# The effect of price and retail availability on the use of illegal and legal non-medical cannabis in Canada and the United States

by

Elle Wadsworth

A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Doctor of Philosophy
in
Public Health Sciences

Waterloo, Ontario, Canada, 2021

# EXAMINING COMMITTEE MEMBERSHIP

The following served on the Examining Committee for this thesis. The decision of the Examining Committee is by majority vote.

External Examiner             DR. ROBERT MANN
Associate Professor
Dalla Lana School of Public Health
University of Toronto

Supervisor             DR. DAVID HAMMOND
Professor
School of Public Health
University of Waterloo

Internal Member             DR. PETE DRIEZEN
Research Assistant Professor
Department of Psychology
School of Public Health
University of Waterloo

Internal Member             DR. BEAU KILMER
Director, Senior Policy Researcher
RAND Corporation, Drug Policy Research Center

Internal-external Member             DR. OWEN GALLUPE
Associate Professor
Department of Sociology and Legal Studies
University of Waterloo

# AUTHOR'S DECLARATION

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

# STATEMENT OF CONTRIBUTIONS

Elle Wadsworth was the sole author for Chapters 1, 2, and 7, which were written under the supervision of Dr. David Hammond and were not written for publication.

This thesis consists in part of four manuscripts that have been published, accepted, or prepared for publication. Exceptions to sole authorship are as follows:

**Study 1 (Chapter 3):** Wadsworth E, Driezen P, Goodman S, Hammond D. Differences in self-reported cannabis prices across purchase source and quantity purchased among Canadians. Addict Res Theory. 2020:28(6):474-483.

**Study 2 (Chapter 4):** Wadsworth E, Driezen P, Hammond D. Retail availability and legal purchases of dried flower in Canada post-legalization. Drug Alcohol Depend. 2021; In Press.

**Study 3 (Chapter 5):** Wadsworth E, Driezen P, Kilmer B, Hammond D.* Trends in price and transitions to legal purchase sources in Canada's dried flower cannabis market in the two years after legalization of recreational cannabis. Prepared for publication, June 2021.

**Study 4 (Chapter 6):** Wadsworth E, Driezen P, Kilmer B, Hammond D.* Trends in price and purchase sources in the dried flower cannabis market in the United States, 2019-2020. Prepared for publication, June 2021.

As lead author of these four chapters, I was responsible for contributing to conceptualizing the study design, conducting the analyses, and drafting and submitting manuscripts. My co-authors provided guidance during each step of the research and provided feedback on draft manuscripts. Dr. David Hammond provided significant direction and editorial assistance throughout.

*Author list currently PhD committee, final author list to be confirmed.

# ABSTRACT

**Background** – Cannabis policy has liberalized in North America over recent decades. In October 2018, Canada legalized non-medical cannabis. The regulatory framework includes some similarities with jurisdiction in the United States (US) that also legalized non-medical cannabis, while setting international precedents in other policy areas. An objective of legalization in Canada is to reduce the illegal market by transitioning consumers to the regulated market. Cannabis prices and retail availability have a strong influence on consumption patterns, including purchase source; however, there is little evidence examining the association between price, retail availability and purchasing in the legal and illegal markets following legalization in Canada and the US.

**Objectives** - The current thesis examined four primary research questions: 1) To what extent are purchase source and quantity purchased associated with the price of dried flower in Canada pre-legalization? 2) To what extent is retail availability associated with purchasing dried flower from legal sources in Canada post-legalization? 3) To what extent is price associated with legal purchases of dried flower in Canada post-legalization? and 4) To what extent is price and the time since legal retail stores opened associated with legal purchases in US states who have a non-medical retail market?

**Methods** - Data come from Waves 1-3 of the International Cannabis Policy Study, a repeat cross-sectional survey conducted in Canada and the US. Wave 1 was conducted in August-September 2018, prior to legalization in Canada, with Wave 2 and Wave 3 conducted post-legalization in September-October 2019 and 2020, respectively. Respondents were recruited through online commercial panels, were aged 16-65, and had purchased dried flower in the past 12 months (Canada: $n_{2018}=1,227$, $n_{2019}=2,506$, $n_{2020}=2,417$; US: $n_{2019}=5,643$, $n_{2020}=4,267$). In Study 1, linear regression models examined the association between price, quantity purchased and purchase source in Canada pre-legalization. In Study 2, binary logistic regression models examined the association between retail availability and likelihood of purchasing dried flower legally in Canada post-legalization. In Study 3, binary logistic regression models examined the association between price and legality of source in Canada post-legalization. In Study 4, binary logistic regression models examined legal purchasing of dried flower in US states that had a legal non-medical retail market. All analyses used weighted data.

**Results**

*Study 1* - Overall, the mean self-reported unit price (price-per-gram) of dried flower among Canadian cannabis consumers was $9.56 CAD in 2018. The unit price of dried flower significantly decreased as quantity purchased increased. For example, the mean price of dried flower purchased in smaller quantities (<3.5g) ($12.81/gram) was more than double the price purchased in larger quantities (>28g) ($5.60/gram). The estimated quantity discount elasticity was -0.21 (95% CI: -0.25, -0.18). The most common purchase sources used were family member/friends (53.0%) and illegal dealers (51.7%). Price-per-gram varied across sources; however, variation was largely accounted for by consumers purchasing different quantities from different sources.

*Study 2* - Overall, 47.7% of past-year Canadian consumers reported last purchasing dried flower legally in 2019, with variation across provinces (range=40.5%-81.2%). Likelihood of purchasing dried flower legally was greater among those who lived closer to a legal retail store based on Euclidean distance (<3 km vs. 10+ km: AOR=1.56, 95% CI: 1.20,2.02), and who had shorter self-reported travel time to a retail store (<5 mins vs. >15 mins: AOR=2.24, 95% CI: 1.56,3.21).

*Study 3* - The proportion of consumers last purchasing dried flower from legal sources increased from 2019 to 2020 (45.7% vs. 58.1%), and in the past 12-months, the average amount of dried flower consumers reported purchasing from legal sources increased from 55.7% in 2019 to 67.5% in 2020. The mean unit price (price-per-gram) of dried flower was $10.64 in 2019 and $10.41 in 2020, and when quantity was accounted for the unit price of dried flower was $7.09 in 2019 and $6.83 in 2020 (CAD). The mean price of legal dried flower decreased in 2020 ($12.63 vs. $11.16; p<0.001), but remained more expensive than illegal dried flower in both years ($12.63 vs. $9.04 in 2019; p<0.001, $11.16 vs. $9.41 in 2020; p<0.001).

*Study 4* – The most common purchase source in 'illegal' and 'medical' states was dealers (2019: 48.8% and 43.5%; 2020: 50.6% and 39.3%, respectively) compared to stores/dispensaries in 'recreational' states (2019: 58.7%; 2020: 57.9%). The mean unit price (price-per-gram) of dried flower in US 'recreational' states increased in 2020 ($11.44 vs $12.24 USD; p=0.044), and when quantity was accounted for the unit price was $7.34 in 2019 and $7.95 in 2020. Consumers in 'recreational' states reported purchasing 74.0% and 77.0% of

their dried flower from legal retail sources in 2019 and 2020. The odds of purchasing from legal sources was greater with each additional year with a legal retail recreational market (AOR=1.68, 95%CI: 1.58, 1.77), with few other sociodemographic differences.

**Conclusions** –The legalization of non-medical cannabis in Canada and some US states represent a unique opportunity to evaluate a novel policy with public health implications. The current thesis demonstrated that consumers show relatively quick uptake of the legal market in the first few years of legalization, and that price and retail availability contribute to consumers purchasing legally; however, it may take several years until retail markets and supply chains establish. At least in the immediate post-legalization period, retail availability may be relatively more important than price in encouraging consumers to purchase from the legal market. With the Canadian government undergoing an evaluation of the Cannabis Act, beginning October 2021, the current evidence may contribute to the legislative review.

# ACKNOWLEDGEMENTS

As with most things, it takes a village:

To Dave, thank you! I'm so grateful for your supervision, mentorship, guidance, and promotion of work/life balance over the past four years. I was not expecting such a supportive, generous, and dedicated supervisor when I cold-emailed you back in 2016, so thank you for exceeding all my expectations. Thank you for getting me to a place where I can critically and independently think academically, format beautiful slides, and give presentations without internally melting from anxiety.

To my committee members, Dr Pete Driezen, Dr Beau Kilmer, Dr Owen Gallupe, and Dr Robert Mann, thank you for your expertise and saying yes to being on my committee in the first place. Pete, thank you for being so patient with me with my barrage of questions. I've acquired so much statistical knowledge through your thorough replies to me. I promise to return your book that I've had for an embarrassing amount of time. Beau, thank you so much for your support over the years. Your career advice to me back when I was a wee master's student was incredibly valuable, and I can confidently say it swayed me to do a PhD. The fact you are on my committee means a lot, and I thank you for all your help through my career thus far.

To Sam, the ICPS research team, and the survey respondents, without you the ICPS would not exist.

To the Hammond Lab of past and present, thank you for making the work environment so supportive and enjoyable. A special thanks to the HL analysts for your patience with me while I bombarded you with questions.

To my PhD cohort, Ashleigh, Huda, Meghan, Dahlia, Stephanie, Teeya, Maggie and Scott. Thank you for making the first year of courses and beyond so enjoyable.

To Rachel & Amanda, my PhD older sisters. Thank you for your friendship and helping me navigate PhD-ness. Rachel, I'm sad this last year wasn't conducted next to you in the office

periodically watching groundhog fights. Amanda, I'm really glad I bagged such a political superstar as a friend.

To my parents, thank you for your constant support and for your encouragement to get out of Barnsley. Special shout-out to my grandma, who doesn't quite understand what I do and so thinks I'm a weed dealer.

To Lindsey and Rob, my podcast buddies, thank you for making academia so enjoyable. I've always tried to find myself a mentor, when I really think it's been you folks all along.

Charlotte and Nik, oreyt pals. Nah then, av reyt enjoyed ar chinwags ont t'interweb overt past year. Yuv bin reyt supportive, speshly when mi ed ant bin quite wi'it. Int end, av just ad t'gerron wi' it and gerrit dun innit. Can't wait t'ava brew wiyer.

To my strong independent women back home. Aren't you glad I'm not in procurement? Thank you for all your help with my writing and my words throughout my education. I've come a long way since I didn't know how to use a comma and I just thought it was when you needed to take a breath in speech. I don't think I would have reached this point without you. I've missed you all so much during this time, and I'm so grateful you still support me even though I'm ages away. Forever La Belle (and no, you're not getting named. I don't want the stress of y'all analyzing the order).

To Islay, you probably came at the worst time in my PhD. You've definitely made this final push more challenging with your unwavering demands and cuteness. I wouldn't change it for the world. Thank you for keeping me sane, my little potato.

To Ash. Ta duck.

