ASSOCIATIONS OF PERCEIVED RISK OF REGULAR CANNABIS USE WITH CANNABIS-RELATED DRIVING AND PASSENGER BEHAVIOURS AMONG CANADIAN HIGH SCHOOL STUDENTS

by

Melissa Carpino

Submitted in partial fulfilment of the requirements
for the degree of Master of Science

at

Dalhousie University
Halifax, Nova Scotia
October 2019

Dedication

Nothing truly great ever came from a comfort zone. - Anonymous

For my parents, Emma and Vince, with gratitude. Without your endless love, support, sacrifice, and patience, none of my success would be possible.

To Nazareno. Your love and encouragement has helped me reach my fullest potential.

Table of Contents

List of Tables

Abstract

Objective: Employing a sample of 33,915 high school students, the present study aimed to examine the association of perceived risk of regular cannabis use with driving under the influence of cannabis (DUIC) and riding with a cannabis-impaired driver (RWCD).
Methods: Participants were drawn from the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey. Multinomial logistic regression techniques were employed in the analysis of adjusted and unadjusted models. Stratified analyses were also performed assessing effect size differences between males and females, and urban and rural students.
Results: Greater perceived risk of regular cannabis use was associated with reduced risk of DUIC and RWCD in a dose-response manner. Associations were consistent for both males and females, and urban and rural students.
Conclusions: Given the strong role played by youth perceptions in shaping cannabis-related driving and passenger behaviours, efforts must be placed on disseminating appropriate information regarding cannabis risks to high school students.

List of Abbreviations Used

ATV	All-terrain vehicle
BAC	Blood alcohol concentration
CAs	Census agglomerations
CADUMS	Canadian Alcohol and Drug Use Monitoring Survey
CB1	Cannabinoid receptor type 1
CMAs	Census metropolitan areas
CSTADS	Canadian Student Tobacco, Alcohol and Drugs Survey
DUIC	Driving under the influence of cannabis
HBM	Health Belief Model
ml	Milliliter
ng	Nanograms
NHTSA	National Highway Traffic Safety Administration
QHSHSS	Québec Health Survey of High School Students
RWCD	Riding with a cannabis-impaired driver
RWDD	Riding with a drunk driver
THC	Delta-9-tetrahydrocannabinol

Acknowledgements

I am grateful to my supervisor, Dr. Mark Asbridge at Dalhousie University, for his many contributions and invaluable input throughout this process. I would like to recognize the assistance and direction of my committee members, Dr. Donald Langille and Dr. Gabriela Ilie at Dalhousie University. I would also like to acknowledge the support of the faculty and staff of the Department of Community Health and Epidemiology at Dalhousie University. Finally, I would like to thank my family and friends for their continuous encouragement and support throughout my academic career.

Chapter 1: Introduction

Impaired driving remains the most frequent criminal cause of preventable death and injury in North America[1]. For years, "impaired driving" has been interpreted as being impaired by alcohol; however, in recent years, there has been *a shift in focus* to *drug-impaired* driving. Despite the decline in rates of drinking and driving since the 1980s[1], the prevalence of driving under the influence of cannabis (DUIC) has remained stable. According to the Canadian Alcohol and Drug Use Monitoring Survey (CADUMS), in 2012, the prevalence of Canadians who reported driving within two hours of using cannabis at least once in the previous 12 months was 2.6%, which is only slightly lower than rates reported in 2008 (2.9%)[2,3,4].

Delta-9-tetrahydrocannabinol (THC), the main psychoactive substance in cannabis, interacts with different receptors in the body to produce euphoric effects as well as feelings of relaxation[5]. Acute cannabis intoxication is known to slow learning, reduce reaction time, and impair short-term memory and psychomotor learning[5]. Due to these properties, there is an expressed public health concern about the effects of cannabis use on driving-related skills and performance.

The impact of cannabis on motor vehicle crash risk has been studied extensively over the past two decades; though its role in crash causation remains unsettled. While previous epidemiological studies have recurrently found that using cannabis before driving significantly increases the risk of motor vehicle collisions[6,7,8,9], recent case-control studies do not support an increase in traffic risk with THC exposure[10,11,12]. Despite mixed findings, cannabis remains the second most common psychoactive substance, after alcohol, found in injured and fatally injured drivers in Canada[13,14,15,16,17].

Equally important are the decisions of passengers to ride with a driver who is under the influence of cannabis (or with impaired drivers in general). Along with stable rates of DUIC, a substantial portion of Canadian youth have reported riding with a cannabis-impaired driver (RWCD)[18,19,20]. Based on national data collected between 2014 and 2015, nearly 20% of Canadian students in grades 9 to 12 reported ever riding with a driver who had used cannabis within the previous two hours[19]. The presence of passengers greatly enhances the impact and harms associated with impaired crashes, including injuries, hospitalizations, fatalities, and economic costs.

In Canada and the United States, the likelihood of DUIC varies according to the sex of the driver. Previous research has shown that males are consistently more likely than females to report driving after using cannabis[19,21,22,23,24,25]. Previous research has also shown that there are clear differences in the likelihood of DUIC in urban versus rural regions in Canada[19,26]. In contrast, there are mixed findings about the role of sex as a risk factor for RWCD. While some studies have reported that the prevalence of RWCD is higher for males than females[27], others have observed no significant sex differences for RWCD[18,28]. Additionally, within Canada, information is limited on whether urban and rural differences exist in relation to cannabis-related passenger behaviour among students.

Perceived risks of DUIC have been found to influence decisions to drive under the influence of cannabis, particularly among young people[28,29,30]. Previous research has shown that greater perceived dangerousness of DUIC is associated with decreased likelihood and frequency of DUIC[28,30]. Less is known about the role of risk perception in shaping a passenger's decision to ride with a cannabis-impaired driver. One study observed that greater perceived dangerousness of DUIC was associated with decreased likelihood of RWCD[28]; however, more research is needed.

For many youth, cannabis is perceived as a safe and benign drug with limited impairing effects[31,32,33]. Known factors influencing youth risk perceptions of cannabis use and DUIC include demographic[34] and cognitive factors[35]. Little is known about whether sociopsychological factors such as autonomy influence risk perceptions of cannabis use and DUIC, and/or engagement in DUIC and RWCD behaviours. The results of a previous study provide some insight on the relationship between autonomy, risk perception, and risk-taking, revealing a positive correlation between autonomy and risk perception, and a negative correlation between autonomy and risk-taking[36]. Therefore, the role of autonomy is also important to consider when assessing the association of perceived risk with DUIC and RWCD.

On October 17, 2018, the *Cannabis Act* (also known as Bill C-45) came into force in Canada, legalizing recreational cannabis use nationwide and establishing controls and regulations over its production, distribution, and sale[37]. On account of this, we anticipate a shift in the public discourse surrounding cannabis use and health, which in turn may lead to new and emerging patterns of cannabis use and cannabis-related driving behaviours. Although the impact of recreational cannabis legalization on the driving habits of young drivers in Canada is unclear, predictions can be made based on evidence of the legalization experiences of other jurisdictions in the United States[38,39,40].

Considering the recent legalization of cannabis in Canada, there is a great need to research the link between perceived risk of cannabis use and cannabis-related driving and passenger behaviours. The proposed study will address the aforementioned gaps in the literature and help inform prevention and educational efforts to reduce risks for both drivers and passengers. Using a cross-sectional study design, the risk of DUIC and RWCD will be quantified and assessed in relation to perceived risk of regular cannabis use among high school students. The effect of sex and rurality in modifying these associations will also be explored. This study will contribute substantially to the scientific literature on risk perception and health behaviour.

Chapter 2: Background

2.1 The Pharmacodynamics of Cannabis

Cannabis, also known as marijuana (among other names), is a naturally occurring psychoactive substance derived from the cannabis plant (e.g., *Cannabis sativa* and some of its subspecies such as *Cannabis sativa* forma *indica*)[41,42]. It is made up of a wide range of cannabinoids, which are chemical compounds that bind to specific cannabinoid receptors and exert a broad range of pharmacological effects including anxiolytic, sedative, analgesic, and euphoric effects[5,41,42]. The most well-known cannabinoid is THC, which is also the main psychoactive ingredient in cannabis[5,41,42]. When cannabis is smoked or inhaled, THC is absorbed through the lungs and into the bloodstream at different rates before it is distributed to various areas in the body including the brain[5,42]. Once absorbed, THC exerts its effects by mimicking anandamide, a naturally-occurring neurotransmitter that binds to cannabinoid receptor type 1 (CB1) in parts of the brain associated with cognition, memory, reward, anxiety, pain perception, and motor coordination[5,41,42]. THC is only detectable in the blood for a few hours because it is quickly processed by the liver into molecules known as metabolites[5,42,43]. Almost 100 different known metabolites are formed from THC[43], and these are stored in fat cells and eliminated slowly from the body through urine and feces[42,43]. While THC is detectable in bodily fluids such as saliva, blood, and urine, urine is the preferred method of testing because it is easily sampled and can detect high concentrations of metabolites[42]. However, a caveat of the commonly used urine test is that it only captures inactive metabolites of THC which are not psychoactive[44].

Some of the short-term effects of cannabis include impairments to memory, learning, coordination, and reaction time – all of which are important functions for driving[43]. The long-term effects of cannabis use are not well-known and often unpredictable; though studies done in rats suggest that chronic exposure to THC during adolescence may induce cognitive impairment and subtle alterations in the emotional circuit in adulthood due to structural and functional changes in the hippocampus[45,46].

2.2 Cannabis use and Driving Under the Influence of Cannabis

Cannabis is the second most commonly used psychoactive substance in Canada[47]. In 2017, the Canadian Tobacco, Alcohol and Drugs Survey reported that the prevalence of past-year cannabis use among Canadians aged 15 years and older was 15%, an increase compared to 2015 (12%)[48]. The prevalence of cannabis use has been found to differ by age group, with rates generally highest among Canadian youth[3,47]. In 2017, rates of past-year cannabis use were highest among Canadians ages 15 to 24 compared to adults ages 25 years and older[48].

Among the general Canadian population, DUIC is also prevalent. Data from the 2012 CADUMS found that 2.6% of Canadians reported driving within two hours of using cannabis at least once in the past year[2]. Recent data collected from roadside testing revealed a slightly higher rate, indicating that between 4 and 6% of Canadians had driven within two hours of using cannabis in the previous 12 months[49]. Youth comprise one of the largest groups of drivers who engage in driving after cannabis use. In 2012, the reported prevalence of DUIC was highest among Canadian drivers ages 18 to 19 years old, followed by those ages 15 to 17 years old[2,4]. Furthermore, rates of DUIC among young people have surpassed rates of drinking and driving in many jurisdictions across North America.

The relationship between cannabis use and motor vehicle crashes has been examined using both experimental and observational approaches. Much of the early research on the effects of cannabis on driving performance was done by laboratory and driving simulator studies. The results of these studies are generally consistent; at higher doses, cannabis and THC impairs psychomotor skills related to safe driving[50,51]. Although laboratory studies are useful for determining the pharmacological (e.g., dose-related) effects of cannabis on driving performance, these studies lack external validity and do not always translate well to real-life driving situations. Previous observational epidemiological studies have addressed many of the limitations of laboratory studies by assessing driving in the general population; though the magnitude of traffic crash risk associated with cannabis-related impairment has been difficult to establish and varies between studies[6,7,8,9,10,11,12]. In the past two decades, many well-designed epidemiological studies have consistently found that recent cannabis use (indicated by either self-reported cannabis use or THC in the blood or urine) doubles the risk of a motor vehicle collision[6,7]. However, in 2016, a contradictory finding about the role of cannabis in motor vehicle crash risk arose from the results of a case-control study sponsored by the National Highway Traffic Safety Administration (NHTSA)[11]. To date, the NHTSA's Drug and Alcohol Crash Risk study remains the largest case-control study of its kind, and was the first study in the United States to estimate the risk of motor vehicle crashes involving drivers using alcohol, drugs, or both[11]. Based on the results, when age, sex, ethnicity, and blood alcohol concentration (BAC) were statistically controlled, there was no significant contribution of any drug (including cannabis) on motor vehicle crash risk[11]. Furthermore, new research led by the University of British Columbia suggests that low levels of THC (less than 5 nanograms per milliliter (ng/ml) of blood) are not associated with an increased risk of crashing[12]. It is possible that the inconsistencies between the results of previous studies are due to different data, methodologies, and/or potency of cannabis (which may vary by location in Canada). Despite mixed findings, cannabis is consistently one of the most frequently detected psychoactive substances in injured and fatally injured drivers in Canada, second after alcohol[13,14,15,16,17]. For instance, drawing on data from 1097 injured drivers from seven trauma centres in British Columbia, cannabis was detected in 12.6%[17]. Additionally, a one-year study of 229 fatally injured drivers in Ontario detected cannabis in 27%[16]. Therefore, the contribution of cannabis in motor vehicle injuries and fatalities cannot be ignored.

There are also considerable harms and costs (economic and healthcare) associated with cannabis-related driving which extend beyond the driver to include passengers, pedestrians, cyclists, and those in other vehicles. Some of these harms include lives lost, injuries, and hospitalizations. In 2012 alone, cannabis-related motor vehicle collisions across Canada were estimated to have caused 75 deaths, 4407 injuries, and 7794 crashes involving only property damage, totaling over one billion dollars in associated costs[52]. Yet more research remains to be undertaken to reveal these related consequences and the impact of cannabis-related traffic collisions on our economy and healthcare system, the community, individuals, and their families.

A recently published evidence brief by Ontario Public Health identified several risk factors and correlates of DUIC[53]. These included sociodemographic factors (e.g., age, sex, and geographical location), school performance and participation in extracurricular activities, and previous substance use and dependence[53]. Risk perceptions of DUIC were also noted as strong correlates of cannabis-related driving behaviours, particularly among highly impressionable youth[53].

Much of the available literature on cannabis-impaired driving has focused on the role of age. There is considerable evidence supporting a negative association between DUIC and age[21,22,49,54]. Canadian research finds that younger drivers are more likely than older drivers to engage in cannabis-impaired driving[21,22,49]. In a 2017 study, the odds of self-reported DUIC were higher among Canadian drivers ages 16 to 24 years old compared to those 65 years and older[22]. Furthermore, an American study examining correlates of DUIC in two states where recreational cannabis is legal found that older age was significantly associated with less openness to drive under the influence of cannabis[54].

In Canada, the prevalence of DUIC also varies by the sex of the driver[21,22]. According to data collected from the Road Safety Monitor from 2002 to 2015, a higher percentage of Canadian males compared to females self-reported driving within two hours of using cannabis (2.8% and 1.5%, respectively)[22]. This may be explained by the results of recent Canadian research which revealed that the odds of ever or last 30-day driving within two hours of using cannabis was higher for males than females[19].

Geographical location is another important sociodemographic factor reported to be associated with DUIC. Canadian research suggests that the likelihood of DUIC differs in urban versus rural areas[19,26]. According to a technical report by the Canadian Centre on Substance Abuse, three out of four self-report surveys found that rural students were more likely to drive under the influence of cannabis compared to urban students[26].

Moreover, a study using data collected from the 2014-2015 wave of the Canadian Student Tobacco, Alcohol and Drugs Survey (CSTADS) found that relative to Ontario students in grades 11 and 12, the self-reported odds of DUIC was higher among students in Nova Scotia, Prince Edward Island, and Newfoundland and Labrador[19]. Based on the Organisation for Economic Co-operation and Development's definition of urban versus rural (whereby urban areas must have at least one small city with 50,000 inhabitants or more)[55], these provinces are among Canada's most rural provinces. Particularly, of all the Atlantic provinces, Newfoundland and Labrador has the highest proportion of its population (60%) living in rural areas[56].

2.3 Being a Passenger of a Driver Impaired by Alcohol or Cannabis

While many studies have explored the factors that contribute to alcohol- or drug-impaired driving, less attention has been directed to an exploration of the behaviour of passengers who ride with impaired drivers. Much of the existing research into passenger behaviour of impaired drivers has focused on passengers riding with a drunk driver (RWDD). According to national survey data, approximately 35% of Canadian high school students have reported ever being a passenger of a driver who had at least one drink within the previous hour[19]. Age is one of the most well-known risk factors for RWDD, with young people in two age groups (18 to 24 and 25 to 44 years old) at an increased risk of RWDD compared to those ages 45 to 64 years old[18]. Sex and degree of rurality have also been identified as important risk factors for RWDD. A recent Canadian study of high school students found that female students and students from rural schools had higher odds of ever RWDD relative to males and urban students, respectively[19].

Having previously driven under the influence of alcohol has also been shown to increase the risk of RWDD[18].

Equally important are the decisions of passengers who ride with a cannabis-impaired driver. According to previous research, between 4 and 8% of Canadian adults reported RWCD in the past year[18]. Surveys of youth report even higher rates (20% and higher) of past-year RWCD[19]. Given the undeniable contribution of cannabis to motor vehicle injuries and fatalities in Canada, the presence of passengers additionally burdens the economy and our healthcare system by potentially contributing to the number of cannabis-related motor vehicle injuries, fatalities, and hospitalizations – all of which are utterly avoidable.

Age is a well-established risk factor for RWCD[18,19]. Young people are at an increased risk of RWCD and older people are at a decreased risk. According to a study examining nationally representative data from the 2008 CADUMS, Canadian youth ages 15 to 24 years old were significantly more likely than older adults ages 45 to 64 years old to ride with a driver who had consumed cannabis within the previous two hours[18]. There also appears to be evidence of a dose-dependent effect of school grade on the likelihood of RWCD among Canadian youth[20]. In a cross-Canada report on alcohol and drug use among students in grades 7 to 12, the likelihood of RWCD was shown to increase with school grade level[20], and overall prevalence estimates of RWCD appeared highest among Canadian students in grade 12 (with more than one-third reporting RWCD)[20]. The increased risk of RWDD and RWCD among youth may be explained by their dependence on others for transportation. This may be especially true among youth living in rural areas where alternative forms of transportation (e.g., buses, taxicabs, subways, trains, etc.) are not as readily available. High prevalence estimates of RWCD among young people may also be explained by the common perception among youth that cannabis is safer for driving than alcohol[31,33]. Evidence from both real and simulated driving studies have shown that while drunk drivers tend to speed and make risky decisions, high drivers tend to drive far below the speed limit and make fewer attempts to overtake other drivers[57]. Therefore, many youth argue that the effects of cannabis on driving skills are much less serious than alcohol due to differences in the way high drivers act behind the wheel compared to drunk drivers.

Our understanding of sex and degree of rurality as risk factors for RWCD is not as well-established as it is for RWDD. There are inconsistent findings regarding the role of sex; some studies have observed no significant sex effect for RWCD[18,28], while others have found that the prevalence of RWCD is higher for males than females[27]. To date, it is not known whether rural Canadian students are more likely than urban students to ride with a cannabis-impaired driver. Understanding the role played by sex and rurality is important as these factors may attenuate or amplify perceptions of risk, and subsequently shape risky passenger behaviours.

