credited to them driving less (Macdonald, Mann, Chipman, & Anglin-Bodrug, 2004). Given the relatively wide confidence intervals, the non-significant odds of reporting a traffic violation stratified by other drug use may have been attributable to sparse data. Sparse data for other substance use may be explained by non-response bias. For instance, research has shown that regular substance users tend to be non-respondents (Zhao, Stockwell & MacDonald, 2009; Mann et al., 2002). Nonetheless, the effect shown in emerging adults who engaged in both regular use of cannabis and other drugs is large and significant effects have been found in the literature (Kleiman, Jones, Miller, Halperin, 2018). While other research suggests that engaging in regular polydrug use does not increase the risk of an accident when compared to drivers who only engage in regular use of one substance (Chipman, Macdonald, & Mann, 2003). Future research should consider analyzing the moderating effect of other drug use when studying the association between traffic violations and cannabis use frequency to better understand its relationship. Significant findings were observed for emerging adults who did not engage in regular use of drugs but engaged in regular or occasional use of cannabis. There was a small difference in effect shown between regular and occasional use of cannabis. However, attenuation in odds were also shown for emerging adults who did not engage in regular use of drugs but engaged in regular use of cannabis. The reduction in odds for regular use may be explained by tolerance to the acute effects of THC in regular users when compared to occasional users (Hartman & Huestis, 2013; Khiabani, Bramness, Bjorneboe & Morland, 2006). To contrast, other literature suggests that less tolerance in individuals who engage in regular use of cannabis may be a result of increased complexity of the task at hand and thus, requiring multiple neurocognitive and/or neuromotor skills (Ramaekers, Kauert, Theunissen, Toennes, Moeller, & 2009).

STRENGTHS & LIMITATIONS

6.1. Strengths

This study has numerous strengths. First, analyses were based on a population-based survey in which the findings can be applied broadly. To date, research has been conducted in small laboratory or treatment group settings and has not been representative of larger populations. Second, this study has been conducted within the emerging adult population which has not been examined extensively in the literature despite the fact that emerging adults are more likely to engage in risky behaviours. Moreover, the leading cause of injury deaths among emerging adults is unintentional motor vehicle traffic accidents (Centers for Disease Control and Prevention, 2019) and the third leading cause of non-fatal injuries is unintentional motor vehicle occupant (Centers for Disease Control and Prevention, 2017), making research in this population imperative. Third, this study can serve as a framework for future research when post-legalization data is made available which is imperative to help understand trends in traffic violations over time.

6.2. Limitations

Some potential limitations of the study must be noted. First, the outcome of traffic violations did not specify if respondents were drivers or passengers, if respondents had valid driver's licences, and the type of stop (i.e., moving/non-moving violation or accident). Second, the most recent CCHS-MH data is from 2012 which was before the legalization of cannabis thus, respondents may have been reluctant to report their use even if researchers reminded them of participant confidentiality. This may have led to underreporting of cannabis use. Third, the outcome of traffic violations was measured using self-report. Self-reporting measures may increase both social desirability and self-evaluation biases. Moreover, self-reporting traffic violations has been shown to decrease validity, with the highest percentage of false self-reporting occurring in first time offenders (Chang & Lapham, 1996). Fourth, the results cannot be extended out to Indigenous communities, members of the Canadian armed forces, and the institutionalized population. These three groups only represent three percent of the Canadian population and we cannot ascertain if these respondents may have had comparable findings to our sample. Fifth, since non-respondents and respondents with missing data were grouped as one variable, we were unable to conduct sensitivity analysis to determine if non-respondents and respondents had similar outcomes. However, other research has proven that non-respondents tend to be heavier substance users (Mann et al., 2002), indicating possible underestimation of our findings. Sixth, the current study is cross-sectional therefore, casual inferences cannot be made since temporality cannot be established. However, the results can offer direction for future research in longitudinal populations utilizing a cohort study design which assesses the trajectories of cannabis use and associations with impaired driving in emerging adults.

IMPLICATIONS

7.1. Research

7.1.1. Longitudinal Analyses

This study investigated the association between engaging in regular and occasional use of cannabis and past-year traffic violations among early, middle, and late emerging adults. Due to the cross-sectional nature of this study, causality could not be determined. Future research should investigate the causal relationship between cannabis use frequency and traffic violations in emerging adults. As presented in our study and the current literature, the prevalence of traffic violations is higher for individuals who engaged in any cannabis use compared to individuals who were non-users of cannabis (Fischer, Rodopoulos, Rehm & Ivsins, 2006; Mann et al., 2007). However, findings suggesting lower levels of risk for high frequency use remains mixed (Hartley et al., 2019). With the increasing concern surrounding cannabis use and driving among health professionals, there is an overwhelming demand to understand the temporal relationship between frequency of cannabis use and driving. In the current study, the measurement of the outcome and exposure has limitations. Currently, Canada does not have access to a roadside survey data system which is present in the United States. However, future research could improve the outcome of traffic violations by determining the type of violation (i.e., routine traffic stop vs. accident), include information on whether or not the driver had a valid license, and if respondents were drivers or passengers. While the exposure was measured using the WHO-CIDI screening method, the criteria for categorization into 'dependence' and 'abuse' should be merged in accordance with the new criteria and thresholds presented in the DSM-5 (Qadeer, Georgiades, Boyle & Ferro, 2019; American Psychiatric Association, 2013). An additional measure to determine the potential risk of driving impaired in emerging adults can be assessed by asking individuals if they have ever driven within two hours of consuming cannabis. Moreover, longitudinal studies can utilize a cohort study design which assesses the trajectories of cannabis use over time. Latent class analysis can be used to create groups of emerging adults based on their frequency of use, since there is variation in patterns of use in emerging adults. For example, a study of cannabis trajectories and associations with driving risk behaviours in Canadian youth classified youth into the following groups based off their patterns of use: abstainers, occasional users, decreasers, increasers, and chronic users (Sukhawathanakul, Thompson, Brubacher, & Leadbeater, 2019).

7.1.2. Natural Experiments

While randomized controlled trials (RCT) sit towards the top of the hierarchy of scientific evidence, their design is often not considered ethical, practical, or suitable, when determining the influence of new legislation (Leatherdale, 2019). The impact of new policy can be evaluated by a natural experiment, which is an experiment that doesn't allow researchers to control the implementation of an intervention (Leatherdale 2019; Craig et al., 2012, 2011). Currently, driving under the influence of cannabis is tested using RCT designs and driving simulators (Arkell et al., 2019; Micallef et al., 2018; Doroudgar et al., 2018; Hartman et al., 2015; Bosker et al., 2012b). However, findings from these studies may not help to inform real-world decisions because of discrepancies between real-world driving and simulated driving. Future research could explore the impact of driving under the influence of cannabis by assessing roadside survey data pre- and post- legalization. For example, a natural experiment in Colorado determined that there was no change in the amount that drivers suspected of driving under the influence were screened for cannabis, however driving with greater or equal to 2 ng/mL of THC in the blood significantly increased after legalization (i.e., 28% pre- and 65% post- legalization) (Urfer, Morton, Beall, Geldmann, & Gunesch, 2014). Similarly, a natural experiment in Washington found a significant increase in drivers testing positive for both THC and a THC metabolite (carboxy-THC) after legalization (Couper & Peterson, 2014).

7.2. Practice & Prevention

7.2.1. Theory of Planned Behaviour

The Theory of Planned Behaviour was a model used to help explain why emerging adults may engage in impaired driving. This study showed that engaging in regular and occasional use of cannabis increased the risk of a traffic violation. Our results are supported by the Theory of Planned Behaviour. For example, increased prevalence of past-year traffic violations in middle and late emerging adults when compared to early emerging adults may be explained by a positive attitude towards the behaviour and favorable subjective norms. If middle and late emerging adults had a negative attitude towards the behavior and unfavourable subjective norms, it would be expected that the prevalence of past-year traffic violations would be less for middle and late emerging adults when compared to early emerging adults. Moreover, our findings also suggest that tolerance in regular users may explain the reduction in odds when compared to occasional users. Also aligned with the theory, tolerance can lead to increased behavioral control. For instance, regular cannabis users may be resilient to the acute effects of THC (Hartman & Huestis, 2013) and feel they do not need to adjust their driving behaviour to offset impairment (Watson, Mann, Wickens, & Brands, 2019), making them feel like they are in complete control. While our findings indicate that positive attitude towards the behaviour, favourable subjective norms, and increased perceived behavioural control may explain the increased risk of traffic violations in regular and occasional cannabis users, this theory should be used to help implement population-based interventions to reduce driving impaired by cannabis.

7.2.2. Population-Based Interventions

The theory of planned behaviour can be a useful tool to help understand perceptions of current laws regarding driving under the influence of cannabis. Both qualitative and quantitative research have demonstrated an association between lower perceived risk of legal penalties and driving under the influence of cannabis when compared to driving under the influence of alcohol (Goodman, Leos-Toro, & Hammond, 2019; Terry & Wright, 2005). This perception may be attributed to less random roadside testing for cannabis when compared to alcohol, despite having laws in place which allow law enforcement to stop and examine drivers (Jones, Donnelly, Swift, & Weatherburn, 2005; European Monitoring Centre for Drugs and Drug Addiction, 2003). Moreover, current detection methods for cannabis impairment have not been empirically validated (Bosker et al., 2012a) and do not meet sensitivity or specificity requirements (Capler, Bilsker, Van Pelt, & MacPherson, 2017), which could lower perceived risk by impacting both behavioural and normative beliefs. Lower perception of risk may also be influenced by tolerance in high frequency users who believe they do not have to acclimatize to compensate for impairment (Watson, Mann, Wickens, & Brands, 2019). Thus, population-based interventions should keep the following two recommendations in mind: (1) increase risk perception by improving random roadside testing for cannabis; and (2) defining *per se* laws for driving under the influence of cannabis once more research becomes available so high frequency users do not run the risk of unlawful criminalization.

