

**THE IMPACT OF NON-MEDICAL CANNABIS
LEGALIZATION ON RISK PERCEPTIONS AND DRIVING
PERCEPTIONS IN ATLANTIC CANADA**

by

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ABSTRACT

Objective: This research examined the impact of non-medical cannabis legalization on health risk perceptions and driving perceptions in Atlantic Canada compared to non-Atlantic Canada.

Methods: Secondary cross-sectional analysis was conducted on the International Cannabis Policy Study (ICPS) surveys (2018-2021) on 58,045 participants aged 16- 65 residing in Canada. We employed ordinal logistic regression to examine the impact of legalization on the health risk perception of different cannabis consumption modes (Study 1) and driving perceptions (Study 2) in Atlantic Canada compared to non-Atlantic Canada.

Results: Study 1 indicated a decreased perceived health risk associated with daily cannabis smoking, edibles, synthetic cannabis, and high potency, except for vaping. Perceived risk from daily vaping was higher in Atlantic Canadians than non-Atlantic Canadians following legalization. In Study 2, Atlantic Canadians had a weaker perception of police, decreased risk perception of accidents and increased perceived ease of identifying cannabis intoxication. However, post-legalization, Atlantic Canadians perceived higher risk of accident and greater perceived efforts to prevent an intoxicated friend from driving compared to non-Atlantic Canadians.

Conclusion: The effect of cannabis legalization was more pronounced in Atlantic Canada for several outcomes, suggesting that for those perceived risks, Atlantic Canadians had a stronger change in perception than non-Atlantic Canadians over time.

Keywords: Cannabis, Atlantic Canada, Legalization, Risk Perception, Driving Perception

General Summary

This research investigated how recreational cannabis legalization affected Atlantic Canadian's perception of health risks linked to the daily use of various cannabis forms and driving perceptions compared to non-Atlantic Canadians. We studied survey data from 2018-2021 ICPS surveys from 58,045 people between the ages of 16 and 65. Following legalization, perceptions of risk linked to smoking, edibles, synthetic cannabis, and high-potency cannabis decreased in Canada, while risk perception for vaping was higher. Atlantic Canadians held more negative perceptions of health risks linked to daily vaping of cannabis. As for risk perception related to driving under the influence of cannabis (DUIC), Following legalization, Atlantic Canadians had a higher perceived risk of accident and greater perception of trying to stop a friend from DUIC compared to non-Atlantic Canadians. Overall, the legalization's impact on risk perceptions and driving perceptions was greater for several risk perceptions in Atlantic Canada compared to other regions over time.

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Abbreviations/ Acronyms

AAPOR	American Association of Public Opinion Research
ACMPR	Access Cannabis for Medical Purposes
AOR	Adjusted Odds Ratio
BC	British Columbia
CAA	Canadian Automobile Association
CAD	Canadian Dollar
CB1	Cannabinoid Receptor Type 1
CBC	Canadian Broadcasting Corporation
CBD	Cannabidiol
CCS	Canadian Cannabis Survey
CDC	Centers for Disease Control and Prevention
CHERP	Cannabis Health Evaluation and Research Partnership
CI	Confidence Interval
CNN	Cable News Network
COVID-19	Coronavirus Disease 2019
CTADS	Canadian Tobacco, Alcohol and Drug Survey
CUD	Cannabis Use Disorder
DUIA	Driving Under the Influence of Alcohol
DUIC	Driving Under the Influence of Cannabis
ECS	Endocannabinoid System
ESPAD	European School Survey Project on Alcohol and Drugs

EVALI	E-cigarette or Vaping-Associated Lung Injuries
FDA	Food and Drug Administration
ICPS	International Cannabis Policy Study
IMB	International Business Machine Corporation
LRCUG	Lower-Risk Cannabis Use Guidelines
NB	New Brunswick
NCS	National Cannabis Survey
NL	Newfoundland and Labrador
NS	Nova Scotia
NSDUH	National Survey on Drug Use and Health
OCS	Ontario Cannabis Store
PEI	Prince Edward Island
REF	Reference
RWCD	Riding with a Cannabis-Impaired Driver
SAMHSA	Substance Abuse & Mental Health Service Administration
SE	Standard Error
SPSS	Statistical Package for the Social Sciences
THC	Delta-9-Tetrahydrocannabinol
US	United States
WHO	World Health Organization

Chapter 1:

1.0 Introduction

Cannabis is the most commonly consumed drug worldwide and is notably more prevalent than other drugs like cocaine and opiates (World Health Organization, 2016). According to the 2022 World Drug Report, approximately 209 million people between the ages of 15 to 65, or roughly 4% of the global population, reportedly consumed cannabis within the past year.

Cannabis consumption varied by region, with North America, Oceania, and West Africa having some of the highest rates of use (United Nations, 2022). For instance, of the American adult population in 2019, around 48.2 million people, or 18%, reportedly used cannabis at least once in the last year, making it the most consumed federally illegal drug in the United States (US) (Substance Abuse and Mental Health Services Administration, 2020). Although cannabis consumption is increasing globally, only a handful of countries, such as Uruguay, Canada, and Malta, have completely legalized the substance for non-medical purposes through legislative means (Government of Canada, 2018c; Government of Malta, 2021; Government of Uruguay, 2013).

Following the legalization of non-medical cannabis in 2018, there has been a modest increase in cannabis consumption in Canada. Survey data from the Canadian Cannabis Survey (CCS) found that 27% of Canadians reported using cannabis in the past 12 months in 2022, compared to 22% in 2018 (Health Canada, 2022). Although the country has experienced a significant rise over the past several years, the consumption of cannabis use varied across the regions in Canada, with higher rates reported in the Atlantic Canadian provinces. For instance, in 2021, 31% of individuals from Newfoundland and Labrador (NL) and Nova Scotia (NS), and 27% of individuals from New Brunswick (NB) and Prince Edward Island (PEI) reported using cannabis

in the past 12 months, compared to 25% of the rest of the country (Health Canada, 2022). Even more concerning is the considerable proportion of past 12-month users who use cannabis daily or almost daily. On average, 32% of Atlantic Canadians who reported using cannabis in the past year reported using cannabis daily or almost daily in 2021 (Health Canada, 2022). This is in contrast with 26% of the broader Canadian population (of past 12-month consumers) who reported using cannabis daily or almost daily in 2021 (Health Canada, 2022). Despite the growing prevalence of cannabis consumption in Atlantic Canada, there still remains a significant lack of research on cannabis patterns, prevalence, and potential health risks associated with cannabis use in this region. The current paucity of regional research creates a knowledge gap in the literature, highlighting the need for more regional-focused research to address the potential disparities.

In recent years, the Cannabis Health Evaluation and Research Partnership (CHERP) research group, based in Atlantic Canada, has published several studies on various aspects of cannabis use, such as education, risk perception and driving perception in NL (Bishop et al., 2022; Donnan et al., 2022, 2023; Grandy et al., 2022; Harris-Lane et al., 2023; Josey et al., 2022; Najafizada et al., 2022). Recent research by CHERP has suggested that perceived risks of cannabis use and driving perceptions among youths and young adults from NL may raise concerns about potential safety issues and impaired driving behaviours (Donnan et al., 2022). However, it remains to be seen if those concerns are consistent across the Atlantic Canadian region. Cannabis legalization was intended to provide safe access to cannabis, reduce risks associated with its use, and minimize any adverse public health and safety impacts on Canadian society, with the overarching objective of preventing harm, promoting health at the population level, and targeting interventions (i.e. harm reduction educational strategies) for individuals at

high-risk (Health Canada, 2016b). Despite cannabis being legalized in Canada for the past 5 years, a substantial proportion of cannabis consumers still access the illicit market (illicit market makes up 33% of the total market share), posing safety concerns and continuously undermining the public health objectives (Statistics Canada, 2022a; Toronto Sun, 2023).

Gauging the population's perceived risk of cannabis use can be a crucial indicator in evaluating the success of the government's public health and safety objectives. Therefore, examining the impact that cannabis legalization may have on risk perception and driving perception in Atlantic Canada is significant not only on a regional level but also crucial to the federal government for achieving its public health goals. To achieve this goal, policymakers and public health officials must have a greater understanding of the potential policy implications of various perceived risks. This will enable officials to develop targeted interventions to address unique needs in the Atlantic Canadian region.

1.1 Background

1.1.1 Cannabis Properties

Cannabis, also colloquially referred to as weed or marijuana, is often known for its psychoactive effect (i.e. the high), but it also has therapeutic and industrial applications (Crini et al., 2020; Di Marzo et al., 2004; National Academies of Sciences, Engineering, and Medicine, Division, et al., 2017; Thompson, 2013). Currently, there are three main types of cannabis plants, namely Sativa, Indica, and Ruderalis (Hillig & Mahlberg, 2004; Russo, 2007). Cannabis can be consumed in various ways, including inhalation (smoking and vaporizing), ingestion (edibles, drinks, oils and capsules), or topical application (creams). The cannabis plant contains various chemical compounds with roughly 100 known cannabinoids. However, due to the limited research conducted on the array of chemical compounds found in the plant (Cooper et al., 2021),

the pharmacology of cannabis remains complex and not entirely understood. Presently, research has primarily focused on two main types of cannabinoids: delta-9-tetrahydrocannabinol (THC) and cannabidiol (CBD). THC and CBD, which are chemically like endocannabinoids in the body, carry out their known pharmacodynamical effects on the human body by engaging with the endocannabinoid system (ECS) in the body. The ECS is responsible for many internal homeostatic functions, such as regulating appetite, sleep, mood, memory, pain, and psychomotor controls (Kaur et al., 2016).

Within the ECS, there exist cannabinoid receptors, cannabinoid receptor type 1 (CB1) and cannabinoid receptor type 2 (CB2), which help to elicit various responses based on the binding of cannabinoids like THC and CBD (Di Marzo et al., 2004; Karila et al., 2014). The CB1 receptor is located throughout the nervous system and is responsible for moderating pain regulation, memory tasks and the psychomotor control (Di Marzo et al., 2004). The CB2 receptor is primarily found in the immune system, peripheral nerve terminals, and hematopoietic cells and is responsible for immune and anti-inflammatory responses (D. Abrams & Guzman, 2015). THC primarily binds to and activates the CB1 receptors, which are located in the central nervous system. This produces the intoxicating effects of cannabis, such as euphoria, and can elicit hallucinations and cognitive impairments (Colizzi & Bhattacharyya, 2017). Conversely, CBD has a low affinity to CB1 and CB2 receptors but elicits a wide range of psychological actions within and outside the ECS. Unlike THC, CBD is non-psychotic and, therefore, does not induce the intoxicating effects associated with THC. Moreover, CBD is typically associated with potential therapeutic effects, including anxiolytic, antipsychotic and neuroprotective properties (Crippa et al., 2018; T. P. Freeman et al., 2020; Hurd et al., 2019; McGuire et al., 2018).

However, rigorous evidence on the therapeutic efficacy of CBD is lacking for many health conditions in the literature (Sholler et al., 2020).

CBD may incite antagonistic effects in the presence of THC. For instance, research has demonstrated that CBD can moderate and thus reduce some of the acute effects of THC when both are administered together (Bhattacharyya et al., 2010). Furthermore, the pharmacological effects of cannabis are influenced by several factors, including the frequency of use (regular or occasional), THC levels and the method of administration, which can vary between smoking, vaping and edible consumption (Grotenhermen, 2003). Although smoking remains the most commonly reported mode of cannabis consumption, there has been a noticeable shift towards non-combustible methods such as edible and vaping in Canada (Blake & Nahtigal, 2019; Government of Canada, 2022b; Hammond et al., 2022). The 2020 CCS data revealed that among individuals who used cannabis, 70% reported smoking cannabis, 52% reported using edibles, and 31% reported vaping cannabis (Government of Canada, 2022b). The pharmacology of cannabis, including its psychoactive properties and evidence-informed and anecdotal potential therapeutic applications, has contributed to the widespread prevalence of cannabis use for medical and non-medical purposes.

1.1.2 Prevalence of Cannabis Use

According to the Canadian Tobacco, Alcohol and Drug Survey (CTADS) 2016-2017, cannabis was a commonly used substance among Canadians, with 4.4 million people or 15% of the population who reported using the substance within the year before legalization (Health Canada, 2018a). It was expected that the prevalence of consumption might increase following the legalization of non-medical cannabis in Canada, as similar trends had been observed in other legalized jurisdictions. For example, Washington and Colorado reported increased cannabis

consumption, which coincided with non-medical cannabis legalization (Burgard et al., 2019; Colorado Division of Criminal Justice, 2021; Kilmer et al., 2022). Cannabis use is relatively common in the general Canadian population, with approximately 1 in 7 (14.8%) Canadians aged 15+ reported using cannabis in the past year, according to the 2017 Canadian Tobacco, Alcohol and Drug Survey (CTADS) (Statistics Canada, 2018). Since legalization in October 2018, a significant rise in cannabis use has been observed in Canada over the past several years.

According to the CCS data, the proportion of individuals who reported using cannabis in the past 12 months was 27% in 2022, as opposed to 22% in 2018, demonstrating a 5% increase since the legalization of non-medical cannabis (Health Canada, 2022). However, one should exercise caution when taking cannabis prevalence (pre and post-legalization) from surveys at face value due to the inherent challenges in accurately measuring prevalence due to the limitations of surveys (Hammond et al., 2020).

Regionally, cannabis consumption varied across Canada before and after cannabis legalization. CCS data have highlighted significant variation post-legalization in the prevalence of cannabis use across Canada, with usage rates ranging from 18% in Quebec to 41% in the Canadian territories (Health Canada, 2022). Compared to the national cannabis use average of 25%, the Atlantic Canadian provinces have demonstrably higher past 12-month cannabis use, which ranged from 27% to 31% amongst the provinces, according to 2021 CCS data. Furthermore, in 2021, an average of 32% of Atlantic Canadian cannabis users reported daily or almost daily usage within the past year, compared to 26% of Canadians (Health Canada, 2022), indicating a noteworthy pattern. Despite the higher cannabis use pattern in Atlantic Canada, there remains a knowledge gap in cannabis research (such as cultural factors, public awareness and education) within the region. The underlying factors for the regional differences in cannabis

consumption remain unknown. Although survey data may be prone to many biases, such as social desirability bias, self-reported surveys remain the only feasible method for estimating cannabis use prevalence in the general population (Hammond et al., 2020). Additionally, all the national benchmark surveys in Canada still utilized this method to capture and measure cannabis-related data (Government of Canada, 2022b; Hammond et al., 2020; Health Canada, 2019, 2020b; Statistics Canada, 2018, 2019a).

Wickens et al., (2019) suggested that the legalization of cannabis in Canada may have led to an increase in the social acceptance of the substance, resulting in many individuals considering it innocuous or without risk. This change in public perception may have been a contributory factor in the cannabis use increase observed following non-medical cannabis legalization in Canada. Researchers found that individuals who perceived cannabis as low-risk and accessible were more likely to report using it frequently in the past year than those who perceived it as high-risk and unavailable (Levy et al., 2021). The legalization of cannabis has raised concerns about the potential public health and safety implications associated with its use (Chiu et al., 2021; Donnelly et al., 2022), prompting the Canadian government to implement cannabis policies centred around health risk mitigation, public awareness strategy and safe cannabis consumption (such as the ‘Don’t Drive High’ campaigns) (Government of Canada, 2019; Health Canada, 2020a).

1.1.3 Canadian Cannabis Legalization

On October 17, 2018, Canada was the first G20 country to legalize and regulate cannabis for non-medical adult consumption (Government of Canada, 2018c). Prior to this, medical cannabis had been legalized in the country since 2001 and regulated solely by the federal government under the *Access Cannabis for Medical Purposes (ACMPR)* (Government of

Canada, 2001). Following the legalization of non-medical cannabis, the ACMPR was then replaced by *The Cannabis Act* in October 2018. In Canada, *The Cannabis Act* created a strict legal and regulatory framework for controlling the country's production, distribution, sale, and possession of cannabis (Government of Canada, 2018b). Based on the recommendations from the Cannabis Task Force, the Canadian government decided to legalize non-medical cannabis using a public health approach to protect young people, promote public health and safety, and eliminate the illicit market. (Health Canada, 2016b). Under the current legislation, jurisdictional responsibilities are divided among federal, provincial/ territorial, and municipal governments. The federal government is primarily responsible for possession limits, age limits (federal minimum), production, cultivation, medical cannabis, advertisement and packaging. The retail model, retail location rules, distribution, and workplace safety policies are primarily under the jurisdiction of provincial and territorial governments. Moreover, municipal governments have shared responsibilities under education, taxation, zoning, and public consumption policies. Under *The Cannabis Act*, the federal government has deferred the responsibility of enacting restrictions and regulations for sale and distribution to the provinces and territories (Government of Canada, 2018c). Therefore, provincial and territorial cannabis policies are tailored to their respective jurisdiction.

The cannabis retail models vary across Canada. However, within the Atlantic Canadian region, NL is the only province to deviate from the public retail model approach that is observed in the other three Atlantic Canadian provinces (NB, NS, and PEI) (Statistics Canada, 2019b). NL implemented a hybrid retail model consisting of public and private retail models, with four different tiers of stores under the private umbrella and an online government-operated store under the public (Government of Newfoundland and Labrador, 2018). Despite the varying policy

differences, all provinces and territories in Canada are in alignment with the federal objective of protecting the public health and safety of Canadians. Considering that public health is a shared responsibility of the federal and provincial/ territorial governments under *The Cannabis Act*, both have promoted evidence-based guidelines for low-risk cannabis use called the Lower-Risk Cannabis Use Guidelines (LRCUG) (Health Canada, 2020a). The LRCUG aims to enable individuals to reduce health risks associated with cannabis use by providing evidence-based recommendations (Fischer et al., 2017, 2022). From a harm reduction policy perspective, cannabis consumers need to recognize and be aware of the health risks associated with its use and make informed decisions regarding their personal cannabis choice. To facilitate cannabis consumers' choices, the evidence-based LRCUG serves as a population-level education and intervention tool to achieve this (Fischer et al., 2022). In addition, the Government of Canada committed over \$100 million CAD over six years (2018 to 2024) to public education, awareness, and surveillance efforts related to cannabis use to mitigate the impact on public health and road safety (Health Canada, 2018b). Overall, cannabis legalization, along with the LRCUG and other public health and safety strategies, has provided a means of striking a balance between providing safe access to cannabis and reducing the risks associated with its use, thereby safeguarding the health and safety of Canadian society.

1.1.4 Health Risks Associated with Cannabis Use

1.1.4.1 Acute Health Risks Associated with Cannabis Use

Despite the widespread use of the cannabis plant for its therapeutical applications (D. I. Abrams, 2018; Whiting et al., 2015), research has demonstrated that cannabis use can lead to several adverse mental and physical health outcomes, which can be magnified by demographic and psychosocial factors (National Academies of Sciences, Engineering, and Medicine, Health

and Medicine Division, et al., 2017). Depending on the dose, the method of consumption, and the individual's previous experience with cannabis use, cannabis may have short-term effects after a single use (World Health Organization, 2016). The literature has provided substantial evidence which has demonstrated that cannabis use can lead to many acute adverse health outcomes by causing side effects such as several cognitive and psychomotor impairments, confusion, anxiety, suicidal tendencies, as well as psychotic symptoms marked by delusions, hallucinations, and paranoid (Broyd et al., 2016; Crean et al., 2011; Ford et al., 2017; Government of Canada, 2018a; National Academies of Sciences, Engineering, and Medicine, Division, et al., 2017). In addition, acute effects of cannabis use include cannabis hyperemesis syndrome (a condition characterized by reoccurring nausea, vomiting, and abdominal pain), acute intoxication, nausea and vomiting, acute cardiovascular events, and various gastrointestinal symptoms (Ford et al., 2017; Karila et al., 2014; National Academies of Sciences, Engineering, and Medicine, Health and Medicine Division, et al., 2017). Systematic reviews indicated that tolerance to acute effects of THC, especially on memory, executive function, and psychomotor impairments, may develop in individuals who are frequent (daily or almost daily) or chronic (long-term) users of cannabis (Colizzi & Bhattacharyya, 2017; Curran et al., 2016; A. M. Freeman et al., 2021; Ramaekers et al., 2021). Although the acute effects of THC may dissipate once the substance is not present in the brain, it still poses significant health risks that may accumulate over time or with excessive/chronic use (Volkow et al., 2016).

1.1.4.2 Chronic Health Risks Associated with Cannabis Use

Over time, long-term regular consumption of cannabis can result in adverse effects that negatively impact functions related to memory, concentration, and intelligence and lead to an increase in developing chronic bronchitis and other lung infections, withdrawal syndrome and

pregnancy complications (Grzeskowiak et al., 2020; Hall et al., 2019; National Academies of Sciences, Engineering, and Medicine, Division, et al., 2017). As evidenced by several studies, cannabis exposure not only impacts pregnant individuals but may also put the fetus' health in jeopardy by increasing the risk of stillbirth, preterm birth, low birth weight and growth restriction, and long-term brain development issues related to memory, learning and behaviour (Conner et al., 2016; Gunn et al., 2016; Ryan et al., 2018; Substance Abuse and Mental Health Services Administration, 2019b). In addition, chronic cannabis use may contribute to an increased risk of mood disorders, cardiovascular diseases, and the escalation of psychosis in vulnerable individuals and cannabis use disorders (CUD) (Government of Canada, 2018a; Karila et al., 2014; Sidney, 2002; Subramaniam et al., 2019; Volkow et al., 2016). In 2012, CUD was identified as a significant contributor to the burden of disease associated with cannabis in Canada, resulting in 55,813 years lost to disability (Imtiaz et al., 2016). It has been estimated that 1 in 10 individuals who consume cannabis will develop cannabis use disorder, and the rates increase to 1 in 6 when early initiation occurs before 18 years old (Substance Abuse and Mental Health Services Administration, 2019a). Research has shown that individuals who start using cannabis at an early age commonly use it more intensely, resulting in poorer cognitive and executive functioning (Gruber et al., 2012).

The chronic effects of synthetic cannabinoids, an illegal product, have been highlighted as toxic to the health of many cannabis consumers (Food and Drug Administration (FDA), 2020).

Synthetic cannabinoids, which mimic the effects of endocannabinoids in the body, have been associated with a range of severe adverse health outcomes, including acute cognitive impairment, psychosis, seizures, myocardial infarction, tachycardia and fatalities (Harris & Brown, 2013; Seely et al., 2012; Van Amsterdam et al., 2015). Although there are similarities in chemical

structures, synthetic cannabinoids can induce more intense reactions compared to natural cannabis. However, the pharmacology and toxicology of synthetic cannabinoids remain limited, with very few human studies in the literature (European Monitoring Centre for Drugs and Drug Addiction., 2021). A newly published research has revealed that cannabis legalization is associated with a reduction in the use of synthetic cannabinoids, highlighting a potential benefit of legalization (Klein et al., 2022). Furthermore, the effect of cannabis on an individual's health can vary depending on several factors such as age, sex, genetic factors unique to each person, pre-existing medical conditions, frequency and duration of use, as well as the mode of consumption that is used. (Curran et al., 2016; Government of Canada, 2018a). For instance, cannabis effects through smoking and vaping are normally experienced by the users shortly after consumption ranging from seconds to minutes and duration of effect can last up to 6 hours or longer (Health Canada, 2018). Conversely, when cannabis is consumed orally, the onset of effects can take up to 30 minutes, and the duration of the effect can last up to 12 hours or longer (Health Canada, 2018).