Passengers of impaired drivers have the potential to be used as agents of change when developing policies aimed at reducing rates of alcohol- or drug-impaired driving. If a driver has been using alcohol or drugs, there is a good chance that the passenger(s) have also been using. In fact, passengers of non-fatally and fatally injured drunk drivers have been found to have levels of alcohol intoxication similar to the drivers[58,59]. More importantly, passengers who ride with an alcohol-impaired driver report a greater number of occasions of driving under the influence of alcohol themselves[60]. These findings provide growing support for the view that passengers of impaired drivers (alcohol or drugs) should be educated alongside drivers themselves in order to lower the economic and healthcare burden of alcohol- or drug-related motor vehicle collisions.

2.4 Cannabis Legalization in Canada and DUIC

On October 17, 2018, the *Cannabis Act* (Bill C-45) came into force in Canada*,* legalizing recreational cannabis use nationwide and establishing controls and regulations over its production, distribution, and sale[37]. Additionally, Bill C-46, *An Act to Amend the Criminal Code*, was introduced to strengthen the laws pertaining to alcohol- and drug-impaired driving[61]. This legislation set out *per se* limits for the concentration of THC (measured in ng/ml) legally allowed in the blood of a motorist. Part I of Bill C-46 introduced three new criminal offences related to drug-impaired driving: an offence for low-level THC concentration (between 2 ng/ml and 5 ng/ml), an offence for high-level THC concentration (5 ng/ml or more), and a hybrid offence that recognizes the effects of cannabis combined with alcohol (2.5 ng/ml or more of THC plus a BAC of 50 milligrams of alcohol per 100 ml of blood)[61]. This Bill also grants police officers the right to use oral fluid screening equipment or a blood test to determine if a driver is under the influence of drugs at the time of driving[61]. While this legislation is a milestone in the legal history of cannabis in Canada, unlike BAC testing which is the universal standard used on the road to detect driving impaired by alcohol, reliable roadside THC detection testing is still under development. Presently, roadside THC tests do not test for impairment by cannabis and therefore, cannot accurately determine whether an individual is too high to drive. For instance, a person with a high blood level of THC may not be impaired because of the development of tolerance. It is conceivable that the recent legalization of recreational cannabis use combined with the lack of a universal roadside standard for detecting cannabis impairment may increase the prevalence of DUIC and RWCD among Canadian youth via perpetuation of misperceptions regarding the safety of cannabis use and driving. In fact, evidence from a recent study done in the United States found that perceived risk of cannabis use significantly decreased among students in Washington state following the legalization of recreational cannabis use[38].

Although the impact of recreational cannabis legalization on the driving behaviour of young drivers in Canada is unclear, predictions can be made based on evidence of the legalization experiences of other jurisdictions in the United States[39,40]. The effect of recreational cannabis legalization on the prevalence of DUIC has been explored in several jurisdictions in the United States, particularly Colorado and Washington state. In November 2012, Colorado and Washington state became the first two states – and first two jurisdictions in the world – to legalize cannabis for recreational use for adults 21 years of age and older[62]. Previous research done in these states has demonstrated that the prevalence of DUIC increased after cannabis legalization. For instance, in Washington state, there was a statistically significant increase in suspected impaired drivers testing positive for THC and carboxy-THC post-legalization (2013) compared with pre-legalization (2009 to 2012)[39]. Further evidence from Washington state suggests that the legalization of recreational cannabis in Canada may increase the number of motor vehicle collision fatalities involving cannabis. For example, after Washington state went from medical to recreational legalization in 2012, the number of cannabis-related motor vehicle collision fatalities increased by 31.2% compared to states with only medical legalization, including Hawaii, Montana, and New Mexico[40].

2.5 Risk Perceptions and Health Behaviours Among Adolescents and Youth

Risk perception – an individual's subjective assessment of the likelihood of negative occurrences[63] – is an important precursor to health behaviour change. Health behaviours can be defined as protective (e.g., exercising regularly, consuming a low-fat diet, etc.) or risky (e.g., engaging in risky sexual activity, using illicit drugs, smoking, binge drinking, driving fast or impaired, etc.)[64]. To some extent, perceptions of risk are assumed to influence our health behaviours (protective or risky) and subsequently, our exposure to harmful risks. Often, individuals unwarrantably believe that compared to others, they are less likely to experience a specific negative health outcome and more likely to experience a positive health event[65]. For example, those who drink and drive may be less concerned about their risk of getting into a motor vehicle collision and in turn, estimate their own risk of a motor vehicle collision as lower than that of others. This type of bias, which is commonly referred to as comparative optimism[65], is quite prevalent in the general population[66]. In a recent study examining the implications of comparative optimism on DUIC it was found that many participants expressed a comparative optimism bias, perceiving themselves as less likely than others to be involved in a motor vehicle collision when driving after using cannabis[35]. According to a recent review which explored the causes of comparative optimism, there are a variety of viable cognitive, motivational, and affective explanations supported by empirical evidence for why people estimate that their risk of an event is lower than that of others[67].

In various social and health psychology models such as the psychometric paradigm[63,68] and the Health Belief Model (HBM)[69], risk perception plays a central role in motivating behaviour. The HBM is a theoretical model which was developed to explain and predict health-related behaviours, particularly in regards to the uptake of health services[69]. The HBM posits that people's beliefs and perceptions about health and disease can explain and predict their engagement (or lack thereof) in health-promoting or self-protective behaviours[69]. The HBM consists of three important characteristics: perceived susceptibility, perceived seriousness (severity), and perceived benefit[69]. Based on this theory, in order for an individual to take action to avoid a disease or condition, they must believe that: 1) they are personally susceptible to it, 2) the occurrence of the disease would have at least moderate severity on some component of their personal life, and 3) a particular action would be beneficial by reducing personal susceptibility and severity, and would not involve taking action to overcome barriers[69]. According to the HBM, people with heightened perceptions of risk may be less likely to engage in behaviours that they believe will lead to negative consequences[69]. Based on this notion, heightening people's perceptions of risk or benefit may be useful for motivating positive changes in health behaviours. In fact, a recent meta-analysis of experimental evidence found that people's intentions and behaviours changed when individual elements of risk appraisal, including risk perception, anticipated emotion, and perceived severity, were heightened[70].

Understanding the implications of risk perceptions on health behaviours and the factors that modify this association is important in the control and reduction of harm exposure. According to the HBM, demographic factors (e.g., age, sex, race, ethnicity, etc.), sociopsychological variables (e.g., personality, social class, peer pressure, etc.), and structural variables (e.g., prior knowledge or exposure to a condition) may modify an individual's perceptions of susceptibility, seriousness, or benefit of an outcome[69]. Large national surveys in Canada have identified these factors as strong correlates of risk perception. Among adolescent populations, consistent racial and sex differences in perceptions of risk have emerged across studies representing a diversity of samples[71]. Results of these studies show that Black adolescents are more concerned about drug use than White adolescents, and female adolescents perceive greater risks and fewer benefits associated with alcohol and drug use and sexual behaviour compared to males[71]. As well, across many studies, females consistently reported thinking more about their health and had more health concerns than their male counterparts[71].

The psychometric paradigm is a theoretical framework which explains how laypeople perceive the risks they face[63,68]. According to the psychometric paradigm, risk is subjectively defined by individuals who may be influenced by a broad range of social, psychological, institutional, and cultural factors[63,68]. Therefore, sociopsychological factors are also important to consider as they may influence risk perception, and/or the association between risk perception and risky health behaviours such as DUIC and RWCD. One sociopsychological factor believed to be associated with risk perception and likely associated with DUIC and RWCD is autonomy. Autonomy, which is defined as the ability to self-govern, develops over the course of adolescence and extends into adulthood as a result of a number of physical and cognitive changes[72]. In a recently published manuscript examining the relationship between autonomy, risk perception, and risk-taking, autonomy was found to be positively correlated with risk perception and negatively correlated with risk-taking[36]. In other words, those who reported feeling more autonomous had higher risk perception and were less likely to partake in risky behaviours[36].

2.5.1 Risk-Taking and the Adolescent Brain

Adolescents and young adults are notorious for engaging in more risky behaviour than any other age group[73]. Despite efforts to educate youth about the risks associated with such behaviours, many adolescents continue to engage in risky behaviour. While it has often been thought that youth engage in risky behaviour because they are not equipped with the required skills to evaluate risk, early research in this area has shown that adolescents are as capable as adults at evaluating risk across a wide range of risky behaviours[74].

Increased engagement in risky behaviours among youth may be explained by neurobiological changes occurring in the brain during adolescence[73,75,76]. During adolescence and early adulthood, the prefrontal cortex (which is the part of the brain responsible for self-control, reason, logic, and decision-making) undergoes structural and functional changes[73,75,76]. In turn, self-control and other important executive functions are relatively immature during adolescence. At the same time, the limbic system, which controls emotion and arousal, appears to mature earlier, leading to increased reward-seeking[77]. The differing rates of development of these areas of the brain makes the period of adolescence a time of heightened vulnerability to risky and reckless behaviour[73,76,77,78]. Between adolescence and adulthood, risk-taking declines due to changes in the prefrontal cortex which improve individuals' capacity for self-control[73].

Increased risk-taking behaviour during adolescence may also be explained by risk-taking personality traits (e.g., sensation-seeking or impulsivity), social influence (e.g., peer pressure or relationships), and/or individual differences in genetics and environmental exposures. Collectively, these factors are believed to enhance vulnerability to risky behaviours during the period of adolescence.

2.6 Risk Perceptions Related to Drinking and Driving Behaviours

A clear correlation has been observed between risk perception and drinking and driving behaviours[79,80,81,82,83,84]. In general, risk perception and the likelihood of drinking and driving seem to be inversely related; the greater the perceived risk, the lower the likelihood of drinking and driving, and vice versa[80,81,82,83,84]. Research has also shown that an individual's propensity to drink and drive decreases as the perceived probability of being apprehended for alcohol-impaired driving (being stopped by the police or being arrested) or being in a traffic collision increases[80,81,82]. This observation is consistent with theories of health behaviour change which emphasize that heightening people's perceptions of risk may be useful for motivating self-protective behaviours[69]. In contrast, a recent study found that among drivers who frequently commit the offence of drinking and driving, the risk of traffic collisions associated with drinking and driving was perceived as low[83]. This finding may be related to the social cognition of comparative optimism[65]. In other words, those who drink and drive may be overly optimistic about the low probability of adverse or legal consequences from alcohol-impaired driving.

2.7 Risk Perceptions and Cannabis-Related Driving Behaviours

The link between risk perception and cannabis-related driving behaviours is less straightforward. The literature exploring the association between risk perception and cannabis-related driving behaviours can be divided into two categories: quantitative and qualitative studies.

2.7.1 Quantitative Studies on Perceptions of Cannabis-Related Harms

The link between specific cannabis-related driving cognitions (e.g., perceived dangerousness[28,29,30] and perceived negative consequences[29,30]) and engagement in cannabis-related driving behaviours has been explored in quantitative studies. In these studies, perceived dangerousness was assessed via one question whereby participants rated how dangerous it is to drive within two hours of using cannabis on a four-point Likert scale ranging from "not at all dangerous" to "very dangerous"[28,29,30]. Perceived negative consequences of DUIC were assessed using four questions whereby participants rated the likelihood of a driver their age being stopped by the police, being breath or drug tested, being arrested, and having an accident on a four-point Likert scale ranging from "not very likely" to "very likely"[29,30]. Greater perceived dangerousness of DUIC was recurrently found to be associated with decreased likelihood and frequency of DUIC[28,30]. On the other hand, lower perceived dangerousness of DUIC among college students was shown to be uniquely associated with both increased likelihood and frequency of DUIC[29]. The role played by perceived negative consequences of DUIC in shaping cannabis-related driving behaviours is less clear; some studies have found an association between lower perceived likelihood of negative consequences and increased frequency of DUIC[29] while others have reported no link[30]. Less is known about the role of risk perception in shaping a passenger's decision to ride with a cannabis-impaired driver. One study observed that greater perceived dangerousness of DUIC was associated with decreased likelihood of RWCD[28]; however, more research is needed.

Evidence from quantitative studies also show that perceptions of cannabis-related harms differ by sex, age, and ethnicity. A recent study which examined data from the

National Survey on Drug Use and Health in the United States between 2002 and 2012 found that females, those aged 50 years and older, and Non-White people were more likely to perceive regular cannabis consumption to pose great risk[34]. According to the same study, those aged 12 to 17 and 18 to 25 had the lowest odds of perceived great risk of regular cannabis use[34].

2.7.2 Qualitative Studies on Perceptions of Cannabis-Related Harms

Qualitative studies compliment the results of quantitative studies by unveiling the attitudes, values, and beliefs of cannabis use and cannabis-related driving behaviours. A key and consistent finding that has emerged several times in qualitative studies on this topic is that cannabis is perceived to be a safe drug for driving[31,32,33]. Two of the most common youth perceptions about driving after cannabis use are: 1) cannabis elicits compensatory behaviours (e.g., driving at a reduced speed, staying within the lines, etc.) which may induce greater caution and mitigate crash risk[31,33], and 2) regular cannabis use leads to tolerance[33]. Moreover, young adults have expressed that they perceive that the driving behaviour of regular users would be less impaired than those who use cannabis occasionally[33]. Among young focus group participants (aged 18 to 25) living in a rural Montana county, most were familiar with and knowledgeable about alcohol-related driving policies; however, many participants had conflicting beliefs about the effects of cannabis on driving ability and the policies surrounding DUIC[33]. For many participants, driving after cannabis use was perceived as less dangerous and more acceptable than driving after alcohol use[33]. While there was a shared consensus among rural young adults about the impairing effects of alcohol, many believed that the impairing ability of cannabis is dependent on the characteristics of the individual, the cannabis itself, the amount and type of cannabis consumed, and the presence of other drugs[33].

Chapter 3: Study Objectives

While several studies have examined the association between perceptions of cannabis-related harms and cannabis-related driving behaviours, to date, little epidemiological data has explored the role played by youth perceptions in shaping cannabis-related passenger behaviours. This has led to a significant gap in the impaired driving prevention research. With respect to this gap, the scope and merit of existing studies, and considering the recent legalization of cannabis in Canada, there is a great need to research the link between perceived risk of cannabis use and cannabis-related driving and passenger behaviours. It is important that policymakers, healthcare providers, and educators understand how Canadian youth perceive the harms associated with DUIC and RWCD. Among youth, there are misperceptions about the risks associated with smoking cannabis on a regular basis. We propose that youth perceptions of risk of cannabis and DUIC play a strong role in shaping engagement in risky driving and passenger behaviours. We hypothesize that youth who perceive regular cannabis use to be more harmful are less likely to drive under the influence of cannabis and ride with a cannabis-impaired driver. **This study** adds to the current state of knowledge on risk perception and youth engagement in risky health behaviours by enhancing the understanding of the path of association of perceived risk with DUIC and RWCD among high school students. Understanding the scope of this relationship and whether it is modified by important demographic characteristics will help identify high-risk subgroups of high school drivers and passengers, and can serve to inform harm-reduction policies and interventions. **The primary objective** of this study is to determine the association of perceived risk of regular cannabis use with cannabis-related driving and passenger behaviours among high school students utilizing a cross-sectional study design.

The **three key research questions** are:

1. Is the association between perceived risk of regular cannabis use and cannabis-related driving and passenger behaviours dose-related, such that greater perceived risk is associated with reduced risk of DUIC and RWCD?
2. Are these associations different between males and females?
3. Are these associations different between urban and rural students?

Chapter 4: Associations of Perceived Risk of Regular Cannabis use With Cannabis-Related Driving and Passenger Behaviours Among Canadian High School Students

Melissa Carpino[1], Mark Asbridge[1,2], Donald Langille[1], Gabriela Ilie[1,3,4,5]

[1]Department of Community Health and Epidemiology, Dalhousie University
[2]Department of Emergency Medicine, Dalhousie University
[3]Department of Urology, Dalhousie University
[4]Department of Psychology and Neuroscience, Dalhousie University
[5]Department of Radiation Oncology

4.1 Introduction

As of Canada's recent legalization of recreational cannabis use, driving under the influence of cannabis (DUIC) has become increasingly relevant to public health and safety. Although Bill C-45 and C-46 were introduced in combination in effort to prevent youth from accessing cannabis and to strengthen the laws pertaining to cannabis-impaired driving[37,61], we anticipate new and emerging patterns of cannabis use and cannabis-related behaviours. Based on evidence of the legalization experiences of other jurisdictions in the United States[38,39], there is widespread concern about the potential for legalization of recreational cannabis use to increase the prevalence of cannabis use and DUIC in Canada, particularly among youth.

After alcohol, cannabis is the most widely used psychoactive substance in the Canadian population (used by 15% of Canadians in the general population in 2017) for both medical and recreational purposes[48]. Based on self-reports, 2.4% of all Canadian drivers have driven under the influence of cannabis in the last 30 days[85]. According to previous roadside survey studies, cannabis is often the most frequently detected drug among Canadian drivers[86,87]. Youth comprise one of the largest groups of drivers who engage in driving after cannabis use[2,4]. In 2012, the reported prevalence of DUIC was highest among Canadian drivers ages 18 to 19 years old (8.3%), followed by those ages 15 to 17 years old (6.4%)[2,4]. Furthermore, Canadian youth ages 15 to 24 are more than twice as likely as older Canadians to self-report driving after cannabis use[2,23].

While the effects of cannabis on driving and motor vehicle crash risk have been studied extensively over the past two decades, the magnitude of traffic crash risk associated with cannabis-related impairment is difficult to establish and varies between studies[6,7,8,9,10,11,12]. The general consensus from systematic reviews of observational epidemiological studies is that there is an approximate two-fold increase in the risk of a motor vehicle collision with recent cannabis use (indicated by either self-reported cannabis use or delta-9-tetrahydrocannabinol (THC) in the blood or urine), and risk of crash involvement increases with increasing THC levels[6,7]. However, recent case-control studies do not support an increase in traffic crash risk with THC exposure after adjusting for age, sex, ethnicity, and alcohol consumption[10,11]. Furthermore, a new prospective case-control study led by the University of British Columbia suggests that low levels of THC (less than 5 nanograms per milliliter (ng/ml) of blood) are not associated with an increased risk of crashing[12]. Despite mixed findings, cannabis is consistently one of the most frequently detected psychoactive substances in injured and fatally injured drivers in Canada, second after alcohol[13,14,15,16,17]. For instance, drawing on data from 1097 injured drivers from seven trauma centres in British Columbia, cannabis was detected in 12.6%[17]. Additionally, a one-year study of 229 fatally injured drivers in Ontario detected cannabis in 27%[16].