Understanding the theory of planned behavior can help public health professionals create and implement mass-media campaigns. Applying the theory of planned behaviour, an individual is more likely to drive under the influence of cannabis if they have positive attitudes the behaviour (i.e., believing that the risks of driving under the influence of cannabis are low), favourable subjective norms (i.e., friends and family also believe that the risks of driving under the influence are low), and increased perceived behaviour control (i.e., believing that cannabis does not impair their ability to drive). Aforementioned, the lack of mass media campaigns for driving under the influence of cannabis may be associated with reduced social stigma when compared to driving under the influence of alcohol (McGuire, Dawe, Shield, Rehm, Fischer, 2011). In Colorado, a mass-media campaign called "Drive High, Get a DUI" was implemented in 2014 (Brooks-Russell, Levinson, Li, Roppolo, & Bull, 2017). A large prospective cohort evaluating the effectiveness of the campaign determined that cannabis users who reported seeing the campaign at least once were significantly more likely to have an accurate understanding of the new legislation when compared to cannabis users who never reported seeing the campaign [OR=2.53 (1.29-4.95)] (Brooks-Russell, Levinson, Li, Roppolo, & Bull, 2017). Moreover, other research suggests that knowledge of Colorado legislature is a weak predictor of driving under the influence of cannabis (Davis et al., 2016). However, data generated from the research conducted by Davis and colleagues was limited to an online convenience sample and may not be representative of larger populations (Davis et al., 2016). Nonetheless, there is strong evidence to suggest that mass-media campaigns are effective at reducing substance impaired driving (Young et al., 2018; Yadav & Kobayashi, 2015; Terry & Wright, 2005; Elder et al., 2004).

CONCLUSION

Since the legalization of cannabis, driving under the influence of cannabis has become a chief public health concern in Canada. The shortage of research on traffic violations among emerging adults who engage in regular or occasional use of cannabis emphasizes the importance of understanding this relationship and if tolerance plays a role in reducing the risk of a traffic violation. The findings presented in this thesis can be used as a paradigm for future research in longitudinal populations and natural experiments to evaluate the impact of cannabis legalization in Canada and other large populations. The results of this study can also offer recommendations for population-based interventions targeting regular and occasional cannabis users by utilizing the Theory of Planned Behaviour model to help understand how individual beliefs, social norms, and perceived risks can influence intention to engage in impaired driving. The implications of population-based interventions such as improving random roadside drug testing, defining *per se* laws, and creating mass-media campaigns can help reduce the prevalence of traffic violations observed in regular and occasional cannabis users.

REFERENCES

Agosti, V., Nunes, E., & Levin, F. (2002). Rates of psychiatric comorbidity among US residents with lifetime cannabis dependence. *The American journal of drug and alcohol abuse*, *28*(4), 643-652.

Aldridge, J., Measham, F., & Williams, L. (2013). *Illegal leisure revisited: Changing patterns of alcohol and drug use in adolescents and young adults*. Routledge.

American Psychiatric Association. (2013). Highlights of changes from DSM-IV-TR to DSM-5. Washington, DC: Author.

Arkell, T. R., Lintzeris, N., Kevin, R. C., Ramaekers, J. G., Vandrey, R., Irwin, C., ... & McGregor, I. S. (2019). Cannabidiol (CBD) content in vaporized cannabis does not prevent tetrahydrocannabinol (THC)-induced impairment of driving and cognition. *Psychopharmacology*, 1-12.

Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American psychologist*, *55*(5), 469.

Arnett, J. J. (2001). Conceptions of the transition to adulthood: Perspectives from adolescence through midlife. *Journal of adult development*, *8*(2), 133-143.

Arnett, J. J., Žukauskienė, R., & Sugimura, K. (2014). The new life stage of emerging adulthood at ages 18–29 years: Implications for mental health. *The Lancet Psychiatry, 1*(7), 569 576.

Asbridge, M., Hayden, J. A., & Cartwright, J. L. (2012). Acute cannabis consumption and motor vehicle collision risk: systematic review of observational studies and meta-analysis. *Bmj*, *344,* e536.

Asbridge, M., Mann, R., Cusimano, M. D., Trayling, C., Roerecke, M., Tallon, J. M., ... & Rehm, J. (2014). Cannabis and traffic collision risk: findings from a case-crossover study of injured drivers presenting to emergency departments. *International journal of public health*, *59*(2), 395-404.

Auer, R., Vittinghoff, E., Yaffe, K., Künzi, A., Kertesz, S. G., Levine, D. A., ... & Glymour, M. M. (2016). Association between lifetime marijuana use and cognitive function in middle age: the Coronary Artery Risk Development in Young Adults (CARDIA) study. *JAMA internal medicine*, *176*(3), 352-361.

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In *Action control* (pp. 11-39). Springer, Berlin, Heidelberg.

Beirness, D. J., Beasley, E. E., & Boase, P. (2013, August). Drug use among fatally injured drivers in Canada. In *Proceedings of the 20th International Conference on Alcohol, Drugs and Traffic Safety*. Brisbane: Centre for Accident Research and Road Safety.

Bill C-45: *An Act respecting cannabis and to amend the Controlled Drugs and Substances Act, the Criminal Code and other Acts*. Royal Assent June 21, 2018. 42nd Parliament, 1st session. Retrieved from the Parliament of Canada website: http://www.parl.ca/DocumentViewer/en/42-1/bill/C-45/royal-assent. Accessed 15 Sept 2019.

Bill C-46: *An Act to amend the Criminal Code (offences relating to conveyances) and to make consequential amendments to other Acts.* Royal Assent June 21, 2018. 42nd Parliament, 1st session. Retrieved from the Parliament of Canada website: https://www.parl.ca/DocumentViewer/en/42-1/bill/c-46/royal-assent. Accessed 15 Sept 2019.

Bosker, W. M., Theunissen, E. L., Conen, S., Kuypers, K. P. C., Jeffery, W. K., Walls, H. C., ... & Ramaekers, J. G. (2012a). A placebo-controlled study to assess Standardized Field Sobriety Tests performance during alcohol and cannabis intoxication in heavy cannabis users and accuracy of point of collection testing devices for detecting THC in oral fluid. *Psychopharmacology*, *223*(4), 439-446.

Bosker, W. M., Kuypers, K. P., Theunissen, E. L., Surinx, A., Blankespoor, R. J., Skopp, G., ... & Ramaekers, J. G. (2012b). Medicinal Δ9-tetrahydrocannabinol (dronabinol) impairs on the-road driving performance of occasional and heavy cannabis users but is not detected in Standard Field Sobriety Tests. *Addiction*, *107*(10), 1837-1844.

Brochu, S., Duff, C., Asbridge, M., & Erickson, P. G. (2011). "There's what's on Paper and then there's What Happens, out on the Sidewalk": Cannabis Users Knowledge and Opinions of Canadian Drug Laws. *Journal of Drug Issues*, *41*(1), 95-115.

Brooks-Russell, A., Levinson, A., Li, Y., Roppolo, R. H., & Bull, S. (2017). What do Colorado adults know about legal use of recreational marijuana after a media campaign?. *Health promotion practice*, *18*(2), 193-200.

Capler, R., Bilsker, D., Van Pelt, K., & MacPherson, D. (2017). Cannabis use and driving: evidence review. *Burnaby (BC): Simon Fraser University, Canadian Drug Policy Coalition*.

Centers for Disease Control and Prevention. (2017). *Ten Leading Causes of Nonfatal Injuries Treated in Hospital Emergency Departments*.
Retrieved from
https://www.cdc.gov/injury/wisqars/pdf//leading_causes_of_nonfatal_injury_2017 508.pdf. Accessed 13 Feb. 2020.

Centers for Disease Control and Prevention. (2019). *Ten Leading Causes of Death and Injury*. Retrieved from
https://www.cdc.gov/injury/wisqars/LeadingCauses.html. Accessed 10 Sept. 2019.

Chang, I., & Lapham, S. C. (1996). Validity of self-reported criminal offences and traffic violations in screening of driving-while-intoxicated offenders. *Alcohol and Alcoholism*, *31*(6), 583-590.

Cheung, N. W., & Cheung, Y. W. (2006). Is Hong Kong experiencing normalization of adolescent drug use? Some reflections on the normalization thesis. *Substance use & misuse*, *41*(14), 1967-1990.

Chipman, M. L., Macdonald, S., & Mann, R. E. (2003). Being "at fault" in traffic crashes: does alcohol, cannabis, cocaine, or polydrug abuse make a difference?. *Injury Prevention*, *9*(4), 343-348.

Colizzi, M., & Bhattacharyya, S. (2018). Cannabis use and the development of tolerance: a systematic review of human evidence. *Neuroscience & Biobehavioral Reviews*, *93*, 1-25.

Couper, F. J., & Peterson, B. L. (2014). The prevalence of marijuana in suspected impaired driving cases in Washington state. *Journal of analytical toxicology*, *38*(8), 569-574.

Craig, P., Cooper, C., Gunnell, D., Haw, S., Lawson, K., Macintrye, S., ... & Thompson, S. (2011). Using natural experiments to evaluate population health interventions: guidance for producers and users of evidence. *Medical Research Council*, xx.

Craig, P., Cooper, C., Gunnell, D., Haw, S., Lawson, K., Macintyre, S., ... & Thompson, S. (2012). Using natural experiments to evaluate population health interventions: new Medical Research Council guidance. *J Epidemiol Community Health*, *66*(12), 1182-1186.