1.1.4.3 Health Risks Associated with Modes of Consumption

The different methods of cannabis consumption and cannabis product types are associated with varying health risks (Russell et al., 2018; Steeger et al., 2021), and cannabis commercialization has highlighted the need for cannabis consumers to recognize these varying health risks to make informed decisions based on the evidence (Fischer et al., 2022). While smoking remains the most commonly reported method of consuming cannabis in Canada (Government of Canada, 2022b), research has established that cannabis smoking is associated with various acute adverse health outcomes on the respiratory system, such as coughing, wheezing, and dyspnea (Ghasemiesfe et al., 2018; Hall & Degenhardt, 2009; National

Academies of Sciences, Engineering, and Medicine, Health and Medicine Division, et al., 2017). Moreover, chronic cannabis smoking has been linked to acute bronchitis and other impaired respiratory functioning associated with its use (Gates et al., 2014; Martinasek et al., 2016).

Although vaping cannabis is considered a less risky alternative to smoking cannabis (Loflin & Earleywine, 2015), research has suggested it may be associated with other negative health outcomes when paired with the use of high-potency concentrates (Petrilli et al., 2022). The consumption of high-potency concentrates via vaping also correlates with a higher incidence of negative mental and physical health outcomes and may lead to an increased risk of developing acute adverse effects such as psychosis, paranoia, and cannabis hyperemesis syndrome (Chadi et al., 2020; Prince & Conner, 2019). Furthermore, research by Bhat et al., (2023) revealed that vaping CBD induces a potent inflammatory response and results in more pathological changes associated with lung injury compared to vaping nicotine. During the outbreak of e-cigarette or vaping-associated lung injuries (EVALI), early data indicated that youths who consume cannabis via vaping were at increased risk of developing EVALI (Chadi et al., 2020; Siegel et al., 2019). However, recent research by Boakye et al., (2022) has found no direct connection between state-level cannabis vaping and the prevalence of EVALI cases, indicating that the relationship may be more nuanced than previously noted. Nonetheless, the literature lacks evidence regarding the comparative long-term effects on lung health associated with smoking versus vaping cannabis (Chadi et al., 2020).

The consumption of edible cannabis is another lower-risk alternative to smoking cannabis that reduces the health risks associated with smoking and vaping (Grotenhermen, 2001). However, consumption of edible cannabis may lead to acute cannabis intoxication, which can result in cognitive and motor impairment, extreme sedation, anxiety, cardiac stress and vomiting

(Galli et al., 2011; Grotenhermen, 2007). Due to the delayed onset of the effects, cannabis edibles are more likely to lead to acute cannabis intoxication compared to other methods, as consumers often consume more than intended before experiencing full impact (American Addiction Centers, 2022; Grewal & Loh, 2020). In addition, some individuals may experience cannabis-induced psychosis; however, the research on this is limited (Barrus et al., 2016; Bui et al., 2015; Hudak et al., 2015). Although cannabis edible overdose is unlikely to result in death, unintentional ingestion by children has become increasingly common since legalization (Myran et al., 2023; Richards et al., 2017; Vogel, 2019). Cannabis poisoning or intoxication in children manifests vastly differently from adults. It presents more severely compared to clinical presentations in adults with adverse symptoms such as decreased level of consciousness, respiratory depression, and seizures and often results in hospitalization, (Cohen et al., 2022; Ontario Poison Centre, 2020; Wang et al., 2016).

1.1.5 Risk Perception of cannabis use

Risk perception refers to an individual's subjective judgement, beliefs, or attitude about the likelihood of negative occurrences (Slovic, 2016) and can be divided into two dimensions, cognitive and emotional (Coleman, 1993; Dohle et al., 2010; Dunwoody & Neuwirth, 1991). Risk perceptions are important precursors to health-related behaviours because they determine which hazards people care about and how they deal with them (Paek & Hove, 2017). Many health behaviour change models include risk perception as a critical component (Ferrer & Klein, 2015) since interventions that successfully change risk perception can lead to increased healthy behaviours and a reduction in the initiation of substance use (Johnston et al., 2017; Sheeran et al., 2014; Walker & Loprinzi, 2014). For instance, a prospective longitudinal study found that changes in risk perception predicted changes in future substance use of cannabis, tobacco, and

alcohol (Grevenstein et al., 2015). Research has shown risk perception to be negatively correlated with cannabis use, with individuals who perceived it as having a higher risk being less likely to use it (Johnston et al., 2017; Parker & Anthony, 2018; Salloum et al., 2018). Additionally, research has demonstrated a stronger association between cannabis use and a diminished perception of health risks (Salloum et al., 2018). However, recent research has suggested that risk perception may be becoming a weaker determinant of cannabis use (Schleimer et al., 2019). According to (2019), the perceived availability of cannabis, which refers to an individual's subjective perception about the ease of obtaining cannabis, is becoming an increasingly important driver of cannabis use, particularly in some South American countries. This finding is supported by another study, which found that individuals who have a low-risk perception of cannabis and perceive it as available are more likely to report using the drug in the past year and almost daily compared to those individuals who perceived cannabis as high-risk and unavailable (Levy et al., 2021).

Several previous research studies have evaluated the overall risk perception associated with cannabis use (Erin Goodman et al., 2020; Hellemans et al., 2019; Pacek et al., 2015), with minimal research into risk perception associated with different methods of cannabis consumption and cannabis products (Leos-Toro et al., 2020). A study conducted among Norwegian adolescents between 2007 to 2015 revealed that the perceived risk of harm from cannabis use varied across usage modes and observed a decline in perceived risk across usage modes since 2007 (Burdzovic Andreas, 2019). Several studies have revealed that the traditional method of cannabis consumption by smoking is often perceived to be riskier than non-combustible cannabis products (Borodovsky et al., 2016; Giombi et al., 2018; Johnson et al., 2016; Yoo et al., 2019). Despite limited evidence on the health effects of long-term vaping of cannabis, individuals who

use cannabis tend to perceive vaping as less harmful or safer than combustible smoking methods (Budney et al., 2015; Etter, 2015; Malouff et al., 2014). According to a study by Leos-Toro et al., (2020), cannabis products that are smoked, vaped, or consumed as edibles were generally perceived to have similar levels of risk, while products that are high potency THC or synthetic cannabinoids were considered to be somewhat riskier. Nonetheless, there remains a dearth of evidence of the comparative health risks of the various methods of administration and cannabis products.

As state-level cannabis policies change over time in the United States (US), there has been a noticeable trend of the declining perceived risk of cannabis use, as evidenced by several US studies (Chiu et al., 2021; Compton et al., 2016; Hansteen et al., 1976; Miech et al., 2017; Pacek et al., 2015). However, the evidence remains unclear as to whether cannabis legalization has significantly contributed to this trend. A 2014 study found that the legalization and commercialization of cannabis in Colorado were associated with a reduced perception of its risks (Schuermeyer et al., 2014). In contrast, an Uruguayan study by Laqueur et al., (2020) found no evidence of an impact of cannabis legalization on the perceived risk of use by adolescents. Similarly, a recent 2022 study found that US state-level recreational cannabis legalizations were not associated with the differential perception of cannabis risk among children, even after controlling for demographics (Gilman et al., 2022). The mixed findings from these studies suggest that the relationship between cannabis legalization and risk perception may be more complicated than previously noted and may warrant further research.

1.1.5.1 Factors associated with perceived health risk of cannabis use

According to the literature, health risk perception related to cannabis use can be influenced by various factors, such as age, gender/sex, substance use, frequency of cannabis use

and prior experience with cannabis use (Gil-Lacruz & Gil-Lacruz, 2010; Herruzo et al., 2020; Kilmer et al., 2006; Koval et al., 2019; Lopez-Quintero & Neumark, 2010; Mihalca et al., 2012). For instance, research from Goodman & Hammond, (2022) has revealed that individuals who had never used cannabis or used it infrequently were found to have a higher health risk perception, and those who were frequent users had a lower health risk perception of cannabis use. Herruzo et al., (2020) opined that many of these factors are linked to the information source and drug exposure, but only a limited number of studies have examined that issue. Research findings from various studies have suggested that females tend to have a higher perceived risk of cannabis use compared to males, and individuals who perceived lower levels of risk were more likely to use cannabis (Grevenstein et al., 2015; Herruzo et al., 2020; Jurcik et al., 2013; Kilmer et al., 2007; O’Callaghan et al., 2006). Additionally, in a Canadian vignette (simulations of real events) study, participants perceived female cannabis use to be more dangerous in terms of social life compared to male cannabis use (L. Harris-Lane et al., 2021). Moreover, Lopez-Quintero & Neumark, (2010) research findings indicated that after controlling for multiple confounders, being male, aged 14- 16 years and having previously used cannabis were significantly associated with a low perceived risk of cannabis use. Furthermore, research from Harris-Lane et al., (2021) revealed that young adults in Canada perceive cannabis use by the younger age group (14-year-olds) as more dangerous compared to older age groups (21- and 28-year-olds).

A recently published study conducted by Mariani & Williams, (2021) suggested that adolescents’ perceived monthly cannabis use was significantly associated with other factors, including the perception of peers using cannabis, perception of peers’ disapproval of cannabis use, perception of school importance, and participation in extracurricular activities. The study demonstrated that adolescents who perceived monthly cannabis use as risky had higher parental

monitoring, lower perception of peer usage, greater peers' disapproval, and higher perception of school importance (Mariani & Williams, 2021). While these factors do not directly predict whether an individual will have low or high perceived risk, understanding them might offer insight related to the development of targeted public health awareness campaigns.

1.1.6 Cannabis Use and Driving

1.1.6.1 Prevalence of Driving Under the Influence of Cannabis (DUIC)

Various approaches are employed when assessing the prevalence of DUIC in the Canadian population, such as self-report surveys, roadside surveys, hospital studies and fatal crash studies (Beirness et al., 2011, 2021; Brubacher et al., 2019; Hammond et al., 2021). Each method carries its own biases, which ultimately pose a unique challenge for law enforcement and the detection of cannabis in drivers (Dobri et al., 2019). While Canadian law enforcement has used specific tests (oral fluid test, Standardized Field Sobriety Tests (SFST), Drug Evaluation and Classification (DEC) program) to assess cannabis impairments in drivers, the evidence on validity and reliability of those tests to reflect a tested individual's actual impairment is lacking (Bergamaschi et al., 2013; Canadian Centre on Substance Use and Addiction, 2017; Dobri et al., 2019). Unlike alcohol, where blood alcohol and impairment are well-established, the correlation between blood and saliva THC and impairment remains substantially unverified (Downey et al., 2012; Martin et al., 2013). Cannabis metabolites (i.e. mainly THC) can remain for up to 25 days in the body (Lowe et al., 2009). However, current research has suggested that THC levels in the blood at this timeframe are not reliable indicators of impairment (Ginsburg, 2019; Johnson et al., 2022). Further research is needed to contribute nuance to the discourse around vehicular collisions and cannabis presence in the blood.

Research indicating that medical cannabis laws were linked to an increase in the prevalence of DUIC (Fink et al., 2020) has raised concerns about the potential impact of legalizing non-medical cannabis on the DUIC rate. According to public opinion research, it was revealed that about one-third, or 33 percent of Canadians who reported having used cannabis within the previous year, reported that they have driven under the influence (Government of Canada, 2022a). Additionally, survey data from the National Cannabis Survey (NCS) reported that 4.1% of participants had ridden as a passenger in a vehicle with a driver who had smoked cannabis within the past 2 hours (Statistics Canada, 2019a). However, there is a lack of research on the correlation between passengers' decisions to ride with an impaired driver and impaired driving (D. Beirness, 2014; Cartwright & Asbridge, 2011). More accurate DUIC estimates can be ascertained from fatal crashes and hospital studies, demonstrating a clearer picture of THC-positive rates among drivers (for extreme cases when an accident happens). For instance, a post-mortem blood sample related to fatal crashes in Ontario between 2016 and 2018 found that among the 921 cases examined, 27% tested positive for THC, exceeding the number of cases that tested positive for alcohol (D. J. Beirness et al., 2021). However, a limitation of this type of study is that the presence of THC does not correlate to impairment (Downey et al., 2012; Martin et al., 2013); therefore, findings from D. J. Beirness et al., (2021) may not conclusively suggest that cannabis is surpassing alcohol.

Furthermore, a hospital study in British Columbia revealed that among drivers who presented to the emergency department following a motor vehicle crash from 2010 to 2016, 8.3% tested positive for THC (Brubacher et al., 2019). Although evidence has demonstrated the impairing effects cannabis may have on important cognitive tasks to operate a vehicle safely (Arkell, Vinckenbosch, et al., 2020; Hartman & Huestis, 2013; McCartney et al., 2021; Pearson

et al., 2021), the prevalence of DUIC is on the rise, and this creates potential challenges in the wake of non-medical cannabis legalization.

1.1.6.2 Effects of Cannabis on Driving Performances

Research has suggested that cannabis may acutely impair drivers by activating the ECS, which plays a crucial role in processing sensory information, psychomotor functions, memory, and emotional regulation (Brands et al., 2019; Desrosiers et al., 2015; Hartman & Huestis, 2013). Meta-analyses have established that the acute (immediate or short-term) use of THC impairs various aspects of driving performance (McCartney et al., 2021). Even in the absence of acute intoxication (immediate impairment after use), cannabis users had poorer driving performance via the simulator, which suggests residual effects (lingering impact after cannabis use has stopped) of cannabis use (Dahlgren et al., 2020). Moreover, Dahlgren et al., (2020) concluded that frequent, heavy cannabis use (used at least 5 of the last seven days or at least 1500 lifetime uses) was linked with worse driving performance in non-intoxicated drivers and a greater impairment was associated with earlier onset of cannabis use. Although most driving skills are more likely to recover within approximately 5-7 hours of smoking (20mg) THC, oral THC-induced impairments may take longer to dissipate (McCartney et al., 2021). The strength of the effect of cannabis use is influenced by a variety of factors, such as quantity, strength, and frequency of cannabis use, as well as the experience of the driver (Canadian Centre on Substance Use and Addiction, 2017; McCartney et al., 2021). Several studies have sought to examine the association between cannabis use and cognitive and psychomotor functions, where changes in these functions may negatively impact the ability to drive safely (Arnell, Vinckenbosch, et al., 2020; Crean et al., 2011; McCartney et al., 2021; Ramaekers et al., 2004, 2006). In their recently published review, Pearlson et al., (2021) have highlighted various cognitive tasks related to

driving that can be impaired by cannabis use, such as motor tracking, time estimation, and reaction time. Additionally, Pearlson et al., (2021) have identified driving measures that may be impaired by cannabis use, such as increased lateral position errors, increased start time (in response to light signal), speed variability on curves, and error in speedometer tracking.

Some studies have highlighted a dose-response relationship, indicating that the negative impact of cannabis on driving performance is mild at low doses and increases at higher doses (Khiabani et al., 2006; Ramaekers et al., 2004; Weinstein et al., 2008). However, this dose-response relationship can be compromised when accounting for tolerance, which can develop in chronic or frequent users (Bosker et al., 2012; Colizzi & Bhattacharyya, 2018; Desrosiers et al., 2015). For instance, research has suggested that cannabis impairments are more likely to manifest in occasional cannabis users compared to frequent cannabis users (Reisfield et al., 2012). This is further supported by meta-regression analyses, which have indicated that regular cannabis users experience less THC-induced impairment than occasional users ($p = 0.003$) (McCartney et al., 2021). In addition, another factor that can modulate the effect of cannabis is the combined use of other substances, like alcohol (Hartman et al., 2015). Cannabis consumption in conjunction with alcohol use can amplify the impairment of driving abilities (Baldock & Lindsay, 2015; Hels et al., 2013). Even small consumed quantities of alcohol with the combination of cannabis have been shown to increase the negative effects on driving skills greatly (Downey et al., 2013; Hartman et al., 2015; Ramaekers et al., 2000). When substances are consumed simultaneously, the potential for synergistic and additive effects of substance use is at its highest level (Collins et al., 1998). However, some studies have mixed conclusions, suggesting that cannabis may potentiate the effects of alcohol, while other studies have reported

no synergistic or additive effects related to impairment (Ballard & de Wit, 2011; Downey et al., 2013; Lenne et al., 2010; Ramaekers et al., 2011; Subbaraman, 2014).

1.1.6.3 Risks related to DUIC

Cannabis is among the most frequently identified drugs in drivers involved in serious crashes (D. J. Beirness & Porath, 2019). Among drivers who die in vehicular crashes, cannabis is the second most detected substance, following alcohol (Beasley & Beirness, 2011; Canadian Centre on Substance Use and Addiction, 2017). In 2012, Canada's cannabis-related collisions caused 75 deaths, 4,407 injuries and resulted in property damage (destruction to physical possessions, i.e., vehicles) for up to 24,879 people, with costs ranging from \$1.09 to \$1.28 billion CAD (Wettlaufer et al., 2017). Despite representing only 32% of the population in Canada, young adults aged 16-34 accounted for a significant proportion of cannabis-related fatalities (61%), injuries (59%), and property damage-only collisions (68%) (Wettlaufer et al., 2017). Research by Voy, (2023) has suggested that the legalization of non-medical cannabis in Washington State resulted in a reduction in fatal, serious and minor injury traffic collisions. A recent study suggests that cannabis legalization in Canada was not associated with increased traffic injuries (Callaghan et al., 2021). However, road safety remains a major concern for Canadians, especially regarding DUIC. Nonetheless, evidence on cannabis crash risk is mixed, with some research studies reporting that there is no significant increase in collision risk, while others have demonstrated that crash risk increases at very low levels of cannabis and at higher dose (Asbridge et al., 2012; Drummer et al., 2004; Lacey et al., 2016; Laumon et al., 2005; Mura et al., 2003; Rogeberg & Elvik, 2016).

Recent research has begun to challenge the claim that DUIC may increase the likelihood of a crash and that the magnitude of the cannabis impairment related to crash risk (Conde et al.,

2022; Simmons et al., 2022; White & Burns, 2021). A systematic review and meta-analysis concluded that there is limited evidence to support the hypothesis that the recent use of cannabis increases the risk of crashing while driving (random-effects meta-analyses produced a bias-adjusted summary odds ratio of 0.68 (0.45–1.05) for the culpability studies and 1.45 (0.94–2.25) for the case–control studies) (White & Burns, 2021). In addition, White & Burns, (2021) found no clear association between the concentration of THC and the risk of crashing and concluded that the findings apply to all levels of THC, regardless of threshold. Further research is important to determine if the presence of THC results in impairment leading to traffic accidents and subsequent fatalities. As the discourse on the research implication of cannabis legalization and road safety progresses, it is becoming increasingly vital post-legalization to monitor the population’s driving perceptions because the intention to DUIC is considered to be the most significant predictor of future DUIC behaviour (Scott et al., 2021).

1.1.6.4 Risk Perception of Cannabis Use and Driving

Over the past decade, several studies have sought to examine DUIC behaviours in Canada (Colonna et al., 2021b, 2021a; Donnan et al., 2022; McDonald et al., 2021a; Wadsworth & Hammond, 2018; Wickens et al., 2022). For instance, McDonald et al., (2021) revealed that 90% of adults believed that DUIC increases the risk of motor vehicle collisions, and 56% felt that DUIC is not safer than driving under the influence of alcohol (DUIA). Furthermore, according to a 2021 opinion poll by the Canadian Automobile Association (CAA), 85% of Canadians reported that people who drove after using cannabis pose a serious threat to their safety (Canadian Automobile Association, 2021). Post-legalization, CCS survey data revealed that a majority of Canadians (85%) in 2019 believed that cannabis impairs driving ability, with relatively little change in 2020 (83%) (Health Canada, 2019, 2020b). However, in a qualitative

study with individuals convicted of DUIC, it was noted that participants perceived the act of legalization was an indication that society and government now view cannabis as being low risk in relation to driving (Wickens et al., 2019). Another study reinforced similar sentiments of normalization of DUIC, as a focus group study on the DUIC perception of youth and young adults from NL suggested that the practice of DUIC had become more normalized and socially acceptable (Donnan et al., 2022). A separate Canadian study revealed that youths perceive DUIC as convenient, socially acceptable, and safe, regardless of whether they are non-users or users (Colonna et al., 2021b).

Although the government implemented strict drug driving laws, a zero-tolerance policy, and invested heavily in law enforcement (Government of Canada, 2019), Canadians' perceived confidence in the police's ability to enforce DUIC remained low even after legalization. For example, the 2018 to 2020 CCS data found that only approximately one-quarter of Canadians believed it was likely or highly likely that a driver would be caught DUIC (Health Canada, 2018c, 2019, 2020b). Earlier studies have validated this observation, indicating that most cannabis users had a very low perception of the legal risks (Matthews et al., 2009, 2014). A recent study found that DUIC behaviour was significantly associated with perceived safety but not perceived legal risk (McDonald et al., 2021a). However, some studies have demonstrated that individuals with a greater knowledge of drug driving laws or those who perceived a greater chance of enforcement were less likely to engage in DUIC (Arterberry et al., 2017; Davis et al., 2016; McDonald et al., 2021a). The intention to DUIC was significantly associated with future DUIC behaviour, and this intention was seemingly influenced by past DUIC occurrences, attitude towards cannabis, and perception of the normalization of cannabis (Scott et al., 2021). The evidence on the potential impact of legalization on DUIC behaviours is limited and remains

unclear (Benedetti et al., 2021; Eichelberger, 2019; Lensch et al., 2020; Wadsworth & Hammond, 2018). According to Benedetti et al., (2021), there was a lack of substantial evidence that drivers from legalized states had higher odds of DUIC compared to states where both medical and non-medical cannabis were illegal. However, Canada is still in the early stages of cannabis legalization, with not enough time passed to observe or differentiate between pre- and post-legalization trends around DUIC behaviour.

1.1.6.5 Factors Associated with DUIC Behaviours

Perceptions relating to DUIC can be influenced by factors such as age, sex, and cannabis use experience (Erin Goodman et al., 2020; Fischer et al., 2014; Jones et al., 2007; Matthews et al., 2009; McDonald et al., 2021a). In particular, evidence has demonstrated that being younger (youths and young adults) and being male increased the likelihood of DUIC compared to older individuals and females, respectively (Erin Goodman et al., 2020; Koundakjian et al., 2019; McDonald et al., 2021a). In one study conducted in Ontario, participants who were male, had less education, or used cannabis at least monthly did not feel that DUIC contributed to an increase in vehicle collisions (McDonald et al., 2021b). A scoping review with similar findings revealed that the primary predictors of DUIC included being a male, being a high school senior, having lower grades, having a higher frequency of consumption, having a reduced perception of danger, repeatedly binge drinking, and living with fewer parents (Sterzer et al., 2022). Higher perceptions of risk towards DUIC were generally noted among females, whereas higher risk-taking behaviours were observed among males (Koundakjian et al., 2019; Rivera & Patten, 2020). Gender differences in DUIC prevalence and perceptions may be influenced by sociocultural factors, which tend to be shaped by differences in societal gender roles and identity (Lloyd et al., 2020). In addition, an individual's attitude towards DUIC may also be shaped by

their frequency of cannabis use, as people who use cannabis more frequently were less likely to believe cannabis use can impair driving ability, compared to occasional or infrequent users (Health Canada, 2018c, 2019; Koundakjian et al., 2019). However, there was no difference in DUIC perception associated with collision risk or risk of police enforcement among the type of cannabis users (i.e., medical, non-medical, and dual-purpose) (Wickens et al., 2023).

Additionally, medical cannabis users were more likely to perceive DUIC to be low-risk and not impair one's driving ability (Arkell, Lintzeris, et al., 2020).

Several research findings have demonstrated that individuals who perceive DUIC as risky are less likely to engage in DUIC (Arterberry et al., 2017; Davis et al., 2016; McDonald et al., 2021a). Among youths, (2021a) have identified past DUIC incidence, moral awareness, perceived dangerousness, minor accident risk, and vicarious punishment avoidance as some of the predictors of the intention of DUIC in the future. This finding has been supported by Scott et al., (2021), which have suggested that the intention to DUIC was significantly associated with future DUIC behaviour. DUIC attitudes and perceptions and their influences are important for policymakers and researchers to understand as they can make public awareness interventions more effective by targeting the appropriate audience with the most relevant content and appeal (Razaghizad et al., 2021; Wickens et al., 2023).