Equally important are the decisions of passengers to ride with a driver who is under the influence of cannabis (or with impaired drivers in general). According to previous research, between 4 and 8% of Canadian adults reported riding with a cannabis-impaired driver (RWCD) in the past year[18]. Surveys of Canadian youth often report even higher rates (20% and higher) of past-year RWCD[19]. Given the undeniable contribution of cannabis to motor vehicle injuries and fatalities in Canada, the presence of passengers additionally burdens the economy and our healthcare system by potentially contributing to the number of cannabis-related motor vehicle injuries, fatalities, and hospitalizations – all of which are entirely preventable.

In Canada and the United States, the likelihood of DUIC varies according to the sex of the driver. Previous research has shown that males are consistently more likely than females to report driving after using cannabis[19,21,22,23,24,25]. However, there are inconsistencies surrounding the role of sex as a risk factor for RWCD. While some studies have found that the prevalence of RWCD is higher for males than females[27], others have observed no significant sex effect for RWCD[18,28]. Along with sex, degree of rurality has been identified as another important risk factor for DUIC. Previous research has shown that there are clear differences in the likelihood of DUIC in urban versus rural regions in Canada[19,26]. According to a technical report by the Canadian Centre on Substance Abuse, three out of four self-report surveys found that rural students were more likely to drive under the influence of cannabis compared to urban students[26]. Moreover, a study using national data collected between 2014 and 2015 found that relative to Ontario high school students, the odds of DUIC was self-reportedly higher among students in Nova Scotia, Prince Edward Island, and Newfoundland and Labrador[19] – which are among Canada's most rural provinces[56]. In contrast, within Canada, information is limited on whether urban and rural differences exist in relation to cannabis-related passenger behaviour among students.

Increased engagement in risky behaviours such as DUIC and RWCD among youth may be explained by neurobiological changes occurring in the brain during adolescence[73,75,76]. During adolescence and early adulthood, the prefrontal cortex (which is the part of the brain responsible for self-control, reason, logic, and decision-making) undergoes structural and functional changes[73,75,76]. In turn, self-control and other important executive functions are relatively immature during adolescence. At the same time, the limbic system, which controls emotion and arousal, appears to mature earlier, leading to increased reward-seeking[77]. The differing rates of development of these areas of the brain makes the period of adolescence a time of heightened vulnerability to risky and reckless behaviour[73,76,77,78].

Perceived risks of cannabis use and DUIC have been a focus of recent drug-impaired driving research. Perceived risks of cannabis use and DUIC among youth have been unveiled in qualitative studies[31,33]. Generally, for many youth, cannabis is perceived as a safe drug with limited impairing effects for driving performance[31,32,33]. A common risk perception of DUIC among youth is that driving after cannabis use is less dangerous and more acceptable than driving after alcohol use[33]. There are even many young people who believe that cannabis elicits compensatory behaviours (e.g., driving at a reduced speed, staying within the lines, etc.) which may induce greater caution and mitigate crash risk[31,33], and that regular cannabis use leads to tolerance[33].

A variety of viable factors are believed to explain the formation of risk perceptions of cannabis use and DUIC among youth. Social and health psychology models such as the psychometric paradigm[63,68] and the Health Belief Model[69] theorize that demographic characteristics (e.g., age, sex, race, ethnicity, etc.), sociopsychological factors (e.g., autonomy), and structural variables (e.g., prior knowledge or exposure to a condition) influence an individual's perception of risk and/or the association between risk perception and health behaviours (protective or risky)[63,68,69]. In fact, empirical data from the United States found that perceived risks of cannabis use differed by sex, age, and ethnicity[34]. Less is known about whether sociopsychological factors such as autonomy influence risk perceptions of cannabis use and DUIC, and/or engagement in DUIC and RWCD behaviours. However, the results of previous research provide us with a better understanding of the relationship between autonomy, risk perception, and risk-taking[36]. In this study, autonomy was found to be positively correlated with risk perception and negatively correlated with risk-taking[36]. Therefore, the role of autonomy is also important to consider when assessing the association of perceived risk with DUIC and RWCD. Finally, youth perceptions about the risks associated with cannabis use and DUIC may in part be due to a number of cognitive factors, including comparative optimism bias[65]. Comparative optimism bias is a prevalent cognition among the general population that leads individuals to estimate their own risk of a negative event as lower than that of others[65,66]. Recent qualitative evidence from Toronto, Ontario found that many participants who reported driving after cannabis use expressed a comparative optimism bias, perceiving themselves as less likely than others to be involved in a motor vehicle collision when driving after using cannabis[35]. This type of bias could serve as a means to rationalize engagement in DUIC or RWCD.

Few empirical studies have explored the role of risk perception in shaping cannabis-related driving behaviours such as DUIC and RWCD among youth. Among the existing studies that have, perceived dangerousness of DUIC (how dangerous it is to drive within two hours of using cannabis)[28,29,30] and perceived negative consequences of DUIC (how likely it is that a driver would be stopped by the police, breath or drug tested, arrested, or have an accident)[29,30] have been explored as cognitive predictors of DUIC. In these studies, greater perceived dangerousness of DUIC was found to be associated with decreased likelihood and frequency of DUIC[28,30]. Moreover, among college students, lower perceived dangerousness of DUIC was shown to be associated with both increased likelihood and frequency of DUIC[29]. Less is known about the role of risk perception in shaping a passenger's decision to ride with a cannabis-impaired driver. One study observed that greater perceived dangerousness of DUIC was associated with decreased likelihood of RWCD[28]; however, more research is needed.

The current study extends this body of research by exploring recent and past behaviours of DUIC and RWCD in a non-clinical sample of high school students across nine Canadian provinces. The primary objective of the present study was to examine the association of perceived risk of regular cannabis use with cannabis-related driving and passenger behaviours among Canadian high school students. Our study set out to determine: 1) whether the association of perceived risk of regular cannabis use with DUIC and RWCD was dose-related, such that greater perceived risk was associated with reduced risk of DUIC and RWCD, and 2) whether these associations differed between males and females, and urban and rural students.

4.2 Methods

4.2.1 Design

A cross-sectional study design was used to address the research questions. We examined data from the 2016-2017 cycle of the Canadian Student Tobacco, Alcohol and Drugs Survey (CSTADS), a biennial school-based survey administered to students across Canada. The survey used a stratified single-stage cluster design to obtain the student sample[88]. Strata were based on two classifications: health region cigarette smoking rate and school type[88]. Within each provincial sampling frame, two or three smoking rate strata (six in Nova Scotia) and two school-level strata (elementary and high school) were defined[88]. To ensure a generalizable sample within each province, schools were selected from strata at random, and then all eligible students within selected schools were surveyed[88]. This sampling design was used in all provinces except Québec since the 2016-2017 CSTADS was conducted in partnership with the Québec Health Survey of High School Students (QHSHSS). The QHSHSS is a provincial-wide health survey of students in grades 7 to 11 (secondary I to V) implemented in Québec every six years to attain precise estimates on various health behaviours for each of the regions in Québec[88]. In order to minimize the burden at the school level, the CSTADS and QHSHSS approached schools together as one project, in which a majority of students completed the QHSHSS form and some completed the CSTADS form[88]. As a result, the sampling design in Québec was altered to allow for such collaboration. Detailed information on the sampling strategy used in Québec can be found in the CSTADS' publicly available microdata file[88].

4.2.2 Setting

The survey was administered between October 2016 and June 2017 in private, public, and Catholic schools attended by students in grades 7 to 12 (secondary I to V in Québec) across nine Canadian provinces[88]. The sample excluded schools in New Brunswick (who declined participation in this cycle of the survey) and schools in the three territories. Schools with fewer than 20 students enrolled in at least one eligible grade, schools for special needs, schools on First Nation reserves, virtual schools, schools on military bases, international schools, and daycares were also excluded[88].

4.2.3 Participants

The present study is based on 33,915 high school students in grades 9 to 12 who took part in the 2016-2017 cycle of the survey. In total, 117 school boards (excluding Québec), 699 schools, and 52,103 students in grades 7 to 12 participated in this cycle of the survey[88]. A mix of active and passive permission protocols were used to obtain parental permission in participating schools. School boards and schools determined the permission protocol best suited within their schools. Schools participating with active permission protocols required written consent from parents for students to participate (e.g., parents indicated "yes" on a permission form)[88]. Schools participating with passive permission protocols required that parents call a toll-free number if they did not want their child to participate in the survey, and students themselves also had the option to decline participation on the day of the survey[88]. Overall, the student level response rate across Canada (excluding Québec) was 76%[88].

Given that adolescents in Canada can independently operate a motor vehicle between 16 and 17 years of age, the sample was further refined to include only students in grades 11 and 12 for all analyses of DUIC. This led to a sample of 14,520 senior students. All analyses of RWCD were based on all 33,915 students in grades 9 to 12 for two reasons: 1) self-reported data suggests that there is an increased likelihood of RWCD among Canadians ages 15 to 24[18], and 2) nearly 20% of Canadian students in grades 9 to 12 have reported ever riding with a driver who had used cannabis within the previous two hours[19].

4.2.4 Outcome Variables

Two cannabis-related driving outcomes were analyzed: **DUIC** and **RWCD**. The first outcome was derived from survey responses to the question: "Have you driven a vehicle (e.g., car, snowmobile, motor boat, or all-terrain vehicle (ATV)) within 2 hours of using marijuana or cannabis?"[88]. Response options included: "No, never", "Yes, in the last 30 days", and "Yes, more than 30 days ago"[88]. For our study, DUIC was coded 0 for "No, never"; 1 for "Yes, in the last 30 days"; and 2 for "Yes, more than 30 days ago". The second outcome was derived from survey responses to the question: "Have you ever been a passenger in a vehicle (e.g., car, snowmobile, motor boat, or ATV) driven by someone who had been using marijuana or cannabis in the last 2 hours?"[88]. For this question, respondents were provided with the following response options: "No, never", "Yes, in the last 30 days", "Yes, more than 30 days ago", and "I do not know"[88]. To avoid having more than three categories for this outcome, RWCD was coded 0 for "No, never" and "I do not know"; 1 for "Yes, in the last 30 days"; and 2 for "Yes, more than 30 days ago".

4.2.5 Independent Variable

Perceived risk of regular cannabis use was assessed from the question: "How much do you think people risk harming themselves when they smoke marijuana or cannabis on a regular basis?"[88]. Response options included: "No risk", "Slight risk", "Moderate risk", "Great risk", and "I do not know"[88]. Using "No risk" as the reference category, the variable was coded 0 for "No risk"; 1 for "Slight risk"; 2 for "Moderate risk"; 3 for "Great risk"; and 4 for "I do not know" and/or not stated. This question and its corresponding scale came from the 2009 version of the Health Behaviour in School-aged Children study in Canada[89]. Given the multidimensional nature of this construct, operationalizing definitions of perceived risk has been a consistent challenge across similar studies. Many studies have relied solely on indicators with unidimensional scales[90] which have oversimplified the construct. Our study falls victim to the same shortcoming since only one question pertaining to risk perception was included in the survey. After an extensive search of the literature, there is no evidence to suggest that this scale has been empirically validated. Despite this major limitation, versions of this Likert scale have been used in various studies examining risk perception of substance use (including cannabis) among adolescent populations[91,92,93]. Findings from these studies suggest that this measure has good face validity. Furthermore, according to the Children, Youth, and Families at Risk summary assessment of this instrument, this scale (which was used in the adolescent form of the 2005 American Drug and Alcohol Survey) has high test-retest reliability (0.94)[91].

4.2.6 Covariates

Analyses were also controlled for sociodemographic variables including sex, school grade, rurality, province of residence, and autonomy. **Sex** ("Are you female or male?")[88] was coded 0 for "Female" and 1 for "Male". Since the literature suggests that males are consistently more likely than females to report DUIC[19,21,22,23,24,25], and the prevalence of RWCD has been found to be higher among males than females[27], females were used as the reference group when assessing both outcomes. **School grade** was determined by responses to the following question: "What grade are you in?"[88]. Response options included: "Grade 7", "Grade 8", "Grade 9", "Grade 10", "Grade 11", and "Grade 12"[88]. School grade was used as a proxy for age since age was not allowed to be used by Health Canada. For all analyses of DUIC (which included students in grades 11 and 12 only), school grade was coded 0 for "Grade 11" and 1 for "Grade 12". Given that the number of Canadian students who report DUIC is almost entirely accounted for by grade 12 students, students in grade 11 were used as the reference group[20]. For all analyses of RWCD, school grade was coded 0 for "Grade 9"; 1 for "Grade 10"; 2 for "Grade 11"; and 3 for "Grade 12". Since evidence suggests that students in lower grades are less likely to ride with a cannabis-impaired driver[20], students in grade 9 were used as the reference group. **Rurality** was derived from survey responses to the question: "Is the respondent's school in an urban or rural location?"[88]. Urban and rural categories were derived from school postal codes that were based on Statistics Canada's Statistical Area Classification system[88]. Urban areas were considered census metropolitan areas (CMAs) or census agglomerations (CAs)[88]. CMAs are defined as having a total population of at least 100,000, of which 50,000 or more live in the urban core. CAs are areas that must have an urban core population of at least 10,000 and consist of one or more neighbouring municipalities situated around the core. Rural areas were considered non-CMAs/CAs. These definitions of urban versus rural region were adopted from the survey's publicly available microdata file[88]. Rurality was coded 0 for "No" and 1 for "Yes". Since Canadian evidence suggests that the likelihood of DUIC is higher among students from rural schools compared to urban schools[26], and since cannabis-impaired drivers are more likely to reside in rural areas[21], non-rural (urban) was used as the reference group when assessing the first outcome (DUIC). Although information is limited on whether urban and rural differences exist in relation to RWCD among students, a consistent finding in the literature is that the odds of ever RWDD is higher among rural students than urban students[19]. Assuming this pattern holds true for RWCD, non-rural (urban) was also used as the reference group when assessing the second outcome. **Province of residence** was coded 0 for "Ontario"; 1 for "Québec"; 2 for "British Columbia"; 3 for "Alberta"; 4 for "Saskatchewan"; 5 for "Manitoba"; 6 for "Nova Scotia"; 7 for "Prince Edward Island"; and 8 for "Newfoundland and Labrador". For our study, Ontario was used as the reference group. **Autonomy**, which was defined by the survey as "our need for personal freedom to make choices or decisions that affect our lives"[88], was measured using six items to capture students' overall autonomy in the past week: "I feel free to express myself at home", "I feel free to express myself with my friends", "I feel I have a choice about when and how to do my schoolwork", "I feel I have a choice about which activities to do with my friends", "I feel free to express myself at school", and "I feel like I have a choice about when and how to do my household chores"[88]. The set of six items used to measure autonomy had high internal consistency as determined by Cronbach's alpha (Cronbach's $\alpha = 0.95$). This indicated that the set of items were closely related as group. Response options for each of these items were: "Really false for me", "Sort of false for me", "Sort of true for me", and "Really true for me"[88]. Considering that students may respond differently to each of the six items, we created an autonomy scale (scored 0 to 3, meaning least to most autonomy) for each of the six items, with a total score ranging from 0 to 18 (lowest to highest autonomy). For each of the six items, "Really false for me" responses were assigned a score of 0; "Sort of false for me" responses were assigned a score of 1; "Sort of true for me" responses were assigned a score of 2; and "Really true for me" responses were assigned a score of 3. For each item that a response was not stated, a score of 0 was assigned. The square transformation of autonomy score was used in all analyses to correct for outliers and a departure from a normal distribution (see

Appendix A – Figures A1 to A4). Skewness of the square transformation of autonomy score was -0.02 (compared to -1.04) and kurtosis was 2.16 (compared to 4.02) (see Appendix A – Figures A3 and A4). The square transformation of autonomy score was then divided into quartiles which were labeled "High", "Moderate", "Low", and "Very low". Since recent literature suggests that those who report feeling more autonomous have higher risk perception and are less likely to partake in risky behaviours[36], "High" autonomy score was used as the reference group.

4.2.7 Statistical Analysis

All prevalence estimates and statistical tests accounted for the stratified cluster sample design and were based on survey weights and bootstrap weights. Survey weights were used to adjust for school selection and non-response at the school, grade, and student level, and to derive meaningful population estimates from the survey sample. The construction of survey weights was achieved in a series of six stages[88]. Further details and explanations on how these weights were constructed can be found in the CSTADS' publicly available microdata file[88]. Bootstrap weights were used to account for the effects of the survey design (e.g., the clustered data) on variance estimates, and to more precisely estimate sampling error. All weights were calculated by the CSTADS and provided in the dataset.

Multinomial logistic regression was used to examine the association between perceived risk of regular cannabis use and cannabis-related driving and passenger behaviours. Our choice to use multinomial logistic regression over ordinal logistic regression was based on the violated assumptions associated with ordinal logistic regression. Ordinal logistic regression assumes that the distance between each of the response categories of the outcome are equal – an assumption which was not tenable for either of our outcome variables. To determine whether these associations differed between males and females and/or rural and urban students, again multinomial logistic regression was employed, now with two stages of testing. In the first stage, effect modification was tested using a sex by perceptions interaction term (and a rurality by perceptions interaction term) to see if we should pursue further with stratification (stage two) by sex and/or rurality. Finally, to test the robustness of the main findings, a sensitivity analysis for the DUIC model was performed, whereby the association between perceived risk of regular cannabis use and DUIC was tested separately for students in grades 11 and 12 who had used cannabis at least once in the past year. To handle missing data, listwise deletion was used to achieve a complete case analysis. Listwise deletion reduced the estimation sample to 14,147 students from 14,520 for all analyses assessing DUIC, and to 33,116 students from 33,915 for all analyses assessing RWCD. This missing data analysis procedure was employed since less than 5% of data were missing for each outcome variable[94] (range from 2% [RWCD] to 3% [DUIC]). All multinomial logistic regression analyses were performed using Stata/IC (version 15.0).

4.2.8 Ethics Approval

Ethics approval for this study was obtained from the Health Canada Research Ethics Board, the University of Waterloo Office of Research Ethics, and the ethics review boards located in affiliated provincial institutions and school boards.

4.3 Results

Descriptive statistics from Table 4.3.1 revealed that nearly 5% of high school students in grades 11 and 12 reported having driven under the influence of cannabis in the last 30 days, while 3.9% of students reported having driven under the influence of cannabis more than 30 days ago. In terms of passenger behaviour, 8.5% of high school students in grades 9 to 12 reported having ridden with a driver impaired by cannabis in the last 30 days, while 8.9% of students reported having ridden in a vehicle with a cannabis-impaired driver more than 30 days ago. In terms of perceived risk of regular cannabis use, 46.9% of all high school students reported that they perceived great risk from smoking cannabis on a regular basis, while 10% of students perceived no risk.