Crean, R. D., Crane, N. A., & Mason, B. J. (2011). An evidence based review of acute and long

term effects of cannabis use on executive cognitive functions. *Journal of addiction medicine*, *5*(1), 1.
Davis, K. C., Allen, J., Duke, J., Nonnemaker, J., Bradfield, B., Farrelly, M. C., ... & Novak, S. (2016). Correlates of marijuana drugged driving and openness to driving while high: evidence from Colorado and Washington. *PloS one*, *11*(1).
Degenhardt, L., & Hall, W. (2012). Extent of illicit drug use and dependence, and their contribution to the global burden of disease. *The Lancet*, *379*(9810), 55-70.
Di Forti, M., Marconi, A., Carra, E., Fraietta, S., Trotta, A., Bonomo, M., ... & Stilo, S. A. (2015). Proportion of patients in south London with first-episode psychosis attributable to use of high potency cannabis: a case-control study. *The Lancet Psychiatry*, *2*(3), 233-238.
Doroudgar, S., Mae Chuang, H., Bohnert, K., Canedo, J., Burrowes, S., & Perry, P. J. (2018). Effects of chronic marijuana use on driving performance. *Traffic injury prevention*, *19*(7), 680-686.
Duff, C. (2005). Party drugs and party people: Examining the 'normalization' of recreational drug use in Melbourne, Australia. *International journal of drug policy*, *16*(3), 161-170.
Duff, C., Asbridge, M., Brochu, S., Cousineau, M. M., Hathaway, A. D., Marsh, D., & Erickson, P. G. (2012). A Canadian perspective on cannabis normalization among adults. *Addiction Research & Theory*, *20*(4), 271-283.
Duff, C., & Erickson, P. G. (2014). Cannabis, risk and normalisation: evidence from a Canadian study of socially integrated, adult cannabis users. *Health, Risk & Society*, *16*(3), 210-226.
Elder, R. W., Shults, R. A., Sleet, D. A., Nichols, J. L., Thompson, R. S., Rajab, W., & Task Force on Community Preventive Services. (2004). Effectiveness of mass media campaigns for reducing drinking and driving and alcohol-involved crashes: a systematic review. *American journal of preventive medicine*, *27*(1), 57-65.
European Monitoring Centre for Drugs and Drug Addiction, 2003. Drugs and Driving. European Monitoring Centre for Drugs and Drug Addiction, Lisbon.
Fabritius, M., Chtioui, H., Battistella, G., Annoni, J. M., Dao, K., Favrat, B., ... & Giroud, C. (2013). Comparison of cannabinoid concentrations in oral fluid and whole blood between occasional and regular cannabis smokers prior to and after smoking a cannabis joint. *Analytical and bioanalytical chemistry*, *405*(30), 9791-9803.
Farmer, R. F., Kosty, D. B., Seeley, J. R., Duncan, S. C., Lynskey, M. T., Rohde, P., ... & Lewinsohn, P.M. (2015). Natural course of cannabis use disorders. *Psychological Medicine*, *45*(1), 63-72.
Fergusson, D. M., Boden, J. M., & Horwood, L. J. (2015). Psychosocial sequelae of cannabis use and implications for policy: findings from the Christchurch Health and Development Study. *Social psychiatry and psychiatric epidemiology*, *50*(9), 1317-1326.
FindLaw. (n.d.). *What is a Traffic Violation?*
Retrieved from
https://hirealawyer.findlaw.com/choosing-the-right-lawyer/traffic-violations.html
Accessed 20 Nov 2019.
Fischer, B., Rodopoulos, J., Rehm, J., & Ivsins, A. (2006). Toking and driving: characteristics of Canadian university students who drive after cannabis use—an exploratory pilot study. *Drugs: education, prevention and policy*, *13*(2), 179-187.
Goldscheider, F. K., & DaVanzo, J. (1986). Semiautonomy and leaving home in early adulthood. *Social Forces*, *65*(1), 187-201.
Goldscheider, F. K., & Goldscheider, C. (1994). Leaving and returning home in 20th century

America. *Population Bulletin*, *48*(4), 1-35.
Goodman, S., Leos-Toro, C., & Hammond, D. (2019). Risk perceptions of cannabis-vs. alcohol-impaired driving among Canadian young people. *Drugs: Education, Prevention and Policy*, 1-8.
Government of Alberta. (2019). Get a driver's license. Retrieved from: https://www.alberta.ca/get-drivers-licence.aspx. Accessed 15 Sept 2019.
Government of Canada. (2018). Driving in Canada. Retrieved from: https://www.canada.ca/en/immigration-refugees-citizenship/services/new-immigrants/new-life-canada/driving.html. Accessed 15 Sept 2019.
Government of Canada. (2019). Summary results for 2017 Canadian Tobacco, Alcohol and Drugs Survey. Retrieved from: https://www.canada.ca/en/health-canada/services/canadian-tobacco-alcohol-drugs-survey/2017-summary.html.
Guttmannova, K., Lee, C. M., Kilmer, J. R., Fleming, C. B., Rhew, I. C., Kosterman, R., & Larimer, M. E. (2016). Impacts of changing marijuana policies on alcohol use in the United States. *Alcoholism: Clinical and Experimental Research*, *40*(1), 33-46.
Haberstick, B. C., Young, S. E., Zeiger, J. S., Lessem, J. M., Hewitt, J. K., & Hopfer, C. J. (2014).Prevalence and correlates of alcohol and cannabis use disorders in the United States: results from the national longitudinal study of adolescent health. *Drug and alcohol dependence*, *136*, 158-161.
Hall, W., & Pacula, R. L. (2003). *Cannabis use and dependence: public health and public policy*. Cambridge university press.
Hall, W., & Degenhardt, L. (2009). Adverse health effects of non-medical cannabis use. *The Lancet*, *374*(9698), 1383-1391.
Hartley, S., Simon, N., Larabi, A., Vaugier, I., Barbot, F., Quera-Salva, M. A., & Alvarez, J. C. (2019). Effect of Smoked Cannabis on Vigilance and Accident Risk Using Simulated Driving in Occasional and Chronic Users and the Pharmacokinetic–Pharmacodynamic Relationship. *Clinical chemistry*, *65*(5), 684-693.
Hartman, R. L., & Huestis, M. A. (2013). Cannabis effects on driving skills. *Clinical chemistry*, *59*(3), 478-492.
Hartman, R. L., Brown, T. L., Milavetz, G., Spurgin, A., Pierce, R. S., Gorelick, D. A., ... & Huestis, M. A. (2015). Cannabis effects on driving lateral control with and without alcohol. *Drug and alcohol dependence*, *154*, 25-37.
Hartman, R. L., Richman, J. E., Hayes, C. E., & Huestis, M. A. (2016). Drug Recognition Expert (DRE) examination characteristics of cannabis impairment. *Accident Analysis & Prevention*, *92*, 219-229.
Hasin, D. S., Kerridge, B. T., Saha, T. D., Huang, B., Pickering, R., Smith, S. M., … Grant, B. F. (2016). Prevalence and Correlates of DSM-5 Cannabis Use Disorder, 2012-2013: Findings from the National Epidemiologic Survey on Alcohol and Related Conditions III. *The American journal of psychiatry*, *173*(6), 588–599. doi:10.1176/appi.ajp.2015.15070907.
Hathaway, A. D., Mostaghim, A., Erickson, P. G., Kolar, K., & Osborne, G. (2018). "It's Really No Big Deal": The Role of Social Supply Networks in Normalizing Use of Cannabis by Students at Canadian Universities. *Deviant Behavior*, *39*(12), 1672-1680.
Health Canada. (2013). *Canadian Alcohol and Drug User Monitoring Survey (CADMUS).* Ottawa, ON: Health Canada.

Jafarpour, S., & Rahimi-Movaghar, V. (2014). Determinants of risky driving behavior: a narrative review. *Medical journal of the Islamic Republic of Iran*, *28*, 142.

Jones, C., Donnelly, N., Swift, W., & Weatherburn, D. (2006). Preventing cannabis users from driving under the influence of cannabis. *Accident Analysis & Prevention*, *38*(5), 854-861.

Kalant, H., & PorathWaller, A. (2019). Clearing the smoke on cannabis – An Update. *Medical Use of Cannabis and Cannabinoids. Raport CCSA Ottawa*, 1-7.

Kerridge, B. T., Pickering, R., Chou, P., Saha, T. D., & Hasin, D. S. (2018). DSM-5 cannabis use disorder in the National Epidemiologic Survey on Alcohol and Related Conditions-III: gender-specific profiles. *Addictive behaviors*, *76*, 52-60.

Khiabani, H. Z., Bramness, J. R. G., Bjorneboe, A., & Morland, J. R. (2006). Relationship between THC concentration in blood and impairment in apprehended drivers. *Traffic injury prevention*, *7*(2), 111-116.

Kleiman, M. A., Jones, T., Miller, C. J., & Halperin, R. (2018). Driving while stoned: Issues and policy options. *Journal of Drug Policy Analysis*, *11*(2).

Lai, H. M. X., & Sitharthan, T. (2012). Exploration of the comorbidity of cannabis use disorders and mental health disorders among inpatients presenting to all hospitals in New South Wales, Australia. *The American journal of drug and alcohol abuse*, *38*(6), 567-574.

LaMorte, W.W. (2019). Behavioral Change Models: The Theory of Planned Behaviour. Retrieved from http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories3.html. Accessed 25 Feb 2020.

Leatherdale, S. T. (2019). Natural experiment methodology for research: a review of how different methods can support real-world research. *International Journal of Social Research Methodology*, *22*(1), 19-35.

Lee, D., & Huestis, M. A. (2014). Current knowledge on cannabinoids in oral fluid. *Drug testing and analysis*, *6*(1-2), 88-111.

Leos-Toro, C., Rynard, V., & Hammond, D. (2017). Prevalence of problematic cannabis use in Canada: Cross-sectional findings from the 2013 Canadian Tobacco, Alcohol and Drugs Survey. *Canadian Journal of Public Health*, *108*(5-6), e516-e522.

Lev-Ran, S., Le Foll, B., McKenzie, K., George, T. P., & Rehm, J. (2013). Cannabis use and cannabis use disorders among individuals with mental illness. *Comprehensive psychiatry*, *54*(6), 589-598.

Li, M. C., Brady, J. E., DiMaggio, C. J., Lusardi, A. R., Tzong, K. Y., & Li, G. (2011). Marijuana use and motor vehicle crashes. *Epidemiologic reviews*, *34*(1), 65-72.

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

Macdonald, S., Mann, R. E., Chipman, M., & Anglin-Bodrug, K. (2004). Collisions and traffic violations of alcohol, cannabis and cocaine abuse clients before and after treatment. *Accident Analysis & Prevention*, *36*(5), 795-800.