1.2 Study Rationale

Non-medical cannabis legalization in Canada is still in the nascent stages, and there are many unknowns regarding its long-term impact on various aspects of society (Chiu et al., 2021; Hammond et al., 2020). The intention of cannabis legalization in Canada was to provide safe access to cannabis while protecting and safeguarding the health and safety of Canadians (Government of Canada, 2018b). However, an area of concern is the impact that legalization

may have on the perceived risk associated with cannabis use, considering evidence has shown a decline in the perceived risk of cannabis in the United States over the past decade (Chiu et al., 2021; Compton et al., 2016; Hansteen et al., 1976; Miech et al., 2017; Pacek et al., 2015). Recent research conducted in NL has highlighted potential concerns around risk perception and driving perception related to cannabis use, as well as the deficit in youth cannabis education in the province (Bishop et al., 2022; Donnan et al., 2022). However, it is yet to be known whether these findings may be representative of the broader region of Atlantic Canada and whether these findings might differ from the rest of the country.

Furthermore, there is a paucity of research on cannabis use conducted, particularly in the Atlantic Canadian region, where distinct regional factors may influence patterns of cannabis use (MacDougall & Maston, 2021). A focus on Atlantic Canada should be a priority since the region has demonstrably higher cannabis use prevalence than the national average (Health Canada, 2022). Overall, there is a lack of population-level data and a scarcity of evidence on these critical factors in the region. Therefore, the purpose of this research was to investigate the impact of cannabis legalization on risk perception associated with modes of consumption and driving attitudes surrounding driving under the influence of cannabis in Atlantic Canada compared to the rest of the country. The findings from the research will have implications for public health and safety policies and interventions in the region to support a more tailored policy approach.

1.3 Research Questions and Objectives

This thesis had two research questions and was examined in two unique studies.

Study 1's research question: How does non-medical cannabis legalization impact perceived health risks of daily cannabis consumption modes in Atlantic Canada compared to non-Atlantic Canada?

Study 1's objective is:

- To describe and determine the impact of legalization on the health risk perception of cannabis consumption modes in Atlantic Canada compared to non-Atlantic Canada.

Study 2's research question: How does non-medical cannabis legalization impact cannabis-related driving attitudes among Atlantic Canadians compared to non-Atlantic Canadians?

Study 2's objectives are:

- To determine the prevalence of driving under the influence of cannabis (DUIC) and passengers' decision to ride with a driver under the influence of cannabis before and after legalization in Atlantic Canada compared to non-Atlantic Canada.
- To examine the impact of legalization in Atlantic Canada on various DUIC perceptions, including the likelihood of being stopped by police and charged, the ease of detecting impairment, the perceived risks of accidents caused by cannabis impairment, and the likelihood of preventing others from DUIC.

1.4 Methods

The purpose of this thesis is to examine the impact of non-medical cannabis legalization on health risk perception of daily cannabis consumption modes and driving perception in Atlantic Canada relative to non-Atlantic Canada by conducting a secondary cross-sectional analysis employing population-based data. This section provides an overview of the methodological approach used, including data source and collection methods, outcome measures, and statistical analyses applied to assess the relationship between legalization and perceived outcomes.

1.4.1 Research Setting

This research focused on the Atlantic provinces collectively, using non-Atlantic Canada (excluding the Atlantic provinces) as the comparator. The term ‘Atlantic Canada’ is often used to describe the easternmost region of Canada, excluding the province of Quebec (Government of Canada, 2010). It includes four provinces: NB, NS, PEI, and NL. In the 2022 Canadian census, the Atlantic Canadian provinces had a collective population of 2,409,874 people or approximately 7% of the total Canadian population (Statistics Canada, 2022b). Apart from their shared geographical, cultural, and political values, these provinces also have separately and collectively higher rates of cannabis use than the national average (Health Canada, 2022).

1.4.2 Data Source and Collection

Repeated cross-sectional data from four distinct survey periods, referred to as Waves 1, 2, 3, and 4, of the International Cannabis Policy Study (ICPS) survey (Hammond et al., 2020) conducted in Canada from 2018- 2021 were requested. The ICPS survey is an in-depth annual prospective cross-sectional survey that has sought to support cannabis policy evaluation in Canada and the United States since 2018 and recently added Australia and New Zealand in the 2021 (Hammond et al., 2020). The ICPS survey examined five primary research questions, including: i) the extent to which legalization is associated with changes in the prevalence and pattern of cannabis use, ii) risk behaviours: including driving after cannabis use, iii) commercial retail environment, iv) perceptions of risk and social norms, and v) effectiveness of specific regulatory policies (Hammond et al., 2020). Survey data was collected via self-completed web-based surveys, and participants were recruited through the Nielsen Consumer Insights Global Panel and their partners’ panels. The surveys were conducted in English and French in Canada (based on the participants’ language selection preference). The ICPS survey was reviewed and

approved by the University of Waterloo Research Ethics Committee. The complete details on the methods utilized in the data collection can be found in a previously published paper, (Hammond et al., 2020), or at <http://cannabisproject.ca/methods/>. The technical report corresponding with the wave or survey year can be downloaded to examine any variations in methodology, questionnaire, quality control and sampling.

There are several best practices for conducting online surveys that the ICPS survey incorporates in order to ensure the quality of the information collected, including “trap” questions aimed at identifying ‘speeders’ and disengaged participants (American Association of Public Opinion Research (AAPOR), 2010, 2019; Hammond et al., 2020). Data integrity was assessed using two questions: “What is the current month?” and “Were you able to provide ‘honest’ answers about your marijuana use during the survey. If the participants selected the wrong month or could not provide honest answers for “all questions,” they were removed from all four waves (Hammond et al., 2020).

1.4.3 Participants

Data were requested for four waves (2018-2021) of the ICPS survey. Each wave was carried out in the fall of the respective survey year. The participants included in the requested data were aged 16-65 years and living in Canada. A total of 58,045 participants were analyzed, with individuals grouped into Atlantic Canadian (n= 3,684) and non-Atlantic Canada (n= 54,361). Post-stratification sample weights were constructed for participants from Canada (age-by-sex-by-province and education levels) using population estimates from Statistics Canada.

1.4.4 Measures

In this research, we used the following variables of interest:

Sociodemographic Information

The following sociodemographic characteristics were included in this study: sex at birth, age group, ethnicity, Jurisdiction, education level, gross personal income, and population density.

Cannabis Use

The cannabis use frequency variable was coded using a 6-level ‘cannabis use status’ variable (never user, used more than 12 months ago, past 12-month user, monthly user, weekly user, and daily/almost daily user). Construction of this variable was mainly adopted from the Canadian Student Tobacco, Alcohol and Drug Survey (CSTADS) and the National Survey on Drug Use and Health (NSDUH) (Health Canada, 2018a; Substance Abuse and Mental Health Services Administration (SAMHSA), 2018). Additionally, the past 12-month cannabis use variable was used to capture the cannabis use prevalence.

Health risk perception

The health risk perception variable was assessed using five questions about how individuals viewed the risk associated with daily use of different forms of cannabis consumption. The perceptions of risk of cannabis consumption mode questions were closely modelled from the 2015 European School Survey Project on Alcohol and Other Drugs (ESPAD) (European School Survey Project on Alcohol and Other Drugs (ESPAD), 2015).

Driving Behaviours and Attitudes

The driving perception variable was assessed by using seven questions from the ‘Driving and Cannabis Use’ section of the survey. Some questions were closely modelled from the CSTADS 2014 and British Columbia (BC) Roadside Survey by ICPS team (D. J. Beirness et al., 2011; Health Canada, 2016a). Similar to the CCS, the ICPS assesses DUIC and riding with a cannabis-impaired driver (RWCD) within a standard 2-hour timeframe after cannabis use (Government of

Canada, 2022; Hammond et al., 2021). Notably, the CCS in 2019 and 2020 adapted, driving within 4 hours of consuming cannabis edibles to capture the growing popularity of cannabis edibles (Health Canada, 2019, 2020). However, this nuance was not reflected in our selected ICPS driving and cannabis use questions. Moreover, these timeframes are largely influenced by the pharmacology of cannabis (Grotenhermen, 2003), albeit imperfect in the face of emerging evidence.

1.5 Analysis

The analyses performed for both studies were similar; however, each study had differences in the dependent variable being measured within the study population. Study 1 examined the perceived health risks associated with daily cannabis consumption, while Study 2 examined driving perceptions and risks associated with DUIC. All analyses were conducted using IBM SPSS statistical software (IMP Corp., 2021), using survey-weighted data constructed from Statistics Canada (Hammond et al., 2020; Statistics Canada, 2017, 2022a). Descriptive statistics, chi-square tests, and ordinal logistic regressions were performed to analyze the data and explore the respective research objectives. Descriptive statistics were used to characterize the sample characteristics, risk perception of various cannabis consumption modes, determine the prevalence of DUIC and passengers' decision to ride with a driver under the influence of cannabis. Chi-square tests were conducted to determine whether there were any significant differences in the distribution of the sample's characteristics and cannabis prevalence across the two jurisdictions and four years. Ordinal logistic regression examined the association of legalization on the various perceived risk measures of interest in the Atlantic Canadian region in relation to non-Atlantic Canada. Ordinal logistic regression models were fitted for each perceived risk measure of interest.

The mathematical form of the ordinal regression model with an interaction term between jurisdiction and time variables is:

$$\text{logit}(P(Y \leq j)) = \beta_0 + \beta_1(\text{jurisdiction}) + \beta_2(\text{pre/post}) + \beta_3(\text{jurisdiction} \times \text{pre/post}) + \beta_4(\text{age}) + \beta_5(\text{sex}) + \beta_6(\text{ethnicity}) + \beta_7(\text{income}) + \beta_8(\text{education})$$

The variable of interest was the interaction term, $\beta_3(\text{jurisdiction} \times \text{time})$, which conveyed the differential effect of legalization on the outcome between Atlantic Canada and non-Atlantic Canada. All models were adjusted for sex, age group, ethnicity, education level, and gross personal income unless stated otherwise. The adjusted odds ratio (AOR) and 95% confidence interval (CI), as well as the p-value for the regression models were calculated. A p-value less than 0.05 was considered statistically significant. The AORs were used to determine the strength and direction of the association between each predictor variable and the outcome variable. The 95% CI provided a range of values within which the true population parameter was expected to fall with a 95% degree of confidence.

1.6 Thesis Organization

This master's thesis is written in a manuscript-style format, consisting of four chapters, which includes this introductory chapter. Chapter one of the thesis provides the foundation for the research by outlining the background, rationale, and overview of the methodology. Chapter two presents the first study, which examines the impact of non-medical cannabis legalization on health risk perception of daily cannabis consumption modes in Atlantic Canada compared to non-Atlantic Canada. Chapter three introduces the second study of the thesis, which investigates the effect of non-medical cannabis legalization on driving perceptions and attitudes in the

Atlantic Canadian regions in relation to non-Atlantic Canada. Both chapters 2 and 3 will be divided into five main parts: introduction, methods, results, discussion and limitations. In addition, both chapters 2 and 3 are written as standalone publications. Chapter 4 concludes the thesis and summarizes the research findings from studies 1 and 2, along with research implications, suggestions for future studies, policy recommendations, limitations and conclusion.

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Co-authorship Statement

This master's thesis represents a collaborative effort spanning the entire research process. The research proposal was created in consultation with the first author (Michael Blackwood) and the supervisor committee, consisting of two co-supervisors, Dr. Jennifer Donnan and Dr. Lisa Bishop, and the committee member, Dr. Hai Nguyen. The foundation of this research is the utilization of secondary cross-sectional data from the International Cannabis Policy Study (ICPS) survey, which was designed and collected by Dr. David Hammond and his team. All authors' contributions are outlined below:

1. **Michael Blackwood:** Conceptualization, Design, Methodology, Data Analysis, Writing- Original Draft, Writing- Review and Editing, Visualization.
2. **Dr. Jennifer Donnan:** Conceptualization, Design, Methodology, Data Analysis, Writing- Original Draft, Writing- Review and Editing, Supervision, Funding Acquisition, Intellectual Input and Critical Feedback.
3. **Dr. Lisa Bishop:** Conceptualization, Design, Methodology, Data Analysis, Writing- Original Draft, Writing- Review & Editing, Supervision, Funding Acquisition, Intellectual Input and Critical Feedback.
4. **Dr. Hai Nguyen:** Conceptualization, Design, Methodology, Data Analysis, Writing- Original Draft, Writing- Review and Editing, Supervision, Funding Acquisition, Intellectual Input and Critical Feedback.
5. **Dr. David Hammond:** Data Curation, Writing- Review and Editing, Intellectual Input and Critical Feedback.

We affirm that the co-authorship statement accurately reflects the significant contribution made by each author throughout the research process. We acknowledge that there are no conflicts of interest concerning this research and thesis publication. The manuscript is in preparation to be submitted for publication in the Drug: Education, Prevention, and Policy journal.

Chapter 2:

The Impact of Non-Medical Cannabis Legalization on Health Risk Perceptions of Daily Cannabis Consumption Modes in Atlantic Canada

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Abstract

Background: Following non-medical cannabis legalization in Canada, the Atlantic provinces have seen higher cannabis use than the national average. This research examined the impact of legalization on the perceived health risk of daily cannabis consumption modes (smoking, vaping, edibles, synthetic and high potency) in Atlantic Canada compared to non-Atlantic Canada.

Methods: A secondary cross-sectional analysis was conducted on the International Cannabis Policy Study (ICPS) surveys from 2018-2021 on 58,045 participants aged 16- 65 from Canada. We used ordinal logistic regression to examine the impact of legalization on the risk perception of different daily cannabis consumption modes in Atlantic Canada compared to non-Atlantic Canada.

Results: Jurisdictional differences were observed, with Atlantic Canadians having lower perceived risks of various consumption modes than non-Atlantic Canadians. A significant decrease was observed post-legalization in perceived risk associated with daily smoking, edibles, synthetic cannabis, and high-potency cannabis, except for vaping. Perceived daily vaping was higher in Atlantic Canada compared to non-Atlantic Canada following legalization.

Conclusion: Overall, Atlantic Canadians had lower perceived risk than non-Atlantic Canadians. However, after legalization, there was an increase in the perception of higher health risks of daily vaping was observed in Atlantic Canada relative to non-Atlantic Canada. The findings highlight the significance of recognizing regional differences to ensure equal and beneficial impact of policies.

Keywords: Marijuana, Cannabis, Risk Perception, Cannabis Consumption, Atlantic Canada

2.1 Introduction

Globally, cannabis is the most widely used drug, with an estimated 209 million people aged 15-65, or approximately 4% of the world's population, having used cannabis in the past year (United Nations, 2022). Legalizing non-medical cannabis in Canada was intended to provide safe access to cannabis products, reduce the risks associated with cannabis use, and protect Canadians' public health and safety. A public health approach was adopted during the legalization process to prevent harm, promote population-level health, and target interventions for individuals in high-risk (Health Canada, 2016). Since the legalization of non-medical cannabis in Canada in October 2018, there has been a considerable increase in consumption, which has remained relatively sustained post-legalization (Health Canada, 2022a). This raises concerns as it is well-documented in the literature that chronic use may negatively impact physical and mental health outcomes (National Academies of Sciences, Engineering, and Medicine, Health and Medicine Division, et al., 2017; Volkow et al., 2016)

According to the Canadian Cannabis Survey (CCS) data, in 2022, 27% of Canadians reported using cannabis in the past 12 months, compared to 22% in 2018 (Health Canada, 2022a). However, the Atlantic Canadian region, which consists of New Brunswick (NB), Newfoundland and Labrador (NL), Nova Scotia (NS), and Prince Edward Island (PEI), has recorded some of the highest rates of cannabis use in the country. The 2022 CCS data highlighted that, on average, 30% of Atlantic Canadians reported using cannabis in the past 12 months compared to the national average of 27%, with PEI (34%) and NB (30%) having the highest in the region (Health Canada, 2022b). Moreover, in 2022, 29% of the past 12 months of cannabis users in Atlantic Canada reported engaging daily or almost daily, compared to 25% of Canadians overall in the past 12 months of cannabis users (Health Canada, 2022a). However,

there is a lack of evidence within the Atlantic region to explain these findings (MacDougall & Maston, 2021). Given the higher cannabis usage in Atlantic Canada, the provincial governments need to monitor and evaluate the potential impact of legalization on the population's perceived risks associated with cannabis use. This evaluation could play an important role in achieving the public health goals set by the federal government.

Understanding how people perceive risks is an essential factor in many health behaviour change models as it determines which risks people care about and how they respond to them (Ferrer & Klein, 2015). Therefore, improving risk perception may be beneficial in reducing substance use initiation and promoting health-protective behaviours (Grevenstein et al., 2015; Griffin & Botvin, 2010; Lipari et al., 2012; Walker & Loprinzi, 2014). The link between cannabis use and risk perception seemingly functions bidirectionally, as lowered risk perception can drive increased usage, and current usage can lead to decreased risk perception. For instance, research findings have demonstrated that individuals who perceive a higher health risk associated with cannabis use are less likely to use cannabis and vice versa (Johnston et al., 2017; Parker & Anthony, 2018; Salloum et al., 2018). However, in a 2019 cross-sectional study conducted in South America on adolescents, the authors suggested that the influence of risk perception on cannabis use may be weakening while perceived cannabis availability is increasingly becoming an important factor in its use (Schleimer et al., 2019). According to Levy et al., (2021), people perceiving cannabis as low-risk and readily available were 22 times more likely to report using the drug in the past year and almost daily compared to those perceiving cannabis as high-risk and unavailable.

Previous research has primarily examined the overall perceived risks of cannabis use (Erin Goodman et al., 2020; Hellemans et al., 2019; Pacek et al., 2015), with a limited

exploration into the perceived risks associated with different methods of cannabis consumption (Leos-Toro et al., 2020). This inadvertently overlooks that risk perception related to specific modes of cannabis consumption may be viewed differently by the general population, especially with the rapid commercialization of cannabis. The various cannabis consumption modes and product types (e.g. consuming dried flower (smoking or vaping), edibles/gummies/baked goods (ingesting), synthetic cannabis (smoking or vaping), and high-potency cannabis (smoking or vaping) can have differential adverse health impacts on the human body. This is because the pharmacological effects of cannabis, primarily due to delta-9-tetrahydrocannabinol (THC), can vary based on how the product is consumed (Grotenhermen, 2003; Leos-Toro et al., 2020). For instance, the consumption of edibles is more likely to result in acute cannabis intoxication than other modes due to the delayed onset of the effects resulting in overconsumption (Grewal & Loh, 2020; Grotenhermen, 2003).

According to a study by Leos-Toro et al., (2020), cannabis products that are smoked, vaped, or consumed as edibles were generally perceived to have similar risk profiles, while products that are high potency THC or synthetic cannabinoids were considered to be somewhat riskier. Several studies have revealed that the traditional method of cannabis consumption by smoking was often perceived to be riskier than non-combustible cannabis products (Borodovsky et al., 2016; Giombi et al., 2018; Johnson et al., 2016; Yoo et al., 2019). Despite limited evidence on the health effects of long-term vaping of cannabis, individuals who use cannabis tend to perceive vaping as less harmful or safer than combustible smoking methods (Budney et al., 2015; Etter, 2015; Malouff et al., 2014). Nonetheless, there remains a lack of evidence of the comparative health risks of the various methods of administration and cannabis products

There has been a noticeable trend of the declining perceived risk of cannabis use, as shown by many studies from the United States (Chiu et al., 2021; Compton et al., 2016; Hansteen et al., 1976; Miech et al., 2017; Pacek et al., 2015). However, the evidence remains unclear whether non-medical cannabis legalization has significantly contributed to this trend. A 2014 study found that the legalization and commercialization of cannabis in Colorado were associated with a reduced perception of its risks (Schuermeyer et al., 2014). In contrast, an Uruguayan study by Laqueur et al., (2020) found no evidence of an impact of cannabis legalization on adolescents' perceived risk of use. The findings from these studies suggest that the relationship between cannabis legalization and risk perception may be more complex than previously thought and may warrant further research.

Our current study sought to investigate the impact of legalization on the perceived risk of daily use of different cannabis consumption modes (smoking cannabis, vaping cannabis, consuming cannabis edibles, using synthetic cannabis, and using high-potency cannabis) in the Atlantic Canadian region compared to non-Atlantic Canada. The high prevalence of cannabis use, in conjunction with the limited existing research, underscores the importance of conducting cannabis research in Atlantic Canada, as it can contribute to shaping evidence-based public policies and interventions. Although retail models vary across Canada, the Atlantic Canadian regions, with the exception of NL, all adopted a public retail mode, highlighting their similarity amidst the variation of retail approaches in the country (Government of Newfoundland and Labrador, 2018; Statistics Canada, 2019). NL uses a hybrid model, which is a mix of public and private cannabis retail models (Government of Newfoundland and Labrador, 2018). We hypothesized that non-medical cannabis was associated with a decreasing or lower risk perception by those in Atlantic Canada since legalization.

2.2 Methods

To investigate the association of legalization with the perceived risk of daily use for different cannabis consumption modes, we conducted a secondary cross-sectional analysis of survey data from the International Cannabis Policy Study (ICPS) survey between 2018 and 2021. The ICPS survey is an in-depth annual repeat cross-sectional survey designed to support cannabis policy evaluation in the United States and Canada since 2018 and recently added Australia and New Zealand in 2021 (Hammond et al., 2020, 2021). The primary focus of the ICPS survey is to examine five key research areas: i) the extent to which legalization is associated with changes in the prevalence and pattern of cannabis use, ii) risk behaviours: including driving after cannabis use, iii) commercial retail environment, iv) perceptions of risk and social norms, and v) effectiveness of specific regulatory policies (Hammond et al., 2020).

2.2.1 Data Source and Collection

Cross-sectional survey data from four different annual data collection periods, referred to as Waves 1, 2, 3, and 4 (2018- 2021), of the ICPS survey (Hammond et al., 2020), conducted in Canada were examined in this study. The survey data were collected via web-based, self-completed surveys in the fall of each respective survey year. ICPS recruited participants through the Nielsen Consumer Insights Global Panel and their partner's panels by emailing a random sample of eligible panellists with a unique link. The ICPS survey was reviewed and approved by the University of Waterloo Research Ethics Committee. The complete details on the methods utilized in the data collection can be found in a previously published paper, (Hammond et al., 2020), or at <http://cannabisproject.ca/methods/>.

2.2.2 Participants

The participants included those aged 16-65 years and living in Canada. The American Association of Public Opinion Research (AAPOR) cooperation rate, which represents the proportion of eligible participants who completed the survey, varied from 61% to 64% over the four years (2018- 64%, 2019- 63%, 2020- 62%, and 2021- 61%) (American Association of Public Opinion Research (AAPOR), 2019; The International Cannabis Policy Study (ICPS), 2023). For the current analysis, participants were excluded if they either refused to answer or did not provide valid responses to the questions of interest. Missing data values were excluded from the analyses, and appropriate weights were assigned to completed data to counter potential bias resulting from missing data. Post-stratification sample weights were constructed for participants from Canada (age-by-sex-by-province and education groups) using population estimates from Statistics Canada (Statistics Canada, 2017, 2022).

2.2.3 Measures

Variables relating to socio-demographic information, cannabis use, and risk perception were obtained. The following socio-demographic characteristics were included in this study: sex at birth, age group, ethnicity, jurisdiction, income and education level. Additionally, cannabis use frequency and the past 12-month cannabis use were examined. The perceived risk measure was assessed using five survey questions relating to how individuals viewed the risk associated with the daily use of five different forms of cannabis consumption modes, including smoking cannabis, vaping cannabis, consuming cannabis edibles, using synthetic cannabis, and using high potency cannabis (1= Very low risk, 2= Low risk, 3= Moderate risk, 4= High risk, 5= Very high risk). For a list of survey questions, see Appendix A.