# TABLE OF CONTENTS

# LIST OF FIGURES

## Chapter 1

## Chapter 2

## Chapter 3

## Chapter 5

## Chapter 6

# LIST OF TABLES

## Chapter 1

## Chapter 2

## Chapter 3

## Chapter 4

## Chapter 5

## Chapter 6

# Appendices

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AAPOR | American Association for Public Opinion Research |
| AB | Alberta |
| ACMPR | Access to Cannabis for Medical Purposes Regulations |
| AOR | Adjusted odds ratio |
| BC | British Columbia |
| CAD | Canadian dollars |
| CBD | Cannabidiol |
| CCS | Canadian Cannabis Survey |
| CI | Confidence interval |
| COVID-19 | Coronavirus disease of 2019 |
| CSTADS | Canadian Student Tobacco, Alcohol and Drugs Survey |
| CTADS | Canadian Tobacco, Alcohol and Drugs Survey |
| ESPG | European Petroleum Survey Group |
| g | Grams |
| km | Kilometers |
| ICPS | International Cannabis Policy Study |
| LGBTQIA+ | Lesbian, Gay, Bisexual, Transgender, Questioning/Queer, Intersex, Asexual (+: Other non-heterosexual people) |
| MB | Manitoba |
| MLA | Minimum Legal Age |
| mg | Milligrams |
| NASEM | National Academies of Sciences, Engineering, Medicine |
| NB | New Brunswick |
| NCS | National Cannabis Survey |
| NL | Newfoundland and Labrador |
| NS | Nova Scotia |
| OCS | Ontario Cannabis Store |
| OLCC | Oregon Liquor Control Commission |
| ON | Ontario |
| ORE | Office of Research Ethics |
| PCCF+ | Postal Code Conversion File Plus |
| PEI | Prince Edward Island |
| QC | Quebec |
| QGIS | Quantum Geographic Information System |
| QR | Quick Response |
| SE | Standard error |
| SEM | Standard error of the mean |
| SK | Saskatchewan |
| SQDC | Société Québécoise du Cannabis |
| THC | Δ9-tetrahydrocannabinol |
| US | United States |
| USD | United States dollars |

# TERMINOLOGY

This dissertation used the term 'cannabis' throughout, instead of names such as 'marijuana', 'weed', 'pot', or many others. Moreover, 'dried flower' was used instead of 'dried cannabis', 'useable cannabis' or 'dried herb'. As an exception, 'dried herb' was used when referring to the measures from the International Cannabis Policy Study (ICPS), to replicate the phrasing used in the survey.

This dissertation primarily used the term 'non-medical', instead of 'recreational' or 'adult-use'. As an exception, 'recreational' was used in Chapter 6 to make a more distinct separation from medical cannabis laws.

In the ICPS, US states were classified into those that have and have not legalized non-medical cannabis; therefore, US states with medical cannabis laws were classed as US 'illegal' states. However, in Chapter 6, US states were classified into US 'illegal' states, US 'medical' states, and US 'recreational' states, where US 'illegal' states were those without medical or non-medical cannabis laws.

This dissertation primarily discussed legal and illegal sources in the non-medical cannabis market in Canada and the US. However, medical sources were incorporated into legal and illegal sources. Briefly, 'illegal' sources refer to dried flower purchased outside of both the legal medical and non-medical markets and 'legal' sources refer to dried flower purchased within the legal medical and non-medical markets.

# CHAPTER 1: INTRODUCTION

## 1.1 Cannabis

Cannabis or 'marijuana' is a term to describe a plant (*Cannabis sativa*) that humans have used for millennia.[1] Cannabis contains over 500 constituents and over 100 of these are phytocannabinoids.[1] The primary phytocannabinoid of interest is Δ9-tetrahydrocannabinol (THC), which is the main psychoactive compound, and to a lesser extent cannabidiol (CBD), a non-psychoactive compound. THC exerts its psychoactive effects through the body's endocannabinoid system by primarily activating the cannabinoid $CB_1$ receptor in the brain.[1,2] The desired acute effects of THC include euphoria and increased sociability; however, frequent undesired acute effects include paranoia and anxiety.[1] Of recent interest are CBD's therapeutic effects and its potential to attenuate psychotropic effects of THC.[3]

## 1.2 Prevalence and patterns of use

Cannabis is the most widely used illegal substance in the world, and Canada and the United States (US) have among the highest prevalence rates in the world.[4-8] In the 2020 Canadian Cannabis Survey (CCS), 27% and 18% of Canadians over 16 years reported past 12-month and past-month cannabis use, respectively, which represents an increase from 2018 (22% and 15%) and 2019 (25% and 17%).[9-11] In the US, the 2019 National Survey on Drug Use and Health reported a past 12-month prevalence rate of 18% and a past-month prevalence of 12% among 12 years and older, both an increase from 2018 (16% and 10%, respectively).[12,13] In Canada and the US, youth and young adults have higher self-reported prevalence of both past 12-month and past-month use than adults over 25 years.[9-13]

## 1.3 Therapeutic benefits of cannabis

Cannabis can produce therapeutic benefits, as well as negative public health consequences. The National Academies of Sciences, Engineering, Medicine (NASEM) conducted a comprehensive review of the therapeutic benefits of cannabis and found conclusive or substantial evidence on the use of cannabis for chronic pain, chemotherapy-induced nausea, and multiple sclerosis spasticity symptoms, but insufficient evidence for cannabis as an effective treatment for epilepsy.[14] However, more recent systematic reviews challenged the

NASEM findings.[15,16] Stockings and colleagues concluded CBD may reduce epileptic seizures among pediatric populations with rare and serious forms of epilepsy.[16] Conversely, in another systematic review, Stockings and colleagues concluded that cannabinoids were unlikely to be an effective treatment for chronic non-cancer pain.[15] Evidence for the effectiveness of the therapeutic benefits of cannabis remains inconclusive. Nevertheless, cannabis is still widely used for therapeutic benefits, such as pain relief.[17-21]

As well as physical ailments, mental health conditions are commonly cited as reasons for using cannabis, such as anxiety, depression, or post-traumatic stress disorder.[22-24] In a systematic review and meta-analysis analyzing the effectiveness of cannabinoids to treat mental health conditions, the authors found insufficient evidence for the use of cannabinoids regarding conditions such as depression and anxiety.[25] Another systematic review that explored mental health and medical cannabis use, concluded medical cannabis use may be beneficial for substance use disorders: consumers substituting other substances for cannabis may benefit through harm reduction.[23] However, the review concluded that the influence of medical cannabis use on mental health varies across conditions, and that evidence is limited and inconclusive. In sum, more evidence in needed on the effect of cannabis and cannabinoids on mental health conditions.[26]

## 1.4 Cannabis and public health

Reducing the potential health risks of cannabis is among the primary objectives of non-medical cannabis legalization in Canada.[27] Common public health concerns surrounding cannabis use include the effects of smoking cannabis,[28,29] the risk of addiction,[28,30,31] mental health conditions,[14,32-37] and impaired driving.[14,38-40] An additional concern is the negative consequences that cannabis use can have on vulnerable populations, such as pregnant women,[14,41,42] and young people.[28,43-48]

**1.4.1 Smoking** - Smoking dried flower is the most popular method of consumption in Canada and the US (see Section 1.5).[9-11,29,49,50] Cannabis smoke contains many of the same carcinogens as tobacco smoke, and regular and long-term smokers have a higher risk of developing chronic bronchitis and other respiratory symptoms than non-smokers.[28]

**1.4.2 Risk of addiction** - Longitudinal research has shown that around 1 in 11 cannabis consumers will become dependent, and this probability increases with daily consumption (1 in 2 consumers), and with initiation in adolescence (1 in 6 consumers).[28,30,31]

**1.4.3 Mental health conditions** - Associations have been found between cannabis and mental health, notably psychosis, and to a lesser extent depression.[14,34-37] Heavy cannabis use and use of high potency cannabis has been shown to increase the risk of developing a psychotic disorder.[32,33] High potency cannabis typically contains minimal CBD, yet prior research has concluded fewer psychotic experiences associated with use of high-CBD cannabis.[51]

**1.4.4 Impaired driving** - Prior research indicates that recent use of cannabis doubles risk of a motor vehicle crash.[14,38,40] THC has been shown to impair motor and cognitive functions required to safely drive a vehicle.[39,40] As such, implementation of drug-impaired driving laws accompanied the legalization of cannabis in Canada and US states. For example, the Canadian government introduced Bill C-46, which adapted and strengthened previous drug-impaired laws.[52] In particular, it allowed police officers to use oral fluid drug screening devices at the roadside and specified maximum levels of THC permitted in the blood stream.[52]

**1.4.5 Cannabis and pregnancy** – Cannabis is the most commonly used 'illegal' drug during pregnancy.[41] In the US, 5% of pregnant women reported past-month cannabis use in 2016.[53] However, rates are suggested to be underreported due to stigma. Substantial evidence indicates an increased risk of low infant birth weight when cannabis is used during pregnancy.[14] However, the relationship between smoking cannabis during pregnancy and other pregnancy and childhood outcomes is inconclusive, such as premature birth or behavioural issues.[14,42]

**1.4.6 Cannabis and youth** - Cannabis is the most commonly used 'illegal' substance among youth in Canada and the US.[4,6,7,54] Brain development continues through to young adulthood, and there are concerns surrounding the effect of early and regular cannabis use can have on the developing brain.[28,44] Prior research indicates associations between early and regular use and impaired educational attainment, other illegal drug use, and an increased risk of psychosis and addiction.[43-45] Moreover, there are concerns about the potential impact of legalization among youth, such as increased access and lower perceptions of harm, which in turn may increase use and impaired driving.[4,46,47] Longitudinal studies conducted pre- and post-legalization in US states with legal non-medical cannabis markets have generally shown few changes in cannabis

use among youth, which suggests that differences between states with and without legalized non-medical cannabis may be due to pre-existing trends rather than policy changes.[46,48,55-60]

## 1.5 Products and methods of consumption

As previously mentioned, smoking dried flower is the most common method of cannabis consumption in Canada and the US.[9-11,29,49,50,61] In the 2017 Canadian Tobacco, Alcohol and Drugs Survey, 91% of past-year cannabis consumers had smoked dried flower.[6] In the last decade, the types of cannabis products have expanded, with varying potency and methods of administration.[9-11,61,62] The range of cannabis products available on the market includes cannabis oils, cannabis infused foods, and concentrates (see Table 1). These products can be smoked, inhaled, ingested, applied sublingually, and vaped. There is some evidence that preference of methods of administration varies by sex and age. For example, research demonstrates the use of vape pens and edibles decrease with age[10,11,63] and males prefer or report higher rates of inhalation and females prefer or report higher rates of oral consumption.[10,11,64,65]

**Table 1: Cannabis products and modes of consumption**

| Smoked/Combustible | Vaporized/Dabbing | Oral/Sublingual | Topical |
|---|---|---|---|
| Dried flower | Dried flower | Capsules | Topicals (i.e., cream) |
| Solid concentrates (i.e., hash) | THC vape oil | Oral oil | |
| | Solid concentrates (i.e., hash, shatter) | Edibles (i.e., cookies) | |
| | Liquid concentrates (i.e., butane hash oil, wax) | Drinks (i.e., tea) | |
| | | Tinctures | |

Over the last decade, THC concentration in cannabis has consistently increased, both in dried flower and concentrates (e.g. hash).[66-69] In a systematic review and meta-analysis examining THC and CBD concentrations in cannabis, authors found a 0.3% increase in THC concentration each year in dried flower from 1970 to 2017, with no changes in CBD concentrations.[68] CBD-rich products have also emerged over the past decade, which are typically associated with medical use.[14,70,71] In Canada, prevalence of dried flower among past 12-month consumers has declined from 88% in 2017 to 79% in 2020.[11,72] By contrast, the prevalence of most non-flower products have increased over the same period, such as edibles and vape pens (see Figure 1 and

2).[11,72] Indeed, in US states where non-medical cannabis is legal, the market share of concentrates and edibles, is increasing.[49,62,73-75] In 2017, a report of the legal cannabis market in Colorado showed that the market share of dried flower had decreased from 66% to 54% since 2014.[73] However, the vast majority of evidence to date focuses on dried flower, given that it still accounts for most of the market share.[9-11,49,69,73-77] The current thesis will focus on dried flower only.