MacDonald, S., Mann, R., Chipman, M., Pakula, B., Erickson, P., Hathaway, A., & MacIntyre, P. (2008). Driving behavior under the influence of cannabis or cocaine. *Traffic Injury Prevention*, *9*(3), 190-194.

Malhotra, N., Starkey, N. J., & Charlton, S. G. (2017). Driving under the influence of drugs:

Perceptions and attitudes of New Zealand drivers. *Accident Analysis & Prevention*, *106*, 44-52.
Mann, R. E., Macdonald, S., Chipman, M. L., Adlaf, E. M., Anglin-Bodrug, K., & Zhao, J. (2002). Identifying possible sources of bias introduced in traffic safety research: comparison of blind linkage with volunteer clinical samples. In *Proceedings International Council on Alcohol, Drugs and Traffic Safety Conference* (Vol. 2002, pp. 275-280). International Council on Alcohol, Drugs and Traffic Safety.
Mann, R. E., Adlaf, E., Zhao, J., Stoduto, G., Ialomiteanu, A., Smart, R. G., & Asbridge, M. (2007). Cannabis use and self-reported collisions in a representative sample of adult drivers. *Journal of safety research*, *38*(6), 669-674.
Manitoba Public Insurance. (2019). Licensing and ID. Retrieved from: https://www.mpi.mb.ca/Pages/Licensing-ID.aspx?sct=Driver%20Licensing. Accessed 15 Sept 2019.
Mason, N. L., Theunissen, E. L., Hutten, N. R., Desmond, H. Y., Toennes, S. W., Jansen, J. F., ... & Ramaekers, J. G. (2019). Reduced responsiveness of the reward system underlies tolerance to cannabis impairment in chronic users. *bioRxiv*, 708677.
McCarthy, D. M., Lynch, A. M., & Pederson, S. L. (2007). Driving after use of alcohol and marijuana in college students. *Psychology of addictive behaviors*, *21*(3), 425.
McGuire, F., Dawe, M., Shield, K. D., Rehm, J., & Fischer, B. (2011). Driving under the influence of cannabis or alcohol in a cohort of high-frequency cannabis users: Prevalence and reflections on current interventions. *Canadian Journal of Criminology and Criminal Justice*, *53*(2), 247-259.
Measham, F., Newcombe, R., & Parker, H. (1994). The normalization of recreational drug use amongst young people in North-West England. *British Journal of Sociology*, 287-312.
Micallef, J., Dupouey, J., Jouve, E., Truillet, R., Lacarelle, B., Taillard, J., ... & Philip, P. (2018). Cannabis smoking impairs driving performance on the simulator and real driving: a randomized, double-blind, placebo-controlled, crossover trial. *Fundamental & clinical pharmacology*, *32*(5), 558-570.
Michael, R. T., Gagnon, J. H., Laumann, E. O., & Kolata, G. (1995). Sex in America: A definitive survey. *BMJ-British Medical Journal-International Edition*, *310*(6978), 540.
Ministry of Transportation. (2013). Impaired driving. Retrieved from http://www.mto.gov.on.ca/english/safety/impaired-driving.shtml
Nelson, L. J., & Barry, C. M. (2005). Distinguishing features of emerging adulthood: The role of self-classification as an adult. *Journal of adolescent research*, *20*(2), 242-262.
Newmeyer, M. N., Swortwood, M. J., Taylor, M. E., Abulseoud, O. A., Woodward, T. H., & Huestis, M. A. (2017). Evaluation of divided attention psychophysical task performance and effects on pupil sizes following smoked, vaporized and oral cannabis administration. *Journal of applied toxicology*, *37*(8), 922-932.
Pacher, P., & Kunos, G. (2013). Modulating the endocannabinoid system in human health and disease–successes and failures. *The FEBS journal*, *280*(9), 1918-1943.
Papafotiou, K., Carter, J. D., & Stough, C. (2005). The relationship between performance on the standardised field sobriety tests, driving performance and the level of Δ9 tetrahydrocannabinol (THC) in blood. *Forensic Science International*, *155*(2-3), 172-178.
Parker, H. J., Measham, F., & Aldridge, J. (1995). *Drugs futures: changing patterns of drug use amongst English youth*. London: Institute for the Study of Drug Dependence.
Parker, H. (2005). Normalization as a barometer: Recreational drug use and the consumption of

leisure by younger Britons. *Addiction research & theory*, *13*(3), 205-215.
Porath-Waller, A. J., & Beirness, D. J. (2013, August). An Examination of the Validity of the Standardized Field Sobriety Test (SFST) in Detecting Drug Impairment. In *International Conference on Alcohol, Drugs and Traffic Safety (T2013), 20th, 2013, Brisbane, Queensland, Australia*.
Patton, G. C., Coffey, C., Carlin, J. B., Degenhardt, L., Lynskey, M., & Hall, W. (2002). Cannabis use and mental health in young people: cohort study. *Bmj*, *325*(7374), 1195 1198.
Qadeer, R. A., Georgiades, K., Boyle, M. H., & Ferro, M. A. (2019). An epidemiological study of substance use disorders among emerging and young adults. *The Canadian Journal of Psychiatry*, *64*(5), 313-322.
Ramaekers, J. G., Kauert, G., Theunissen, E. L., Toennes, S. W., & Moeller, M. R. (2009). Neurocognitive performance during acute THC intoxication in heavy and occasional cannabis users. *Journal of psychopharmacology*, *23*(3), 266-277.
Reisfield, G. M., Goldberger, B. A., Gold, M. S., & DuPont, R. L. (2012). The mirage of impairing drug concentration thresholds: a rationale for zero tolerance per se driving under the influence of drugs laws. *Journal of analytical toxicology*, *36*(5), 353-356.
Rogeberg, O., & Elvik, R. (2016). The effects of cannabis intoxication on motor vehicle collision revisited and revised. *Addiction*, *111*(8), 1348-1359.
SAS Institute. (1985). *SAS user's guide: statistics* (Vol. 2). Sas Inst.
SAS Support. (2010). *Rao-Scott Chi-Square Test.* (2010). Retrieved from https://support.sas.com/documentation/cdl/en/statug/63033/HTML/default/viewer.htm#statug_surveyfreq_a0000000221.htm. Accessed 10 Nov 2019.
Schulenberg, J., O'Malley, P. M., Bachman, J. G., Wadsworth, K. N., & Johnston, L. D. (1996). Getting drunk and growing up: trajectories of frequent binge drinking during the transition to young adulthood. *Journal of studies on alcohol*, *57*(3), 289-304.
Schwope, D. M., Karschner, E. L., Gorelick, D. A., & Huestis, M. A. (2011). Identification of recent cannabis use: whole-blood and plasma free and glucuronidated cannabinoid pharmacokinetics following controlled smoked cannabis administration. *Clinical chemistry*, *57*(10), 1406-1414.
SGI. (2019). Saskatchewan’s driver’s licensing and vehicle registration. Retrieved from: https://www.sgi.sk.ca/licensing. Accessed 15 Sept 2019.
Smith, D., (1968) Acute and Chronic Toxicity of Marijuana, Journal of Psychedelic Drugs, 2:1, 37-48.
Solowij, N., Walterfang, M., Lubman, D. I., Whittle, S., Lorenzetti, V., Styner, M., ... & Yücel, M. (2013). Alteration to hippocampal shape in cannabis users with and without schizophrenia. *Schizophrenia research*, *143*(1), 179-184.
Smiley, A.M. (1986). Marijuana: On road and driving simulator studies. *Alcohol, Drugs, and Driving*, *2*, 121-134.
Spackman, E., Haines-Saah, R., Danthurebandara, V. M., Dowsett, L. E., Noseworthy, T., & Clement, F. M. (2017). Marijuana use and perceptions of risk and harm: a survey among Canadians in 2016. *Healthcare Policy*, *13*(1), 17.
Statistics Canada. (2011). Canadian Community Health Survey (CCHS) – Mental Health. Questionnaire. Available from PDF access on Odesi.
Statistics Canada. (2013a). *Canadian Community Health Survey - Mental Health (CCHS*).

Retrieved from http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5015. Accessed 20 Aug 2019.

Statistics Canada. (2013b). Canadian Community Health Survey (CCHS) – Mental Health. Microdata File User Guide. Available from PDF access on Odesi.

Statistics Canada. (2014). Canadian Community Health Survey (CCHS) – Mental Health. Derived Variable (DV) Specifications. Available from PDF access on Odesi.

Statistics Canada. (2015). *Impaired driving in Canada, 2015*. Retrieved from https://www150.statcan.gc.ca/n1/pub/85-002-x/2016001/article/14679-eng.htm

Statistics Canada. (2017). *Computer-Assisted Personal Interviewing Monitoring Program*. Retrieved from https://www.statcan.gc.ca/eng/about/pia/capi. Accessed 25 Aug 2019.

Statistics Canada. (2020). *What has change since cannabis was legalized?* Retrieved from https://www150.statcan.gc.ca/n1/pub/82-003-x/2020002/article/00002-eng.htm

Substance Abuse and Mental Health Services Administration. (2016). *National Survey on Drug Use and Health: Comparison of 2008-2009 and 2015-2016 Population Percentages (50 States and the District of Columbia).* Retrieved from https://www.samhsa.gov/data/report/comparison-2008-2009-and-2015-2016-nsduh-state prevalence-estimates. Accessed 7 Oct. 2019.

Sukhawathanakul, P., Thompson, K., Brubacher, J., & Leadbeater, B. (2019). Marijuana trajectories and associations with driving risk behaviors in Canadian youth. *Traffic injury prevention*, *20*(5), 472-477.

Stuster, J., & Burns, M. (1998). *Validation of the Standardized Field Sobriety Test battery at BACs below 0.10. US Department of Transportation, National Highway Traffic Safety Administration*. DOTHS-808-839, Washington, DC.

Swift, W., Hall, W., & Teesson, M. (2001). Cannabis use and dependence among Australian adults: results from the National Survey of Mental Health and Wellbeing. *Addiction*, *96*(5), 737-748.