2.2.4 Data Analysis

Descriptive statistics were used to analyze the sample characteristics and determine the prevalence of cannabis use and risk perception of various consumption modes before and after legalization in the Atlantic Canadian region compared to non-Atlantic Canada. Chi-square tests were conducted to determine whether there were any significant differences in the distribution of cannabis prevalence across the two jurisdictions over the four years of data. The risk perception of the five consumption modes measures was ordinal with five levels. Therefore, ordinal logistic regression was used to examine the association of legalization on risk perception in the Atlantic Canadian region compared to the non-Atlantic Canada population. All analyses were conducted using IBM SPSS statistical software (IMP Corp., 2021). The survey weights were constructed by the ICPS team using weighted data from Statistics Canada (Hammond et al., 2020; Statistics Canada, 2017, 2022).

The mathematical form of the ordinal regression model with an interaction term between jurisdiction and time variables is:

$$\text{logit}(P(Y \leq j)) = \beta_0 + \beta_1(\text{jurisdiction}) + \beta_2(\text{pre/post}) + \beta_3(\text{jurisdiction} \times \text{pre/post}) + \beta_4(\text{age}) + \beta_5(\text{sex}) + \beta_6(\text{ethnicity}) + \beta_7(\text{income}) + \beta_8(\text{education})$$

The variable of interest is the interaction term, $\beta_3(\text{jurisdiction} \times \text{time})$, which conveyed the differential effect of legalization on the outcome between Atlantic Canada and non-Atlantic Canada. The adjusted odds ratio (AOR) and 95% confidence interval (CI), as well as the p-value for the regression models, were calculated. The significance of the interaction term was assessed using a p-value less than 0.05, indicating statistical significance. The AOR was used to determine the strength and direction of the association between each predictor variable and the

outcome variable. An AOR greater than 1 indicates that legalization has a stronger association with the outcome of perceived risks in Atlantic Canada compared to non-Atlantic Canada. All models were adjusted for sex, age group, ethnicity, education, and gross income unless stated otherwise.

2.3 Results

Sample characteristics

A total of 58,045 Canadian participants across the four waves (2018- 2021) were included in the study, with 3,684 from Atlantic Canada and 54,361 from non-Atlantic Canada. As per weighting procedures, the proportions reflect the distribution of the actual population (Hammond et al., 2020). Both populations had relatively similar sex distribution, were predominately white, primarily living in urban areas, and one-third or more had at least some college or university education. However, Atlantic Canadians were less racially/ethnically diverse and had a greater proportion of people living in rural areas compared to non-Atlantic Canadians. Approximately one-fifth or more of individuals from Atlantic Canada were in the age group 46-55, while one-fifth or more of individuals from the rest of Canada were in the age group 26-35. The mean age across the four survey years for Atlantic Canada was 42.23 (SE=0.24) years, while for non-Atlantic Canada, it was 40.61 (SE= 0.06) (Table 1).

Table 1: Weighted sample characteristics (n=58,045)

Baseline characteristics	Atlantic Canada (n=3684)				Non-Atlantic Canada (n=54361)			
	2018	2019	2020	2021	2018	2019	2020	2021
	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
Sex								
Female	50.3 (326)	50.3 (487)	50.3 (500)	50.2 (538)	49.8 (4686)	49.7 (7096)	49.7 (7343)	49.6 (7882)
Male	49.7 (323)	49.7 (481)	49.7 (494)	49.8 (534)	50.2 (4723)	50.3 (7191)	50.3 (7443)	50.4 (7998)
Age								
16-25	17.6 (114)	17.5 (170)	17.6 (175)	17.6 (186)	19.0 (1788)	18.9 (26970)	18.7 (2772)	18.4 (2919)
26-35	18.1 (118)	18.1 (175)	18.3 (182)	18.6 (200)	20.9 (1969)	21.1 (3016)	21.3 (3146)	21.4 (3400)
36-45	18.7 (121)	18.4 (178)	18.5 (184)	18.5 (199)	19.6 (1847)	19.8 (2835)	20.1 (2922)	20.4 (3243)
46-55	22.4 (145)	21.8 (211)	21.3 (212)	20.8 (223)	20.6 (1943)	19.8 (2827)	19.3 (2856)	19.1 (3029)
56-65	23.2 (150)	24.2 (235)	24.4 (243)	24.4 (262)	19.8 (1861)	20.4 (2912)	20.6 (3039)	20.7 (3289)
Ethnicity								
White	89.8 (583)	87.5 (847)	85.6 (851)	84.0 (900)	76.5 (7193)	72.2 (10314)	70.0 (10355)	66.9 (10618)
Other/Mixed/Unstated	10.2 (66)	12.5 (121)	14.4 (144)	16.0 (172)	23.5 (2215)	27.8 (3974)	30.0 (4430)	33.1 (5261)
Highest education level								
Less than high school	13.2 (85)	15.0 (144)	14.1 (139)	15.6 (165)	15.7 (1467)	15.7 (2211)	15.6 (2274)	15.6 (2441)
High school diploma	29.0 (187)	29.9 (287)	27.2 (267)	29.0 (307)	26.6 (2484)	26.5 (3748)	26.8 (3906)	26.6 (4177)
Some college/Technical	36.5 (235)	35.0 (336)	38.9 (381)	35.8 (380)	32.5 (3029)	32.6 (4600)	32.4 (4722)	32.5 (5103)
Bachelor's degree or higher	21.4 (138)	20.0 (192)	19.8 (194)	19.6 (208)	25.2 (2351)	25.2 (3563)	25.3 (3689)	25.3 (3970)
Population density								
Urban	69.7 (397)	71.8 (581)	70.3 (584)	70.0 (639)	88.8 (7479)	88.9 (10582)	90.3 (11195)	89.6 (12001)
Rural	30.3 (173)	28.2 (229)	29.7 (247)	30.0 (273)	11.2 (942)	11.1 (1321)	9.7 (1209)	10.4 (1394)
*Gross Personal Income								
Less than \$20,000	23.0 (131)	21.7 (185)	12.7 (109)	10.5 (98)	24.8 (2089)	21.1 (2683)	11.0 (1408)	10.8 (1527)
\$20,000 to less than \$30,000	14.2 (81)	12.7 (109)	10.3 (88)	10.0 (93)	10.3 (865)	11.3 (1441)	8.3 (1067)	10.5 (1478)
\$30,000 to less than \$40,000	11.8 (67)	11.6 (99)	9.5 (82)	11.0 (103)	9.9 (833)	10.0 (1266)	8.5 (1089)	8.2 (1160)

\$40,000 to less than \$50,000	11.0 (63)	11.8 (101)	9.4 (81)	8.8 (82)	8.6 (728)	9.8 (1242)	8.6 (1100)	8.7 (1229)
\$50,000 to less than \$60,000	9.7 (55)	9.1 (78)	11.3 (97)	9.8 (91)	9.4 (790)	9.4 (1191)	9.3 (1184)	9.4 (1330)
\$60,000 to less than \$70,000	6.3 (36)	7.4 (64)	7.8 (67)	9.4 (88)	7.4 (625)	7.7 (983)	7.4 (948)	8.2 (1154)
\$70,000 to less than \$80,000	5.5 (31)	5.3 (45)	7.6 (65)	7.0 (65)	6.0 (506)	6.5 (830)	7.1 (903)	6.8 (962)
\$80,000 to less than \$90,000	4.2 (24)	4.0 (34)	5.5 (47)	6.4 (60)	5.1 (432)	5.2 (667)	6.8 (863)	6.9 (974)
\$90,000 to less than \$100,000	4.5 (25)	4.9 (42)	6.5 (56)	7.6 (71)	5.7 (4820)	5.2 (657)	8.1 (1037)	7.5 (1061)
More than \$100,000	9.7 (55)	11.4 (97)	19.4 (167)	19.5 (182)	12.7 (1067)	13.9 (1765)	24.9 (3184)	22.8 (3204)
Frequency of cannabis use								
Never user	36.2 (235)	31.9 (308)	32.0 (319)	31.7 (340)	44.0 (4141)	38.4 (5490)	39.8 (5890)	38.5 (6111)
Used >12 months ago	32.8 (213)	29.1 (281)	30.0 (299)	28.3 (303)	28.7 (2701)	26.6 (3795)	26.3 (3895)	25.4 (4039)
Past 12-month user	10.4 (68)	12.6 (122)	11.9 (118)	11.7 (125)	8.5 (795)	11.3 (1608)	10.1 (1492)	9.2 (1467)
Monthly user	5.1 (33)	7.7 (74)	5.6 (55)	7.0 (75)	4.9 (457)	6.9 (990)	6.4 (953)	7.2 (1149)
Weekly user	4.3 (28)	5.9 (57)	6.0 (60)	5.6 (60)	5.2 (494)	5.6 (806)	5.7 (836)	6.1 (975)
Daily/almost daily user	11.2 (73)	13 (126)	14.5 (144)	15.8 (169)	8.7 (820)	11.2 (1598)	11.6 (1770)	13.5 (2139)

*Gross Personal Income variable had a significant number of missing data points and 'I don't know' responses, amounting to 6825 out of the 58,045 participants.

Cannabis use

Over time, the proportion of individuals who had used cannabis in the past 12 months in Atlantic and non-Atlantic Canada increased between 2018 and 2021 (Figure 1). The chi-square test indicated significant differences in the past 12-month cannabis use prevalence between Atlantic Canada and non-Atlantic Canada across the four years, with more prevalent use in Atlantic Canada ($\chi^2=24.142$, $df=1$, $p<0.001$) (Figure 1). Further analysis revealed that these differences were significant in each year (2018: $\chi^2= 4.14$, $df= 1$, $p<0.05$; 2019: $\chi^2= 6.48$, $df= 1$, $p<0.05$; 2020: $\chi^2 =7.22$, $df= 1$, $p<0.05$; 2021: $\chi^2 =6.72$, $df= 1$, $p<0.05$). There was a noticeable increase in the past 12-month cannabis use after legalization, with cannabis use remaining higher than pre-legalization figures in both populations.

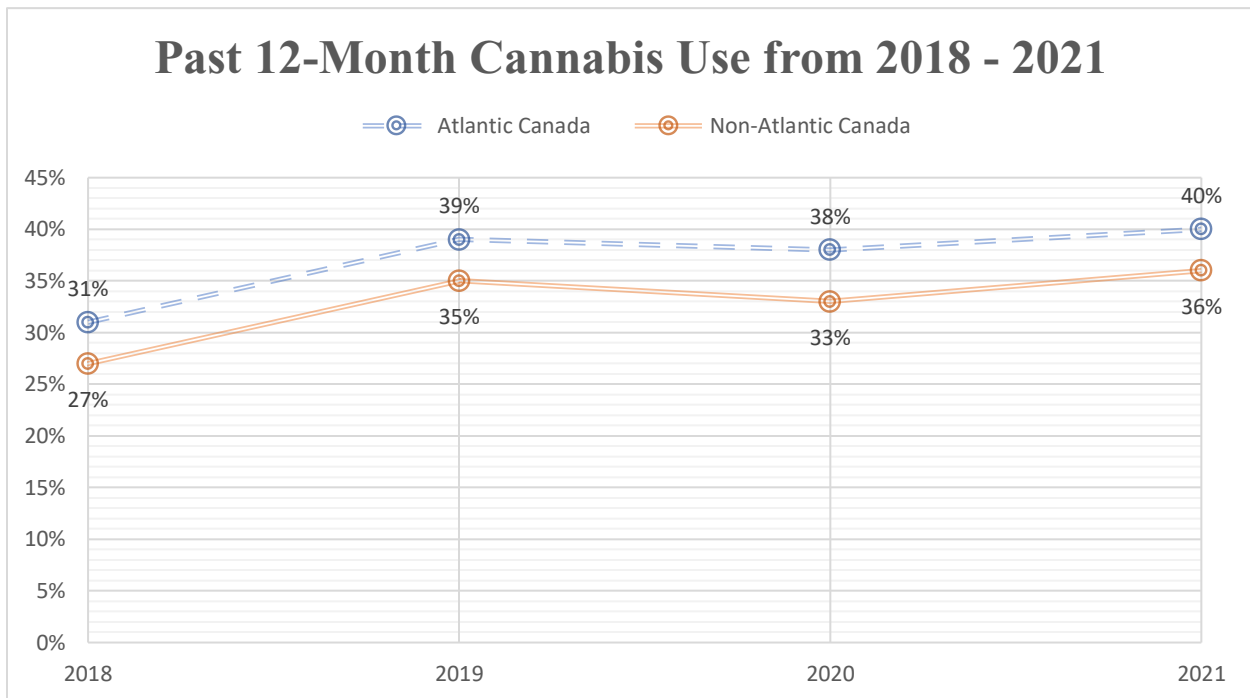


Figure 1: Past 12 months of cannabis use between Atlantic Canada and non-Atlantic Canada from 2018 to 2021 (n= 19, 685).

Smoking: Individuals from Atlantic Canada were significantly less likely to perceive smoking cannabis daily to be very high risk compared to those from non-Atlantic Canada (AOR= 0.744, 95% CI [0.680, 0.814], $p < 0.001$) (Table 2) (Figure 2). The most frequently reported level of perceived risk for smoking cannabis daily in Atlantic Canada was a moderate risk, with an increase between 2018 and 2019 (27%-30%) and relatively stable post-legalization (2019- 2021) (Figure2). Moreover, data collected post-legalization (2019-2022) showed that individuals were significantly less likely to perceive smoking cannabis daily to be very high risk compared to data collected pre-legalization (2018) (AOR= 0.737, 95% CI [0.706, 0.770], $p < 0.001$). However, the interaction term between jurisdiction and time was not statistically significant (AOR= 1.212, 95% CI [0.915, 1.606], $p = 0.181$). This suggests there was no difference in the change over time in the perceived risk of smoking cannabis daily between Atlantic Canadians compared to people in non-Atlantic provinces.

Table 2: Odds of perceiving the health risks of daily cannabis smoking in Atlantic Canada relative to non-Atlantic Canada after legalization.

Variable	Adjusted Odds Ratio (AOR)	95% CI	P-value
Jurisdictions			
Atlantic Canada	0.744	0.680, 0.814	$P < 0.001$
Non-Atlantic Canada	--ref--	--ref--	--ref--
Time			
After legalization	0.737	0.706, 0.770	$P < 0.001$
Before legalization	--ref--	--ref--	--ref--
Interaction term			
Atlantic Canada * After legalization	1.212	0.915, 1.606	$P = 0.181$
N= 46,812			

Model was adjusted for age group, sex at birth, education, ethnicity, and gross personal income. Sample size varies because the model excludes those who selected refuse to answer.

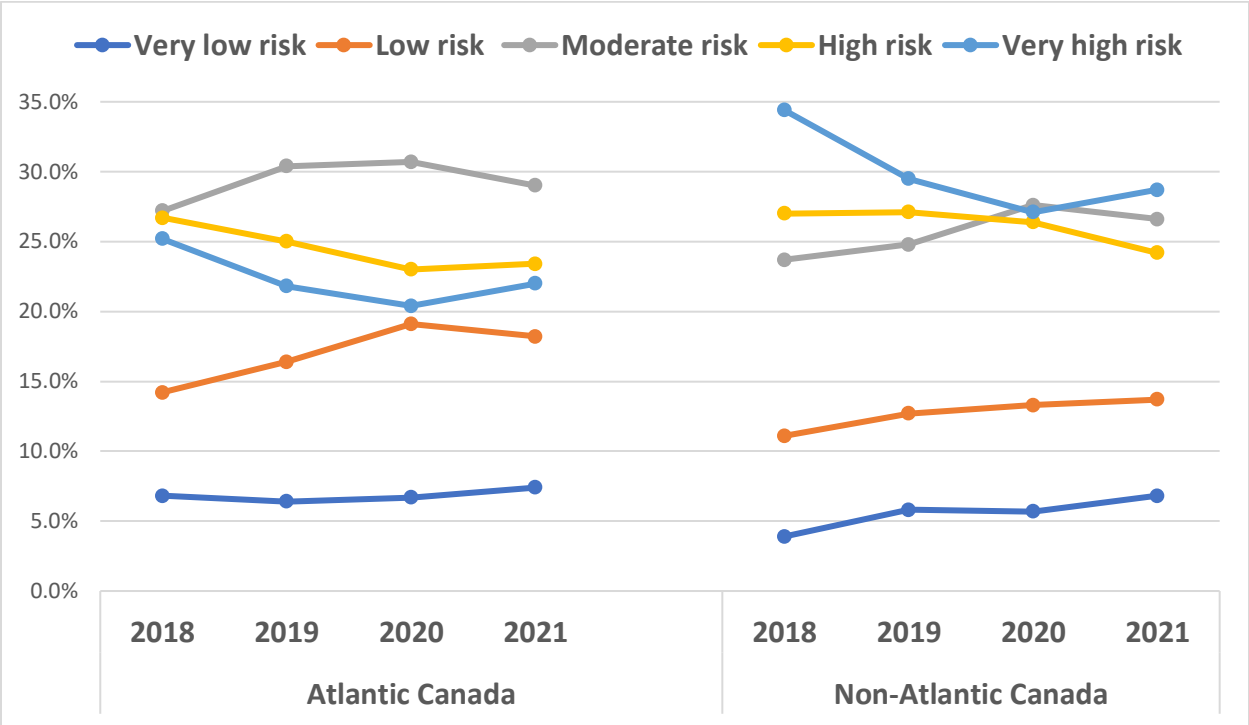


Figure 2: The health risk perception of smoking cannabis daily by Atlantic Canadians and non-Atlantic Canada from 2018-2021.

Vaping: Atlantic Canadians were significantly less likely to perceive vaping cannabis daily as very high-risk compared to non-Atlantic Canadians (AOR= 0.776, 95% CI [0.708, 0.851], $P < 0.001$) (Table 3) (Figure 3). In addition, the data from the period following legalization (2019-2021) revealed that individuals were significantly more likely to perceive vaping cannabis daily as a very high-risk activity compared to the data collected before legalization (2018) (AOR= 1.236, 95% CI [1.180, 1.295], $P < 0.001$). The coefficient on the interaction term suggests the change over time of perceiving daily cannabis vaping as a very high-risk activity was greater in Atlantic Canada compared to non-Atlantic Canada (AOR= 1.374, 95% CI [1.025, 1.841], $P < 0.05$).

Table 3: Odds of perceiving the health risks of daily cannabis vaping in Atlantic Canada relative to non-Atlantic Canada after legalization.

Variable	Adjusted Odds Ratio (AOR)	95% CI	P-value
Jurisdictions			
Atlantic Canada	0.776	0.708, 0.851	P < 0.001
Non-Atlantic Canada	--ref--	--ref--	--ref--
Pre/post status			
After legalization	1.236	1.180, 1.295	P < 0.001
Before legalization	--ref--	--ref--	--ref--
Interaction term			
Atlantic Canada * post-legalization	1.374	1.025, 1.841	P = 0.034
N= 44, 814			

Model was adjusted for age group, sex at birth, education, ethnicity, and gross personal income. Sample size varies because the model excludes those who selected refuse to answer.

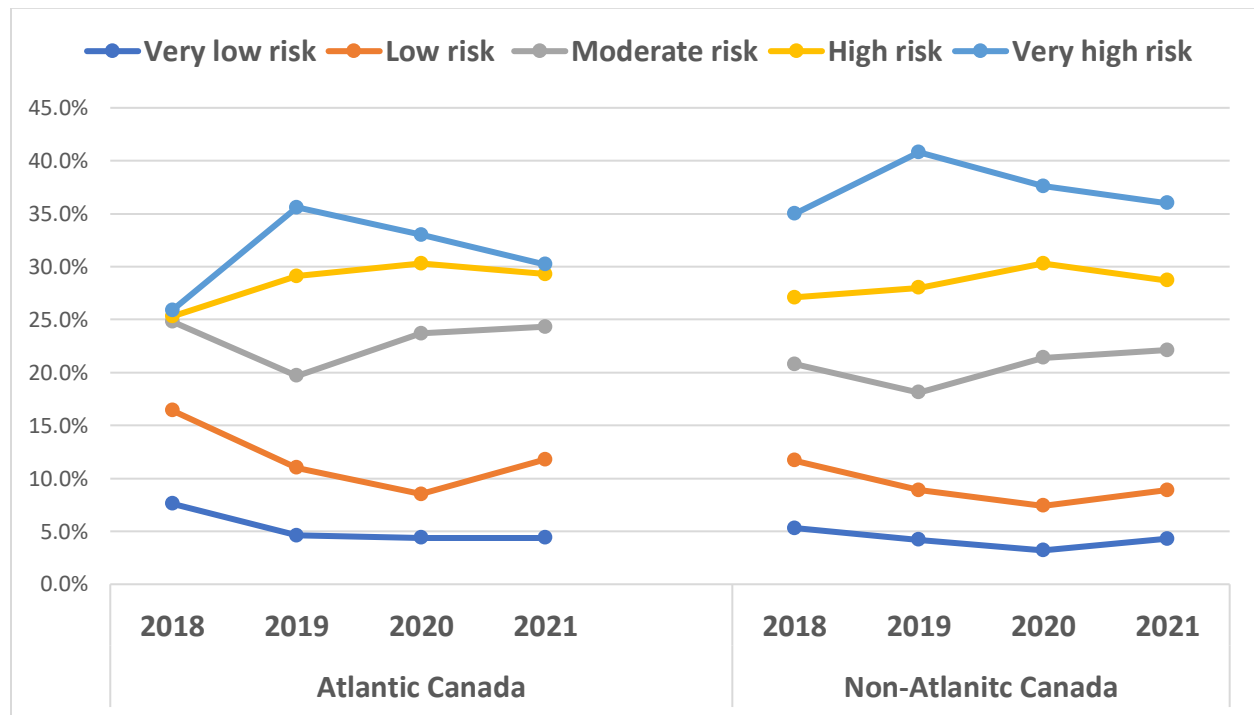


Figure 3: The health risk perception of vaping cannabis daily by Atlantic Canadians and non-Atlantic Canada from 2018-2021.

Edibles: Atlantic Canadians were significantly less likely to perceive consuming cannabis edibles daily as very high risk when compared to non-Atlantic Canadians (AOR= 0.733, 95% CI [0.668, 0.804], $P < 0.001$) (Table 4) (Figure 4). Daily consumption of cannabis edibles was most commonly perceived as a moderately risky activity by Atlantic Canada, while for non-Atlantic Canadians, the most frequently reported level of perceived risk by non-Atlantic Canadians was a very high risk (Figure 4) Additionally, post-legalization data (2019- 2021) showed that individuals were significantly less likely to perceive consuming cannabis edibles daily as very high risk in comparison to data collected before legalization (2018) (AOR= 0.729, 95% CI [0.697, 0.762], $P < 0.001$). However, the interaction between jurisdiction and time was not statistically significant (AOR= 1.305, 95% CI [0.974, 1.748], $P = 0.074$). This suggests that there was no difference in the change over time in the perceived risk of consuming cannabis edibles daily between Atlantic Canadians compared to people in non-Atlantic provinces.

Table 4: Odds of perceiving the health risks of daily consumption of cannabis edibles in Atlantic Canada relative to non-Atlantic Canada after legalization.

Variable	Adjusted Odds Ratio (AOR)	95% CI	P-value
Jurisdictions			
Atlantic Canada	0.733	0.668, 0.804	$P < 0.001$
Non-Atlantic Canada	--ref--	--ref--	--ref--
Pre/post status			
After legalization	0.729	0.697, 0.762	$P < 0.001$
Before legalization	--ref--	--ref--	--ref--
Interaction term			
Atlantic Canada * post-legalization	1.305	0.974, 1.748	$P = 0.074$

N= 44, 505

Model was adjusted for age group, sex at birth, education, ethnicity, and gross personal income. Sample size varies because the model excludes those who selected refuse to answer.