**Figure 1 – Methods of cannabis consumption used among past 12-month cannabis consumers in the past 12-months from the Canadian Cannabis Survey 2017-2020[9-11,72]**
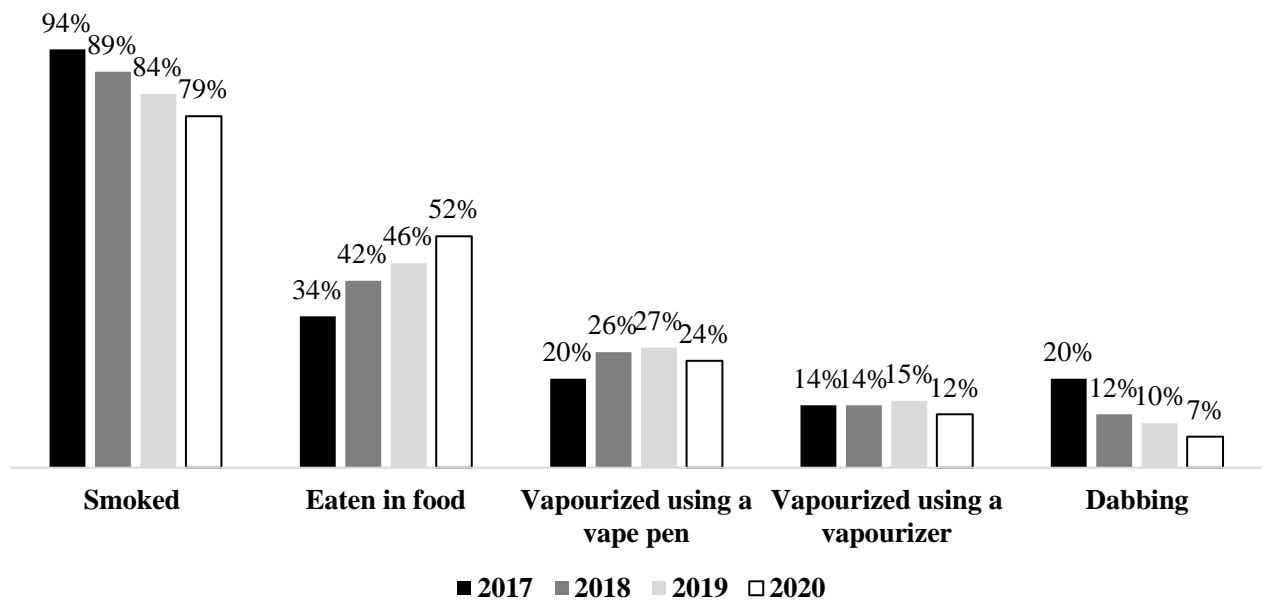


Respondents could select all options that applied. Categories such as "applied to skin", "Oral/sublingually" and "Other" are not shown due to change in categories from 2017 to 2020.

**Figure 2 – Cannabis products consumed among past 12-month cannabis consumers in the past 12-months from the Canadian Cannabis Survey 2017-2020[9-11,72]**
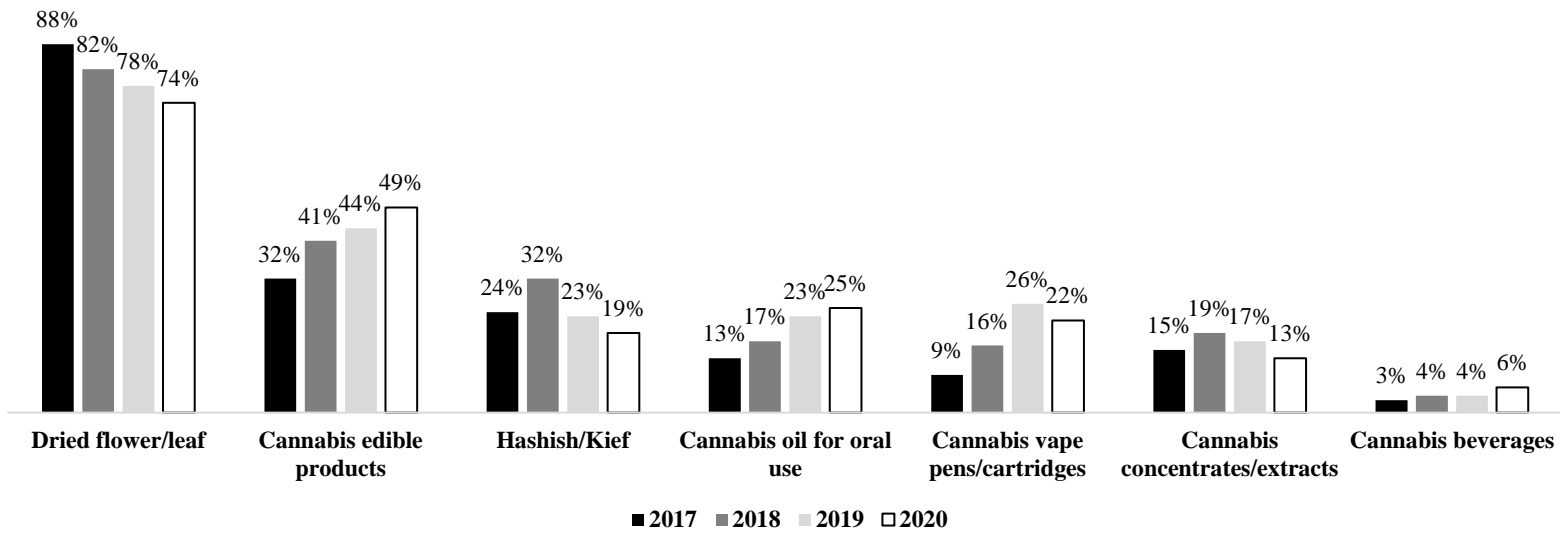


Respondents could select all options that applied. **"Cannabis concentrates/extracts"** classified as "Solid concentrates" in 2017. "Cannabis oil for oral use" classified as "Liquid concentrates" in 2017.

## 1.6 Legal and regulatory status

### 1.6.1 Canada

In Canada, medical cannabis has been legally available since 2001. Under the Access to Cannabis for Medical Purposes Regulations (ACMPR), those with authorization from a licensed physician could access cannabis from either a Health Canada registered licensed producer, grow a personal quantity or designate someone else to grow for them.[78] In October 2018, Canada became the second country after Uruguay to legalize non-medical cannabis. New regulations under the Cannabis Act replaced the ACMPR; however, medical consumers still have the same dried flower public possession limit (150 g) and can still access medical cannabis from the same sources, in addition to all non-medical sources.[79] The Cannabis Act has several objectives, including minimizing young people's access to cannabis, protecting public health, and removing the illegal market.[27] Under the Cannabis Act, Canadians over 18 can purchase up to 30 g of dried flower or its equivalent in non-dried form (e.g. 7.5 g of concentrates), and can access from private or public stores and websites, dependent on varying provincial and territorial laws (see Appendix A1).[27,80]

Cannabis regulations vary across the provinces and territories, i.e., minimum legal age, and retail structure.[80] Initially, all provinces and territories except Manitoba aligned their minimum legal age to purchase cannabis with alcohol regulations – Alberta and Quebec had a minimum legal age of 18 years, and all other provinces and territories of 19 years.[80] However, Quebec raised their minimum legal age to 21 years in 2020, the highest in the country. The retail structure varies across the country: Saskatchewan and Manitoba have a private retail sales model, Quebec, Nova Scotia, New Brunswick, Prince Edward Island, and Northwest Territories have a public (government-run) model, and the rest have a hybrid of public and private. For online sales, all except Saskatchewan and Manitoba have a public online sales system.[80]

Not all cannabis products were available from the beginning of legalization in October 2018. Dried flower and some cannabis oils were available on the legal market on October 2018, and all other products (i.e., concentrates) were available from December 2019.[81] Non-flower products had additional regulations, for example, edible cannabis had a 10mg limit of THC per package and had restrictions on ingredients that could increase the appeal to youth.[81] Indeed, Quebec implemented further restrictions on cannabis products, such that edible cannabis cannot be confectionary (i.e., chocolate) and all cannabis has a THC limit of 30%.[82]

### 1.6.2 United States

In the US, California was the first state to legalize medical cannabis in 1996. By 2021, 36 states had legalized medical cannabis, with an additional six permitting the use of CBD oil only (containing minimal THC).[83-85] Medical cannabis laws vary across states, for example, some states require patient registration, some allow home cultivation, some allow dispensaries. In result, some states have 'stricter' medical programs than others.[86-88] Since Colorado and Washington first legalized non-medical cannabis in 2012, 16 additional states and Washington D.C. have legalized or passed legislation to legalize, with more expected to follow (see Figure 3). To date, over 40% of US residents live in a state where non-medical cannabis is legal.[89]

**Figure 3: Cannabis laws by US state, as of April 2021**
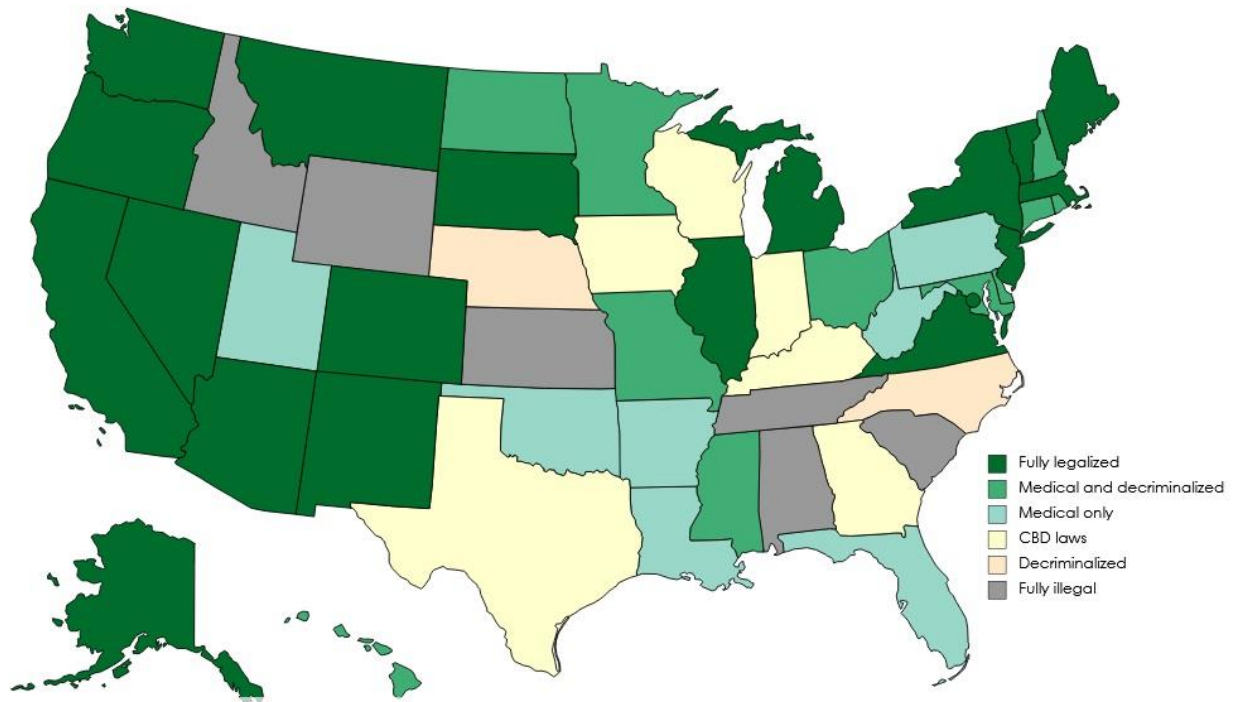


Map adapted from cannabis laws taken from DISA: https://disa.com/map-of-marijuana-legality-by-state

Non-medical cannabis laws vary across the US states (see Appendix A2). The majority of states have a personal possession limit of one ounce of cannabis, with Maine (2.5 oz), Michigan (2.5 oz), New Mexico (2 oz), New York (3 oz), Oregon (8 oz) and the District of Columbia (2 oz) having higher limits.[83-85] Most states allow residents to grow at home, with the exception of Washington State, and most permit up to six plants with no more than three mature. Most states have implemented an ad-valorem excise tax (a tax based on the percentage of the products value) on the retail price of cannabis, with a few notable exceptions (see Section 1.10). Although most states allow delivery for medical cannabis, only three states allow delivery services for non-medical cannabis in 2020, California, Nevada, and Oregon. Non-medical cannabis delivery in Colorado was permitted in January 2021.[90] In short, there is wide variation in the non-medical cannabis regulations across the states that have legalized.