Swift, W., Jones, C., & Donnelly, N. (2010). Cannabis use while driving: A descriptive study of Australian cannabis users. *Drugs: Education, Prevention and Policy*, *17*(5), 573-586.

Talpins, S. K., & Hayes, C. (2004). *Drug Evaluation and Classification (DEC) Program: Targeting Hardcore Impaired Drivers*. American Prosecutors Research Institute.

Teese, R., & Bradley, G. (2008). Predicting recklessness in emerging adults: A test of a psychosocial model. *The journal of social psychology*, *148*(1), 105-128.

Terry, P., & Wright, K. A. (2005). Self-reported driving behaviour and attitudes towards driving under the influence of cannabis among three different user groups in England. *Addictive behaviors*, *30*(3), 619-626.

UNODC (2015). World drug report 2015. Vienna: United Nations Office on Drugs and Crime.

Urfer, S., Morton, J., Beall, V., Feldmann, J., & Gunesch, J. (2014). Analysis of Δ9 tetrahydrocannabinol driving under the influence of drugs cases in Colorado from January 2011 to February 2014. *Journal of analytical toxicology*, *38*(8), 575-581.

Waldeck, T. L., & Miller, L. S. (1997). Gender and impulsivity differences in licit substance use. *Journal of Substance Abuse*, *9*, 269-275.

Watson, T. M., Mann, R. E., Wickens, C. M., & Brands, B. (2019). "Just a Habit": Driving Under the Influence of Cannabis as Ordinary, Convenient, and Controllable Experiences According to Drivers in a Remedial Program. *Journal of Drug Issues*, *49*(3) 531-544.

Wickens, C. M., Mann, R. E., Stoduto, G., Ialomiteanu, A., Smart, R. G., & Rehm, J. (2013). The impact of probable anxiety and mood disorder on self-reported collisions: A population study. *Journal of affective disorders*, *145*(2), 253-255.

Wickens, C. M., Watson, T. M., Mann, R. E., & Brands, B. (2019). Exploring perceptions among people who drive after cannabis use: Collision risk, comparative optimism and normative influence. *Drug and alcohol review*, *38*(4), 443-451.

World Health Organization. (2016). *The health and social effects of nonmedical cannabis use*. World Health Organization.

Yadav, R. P., & Kobayashi, M. (2015). A systematic review: effectiveness of mass media campaigns for reducing alcohol-impaired driving and alcohol-related crashes. *BMC public health*, *15*(1), 857.

Young, B., Lewis, S., Katikireddi, S. V., Bauld, L., Stead, M., Angus, K., ... & Ashie, A. (2018). Effectiveness of mass media campaigns to reduce alcohol consumption and harm: a systematic review. *Alcohol and alcoholism*, *53*(3), 302-316.

APPENDICES

Appendix A – Variables Used to Create New Cannabis Frequency Variable

Table 1. Reported frequencies (n/%) to determine Lifetime Cannabis Dependence.

Cannabis Use Excluding One-Time Use	Cannabis Use Including One-Time Use	Frequency (n)	Percent (%)
Yes	**Yes**	**163**	**100**
	No	**0**	**.**
	Total	**163**	**100**
No	**Yes**	**0**	**.**
	No	**0**	**.**
	Total	**0**	**.**

*Table of *Cannabis Use Excluding One-Time Use* versus *Cannabis Use Including One-Time Use*, controlling for *Lifetime Cannabis Dependence = 'Yes'* and *Lifetime Cannabis Abuse = 'No'*.

Table 2. Reported frequencies (n/%) to determine Lifetime Cannabis Abuse.

Cannabis Use Excluding One-Time Use	Cannabis Use Including One-Time Use	Frequency (n)	Percent (%)
Yes	**Yes**	**444**	**100**
	No	**0**	**.**
	Total	**444**	**100**
No	**Yes**	**0**	**.**
	No	**0**	**.**
	Total	**0**	**.**

*Table of Cannabis Use Excluding One-Time Use versus Cannabis Use Including One-Time Use, controlling for Lifetime Cannabis Dependence = 'No' and Lifetime Cannabis Abuse = 'Yes'.

Table 3. Reported frequencies (n/%) to determine Lifetime Cannabis Use**, One-Time Use***, and Abstinence****.

Cannabis Use Excluding One-Time Use	Cannabis Use Including One-Time Use	Frequency (n)	Percent (%)
Yes	**Yes**	**1683****	**33.8**
	No	**0**	**.**
	Total	**1683****	**33.8**
No	**Yes**	**498*****	**10.0**
	No	**2792******	**56.1**
	Total	**3290**	**66.2**

*Table of *Cannabis Use Excluding One-Time Use* versus *Cannabis Use Including One-Time Use*, controlling for *Lifetime Cannabis Dependence = 'No'* and *Lifetime Cannabis Abuse = 'No'*.
**Lifetime Cannabis Users
***Lifetime Cannabis One-Time Users
****Lifetime Cannabis Abstainers

Appendix B – Grouping 'Regular Use' in Cannabis Frequency Variable

Table 1. Adjusted models of past-year traffic violations for merging cannabis frequency groups and keeping groups separate.

Merging Groups (i.e., 'Regular Use')		Keeping Groups Separate (i.e., 'Dependence' and 'Abuse')	
Effect	**OR (95% CI)**	**Effect**	**OR (95% CI)**
Regular Use	1.93 (1.23-2.92)	Dependence	2.37 (1.25-4.48)
		Abuse	1.82 (1.16-2.84)
Occasional Use	1.93 (1.35-2.74)	Occasional Use	1.93 (1.35-2.75)
Male	2.03 (1.55-2.65)	Male	2.03 (1.55-2.65)
Age 20-24	1.64 (1.20-2.25)	Age 20-24	1.63 (1.19-2.24)
Age 25-29	1.99 (1.35-2.95)	Age 25-29	1.99 (1.35-2.94)
Rural	0.88 (0.68-1.15)	Rural	1.13 (0.87-1.47)
Province	1.34 (1.03-1.76)	Province	1.35 (1.03-1.77)
Regular Alcohol Use	1.19 (0.87-1.64)	Regular Alcohol Use	1.19 (0.87-1.64)
Regular Drug Use	1.27 (0.78-2.04)	Regular Drug Use	1.21 (0.76-1.92)
Mood Disorder	0.96 (0.65-1.41)	Mood Disorder	0.95 (0.65-1.41)
Generalized Anxiety Disorder	1.00 (0.57-1.75)	Generalized Anxiety Disorder	1.00 (0.57-1.74)

Province refers to province group 1 which consists of Alberta, Saskatchewan and Manitoba. All three provinces have a legal driving age that is less than 16 years old.

Appendix C – Dummy Variables for Cannabis Use Frequency

Table 1. Dummy variables for cannabis use frequency.

Cannabis Use Frequency	Dummy Value	
Lifetime Cannabis Dependence	1	0
Lifetime Cannabis Abuse	0	1
Lifetime Cannabis Abstinence (Reference)	0	0

Appendix D – Reference Categories

Table 1. Summary of reference categories that will be used for each variable during statistical analyses.

Variable	Reference Category
Lifetime Cannabis Use Frequency	People who have not engaged in cannabis use
Sex	Female
Age	15-19
Province of Residence	Group 2
Census Metropolitan Area	People who live in a census metropolitan area
Lifetime Alcohol Abuse/Dependence	No
Lifetime Drug Abuse/Dependence	No
Lifetime Mood Disorder	No
Lifetime Generalized Anxiety Disorder	No

Appendix E – Probability Tree Diagrams for Prevalence

Figure 1. Probability tree-diagram using the weighted frequencies for each cannabis use frequency category (i.e., regular use, occasional use, and non-use) obtained in cross tabulation analyses to determine the general period prevalence.

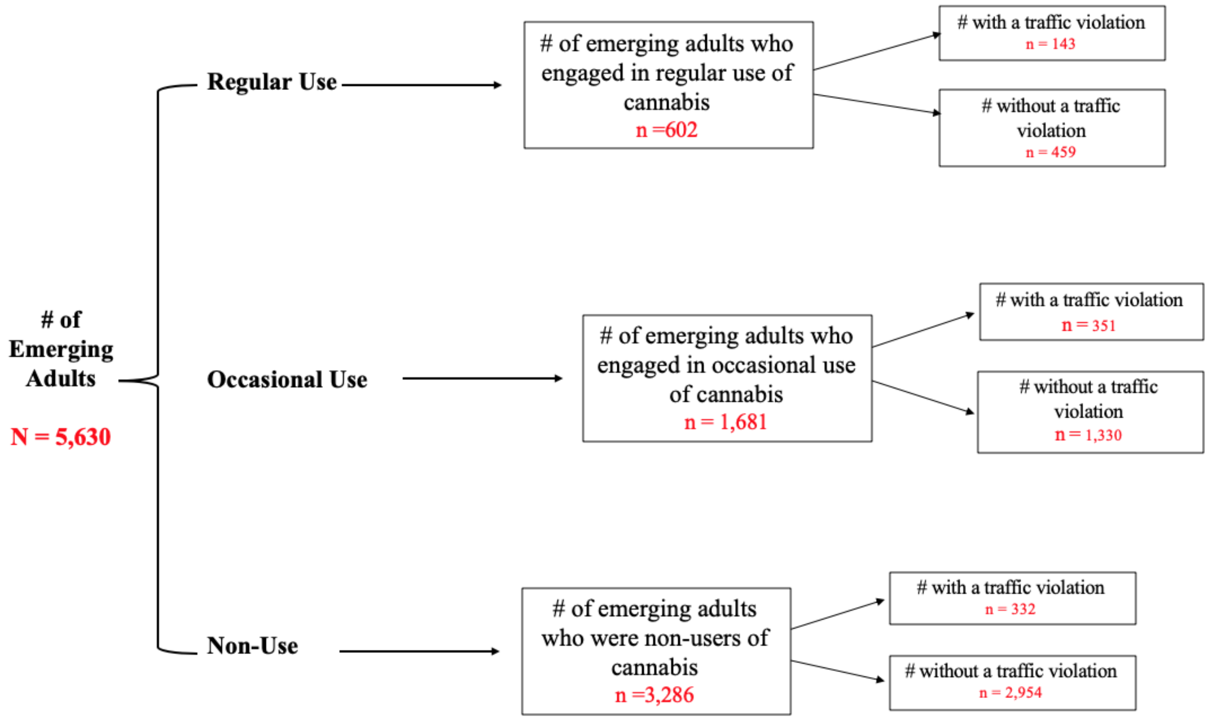


Figure 2. Probability tree-diagram using the weighted frequencies for each cannabis use frequency category (i.e., regular use, occasional use, and non-use) obtained in cross tabulation analyses to determine the sex-specific period prevalence.