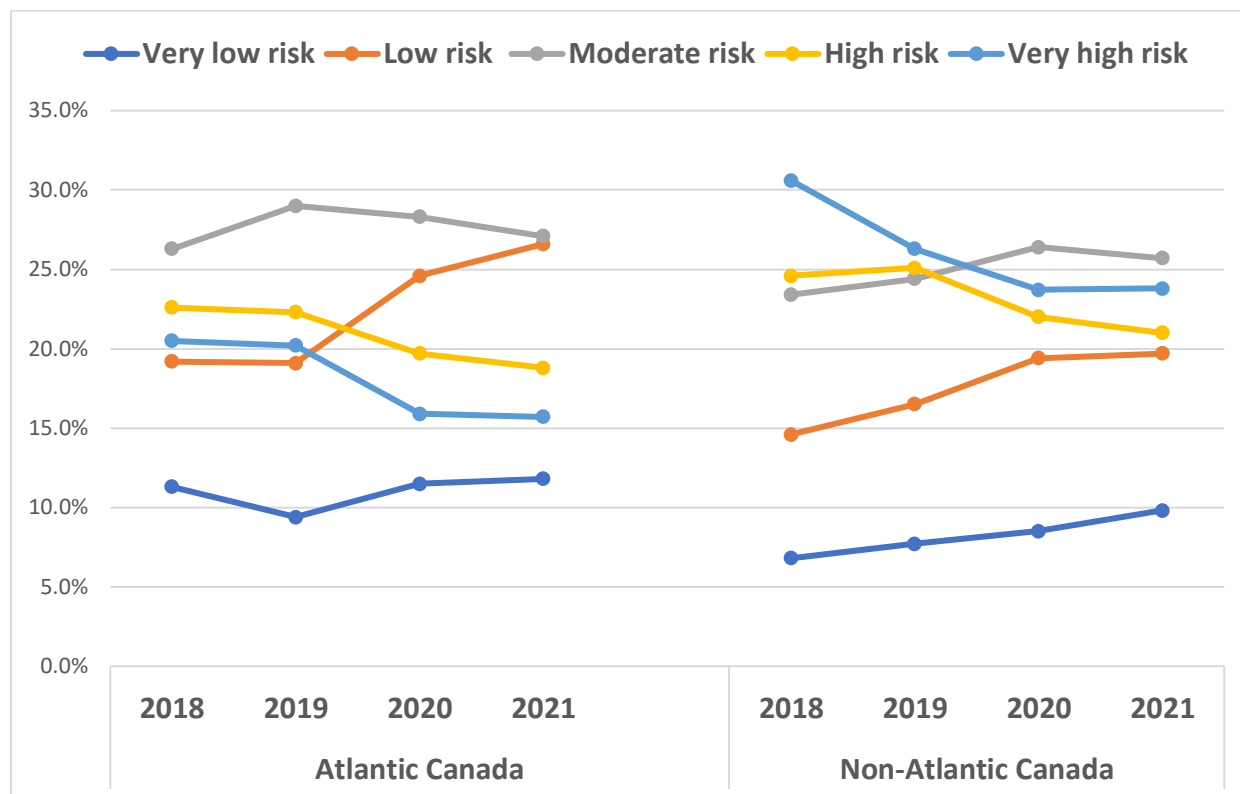


Figure 4: The health risk perception of consuming cannabis edibles daily by Atlantic Canadians and non-Atlantic Canada from 2018-2021.

Synthetic Cannabis: Atlantic Canadians were significantly less likely to perceive the daily use of synthetic cannabis to be very high-risk relative to non-Atlantic Canadians (AOR= 0.781, 95% CI [0.702, 0.869], $P < 0.001$) (Table 5) (Figure 5). Furthermore, the post-legalization data (2019- 2021) revealed that individuals were significantly less likely to perceive daily use of synthetic cannabis to be very high-risk relative to pre-legalization data (2018) (AOR= 0.837, 95% CI [0.794, 0.881], $P < 0.001$). However, the coefficient on the interaction between jurisdiction and time was not statistically significant (AOR= 0.978, 95% CI [0.693, 1.380], $P = 0.900$). This suggests that there was no difference in the change over time in the perceived risk of

using synthetic cannabis daily between Atlantic Canadians compared to people in non-Atlantic provinces.

Table 5: Odds of perceiving the health risks of using synthetic cannabis daily in Atlantic Canada relative to non-Atlantic Canada after legalization.

Variable	Adjusted Odds Ratio (AOR)	95% CI	P-value
Jurisdictions			
Atlantic Canada	0.781	0.702, 0.869	P < 0.001
Non-Atlantic Canada	--ref--	--ref--	--ref--
Pre/post status			
After legalization	0.837	0.794, 0.881	P < 0.001
Before legalization	--ref--	--ref--	--ref--
Interaction term			
Atlantic Canada * post-legalization	0.978	0.693, 1.380	P = 0.900
N= 35, 338			

Model was adjusted for age group, sex at birth, education, ethnicity, and gross personal income. Sample size varies because the model excludes those who selected refuse to answer.

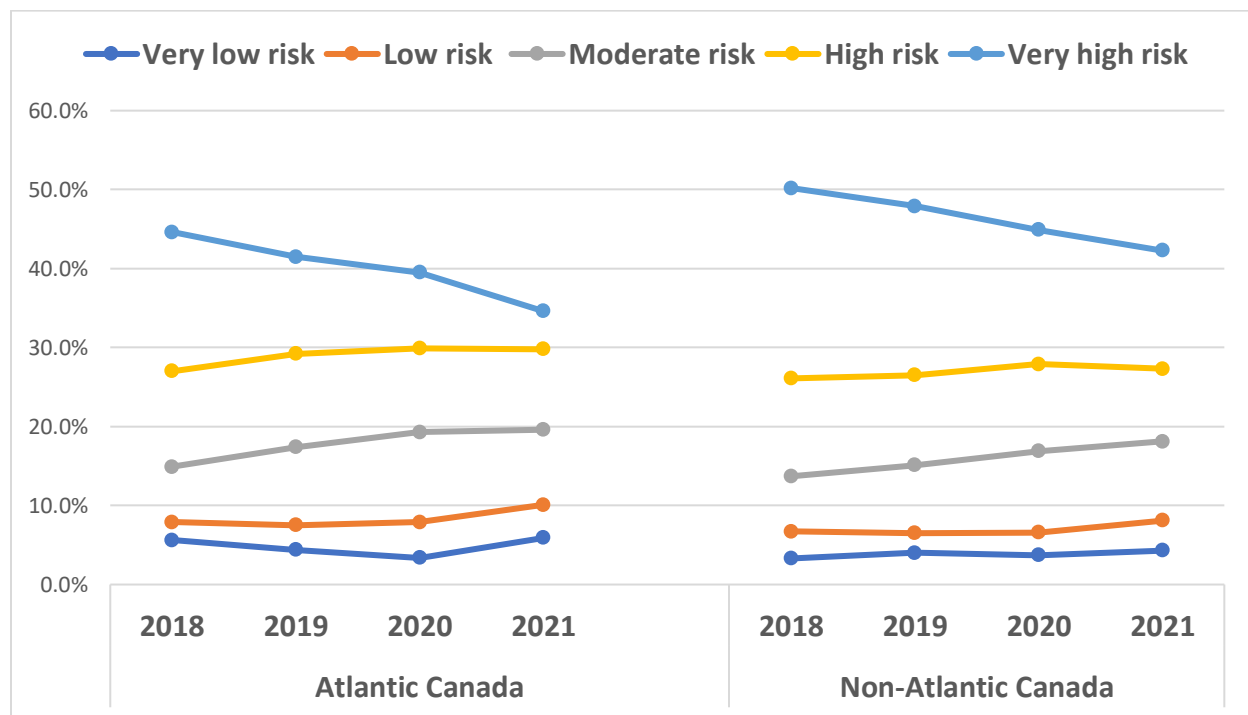


Figure 5: The health risk perception using synthetic cannabis daily by Atlantic Canadians and non-Atlantic Canada from 2018-2021.

High Potency Cannabis: Atlantic Canadians were significantly less likely to perceive the daily use of high-potency cannabis to be very high risk compared to non-Atlantic Canadians (AOR= 0.799, 95% CI [0.724, 0.881], P < 0.001) (Table 6) (Figure 6). In addition, data gathered after legalization (2019- 2021) indicated that individuals were significantly less likely to perceive the daily use of high-potency cannabis to be very high risk compared to before legalization (AOR= 0.760, 95% CI [0.724, 0.798], P < 0.001). However, the coefficient on the interaction between jurisdiction and time was not statistically significant (AOR= 1.327, 95% CI [0.968, 1.820], P = 0.079). This suggests that there was no difference in the change over time in the perceived risk of using high-potency cannabis daily between Atlantic Canadians compared to people in non-Atlantic provinces.

Table 6: Odds of perceiving the health risks of using high-potency cannabis daily in Atlantic Canada relative to non-Atlantic Canada after legalization.

Variable	Adjusted Odds Ratio (AOR)	95% CI	P-value
Jurisdictions			
Atlantic Canada	0.799	0.724, 0.881	P < 0.001
Non-Atlantic Canada	--ref--	--ref--	--ref--
Pre/post status			
After legalization	0.760	0.724, 0.798	P < 0.001
Before legalization	--ref--	--ref--	--ref--
Interaction term			
Atlantic Canada * post-legalization	1.327	0.968, 1.820	P = 0.079
N=40, 628			

Model was adjusted for age group, sex at birth, education, ethnicity, and gross personal income. Sample size varies because the model excludes those who selected refuse to answer.

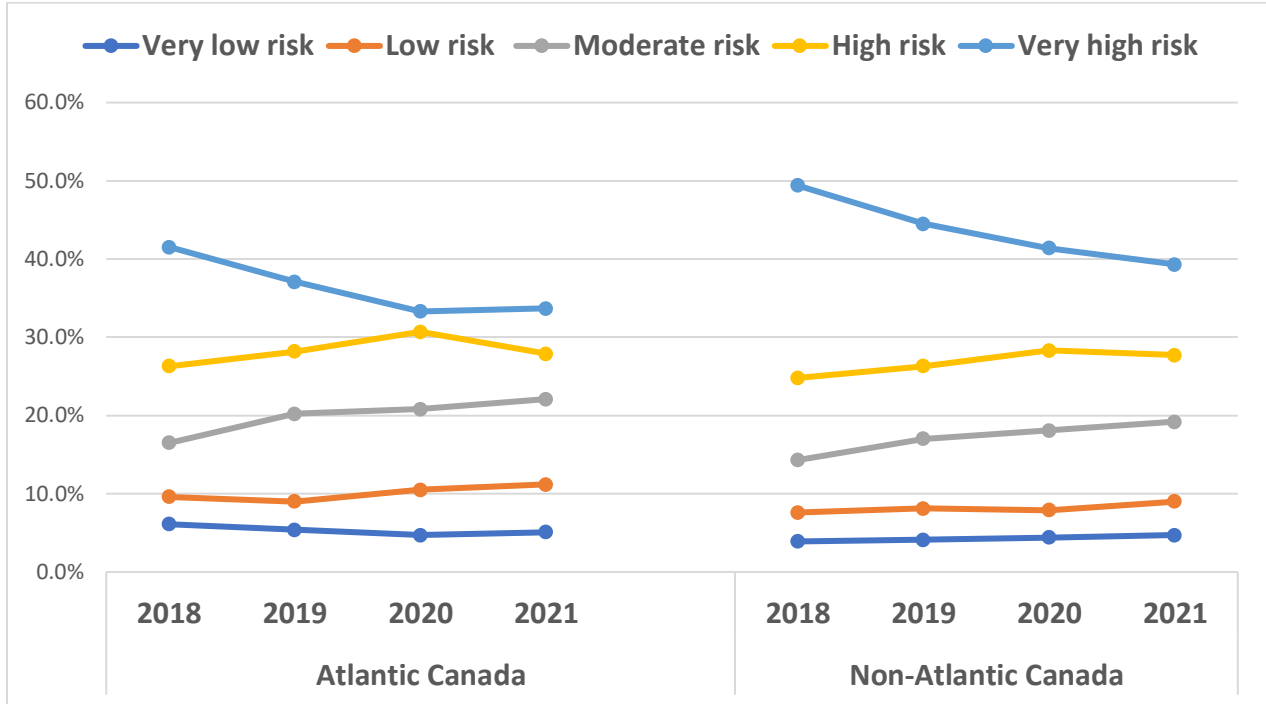


Figure 6: The health risk perception using high-potency cannabis daily by Atlantic Canadians and non-Atlantic Canada from 2018-2021.

2.4 Discussion

As the discourse on the influence of legalization on risk perception continues to progress, regional differences are often obscured or overlooked. This study has provided findings highlighting the dissimilarities in perceived risks associated with different cannabis consumption modes in Atlantic Canada. Utilizing population-based survey data, our current study has contributed to the emerging body of evidence on the impact of non-medical cannabis legalization on health risk perception of daily cannabis consumption modes in Atlantic Canada compared to non-Atlantic Canada. Firstly, the study indicated that overall non-medical cannabis legalization was associated with a decline in daily perceived risks of various daily cannabis consumption modes (smoking cannabis, consuming edibles, using synthetic cannabis, and using high-potency cannabis). Notably, the most significant declines were observed in perceived risk for the two

most popular modes, daily smoking and consumption of cannabis edibles (Hammond et al., 2022). However, only the perceived risk associated with daily cannabis vaping increased following legalization, with a stronger differential impact observed in Atlantic Canada. Additionally, the findings have highlighted notable regional differences, with Atlantic Canadians commonly perceiving daily smoking of cannabis and consumption of edibles as moderately risky compared to people from non-Atlantic provinces.

Our findings align with previous studies that have shown that cannabis legalization was significantly associated with a decrease in perceived risks of cannabis use (Cerdá et al., 2017; Schuermeyer et al., 2014; Wall et al., 2011). However, other studies (Estoup et al., 2016; Gilman et al., 2022; Laqueur et al., 2020) have yielded contrasting findings. In particular, a recent study has challenged these findings, suggesting that state-level non-medical cannabis legalization was not associated with the differential perception of cannabis risk (Gilman et al., 2022). However, our study examined the perceived risks of various cannabis consumption methods in the general population from a regional perspective. Nevertheless, our results have provided a unique perspective on the population's perceived risk of cannabis use by acknowledging the diversity in perceived risk across different forms of cannabis consumption modes. This is particularly relevant in the context of cannabis commercialization, where product availability and market preference continue to change amid the ongoing evolution of cannabis policies (Hammond et al., 2022). There is insufficient comparative research on perceived risks among various cannabis consumption modes, which may limit our understanding of developing effective and receptive public health campaigns.

Notably, our study found that daily cannabis vaping risk perception increased in Atlantic Canada. The heightening of the perceived risk associated with daily cannabis vaping observed

post-legalization may be due in part to the regulatory vaping measures and excessive news media reports on the E-cigarette or Vaping Products, Use Associated Lung Injury (EVALI) outbreaks. (CBC News, 2019; Centers for Disease Control and Prevention (CDC), 2020; CNN, 2019; Global News, 2019a). Consequently, in late 2019, each province and territory enacted regulatory measures to curb the use of vaping products, resulting in limited or restricted sales on or before January 2020 (Global News, 2019b; Government of Canada, 2021; National Post, 2019; Reuters, 2019). Decision makers in three of the four Atlantic Canadian provinces (NL recently eased restrictions in late 2022 (Vancouver Sun, 2022)) implemented some of the strictest vaping measures in the country. These stringent measures, particularly in Atlantic Canada, likely contributed to amplifying the differential change in risk perception in that region over time. Furthermore, research has indicated that the risk perception of vaping increased after EVALI outbreaks (Moustafa et al., 2021), and news of EVALI may have prevented vaping and encouraged vaping cessation among young people (Kreslake et al., 2022). Moreover, the heightened health risk perception of daily vaping may be explained through the agenda-setting theory, which posits that news media can shape public perceptions by prioritizing and framing issues in a particular way (Entman, 1993; McCombs et al., 2014). This highlights the vital role news media could play in health risk communication and the significant impact on shaping public perceptions of health risks (such as accidental overconsumption and pediatric cannabis poisoning) associated with cannabis use (Albalawi & Sixsmith, 2015; Jones, 2017).

Although the current research has highlighted the jurisdictional differences among the daily perceived risks between Atlantic Canada and non-Atlantic Canada, the underlying factors still need clarification. For example, Atlantic Canadians had lower perceived health risks of various modes of cannabis use than people from non-Atlantic provinces. A possible explanation

for this regional difference could be due to pre-existing liberal attitudes towards cannabis use in the Atlantic Canadian provinces before legalization. Research from the United States has indicated that the decline in the perceived harmfulness of cannabis may have contributed to increased support for cannabis legalization (Chiu et al., 2022). A survey conducted by Organigram a few months before legalization in Canada conveyed that Atlantic Canadian parents had a more lenient stance towards legalization than parents in other regions. In particular, parents in Atlantic Canada exhibited the strongest support for legalization, with 39% strongly supporting it and 52% not being concerned about it, compared with 60% of Canadian parents who were concerned about it (OrganiGram, 2018). This may suggest that this perception and attitude from Atlantic Canadians preceded cannabis legalization.

Our results have revealed some normalization of the perceived risk associated with daily cannabis consumption modes, particularly with daily smoking and daily edible consumption as legalization progresses. For instance, Atlantic Canadians most commonly viewed daily smoking and daily consumption of edibles as moderately risky, and this perception has become less intense as time passes. The lower perceived risk among Atlantic Canadians may reflect a greater degree of optimism bias within this population. This bias refers to the tendency for people to view their own health risk as lower than other people's (Arnett, 2000; Weinstein, 1987). This has been supported by studies which have suggested that lower perceived risk among cannabis consumers may be indicative of optimism bias (Goodman & Hammond, 2022; Leos-Toro et al., 2020; Wickens et al., 2019). Despite the well-documented evidence of the adverse health outcomes from smoking cannabis (Fischer et al., 2011; Government of Canada, 2018; National Academies of Sciences, Engineering, and Medicine, Division, et al., 2017), it was unexpected to observe a decrease in the perceived risks of this mode of consumption as legalization progressed.

Moreover, the traditional method of cannabis consumption by smoking is often perceived to be riskier than non-combustible cannabis products (Borodovsky et al., 2016; Johnson et al., 2016). The normalization of cannabis edibles is consistent with recent research indicating that cannabis edibles are potentially being used more frequently and that there is a general lack of awareness of the health risks associated with their use (Doran & Papadopoulos, 2019; Hammond et al., 2022; Reboussin et al., 2019).

The implications of our study may be significant for public health policies and cannabis education initiatives related to risks associated with various cannabis consumption modes, specifically in Atlantic Canada. Although harm reduction measures were introduced with the legalization of non-medical cannabis (Health Canada, 2020a), the findings highlight potential concerns about the gaps in public health messaging and risk communication related to the Lower-Risk Cannabis Use Guidelines (LRCUG). Furthermore, there is a high rate of non-compliance towards recommendations regarding the modes of cannabis consumption from the LRCUG (Lee et al., 2020). An evaluation of the current public health campaign strategies, particularly in Atlantic Canada, may address this notable disparity and ensure that health communication strategies are congruent with changes in cannabis policy and perceptions toward cannabis use. Furthermore, our results underscore the need for cannabis education campaigns to address potential risks associated with cannabis consumption modes. The need for cannabis education is further supported by recent research revealing a significant knowledge deficit in Canada regarding the health risks of cannabis, especially among frequent consumers (Goodman & Hammond, 2022).

2.5 Limitations:

Similar to much research in this field, this study is not exempt from limitations. This study has limitations associated with cross-sectional research, such as social desirability bias. Therefore, this study's findings should be interpreted cautiously, especially since survey data cannot support cause-and-effect conclusions. Social desirability bias refers to the tendency to underreport socially undesirable behaviours and overreport more desirable behaviours) (Latkin et al., 2017). Due to the historical illegal status of cannabis, social desirability bias has been a common concern in cannabis-related surveys, resulting in underreporting of cannabis-related behaviours (Hammond et al., 2020). Nonetheless, the legalization of the substance may have encouraged a softening of this bias. However, stigma is still present despite legalization (Reid, 2020), and therefore may still impact the responses from individuals, especially those from marginalized or typically stigmatized populations.

Moreover, it is important to take into account the potential limitation associated with the pre-legalization data point used in this study. The data from the ICPS 2018 survey was obtained approximately one month before the legalization of cannabis. Given the extensive news media coverage leading up to legalization, attitudes and perceptions related to cannabis may have been undergoing shifts as a result. Hence, it is possible that the 2018 data may not represent true pre-legalization risk perception or cannabis use behaviours. Furthermore, the limited pre-legalization data make it challenging to determine whether observed trends were cyclical or seasonal. Lastly, the ICPS survey (16-65) does not include people over 65 years old, resulting in an exclusion of the older population who historically have lower cannabis use (Government of Canada, 2022; Health Canada, 2018, 2019, 2020b; Statistics Canada, 2019). This absence of the older

population might account for the higher ICPS prevalence estimates compared to the national estimates (Hammond et al., 2020).

Although not expressly considered in the analysis, the timeframe for waves 3 (2020) and 4 (2021) coincided with the Coronavirus Disease 2019 (COVID-19) pandemic and may have introduced an additional factor that could have impacted the results. Lastly, given the omission of cannabis use as a controlled variable within our model, it is essential to recognize the possibility that unaccounted effects could skew current interpretation, especially in the context of the association between risk perception and cannabis use. Therefore, it is prudent to interpret our findings with caution.

2.6 Future research suggestions

In conjunction with our research findings, the gaps in the existing literature have created opportunities for future studies to explore the impact of cannabis legalization on health risk perception of daily cannabis consumption modes in Atlantic Canada. To build upon our findings, future research can examine the effectiveness of cannabis education and public health strategies to enhance cannabis health literacy in the Atlantic Canadian provinces. This type of research could contribute to informing policy evaluation and identifying specific strategies that could be better tailored to improve the cannabis health knowledge of this population. Secondly, given that the findings have indicated that the differences seen in Atlantic Canada between the two jurisdictions may have existed before legalization, future research may be necessary to explore potential reasons for these jurisdictional differences and fill this knowledge gap. Since our study did not investigate variations in sociodemographic factors like age and sex, examining these differences could be a valuable step toward understanding the observed disparities in the region.

2.7 Conclusion

Our study provides evidence of regional disparities in perceived risks of daily cannabis consumption modes, with Atlantic Canadians generally having a lower perceived risk compared to non-Atlantic Canadians. This seemingly suggests a greater level of optimistic bias and normalization in the Atlantic Canadian population, especially for the perceived risk of daily smoking and edible consumption. Interestingly, the general trend post-legalization was a decline in the perceived risk of all cannabis consumption modes except for daily cannabis vaping. Furthermore, the differential impact for the perceived risk of daily cannabis vaping was stronger in Atlantic Canada than in non-Atlantic Canada over time. This could be attributed to strict vaping measures in Atlantic Canada and news coverage of EVALI outbreaks. The study highlights the need for enhanced regional collaboration in Atlantic Canada to effectively address the decline in perceived risks, particularly with daily smoking and edible consumption. Decision-makers in the region should consider these findings as they can inform the development of regional-focused public health strategies and educational campaigns to ensure the public understands the potential health risks of consuming cannabis.

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Appendix:

List of survey questions from the International Cannabis Policy Study (ICPS) survey.