## 1.7 The non-medical cannabis market

### 1.7.1 Canada
Reducing the illegal market for non-medical cannabis was one of the primary objectives of the federal Cannabis Act.[27] In 2017, Canadians spent an estimated $6 billion CAD on cannabis, of

which an estimated 90% was from illegal sources.[91] Before legalization, illegal cannabis was widely available in Canada and could be accessed through street dealers, dispensaries and online retail sources.[77] The purpose of the Cannabis Act is to "provide for the licit production of cannabis to reduce illicit activities in relation to cannabis."[27] However, the well-developed illegal market is not expected to disappear immediately.

After legalization in October 2018, the federal government permitted non-medical cannabis to be sold in both public or private retail and online stores, up to the discretion of the provinces and territories. The implementation of cannabis stores was not immediate and both stores and websites experienced shortages in the initial months of legalization (see Section 1.11).[92] The 2019 Cannabis Economic Account estimated that over a third of all cannabis purchases were made in the legal market in the third quarter of 2019. Focusing on dried flower and some oils – the only products that were available on the legal market at that time – 59% of dried flower and some oil purchases were made legally.[93]

In two of Canada's national cannabis surveys - the Canadian Cannabis Survey and the National Cannabis Survey - the use of the legal cannabis market has increased and the use of the illegal cannabis market has decreased.[10,11,94] In the National Cannabis Survey, the use of legal sources in the past 3-months increased from 23% in 2018 to 68% in 2020, and the use of illegal sources decreased from 51% in 2018 to 35% in 2020.[94] In the Canadian Cannabis Survey, 43% of past 12-month cannabis consumers reported they usually obtain cannabis from legal sources (storefronts, mail order) in 2019 compared to 54% in 2020.[10,11] Conversely, 19% of cannabis consumers reported they usually obtain their cannabis from illegal sources in 2019 compared to 9% in 2020 (illegal storefront, mail order or dealer) (see Figure 4). The differences in percentages obtaining cannabis legally or illegally across the two surveys is perhaps due to the difference in the time frame of question. The National Cannabis Survey asked *any* use of illegal or legal source in the *past 3-months*, whereas the Canadian Cannabis Survey asked *usual* source in the *past 12-months*.

**Figure 4: Sources that past 12-month cannabis consumers usually obtained cannabis from the 2017-2020 Canadian Cannabis Survey**[9-11,72]
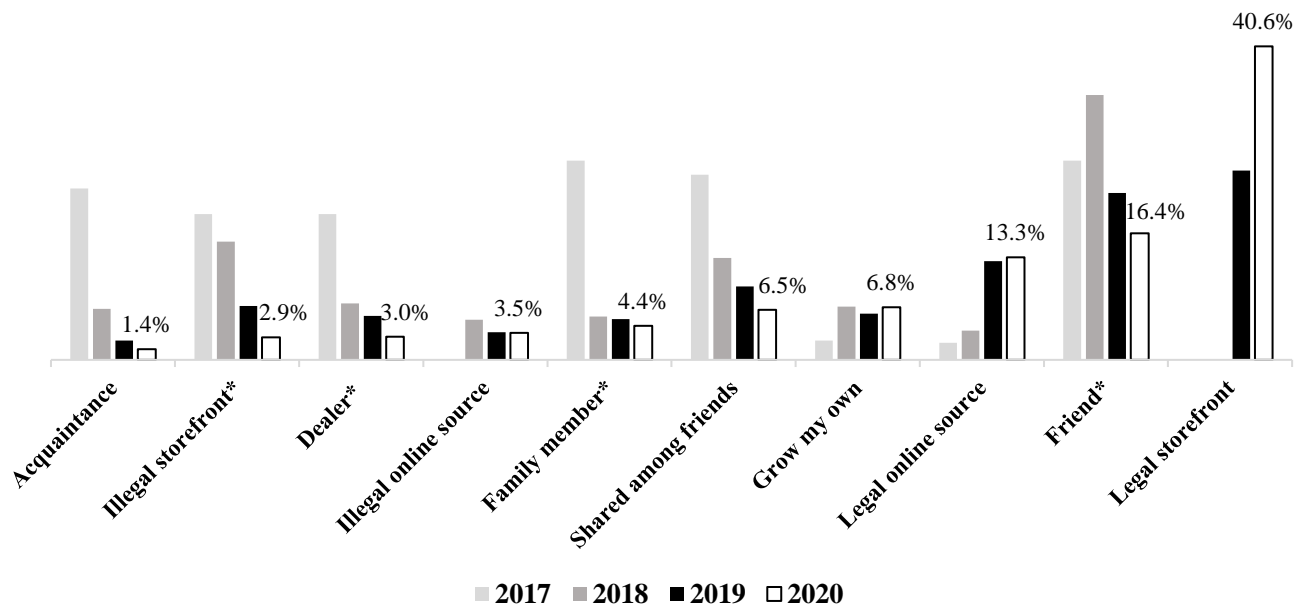


In 2017, "Dealer" and "Illegal storefront" were combined, and "Family member" and "Friend" were combined.

There is some evidence that the use of the legal non-medical market varies by sex. From crowdsourced cannabis price data submitted to Statistics Canada, more submissions from females were of cannabis purchased at legal sources than illegal sources, whereas more submissions from males were of cannabis purchased at illegal sources.[93] In the 2020 Canadian Cannabis Survey, higher percentages of female cannabis consumers 'usually' purchased from legal storefronts or legal online sources than male cannabis consumers.[11] However, similar percentages of female and male cannabis consumers reported to "always" or "mostly" obtain cannabis from legal sources.[11] Comparatively, a lower percentage of female cannabis consumers reported to "always or "mostly" obtain cannabis from illegal sources than male cannabis consumers.[11]

### 1.7.2 United States

In the US, cannabis remains illegal at the federal level. In the states that have legalized non-medical cannabis and permit retail sales, consumers can access cannabis through retail stores, grow at home, family or friends (up to 30 grams), and delivery services (in a few states). Similar to data from Canada, the illegal market still persists.[74,95-100] Researchers can estimate the size of an illegal market using various methods, such as residual methods (discrepancies between

datasets); direct methods (population surveys and waste collection); and expert opinion.[73,100-102] In a study that compared wastewater analysis of cannabis consumption to legal sales data in Washington State in 2013-2016, researchers found a larger increase in legal sales than the increase in consumption over the 3 year period – indicating displacement from the illegal market.[100] Another study found that after three years of retail sales, consumption estimates were larger than legal sales in Washington State, suggesting consumption outside of the legal retail system.[96] In Oregon, the barriers to enter as a cannabis business were lower compared to other states, to incentivize illegal market players into the legal industry.[74] In 2019, a report by the Oregon Liquor Control Commission (OLCC) admitted that the illegal market still persists; however, their oversupply, decreasing prices, and increasing legal sales suggest a reduction in purchases from the illegal market.[74] The 2021 OLCC report concluded that, even though 2020 observed demand come closer to Oregon's supply, low legal prices of cannabis in Oregon remained competitive to the illegal market.[95] In California, an illegal market is said to be still present due to the regulatory process "insufficiently incentivizing unlicensed businesses to seek licensure."[99] In January 2020, California introduced regulations where legal cannabis store must display a Quick Response (QR) code in order to aid consumers in identifying legal retailers.[97] In Colorado, a report by the Marijuana Policy Group suggested that Colorado's legal market had fully absorbed the illegal market in 2017, based on comparisons between the Colorado's inventory tracking system to consumption estimates in self-reported surveys.[*73] However, this indirect method has several limitations, and media articles report the persistence of an illegal market in Colorado as well as other legal states.[103-107] Overall, there are considerable gaps in our understanding of the size of the illegal market in jurisdictions that have legalized non-medical cannabis due to a lack of reliable data on both legal and illegal sales.[108,109]

## 1.8 Social equity

One of the motives behind non-medical cannabis legalization in Canada and US states is to correct the injustices of prohibition. There are prominent racial/ethnic disparities in cannabis arrests and convictions, particularly among Black and Hispanic individuals in the US, and

---

* Colorado was the first state to begin retail sales in January 2014. Initially, only businesses with medical licenses could apply for non-medical licenses. Therefore, Colorado had an efficient start to non-medical cannabis retail sales.

Black and Indigenous individuals in Canada.[110-113] Legalization can help address these disparities, for example, by expunging previous convictions and reducing arrests for cannabis possession. However, there are mixed opinions on the effectiveness of cannabis legislation on social equity in jurisdictions that have legalized.[114-116] For example, a study examining arrest rates before and after legalization of non-medical cannabis in Washington State demonstrated that although arrest rates decreased among both African American and White individuals after legalization, the relative disparities increased.[116] In a review examining whether US states that have legalized non-medical cannabis have begun to rectify the racial injustices of prohibition, progress was reported in some areas, namely expunging criminal records but reported a lack of progress in other areas.[110,114, 117]

The Canadian government has been criticized for not including an objective regarding social justice measures in the Cannabis Act, nor consulting Indigenous communities in the lead up to legalization.[118,119] US states that have legalized non-medical cannabis have introduced various initiatives into their legislation to address social equity. Illinois provides automatic expungement of records for cannabis possession up to 30 g but requires a petition to expunge records over 30 g. Illinois had a deadline to expunge cannabis-related offences by 2025, but achieved their goal in 2021.[115] States that have most recently legalized cannabis, such as New Mexico and Virginia have included automatic expungement for records specific possession of cannabis.[120,121] Other states such has Colorado and California allow individuals to petition for possession offenses. One of the states to most recently legalize cannabis – New York – will automatically expunge all cannabis-related offences, which removes the time and financial labor required from those with cannabis convictions to initiate a petition for expungement.[122] The barrier to expungement has reduced uptake in states that have legalized. For example, in California, it was estimated that fewer than five thousand applications were submitted for close to half a million cannabis-related offenses.[110]

States have implemented measures to encourage and facilitate minority populations to participate in the legal cannabis market.[74,117] However, evidence to date suggests this has not been overly successful.[117] In Massachusetts, 97% of licenses were issued to businesses who did not identify as either women-owned, veteran-owned, minority-owned, LGBTQIA+-owned, or disability-owned, as of November 2019.[117] Similarly, in a policy brief examining the diversity of Canada's legal cannabis market, authors found that leadership positions were overrepresented by white males (84% white, 86% male).[123] The report outlined the little

diversity in Canada's cannabis industry.[123] An offered explanation for the lack of diversity in legal cannabis markets was the high barriers to entry for cultivators, processors or retailers, through applications and costs for licenses, testing, and security.[110]

## 1.9 Price

Price may influence the demand for cannabis from both illegal and legal sources. Briefly, a low price of cannabis could increase consumption but reduce the illegal market, whereas a high price of cannabis could reduce consumption but retain the illegal market. Therefore, accurate price estimates of illegal cannabis are essential for assessing the potential impact of legalization. A legal market should reduce the cost of production, as costs associated with the illegal market are no longer required, such as costs to hide illegal facilities or paying employees compensation for illegal activity.[124,125] A legal market should also reduce costs by creating a more efficient supply chain through innovation, expansion, and technology.[126-128] In addition, the price of legal cannabis may fluctuate over time as the legal retail markets and supply chains become established. The price of cannabis after legalization could dictate the prevalence of illegal cannabis and consumption.[129-133] The legal price of cannabis must reflect this balance of minimizing both the illegal market and consumption.