Table 4.3.2 presents unadjusted and adjusted results of a multinomial logistic regression model of DUIC by perceived risk of regular cannabis use, sex, school grade, rural setting, province, and square of autonomy score among students in grades 11 and 12 in nine Canadian provinces. Adjusted results from Table 4.3.2 revealed a dose-response pattern, whereby greater perceived risk of regular cannabis use was significantly associated with reduced risk of DUIC in the last 30 days and more than 30 days ago. For instance, students who perceived that smoking cannabis on a regular basis posed great risk had a 94% reduction in risk of DUIC in the last 30 days ($p \leq 0.001$), and an 89% reduction in risk of DUIC more than 30 days ago ($p \leq 0.001$), compared to students who perceived that regular cannabis use posed no risk at all. Adjusted estimates also indicated that male students and students in grade 12 had a significant increase in risk of DUIC in the last 30 days and more than 30 days ago, compared to female students and students in grade 11, respectively. As well, compared to students from urban schools, rural students had a significant increased risk of DUIC in the last 30 days, but not more than 30 days ago. Students in all provinces except for Québec, British Columbia, Alberta, and Manitoba had a significant increase in risk of DUIC in the last 30 days compared to Ontario students. Similarly, compared to Ontario, the risk of cannabis-impaired driving more than 30 days ago was significantly increased among students in all provinces except for Québec and British Columbia. Finally, adjusted results found that students with a very low autonomy score had a significantly increased risk of DUIC more than 30 days ago. Unadjusted results from Table 4.3.2 were generally consistent with adjusted results. Results from the sensitivity analysis revealed the same trend as the main analysis. However, in the restricted analysis which included only students in grades 11 and 12 who had used cannabis at least once in the past year, the effect sizes were less robust (see Appendix B – Table B1). This result suggests that risk perception may not play the same role for cannabis users, who are more risk-takers anyway.

Table 4.3.3 presents unadjusted and adjusted results of a multinomial logistic regression model of RWCD by perceived risk of regular cannabis use, sex, school grade, rural setting, province, and square of autonomy score among students in grades 9 to 12 in nine Canadian provinces. Adjusted estimates indicated a dose-response pattern, whereby greater perceived risk of regular cannabis use was significantly associated with reduced risk of RWCD in the last 30 days and more than 30 days ago. Students who perceived that regular cannabis use posed great risk had a 92% reduction in risk of RWCD in the last 30 days ($p \leq 0.001$), and a 77% reduction in risk of RWCD more than 30 days ago ($p \leq 0.001$), compared to students who perceived that regular cannabis use posed no risk at all. Adjusted estimates also indicated a dose-dependent effect of school grade on risk of

RWCD, whereby the risk of RWCD (in the last 30 days and more than 30 days ago) increased significantly with school grade level ($p \leq 0.001$). While male students had a significant reduction in risk of RWCD in the last 30 days and more than 30 days ago compared to female students, adjusted results revealed that relative to urban students, students from rural schools had a significant increased risk of RWCD in the last 30 days and more than 30 days ago (43% and 26%, respectively). Compared to students in Ontario, students from most provinces had a significant increased risk of RWCD in the last 30 days and more than 30 days ago. Finally, the risk of RWCD more than 30 days ago increased significantly as students' self-reported level of autonomy decreased from high to very low. Unadjusted results from Table 4.3.3 were consistent with adjusted results.

Interaction models for DUIC and RWCD by sex and by rurality were tested but revealed no significant interactions (see Tables 4.3.4 to 4.3.7 and Appendix C – Figures C1 to C4). However, we ran stratified analyses to explore effect size differences between males and females, and urban and rural high school students (see Appendix D and E). The impact of risk perception on DUIC was significantly protective for both males and females, and for urban and rural students (see Appendix D – Tables D1 and D2), though the magnitude of the effect was larger for males than females, and for urban versus rural students. Adjusted results revealed that great risk perception was protective of DUIC more than 30 days ago versus never more so for males than females (0.09 versus 0.15) (see Appendix D – Table D1). For rural students, great risk perception was protective of DUIC more than 30 days ago versus never by 0.10, while for urban students great risk perception was protective by 0.12 (see Appendix D – Table D2). Results from adjusted stratified analyses of the association between risk perception and RWCD were consistent with the results from adjusted stratified analyses of the association between risk perception and DUIC (see Appendix E – Tables E1 and E2). Comparably, a significant protective effect of risk perception on RWCD was observed for students of both sexes, and for students from both urban and rural schools (see Appendix E – Tables E1 and E2). Great risk perception was protective of RWCD more than 30 days ago versus never by 0.24 for males and 0.23 for females (see Appendix E – Table E1), and by 0.24 for urban students and 0.20 for rural students (see Appendix E – Table E2). Again, the magnitude of the effect of risk perception on RWCD was larger for males compared to females, and for urban students compared to rural students.

4.4 Discussion

The two major conclusions from this paper can be summarized as follows. First, perceived risk of regular cannabis use was associated with DUIC and RWCD. Observed associations exhibited a dose-response pattern, with risk of DUIC and RWCD in the last 30 days and more than 30 days ago decreasing as perceived risk of regular cannabis use increased from no risk to great risk. These findings replicate results from two recent empirical studies in the United States that explored cognitive risk factors for driving after cannabis use among young people[28,30].

Second, no evidence of significant effect modification by sex or rurality for either the association between risk perception and DUIC, or between risk perception and RWCD was found in the present study. Although no significant effect modification was observed, adjusted stratified analyses revealed that the impact of risk perception of regular cannabis use on DUIC and RWCD was significantly protective for both males and females, and for urban and rural students. To the best of our knowledge, this is the first Canadian study to consider how the association of perceived risk of regular cannabis use with DUIC and RWCD varied between males and females, and urban and rural students.

Given the strong association, heightening the risk perceptions of the small proportion of the student population who feel that regular cannabis use poses no risk at all may be an effective strategy for reducing the prevalence of both behaviours. This strategy is based on the assumption that increasing people's perceptions of risk (or their perceived threat) will engender a change in behaviour. This assumption is central to various health psychology models including the Health Belief Model[69]. Not only is this assumption commonsensical and pervasive in psychology, it is also supported by scientific evidence. For instance, a recent meta-analysis of experimental evidence found that heightening individual elements of risk appraisal (e.g., risk perception, anticipated emotion, and perceived severity) led to a change in people's intentions and behaviours[70]. Moreover, this study found that the effects of risk appraisal on these outcomes were augmented when more than one of these elements of risk appraisal were heightened[70].

Education is considered the best practice for changing people's risk perceptions. Educational institutions such as elementary schools and high schools should disseminate appropriate information regarding cannabis risks to youth, including placing more emphasis on the harmful effects of using cannabis as a means of educating and alerting students on the realities of the known risks associated with driving after cannabis use. Doing so may increase the risk perceptions of the small proportion of the student population who feel that cannabis poses no risk at all, and decrease the prevalence of

DUIC and RWCD behaviours. Social marketing campaigns targeting young people at risk of DUIC or RWCD may also be an effective way of heightening risk perceptions and decreasing the prevalence of both behaviours among young people. Major efforts should be made in this regard to educate the population of Canadian high school students.

This study has several limitations. First, data were cross-sectional rather than longitudinal, and therefore this study was unable to capture any cause-and-effect relationship between risk perception and cannabis-related driving and passenger behaviours. Furthermore, data collected during this brief period may not reflect the patterns of cannabis-related driving and passenger behaviours that may ensue following the recent legalization of cannabis in Canada. Second, involvement in cannabis-related driving and passenger behaviour was based on self-reports and may suffer from biases of under- and over-reporting. Third, our measure of risk perception focused broadly on cannabis use rather than DUIC and RWCD risk perception. Moreover, the question and corresponding Likert scale used to assess risk perception of regular cannabis use has not been empirically validated, despite its use in studies with similar research aims[91,92,93]. Fourth, the current study did not include other unmeasured confounders highly associated with our exposure and outcome variables (e.g., cannabis use, illicit drug use, and excessive alcohol consumption) due to potential risk of multicollinearity. Other potential confounders such as risk-engaging personality, sexual orientation, and depression were also excluded from our analyses since these variables were not available in the survey. Finally, due to the school-based nature of our study, the results may not be generalizable to home-schooled and absentee students (including truant students) who may be at higher risk of engaging in risky behaviours such as DUIC and RWCD.

In sum, the current study found that nearly half of high school students perceived the regular use of cannabis to be harmful (with 1 in 10 perceiving no risk). Just under 10% of students in grades 11 and 12 reported DUIC in the past year, and almost 20% of students in grades 9 to 12 reported RWCD. This study suggests that perceptions of risk matter for young people: greater perceived risk of cannabis was related to reduced risk of cannabis-related driving and passenger behaviour in a robust and dose-response manner, and these associations were consistent for males and females, and for urban and rural students. Given this strong association, we must work to better disseminate appropriate information regarding cannabis risks to high school students. Shifting the small proportion of the student population who feel that regular cannabis use poses no risk at all to recognize that there are some risks involved with cannabis-impaired driving behaviours is also warranted. To achieve this, a multi-pronged approach akin to what has led to substantial reductions in drinking and driving is needed – a combination of robust public health policy and regulation, education, social marketing, effective enforcement approaches, and time (cultural shift).

Table 4.3.1. Sociodemographic and other characteristics of Canadian grade 9-12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey (*n* = 33 915)

Variables	High school students (*n* = 33 915)		
	n	Weighted %	CI[a]
Sex			
Female	16 938	48.7	0.5
Male	16 977	51.3	0.5
School grade			
9	10 643	25.4	0.5
10	8752	25.4	0.5
11	8257	25.2	0.5
12	6263	24.0	0.5
Rural setting			
No	25 665	83.0	0.4
Yes	8250	17.0	0.4
Province			
Ontario	7828	47.0	0.5
Québec	1943	15.6	0.4
British Columbia	4300	13.4	0.4
Alberta	6440	11.8	0.3
Saskatchewan	1905	3.4	0.2
Manitoba	2244	4.3	0.2
Nova Scotia	2624	2.7	0.2
Prince Edward Island	2778	0.4	0.1
Newfoundland and Labrador	3853	1.4	0.1
Sqr. Autonomy score			
High	5824	17.9	0.4
Moderate	9246	29.1	0.5
Low	10 170	30.4	0.5
Very low	8675	22.6	0.4
Perceived risk of regular cannabis use			
No risk	4086	10.0	0.3
Slight risk	4667	12.9	0.4
Moderate risk	7505	22.5	0.4
Great risk	14 581	46.9	0.5
Don't know/Not stated	3076	7.7	0.3
DUIC (*n* = 14 520)			
No, never	12 480	88.9	0.5
Yes, in the last 30 days	907	4.9	0.4
Yes, more than 30 days ago	760	3.9	0.3
Missing	373	2.3	0.2
Not applicable	19 395	–	–
RWCD (*n* = 33 915)			
No, never	26 443	80.4	0.4
Yes, in the last 30 days	3297	8.5	0.3
Yes, more than 30 days ago	3376	8.9	0.3
Missing	799	2.2	0.2

Notes: Sqr. = square transformation; DUIC = driving under the influence of cannabis; RWCD = riding with a cannabis-impaired driver.
[a] 95% Confidence interval.

Table 4.3.2. Multinomial logistic regression of driving under the influence of cannabis (DUIC) by perceived risk of regular cannabis use, sex, school grade, rural setting, province, and square of autonomy score among Canadian grade 11 and 12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey (n = 14 147)

Variables	DUIC (n = 14 147)		Unadjusted RRR (95% CI)		Adjusted RRR[b] (95% CI)	
	n[a]	Weighted estimated %	Last 30-day DUIC vs. Never	More than 30-day ago DUIC vs. Never	Last 30-day DUIC vs. Never	More than 30-day ago DUIC vs. Never
Perceived risk of regular cannabis use						
No risk (referent)	2061	12.1	1.00	1.00	1.00	1.00
Slight risk	2430	15.7	0.54 (0.39, 0.75)***	0.65 (0.49, 0.85)**	0.56 (0.39, 0.80)**	0.67 (0.51, 0.88)**
Moderate risk	3458	25.3	0.17 (0.13, 0.22)***	0.30 (0.23, 0.39)***	0.19 (0.14, 0.27)***	0.34 (0.26, 0.44)***
Great risk	5205	41.4	0.05 (0.03, 0.08)***	0.09 (0.06, 0.12)***	0.06 (0.04, 0.10)***	0.11 (0.08, 0.15)***
Don't know/Not stated	993	5.5	N/A	N/A	N/A	N/A
Sex						
Female (referent)	7126	49.2	1.00	1.00	1.00	1.00
Male	7021	50.8	2.17 (1.56, 3.02)***	1.80 (1.39, 2.33)***	1.74 (1.25, 2.41)***	1.50 (1.17, 1.93)***
School grade						
11 (referent)	8043	51.2	1.00	1.00	1.00	1.00
12	6104	48.8	1.91 (1.48, 2.47)***	1.86 (1.44, 2.39)***	1.91 (1.51, 2.42)***	1.83 (1.42, 2.36)***
Rural setting						
No (referent)	10 516	82.6	1.00	1.00	1.00	1.00
Yes	3631	17.4	2.17 (1.59, 2.95)***	1.72 (1.12, 2.65)*	1.70 (1.30, 2.24)***	1.24 (0.90, 1.71)
Province						
Ontario (referent)	3475	51.7	1.00	1.00	1.00	1.00
Québec	670	9.8	0.66 (0.34, 1.30)	0.72 (0.37, 1.40)	1.59 (0.81, 3.13)	1.50 (0.78, 2.89)
British Columbia	1882	14.0	1.36 (0.78, 2.37)	1.58 (0.86, 2.89)	1.25 (0.72, 2.17)	1.51 (0.81, 2.84)
Alberta	2533	12.0	1.70 (1.12, 2.57)*	2.16 (1.32, 3.53)**	1.37 (0.99, 1.91)	1.90 (1.23, 2.95)**
Saskatchewan	788	3.5	3.08 (1.94, 4.88)***	3.55 (2.19, 5.74)***	2.10 (1.34, 3.29)***	2.91 (1.82, 4.67)***
Manitoba	962	4.5	1.47 (0.94, 2.31)	2.32 (1.41, 3.81)***	1.04 (0.74, 1.47)	1.88 (1.20, 2.96)**
Nova Scotia	1033	2.7	3.39 (2.41, 4.77)***	3.61 (2.32, 5.60)***	2.59 (1.88, 3.58)***	2.89 (1.90, 4.39)***
Prince Edward Island	1103	0.4	2.13 (1.29, 3.51)**	2.44 (1.50, 3.97)***	1.44 (1.07, 1.93)*	2.02 (1.23, 3.31)**
Newfoundland and Labrador	1701	1.4	2.28 (1.39, 3.74)***	2.67 (1.71, 4.16)***	1.82 (1.14, 2.89)*	2.22 (1.45, 3.43)***
Sqr. Autonomy score						
High (referent)	2536	18.4	1.00	1.00	1.00	1.00
Moderate	3864	29.0	1.09 (0.75, 1.58)	1.15 (0.87, 1.52)	0.99 (0.69, 1.43)	1.05 (0.78, 1.40)
Low	3317	23.4	1.05 (0.72, 1.54)	1.44 (1.04, 2.01)*	0.87 (0.58, 1.30)	1.21 (0.88, 1.68)
Very low	4430	29.2	1.91 (1.27, 2.87)**	1.76 (1.30, 2.39)***	1.39 (0.90, 2.14)	1.37 (1.02, 1.84)*
F statistic					$F(36, 464) = 48.13^{***}$	

Notes: DUIC = driving under the influence of cannabis; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable; Sqr. = square transformation.
[a] The weighted prevalence estimates are based on 14 147 cases.
[b] Adjusted for perceived risk of regular cannabis use, sex, school grade, rural setting, province, and square of autonomy score.
* $p < 0.05$.
** $p < 0.01$.
*** $p \leq 0.001$.

Table 4.3.3. Multinomial logistic regression of riding with a cannabis-impaired driver (RWCD) by perceived risk of regular cannabis use, sex, school grade, rural setting, province, and square of autonomy score among Canadian grade 9-12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey (n = 33 116)

Variables	RWCD (n = 33 116)		Unadjusted RRR (95% CI)		Adjusted RRR[b] (95% CI)	
	n^a	Weighted estimated %	Last 30-day RWCD vs. Never	More than 30-day ago RWCD vs. Never	Last 30-day RWCD vs. Never	More than 30-day ago RWCD vs. Never
Perceived risk of regular cannabis use						
No risk (referent)	4026	10.1	1.00	1.00	1.00	1.00
Slight risk	4623	13.0	0.54 (0.45, 0.66)***	0.86 (0.72, 1.03)	0.54 (0.45, 0.65)***	0.85 (0.71, 1.03)
Moderate risk	7442	22.9	0.28 (0.23, 0.33)***	0.55 (0.47, 0.65)***	0.28 (0.24, 0.33)***	0.54 (0.46, 0.64)***
Great risk	14 453	47.5	0.07 (0.06, 0.09)***	0.22 (0.18, 0.26)***	0.08 (0.07, 0.10)***	0.23 (0.19, 0.28)***
Don't know/Not stated	2572	6.5	N/A	N/A	N/A	N/A
Sex						
Female (referent)	16 668	49.1	1.00	1.00	1.00	1.00
Male	16 448	50.9	1.01 (0.87, 1.17)	0.87 (0.77, 0.98)*	0.75 (0.65, 0.87)***	0.73 (0.63, 0.84)***
School grade						
9 (referent)	10 400	25.3	1.00	1.00	1.00	1.00
10	8546	25.4	1.96 (1.62, 2.37)***	2.02 (1.70, 2.41)***	1.78 (1.46, 2.16)***	1.92 (1.60, 2.32)***
11	8062	25.2	2.92 (2.30, 3.71)***	2.48 (2.10, 2.93)***	2.52 (1.99, 3.19)***	2.29 (1.94, 2.70)***
12	6108	24.1	4.27 (3.28, 5.56)***	3.74 (3.10, 4.52)***	3.82 (2.93, 4.99)***	3.86 (3.17, 4.69)***
Rural setting						
No (referent)	25 047	83.0	1.00	1.00	1.00	1.00
Yes	8069	17.0	1.69 (1.34, 2.13)***	1.53 (1.17, 2.00)**	1.43 (1.16, 1.75)***	1.26 (1.01, 1.56)*
Province						
Ontario (referent)	7638	47.0	1.00	1.00	1.00	1.00
Québec	1923	15.8	1.05 (0.81, 1.35)	1.47 (1.16, 1.86)***	2.13 (1.64, 2.78)***	2.57 (2.03, 3.26)***
British Columbia	4168	13.3	1.42 (1.00, 2.02)	1.36 (0.95, 1.94)	1.34 (0.96, 1.86)	1.36 (0.96, 1.92)
Alberta	6315	11.9	1.34 (1.02, 1.77)*	1.84 (1.36, 2.50)***	1.24 (1.01, 1.53)*	1.82 (1.39, 2.39)***
Saskatchewan	1866	3.4	1.93 (1.22, 3.05)**	2.52 (1.85, 3.42)***	1.55 (0.95, 2.54)	2.32 (1.63, 3.31)***
Manitoba	2192	4.2	1.61 (1.20, 2.17)**	1.62 (1.26, 2.08)***	1.35 (1.06, 1.72)*	1.53 (1.24, 1.90)***
Nova Scotia	2570	2.6	3.37 (2.60, 4.36)***	3.13 (2.53, 3.88)***	2.80 (2.20, 3.55)***	2.87 (2.32, 3.56)***
Prince Edward Island	2725	0.4	1.76 (1.32, 2.33)***	1.94 (1.57, 2.38)***	1.41 (1.14, 1.74)***	1.77 (1.39, 2.24)***
Newfoundland and Labrador	3719	1.4	2.13 (1.66, 2.73)***	2.00 (1.60, 2.52)***	1.79 (1.43, 2.24)***	1.85 (1.49, 2.30)***
Sqr. Autonomy score						
High (referent)	5752	18.1	1.00	1.00	1.00	1.00
Moderate	9157	29.4	1.10 (0.85, 1.43)	1.37 (1.14, 1.65)***	1.05 (0.80, 1.38)	1.33 (1.10, 1.61)**
Low	10 044	30.8	1.49 (1.18, 1.90)***	1.50 (1.23, 1.83)***	1.34 (1.05, 1.72)*	1.42 (1.18, 1.72)***
Very low	8163	21.7	1.83 (1.49, 2.26)***	1.78 (1.47, 2.17)***	1.45 (1.17, 1.80)***	1.61 (1.29, 2.01)***
F statistic					$F(40, 460) = 70.16^{***}$	

Notes: RWCD = riding with a cannabis-impaired driver; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable; Sqr. = square transformation.
[a] The weighted prevalence estimates are based on 33 116 cases.
[b] Adjusted for perceived risk of regular cannabis use, sex, school grade, rural setting, province, and square of autonomy score.
* $p < 0.05$.
** $p < 0.01$.
*** $p \leq 0.001$.