Sociodemographic Information

1. How old are you today?

1= 16- 25

2= 26- 35

3= 36- 45

4= 46- 55

5= 56- 65

2. What sex were you assigned at birth, on your original birth certificate?

1= Female

2= Male

3= Intersex

3. Which race category best describes you?

1= Black

2= East/ Southeast Asian

3= Indigenous

4= Latino

5= Middle Eastern

6= South Asian

7= White

8= Other (please specify)

4. What is the highest level of formal education that you have completed?

1= Less than high school

2= High school diploma

3= Some college/Technical

4= Bachelor's degree or higher

5. What was your total personal income (before taxes) over the past 12 months?

1= Less than \$20,000

2= \$20,000 to less than \$30,000

3= \$30,000 to less than \$40, 000

4= \$40,000 to less than \$50,000

5= \$50,000 to less than \$60,000

6= \$60,000 to less than \$70,000

7= \$70,000 to less than \$80,000

8= \$80,000 to less than \$90,000

9= \$90,000 to less than \$100,000

10= More than \$100,000

6. Which province or territory do you currently live in?

1= British Columbia

2= Alberta

3= Saskatchewan

4= Manitoba

5= Ontario

6= Quebec

7= New Brunswick

8= Nova Scotia

9= Prince Edward Island

10= Newfoundland and Labrador

11= Yukon

12= Northwest Territories

13= Nunavut

Perceived Risk of Cannabis Consumption Modes

1. In your opinion, what is the level of health risk from smoking marijuana daily?
 - 1= Very Low risk
 - 2= Low risk
 - 3= Moderate risk
 - 4= High risk
 - 5= Very high risk
2. In your opinion, what is the level of health risk from vaping marijuana daily?
 - 1= Very Low risk
 - 2= Low risk
 - 3= Moderate risk
 - 4= High risk
 - 5= Very high risk
3. In your opinion, what is the level of health risk from consuming marijuana edibles daily?
 - 1= Very Low risk
 - 2= Low risk
 - 3= Moderate risk
 - 4= High risk
 - 5= Very high risk
4. In your opinion, what is the level of health risk from using synthetic marijuana (e.g., spice, K2, K3, scene) daily?
 - 1= Very Low risk

- 2= Low risk
- 3= Moderate risk
- 4= High risk
- 5= Very high risk

5. In your opinion, what is the level of health risk from using high-potency marijuana concentrates daily?

- 1= Very Low risk
- 2= Low risk
- 3= Moderate risk
- 4= High risk
- 5= Very high risk

Co-authorship Statement

This manuscript is part of the first author's (Michael Blackwood) master's thesis and represents collaborative research endeavours with Dr. Jennifer Donnan, Dr. Lisa Bishop, Dr. Hai Nguyen, and Dr. David Hammond. All authors' contributions are outlined below:

- 1) **Michael Blackwood:** Conceptualization, Design, Methodology, Data Analysis, Writing- Original Draft, Writing- Review and Editing, Visualization.
- 2) **Dr. Jennifer Donnan:** Conceptualization, Design, Methodology, Data Analysis, Writing- Original Draft, Writing- Review and Editing, Supervision, Funding Acquisition, Intellectual Input and Critical Feedback.
- 3) **Dr. Lisa Bishop:** Conceptualization, Design, Methodology, Data Analysis, Writing- Original Draft, Writing- Review & Editing, Supervision, Funding Acquisition, Intellectual Input and Critical Feedback.
- 4) **Dr. Hai Nguyen:** Conceptualization, Design, Methodology, Data Analysis, Writing- Original Draft, Writing- Review and Editing, Supervision, Funding Acquisition, Intellectual Input and Critical Feedback.
- 5) **Dr. David Hammond:** Data Curation, Writing- Review and Editing, Intellectual Input and Critical Feedback.

We affirm that the co-authorship statement accurately reflects the significant contribution made by each author throughout the research process. We acknowledge that there are no conflicts of interest concerning this research and thesis publication. The manuscript is in preparation to be submitted for publication in the Drug: Education, Prevention, and Policy journal.

Chapter 3:

The Impact of Non-Medical Cannabis Legalization on Perceptions of Cannabis-Impaired Driving in Atlantic Canada

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Abstract

Background: Since non-medical cannabis was legalized in 2018, the Atlantic provinces have experienced higher cannabis use and increased cannabis-impaired driving in the region. This study investigated the impact of legalization on cannabis-related driving perceptions in Atlantic Canada relative to non-Atlantic Canada.

Methods: Using the International Cannabis Policy Study (ICPS) surveys from 2018-2021, a secondary cross-sectional analysis was conducted on 58,045 participants aged 16- 65 from Canada. We used ordinal logistic regression to examine the impact of legalization on the various driving perceptions in Atlantic Canada compared to non-Atlantic Canada.

Results: Regional differences were observed, with Atlantic Canadians having a lower perception of being stopped by police, decreased perceived risk of accident, and increased perceived ease in identifying cannabis intoxication relative to non-Atlantic Canadians. Passengers' likelihood of riding with an impaired driver was higher in Atlantic Canada. Post-legalization data suggest Canadians' perception of being stopped by police and perceived ease of identifying cannabis intoxication increased following legalization. Atlantic Canada's perceived risk of accidents and perceived efforts to prevent an intoxicated friend from driving were higher following legalization than non-Atlantic Canada.

Conclusion: Our findings suggested regional disparity for some driving perceptions. Legalization in Atlantic Canada led to increased awareness of accident risks and efforts to prevent impaired driving compared to non-Atlantic Canada.

Keywords: Marijuana, Cannabis, Driving Perception, DUIC, Atlantic Canada

3.1 Introduction

On October 17, 2018, Canada made history by becoming the first country among the Group of Twenty (G20) and the second globally, after Uruguay, to legalize and regulate cannabis for non-medical use (Government of Canada, 2018; Government of Uruguay, 2013). The Canadian Government's objectives in pursuing controlled legal access to cannabis are centred on protecting young Canadians, public health and safety, and eliminating the illicit market (Government of Canada, 2018). Prior to legalization, cannabis-attributable collisions in 2012 incurred a financial burden that ranged between 1.09 and 1.28 billion CAD, with up to 24,879 victims of property damages (destruction to physical possessions, i.e., vehicles) (Wettlaufer et al., 2017). Additionally, one study revealed concerning figures for cannabis-related crash deaths, with estimates ranging from 89 and 267 deaths in 2010 (Fischer et al., 2016). Consequently, there were concerns about how the legalization of non-medical cannabis may affect impaired driving rates in the country.

The higher cannabis consumption rate, coupled with the issue of impaired driving in the region, is raising concerns in Atlantic Canada. According to the 2021 Canadian Cannabis Survey (CCS), 29% of Atlantic Canadians had reported using cannabis in the past 12 months compared to the Canadian average of 25%. Notably, Newfoundland and Labrador (NL) and New Brunswick (NB) reported the highest rates in the Atlantic region at 31% (Health Canada, 2022). Moreover, daily or almost daily usage was higher in Atlantic Canada, with 32% of past 12-month cannabis users reported such use, compared to 26% among Canadians (Health Canada, 2022). Conversely, in 2019, the region experienced high rates of impaired driving from any substance, with a significant increase of 95% in NL, 56% in Prince Edward Island (PEI), and

53% in NB (Statistics Canada, 2021). Furthermore, cannabis is among the most frequently identified substances in drivers involved in serious crashes, making it the second most identified substance after alcohol among drivers who die in vehicular accidents (Beasley & Beirness, 2011; Beirness & Porath, 2019; Canadian Centre on Substance Use and Addiction, 2017). Cannabis metabolites can remain for up to 25 days in the body (Lowe et al., 2009), however, current research has suggested that THC levels in the blood at this timeframe are not reliable indicators of impairment (Ginsburg, 2019; Johnson et al., 2022). Further research may be needed to add nuance to the discussion around vehicular accidents and cannabis presence in the blood.

The high rates of cannabis use and drug impaired driving from all substances in the Atlantic Canadian provinces pose potentially serious public health and safety challenges in the region. These challenges can negatively affect multiple aspects of Canadian society, such as increased healthcare costs, decreased economic productivity, and increased strain on the criminal justice system (Canadian Substance Use Costs and Harms Scientific Working Group, 2018). To address these challenges, it is crucial for government agencies and other stakeholders to continuously evaluate and monitor policies to ensure that they can effectively manage emerging issues. This may include assessing and refining existing policies tailored to Atlantic Canada's population including the development of valid and reliable techniques for testing cannabis impairment. Continuous research is critical to better understand and identify effective strategies to prevent and reduce driving under the influence of cannabis (DUIC).

However, there is a lack of cannabis research conducted, particularly in the Atlantic Canadian region, where distinct regional factors may influence patterns of cannabis use (MacDougall & Maston, 2021). Recently, the Cannabis Health Evaluation and Research Partnership (CHERP) research group based in Atlantic Canada explored different aspects of

cannabis use and various cannabis-associated risks in NL (Bishop et al., 2022; Donnan et al., 2022; Josey et al., 2022). For example, a focus group study on the perceptions of youth and young adults from NL regarding DUIC showed that it had become normalized and socially acceptable for all types of motorized vehicles, including recreation vehicles (Donnan et al., 2022). Similarly, another Canadian study reinforced similar sentiments of normalization of DUIC, where former DUIC offenders believed that legalization was an indication that the government and society view cannabis as low risk regarding driving (Wickens et al., 2019). Additionally, besides the influence of social norms, higher impaired driving may be explained through other mechanisms such as lower risk perception of DUIC, perceived low risk of DUIC consequences, and difficulty assessing personal or others' impaired driving risk (Arterberry et al., 2017; Erin Goodman et al., 2020; McDonald et al., 2021).

Following the legalization of cannabis, there was a doubling in the prevalence of moderately injured drivers with a THC concentration of 2ng/mL or higher in British Columbia (Brubacher et al., 2022). Although a recent study suggested that cannabis legalization in Canada was not associated with increased traffic injuries (Callaghan et al., 2021), road safety remains a significant concern for many Canadians. According to a 2021 opinion poll conducted by the Canadian Automobile Association (CAA), 85% of Canadians thought that people who drove after using cannabis posed a serious threat to their safety (Canadian Automobile Association, 2021). To address this issue, the Government of Canada has committed over one hundred million dollars over six years (2018- 2024) to public education, awareness, and surveillance efforts related to cannabis use to help mitigate the impact on public health and road safety (Health Canada, 2018). Moreover, legal measures were implemented to address and deter the potential increase in DUIC cases. The Criminal Code of Canada was updated with the passing of Bill C-46

in June 2018 to include three new offences relating to DUIC and other drugs, with corresponding penalties (Government of Canada, 2019b). These policies aim to discourage DUIC and reduce road safety risks.

The evidence regarding the impact of non-medical cannabis legalization on driving perception is inconsistent. Some research indicated a weak to inconclusive association between legalization and driving perceptions. (Benedetti et al., 2021; Eichelberger, 2019; Lensch et al., 2020; Wadsworth & Hammond, 2018). For example, one study showed little evidence that non-medical cannabis policies were associated with higher odds of self-reported DUIC (Benedetti et al., 2021). As the discourse on the implication of cannabis legalization and road safety progresses, it is becoming increasingly vital post-legalization to monitor the population's driving perceptions because the intention to DUIC is considered the most significant predictor of future DUIC behaviour (Scott et al., 2021).

Given the higher prevalence of cannabis use in the Atlantic Canadian region, the current study was conducted to address the gap in the existing literature and contribute valuable regional insight. The present research had two primary objectives. Despite variations across Canada in retail models, the Atlantic provinces, excluding NL, adhere to a public retail model, emphasizing their shared approach within the diverse retail landscape in the country (Government of Newfoundland and Labrador, 2018; Statistics Canada, 2019) NL's retail model is a hybrid model, which is a mixed between public and private cannabis retail models (Government of Newfoundland and Labrador, 2018). Firstly, the study aimed to determine the prevalence of DUIC and the passengers' decision to ride with an impaired driver in Atlantic Canada compared to non-Atlantic Canada. Secondly, the study examined the impact of non-medical legalization in Atlantic Canada compared to non-Atlantic Canada on various driving perceptions, including the

likelihood of being stopped and charged by police, the ease of detecting impairment, the perceived risks of accidents caused by cannabis impairment, and the likelihood of preventing others from DUIC.

3.2 Methods

A secondary repeat cross-sectional analysis was conducted on data from the International Cannabis Policy Study (ICPS) survey from 2018 to 2021 to explore this study's central research objectives. Designed to evaluate the impact of cannabis policies at the national and provincial/state levels, the ICPS survey is a yearly cross-sectional survey initially conducted in Canada and the United States in 2018 and expanded to Australia and New Zealand in 2021 (Hammond et al., 2020, 2021). The scope of the ICPS survey encompassed topics such as cannabis use prevalence, DUIC, retail market, risk perceptions, and regulatory policies (Hammond et al., 2020).

3.2.1 Data Source and Collection

Survey data from the ICPS survey (Hammond et al., 2020) conducted in Canada from four distinct data collection periods called Waves 1, 2, 3 and 4 (2018-2021) were analyzed for this study. Recruitment of participants was done in the fall of each survey year. The survey was administered to recruited participants using Nielsen Consumer Insights Global Panel and their partner's panels via English or French. The Research Ethics Committee at the University of Waterloo reviewed and granted ethics clearance for the ICPS survey. Detailed information regarding the data collection method or technical reports can be found in a previously published paper (Hammond et al., 2020) and at <http://cannabisproject.ca/methods/>.

3.2.2 Participants

The requested data included all Canadian participants who were aged 16- 65 years old. Participants who either refused to answer or did not provide a valid response to the questions of interest were excluded from the current analysis. Missing data values were excluded from the analyses and appropriate weights were assigned to completed data to counter potential bias resulting from missing data. Using population census estimates from Statistics Canada (Statistics Canada, 2017, 2022a), post-stratification sample weights were constructed for Canadian participants (age-by-sex-by-province and education groups). Lastly, across the four ICPS survey years (2018- 2021), the American of Public Opinion Research (AAPOR) cooperation rate, which indicates the percentage of qualified participants who finished the survey, fluctuated between 61% and 64% (2018- 64%, 2019- 63%, 2020- 62%, and 2021- 61%) (American Association of Public Opinion Research (AAPOR), 2019; The International Cannabis Policy Study (ICPS), 2023).

3.2.3 Measures

The variables of interest for this study included socio-demographic information, cannabis use, and driving perceptions. Socio-demographic information in this study included: sex at birth, age group, ethnicity, jurisdiction, income, and education level. Additionally, the past 12-month cannabis use and cannabis use frequency were also explored for the current research. The driving perception measures were assessed using seven ICPS survey questions from the ‘Driving and Cannabis Use’ section of the survey. These include: i) DUIC, ii) a passenger riding with someone who had DUIC, iii) the likelihood of being stopped by police, iv) the likelihood to be charged by police, v) the likelihood of stopping a friend who is intoxicated from driving, vi) likelihood to determine if someone has consumed too much cannabis to drive, vii) likelihood to

perceive that DUIC increases the chances of having an accident. For a list of survey questions, see Appendix A.

3.3 Data analysis

In this study, we employed descriptive statistics to examine the sample characteristics and utilized Chi-square tests to assess the prevalence of DUIC and passengers' decision to ride with a driver under the influence of cannabis between Atlantic Canada and non-Atlantic Canada and four years period (2018- 2021). Five driving perception measures were ordinal with varying levels (Appendix A). Ordinal logistic regression was used to examine the association of legalization on risk perception in the Atlantic Canadian region compared to the non-Atlantic Canada population. All analyses were conducted using IBM SPSS statistical software (IMP Corp., 2021) to perform all analyses for the current study. The ICPS team created the survey weights by incorporating weighted data obtained from Statistics Canada (Hammond et al., 2020; Statistics Canada, 2017, 2022a)

The mathematical form of the ordinal regression model with an interaction term between jurisdiction and time variables is:

$$\text{logit}(P(Y \leq j)) = \beta_0 + \beta_1(\text{jurisdiction}) + \beta_2(\text{pre/post}) + \beta_3(\text{jurisdiction} \times \text{pre/post}) + \beta_4(\text{age}) + \beta_5(\text{sex}) + \beta_6(\text{ethnicity}) + \beta_7(\text{income}) + \beta_8(\text{education})$$

We explored the interaction term $\beta_3(\text{jurisdiction} \times \text{time})$, the variable of interest, to assess whether legalization had a differential impact on the five ordinal driving measures between Atlantic Canada and non-Atlantic Canada. From the regression models, we computed the

adjusted odds ratio (AOR), 95% confidence interval (CI) and assessed the Statistical significance of the interaction term through a p-value less than 0.05. By analyzing the AOR, we determined the strength and direction of the association between each predictor variable and the outcome variable. A value greater than 1 for the AOR indicates that legalization has a stronger effect on the outcome of perceived risks in Atlantic Canada compared to non-Atlantic Canada.

Conversely, an AOR less than 1 indicates a weaker impact of legalization in Atlantic Canada relative to non-Atlantic Canada. All models were adjusted for sex, age group, ethnicity, education, and gross income unless stated otherwise.

3.4 Results

Sample characteristics

Waves 1-4 of the ICPS surveys from 2018 to 2021 yielded 58,045 Canadian participants, with Atlantic Canadians comprising approximately 6.3% or 3,684 participants. Based on the weighting procedures, the proportions reflect the distribution of the actual population (Hammond et al., 2020). There were several regional distinctions observed between the two populations. Atlantic Canadians were older, with a mean age of 42.23 (SE=0.24) years, compared to the non-Atlantic Canadians, whose mean age was 40.61 (SE= 0.06). Interestingly, the most common age group among Atlantic Canadians was the 46-55 group, accounting for approximately one-fifth or more of that population. By contrast, the most common age group from non-Atlantic Canada was 26-35, which accounted for about one-fifth or more of that population. Additionally, both populations had relatively similar sex distribution, primarily white population, and one-third or more were college/university educated. However, the nuance in the data revealed that Atlantic Canadians were more racially diverse and had a higher distribution of people living in rural areas (Table 1).

Table 1: Weighted sample characteristics (n=58,045)

Baseline characteristics	Atlantic Canada (n=3684)				Non-Atlantic Canada (n=54361)			
	2018	2019	2020	2021	2018	2019	2020	2021
	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
Sex								
Female	50.3 (326)	50.3 (487)	50.3 (500)	50.2 (538)	49.8 (4686)	49.7 (7096)	49.7 (7343)	49.6 (7882)
Male	49.7 (323)	49.7 (481)	49.7 (494)	49.8 (534)	50.2 (4723)	50.3 (7191)	50.3 (7443)	50.4 (7998)
Age								
16-25	17.6 (114)	17.5 (170)	17.6 (175)	17.6 (186)	19.0 (1788)	18.9 (26970)	18.7 (2772)	18.4 (2919)
26-35	18.1 (118)	18.1 (175)	18.3 (182)	18.6 (200)	20.9 (1969)	21.1 (3016)	21.3 (3146)	21.4 (3400)
36-45	18.7 (121)	18.4 (178)	18.5 (184)	18.5 (199)	19.6 (1847)	19.8 (2835)	20.1 (2922)	20.4 (3243)
46-55	22.4 (145)	21.8 (211)	21.3 (212)	20.8 (223)	20.6 (1943)	19.8 (2827)	19.3 (2856)	19.1 (3029)
56-65	23.2 (150)	24.2 (235)	24.4 (243)	24.4 (262)	19.8 (1861)	20.4 (2912)	20.6 (3039)	20.7 (3289)
Ethnicity								
White	89.8 (583)	87.5 (847)	85.6 (851)	84.0 (900)	76.5 (7193)	72.2 (10314)	70.0 (10355)	66.9 (10618)
Other/Mixed/Unstated	10.2 (66)	12.5 (121)	14.4 (144)	16.0 (172)	23.5 (2215)	27.8 (3974)	30.0 (4430)	33.1 (5261)
Highest education level								
Less than high school	13.2 (85)	15.0 (144)	14.1 (139)	15.6 (165)	15.7 (1467)	15.7 (2211)	15.6 (2274)	15.6 (2441)
High school diploma	29.0 (187)	29.9 (287)	27.2 (267)	29.0 (307)	26.6 (2484)	26.5 (3748)	26.8 (3906)	26.6 (4177)
Some college/Technical	36.5 (235)	35.0 (336)	38.9 (381)	35.8 (380)	32.5 (3029)	32.6 (4600)	32.4 (4722)	32.5 (5103)
Bachelor's degree or higher	21.4 (138)	20.0 (192)	19.8 (194)	19.6 (208)	25.2 (2351)	25.2 (3563)	25.3 (3689)	25.3 (3970)
Population density								
Urban	69.7 (397)	71.8 (581)	70.3 (584)	70.0 (639)	88.8 (7479)	88.9 (10582)	90.3 (11195)	89.6 (12001)
Rural	30.3 (173)	28.2 (229)	29.7 (247)	30.0 (273)	11.2 (942)	11.1 (1321)	9.7 (1209)	10.4 (1394)
*Gross Personal Income								
Less than \$20,000	23.0 (131)	21.7 (185)	12.7 (109)	10.5 (98)	24.8 (2089)	21.1 (2683)	11.0 (1408)	10.8 (1527)
\$20,000 to less than \$30,000	14.2 (81)	12.7 (109)	10.3 (88)	10.0 (93)	10.3 (865)	11.3 (1441)	8.3 (1067)	10.5 (1478)
\$30,000 to less than \$40,000	11.8 (67)	11.6 (99)	9.5 (82)	11.0 (103)	9.9 (833)	10.0 (1266)	8.5 (1089)	8.2 (1160)

\$40,000 to less than \$50,000	11.0 (63)	11.8 (101)	9.4 (81)	8.8 (82)	8.6 (728)	9.8 (1242)	8.6 (1100)	8.7 (1229)
\$50,000 to less than \$60,000	9.7 (55)	9.1 (78)	11.3 (97)	9.8 (91)	9.4 (790)	9.4 (1191)	9.3 (1184)	9.4 (1330)
\$60,000 to less than \$70,000	6.3 (36)	7.4 (64)	7.8 (67)	9.4 (88)	7.4 (625)	7.7 (983)	7.4 (948)	8.2 (1154)
\$70,000 to less than \$80,000	5.5 (31)	5.3 (45)	7.6 (65)	7.0 (65)	6.0 (506)	6.5 (830)	7.1 (903)	6.8 (962)
\$80,000 to less than \$90,000	4.2 (24)	4.0 (34)	5.5 (47)	6.4 (60)	5.1 (432)	5.2 (667)	6.8 (863)	6.9 (974)
\$90,000 to less than \$100,000	4.5 (25)	4.9 (42)	6.5 (56)	7.6 (71)	5.7 (4820)	5.2 (657)	8.1 (1037)	7.5 (1061)
More than \$100,000	9.7 (55)	11.4 (97)	19.4 (167)	19.5 (182)	12.7 (1067)	13.9 (1765)	24.9 (3184)	22.8 (3204)
Frequency of cannabis use								
Never user	36.2 (235)	31.9 (308)	32.0 (319)	31.7 (340)	44.0 (4141)	38.4 (5490)	39.8 (5890)	38.5 (6111)
Used >12 months ago	32.8 (213)	29.1 (281)	30.0 (299)	28.3 (303)	28.7 (2701)	26.6 (3795)	26.3 (3895)	25.4 (4039)
Past 12-month user	10.4 (68)	12.6 (122)	11.9 (118)	11.7 (125)	8.5 (795)	11.3 (1608)	10.1 (1492)	9.2 (1467)
Monthly user	5.1 (33)	7.7 (74)	5.6 (55)	7.0 (75)	4.9 (457)	6.9 (990)	6.4 (953)	7.2 (1149)
Weekly user	4.3 (28)	5.9 (57)	6.0 (60)	5.6 (60)	5.2 (494)	5.6 (806)	5.7 (836)	6.1 (975)
Daily/almost daily user	11.2 (73)	13 (126)	14.5 (144)	15.8 (169)	8.7 (820)	11.2 (1598)	11.6 (1770)	13.5 (2139)

*Gross Personal Income variable had a significant number of missing data points and 'I don't know' responses, amounting to 6825 out of the 58,045 participants.