### 1.9.1 Quantity discounts and potency

To ensure that the price of legal cannabis is competitive with illegal cannabis, regulators require accurate price data from the illegal market. However, obtaining an accurate average price on illegal cannabis is challenging, due to quantity discounts and potency.[134] Quantity discounts, where consumers pay less per unit for larger quantities than smaller quantities, are present in illegal drug markets,[69,135-140] and in legal markets.[49,69,141] For example, in the legal non-medical market in Washington State, quantity discounts were present for quantities over 5 g with larger discounts for quantities over 28 g.[49]

Potency is increasing, and has been for the last few decades.[67,68,142] It is argued that price should not be recorded per gram but by potency: i.e., THC content, and tax should be applied by THC content rather than weight (see Section 1.10).[143,144] If potency of cannabis increases but the price of cannabis does not increase at the same rate, then intoxication will become cheaper to achieve. Indeed, in an analysis of Washington States seed-to-sale data, Hansen and colleagues highlighted that since retail sales began, average potency increased whereas average price

decreased.[143] Prior studies have also shown positive associations between perceived potency and price.[49,129,142,145,146] However, potency is often unknown in the illegal market due to lack of information or unreliable labelling; therefore, few studies to date have included potency in price analyses.[49,76,142,147-149] Indeed, in self-reported studies of potency levels, consumers had low knowledge of the THC in the products they used.[150-152] In an experimental task among Canadian young adults pre-legalization, few respondents could understand the quantitative THC labelling on cannabis packages.[148] Even in a legal market, comprehension of THC labels may be low due to inaccurate labelling or packages including too much information.[153] In the 2019 Canadian Cannabis Survey, close to a third of past 12-month cannabis consumers did not know the potency of cannabis when choosing a product.[10] Although self-reported potency is potentially unreliable, potency is an important attribute to cannabis consumers. In a 2020 quarterly report by the Ontario Cannabis Store (OCS) – Ontario's public online store – potency was ranked above price as the most important attribute of cannabis for both new and returning customers.[154] Both quantity discounts and potency can potentially influence the price of cannabis and may contribute to price variations in the illegal and legal markets.

### 1.9.2 Illegal cannabis prices

There are limited data on the price of illegal cannabis in Canada prior to legalization. Appendix B1 displays the available estimates drawn from three sources: 'crowdsourced' data collected online,[76,93,155] self-reported data in population surveys,[9-11,72] and objective price data collected directly from retail sources.[69,77,124] The reliability of crowdsourced data remains highly uncertain and is particularly susceptible to self-selection bias and potential manipulation. Three studies have collected objective prices in Canada's illegal market: Two studies collected data from illegal retailers' websites and another collected data from a darknet marketplace, Alphabay.[69,77,140] One study that collected data from illegal retailers' websites investigated the price of cannabis in illegal retail and online dispensaries in the most populated city of each province and territory.[77] The average price-per-gram of the most popular strain of cannabis was $10.02/g, somewhat higher than crowd-sourced data and self-reported data ($7.14/g - $8.62/g).[77] In the study that obtained cannabis prices from Alphabay, a popular darknet marketplace, found a median price-per-gram of cannabis to be $9.24 in 2015 (converted from US dollars using 2015 Purchasing Power Parity).[140]

### 1.9.3 Legal cannabis prices

Since legalization, Statistics Canada reported crowdsourced price data between December 2018 and December 2019 that showed an increase in the average price of dried flower from legal sources ($9.69/g to $10.30/g) and decrease in the price from illegal sources ($6.44/g to $5.73/g) (Appendix B1).[93] The same crowdsourced data showed variation across the provinces of approximately $4 difference between the lowest price-per-gram (Quebec: $7.88) and the highest price-per-gram of legal cannabis (New Brunswick: $11.36), but a narrower range among cannabis purchased from illegal sources ($4.90-$6.10).[93] In a report examining the average price of legal dried flower taken from retailers between October 2018 and August 2019, the average price-per-gram of dried flower in Canada was $11.15 with similar variation across the provinces between the lowest price-per-gram (Quebec: $8.43) and the highest (Saskatchewan: $12.95).[156]

The price of legal cannabis may influence a consumers' decision to transition from the illegal to legal cannabis market.[131,133] Research among cannabis consumers in Canada and the US demonstrated in a hypothetical marijuana purchasing task that when legal cannabis cost the same or marginally higher than illegal cannabis, consumers preferred legal cannabis and the demand for illegal cannabis was reduced.[133,157] Consumers viewed legal cannabis as a 'superior' product to illegal cannabis, suggesting that even a slightly higher legal price than illegal could still encourage consumer transition to the legal market.[157] However, another study concluded that when considering the substitutability between illegal and legal cannabis, the socially optimal price of legal cannabis should be lower than illegal to be competitive.[131] In Canada, price estimates have shown the average price of legal dried flower to be consistently more expensive than dried flower in the illegal market since legalization.[69,93] Moreover, a government-run crowdsourced application demonstrated that the gap between illegal and legal cannabis has widened since legalization.[93,158] Other research examining illegal and legal cannabis prices, found a similar gap but did not demonstrate the same price differential.[69] Furthermore, in the 2020 Canadian Cannabis Survey, past 12-month cannabis consumers reported to spend a similar amount on cannabis from illegal and legal sources in the past 30 days ($47 vs $49, respectively); however, the product or quantity was not recorded.[11]

In the US, states that have legalized non-medical cannabis lack 'baseline' price data and often have limited data on illegal sources following legalization.[126] In addition, the transition to a legal market has occured incrementally; thus, data are just beginning to emerge on legal

cannabis prices from the first US states to legalize non-medical cannabis.[49,73-75,124,126,159-161] Appendix B2 displays a non-exhaustive list of price estimates in US states that have legalized non-medical cannabis. Using self-reported price data across three waves of medical and non-medical cannabis in Washington, Colorado, and Oregon, the average price-per-gram of non-medical cannabis decreased in the first few months after legal sales became available in Colorado and increased in Washington State.[124] In Washington State, Colorado, and Oregon, three of the first states to legalize non-medical cannabis, average retail prices of cannabis decreased over a longer period - the first few years - of retail sales.[49,73,74,95] For example, the retail price of cannabis declined 50% in Oregon from 2016-2018 due to increased supply, and in 2019 wholesale prices were reported to be the lowest they had been due to demand lower than supply.[74,95] The average price-per-gram of dried flower in Oregon has been $5.50 or lower from July 2018 to 2021.[74,95]

The price of cannabis may change over time as legal retail markets become established. In an analysis of sales data in Washington, Colorado, California and Nevada in 2018 showed that the states with a more mature retail market – Washington and Colorado - had the lowest price-per-gram (e.g. $4.60/g in Colorado compared to $11.60/g in California).[162] A study from the US medical cannabis literature found an association between the legalization of medical cannabis and a gradual reduction in the price of 'high-quality' cannabis.[163] The study concluded that the diversion of 'high-quality' cannabis and thus an increased supply, explained the reduction in price.

In states with legal retail non-medical markets, there is some evidence of price increases in 2020. In a report conducted by a US wholesale cannabis marketplace, wholesale prices of dried flower in Alaska, California, Colorado, Michigan, Nevada, Oregon, and Washington State increased 18% from the previous year.[164,165] In 2020, Alaska and Michigan reported the highest dried flower prices, predicted to be due to high taxes (Alaska: see Section 1.10) and a new retail market (Michigan). Oregon and Washington reported the lowest dried flower prices, predicted to be due to mature retail markets and a high supply.[165] Although still averaging some of the lowest prices of cannabis in the legalized states, Oregon experienced an increase in demand after the start of the COVID-19 pandemic and thus higher prices, The OLCC hypothesized the increased demand to come from three groups: 1) existing consumers; 2) new consumers; and 3) consumers transitioning from the illegal or medical market amid the pandemic.[95] Additional explanations for higher prices in 2020 were local fires in California,[97,166] increased demand and

supply shortages,[167-169] small businesses closing due to poor profit margins,[170] and the legalization of hemp.[171,172]

## 1.10 Tax

### 1.10.1 Price elasticity of demand

Taxes are one method of controlling the price of a legal substance. In economics, 'price elasticity of demand' determines how sensitive consumers are to percentage changes in price. Specifically, it measures the change in consumption in response to a 1% change in price, when other factors remain constant. 'Elastic goods' have a price elasticity of demand of 1 or above. 'Inelastic goods' have a price elasticity of demand between 0 and 1. Price elasticity of demand is usually negative, as an increase in price usually reflects a decrease in quantity demanded. For example, tobacco is an inelastic good, and its price elasticity of demand is estimated to be -0.4 in high-income countries.[173] This means that a 10% increase in price is expected to decrease consumption by 4%. Tobacco is inelastic because there are few substitutes, and nicotine, the main component of tobacco, is highly addictive.[173] Therefore, in tobacco control, research demonstrates the most effective intervention to be the use of taxes to increase price, as consumption decreases and tax revenue would be consistent.[174] One method to retain the price of cannabis close to its pre-legalization price is by introducing taxes.[175,176] However, researchers argue that reliable price elasticities for cannabis do not yet exist, and so predictions on tax revenue and consumption cannot be made.[177] Prior studies have calculated elasticities using prevalence data, which captures infrequent consumers.[177] Infrequent consumers account for the majority of people who use cannabis, but not the majority of cannabis consumed.[134,178,179] As a result, different types of consumers may have different sensitivities to price. Indeed, a consumer who purchases cannabis once a year may not be as financially impacted by changes in price as a consumer who purchases every week. Two populations with particular relevance to public health outcomes – heavy consumers and youth – may have greater price sensitives and warrant special consideration for taxation strategies.[146,147,177,180-183]

### 1.10.2 Types of taxes

Jurisdictions apply distinct non-medical cannabis taxes (Appendix B2). A common tax used is excise tax – specific or ad-valorem - which is levied on cannabis manufacturers, distributors, or retailers. An ad-valorem tax is where the tax is added according to the products value, typically at the point of sale. A drawback of an ad-valorem tax is that it is sensitive to pre-tax

price.[128] Legalization is said to come with a reduction in the price of cannabis.[124,127,184] A reduction in price would reduce the amount of tax revenue collected and stall efforts to reduce consumption. Moreover, low prices would make it difficult for smaller businesses to compete with large companies, losing diversity in the market.[185] However, lower prices and taxes would create a competitive price to the illegal market and encourage transition into a legal market.[131]

Minimum unit pricing, taxes based on potency, and taxes based on weight are other tax strategies proposed for cannabis products.[76,143,144,186] Minimum unit pricing would ensure that the pre-tax price does not fall below a certain limit, and therefore provide consistent revenue. Taxing by weight, although easier to implement, could encourage higher potency products. Taxing by potency could encourage consumers to switch to lower potency products, minimizing heavy use and dependence. Taxing by potency, more so than taxing by weight, would be a more direct form of Pigouvian tax whereby the revenue would account for the negative externalities of the THC content.[132,143] Indeed, the Canadian government implemented a potency-based tax for all cannabis products (i.e. edibles, vape oils) except dried flower and plants, after they entered the market in December 2019.[187] In the US, Illinois is the only state to date to implement potency-based taxes: Cannabis products below 35% THC are taxed at 10% of the retail price and products above 35% THC are taxed at 25%.[188] New York, who legalized in March 2021, have also proposed a tax based on the level of THC.[189] However, taxing by potency can be more complicated and costlier to implement,[128] especially for dried flower where THC is not consistent within or across strains.[143] Moreover, if the potency-based tax is successful in encouraging consumers to switch to lower potency products, there will be a reduction in tax revenue. Another method of encouraging consumers to choose low potency products is to limit the amount of THC in the products. For example, Quebec introduced a 30% limit on all THC products, and Vermont proposed to limit dried flower to 30% THC and concentrates to 60%.[190]

Hansen and colleagues compared the revenue generated by ad valorem tax vs. potency-based tax and concluded potency-based taxes reduced the potency in products, but did not create as much revenue as ad valorem taxes.[143] Kilmer proposed that governments should retain flexibility among which tax strategies to use depending on objectives.[191]

### 1.10.3 Taxes on dried flower

Canada set excise tax rates so that the price of legal cannabis products would be competitive with those in the illegal market. Dried flower is subject to a federal excise tax of $1 per gram or 10% of a product's price, whichever is greater, as well as provincial sales taxes, which vary from 5% to 15%.[187] For example, one gram of dried flower costing $8 pre-tax could cost between $9.45 and $10.35 CAD. In addition, First Nations people will be excise tax exempt when purchasing from a retailer on reserve land.[192] As such, the prevalence of an illegal market could vary across provinces and territories due to tax variation.[76] The US states that have a legal non-medical market have different excise tax rates (Appendix A2). All jurisdictions except Alaska implemented an excise tax at the retail level and as previously mentioned, Illinois is the only jurisdiction to vary tax by cannabis potency (New York has proposed a similar potency tax).[143,188] For example, the retail excise tax rate is 10.75% in Massachusetts, 15% in California, and in Alaska, cannabis growers pay an excise tax of $50 per ounce of dried flower, the cost of which is most likely passed onto the customer.[188,193] Indeed, in 2020, wholesale prices of dried flower in Alaska were the most expensive among states that had legalized non-medical cannabis.[165] New Mexico proposed to implement a 12% excise tax that will increase after 2025.[121] Washington State initially imposed a 25% tax on each stage of cannabis production, which allowed the state to oversee production and prevent diversion to the illegal market.[194] However, this created a discrepancy between the legal, medical, and illegal cannabis markets. In July 2015, the state introduced a combined tax of 37%.[194,195] Even with a high tax rate of 37%, legal cannabis in Washington State is cheaper than illegal cannabis,[126] and has some of the cheapest cannabis in US states that have legalized non-medical cannabis.[165]