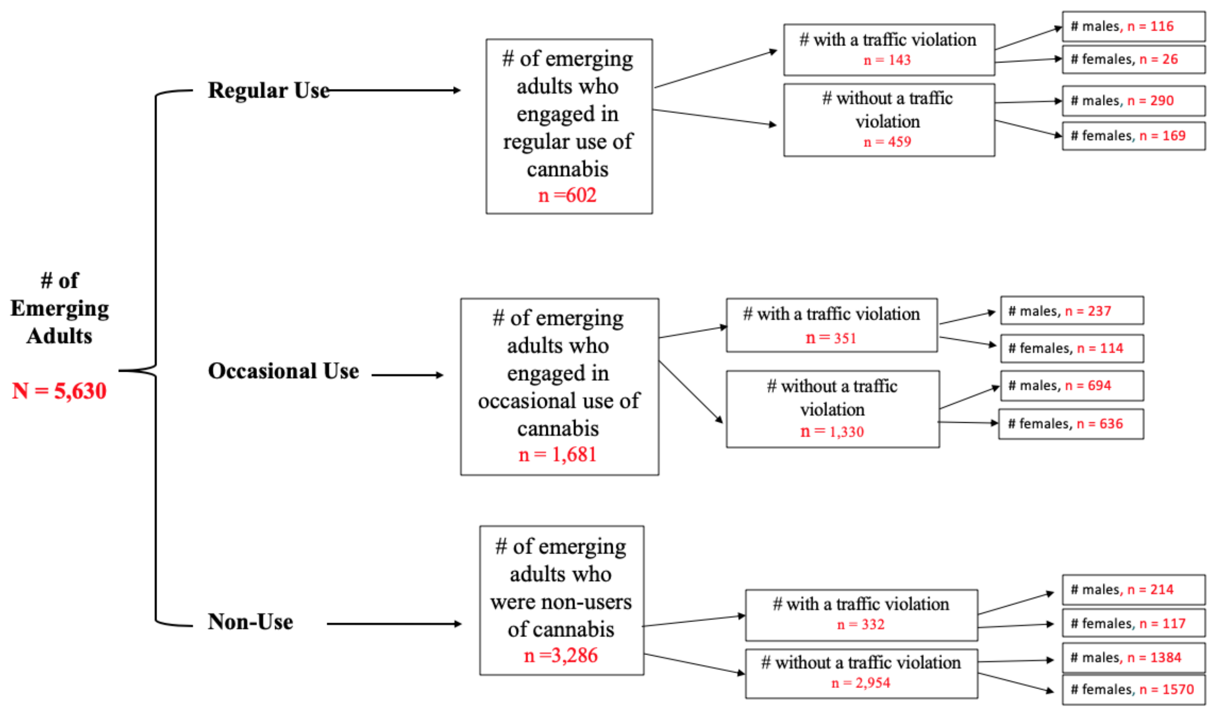
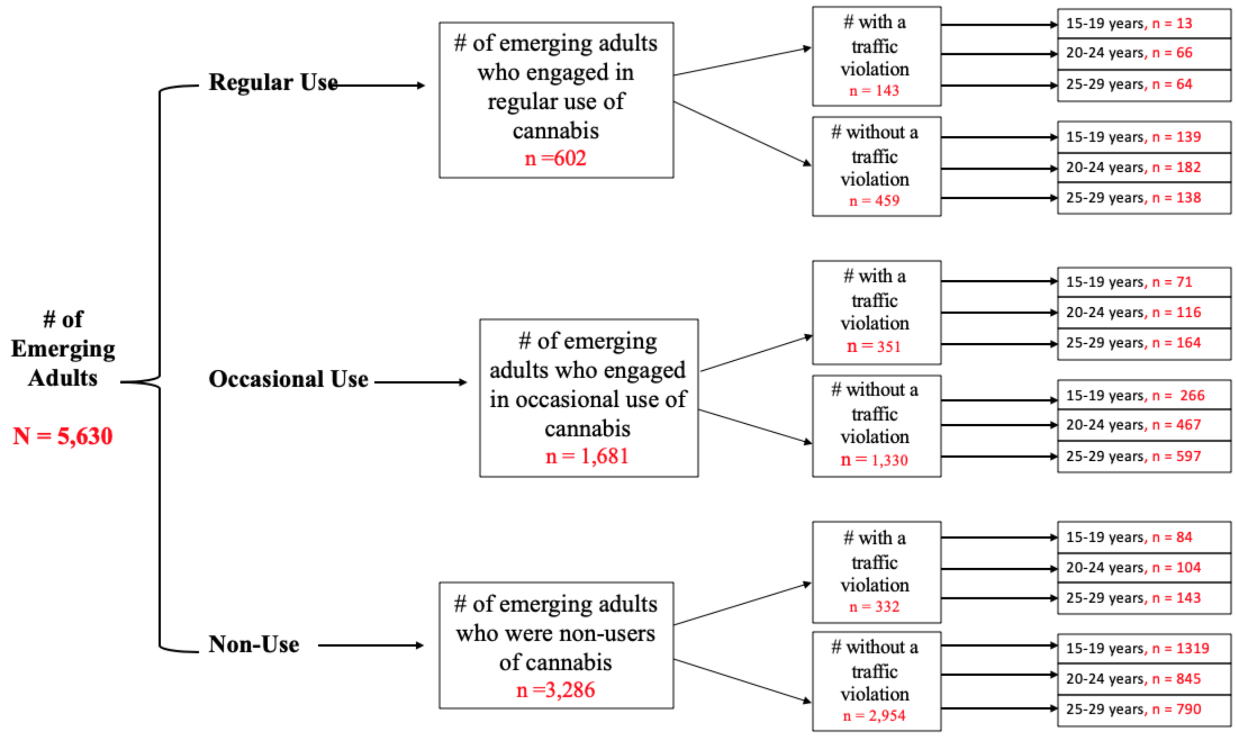


Figure 3. Probability tree-diagram using the weighted frequencies for each cannabis use frequency category (i.e., regular use, occasional use, and non-use) obtained in cross tabulation analyses to determine the age-specific period prevalence.



Appendix F – Prevalence Calculations

i. General Period Prevalence

$$prevalence\ of\ traffic\ violations\ (regular)\ = \frac{\#\ of\ regular\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ heavy\ users}$$

$$prevalence\ of\ traffic\ violations\ (occasional)\ = \frac{\#\ of\ occasional\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ occasional\ users}$$

$$prevalence\ of\ traffic\ violations\ (non)\ = \frac{\#\ of\ non-users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ never\ users}$$

ii. Sex-Specific Period Prevalence

a. Female Prevalence

$$prevalence\ of\ traffic\ violations\ (regular)\ = \frac{\#\ of\ regular\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ heavy\ users}$$

$$prevalence\ of\ traffic\ violations\ (occasional)\ = \frac{\#\ of\ occasional\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ occasional\ users}$$

$$prevalence\ of\ traffic\ violations\ (non)\ = \frac{\#\ of\ non-users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ never\ users}$$

b. Male Prevalence

$$prevalence\ of\ traffic\ violations\ (regular)\ = \frac{\#\ of\ regular\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ heavy\ users}$$

$$prevalence\ of\ traffic\ violations\ (occasional)\ = \frac{\#\ of\ occasional\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ occasional\ users}$$

$$prevalence\ of\ traffic\ violations\ (non)\ = \frac{\#\ of\ non-users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ never\ users}$$

iii. Age-Specific Period Prevalence

a. Early Emerging Adults (15-19)

$$prevalence\ of\ traffic\ violations\ (regular)\ = \frac{\#\ of\ regular\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ heavy\ users}$$

$$prevalence\ of\ traffic\ violations\ (occasional)\ = \frac{\#\ of\ occasional\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ occasional\ users}$$

$$prevalence\ of\ traffic\ violations\ (non)\ = \frac{\#\ of\ non-users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ never\ users}$$

b. **Middle Emerging Adults (20-24)**

$$prevalence\ of\ traffic\ violations\ (regular)\ =\frac{\#\ of\ regular\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ heavy\ users}$$

$$prevalence\ of\ traffic\ violations\ (occasional)\ =\frac{\#\ of\ occasional\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ occasional\ users}$$

$$prevalence\ of\ traffic\ violations\ (non)\ =\frac{\#\ of\ non-users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ never\ users}$$

c. **Late Emerging Adults (25-29)**

$$prevalence\ of\ traffic\ violations\ (regular)\ =\frac{\#\ of\ regular\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ heavy\ users}$$

$$prevalence\ of\ traffic\ violations\ (occasional)\ =\frac{\#\ of\ occasional\ users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ occasional\ users}$$

$$prevalence\ of\ traffic\ violations\ (non)\ =\frac{\#\ of\ non-users\ \boldsymbol{with}\ a\ traffic\ violation}{\#\ of\ never\ users}$$

Appendix G – Hypothesized Main-Effects Models

Model 1

$$\eta_i = \beta_0 + \beta_1 \mathrm{X}_i + \beta_2 X_{2i}$$
$$\eta_i = \beta_0 + \beta_1 REGULAR_i + \beta_2 OCCASIONAL_i;$$

where
η_i is the observed log odds of past-year traffic violations for subject i.
X_{1i} is the observed dummy variable for regular use,
X_{2i} is the observed dummy variable for occasional use,
β_0 is the fixed unknown intercept,
β_1 is the fixed unknown regression coefficient corresponding to regular use,
β_2 is the fixed unknown regression coefficient corresponding to occasional use, and
for any $i \neq j, (X_i, Y_i) \perp (X_j, Y_j)$.