Prevalence of cannabis use and driving behaviours

The prevalence of self-reported DUIC in Atlantic Canada was slightly higher before legalization compared to non-Atlantic Canada (11.4% vs 10.2%). Post-legalization, the prevalence revealed slight fluctuations but remained relatively stable in Atlantic Canada and non-Atlantic Canada. However, non-Atlantic Canada, there was an observed a gradual increase in 2021 (11.8%) ($\chi^2=1.310$, $df=1$, $p= 0.252$). The chi-square test revealed no statistically significant difference in the prevalence of self-reported DUIC between Atlantic Canada and non-Atlantic Canada across the four years ($\chi^2=0.375$, $df=1$, $p= 0.540$) (Figure 1).

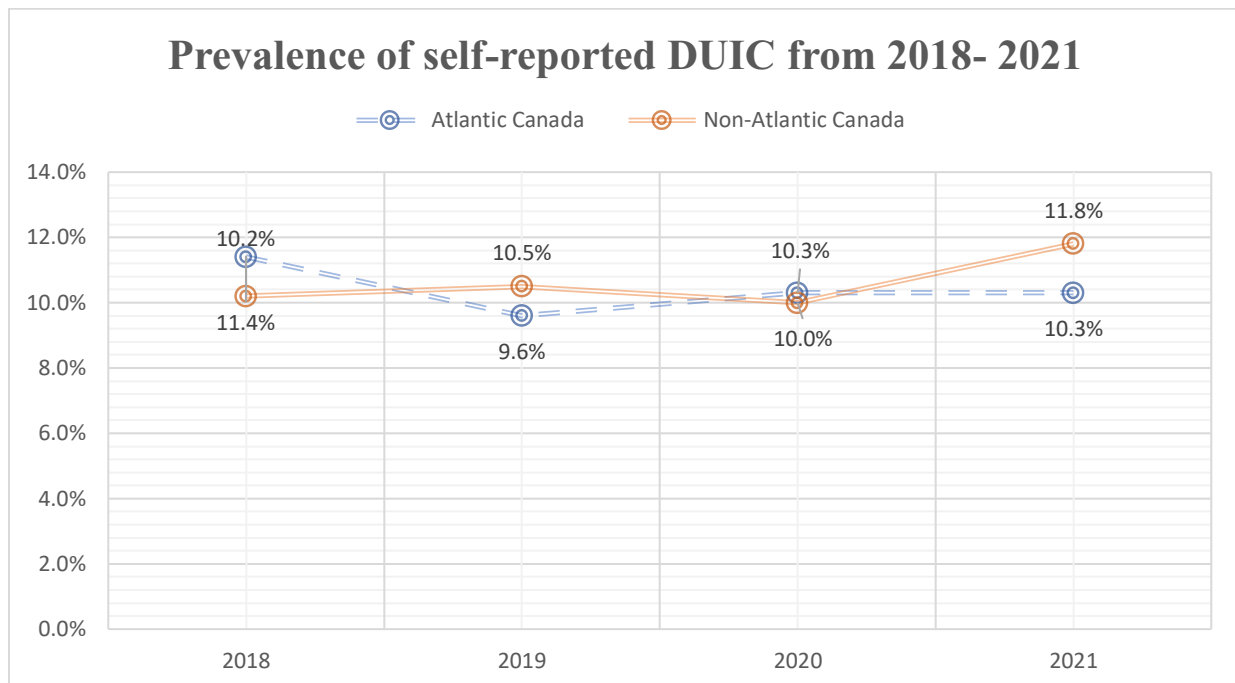


Figure 1: Prevalence of individuals who have driven a vehicle within 2 hours of using cannabis between Atlantic Canada and non-Atlantic Canada from 2018 to 2021 (n= 3,574).

There was a gradual decline in the prevalence of self-reported passengers' likelihood of riding with someone DUIIC in Atlantic Canada, from 18.3% in 2018 to 16.0% in 2021. Meanwhile, the prevalence in non-Atlantic Canada slightly increased from 13.0% in 2018 to 14.3% in 2021. Additionally, chi-square tests revealed a statistically significant difference between the two jurisdictions, with a higher prevalence in Atlantic Canada ($\chi^2=23.987$, $df=1$, $p<0.001$). Further analysis indicated a significant difference was seen in 2018 ($\chi^2=13.277$, $df=1$, $p<0.001$), 2019 ($\chi^2=5.817$, $df=1$, $p<0.05$), and 2020 ($\chi^2=7.331$, $df=1$, $p<0.05$), but not in 2021 ($\chi^2=2.00$, $df=1$, $p = 0.157$) (Figure 2).

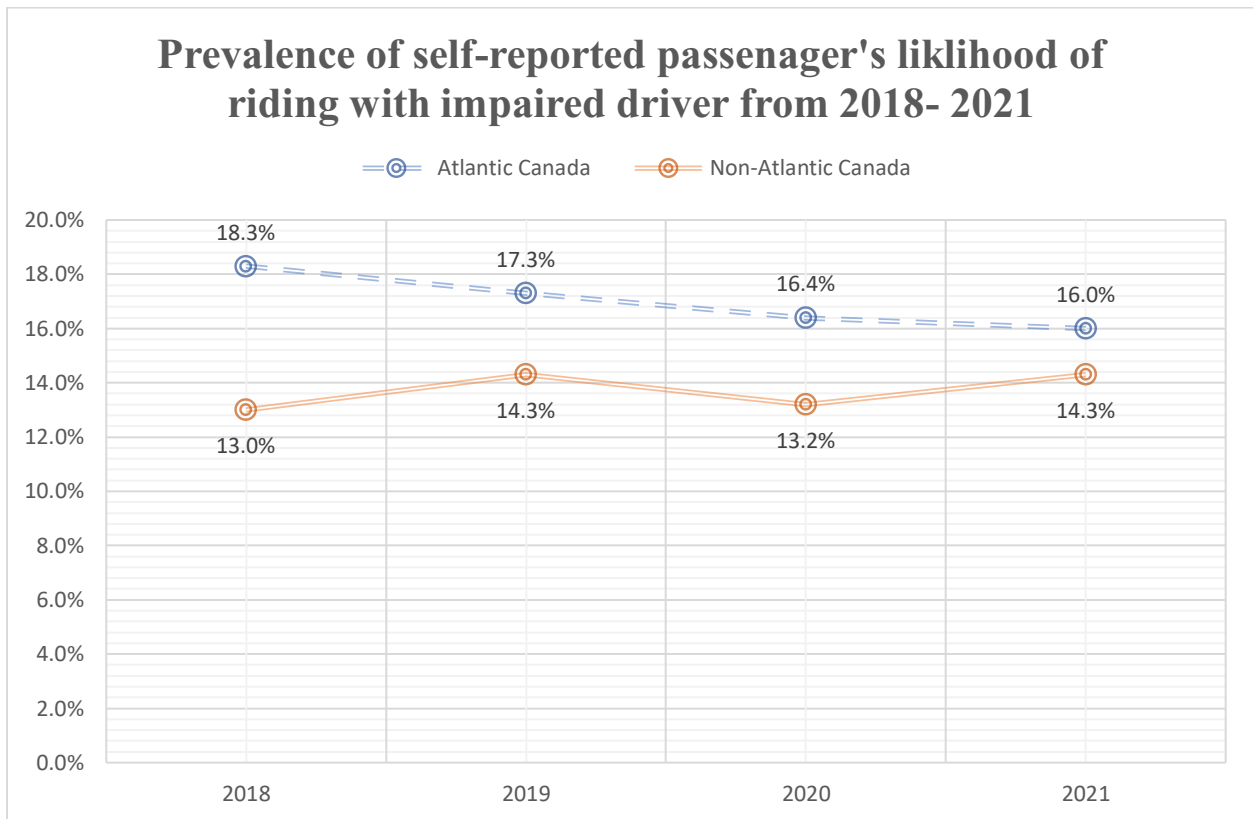


Figure 2: Prevalence of individuals who have been a passenger in a vehicle driven by someone who had been using cannabis in the last 2 hours between Atlantic Canada and non-Atlantic Canada from 2018 to 2021 (n= 3,574).

Driving perception related to cannabis use and driving

Likelihood to be stopped by police: Atlantic Canadians demonstrated a significantly lower perception of being stopped by the police while DUIC compared to individuals from non-Atlantic Canada (AOR=0.837, 95% CL= [0.763, 0.919], p<0.001) (Table 2). In addition, post-legalization data (2019-2022) revealed that individuals had a significantly higher perception of being stopped by law enforcement to be extremely likely compared to data collected pre-legalization (2018) (AOR=1.093, 95% CL= [1.045, 1.143], p<0.001). However, the coefficient on the interaction term between jurisdiction and time was not significant (AOR=0.892, 95% CL= [0.659, 1.207], p= 0.460). Although the results suggest that the odds of perceiving a higher likelihood of being stopped by the police increased after legalization, there was no difference in the change over time in this perception between Atlantic Canadians and non-Atlantic Canadians.

Table 2: Odds of perceiving being stopped by the police if driving under the influence of cannabis in Atlantic Canada relative to non-Atlantic Canada after legalization.

Variable	Adjusted Odds Ratio (AOR)	95% CI	P-value
Jurisdictions			
Atlantic Canada	0.837	0.763, 0.919	P < 0.001
Non-Atlantic Canada	--ref--	--ref--	--ref--
Time			
After legalization	1.093	1.045, 1.143	P < 0.001
Before legalization	--ref--	--ref--	--ref--
Interaction term			
Atlantic Canada * post-legalization	0.892	0.659, 1.207	P = 0.460

N=4 4, 549
 Model was adjusted for age group, sex at birth, education, ethnicity, and gross personal income. Sample size varies because the model excludes those who selected refuse to answer.

Likelihood to be charged by police: Atlantic Canadians’ perception of being charged by police if DUIC was not statistically different from those of non-Atlantic Canadians (AOR=0.963, 95% CL= [0.876, 1.059], p= 0.434), suggesting that there may be similar levels of perceived law enforcement (Table 3). However, when comparing participants before legalization (2018) to those after legalization (2019- 2021), the perception of being charged by law enforcement for DUIC was significantly higher following legalization (AOR=1.101, 95% CL= [1.051, 1.153], p < 0.001). The coefficient on the interaction term between jurisdiction and time was not significant (AOR=1.172, 95% CL= [0.871, 1.578], p = 0.294). The results suggest that while the odds of perceiving a higher likelihood of being charged by the police increased after legalization, there was no difference in this perception between Atlantic Canadians and non-Atlantic Canadians over time.

Table 3: Odds of perceiving being charged by the police if someone is driving while intoxicated in Atlantic Canada relative to non-Atlantic Canada after legalization.

Variable	Adjusted Odds Ratio (AOR)	95% CI	P-value
Jurisdictions			
Atlantic Canada	0.963	0.876, 1.059	P = 0.434
Non-Atlantic Canada	--ref--	--ref--	--ref--
Time			
After legalization	1.101	1.051, 1.153	P < 0.001
Before legalization	--ref--	--ref--	--ref--
Interaction term			
Atlantic Canada * post-legalization	1.172	0.871, 1.578	P = 0.294

N= 44, 046
 Model was adjusted for age group, sex at birth, education, ethnicity, and gross personal income. Sample size varies because the model excludes those who selected refuse to answer.

Likelihood to stop a friend who is intoxicated from driving: The findings revealed that Atlantic Canadians’ perception of trying to stop a friend from DUIC was not statistically

different from those of non-Atlantic Canadians (AOR=0.958, 95% CL= [0.862, 1.065], p=0.428) (Table 4). Furthermore, data collected post-legalization (2019- 2021) revealed that individuals’ perception of this outcome was not significantly different from those collected pre-legalization (2018) (AOR=1.008, 95% CL= [0.955, 1.064], p= 0.766). However, the coefficient on the interaction term between jurisdiction and time was significant for this perception (AOR=1.411, 95% CL= [1.034, 1.925], p < 0.05). This indicates that the change over time in the odds of people considering trying to stop an intoxicated friend is higher in Atlantic Canada relative to non-Atlantic Canada.

Table 4: Odds of considering trying to stop a friend from DUIC in Atlantic Canada relative to non-Atlantic Canada after legalization.

Variable	Adjusted Odds Ratio (AOR)	95% CI	P-value
Jurisdictions			
Atlantic Canada	0.958	0.862, 1.065	P = 0.428
Non-Atlantic Canada	--ref--	--ref--	--ref--
Time			
After legalization	1.008	0.955, 1.064	P = 0.766
Before legalization	--ref--	--ref--	--ref--
Interaction term			
Atlantic Canada * post-legalization	1.411	1.034, 1.925	P = 0.030

Model was adjusted for age group, sex at birth, education, ethnicity, and gross personal income. Sample size varies because the model excludes those who selected refuse to answer.

Likelihood to determine if someone has consumed too much cannabis to drive:

Atlantic Canadians’ perception of difficulty to determine if someone has consumed too much cannabis to DUIC was significantly lower compared to those individuals from non-Atlantic Canada (AOR=0.897, 95% CL= [0.819, 0.983], p< 0.05) (Table 5). Moreover, when comparing participants before legalization (2018) to those after legalization (2019- 2021), the odds were

significantly lower, demonstrating a decrease in this perceived outcome (AOR=0.835, 95% CL= [0.799, 0.873], $p < 0.001$). However, the coefficient on the interaction term between jurisdiction and time was not significant (AOR=1.013, 95% CL= [0.765, 1.343], $p = 0.927$). This suggested no difference in change over time for this perceived outcome between people in Atlantic Canada and those in non-Atlantic provinces.

Table 5: Odds of considering whether one can determine if someone has consumed too much cannabis to drive safely in non-Atlantic Canada relative to Atlantic Canada after legalization.

Variable	Adjusted Odds Ratio (AOR)	95% CI	P-value
Jurisdictions			
Atlantic Canada	0.897	0.819, 0.983	$P < 0.05$
Non-Atlantic Canada	--ref--	--ref--	--ref--
Time			
After legalization	0.835	0.799, 0.873	$P < 0.001$
Before legalization	--ref--	--ref--	--ref--
Interaction term			
Atlantic Canada * post-legalization	1.013	0.765, 1.343	$P = 0.927$
N= 44, 556			

Model was adjusted for age group, sex at birth, education, ethnicity, and gross personal income. Sample size varies because the model excludes those who selected refuse to answer.

Likelihood of perceiving that driving while intoxicated increases the chances of having an accident: Individuals from Atlantic Canada demonstrated a significantly lower perception that DUIC increases the possibility of having an accident compared to people from the non-Atlantic provinces (AOR=0.830, 95% CL= [0.750, 0.918], $p < 0.001$) (Table 6). Furthermore, the post-legalization data (2019- 2021) was revealed to be not statistically significant compared to pre-legalization (2018), suggesting that this perceived outcome did not differ between the periods (AOR=0.982, 95% CL= [0.932, 1.033], $p = 0.503$). However, the coefficient on the interaction term between jurisdiction and time was statistically significant for

this perceived outcome (AOR=1.525, 95% CL= [1.128, 2.060], $p < 0.05$). This finding indicated change over time in the odds of people perceiving that driving while intoxicated increases the chances of an accident is higher in Atlantic Canada than in non-Atlantic Canada after cannabis legalization.

Table 6: Odds of perceiving that driving while intoxicated increases the chance of having an accident in Atlantic Canada relative to non-Atlantic Canada after legalization.

Variable	Adjusted Odds Ratio (AOR)	95% CI	P-value
Jurisdictions			
Atlantic Canada	0.830	0.750, 0.918	$P < 0.001$
Non-Atlantic Canada	--ref--	--ref--	--ref--
Time			
After legalization	0.982	0.932, 1.035	$P = 0.503$
Before legalization	--ref--	--ref--	--ref--
Interaction term			
Atlantic Canada * post-legalization	1.525	1.128, 2.060	$P = 0.006$
N= 47, 722			

Model was adjusted for age group, sex at birth, education, ethnicity, and gross personal income. Sample size varies because the model excludes those who selected refuse to answer.

3.5 Discussion

Amidst the evolving cannabis legalization landscape in Canada, the exploration of DUIC perception often neglects the regional perspective. Using weighted population-based data, our current research has contributed to the existing literature on regional differences and the influence of cannabis legalization on driving perceptions. Findings from our analysis conveyed mixed results, yielding significant and non-significant driving perception outcomes when comparing across regions and over time periods. Firstly, cannabis legalization was associated with an increased perception of law enforcement (being stopped and being charged) and the ease of identifying cannabis intoxication. Secondly, the study highlighted notable regional differences, with Atlantic Canadians having a lower perception of being stopped by police, a

lower perceived risk of accident, and a lower perceived difficulty in identifying cannabis intoxication. Additionally, passengers' likelihood to ride with impaired drivers following legalization decreased in Atlantic Canada, whereas it slightly increased in non-Atlantic provinces. Nevertheless, it remained higher in Atlantic Canada compared to non-Atlantic Canada. Lastly, the results indicated that the perceived risk of accidents and perceived efforts to prevent an intoxicated friend from driving were higher in Atlantic Canada relative to non-Atlantic Canada post-legalization.

Similar to prior studies (Benedetti et al., 2021; Lensch et al., 2020), our research has demonstrated a mixed range of results. The limited literature provides some support for the lack of association or inconclusive nature between cannabis legalization and driving perceptions (Berg et al., 2018; Eichelberger, 2019). Indeed, countervailing forces may be at play for the lack of consensus in the literature. On one hand, there is the liberalization of cannabis and greater access from legalization, but also an increase in public education, public health strategies and enforcement. The latter may play a role in attenuating the negative effects of legalization on perceptions. Research from Lensch et al., (2020) has supported this hypothesis, as protective attitudes were higher in legalized states than in non-legalized states, likely due to increased public education efforts in legalized states.

Cannabis legalization had a stronger differential association with Atlantic Canadians' perceived risk of accidents and perceived efforts to prevent an intoxicated friend from DUI compared to people from non-Atlantic Canadian provinces. The heightened perceptions suggest that cannabis legalization may have positively impacted those driving perceptions. Additionally, legalization in Canada incorporated several public education initiatives. For instance, public awareness campaigns, like the 'Don't Drive High' campaign (Government of Canada, 2017),

implemented alongside legalization could have effectively reached the population and reduced negative DUIC behaviours. Furthermore, Atlantic Canada benefitted from an additional targeted awareness campaign centred on preventing impaired driving, which could have further influenced behaviours in the region (Mothers Against Drink Driving, 2019; Saltwire, 2023).

Although the effectiveness of deterrence campaigns on DUIC behaviour is lacking in the literature (Colonna, 2022), findings indicated that the relationship between legalization and DUIC behaviours is not affected by perceived legal risks but rather by perceived safety (Dutra et al., 2022). Earlier studies have validated this observation, indicating that most cannabis users have a very low perception of the legal risks (Davis et al., 2016; Matthews et al., 2009, 2014), further suggesting that legal consequences may not be as effective at deterring DUIC behaviours. Additionally, increased perceived awareness was observed from Atlantic Canadians, as they were significantly less likely to find it challenging to identify if one was impaired by cannabis to drive safely. This may imply that Atlantic Canadians were more likely to be aware of the signs of cannabis intoxication and may employ behavioural strategies to minimize or mitigate potential risks associated with DUIC.

As expected, individuals had a greater perceived likelihood of being stopped and charged by law enforcement following legalization. This is seemingly consistent with the Canadian government's significant investment in law enforcement in updating drug driving laws, improving cannabis detection methods, and enhancing public awareness (Government of Canada, 2019a, 2019b), resulting in greater perceived law enforcement presence. Therefore, it is not surprising to observe this trend. However, the differences in the perception of law enforcement regarding being stopped by police and the perceived risk of accidents between Atlantic Canadians and non-Atlantic Canadians highlight considerable regional disparity.

Atlantic Canadians had a lower perceived risk of law enforcement and lower perceived risk of accidents than people from non-Atlantic Canada. Gueye et al., (2023) findings suggested that rural/urban living context was a more reliable predictor of substance use and road-safety practices. Additionally, a study by Donnan et al., (2022) suggested that youths and young adults from NL revealed that the limited presence of law enforcement officers in rural areas is a potential contributory factor for choosing to DUIC. Given that approximately 45% of Atlantic Canadians live in rural communities (twice the national average) (Statistics Canada, 2022b), this potentially poses a challenge for the relevant authorities to enforce drug driving laws. Therefore, this underscores the need to consider rural/urban context and the availability of law enforcement resources in Atlantic Canada and similar rural areas.

Our findings may be significant in informing policy decisions and public safety initiatives in Atlantic Canada. Although the results showed few positive impacts on perceptions of DUIC post-legalization in Atlantic Canada, it might be premature to make a definitive conclusion considering the relatively short time since legalization and also when factoring in the countervailing forces at play. The evidence demonstrated some regional disparities between Atlantic Canada and non-Atlantic Canada for some driving perceptions. For instance, Atlantic Canadians had a lower perceived risk of accidents which may be indicative of a greater degree of comparative optimism bias in the region. This is supported by research from Wickens et al., (2019), which has suggested that comparative optimism bias may contribute to DUIC perception. Although further research may be required, targeted interventions and education awareness programs could be developed to address these disparities with a focus on the region's rural/urban context, drivers, and passengers. These findings highlight the important role of continuous public safety awareness initiatives to reduce risky driving behaviours and improve road-safety practices.

3.6 Limitations

Our research's reliance on cross-sectional data has limitations commonly associated with that study design. Therefore, caution should be taken when interpreting the research findings since survey data cannot establish causation but is limited to exploring associations.

Additionally, the research may be prone to sampling bias, which may have affected the accuracy and validity of the findings. The relatively small sample size for Atlantic Canada, coupled with the removal of non-responses, may have posed a challenge in detecting significant differences for some driving perception outcomes. Missing values for key outcomes for the total sample ranged from approximately 17% to 24%. Since our study did not adjust for cannabis use in the model, it is important to acknowledge that potential influences could arise from this unaddressed factor. Additionally, while we did not further explore differences in sociodemographic factors like age and gender, future studies could probe this area to better understand regional disparities.

The legalization of cannabis may have encouraged a reduction in social desirability bias. Social desirability bias refers to the tendency to underreport undesirable behaviours while overreporting more desirable attributes (Latkin et al., 2017). Stigma still exists post-legalization (Reid, 2020) and may have influenced the responses (underreporting) from individuals, especially those from vulnerable, stigmatized populations. Also, it is important to acknowledge the potential limitations of the pre-legalization data point utilized in this research. The ICPS survey's age range (16-65) inadvertently excludes data points from the older population (over 65 years old), thereby contributing to a limitation of our study. Furthermore, ICPS 2018 survey data were collected approximately one month before cannabis legalization. As a result, attitudes and behaviours related to cannabis and driving may have undergone changes, considering the extensive new media coverage prior to legalization. Therefore, it is likely that pre-legalization

data collected in 2018 may not represent an accurate snapshot of cannabis use and driving attitudes before legalization.

Lastly, as it related to the analyses, the models did not account for or controlled cannabis consumption nor did it explicitly address the impact of the Coronavirus Disease 2019 (COVID-19) pandemic in the model. Therefore, it is important recognized those unaccounted-for factors and exercise caution when interpreting our findings.

3.7 Future research suggestions

Future studies should examine additional aspects of cannabis legalization and driving perceptions in Atlantic Canada. Firstly, for instance future research should consider employing studies conducted in hospital settings and fatality crash data to complement self-reported surveys to gain a complete understanding of the DUIC prevalence in the region. Secondly, longitudinal studies could assess the sustained impacts of legalization on driving perceptions over a more extended period in the region. Thirdly, considering that the findings have suggested some significant differences between the two regions, future studies may be warranted to explore potential reasons for these jurisdictional differences. Since this research did not examine the sociodemographic differences among driving perceptions, future researchers could explore this further.