## 1.11 Retail availability

In addition to price, the availability of cannabis may be a primary factor in the decision to transition to a legal market. To compete with illegal sources, the legal market must be accessible. From the tobacco literature, the more convenient the transaction, the higher the probability of purchasing tobacco (whether legal or illegal).[174,196]

Cannabis retail density is considerably lower than tobacco in most jurisdictions that have legalized non-medical cannabis, particularly early in the implementation stage. For example, in Ontario, there was a tobacco retailer for every 231 smokers in 2018, based on a past-30-day

smoking prevalence of 18%.[197] In 2018, Ontario's cannabis prevalence was approximately 18% with no retail stores for the first six months of legalization.[198] After the first year of legalization, there was one physical cannabis store for every 84,288 past 3-month cannabis consumers in Ontario.[199,200] In most US states that have legalized, retail stores have not opened immediately after legalization but one to two years later.[201] However, the speed at which stores opened varied. For example, Colorado and Washington were the first two states to legalize non-medical cannabis and opened their retail market in January and July 2014, respectively. Prior to legalization, Colorado had many licensed medical cannabis retail stores, and initially after legalization only businesses with medical licenses could apply for non-medical licenses. Therefore, Colorado had an efficient start to non-medical cannabis retail sales. Conversely, Washington State did not have licensed medical cannabis stores prior to legalization, and when legalized, there was a cap on the number of retail stores permitted across the state. As such, Washington State did not have an efficient start to retail sales.[124] Some states still do not have a legal retail market, such as Vermont and District of Columbia. However, Vermont plans to allow retail sales in May 2022.[190] A balance must be reached between having enough retail stores to ensure greater accessibility to legal cannabis, without increasing consumption.

Retail models vary across Canadian provinces (see Appendix A1). Saskatchewan and Manitoba opted for private-only sales models; Quebec, New Brunswick, Nova Scotia, and Prince Edward Island opted for public models; and British Columbia, Alberta, Ontario, and Newfoundland & Labrador opted for a hybrid of private and public.[80] The number of legal retail stores in Canada increased from under 200 stores at the end of 2018 to close to 1,500 stores at the end of 2020.[94] However, the opening of cannabis retail stores across Canada has not occurred at an equal rate across the provinces (see Table 2). For example, in Ontario – Canada's most populated province – a change in provincial government resulted in a late switch from a proposed public system to a hybrid system whereby the online store would remain public (Ontario Cannabis Store) and the physical retail stores would be privately run. This change resulted in no stores available in October 2018, and the first stores opened in April 2019, six-months after legalization. Ontario continued to experience a slow opening of their private market due to a lottery license system. However, Ontario removed its lottery system and, from February 2021, the Alcohol and Gaming Commission of Ontario increased its pace of license approvals to 30 stores a week.[202] Indeed, by September 2019, Ontario had 24 stores, 69 stores by February 2020, 112 stores by September 2020, and 563 stores by March 2021.[203] By contrast, Alberta – a province with a hybrid model of a public online store and private physical retail stores – had

opened close to 300 stores by September 2019, over 500 in September 2020 and over 600 in March 2021.[204] Regardless of Ontario's slow start to opening retail stores, by September 2019 Ontario had exceeded Alberta's total retail sales from cannabis stores.[205] With the exception of Quebec, there was little change in the number of stores from March 2019 to September 2020 among provinces with public physical retail stores.[205] However, most provinces with public physical stores have lower populations (Atlantic provinces). As shown in Table 2, Alberta has the highest stores per 100,000 residents over 15 years of all the provinces, with one store serving close to seven thousand residents over 15 years. Indeed, the average distance travelled to get to the nearest store has reduced in all provinces that have increased their number of stores. In British Columbia, there were 16 stores in March 2019 and 57 in July 2019, the population weighted average distance (in kilometers) to the nearest store reduced from 57 km in March 2019 to 24 km in July 2019.[205] This translated into an average of 28% of the British Columbian residents living within 10 km of a retail store in March 2019 and 46% in July 2019.[205]

**Table 2: Number of stores, stores per 100,000 residents over 15 years, and number of residents over 15 years per one store in Canada and across the provinces in September 2019 and 2020.**

| | September 2019 | | | September 2020 | | |
|---|---|---|---|---|---|---|
| | Number of stores | Stores per 100,000 residents over 15 years | Number of residents over 15 years per one store | Number of stores | Stores per 100,000 residents over 15 years | Number of residents over 15 years per one store |
| **All 10 provinces** | 508 | 1.61 | 62,179 | 1129 | 3.57 | 27,978 |
| **Alberta** | 279 | 7.87 | 12,705 | 527 | 14.64 | 6,828 |
| **British Columbia** | 67 | 1.53 | 65,304 | 294 | 6.72 | 14,882 |
| **Newfoundland & Labrador** | 25 | 5.53 | 18,088 | 26 | 5.75 | 17,390 |
| **Saskatchewan** | 35 | 3.71 | 26,945 | 47 | 4.96 | 20,171 |
| **Manitoba** | 23 | 2.07 | 48,287 | 37 | 3.31 | 30,215 |
| **New Brunswick** | 20 | 3.01 | 33,254 | 20 | 2.99 | 33,467 |
| **Prince Edward Island** | 4 | 3.01 | 33,219 | 4 | 2.96 | 33,803 |
| **Nova Scotia** | 12 | 1.44 | 69,492 | 16 | 1.90 | 52,660 |
| **Ontario** | 24 | 0.20 | 511,424 | 112 | 0.90 | 111,209 |
| **Quebec** | 19 | 0.27 | 376,745 | 46 | 0.64 | 156,979 |

Population estimates: Statistics Canada. Table 17-10-0060-01 Estimates of population as of July 1st, by marital status, age and sex. Doi: 10.25318/1710006001-eng

### 1.11.1 Locations of retail cannabis stores

In addition to the number of physical retail stores in a province or state, provinces, states, and local municipalities also implement other retail policies that may affect availability.[80] Some local communities may ban stores completely and some may enact restrictions on proximity to schools or youth-oriented spaces.[80] For example, approximately two years after retail sales opened in Colorado, the only 26% of local jurisdictions permitted non-medical retail stores.[206] In Washington State, to a lesser extent, found 30% of residents lived in an area that had prohibited retail sales two years after retail stores opened.[207] Oregon allowed communities to opt out of retail sales; however, a study demonstrated that an increase in cannabis use was seen among youth cannabis consumers who lived in communities that had opted out of retail sales.[208] Therefore, availability of stores may depend on local or provincial policy rather than demand. These policies may influence who lives in or near to communities where retail stores are permitted. For example, research conducted in California examining equity in the distribution of illegal and legal retail cannabis stores demonstrated that compared to areas with only legal retail stores, areas with only illegal retail stores or both illegal and legal stores had higher percentages of minority populations and people living in poverty.[209] Similar research exploring equity in location of retail stores in Oregon, California, and Washington State concluded that retail stores were located in areas with higher proportions of minority populations, alcohol retail stores, and people living in poverty.[210-214] Similar conclusions have been drawn from the alcohol and tobacco literature, where alcohol and tobacco retail stores were more likely to be located in poorer census tracts.[215,216]

### 1.11.2 Online stores and delivery services

Restrictions on location do not apply to online spaces, and therefore, the importance of proximity and access to physical retail stores may depend on the availability of legal mail order or delivery services.[217,218] Online sales and delivery are available in all Canadian provinces (Appendix A1). Although most US states that have legalized non-medical cannabis allow delivery of medical cannabis (except Alaska and Washington State), only California, Nevada, Oregon, and Colorado allow delivery for non-medical cannabis at the time of writing – July 2021 (Appendix A2).[219,220] The availability of delivery services, access to the internet and a credit card, and patience for delivery may determine how important proximity to a physical retail store is. Indeed, although Canadians experienced delays in online delivery at the start of legalization,[221] most provinces now provide same-day delivery in some regions of each

province.[222] The Ontario Cannabis Store reported that approximately two thirds of consumers who used their store accessed express shipping in the first quarter of 2020.[154] Regardless of changes to speed of delivery, online sales still only account for a small proportion of the total sales in Canada – 13% in September 2019.[205] However, the COVID-19 pandemic may change consumer habits temporarily. During the pandemic, further changes were introduced to online sales, where some provinces allowed online ordering and curbside pickup from private physical retail stores, which was previously not allowed.[80] The ability to travel to the physical retail store for collection is still necessarily in this case. In sum, since the COVID-19 pandemic and increased availability of online services or curb-side pickup, physical access to cannabis stores may not matter as much as before the pandemic.

**1.11.3 Retail availability and cannabis use**

A concern with increased retail availability is that prior research from tobacco and alcohol indicates that increased retail availability is associated with increased initiation and frequency of use, especially among youth.[173,223-225] Retail availability can be defined and measured in various ways such as through retail density, retail proximity, or retail store opening times. Previous literature on the relationship with retail availability and cannabis use has examined retail density and retail proximity to medical and non-medical retail stores, with mostly positive associations.[223,226-229] For example, research in Washington State observed a positive association between current cannabis use and proximity to non-medical retail stores and per capita retail density.[226] Among pregnant women in post-legalization California, a shorter drive time to retailers (proximity) and more retailers within a short drive (density) was associated with higher odds of cannabis use.[227] Research in Los Angeles, California, observed a positive association between retail density of unlicensed and licensed retail stores, and heavy cannabis use.[228] Two more studies in California demonstrated that living near a higher density of medical cannabis retail stores was positively associated with frequent cannabis use.[218,229] However, research in the Netherlands did not find a relationship between cannabis use and proximity to non-medical retail stores ("coffee shops").[230]

Relationships between youth cannabis use and availability are inconclusive.[231-236] For example, a positive relationship was found between adolescents living in a county with non-medical cannabis stores and cannabis use.[234] However, other research among US youth found no association in the relationship between cannabis use and availability, where availability was represented as proximity to medical retail stores[235,236] or non-medical retail stores.[237]

To date, most research on the relationship between retail availability of cannabis - measured by proximity or density of retail stores - and cannabis outcomes has been conducted on US samples. To our knowledge, there is no research on Canadian samples after non-medical cannabis legalization.

Similar to price, retail availability should encourage a transition to a legal market, yet not increase initiation and use. To date, no research has examined the relationship between retail availability and purchasing cannabis from a legal source.

## 1.13 Study rationale

Canada's decision to legalize non-medical cannabis represents a unique opportunity to evaluate a novel policy with public health implications. The objective of the Cannabis Act in Canada is to displace the illegal market with a regulated market. From the tobacco and alcohol literature, price and retail availability will be the primary factors that dictate the demand and prevalence of illegal cannabis.[173] However, no studies have explored the association between price, retail availability and purchasing legal and illegal cannabis in pre- and post- legalization in Canada, and few studies have explored the association between price and purchasing legal and illegal cannabis in the US post-legalization.[49,96,134,161,163]

This study seeks to examine the impact of cannabis legalization on the use of the legal market in Canada and the US, with a focus on the association between price of dried flower, quantity purchased of dried flower, sources used to purchase dried flower including the legality of source, and proximity to legal retail stores.

The Canadian government is conducting a legislative review of cannabis legalization. The current thesis will produce timely scientific evidence that can contribute to the Government of Canada's legislative review.