Table 4.3.4. Multinomial logistic regression of driving under the influence of cannabis (DUIC) by sex, perceived risk of regular cannabis use, and their interaction term among Canadian grade 11 and 12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey (*n* = 14 147)

	Adjusted RRR[a] (95% CI)	
	Last 30-day DUIC vs. Never	More than 30-day ago DUIC vs. Never
Male		
No (referent)	1.00	1.00
Yes	1.71 (1.08, 2.70)*	1.74 (1.00, 3.02)
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.58 (0.36, 0.93)*	0.72 (0.41, 1.25)
Moderate risk	0.19 (0.11, 0.32)***	0.42 (0.24, 0.74)**
Great risk	0.05 (0.03, 0.11)***	0.13 (0.07, 0.24)***
Don't know/Not stated	N/A	N/A
Male*Perceived risk of regular cannabis use		
Male*No risk (referent)	1.00	1.00
Male*Slight risk	0.96 (0.46, 2.01)	0.91 (0.37, 2.23)
Male*Moderate risk	1.01 (0.50, 2.04)	0.70 (0.33, 1.49)
Male*Great risk	1.32 (0.55, 3.15)	0.73 (0.30, 1.76)
Male*Not stated risk	N/A	N/A

Notes: DUIC = driving under the influence of cannabis; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable.

[a] Adjusted for school grade, rural setting, province, and square of autonomy score.

* $p < 0.05$.

** $p < 0.01$.

*** $p \leq 0.001$.

Table 4.3.5. Multinomial logistic regression of driving under the influence of cannabis (DUIC) by rural setting, perceived risk of regular cannabis use, and their interaction term among Canadian grade 11 and 12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey (*n* = 14 147)

	Adjusted RRR[a] (95% CI)	
	Last 30-day DUIC vs. Never	More than 30-day ago DUIC vs. Never
Rural setting		
No (referent)	1.00	1.00
Yes	1.59 (1.03, 2.44)*	1.64 (1.13, 2.37)**
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.51 (0.32, 0.79)**	0.73 (0.52, 1.01)
Moderate risk	0.20 (0.15, 0.28)***	0.40 (0.30, 0.54)***
Great risk	0.06 (0.03, 0.10)***	0.12 (0.08, 0.18)***
Don't know/Not stated	N/A	N/A
Rural*Perceived risk of regular cannabis use		
Rural*No risk (referent)	1.00	1.00
Rural*Slight risk	1.40 (0.73, 2.66)	0.78 (0.41, 1.48)
Rural*Moderate risk	0.79 (0.34, 1.80)	0.51 (0.29, 0.92)*
Rural*Great risk	1.56 (0.64, 3.79)	0.82 (0.42, 1.57)
Rural*Not stated risk	N/A	N/A

Notes: DUIC = driving under the influence of cannabis; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable.
[a] Adjusted for sex, school grade, province, and square of autonomy score.
* $p < 0.05$.
** $p < 0.01$.
*** $p \leq 0.001$.

Table 4.3.6. Multinomial logistic regression of riding with a cannabis-impaired driver (RWCD) by sex, perceived risk of regular cannabis use, and their interaction term among Canadian grade 9-12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey (*n* = 33 116)

	Adjusted RRR[a] (95% CI)	
	Last 30-day RWCD vs. Never	More than 30-day ago RWCD vs. Never
Male		
No (referent)	1.00	1.00
Yes	0.69 (0.54, 0.90)**	0.75 (0.56, 1.00)
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.56 (0.41, 0.76)***	0.87 (0.65, 1.18)
Moderate risk	0.27 (0.22, 0.35)***	0.60 (0.45, 0.80)***
Great risk	0.07 (0.05, 0.09)***	0.22 (0.17, 0.29)***
Don't know/Not stated	N/A	N/A
Male*Perceived risk of regular cannabis use		
Male*No risk (referent)	1.00	1.00
Male*Slight risk	0.94 (0.60, 1.46)	0.96 (0.56, 1.64)
Male*Moderate risk	1.01 (0.71, 1.42)	0.80 (0.54, 1.19)
Male*Great risk	1.39 (0.92, 2.10)	1.11 (0.78, 1.58)
Male*Not stated risk	N/A	N/A

Notes: RWCD = riding with a cannabis-impaired driver; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable.

[a] Adjusted for school grade, rural setting, province, and square of autonomy score.

* $p < 0.05$.

** $p < 0.01$.

*** $p \leq 0.001$.

Table 4.3.7. Multinomial logistic regression of riding with a cannabis-impaired driver (RWCD) by rural setting, perceived risk of regular cannabis use, and their interaction term among Canadian grade 9-12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey (*n* = 33 116)

	Adjusted RRR[a] (95% CI)	
	Last 30-day RWCD vs. Never	More than 30-day ago RWCD vs. Never
Rural setting		
No (referent)	1.00	1.00
Yes	1.52 (1.10, 2.11)*	1.48 (1.01, 2,15)*
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.51 (0.42, 0.63)***	0.87 (0.70, 1.09)
Moderate risk	0.29 (0.24, 0.35)***	0.58 (0.47, 0.71)***
Great risk	0.08 (0.07, 0.11)***	0.24 (0.19, 0.30)***
Don't know/Not stated	N/A	N/A
Rural*Perceived risk of regular cannabis use		
Rural*No risk (referent)	1.00	1.00
Rural*Slight risk	1.22 (0.80, 1.85)	0.93 (0.63, 1.36)
Rural*Moderate risk	0.85 (0.57, 1.26)	0.76 (0.52, 1.12)
Rural*Great risk	0.73 (0.44, 1.22)	0.86 (0.58, 1.28)
Rural*Not stated risk	N/A	N/A

Notes: RWCD = riding with a cannabis-impaired driver; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable.

[a] Adjusted for sex, school grade, province, and square of autonomy score.

* $p < 0.05$.

** $p < 0.01$.

*** $p \leq 0.001$.

Chapter 5: Conclusion

5.1 Summary of Main Findings

The major findings of this study can be summarized as follows. First, nearly half (46.9%) of high school students in grades 9 to 12 perceived the regular use of cannabis to be harmful, with 1 in 10 perceiving no risk. In terms of cannabis-related driving and passenger behaviours, just under 10% of students in grades 11 and 12 reported DUIC in the past year, while almost 20% of students reported RWCD. Second, adjusted analyses found that greater perceived risk of regular cannabis use was associated with reduced risk of DUIC and RWCD (in the last 30 days and more than 30 days ago) in a dose-response manner. Finally, no evidence of significant effect modification by sex or rurality for either the association between risk perception and DUIC, or between risk perception and RWCD was observed. Although no effect modification was found, adjusted stratified analyses revealed that the impact of risk perception of regular cannabis use on DUIC and RWCD was significantly protective for both males and females, and for urban and rural students.

5.2 Strengths and Limitations

The study has several limitations and biases that may threaten the internal validity, reliability, and generalizability of our results. First, the cross-sectional nature of the data limits inferences about the direction of the association (temporality) between perceptions of risk and cannabis-related driving and passenger behaviours among Canadian high school students. In other words, it was not possible to determine whether perceived risk of regular cannabis use preceded DUIC and RWCD outcomes among Canadian high school students. Since temporality of association is an indisputable criterion for causality according to Bradford Hill[95], this study had a limited ability to infer causation. In addition, data collected during this brief period may not reflect the patterns of cannabis-related driving and passenger behaviours that may ensue following the recent legalization of cannabis in Canada. Second, given that this was a secondary analysis, the survey question "Are you female or male?" lacked broader response options that included other identities, and consequently, information regarding gender was not available. Although gender has broader implications on our work, our focus was primarily based on sex rather than gender. Third, involvement in cannabis-related driving and passenger behaviour in the past year was based on self-reports rather than objective measures and may suffer from biases of under- and over-reporting. Plausibility for underreporting is fear that certain responses might prove to be personally damaging, potentially leading to social desirability bias. Additionally, due to the school-based nature of our study, the results may not be generalizable to home-schooled and absentee students (including truant students) who may be at higher risk of engaging in risky behaviours such as DUIC and RWCD. In terms of measurement, there are some important limitations to acknowledge. First and foremost, our measure of risk perception focused broadly on cannabis use rather than DUIC and RWCD risk perception. Moreover, the question and corresponding Likert scale used by the CSTADS to assess risk perception of regular cannabis use has not been empirically validated, despite its use in studies with similar research aims[91,92,93]. Measuring perceived risk of DUIC (and RWCD) would have been more ideal since students who perceived that regular cannabis use posed no risk at all may not perceive the same of DUIC or RWCD. Although having a direct measure of risk perception of DUIC and RWCD would likely have resulted in the same pattern of association (e.g., dose-response pattern), it is possible that the observed magnitude of effect would have been larger (e.g., a greater reduction in risk of DUIC and RWCD). Lastly, other unmeasured confounders highly associated with our exposure and outcome variables (e.g., cannabis use, illicit drug use, and excessive alcohol consumption) were not included in our analyses due to potential risk of multicollinearity. Other potential confounders such as risk-engaging personality, sexual orientation, and depression were also excluded since these variables were not available in the survey. Despite these limitations, this study has important strengths including the survey's national scope, high response rate, large sample size, and provincially generalizable estimates. Although students from New Brunswick and Canada's three territories were not surveyed, our sample is quite representative of Canadian high school students since these excluded populations represent only a small fraction of the Canadian population.

5.3 Future Implications

There are several policy implications of the present study. Collectively our findings indicate that current policies and prevention efforts to reduce the prevalence of DUIC and RWCD should concentrate not only on drivers, but also on passengers who choose to ride with a driver who is under the influence of cannabis. As shown by the results of a recent study, pediatrician screening and brief counseling on substance use may be a promising strategy for reducing the short-term risk of riding with a substance-using driver among Canadian youth[96]. Given the strong role played by risk perception in shaping DUIC and RWCD behaviours among Canadian high school students, reducing the prevalence of DUIC and RWCD among young people may also be achieved by changing the risk perceptions of the small proportion of the student population who feel that cannabis poses no risk at all. Education is a key means of changing people's risk perceptions. Education programs should disseminate appropriate information regarding cannabis risks to youth, including alerting students of the harmful effects of cannabis use on driving-related skills and performance. Doing so may increase risk perceptions, and subsequently decrease the prevalence of DUIC and RWCD behaviours. Allocating a share of Canada's cannabis tax revenues to fund public education and social marketing campaigns on the risks and harms of driving after cannabis use may be a cost-effective strategy for doing so and an important policy consideration. A similar policy has already been implemented in Colorado and Washington state[62]. Due to the novelty of this policy, evidence regarding its positive impact in the United States is lacking. Monitoring the impact of these policies and education programs is therefore needed, and is especially important within the context of a changing legislative and policy landscape in Canada.

References

1. Perreault S. Impaired driving in Canada, 2015 [Internet]. Canada: Statistics Canada; 2016 Dec 14 [cited 2018 Mar 16]. Available from: https://www150.statcan.gc.ca/n1/pub/85-002-x/2016001/article/14679-eng.htm

2. Health Canada. Canadian Alcohol and Drug Use Monitoring Survey: summary of results for 2012 [Internet]. Ottawa, ON: Government of Canada; 2014 Apr 8 [cited 2018 Mar 17]. Available from: https://www.canada.ca/en/health-canada/services/health-concerns/drug-prevention-treatment/drug-alcohol-use-statistics/canadian-alcohol-drug-use-monitoring-survey-summary-results-2012.html

3. Canadian Centre on Substance Use and Addiction. Cannabis [Internet]. Ottawa, ON: Canadian Centre on Substance Use and Addiction; 2017 Aug [cited 2018 Mar 17]. Available from: https://www.cpha.ca/sites/default/files/uploads/resources/cannabis/ccsa-canadian-drug-summary-cannabis-2017-en.pdf

4. Canadian Centre on Substance Abuse. Cannabis, driving and implications for youth [Internet]. Ottawa, ON: Canadian Centre on Substance Abuse; 2015 [cited 2018 Mar 17]. Available from: https://www.ccsa.ca/sites/default/files/2019-04/CCSA-Cannabis-Driving-Implications-for-Youth-Summary-2015-en.pdf

5. Ashton CH. Pharmacology and effects of cannabis: a brief review. Br J Psychiatry. 2001 Feb;178(2):101-106.

6. Asbridge M, Hayden JA, Cartwright JL. Acute cannabis consumption and motor vehicle collision risk: systematic review of observational studies and meta-analysis. BMJ. 2012 Feb;344:e536.

7. Li MC, Brady JE, DiMaggio CJ, Lusardi AR, Tzong KY, Li G. Marijuana use and motor vehicle crashes. Epidemiol Rev. 2012 Jan;34(1):65-72.

8. Elvik R. Risk of road accident associated with the use of drugs: a systematic review and meta-analysis of evidence from epidemiological studies. Accid Anal Prev. 2013 Nov;60:254-267.

9. Rogeberg O, Elvik R. The effects of cannabis intoxication on motor vehicle collision revisited and revised. Addiction. 2016 Aug;111(8):1348-1359.

10. Compton RP, Berning A. Drug and alcohol crash risk [Internet]. Washington, DC: National Highway Traffic Safety Administration; 2015 Feb [cited 2018 Aug 27]. Report No.: DOT HS 812 117. Available from: https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812117-drug_and_alcohol_crash_risk.pdf

11. Lacey JH, Kelley-Baker T, Berning A, Romano E, Ramirez A, Yao J, et al. Drug and alcohol crash risk: a case-control study [Internet]. Washington, DC: National Highway Traffic Safety Administration; 2016 Dec [cited 2018 Aug 27]. Report No.: DOT HS 812 355. Available from: https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/812355_drugalcoholcrashrisk.pdf

12. Brubacher JR, Chan H, Erdelyi S, Macdonald S, Asbridge M, Mann RE, et al. Cannabis use as a risk factor for causing motor vehicle crashes: a prospective study. Addiction. 2019 Sep;114(9):1616-1626.

13. Cimbura G, Lucas DM, Bennett RC, Donelson AC. Incidence and toxicological aspects of cannabis and ethanol detected in 1394 fatally injured drivers and pedestrians in Ontario (1982-1984). J Forensic Sci. 1990 Sep;35(5):1035-1041.

14. Stoduto G, Vingilis E, Kapur BM, Sheu WJ, McLellan BA, Liban CB. Alcohol and drug use among motor vehicle collision victims admitted to a regional trauma unit: demographic, injury, and crash characteristics. Accid Anal Prev. 1993 Aug;25(4):411-420.

15. Mercer GW, Jeffery WK. Alcohol, drugs, and impairment in fatal traffic accidents in British Columbia. Accid Anal Prev. 1995 Jun;27(3):335-343.

16. Woodall KL, Chow BL, Lauwers A, Cass D. Toxicological findings in fatal motor vehicle collisions in Ontario, Canada: a one-year study. J Forensic Sci. 2015 May;60(3):669-674.

17. Brubacher JR, Chan H, Martz W, Schreiber W, Asbridge M, Eppler J, et al. Prevalence of alcohol and drug use in injured British Columbia drivers. BMJ Open. 2016 Mar;6(3):e009278.

18. Cartwright J, Asbridge M. Passengers' decisions to ride with a driver under the influence of either alcohol or cannabis. J Stud Alcohol Drugs. 2011 Jan;72(1):86-95.

19. Minaker LM, Bonham A, Elton-Marshall T, Leos-Toro C, Wild TC, Hammond D. Under the influence: examination of prevalence and correlates of alcohol and marijuana consumption in relation to youth driving and passenger behaviours in Canada. A cross-sectional study. CMAJ Open. 2017 May;5(2):E386-E394.

20. Young MM, Saewyc E, Boak A, Jahrig J, Anderson B, Doiron Y, et al. Cross-Canada report on student alcohol and drug use: technical report [Internet]. Ottawa, ON: Canadian Centre on Substance Abuse; 2011 [cited 2018 Oct 18]. Available from: http://www.ccsa.ca/Resource%20Library/2011_CCSA_Student_Alcohol_and_Drug_Use_en.pdf

21. Beirness DJ, Davis CG. Driving under the influence of cannabis: analysis drawn from the 2004 Canadian Addiction Survey [Internet]. Ottawa, ON: Canadian Centre on Substance Abuse; 2006 Dec [cited 2018 Oct 11]. Available from: http://www.ccsa.ca/Resource%20Library/ccsa-011481-2006.pdf

22. Robertson RD, Mainegra Hing M, Pashley CR, Brown SW, Vanlaar WGM. Prevalence and trends of drugged driving in Canada. Accid Anal Prev. 2017 Feb;99(Pt A):236-241.