Model 2

$$\eta_i = \beta_0 + \beta_1 \mathrm{X}_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 \mathrm{X}_{5i} + \beta_6 \mathrm{X}_{6i};$$
$$\eta_i = \beta_0 + \beta_1 REGULAR_i + \beta_2 OCCASIONAL_i + \beta_3 SEX_i + \beta_4 AGE_i + \beta_5 CMA_i + \beta_6 PROV_i;$$

where
η_i is the observed log odds of past-year traffic violations for subject i.
X_{1i} is the observed dummy variable for regular use,
X_{2i} is the observed dummy variable for occasional use,
X_{3i} is the observed dummy variable for sex for subject i,
X_{4i} is the observed dummy variable for age for subject i,
X_{5i} is the observed predictor of census metropolitan area i,
X_{6i} is the observed predictor of province for subject i,
β_0 is the fixed unknown intercept,
β_1 is the fixed unknown regression coefficient corresponding to regular use,
β_2 is the fixed unknown regression coefficient corresponding to occasional use,
β_3 is the fixed unknown regression coefficient corresponding to sex,
β_4 is the fixed unknown regression coefficient corresponding to age,
β_5 is the fixed unknown regression coefficient corresponding to census metropolitan area,
β_6 is the fixed unknown regression coefficient corresponding to province, and
for any $i \neq j, (X_i, Y_i) \perp (X_j, Y_j)$.

Model 3

$$\eta_i = \beta_0 + \beta_1 \mathrm{X}_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 \mathrm{X}_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i};$$
$$\eta_i = \beta_0 + \beta_1 REGULAR_i + \beta_2 OCCASIONAL_i + \beta_3 SEX_i + \beta_4 AGE_i + \beta_5 CMA_i + \beta_6 PROV_i + \beta_7 ALC_i + \beta_8 DRUG_i;$$

where
η_i is the observed log odds of past-year traffic violations for subject i.
X_{1i} is the observed dummy variable for regular use,
X_{2i} is the observed dummy variable for occasional use,
X_{3i} is the observed dummy variable for sex for subject i,
X_{4i} is the observed dummy variable for age for subject i,
X_{5i} is the observed predictor of census metropolitan area i,
X_{6i} is the observed predictor of province for subject i,
X_{7i} is the observed predictor of regular alcohol use for subject i,
X_{8i} is the observed predictor of other regular drug use for subject i,
β_0 is the fixed unknown intercept,
β_1 is the fixed unknown regression coefficient corresponding to regular use,
β_2 is the fixed unknown regression coefficient corresponding to occasional use,
β_3 is the fixed unknown regression coefficient corresponding to sex,
β_4 is the fixed unknown regression coefficient corresponding to age,
β_5 is the fixed unknown regression coefficient corresponding to census metropolitan area,
β_6 is the fixed unknown regression coefficient corresponding to province,
β_7 is the fixed unknown regression coefficient corresponding to regular alcohol use,
β_8 is the fixed unknown regression coefficient corresponding to regular drug use, and
for any $i \neq j, (X_i, Y_i) \perp (X_j, Y_j)$.

Model 4

$$\eta_i = \beta_0 + \beta_1 \mathrm{X}_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 \mathrm{X}_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i} + \beta_{10} X_{10i};$$

$$\eta_i = \beta_0 + \beta_1 REGULAR_i + \beta_2 OCCASIONAL_i + \beta_3 SEX_i + \beta_4 AGE_i + \beta_5 CMA_i + \beta_6 PROV_i + \beta_7 ALC_i + \beta_8 DRUG_i + \beta_9 MOOD_i + \beta_{10} GAD_i;$$

where
X_{1i} is the observed dummy variable for regular use,
X_{2i} is the observed dummy variable for occasional use,
X_{3i} is the observed dummy variable for sex for subject i,
X_{4i} is the observed dummy variable for age for subject i,
X_{5i} is the observed predictor of census metropolitan area i,
X_{6i} is the observed predictor of province for subject i,
X_{7i} is the observed predictor of regular alcohol use for subject i,
X_{8i} is the observed predictor of regular drug use for subject i,
X_{9i} is the observed predictor of mood disorder for subject i,
X_{10i} is the observed predictor of generalized anxiety disorder for subject i,
β_0 is the fixed unknown intercept,
β_1 is the fixed unknown regression coefficient corresponding to regular use,
β_2 is the fixed unknown regression coefficient corresponding to occasional use,
β_3 is the fixed unknown regression coefficient corresponding to sex,
β_4 is the fixed unknown regression coefficient corresponding to age,
β_5 is the fixed unknown regression coefficient corresponding to census metropolitan area,
β_6 is the fixed unknown regression coefficient corresponding to province,
β_7 is the fixed unknown regression coefficient corresponding to regular alcohol use,
β_8 is the fixed unknown regression coefficient corresponding to regular drug use,
β_9 is the fixed unknown regression coefficient corresponding to mood disorder,
β_{10} is the fixed unknown regression coefficient corresponding to generalized anxiety disorder,
and
for any $i \neq j, (X_i, Y_i) \perp (X_j, Y_j)$.

Appendix H – Hypothesized Two-Way Interactions Model

$$\eta_i = \beta_0 + \beta_1 \mathrm{X}_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 \mathrm{X}_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i} + \beta_{10} X_{10i} + \beta_{11} X_1 X_{3i} + \beta_{12} X_1 X_{4i} + \beta_{13} X_1 X_{7i} + \beta_{14} X_1 X_{8i} + \beta_{15} X_1 X_{9i} + \beta_{16} X_1 X_{10i} + \beta_{17} X_2 X_{3i} + \beta_{18} X_2 X_{4i} + \beta_{19} X_2 X_{7i} + \beta_{20} X_2 X_{8i} + \beta_{21} X_2 X_{9i} + \beta_{22} X_2 X_{10i};$$

$$\eta_i = \beta_0 + \beta_1 REGULAR_i + \beta_2 OCCASIONAL_i + \beta_3 SEX_i + \beta_4 AGE_i + \beta_5 CMA_i + \beta_6 PROV_i + \beta_7 ALC_i + \beta_8 DRUG_i + \beta_9 MOOD_i + \beta_{10} GAD_i + \beta_{11} REGULAR * SEX_i + \beta_{12} REGULAR * AGE_i + \beta_{13} REGULAR * ALC_i + \beta_{14} REGULAR * DRUG_i + \beta_{15} REGULAR * MOOD_i + \beta_{16} REGULAR * GAD_i + \beta_{17} OCCASIONAL * SEX_i + \beta_{18} OCCASIONAL * AGE_i + \beta_{19} OCCASIONAL * ALC_i + \beta_{20} OCCASIONAL * DRUG_i + \beta_{21} OCCASIONAL * MOOD_i + \beta_{22} OCCASIONAL * GAD_i;$$

where
η_i is the observed log odds of past-year traffic violations for subject i.
X_{1i} is the observed dummy variable for regular use,
X_{2i} is the observed dummy variable for occasional use,
X_{3i} is the observed dummy variable for sex for subject i,
X_{4i} is the observed dummy variable for age for subject i,
X_{5i} is the observed predictor of census metropolitan area i,
X_{6i} is the observed predictor of province for subject i,
X_{7i} is the observed predictor of regular use of alcohol for subject i,
X_{8i} is the observed predictor of regular use of drugs for subject i,
X_{9i} is the observed predictor of mood disorder for subject i,
X_{10i} is the observed predictor of generalized anxiety disorder for subject i,
X_{11i} is the observed predictor for the interaction term of regular use and sex for subject i,
X_{12i} is the observed predictor for the interaction term of regular use and age for subject i,
X_{13i} is the observed predictor for the interaction term of regular use and regular use of alcohol for subject i,
X_{14i} is the observed predictor for the interaction term of regular use and regular use of drugs for subject i,
X_{15i} is the observed predictor for the interaction term of regular use and mood disorder for subject i,
X_{16i} is the observed predictor for the interaction term of regular use and generalized anxiety disorder for subject i,
X_{17i} is the observed predictor for the interaction term of occasional use and sex for subject i,
X_{18i} is the observed predictor for the interaction term of occasional use and age for subject i,
X_{19i} is the observed predictor for the interaction term of occasional use and regular use of alcohol for subject i,
X_{20i} is the observed predictor for the interaction term of occasional use and regular use of drugs for subject i,
X_{21i} is the observed predictor for the interaction term of occasional use and mood disorder for subject i,
X_{22i} is the observed predictor for the interaction term of occasional use and generalized anxiety disorder for subject i,
β_0 is the fixed unknown intercept,

β_1 is the fixed unknown regression coefficient corresponding to regular use,
β_2 is the fixed unknown regression coefficient corresponding to occasional use,
β_3 is the fixed unknown regression coefficient corresponding to sex,
β_4 is the fixed unknown regression coefficient corresponding to age,
β_5 is the fixed unknown regression coefficient corresponding to census metropolitan area,
β_6 is the fixed unknown regression coefficient corresponding to province,
β_7 is the fixed unknown regression coefficient corresponding to regular alcohol use,
β_8 is the fixed unknown regression coefficient corresponding to regular drug use,
β_9 is the fixed unknown regression coefficient corresponding to mood disorder,
β_{10} is the fixed unknown regression coefficient corresponding to generalized anxiety disorder,
β_{11i} is the fixed unknown regression coefficient corresponding to the interaction term of regular use and sex for subject i,
β_{12i} is the fixed unknown regression coefficient corresponding to the interaction term of regular use and age for subject i,
β_{13i} is the fixed unknown regression coefficient corresponding to the interaction term of regular use and regular alcohol use for subject i,
β_{14i} is the fixed unknown regression coefficient corresponding to the interaction term of regular use and regular drug use for subject i,
β_{15i} is the fixed unknown regression coefficient corresponding to the interaction term of regular use and mood disorder for subject i,
β_{16i} is the fixed unknown regression coefficient corresponding to the interaction term of regular use and generalized anxiety disorder for subject i,
β_{17i} is the fixed unknown regression coefficient corresponding to the interaction term of occasional use and sex for subject i,
β_{18i} is the fixed unknown regression coefficient corresponding to the interaction term of occasional use and age for subject i,
β_{19i} is the fixed unknown regression coefficient corresponding to the interaction term of occasional use and regular alcohol use for subject i,
β_{20i} is the fixed unknown regression coefficient corresponding to the interaction term of regular drug use for subject i,
β_{21i} is the fixed unknown regression coefficient corresponding to the interaction term of occasional use and mood disorder for subject i,
β_{22i} is the fixed unknown regression coefficient corresponding to the interaction term of occasional use and generalized anxiety disorder for subject i, and
for any $i \neq j, (X_i, Y_i) \perp (X_j, Y_j)$.