Despite limited research, evidence from other research suggests a correlation between passengers' decision to ride with an impaired driver and impaired driving (Beirness, 2014; Cartwright & Asbridge, 2011). This area could be further examined since results from our study indicated that passengers' decision to ride with an impaired driver was significantly higher in Atlantic Canada compared to non-Atlantic Canada before and after legalization. Additionally, it may be necessary to explore the effectiveness of current public safety campaigns aimed at

promoting safer driving practices and how Atlantic Canadians receive and interpret these initiatives compared to non-Atlantic Canada. Finally, given that the risk of impaired driving is higher when cannabis is consumed with alcohol (Gonçalves et al., 2022; Simmons et al., 2022), there is merit in delving into the use of concurrent or simultaneous substances (cannabis and alcohol) from a regional perspective.

2.9 Conclusion

Our research showed that data collected following legalization indicated an increase in the perception of law enforcement agencies and the ease of identifying cannabis intoxication by Canadians. Additionally, jurisdiction differences conveyed that Atlantic Canadians had a lower perception of being stopped by police, a lower perceived risk of accident, and a lower perceived difficulty for individuals to identifying cannabis intoxication. Regional differences may highlight a higher level of comparative optimism bias in Atlantic Canada, where optimism bias and normative influence have been linked to DUIC perception. Our research suggests that in Atlantic Canada, non-medical cannabis legalization resulted in an increased perceived risk of accidents and perceived efforts to prevent an intoxicated friend from driving compared to non-Atlantic Canada. Although the result showed few positive impacts in Atlantic Canada, there is a need for enhanced regional collaboration and continuous monitoring and evaluation to ensure policies are congruent with the practical realities and changing context.

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Appendix:

Appendix A: List of survey questions from the International Cannabis Policy Study (ICPS) survey.

ICPS) Survey Questions

Sociodemographic Information

1. How old are you today?

1= 16- 25

2= 26- 35

3= 36- 45

4= 46- 55

5= 56- 65

2. What sex were you assigned at birth, on your original birth certificate?

1= Female

2= Male

3= Intersex

3. Which race category best describes you?

1= Black

2= East/ Southeast Asian

3= Indigenous

4= Latino

5= Middle Eastern

6= South Asian

7= White

8= Other (please specify)

4. What is the highest level of formal education that you have completed?

1= Less than high school

2= High school diploma

3= Some college/Technical

4= Bachelor's degree or higher

5. What was your total personal income (before taxes) over the past 12 months?

1= Less than \$20,000

2= \$20,000 to less than \$30,000

3= \$30,000 to less than \$40, 000

4= \$40,000 to less than \$50,000

5= \$50,000 to less than \$60,000

6= \$60,000 to less than \$70,000

7= \$70,000 to less than \$80,000

8= \$80,000 to less than \$90,000

9= \$90,000 to less than \$100,000

10= More than \$100,000

6. Which province or territory do you currently live in?

1= British Columbia

2= Alberta

3= Saskatchewan

4= Manitoba

5= Ontario

6= Quebec

7= New Brunswick

8= Nova Scotia

9= Prince Edward Island

10= Newfoundland and Labrador

11= Yukon

12= Northwest Territories

13= Nunavut

Driving and Cannabis Use

1. Have you ever driven a vehicle (e.g. car, snowmobile, motor boat, or an off-road vehicle (ATV) within 2 hours of using marijuana?

1= Yes, in the past 12 months

2= No, not in the past 12 months

2. Have you ever been a passenger in a vehicle (e.g. car, snowmobile, motor boat, or an off-road vehicle (ATV) driven by someone who had been using marijuana in the last 2 hours?

1= Yes, in the past 12 months

2= No, not in the past 12 months

3. If someone drives after using marijuana, how likely are they to be stopped by the police?

1= Extremely unlikely

2= Unlikely

3= Neither likely nor unlikely

4= Likely

5= Extremely likely

4. If someone is stopped by the police after using marijuana, how likely are they to be charged?

1= Extremely unlikely

2= Unlikely

3= Neither likely nor unlikely

4= Likely

5= Extremely likely

5. If a friend was high and was going to drive, would you try to stop them?

1= I wouldn't do anything

2= I would tell them not to drive, but I wouldn't try to stop them

3= I would try a little bit to stop them from driving

4= I would try very hard to stop them from driving

6. Is it easy or difficult to tell if someone has had too much marijuana to drive safely?

1= Very easy

2= Easy

3= Neither easy nor difficult

4= Difficult

5= Very Difficult

7. Does driving high increase the risk of getting into an accident?

1= Not at all

2= A little

3= Somewhat

4= A lot

Chapter 4:

4.0 Overview

As more jurisdictions consider permissive cannabis policies, researchers and other stakeholders are increasingly concerned with understanding the implications of non-medical cannabis legalization on various aspects of society (Chiu et al., 2021). Perceived risks and driving perceptions can serve as important indicators to assess the impact of cannabis legalization on public health and safety. However, there still needs to be more substantive evidence in Canada, and by extension, in the Atlantic Canadian region. The presentation of national survey data can sometimes obscure or mask specific regional issues, ultimately hindering our understanding of potential policy impact on a regional level. Currently, cannabis research lags considerably behind cannabis policies (Pearlson et al., 2021), inadvertently resulting in knowledge and population gaps, particularly in smaller regions or limitedly funded areas. For instance, in the Atlantic region and the Canadian Territories (Northwest Territories, Yukon, and Nunavut), the 2022 prevalence of cannabis use in the past 12 months at 30% and 41%, respectively, surpass the Canadian average of 27% (Health Canada, 2022). However, research from those regions is routinely limited and often pales in comparison to the effort seen nationally or in highly funded areas. Given the considerable disparities in cannabis use, a need to prioritize tailored public health and safety intervention programs may be needed. Additionally, further research is warranted to address these regional disparities effectively.

The overall objective of this thesis was to examine the impact of cannabis legalization on the perceived health risks of daily cannabis consumption modes (smoking, vaping, consuming edibles, using synthetic cannabis, and using high-potency cannabis) and driving perceptions in

Atlantic Canada relative to non-Atlantic Canada. To achieve this objective, a secondary cross-sectional analysis was conducted on the International Cannabis Policy Study (ICPS) survey data (Hammond et al., 2020) collected from 2018 to 2021. According to the weighting procedures (Hammond et al., 2020), the proportions from research reflect the actual population distribution. For this thesis, two studies were conducted. Both studies employed similar methodologies but differed in the specific outcome being assessed. Study 1's outcome measure focused on the perceived risk of daily cannabis consumption modes (smoking, vaping, consuming edibles, using synthetic cannabis, and using high-potency cannabis), while Study 2 focused on various perceptions of driving and cannabis use. The data analysis employed was an ordinal logistic regression approach, focusing particularly on the interaction term, β_3 (jurisdiction x time). The interaction term, which was the variable of interest, was used to capture the differential effect of legalization on the outcome between Atlantic Canada relative to non-Atlantic Canada.

4.1 Summary of Findings

The first study (Study 1), which examined perceived health risks associated with five daily cannabis consumption modes (smoking cannabis, vaping cannabis, consuming cannabis edibles, using synthetic cannabis, and using high-potency cannabis), revealed six key findings:

- i) Overall, cannabis legalization was associated with a reduction in perceived risk for four out of the five cannabis consumption modes (smoking cannabis, consuming edibles, using synthetic cannabis, and using high-potency cannabis).
- ii) The perceived risk from daily cannabis vaping was associated with increased risk perception; however, this change in risk perception was notably higher in Atlantic Canada than in non-Atlantic Canada over time.

- iii) The most significant risk perception reductions over time (pre-compared to post-legalization) were observed for smoking cannabis daily and consuming cannabis edibles daily.
- iv) Atlantic Canadians had a lower perceived risk of daily cannabis consumption modes than individuals from non-Atlantic Canada, indicating notable regional disparities.
- v) Atlantic Canadians' most commonly perceived daily smoking of cannabis and consumption of edibles as moderately risky, in contrast to non-Atlantic Canadians, who commonly viewed these risk perceptions as very high risk.
- vi) Atlantic Canadians' past 12-month cannabis use prevalence was significantly higher than non-Atlantic Canadians across all four years.

In the second study (Study 2), which examined driving under the influence of cannabis (DUIC) perceptions, four notable findings were identified:

- i) Overall, cannabis legalization was significantly associated with an increased perception of law enforcement (being stopped and charged by police) and an increased perceived ease in identifying cannabis intoxication.
- ii) Over time, Atlantic Canadians exhibited a greater increase in the perceived risk of accidents and perceived efforts to prevent an intoxicated friend from driving compared to non-Atlantic Canadians.
- iii) Atlantic Canadians had a lower perception of being stopped by police, a lower perceived risk of accidents, and increased perceived ease in identifying cannabis intoxication relative to non-Atlantic Canadians.
- iv) Passengers' likelihood to ride with impaired drivers following legalization decreased in Atlantic Canada, whereas it slightly increased in non-Atlantic provinces; nevertheless, it remained higher in Atlantic Canada compared to non-Atlantic Canada.

4.2 Discussion

Both studies have contributed to the current emerging cannabis literature and provided insights into legalization's potential impact on public health and safety in Atlantic Canada. Collectively, there were observed variations in the impact of legalization between the two studies. In particular, following legalization, Atlantic Canadians exhibited heightened perceived risk from daily cannabis vaping in Study 1 and heightened perceived risk of accidents and perceived efforts to prevent an intoxicated friend from driving in Study 2, compared to non-Atlantic Canada. Given that only a handful of countries have a national framework for the legalization and regulation of non-medical cannabis (Government of Canada, 2018; Government of Malta, 2021; Government of Uruguay, 2013), the research on how policies might impact different regions within the same country is generally lacking. Furthermore, the regional perspectives (especially for Atlantic Canada) are often scarce or absent from the literature, resulting in a significant gap in population and knowledge research from the region. Hence, there is a dire need to address the research gap and explore cannabis policy implications at a regional level.

In Study 1, which examined perceived health risks associated with daily cannabis consumption modes, our findings were mostly consistent with previous research that has shown that cannabis legalization was significantly associated with a decrease in perceived risks of cannabis use (Cerdá et al., 2017; Schuermeyer et al., 2014; Wall et al., 2011). Despite some similarities, none of the studies explored differences between specific cannabis consumption modes or regional differences. The comparative research on the perceived risks of different cannabis consumption methods is limited, with emphasis on the overall perceived risk of cannabis use (Leos-Toro et al., 2020). This is an area that holds much potential for future

research undertakings. Additionally, jurisdictions that are considering cannabis legalization should prioritize creating their population-specific research in this perceived risk domain (cannabis consumption modes) to inform public health initiatives and policies effectively.

In Study 2, which examined risk perceptions associated with DUIC, our findings were mixed, which is also reflected in the published literature (Benedetti et al., 2021; Lensch et al., 2020). For instance, research from Lensch et al., (2020) conveyed that legalized states showed a higher occurrence of DUIC, while also displaying increased protective attitudes towards DUIC. It is possible that the mixed or contradictory results from the literature could be due to the countervailing mechanisms. That is, on the one hand, there is the liberalization of cannabis resulting in the normalization of DUIC, as evidenced by research from Wickens et al., (2019). On the other hand, there has been a concurrence increase in public education, public health strategies, and enforcement which could counterbalance any negative effects of legalization. Nonetheless, our study added a regional lens on the impact of legalization on DUIC perceptions in Atlantic Canada. The findings from this thesis can serve as a catalyst for further regional research in Atlantic Canada and in other jurisdictions considering cannabis legalization around the globe.

Additionally, regional differences were a common theme within the two studies between Atlantic Canadians and non-Atlantic Canadians. Regional disparities observed from both studies may be an indication of a higher degree of comparative optimism bias from Atlantic Canadians. As research findings have suggested, cannabis consumers' lower risk perception has been linked to optimism bias (Goodman & Hammond, 2022; Leos-Toro et al., 2020; Wickens et al., 2019). Furthermore, the thesis, similar to other national surveys (Health Canada, 2022), has demonstrated higher proportions of past 12 months of cannabis use in Atlantic Canada compared

to the rest of the country. It is also possible that risk perceptions are generally lower in Atlantic Canada than in non-Atlantic Canada because there are more cannabis consumers in Atlantic Canada.

It is worth noting that Atlantic Canadians generally exhibited lower risk perceptions (for the various cannabis consumption modes and some driving perceptions) and higher cannabis use prevalence compared with non-Atlantic Canadians. Although this observation was not the primary focus of the thesis (i.e., it was not statistically tested), the association aligned with previous studies in the literature that have substantiated the inverse relationship between cannabis use and risk perception (Johnston et al., 2017; Parker & Anthony, 2018; Salloum et al., 2018). That is, individuals who perceive a lower risk of cannabis use were more likely to use cannabis and vice-versa (Johnston et al., 2017; Parker & Anthony, 2018; Salloum et al., 2018). This association could warrant further research to assess how this relationship may change over time within the region, especially from the lens of the perceived health risk of each cannabis consumption mode. Understanding this relationship and other factors could be central to interpreting the impact of legalization, as it could: i) decrease the risk perception leading to more consumption, or ii) increase consumption due to greater access, lower prices and other factors (Chiu et al., 2021).

4.3 Research implications

One of the ultimate goals of non-medical cannabis legalization was to safeguard Canadians' public health and safety by minimizing the health and social risks associated with cannabis use (Government of Canada, 2018; Health Canada, 2016). Research can help in the evaluative process and identify the unintended consequences of these policies so that they can be further refined. The findings from this research may have significant implications for public

health and safety campaigns and contribute to the existing cannabis literature in Atlantic Canada.

Possible implications are as follows:

1. **Cannabis Education Initiatives:** The findings of our research indicated that cannabis legalization is associated with a decline in the perceived health risks associated with various cannabis consumption modes. Given that earlier research has demonstrated that individuals' perception of harm could be influenced by their limited knowledge and belief (Weinstein, 1999), targeted cannabis education initiatives could be promising in addressing these knowledge gaps. Cannabis education programs could be developed with a focus on the health risks (physical and mental) of different cannabis consumption modes. Moreover, the urgency to take action is further highlighted by recent research conducted by Goodman & Hammond, (2022), which revealed a significant knowledge deficit in Canada regarding the health risks of cannabis, especially among frequent consumers. These initiatives could prioritize the promotion of evidence-based information to enable people to make low-risk, informed decisions about their modes of cannabis use as well as cannabis use overall.
2. **Public Health Communication:** Prior evaluation by the Government of Canada had demonstrated that public education campaigns were moderately successful in reaching the target audience (youths and young adults) (Health Canada, 2018a). However, our findings, which indicated a regional disparity, may call those evaluations into question, as they may suggest that this success was not consistent across the country. In addition, although harm reduction guidance, like the Lower-Risk Cannabis Use Guidelines (LRCUG) (Fischer et al., 2011, 2017), have been promoted by the government, our results may call into question how these promotions may be received by the population,

especially on a regional level. Prior research indicated that recommendations from the LRCUG on modes of cannabis consumption have the highest rate of non-compliance among cannabis users (Lee et al., 2020). This may possibly suggest potential gaps in public health messaging and health risk communication around the cannabis consumption modes. Future research is warranted in identifying factors contributing to the gaps and exploring strategies to improve the effectiveness of public health messaging, especially on a regional level (Atlantic Canada).

- 3. Public Safety Campaigns:** Notably, our research findings indicated regional disparities between Atlantic and non-Atlantic Canada among driving perceptions (perception of being stopped by police, perception of risk of accidents, and passengers' likelihood to ride with a driver DUIC). Given the unique geographical landscape of Atlantic Canada, with 45% of the region being rural (twice the national average) (Statistics Canada, 2022b), public safety campaigns should consider the urban and rural context when designing and implementing these campaigns. By acknowledging specific challenges to the region (such as law enforcement resources), safety campaigns may be better equipped to address the concerns of the population. Additionally, further research may be needed to identify other factors that may contribute to the regional disparities and to develop more focused strategies in an Atlantic Canadian context.

4.4 Limitations

Our analyses have several limitations. Cross-sectional survey data can only denote association and not the causal relation between legalization and risk perception, as noted in Chapters 2 and 3. Furthermore, as the Atlantic Canada sample in the survey was relatively small, which was further reduced when participants who refused to answer research-relevant questions

were excluded from the analysis, there may be sample selection bias which might impact the validity and reliability of the findings. In addition, although the legality of cannabis might have aided the reduction of social desirability bias, stigma is still present post-legalization (Reid, 2020). Therefore existing stigma may influence how individuals responded to questions, leading to social desirability bias, especially those from vulnerable populations. However, survey data remains the most feasible method of capturing cannabis-related data and is used by many national surveys (Hammond et al., 2020).

Furthermore, ICPS 2018 Wave 1 was collected approximately one month prior to legalization. Given the media attention around that time, it is possible that Wave 1 may have yet to encapsulate an accurate snapshot of pre-legalization sentiment. As posited by the agenda-setting theory, the new media can shape the perception (Entman, 1993; McCombs et al., 2014), and it is possible for perceptions and behaviours to be undergoing shifts as a result. In addition, the limited pre-legalization data made it challenging to elucidate whether trends observed post-legalization were also occurring before legalization. Additionally, the ICPS survey age range (16-65) may pose another limitation since it excluded individuals over 65. This exclusion could explain the reason ICPS prevalence estimates are elevated compared to national estimates (Government of Canada, 2022; Hammond et al., 2020). As our study did not adjust for cannabis use and the impact of the Coronavirus Disease 2019 (COVID-19) pandemic in our models, it is important to interpret findings with caution as potential influence could arise from this unaccounted factor.

Another limitation is that while the thesis found regional disparities between Atlantic Canada and non-Atlantic Canada for perceived risks and cannabis use prevalence, it did not provide reasons for the existence of these observed differences. Further research is needed to

account for this variation. Lastly, the findings from this thesis may only be generalized within the targeted population, which may limit the external validity in other populations. As noted by Hammond et al., (2020), the impact of cannabis legalization will not be determined simply by whether cannabis is legalized but rather by how it is regulated in the legal framework. Therefore, it is important to acknowledge and consider the cannabis policies (within each study) since they can vary from country to country.

4.5 Suggestions for future studies

Considering the limitations of the thesis, as well as the findings of the two studies, there are several opportunities to explore for future research. The following are some possible suggestions:

- Conduct qualitative research to explore the reason for the differences in perceived risks in Atlantic Canada compared to non-Atlantic Canada.
- Evaluate and explore public communication/messaging strategies for effectively promoting the Lower-Risk Cannabis Use Guidelines (LRCUG) among different groups within the Atlantic Canadian population.
- Explore and examine how receptive Atlantic Canadians are to current public health strategies related to cannabis use risk compared to the rest of the country.
- Conduct longitudinal studies that track changes in risk perception over time to provide more insights into the impact of legalization and to help identify trends in risk perception in the region.
- Explore the effectiveness and receptiveness of current road safety campaigns between urban and rural populations within Atlantic Canada.

- Investigate the socio-demographic factors associated with a passenger's decision to ride with an impaired driver in Atlantic Canada and tailor these findings to design public safety initiatives to target passengers.
- Conduct hospital and fatality crash studies in Atlantic Canada to complement self-reported DUIC surveys.

4.6 Policy Recommendations

Policymakers could use these findings to refine regulatory policies regarding cannabis packaging as a means of addressing the decline in the perceived risk of daily use of cannabis consumption modes. The mandated warning on cannabis packaging from Health Canada serves as a public health communication tool to highlight the potential risks of cannabis use (Health Canada, 2018b). However, the uniformity of cannabis packaging may be limiting its purported functions of increasing awareness of health risks, as noted by Ontario Cannabis Store (OCS), (2022). Further diminishing the effectiveness and reach of these warning labels is the fact that people who solely purchase from the unregulated market (which makes up approximately 33% or more of the overall market (Statistics Canada, 2022a; Toronto Sun, 2023)) are not exposed to these warning labels. Given our findings, it may be warranted to consider reforming regulatory measures related to cannabis packaging to correspond health risk information with specific cannabis consumption modes and products. Since research has shown that mandatory health warning labels can increase recall of the health risks of cannabis (Goodman et al., 2021, 2022), tailoring warnings to cannabis products and/ or consumption modes might be an effective way to boost awareness in this regard. This policy refinement could boost health risks associated with the many available cannabis consumption modes and products in the regulated market.

In addition, regional disparities observed from the research (Studies 1 and 2) may indicate a significant gap in the availability or reach of cannabis education in the region. Recent research by Goodman & Hammond,(2022) has already indicated that Canadians have a significant knowledge deficit in Canada regarding the health risks of cannabis. However, there might be a greater need for enhanced cannabis education in Atlantic Canada, considering the implication of our research’s findings. The primary access point for the majority of cannabis consumers in the Canadian regulated market is through retail stores (physical and online) (Government of Canada, 2019), where retailers are prohibited from providing medical or therapeutic educational promotion related to cannabis (Health Canada, 2018c). Even though the intention behind this rule is to prioritize consumers’ public health, it unintentionally creates a missed opportunity for cannabis consumers to be educated at the first point of entry. A few potential policy compromises to bridge this gap without sacrificing public health could involve:

- **Cannabis Educational Material for Retail Stores:** Develop and provide federally/provincially approved educational materials (e.g. Brochures) that are based on the best currently available evidence for distribution in cannabis retail stores (physical and online). These materials could be used to i) address myths and misinformation related to health and safety risks, ii) provide low-risk guidance tips on cannabis consumption modes, iii) mitigatory behaviour strategies to prevent DUIC, iv) provide an overview of cannabis drug driving laws, and v) provide additional resources to cannabis consumers like poison control centers contacts.
- **Train Healthcare Professionals and Community Educators:** Develop, administer and promote Continuing Education (CE) credits in cannabis education for various healthcare professionals (e.g., pharmacists, nurses, and physicians) and community educators (e.g.,

health educators and guidance counsellors) to bridge the gap and provide necessary guidance in cases where regulations prohibit retailers from giving medical or therapeutic guidance. This training can equip educators and healthcare providers with the best available knowledge and enable them to engage in open discussion on responsible, low-risk cannabis use and its health risks. Additionally, these trained professionals can play an important role in promoting safe cannabis consumption and road safety practices, especially in rural communities and for cannabis consumers in long-term care facilities.

4.7 Conclusion

The existing literature on cannabis research in Canada often lacks the Atlantic Canadian regional perspective despite the higher cannabis use in the region. However, the findings from this research highlight the importance of considering the regional lens in understanding the perceived risk of cannabis consumption modes and driving perceptions. While retail models differ by province, all the Atlantic Canadian provinces, except for Newfoundland and Labrador (NL), share a public retail model, highlighting their collective approach in retail strategy (Government of Newfoundland and Labrador, 2018; Statistics Canada, 2019). The current thesis presented the results of two population-based studies examining legalization's impact on perceived risk and driving attitudes toward cannabis consumption, respectively. Study 1 (which examined the perceived health risk of cannabis consumption modes) demonstrated that non-medical cannabis legalization was associated with a heightened daily risk of cannabis vaping, where the daily vaping risk perception was higher in Atlantic Canada than in non-Atlantic Canada following legalization. However, Study 1 also suggested regional differences between the two regions, with Atlantic Canadians having a lower risk perception of various modes

(smoking cannabis, consuming edibles, using synthetic cannabis, and using high-potency cannabis).

Study 2 (which examined driving perceptions) showed that non-medical cannabis legalization was significantly linked to an increased perceived risk of accidents and perceived increased efforts to prevent an intoxicated friend from driving in Atlantic Canada compared to non-Atlantic Canada. Similar evidence of regional differences was noted in Study 1, where Atlantic Canadians had a lower perceived risk of being stopped by police, a lower perceived risk of accidents, and an increased perceived ease in identifying cannabis intoxication. Regional differences (i.e., lower perceived risk from Atlantic Canadians) observed across both studies may reflect a greater degree of comparative optimism bias from Atlantic Canadians relative to non-Atlantic Canadians. Overall, these findings have important implications for public health and safety policies in Atlantic Canada. Strategies and interventions aimed at promoting low-risk cannabis use education may need to be customized to this region's general population.

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