23. Canadian Centre on Substance Use and Addiction. Impaired driving in Canada [Internet]. Ottawa, ON: Canadian Centre on Substance Use and Addiction; 2019 Mar [cited 2019 Aug 4]. Available from: https://www.ccsa.ca/sites/default/files/2019-04/CCSA-Impaired-Driving-Canada-Summary-2019-en.pdf

24. O'Malley PM, Johnston LD. Drugs and driving by American high school seniors, 2001-2006. J Stud Alcohol Drugs. 2007 Nov;68(6):834-842.

25. O'Malley PM, Johnston LD. Driving after drug or alcohol use by US high school seniors, 2001-2011. Am J Public Health. 2013 Nov;103(11):2027-2034.

26. McInnis OA, Young MM, Saewyc E, Jahrig J, Adlaf E, Lemaire J, et al. Urban and rural student substance use: technical report [Internet]. Ottawa, ON: Canadian Centre on Substance Abuse; 2015 Sep [cited 2018 Oct 3]. Available from: http://www.ccsa.ca/Resource%20Library/CCSA-Urban-Rural-Student-Substance-Use-Report-2015-en.pdf

27. Whitehill JM, Rivara FP, Moreno MA. Marijuana-using drivers, alcohol-using drivers, and their passengers: prevalence and risk factors among underage college students. JAMA Pediatr. 2014 Jul;168(7):618-624.

28. Arterberry BJ, Treloar HR, Smith AE, Martens MP, Pedersen SL, McCarthy DM. Marijuana use, driving, and related cognitions. Psychol Addict Behav. 2013 Sep;27(3):854-860.

29. McCarthy DM, Lynch AM, Pederson SL. Driving after use of alcohol and marijuana in college students. Psychol Addict Behav. 2007 Sep;21(3):425-430.

30. Aston ER, Merrill JE, McCarthy DM, Metrik J. Risk factors for driving after and during marijuana use. J Stud Alcohol Drugs. 2016 Mar;77(2):309-316.

31. Aitken C, Kerger M, Crofts N. Drivers who use illicit drugs: behaviour and perceived risks. Drugs: Educ Prev Polic. 2000 Feb;7(1):39-50.

32. Kelly E, Darke S, Ross J. A review of drug use and driving: epidemiology, impairment, risk factors and risk perceptions. Drug Alcohol Rev. 2004 Sep;23(3):319-344.

33. Greene KM. Perceptions of driving after marijuana use compared to alcohol use among rural American young adults. Drug Alcohol Rev. 2018 Jul;37(5):637-644.

34. Pacek LR, Mauro PM, Martins SS. Perceived risk of regular cannabis use in the United States from 2002 to 2012: differences by sex, age, and race/ethnicity. Drug Alcohol Depend. 2015 Apr;149:232-244.

35. Wickens CM, Watson TM, Mann RE, Brands B. Exploring perceptions among people who drive after cannabis use: collision risk, comparative optimism and normative influence. Drug Alcohol Rev. 2019 May;38(4):443-451.

36. Anton LR. Autonomy, risk perception, and risk taking in emerging adulthood [master's thesis on the Internet]. San Francisco, CA: San Francisco State University; 2015 May. Available from: https://core.ac.uk/download/pdf/48500920.pdf

37. MacKay R, Phillips K, Tiedemann M. Legislative summary of Bill C-45: An Act respecting cannabis and to amend the Controlled Drugs and Substances Act, the Criminal Code and other Acts [Internet]. Ottawa, ON: Library of Parliament; revised 2018 Jul 5 [cited 2019 Jul 28]. Publication No.: 42-1-C45-E. Available from: https://lop.parl.ca/sites/PublicWebsite/default/en_CA/ResearchPublications/LegislativeSummaries/421C45E

38. Cerdá M, Wall M, Feng T, Keyes KM, Sarvet A, Schulenberg J, et al. Association of state recreational marijuana laws with adolescent marijuana use. JAMA Pediatr. 2017 Feb;171(2):142-149.

39. Couper FJ, Peterson BL. The prevalence of marijuana in suspected impaired driving cases in Washington state. J Anal Toxicol. 2014 Oct;38(8):569-574.

40. Lee J, Abdel-Aty A, Park J. Investigation of associations between marijuana law changes and marijuana-involved fatal traffic crashes: a state-level analysis. J Transp Health. 2018 Sep;10:194-202.

41. Iversen L. Cannabis and the brain. Brain. 2003 Jun;126(6):1252-1270.

42. Sharma P, Murthy P, Bharath MM. Chemistry, metabolism, and toxicology of cannabis: clinical implications. Iran J Psychiatry. 2012 Fall;7(4):149-156.

43. Grotenhermen F. Pharmacokinetics and pharmacodynamics of cannabinoids. Clin Pharmacokinet. 2003 Apr;42(4):327-360.

44. Kulig K. Interpretation of workplace tests for cannabinoids. J Med Toxicol. 2017 Mar;13(1):106-110.

45. Rubino T, Viganò D, Realini N, Guidali C, Braida D, Capurro V, et al. Chronic delta 9-tetrahydrocannabinol during adolescence provokes sex-dependent changes in the emotional profile in adult rats: behavioral and biochemical correlates. Neuropsychopharmacol. 2008 Oct;33(11):2760-2771.

46. Rubino T, Realini N, Braida D, Guidi S, Capurro V, Viganò D, et al. Changes in hippocampal morphology and neuroplasticity induced by adolescent THC treatment are associated with cognitive impairment in adulthood. Hippocampus. 2009 Aug;19(8):763-772.

47. Beirness DJ, Porath AJ. Clearing the smoke on cannabis: cannabis use and driving - an update [Internet]. Ottawa, ON: Canadian Centre on Substance Use and Addiction; 2017 [cited 2018 Mar 16]. Available from: https://www.ccsa.ca/sites/default/files/2019-10/CCSA-Cannabis-Use-Driving-Report-2019-en_1.pdf

48. Statistics Canada. Canadian Tobacco, Alcohol and Drugs Survey (CTADS): summary of results for 2017 [Internet]. Ottawa, ON: Government of Canada; 2019 Jan 4 [cited 2019 Aug 2]. Available from: https://www.canada.ca/en/health-canada/services/canadian-tobacco-alcohol-drugs-survey/2017-summary.html

49. Capler R, Bilsker D, Van Pelt K, MacPherson D. Cannabis use and driving: evidence review [Internet]. Simon Fraser University, BC: Canadian Drug Policy Coalition; 2017 Mar 27 [cited 2018 Oct 18]. Available from: https://drugpolicy.ca/wp-content/uploads/2017/02/CDPC_Cannabis-and-Driving_Evidence-Review_FINALV2_March27-2017.pdf

50. Moskowitz H. Marihuana and driving. Accid Anal Prev. 1985 Aug;17(4):323-345.

51. Robbe HW, O'Hanlon JF. Marijuana and actual driving performance [Internet]. Washington, DC: National Highway Traffic Safety Administration; 1993 Nov [cited 2018 Aug 27]. Report No.: DOT HS 808 078. Available from: https://rosap.ntl.bts.gov/view/dot/1558

52. Wettlaufer A, Florica RO, Asbridge M, Beirness D, Brubacher J, Callaghan R, et al. Estimating the harms and costs of cannabis-attributable collisions in the Canadian provinces. Drug Alcohol Depend. 2017 Apr;173:185-190.

53. Cadieux G, Leece P, Ontario Agency for Health Protection and Promotion (Public Health Ontario). Evidence brief: driving under the influence of cannabis - risk factors and preventive interventions [Internet]. Toronto, ON: Ontario Agency for Health Protection and Promotion (Public Health Ontario); 2017 Sep [cited 2018 Mar 17]. Available from: https://www.publichealthontario.ca/en/eRepository/EB_DUIC_RFs_Interventions.pdf

54. Davis KC, Allen J, Duke J, Nonnemaker J, Bradfield B, Farrelly MC, et al. Correlates of marijuana drugged driving and openness to driving while high: evidence from Colorado and Washington. PLoS One. 2016 Jan;11(1):e0146853.

55. Dijkstra L, Poelman H. Cities in Europe: the new OECD-EC definition [Internet]. Paris, FR: Organisation for Economic Co-operation and Development; 2012 Jan [cited 2018 Nov 4]. Available from: http://ec.europa.eu/regional_policy/sources/docgener/focus/2012_01_city.pdf

56. Canadian Rural Revitalization Foundation. State of rural Canada 2015. Canadian Rural Revitalization Foundation. 2015;1-114.

57. Sewell RA, Poling J, Sofuoglu M. The effect of cannabis compared with alcohol on driving. Am J Addict. 2009 May-Jun;18(3):185-193.

58. Isaac NE, Kennedy B, Graham JD. Who's in the car? Passengers as potential interveners in alcohol-involved fatal crashes. Accid Anal Prev. 1995 Apr;27(2):159-165.

59. Soderstrom CA, Dischinger PC, Kerns TJ. Alcohol use among injured sets of drivers and passengers. Accid Anal Prev. 1996 Jan;28(1):111-114.

60. Shults RA, Kresnow MJ, Lee KC. Driver- and passenger-based estimates of alcohol-impaired driving in the U.S., 2001-2003. Am J Prev Med. 2009 Jun;36(6):515-522.

61. Charron-Tousignant M, Valiquet D. Legislative summary of Bill C-46: An Act to amend the Criminal Code (offences relating to conveyances) and to make consequential amendments to other Acts [Internet]. Ottawa, ON: Library of Parliament; revised 2018 Jul 24 [cited 2019 Jul 28]. Publication No.: 42-1-C46-E. Available from: https://lop.parl.ca/sites/PublicWebsite/default/en_CA/ResearchPublications/LegislativeSummaries/421C46E

62. Drug Policy Alliance. From prohibition to progress: a status report on marijuana legalization [Internet]. United States: Drug Policy Alliance; 2018 Jan [cited 2019 Jul 29]. Available from: https://www.drugpolicy.org/sites/default/files/dpa_marijuana_legalization_report_v6_0.pdf

63. Slovic P. Perceptions of risk: reflections on the psychometric paradigm. In: Golding D, Krimsky S, editors. Social theories of risk. New York: Praeger; c1992. p. 1-54.

64. Sutton S. Determinants of health-related behaviours: theoretical and methodological issues. In: Sutton S, Baum A, Johnston M, editors. The SAGE handbook of health psychology. London: SAGE Publications; c2004. p. 94-126.

65. Weinstein ND. Unrealistic optimism about future life events. J Pers Soc Psychol. 1980;39(5):806-820.

66. Ferrer RA, Klein WM. Risk perceptions and health behavior. Curr Opin Psychol. 2015 Oct;5:85-89.

67. Shepperd JA, Carroll P, Grace J, Terry M. Exploring the causes of comparative optimism. Psychol Belg. 2002 Jan;42(1):65-98.

68. Sjöberg L, Moen BE, Rundmo T. Explaining risk perception. An evaluation of the psychometric paradigm in risk perception research [Internet]. Trondheim, NO: Rotunde; 2004 Sep [cited 2018 Apr 10]. Available from: http://www.svt.ntnu.no/psy/torbjorn.rundmo/psychometric_paradigm.pdf

69. Rosenstock IM. Historical origins of the health belief model. Health Educ Monogr. 1974 Dec;2(4):328-335.

70. Sheeran P, Harris PR, Epton T. Does heightening risk appraisals change people's intentions and behavior? A meta-analysis of experimental studies. Psychol Bull. 2014 Mar;140(2):511-543.

71. Millstein SG, Halpern-Felsher BL. Perceptions of risk and vulnerability. J Adolesc Health. 2002 Jul;31(1 Suppl):10-27.

72. Spear HJ, Kulbok P. Autonomy and adolescence: a concept analysis. Public Health Nurs. 2004 Mar-Apr;21(2):144-152.

73. Steinberg L. A social neuroscience perspective on adolescent risk-taking. Dev Rev. 2008 Mar;28(1):78-106.

74. Beyth-Marom R, Austin L, Fischhoff B, Palmgren C, Jacobs-Quadrel M. Perceived consequences of risky behaviors: adults and adolescents. Dev Psychol. 1993 May;29(3):549-563.

75. Blakemore SJ, Burnett S, Dahl RE. The role of puberty in the developing adolescent brain. Hum Brain Mapp. 2010 Jun;31(6):926-933.

76. Balogh KN, Mayes LC, Potenza MN. Risk-taking and decision-making in youth: relationships to addiction vulnerability. J Behav Addict. 2013 Mar;2(1).

77. Casey BJ, Getz S, Galvan A. The adolescent brain. Dev Rev. 2008 Aug;28(1):62-77.

78. Somerville LH, Jones RM, Casey BJ. A time of change: behavioral and neural correlates of adolescent sensitivity to appetitive and aversive environmental cues. Brain Cogn. 2010 Feb;72(1):124-133.

79. Thurman QC. Estimating social-psychological effects in decisions to drink and drive: a factorial survey approach. J Stud Alcohol. 1986 Nov;47(6):447-454.

80. Turrisi RJ, Jaccard J. Judgment processes relevant to drunk driving. J Appl Soc Psychol. 1991 Jan;21(2):89-118.

81. Bertelli AM, Richardson LE. The behavioral impact of drinking and driving laws. Pol Stud J. 2008 Nov;36(4):545-569.

82. Sloan FA, McCutchan SA, Eldred LM. Alcohol-impaired driving and perceived risks of legal consequences. Alcohol Clin Exp Res. 2017 Feb;41(2):432-442.

83. Alonso F, Pastor JC, Montoro L, Esteban C. Driving under the influence of alcohol: frequency, reasons, perceived risk and punishment. Subst Abuse Treat Prev Policy. 2015 Mar;10:11.

84. Harbeck EL, Glendon AI. How reinforcement sensitivity and perceived risk influence young drivers' reported engagement in risky driving behaviors. Accid Anal Prev. 2013 May;54:73-80.

85. Jonah B. CCMTA public opinion survey of drugs and driving in Canada: summary report [Internet]. Ottawa, ON: Canadian Council of Motor Transport Administrators; 2013 Oct 3 [cited 2019 Aug 1]. Available from: https://ccmta.ca/images/publications/pdf//CCMTA_Public_Opinion_Survey_of_Drugs_and_Driving_in_Canada_revised_2014_04_14_FINAL_ENGLISH.pdf

86. Beirness DJ, Beasley EE. A roadside survey of alcohol and drug use among drivers in British Columbia. Traffic Inj Prev. 2010 Jun;11(3):215-221.

87. Beasley EE, Beirness DJ. Alcohol and drug use among drivers following the introduction of immediate roadside prohibitions in British Columbia: findings from the 2012 Roadside Survey [Internet]. Ottawa, ON: Beirness & Associates, Inc; 2012 Oct [cited 2019 Aug 1]. Available from: https://ccmta.ca/images/publications/pdf//bc-roadside-report2012.pdf

88. Burkhalter R, Thompson-Haile A, Rynard V, Manske S. 2016/2017 Canadian Student, Tobacco, Alcohol and Drugs Survey microdata user guide. Waterloo, ON: Propel Centre for Population Health Impact; 2017 Dec. p. 1-51.

89. Roberts C, Freeman J, Samdal O, Schnohr CW, de Looze ME, Nic Gabhainn S, et al. The Health Behaviour in School-aged Children (HBSC) study: methodological developments and current tensions. Int J Public Health. 2009 Sep;54 Suppl 2:140-150.

90. Ziegler M, Hagemann D. Testing the unidimensionality of items: pitfalls and loopholes. Eur J Psychol Assess. 2015 Oct;31(4):231-237.

91. American Drug and Alcohol Survey. Perceived harm from drug use [Internet]. United States: Rocky Mountain Behavioral Science Institute; 2005 [cited 2018 Apr 9]. Available from: https://cyfar.org/sites/default/files/PsychometricsFiles/RMBSI-Perceived%20Harm%20from%20Drug%20Use%20%28Grades%206-12%29_0.pdf

92. Lipari RN, Ahrnsbrak RD, Pemberton MR, Porter JD. Risk and protective factors and estimates of substance use initiation: results from the 2016 National Survey on Drug Use and Health [Internet]. Rockville, MD: Substance Abuse and Mental Health Services Administration; 2017 Sep [cited 2018 Apr 14]. Available from: https://www.samhsa.gov/data/sites/default/files/NSDUH-DR-FFR3-2016/NSDUH-DR-FFR3-2016.htm

93. Johnston LD, O'Malley PM, Miech RA, Bachman JG, Schulenberg JE. Monitoring the Future national survey results on drug use, 1975-2016: overview, key findings on adolescent drug use [Internet]. Ann Arbor, MI: Institute for Social Research; 2017 Jan [cited 2018 Apr 14]. Available from: http://www.monitoringthefuture.org/pubs/monographs/mtf-overview2016.pdf

94. Tabachnick BG, Fidell LS. Using multivariate statistics. 6th ed. New Jersey: Pearson Education; 2013.

95. Gordis L. Epidemiology. 5th ed. Philadelphia: Elsevier Saunders; c2014. From association to causation: deriving inferences from epidemiologic studies; p. 250-253.

96. Knight JR, Csemy L, Sherritt L, Starostova O, Van Hook S, Bacic J, et al. Screening and brief advice to reduce adolescents' risk of riding with substance-using drivers. J Stud Alcohol Drugs. 2018 Jul;79(4):611-616.