## 1.14 Research questions

The current study will answer the following specific research questions:

1. To what extent are purchase source and quantity purchased associated with the price of dried flower in Canada pre-legalization?

2. To what extent is retail availability associated with purchasing dried flower from legal sources in Canada post-legalization?

3. To what extent is the price of dried flower associated with legal purchases of dried flower in Canada post-legalization?

4. To what extent is the price of dried flower and the 'age' of a retail market associated with purchases from legal sources in US states that have a legal non-medical retail market?

## 1.15 Conceptual framework

The conceptual framework for the current study was based on the conceptual model of the International Tobacco Control Policy Evaluation Project and the economic theory outlined by the International Agency for Research on Cancer, which are used to evaluate the behavioural impact of tobacco policies, prices, taxes, and illegal markets.[174,238-240] These frameworks present price and retail availability as the primary 'proximal' policy-specific variable of interest and purchasing behaviours as the 'distal' policy-relevant outcome. The moderators in the framework include, but are not limited to, sociodemographic characteristics, frequency of use, and geographic location (See Figure 5).[238,240]

**Figure 5: Conceptual Framework based upon the economic theory of the International Agency for Research on Cancer and the conceptual model of the International Tobacco Control Policy Evaluation Project**[174,239,240]
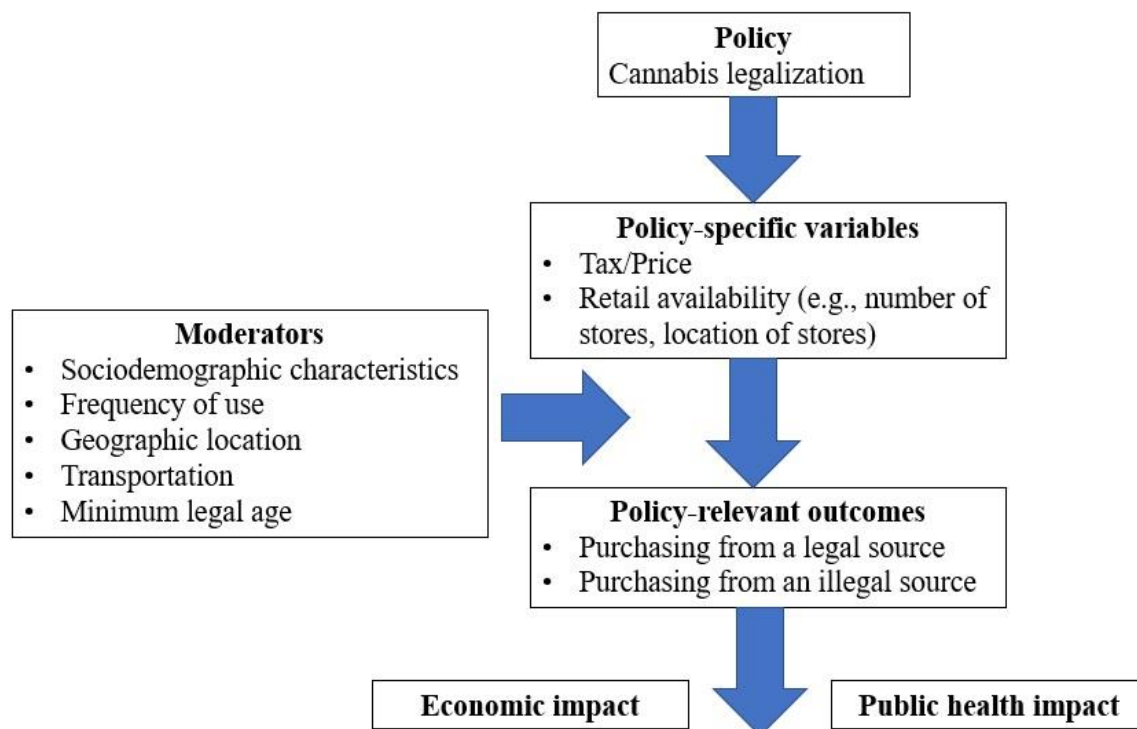


As an example, the conceptual theory of price leading to purchase behaviours is based on the relationship between price and quantity demanded in economic theory, i.e., a decrease in the price of a product – cannabis – increases the quantity demanded, while all other factors remain constant. For instance, in theory, if there is a decrease in the price of cannabis, we should see an increase in quantity purchased, the quantity demanded from a specific source, or the quantity demanded of a specific product. In a legal cannabis market, the monetary price of both legal and illegal cannabis should be taken into consideration as well as the "full price" of legal and illegal cannabis.[174,239] Indeed, the "full price" of cannabis includes more than just the cost of the product. The full price includes the negative consequences of use such as negative social, financial, emotional, or health effects.[174,239] For injecting drug use, this would include risk of blood borne viruses and risk of police involvement. The full price of cannabis since legalization may have reduced in the legal market since the risks of fines, criminal records, and unknown quality/content of the product associated with illegal cannabis is no longer included. Indeed, the full price of legal cannabis may reduce below the full price of illegal cannabis, even though the illegal monetary price of cannabis may be cheaper.

# CHAPTER 2: METHODS

The proposed thesis consists of four studies, corresponding to each of the four primary research questions. The current chapter will summarize the methods across the four studies.

## 2.1 Study design

Data are from Wave 1-3 of the International Cannabis Policy Study (ICPS), a repeat cross-sectional study conducted annually in Canada and the US.[1] Data were collected via self-completed web-based surveys with respondents aged 16-65. Wave 1 was conducted between August 27, 2018 and October 7, 2018; Wave 2 was conducted between September 13, 2019 and October 31, 2019; and Wave 3 was conducted between September 3, 2020 and November 2, 2020. In general, the ICPS seeks to evaluate the overall impact of non-medical legalization to examine the effectiveness of specific policy measures, in three jurisdictions: Canada (all 10 provinces); US states that have legalized non-medical cannabis (US 'legal' states); and those that have not (US 'illegal' states). US 'illegal' states include states with legal medical cannabis laws. At Wave 1, US 'legal' states included Alaska, California, Colorado, Maine, Massachusetts, Nevada, Oregon, Vermont, Washington State, and the District of Columbia. At Wave 2, US 'legal' states additionally included Michigan, and at Wave 3, US 'legal' states additionally included Illinois. Wave 1 was conducted pre-legalization in Canada and Wave 2 and 3 were conducted post-legalization in Canada (Table 1).

**Table 1: Non-medical cannabis laws in Canada, US 'legal' states and US 'illegal' states in 2018-2020**

|                | Canada  | US 'legal' states | US 'illegal' states |
| -------------- | ------- | ----------------- | ------------------- |
| **Wave 1 (2018)** | Illegal | Legal             | Illegal             |
| **Wave 2 (2019)** | Legal   | Legal             | Illegal             |
| **Wave 3 (2020)** | Legal   | Legal             | Illegal             |

Canada legalized non-medical cannabis in October 2018, immediately after data collection in Wave 1
For non-medical cannabis laws, US 'illegal' states include states with legal medical cannabis laws.

## 2.2 Respondents and recruitment

Respondents were eligible to participate if they resided in a Canadian province or US state, were 16-65 years of age at the time of recruitment, and had access to the internet. Respondents were recruited using non-probability sampling methods through the Nielsen Consumer Insights Global Panel and their partners' panels, which maintains panels in Canada and the US. Data were collected via self-completed web-based surveys. After targeting for age and country, email invitations with a unique link were sent to a random sample of panelists; ineligible panelists were not invited. Surveys were conducted in English in the US and English or French in Canada. Median survey time was 20 minutes in 2018, 25 minutes in 2019, and 21 minutes in 2020.

Respondents were provided with information about the study and provided consent prior to completing the survey. Respondents received remuneration in accordance with their panel's usual incentive structure (e.g., points-based or monetary rewards, chances to win prizes). In 2018, 44,364 respondents accessed the survey link, of whom 28,471 completed the entire survey for an AAPOR cooperation rate of 64.2%.[2,3] In 2019, 81,263 respondents accessed the survey link, of whom 51,087 completed the entire survey for an AAPOR cooperation rate of 62.9%.[2,4] In 2020, 78,438 respondents accessed the survey link, of whom 48,633 completed the entire survey for an AAPOR cooperation rate of 62.0%.[2,5] The study received ethics clearance through a University of Waterloo Research Ethics Committee (ORE# 22392).

## 2.3 Measures

The full survey for all three survey waves included in the current thesis can be found online.[6-8] Survey measures were drawn or adapted from national surveys or selected based on previous research. To develop and test the survey measures, a pilot survey of 870 youth and young adults was conducted in October 2017.[9] To examine the comprehension of measures, focus groups and cognitive interviews were conducted in January-February 2018 and August 2019.[10] In all cases, respondents had the option of selecting 'Don't Know' or 'Refuse'. In all variables except "perceived income adequacy", "Refuse to answer" was treated as missing. For all measures except "perceived income adequacy", "purchase source at last purchase", and "self-reported time to nearest store", "Don't know" was treated as missing.

### 2.3.1 Socio-demographic measures

Socio-demographic measures included sex at birth (Male, Female), age in years (16-25, 26-35, 36-45, 46-55, 56-65) or age beginning at legal purchase age (minimum legal age [MLA]-25, 26-35, 46-55, 56-65), ethnicity/race (Canada: Black, East/Southeast Asian, Indigenous, Latinx, Middle Eastern, South Asian, White, Other/Mixed; US: Non-Hispanic White, Hispanic White, American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Pacific Islander, Mixed/Other), highest level of education (Less than high school, High school diploma, Some college or technical vocation, Bachelor's degree or higher), perceived income adequacy (Very difficult, Difficult, Neither easy nor difficult, Easy, Very easy, Not reported), device used to complete survey (Smartphone, Tablet, Computer), province of residence (Canadian respondents), and state of residence (US respondents).

For Canadian respondents, MLA was taken from provincial laws in September 2019 and 2020.[11] In 2019, MLA was 18 years in Alberta and Quebec, and 19 years elsewhere. In 2020, MLA was 18 years in Alberta, 21 years in Quebec, and 19 years elsewhere. For US 'legal' respondents, MLA was taken from non-medical state laws. MLA was 21 years in all 'legal' states.

### 2.3.2 Cannabis use frequency

Cannabis use frequency was assessed through questions, "Have you ever tried cannabis?" (Yes/No), "When was the last time you used cannabis?" (More than 12 months ago/More than 3 months ago but less than 12 months ago/More than 30 days ago, but less than 3 months ago/Within the past 30 days) and "How often do you use cannabis?" (Less than once per month/One or more times per month/One or more times per week/Every day or almost every day). Responses from past 12-month cannabis consumers were recoded into exclusive categories: "Less than monthly consumer", "Monthly consumer", "Weekly consumer", "Daily/almost daily consumer".

### 2.3.3 US cannabis laws

For analyses using US data in 2019 and 2020, US states were categorized into 'recreational', 'medical' and 'illegal' states. US 'recreational' states were defined as those with non-medical cannabis laws in place on or before the start of the survey in each year. US 'medical' states were defined as those with medical cannabis laws in place on or before the start of survey in each year. US 'illegal' states were defined as states without medical or non-medical cannabis

laws at the time of survey. For this measure, the term 'recreational' is used instead of 'non-medical' to make a clearer distinction from 'medical'.


### 2.3.4 Time since legal retail sales

For analyses using US data in 2019 and 2020, US states that had legalized non-medical cannabis with retail non-medical markets in 2020 were recorded to a continuous variable according to the time (in years) since their state began non-medical retail sales to the time of the survey.