Appendix I – Stratified Main-Effects Models

By Age

Early Emerging Adults (15-19 y)

$$\eta_i = \beta_0 + \beta_1 X_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i};$$
$$\eta_i = \beta_0 + \beta_1 REGULAR_i + \beta_2 OCCASIONAL_i + \beta_3 SEX_i + \beta_4 CMA_i + \beta_5 PROV_i + \beta_6 ALC_i + \beta_7 DRUG_i + \beta_8 MOOD_i + \beta_9 GAD_i;$$

where
X_{1i} is the observed dummy variable for regular use,
X_{2i} is the observed dummy variable for occasional use,
X_{3i} is the observed dummy variable for sex for subject i,
X_{4i} is the observed predictor of census metropolitan area i,
X_{5i} is the observed predictor of province for subject i,
X_{6i} is the observed predictor of regular use of alcohol for subject i,
X_{7i} is the observed predictor of regular use of drugs for subject i,
X_{8i} is the observed predictor of mood disorder for subject i,
X_{9i} is the observed predictor of generalized anxiety disorder for subject i,
β_0 is the fixed unknown intercept,
β_1 is the fixed unknown regression coefficient corresponding to regular use,
β_2 is the fixed unknown regression coefficient corresponding to occasional use,
β_3 is the fixed unknown regression coefficient corresponding to sex,
β_4 is the fixed unknown regression coefficient corresponding to census metropolitan area,
β_5 is the fixed unknown regression coefficient corresponding to province,
β_6 is the fixed unknown regression coefficient corresponding to regular use of alcohol,
β_7 is the fixed unknown regression coefficient corresponding to regular use of drugs,
β_8 is the fixed unknown regression coefficient corresponding to mood disorder,
β_9 is the fixed unknown regression coefficient corresponding to generalized anxiety disorder,
and
for any $i \neq j, (X_i, Y_i) \perp (X_j, Y_j)$.

Middle Emerging Adults (20-24 y)

$$\eta_i = \beta_0 + \beta_1 X_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i};$$
$$\eta_i = \beta_0 + \beta_1 REGULAR_i + \beta_2 OCCASIONAL_i + \beta_3 SEX_i + \beta_4 CMA_i + \beta_5 PROV_i + \beta_6 ALC_i + \beta_7 DRUG_i + \beta_8 MOOD_i + \beta_9 GAD_i;$$

where
X_{1i} is the observed dummy variable for regular use,
X_{2i} is the observed dummy variable for occasional use,
X_{3i} is the observed dummy variable for sex for subject i,
X_{4i} is the observed predictor of census metropolitan area i,
X_{5i} is the observed predictor of province for subject i,
X_{6i} is the observed predictor of regular use of alcohol for subject i,
X_{7i} is the observed predictor of regular use of drugs for subject i,
X_{8i} is the observed predictor of mood disorder for subject i,
X_{9i} is the observed predictor of generalized anxiety disorder for subject i,
β_0 is the fixed unknown intercept,
β_1 is the fixed unknown regression coefficient corresponding to regular use,
β_2 is the fixed unknown regression coefficient corresponding to occasional use,
β_3 is the fixed unknown regression coefficient corresponding to sex,
β_4 is the fixed unknown regression coefficient corresponding to census metropolitan area,
β_5 is the fixed unknown regression coefficient corresponding to province,
β_6 is the fixed unknown regression coefficient corresponding to regular use of alcohol,
β_7 is the fixed unknown regression coefficient corresponding to regular use of drugs,
β_8 is the fixed unknown regression coefficient corresponding to mood disorder,
β_9 is the fixed unknown regression coefficient corresponding to generalized anxiety disorder,
and
for any $i \neq j, (X_i, Y_i) \perp (X_j, Y_j)$.

Late Emerging Adults (25-29 y)

$$\eta_i = \beta_0 + \beta_1 \mathrm{X}_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 \mathrm{X}_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i};$$

$$\eta_i = \beta_0 + \beta_1 REGULAR_i + \beta_2 OCCASIONAL_i + \beta_3 SEX_i + \beta_4 CMA_i + \beta_5 PROV_i + \beta_6 ALC_i + \beta_7 DRUG_i + \beta_8 MOOD_i + \beta_9 GAD_i;$$

where
X_{1i} is the observed dummy variable for regular use,
X_{2i} is the observed dummy variable for occasional use,
X_{3i} is the observed dummy variable for sex for subject i,
X_{4i} is the observed predictor of census metropolitan area i,
X_{5i} is the observed predictor of province for subject i,
X_{6i} is the observed predictor of regular use of alcohol for subject i,
X_{7i} is the observed predictor of regular use of drugs for subject i,
X_{8i} is the observed predictor of mood disorder for subject i,
X_{9i} is the observed predictor of generalized anxiety disorder for subject i,
β_0 is the fixed unknown intercept,
β_1 is the fixed unknown regression coefficient corresponding to regular use,
β_2 is the fixed unknown regression coefficient corresponding to occasional use,
β_3 is the fixed unknown regression coefficient corresponding to sex,
β_4 is the fixed unknown regression coefficient corresponding to census metropolitan area,
β_5 is the fixed unknown regression coefficient corresponding to province,
β_6 is the fixed unknown regression coefficient corresponding to regular use of alcohol,
β_7 is the fixed unknown regression coefficient corresponding to regular use of drugs,
β_8 is the fixed unknown regression coefficient corresponding to mood disorder,
β_9 is the fixed unknown regression coefficient corresponding to generalized anxiety disorder,
and
for any $i \neq j, (X_i, Y_i) \perp (X_j, Y_j)$.

By Regular Use of Other Drugs

Regular Use of Other Drugs = YES

$$\eta_i = \beta_0 + \beta_1 \mathrm{X}_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 \mathrm{X}_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i};$$
$$\eta_i = \beta_0 + \beta_1 REGULAR_i + \beta_2 OCCASIONAL_i + \beta_3 SEX_i + \beta_4 AGE_i + \beta_5 CMA_i + \beta_6 PROV_i + \beta_7 ALC_i + \beta_8 MOOD_i + \beta_9 GAD_i;$$

where
X_{1i} is the observed dummy variable for regular use,
X_{2i} is the observed dummy variable for occasional use,
X_{3i} is the observed dummy variable for sex for subject i,
X_{4i} is the observed dummy variable for age for subject i,
X_{5i} is the observed predictor of census metropolitan area i,
X_{6i} is the observed predictor of province for subject i,
X_{7i} is the observed predictor of regular use of alcohol for subject i,
X_{8i} is the observed predictor of mood disorder for subject i,
X_{9i} is the observed predictor of generalized anxiety disorder for subject i,
β_0 is the fixed unknown intercept,
β_1 is the fixed unknown regression coefficient corresponding to regular use,
β_2 is the fixed unknown regression coefficient corresponding to occasional use,
β_3 is the fixed unknown regression coefficient corresponding to sex,
β_4 is the fixed unknown regression coefficient corresponding to age,
β_5 is the fixed unknown regression coefficient corresponding to census metropolitan area,
β_6 is the fixed unknown regression coefficient corresponding to province,
β_7 is the fixed unknown regression coefficient corresponding to regular use of alcohol,
β_8 is the fixed unknown regression coefficient corresponding to mood disorder,
β_9 is the fixed unknown regression coefficient corresponding to generalized anxiety disorder,
and
for any $i \neq j, (X_i, Y_i) \perp (X_j, Y_j)$.

Regular Use of Other Drugs = NO

$$\eta_i = \beta_0 + \beta_1 X_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i};$$
$$\eta_i = \beta_0 + \beta_1 REGULAR_i + \beta_2 OCCASIONAL_i + \beta_3 SEX_i + \beta_4 AGE_i + \beta_5 CMA_i + \beta_6 PROV_i + \beta_7 ALC_i + \beta_8 MOOD_i + \beta_9 GAD_i;$$

where
X_{1i} is the observed dummy variable for regular use,
X_{2i} is the observed dummy variable for occasional use,
X_{3i} is the observed dummy variable for sex for subject i,
X_{4i} is the observed dummy variable for age for subject i,
X_{5i} is the observed predictor of census metropolitan area i,
X_{6i} is the observed predictor of province for subject i,
X_{7i} is the observed predictor of regular use of alcohol for subject i,
X_{8i} is the observed predictor of mood disorder for subject i,
X_{9i} is the observed predictor of generalized anxiety disorder for subject i,
β_0 is the fixed unknown intercept,
β_1 is the fixed unknown regression coefficient corresponding to regular use,
β_2 is the fixed unknown regression coefficient corresponding to occasional use,
β_3 is the fixed unknown regression coefficient corresponding to sex,
β_4 is the fixed unknown regression coefficient corresponding to age,
β_5 is the fixed unknown regression coefficient corresponding to census metropolitan area,
β_6 is the fixed unknown regression coefficient corresponding to province,
β_7 is the fixed unknown regression coefficient corresponding to regular use of alcohol,
β_8 is the fixed unknown regression coefficient corresponding to mood disorder,
β_9 is the fixed unknown regression coefficient corresponding to generalized anxiety disorder,
and
for any $i \neq j, (X_i, Y_i) \perp (X_j, Y_j)$.