Appendix A: Boxplots and Histograms of Autonomy Score

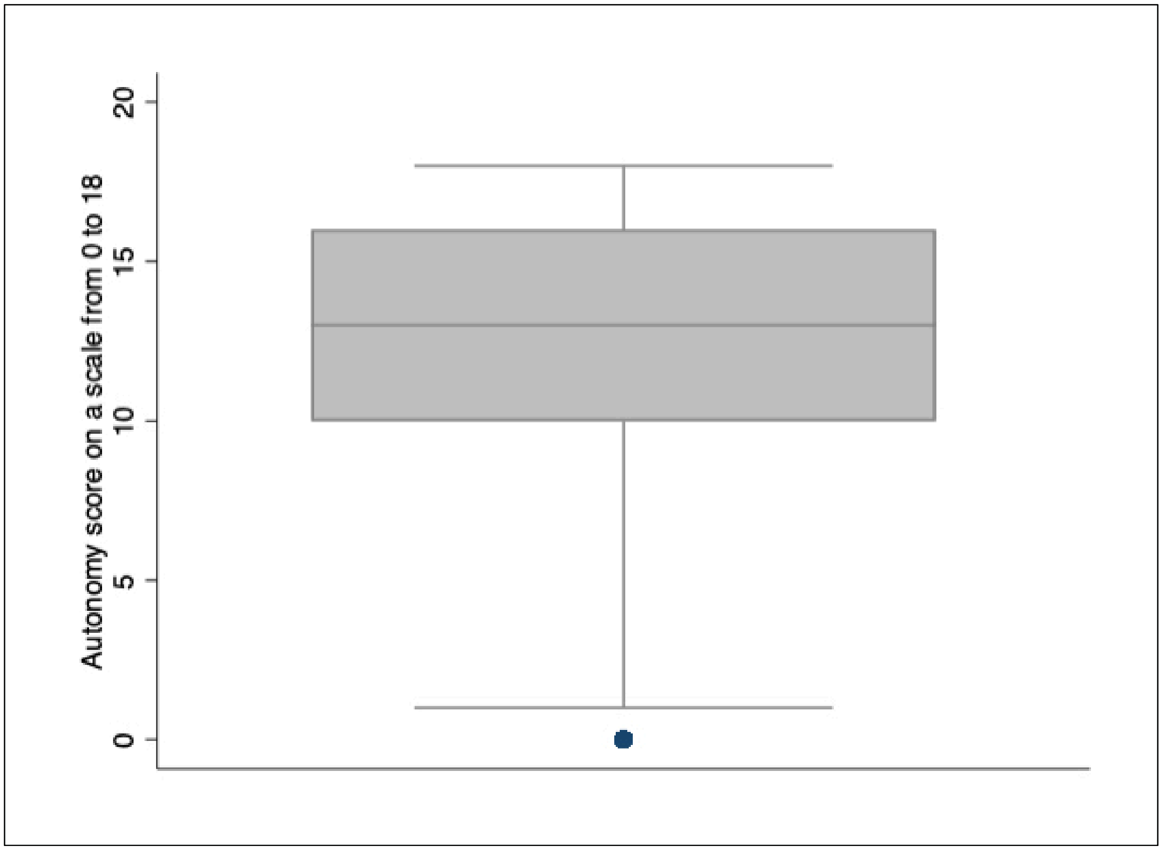

Figure A1. Boxplot of autonomy score (original identity) depicting a potential outlier and a negatively skewed distribution; based on an estimation sample of 33 915 high school students.

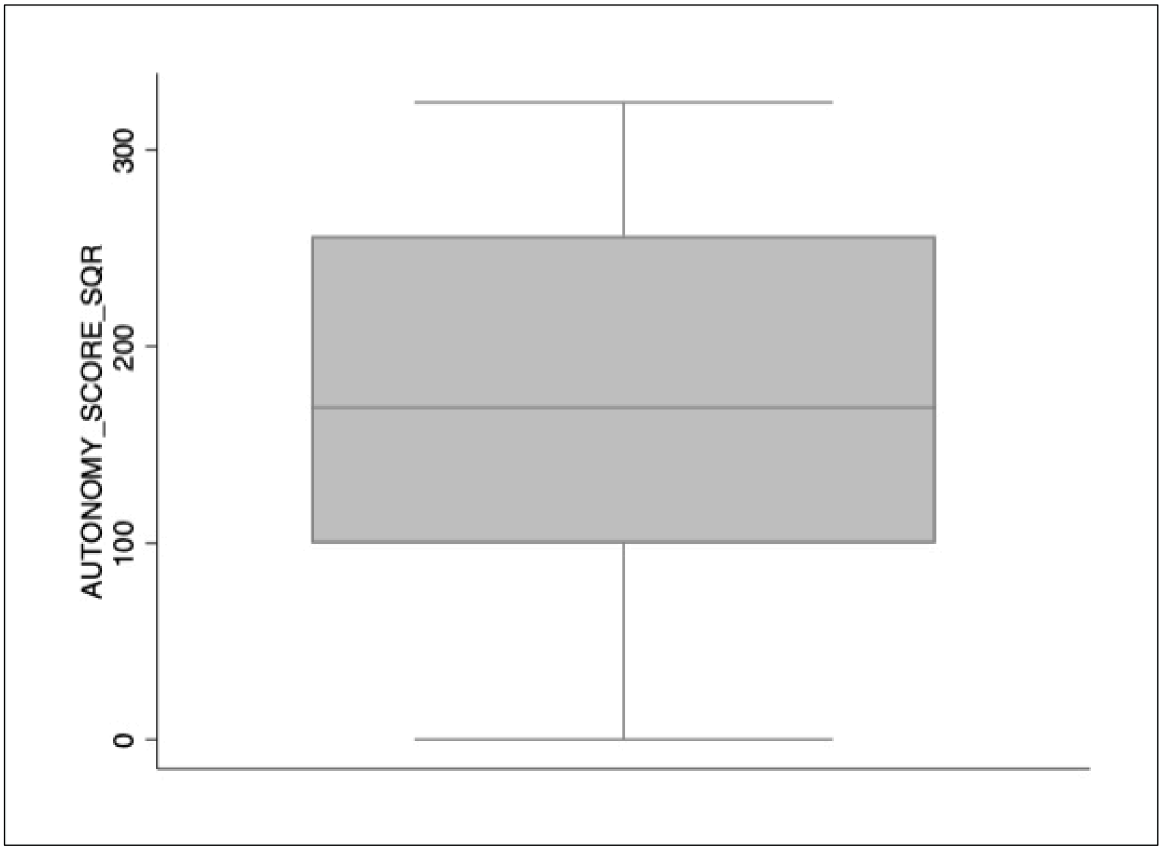

Figure A2. Boxplot of the square transformation of autonomy score depicting a relatively normal distribution without any outliers; based on an estimation sample of 33 915 high school students.

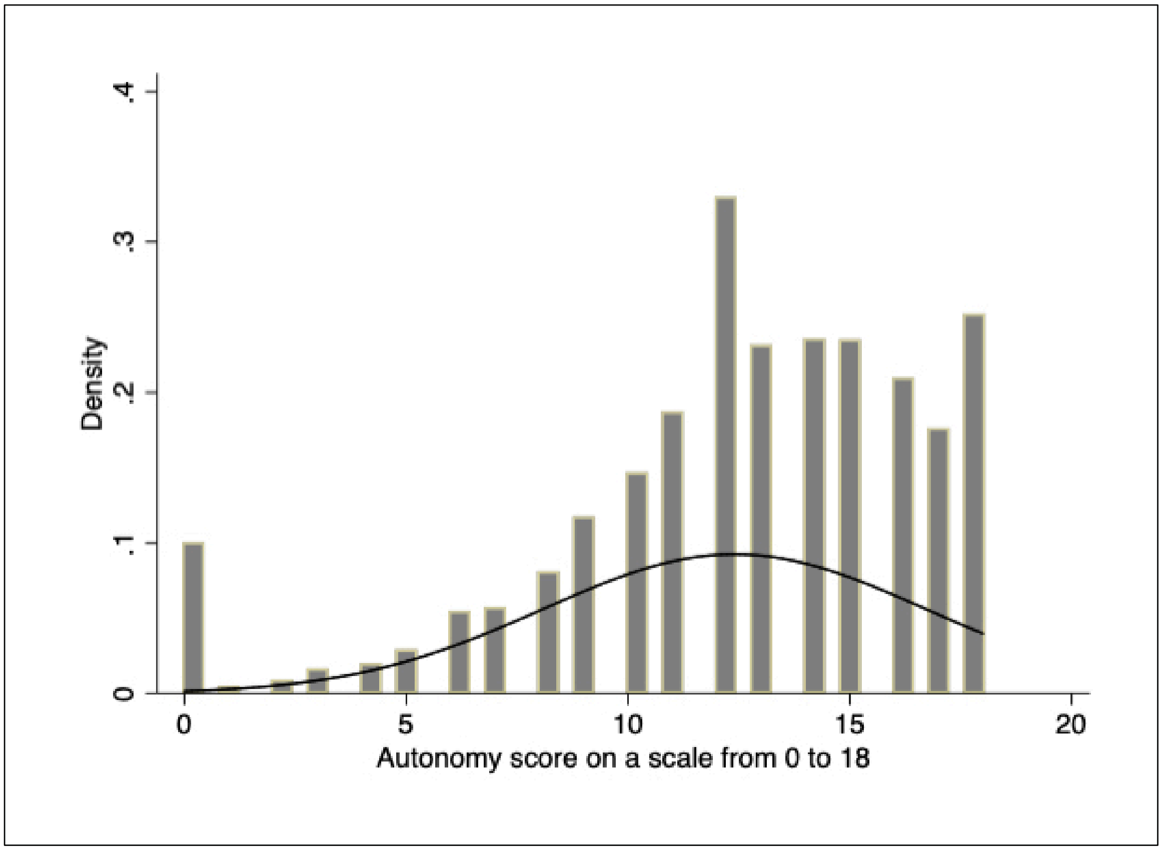

Figure A3. Histogram of autonomy score (original identity) depicting a negatively skewed distribution (skewness = -1.04, kurtosis = 4.02); based on an estimation sample of 33 915 high school students.

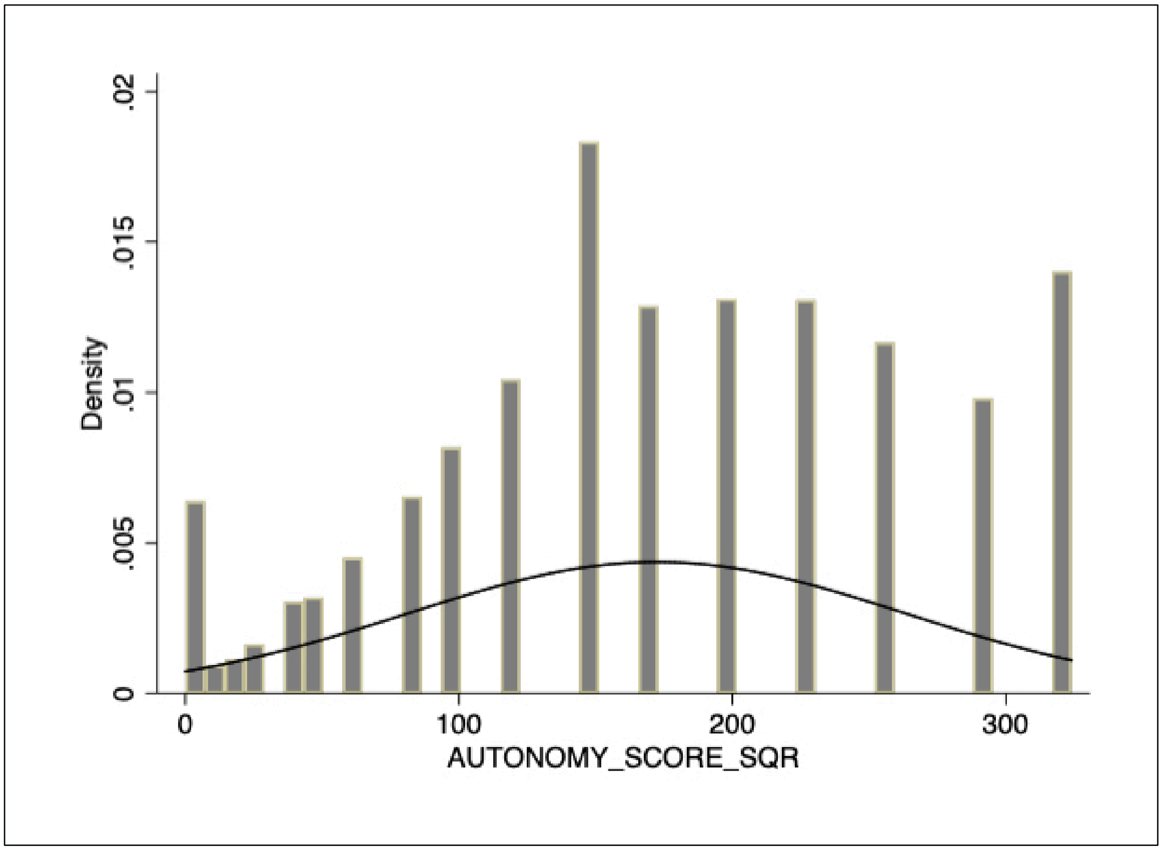

Figure A4. Histogram of the square transformation of autonomy score depicting a fairly normal distribution (skewness = -0.02, kurtosis = 2.16); based on an estimation sample of 33 915 high school students.

Appendix B: Sensitivity Analysis for DUIC Model

Table B1. Multinomial logistic regression of driving under the influence of cannabis (DUIC) by perceived risk of regular cannabis use among Canadian grade 11 and 12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey and used cannabis at least once in the past year (n = 3068)

	Adjusted RRR[a] (95% CI)	
	Last 30-day DUIC vs. Never	More than 30-day ago DUIC vs. Never
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.77 (0.52, 1.13)	0.73 (0.49, 1.08)
Moderate risk	0.48 (0.30, 0.76)**	0.62 (0.42, 0.92)*
Great risk	0.35 (0.22, 0.56)***	0.60 (0.39, 0.93)*
Don't know/Not stated	N/A	N/A

Notes: DUIC = driving under the influence of cannabis; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable.

[a] Adjusted for perceived risk of regular cannabis use, sex, school grade, rural setting, province, and square of autonomy score.

* $p < 0.05$.

** $p < 0.01$.

*** $p \leq 0.001$.

Appendix C: Profile (Interaction) Plots

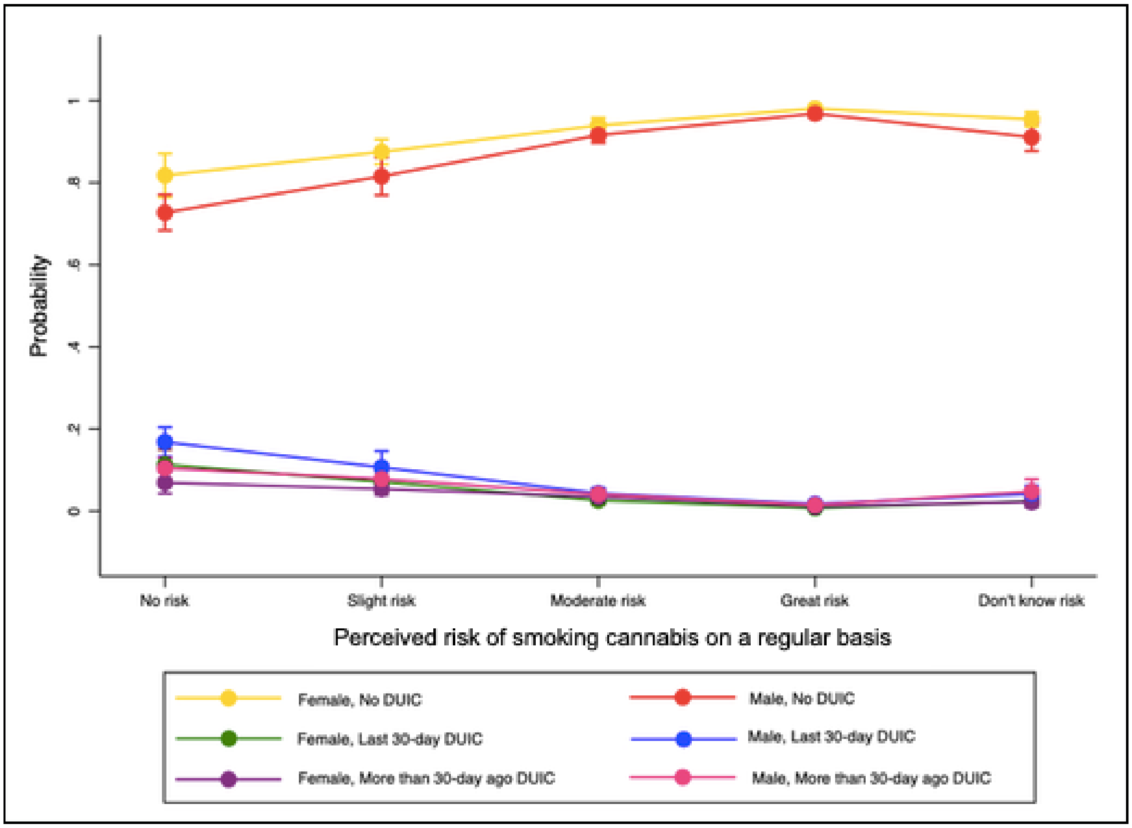

Figure C1. Profile plot graphically depicting no interaction between sex and perceived risk of smoking cannabis on a regular basis for DUIC (predictive margins of the interaction between sex and perceived risk of smoking cannabis on a regular basis and 95% confidence intervals).

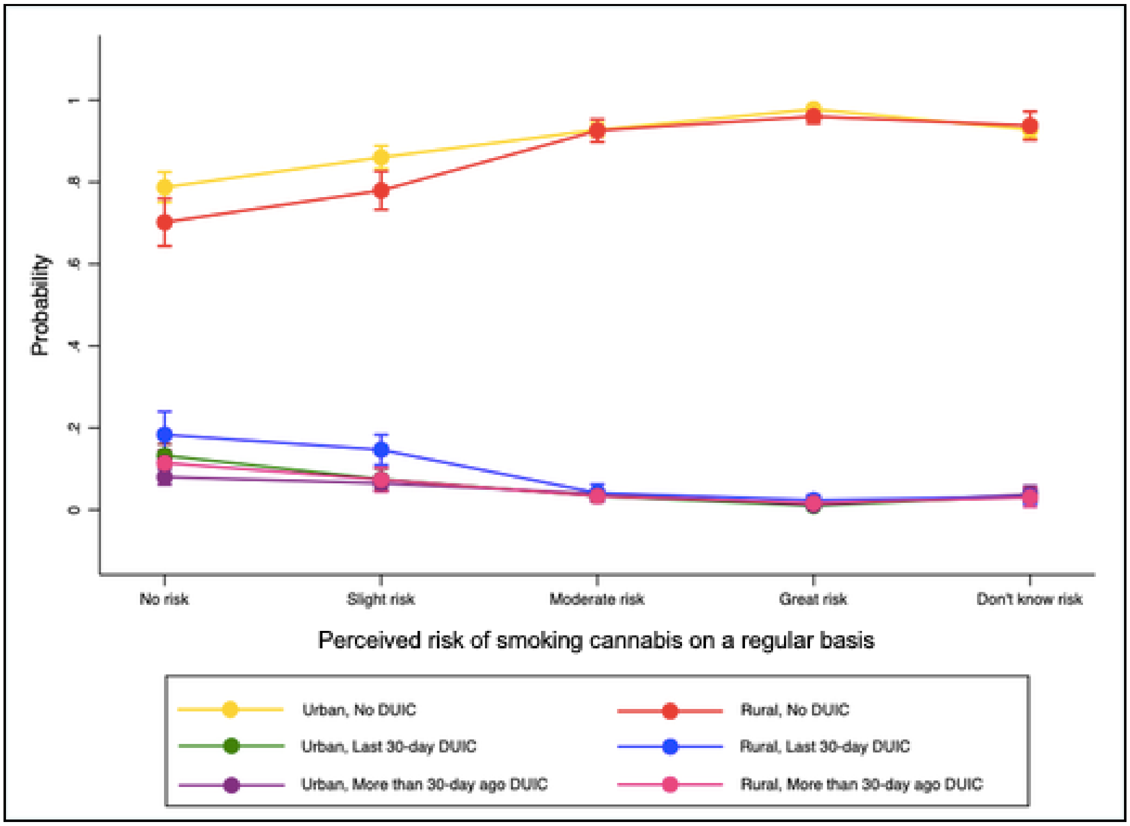

Figure C2. Profile plot graphically depicting no interaction between rural setting and perceived risk of smoking cannabis on a regular basis for DUIC (predictive margins of the interaction between rural setting and perceived risk of smoking cannabis on a regular basis and 95% confidence intervals).

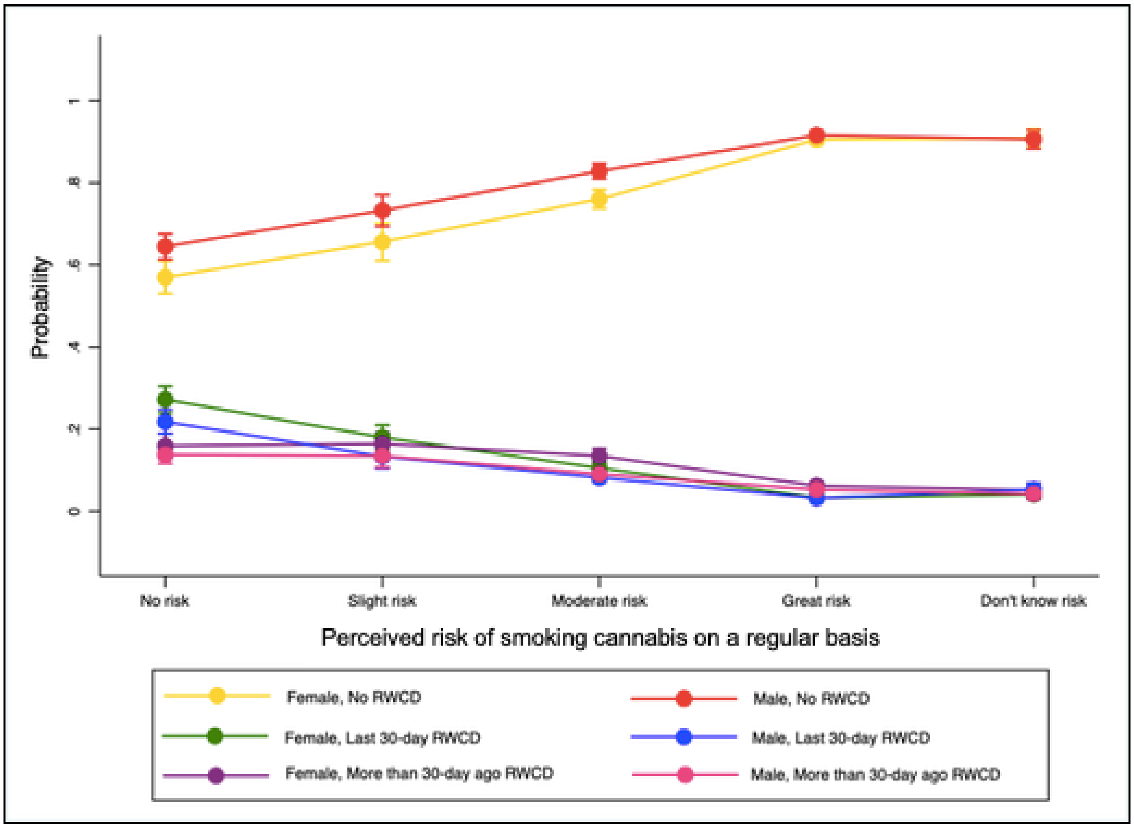

Figure C3. Profile plot graphically depicting no interaction between sex and perceived risk of smoking cannabis on a regular basis for RWCD (predictive margins of the interaction between sex and perceived risk of smoking cannabis on a regular basis and 95% confidence intervals).

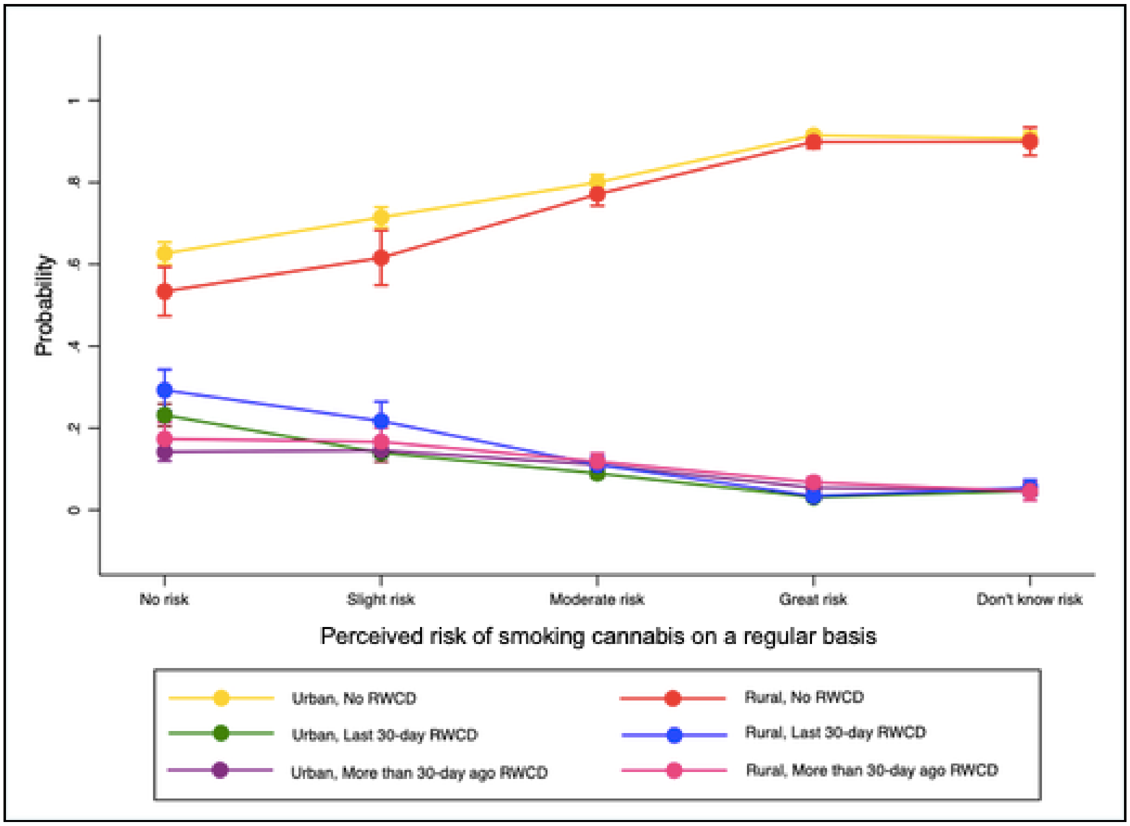

Figure C4. Profile plot graphically depicting no interaction between rural setting and perceived risk of smoking cannabis on a regular basis for RWCD (predictive margins of the interaction between rural setting and perceived risk of smoking cannabis on a regular basis and 95% confidence intervals).

Appendix D: Stratified Analyses by Sex and Rurality for the Association Between Perceived Risk of Regular Cannabis use and DUIC

Table D1. Association between perceived risk of regular cannabis use and driving under the influence of cannabis (DUIC) among Canadian grade 11 and 12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey, stratified by sex (n = 14 147)

	Last 30-day DUIC vs. Never	More than 30-day ago DUIC vs. Never
	Adjusted RRR[a] (99% CI)	Adjusted RRR[a] (99% CI)
Females (*n* = 7126)		
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.58 (0.31, 1.09)*	0.74 (0.35, 1.57)
Moderate risk	0.20 (0.10, 0.42)***	0.46 (0.21, 0.98)**
Great risk	0.06 (0.02, 0.16)***	0.15 (0.07, 0.34)***
Don't know/Not stated	N/A	N/A
Males (*n* = 7021)		
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.55 (0.29, 1.06)*	0.63 (0.33, 1.23)
Moderate risk	0.19 (0.11, 0.33)***	0.29 (0.17, 0.49)***
Great risk	0.07 (0.04, 0.13)***	0.09 (0.05, 0.18)***
Don't know/Not stated	N/A	N/A

Notes: DUIC = driving under the influence of cannabis; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable.
[a] Adjusted for school grade, rural setting, province, and square of autonomy score.
* $p < 0.05$.
** $p < 0.01$.
*** $p \leq 0.001$.

Table D2. Association between perceived risk of regular cannabis use and driving under the influence of cannabis (DUIC) among Canadian grade 11 and 12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey, stratified by degree of rurality (*n* = 14 147)

	Last 30-day DUIC vs. Never	More than 30-day ago DUIC vs. Never
	Adjusted RRR[a] (99% CI)	Adjusted RRR[a] (99% CI)
Urban (*n* = 10 516)		
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.51 (0.29, 0.92)**	0.72 (0.46, 1.12)
Moderate risk	0.21 (0.14, 0.32)***	0.40 (0.27, 0.59)***
Great risk	0.06 (0.03, 0.12)***	0.12 (0.07, 0.20)***
Don't know/Not stated	N/A	N/A
Rural (*n* = 3631)		
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.63 (0.32, 1.26)	0.57 (0.28, 1.16)*
Moderate risk	0.14 (0.05, 0.43)***	0.21 (0.11, 0.39)***
Great risk	0.08 (0.03, 0.22)***	0.10 (0.05, 0.19)***
Don't know/Not stated	N/A	N/A

Notes: DUIC = driving under the influence of cannabis; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable.
[a] Adjusted for sex, school grade, province, and square of autonomy score.
* $p < 0.05$.
** $p < 0.01$.
*** $p \leq 0.001$.

Appendix E: Stratified Analyses by Sex and Rurality for the Association Between Perceived Risk of Regular Cannabis use and RWCD

Table E1. Association between perceived risk of regular cannabis use and riding with a cannabis-impaired driver (RWCD) among Canadian grade 9-12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey, stratified by sex (*n* = 33 116)

	Last 30-day RWCD vs. Never	More than 30-day ago RWCD vs. Never
	Adjusted RRR[a] (99% CI)	Adjusted RRR[a] (99% CI)
Females (*n* = 16 668)		
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.56 (0.38, 0.84)***	0.88 (0.60, 1.30)
Moderate risk	0.28 (0.20, 0.38)***	0.61 (0.42, 0.90)***
Great risk	0.07 (0.05, 0.09)***	0.23 (0.16, 0.33)***
Don't know/Not stated	N/A	N/A
Males (*n* = 16 448)		
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.50 (0.36, 0.72)***	0.82 (0.53, 1.28)
Moderate risk	0.27 (0.19, 0.36)***	0.47 (0.34, 0.65)***
Great risk	0.09 (0.06, 0.14)***	0.24 (0.18, 0.32)***
Don't know/Not stated	N/A	N/A

Notes: RWCD = riding with a cannabis-impaired driver; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable.

[a] Adjusted for school grade, rural setting, province, and square of autonomy score.

* $p < 0.05$.

** $p < 0.01$.

*** $p \leq 0.001$.

Table E2. Association between perceived risk of regular cannabis use and riding with a cannabis-impaired driver (RWCD) among Canadian grade 9-12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey, stratified by degree of rurality (*n* = 33 116)

	Last 30-day RWCD vs. Never	More than 30-day ago RWCD vs. Never
	Adjusted RRR[a] (99% CI)	Adjusted RRR[a] (99% CI)
Urban (*n* = 25 047)		
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.51 (0.39, 0.67)***	0.87 (0.65, 1.17)
Moderate risk	0.29 (0.22, 0.37)***	0.58 (0.44, 0.77)***
Great risk	0.08 (0.06, 0.11)***	0.24 (0.18, 0.32)***
Don't know/Not stated	N/A	N/A
Rural (*n* = 8069)		
Perceived risk of regular cannabis use		
No risk (referent)	1.00	1.00
Slight risk	0.61 (0.38, 0.98)**	0.79 (0.52, 1.19)
Moderate risk	0.25 (0.16, 0.39)***	0.43 (0.28, 0.67)***
Great risk	0.06 (0.04, 0.11)***	0.20 (0.13, 0.32)***
Don't know/Not stated	N/A	N/A

Notes: RWCD = riding with a cannabis-impaired driver; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable.

[a] Adjusted for sex, school grade, province, and square of autonomy score.

* $p < 0.05$.

** $p < 0.01$.

*** $p \leq 0.001$.

Appendix F: Additional Tables

Table F1. Multinomial logistic regression of riding with a cannabis-impaired driver (RWCD) by perceived risk of regular cannabis use, sex, school grade, rural setting, province, square of autonomy score, and past 30-day cannabis use among Canadian grade 9-12 students who participated in the 2016-2017 Canadian Student Tobacco, Alcohol and Drugs Survey (*n* = 33 116)

Variables	RWCD (*n* = 33 116)		Unadjusted RRR (95% CI)		Adjusted RRR[b] (95% CI)	
	n[a]	Weighted estimated %	Last 30-day RWCD vs. Never	More than 30-day ago RWCD vs. Never	Last 30-day RWCD vs. Never	More than 30-day ago RWCD vs. Never
Perceived risk of regular cannabis use						
No risk (referent)	4026	10.1	1.00	1.00	1.00	1.00
Slight risk	4623	13.0	0.54 (0.45, 0.66)***	0.86 (0.72, 1.03)	0.70 (0.55, 0.87)**	0.85 (0.68, 1.06)
Moderate risk	7442	22.9	0.28 (0.23, 0.33)***	0.55 (0.47, 0.65)***	0.63 (0.53, 0.74)***	0.75 (0.61, 0.93)**
Great risk	14 453	47.5	0.07 (0.06, 0.09)***	0.22 (0.18, 0.26)***	0.35 (0.28, 0.44)***	0.52 (0.40, 0.66)***
Don't know/Not stated	2572	6.5	N/A	N/A	N/A	N/A
Sex						
Female (referent)	16 668	49.1	1.00	1.00	1.00	1.00
Male	16 448	50.9	1.01 (0.87, 1.17)	0.87 (0.77, 0.98)*	0.66 (0.56, 0.77)***	0.74 (0.65, 0.84)***
School grade						
9 (referent)	10 400	25.3	1.00	1.00	1.00	1.00
10	8546	25.4	1.96 (1.62, 2.37)***	2.02 (1.70, 2.41)***	1.32 (1.10, 1.59)**	1.53 (1.28, 1.84)***
11	8062	25.2	2.92 (2.30, 3.71)***	2.48 (2.10, 2.93)***	1.63 (1.25, 2.14)***	1.57 (1.33, 1.86)***
12	6108	24.1	4.27 (3.28, 5.56)***	3.74 (3.10, 4.52)***	2.23 (1.66, 3.00)***	2.36 (1.94, 2.86)***
Rural setting						
No (referent)	25 047	83.0	1.00	1.00	1.00	1.00
Yes	8069	17.0	1.69 (1.34, 2.13)***	1.53 (1.17, 2.00)**	1.35 (1.14, 1.61)***	1.19 (1.00, 1.42)
Province						
Ontario (referent)	7638	47.0	1.00	1.00	1.00	1.00
Québec	1923	15.8	1.05 (0.81, 1.35)	1.47 (1.16, 1.86)***	1.54 (1.17, 2.03)**	1.86 (1.49, 2.32)***
British Columbia	4168	13.3	1.42 (1.00, 2.02)	1.36 (0.95, 1.94)	1.24 (0.94, 1.64)	1.25 (0.96, 1.63)
Alberta	6315	11.9	1.34 (1.02, 1.77)*	1.84 (1.36, 2.50)***	1.32 (1.10, 1.59)**	1.83 (1.44, 2.32)***
Saskatchewan	1866	3.4	1.93 (1.22, 3.05)**	2.52 (1.85, 3.42)***	1.45 (1.03, 2.05)*	2.18 (1.55, 3.06)***
Manitoba	2192	4.2	1.61 (1.20, 2.17)**	1.62 (1.26, 2.08)***	1.38 (1.09, 1.75)**	1.54 (1.29, 1.83)***
Nova Scotia	2570	2.6	3.37 (2.60, 4.36)***	3.13 (2.53, 3.88)***	2.50 (2.05, 3.06)***	2.42 (2.03, 2.88)***
Prince Edward Island	2725	0.4	1.76 (1.32, 2.33)***	1.94 (1.57, 2.38)***	1.44 (1.16, 1.80)***	1.66 (1.36, 2.02)***
Newfoundland and Labrador	3719	1.4	2.13 (1.66, 2.73)***	2.00 (1.60, 2.52)***	1.69 (1.31, 2.16)***	1.65 (1.36, 2.00)***
Sqr. Autonomy score						
High (referent)	5752	18.1	1.00	1.00	1.00	1.00
Moderate	9157	29.4	1.10 (0.85, 1.43)	1.37 (1.14, 1.65)***	1.01 (0.75, 1.36)	1.34 (1.10, 1.64)**
Low	10 044	30.8	1.49 (1.18, 1.90)***	1.50 (1.23, 1.83)***	1.20 (0.92, 1.56)	1.35 (1.10, 1.65)**
Very low	8163	21.7	1.83 (1.49, 2.26)***	1.78 (1.47, 2.17)***	1.17 (0.93, 1.48)	1.51 (1.19, 1.92)***
Past 30-day cannabis use						
Never used (referent)	23 735	73.0	1.00	1.00	1.00	1.00
Used but not in the last 30 days	4201	12.1	7.37 (6.00, 9.06)***	11.32 (9.75, 13.15)***	5.20 (4.16, 6.49)***	8.43 (7.25, 9.81)***
Used once or twice in the last 30 days	3286	9.8	29.16 (22.17, 38.35)***	12.48 (10.52, 14.80)***	19.66 (14.69, 26.30)***	9.12 (7.54, 11.02)***
Used three or more times in the last 30 days	1894	5.1	107.51 (85.76, 134.78)***	17.84 (14.42, 22.09)***	64.98 (52.38, 80.62)***	12.11 (9.22, 15.92)***
F statistic					$F(46, 454) = 187.53^{***}$	

Notes: RWCD = riding with a cannabis-impaired driver; RRR = relative risk ratio; CI = confidence interval; N/A = not applicable; Sqr. = square transformation.
[a] The weighted prevalence estimates are based on 33 116 cases.
[b] Adjusted for perceived risk of regular cannabis use, sex, school grade, rural setting, province, square of autonomy score, and past 30-day cannabis use.
* $p < 0.05$.
** $p < 0.01$.
*** $p \leq 0.001$.