### 2.3.5 Quantity purchased of dried flower at last purchase

Respondents were asked, "The last time you purchased dried herb, how much did you buy…?" with answers "1/8 gram or less", "1/4 gram", "1/2 gram", "3/4 gram", "1 gram", "2 grams", "3 grams", "1/8 ounce", "1/4 ounce", "1/2 ounce", "3/4 ounce", "1 ounce" and "More than 1 ounce" (see Figure 1). Respondents could provide open-ended responses if they reported purchasing more than one ounce. Respondents could also report the quantity purchased in joints, with answers "1 joint" and increased in increments of one up to "More than 20 joints" (see Figure 2). Respondents answering in joints were asked to report the weight that was closest to the size that they purchased, with answers beginning at "0.2g" and increasing in 0.2g increments to 1.2g. Units were standardized into grams (g) and responses were treated as continuous. This question was only asked of respondents who reported last purchasing dried flower, i.e., not obtained for free or through non-monetary exchange.

**Figure 1: Visual prompt for question: The last time you bought dried herb, how much did you buy…?**



**Figure 2: Visual prompt for question: Please choose the joint that is closest to the size you bought.**



### 2.3.6 Self-reported price-per-gram of dried flower at last purchase

Respondent's price-per-gram was calculated from two questions. First, quantity purchased at last purchase (see above). Second, respondents were asked, "How much did you spend the last

time you bought dried herb?" and respondents were given a numerical open-ended response. Units were in Canadian dollars (CAD) for analysis including Canadian respondents and US dollars (USD) for analysis including US respondents. As with quantity purchased, this question was only asked to respondents that *purchased* dried flower, i.e., not obtained for free or through non-monetary exchange. For analyses with 2019 and 2020 data, prices in 2019 were inflated to 2020 prices using the 12-month change in Consumer Price Index from September 2019 to September 2020.

### 2.3.7 Quantity-adjusted price of dried flower at last purchase

The average unit price (price-per-gram) of dried flower adjusted for the quantity purchased for all respondents was computed as the ratio:

$$\textit{Quantity-adjusted price} = \sum (P_r * QP_r)/ \sum (QP_r)$$

Where $P_r$ is the respondents' unit price and $QP_r$ is the respondent's quantity purchased

Calculations were taken from Ontario Cannabis Stores annual review 2019-2020.[12]

### 2.3.8 Purchase source at last purchase

In 2018, respondents were asked: "In the past 12 months, how did you get the dried herb you used?" with answer options: "I grew my own", "From a family member or friend", "From a dealer (in person)", "Health Canada medical cannabis licensed producer, by mail order [Canada only]", "Other internet delivery service", "From a store, co-operative or dispensary (in person)", "Other". For 2018 analyses, "I grew my own" responses were included in descriptive statistics but excluded from analyses because price paid for seeds/plants may differ from dried flower. "Other" was re-categorized according to answers provided. Respondents could select all that apply; however, only respondents who purchased from only one source in the past 12 months were recoded to that source. Respondents who purchased from more than one source were recoded to 'Not reported'.

In 2019 and 2020, respondents were asked "The last time you purchased dried herb, where did you buy it?" with answer options, "From a family member or friend", "From a dealer (in person)", "Internet delivery service or mail order (delivered to me)", "From a store, co-operative or dispensary (in person/curbside pickup)", "Other". "Other" was re-categorized

according to answers provided. In all years, this question was only asked to respondents that *purchased* dried flower, i.e., not obtained for free or through non-monetary exchange.

### 2.3.9 Legality of last purchase source

Purchase source was categorized into "Illegal sources" and "Legal sources", as shown in Appendix C. The criteria for illegal and legal sources was based on a review of the Canadian and US state regulations in 2018, 2019, and 2020. In addition, illegal and legal stores or dispensaries were determined by the following question: "What type of physical store or dispensary did you buy the dried herb from?" with answer options: "A legal medical dispensary or co-operative [US only]", "A legal/authorized store [Canada only]", "A legal non-medical store [US only]", "An illegal or unauthorized store/dispensary", "Other". "Other" was re-categorized according to answers provided. Illegal and legal online sources or mail order were determined by the following question: "Where did you buy the dried herb online?" with answer options: "An authorized/legal website", "An unauthorized/illegal website, private delivery service or dealer (including through Weedmaps or Leafly)", "Other". "Other" was re-categorized according to answers provided.

### 2.3.10 Legal purchases of dried flower in past 12-months

In 2019 and 2020, respondents who consumed dried flower in the past 12-months were asked "Overall, about what percentage of the dried herb that you used in the past 12-months came from LEGAL/AUTHORIZED sources?". Answers were open-ended from 0%-100%. Respondents were able to report both medical and non-medical legal/authorized sources.

### 2.3.11 Retail proximity (Self-reported time to retail store)

Respondents were asked "How long would it take you to get to the nearest store that sells cannabis using your usual mode of transportation?" Responses began at "Less than five minutes" and increased in five-minute increments up to one hour and ended with "More than an hour" and "I don't know any store near to where I live". Responses were categorized into: "Under 5 mins", "5-15 mins", "Over 15 mins", "I don't know any stores where I live". To approximately match the time taken to travel 3 km and 10 km by car at 40-60 km per hour, as the majority of respondents' usual mode of transport (see measure below, Table 2) was via private transportation (car/taxi) in 2019 and 2020. This variable included both legal and illegal retail stores.

*Usual mode of transport:* Respondents were asked "What is your usual mode of transportation?" with answer options, "Walking", "Driving (e.g., car, taxi)", "Bike", "Bus/streetcar", "Train/subway/high-speed rail", "Other". "Other" was re-categorized according to answers provided. Responses were categorized into: "Private transport (car/taxi)", "Active transport (bike/walk)", and "Public transport (bus/train)".

**Table 2: Percentage of Canadian respondents' usual mode of transport in 2019**

| | Private transport (car/taxi) % (n) | Active transport (bike/walk) % (n) | Public transport (train/bus) % (n) |
|---|---|---|---|
| All Canadian respondents (n=12,043) | 68.7 (8894) | 14.8 (1497) | 16.6 (1652) |
| Canadian respondents who had consumed and purchased in the past 12-months (n=2,402) | 65.8 (1666) | 17.2 (391) | 16.9 (345) |
| Canadian respondents of legal age to purchase cannabis and had consumed and purchased in the past 12-months (n=2,322) | 66.8 (1625) | 16.9 (372) | 16.3 (325) |

Weighted %, unweighted (n).

### 2.3.12 Provincial retail density (stores per 100,000 residents aged 15 years and over)

For analyses using 2019 data, legal retailers in each province were identified and downloaded from provincial websites in September 2019 and cross-checked with lists displayed on Leafly, a website dedicated to cannabis and legal cannabis stores (www.leafly.ca).[13,14] The number of stores in each province was divided by the provincial population aged 15 and over for 2019 and multiplied by 100,000.[15] Illegal retail stores were not included.

### 2.3.13 Retail proximity (Euclidean distance)

For analyses using Canadian 2019 data, respondents were asked "Please provide the postal code where you live for most of the year". A total of 2,900 respondents at Wave 2 either didn't know their postal code ($n_{2019}$=1,175), refused to provide their postal code ($n_{2019}$=1,676), or their postal code did not match their province ($n_{2019}$=49). If respondents answered, 'Don't know' or 'Refuse to answer', they were given an opportunity to provide their intersection of residence. Those respondents were asked "Please name the 2 cross-streets of this intersection". Respondents were given the option of 'Don't know' ($n_{2019}$=581) or 'Refuse to answer'

($n_{2019}$=1,189) for the intersection. Of those who provided their intersection ($n_{2019}$=1,081), Google Maps was used to obtain postal codes, cross-referencing with the respondent's city and province. If Google Maps did not recognize the intersection, each street name was entered individually to clarify. All intersections where Google Maps could not find a postal code, were left blank ($n_{2019}$=272). A total of 809 postal codes were retrieved.

The postal codes of legal retailers in each province were identified using provincial websites and cross-checked with lists from Leafly. The Canadian respondents' postal codes and postal codes of legal retail stores were linked to the Postal Code Conversion File Plus (PCCF+), version 7B to obtain geographic coordinates (in latitude and longitude).[16] In 2019, the postal codes of legal retail stores in Canada were also linked to the PCCF+ v7B to obtain latitudes and longitudes. The postal codes were assigned 'residential' status; however, the postal codes were assigned 'institutional' as a sensitivity analysis and results were largely identical. An open-source geographic information system (GIS) application (QGIS v3.6) was used to geocode the latitudes and longitudes of legal retail stores and respondents' postal codes. For respondents in urban areas, Canadian postal codes can cover a single house/apartment building, whereas postal codes in rural areas cover a larger landmass. In analyses using 2019 data, 88% of respondents lived in urban areas and so a certain degree of accuracy could be assumed from postal codes as a proxy for Canadian respondent locations (Table 3).[17,18]

**Table 3: Percentage of Canadian respondents with valid postal code data residing in urban and rural areas in 2019 (n=12,923)**

| | | % (n) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **All 10 provinces** | **BC** | **AB** | **SK** | **MB** | **ON** | **QC** | **NB** | **NS** | **PEI** | **NL** |
| **Urban** | 87.8 | 90.6 | 88.9 | 78.3 | 82.0 | 91.9 | 85.2 | 74.7 | 72.7 | 68.1 | 66.8 |
| | (11145) | (1691) | (1673) | (601) | (620) | (2561) | (2635) | (448) | (540) | (87) | (289) |
| **Rural** | 12.2 | 9.4 | 11.1 | 21.7 | 18.0 | 8.1 | 14.8 | 25.3 | 27.3 | 31.9 | 33.2 |
| | (1778) | (176) | (198) | (147) | (132) | (206) | (404) | (143) | (200) | (40) | (132) |

Weighted %, unweighted n

BC=British Columbia, AB=Alberta, SK=Saskatchewan, MB=Manitoba, ON=Ontario, QC=Quebec, NB=New Brunswick, NS=Nova Scotia, PEI=Prince Edward Island, NL=Newfoundland and Labrador

The North American Equidistant Conic Projection (EPSG:102010) was used to minimize distance distortions. The Euclidean distance between the postal code of the legal retail store and the respondents address were computed and standardized into kilometers (km). Distances were categorized into: "Under 3 km", "3-4.9 km", "5-9.9 km", "10 km or over" to mimic categories used by Statistics Canada.[19] A sensitivity analysis was conducted to examine the effect of distance as a categorical measure using breaks at the quartiles as well as a continuous measure (see Chapter 4).

## 2.4 Data Analysis

All analyses were conducted using survey procedures in SAS (SAS version 9.4, SAS Institute Inc., Cary, NC, USA).

In 2018, 28,471 respondents completed the survey. After removing respondents due to dishonesty (n=208), poor data quality (n=1,073), ineligible country of residence (n=5), smartphone use (n=2), or residence in District of Columbia (due to inadequate sample size, n=14), 27,169 respondents were retained in the analytical sample.

In 2019, 51,087 respondents completed the 2019 survey. After removing respondents due to dishonesty (n=717), poor data quality[†] (n=2,235), those who identified as intersex and an 'other'/unstated gender identity (due to insufficient cell counts for weighting) (n=11), speeding (n=16) or duplicate entries (n=361), 47,747 respondents were retained. Of these, 2,012 returners from 2018 were excluded. The remaining 45,735 comprised the 2019 cross-sectional sample.

In 2020, 48,633 respondents completed the 2020 survey. After removing respondents due to dishonesty (n=893), poor data quality (n=2,538), those who identified as intersex and an 'other'/unstated gender identity (due to insufficient cell counts for weighting) (n=12), speeding (n=84), duplicate entries (n=2), or age >65 (n=189), 45,680 respondents were retained in the analytical sample.

---

[†] Respondents were asked a 'data quality' question: "What is the current month". Respondents who did not answer correctly were excluded.

### 2.4.1 Survey Weights

In 2018, post-stratification sample weights were constructed based on the Canadian Census estimates. Respondents from Canada were classified into age-by-sex-by-province and education groups. Correspondingly grouped population count and proportion estimates were obtained from Statistics Canada.[20,21] A raking algorithm was applied to the full analytic sample to compute weights that were calibrated to these groupings. The SAS macro "RAKE_AND_TRIM_G4_V5" was used for running the raking program with trimming set to 6.[25-27] Weights were rescaled to the sample size for Canada. All estimates are weighted unless specified.

In 2019 and 2020, post-stratification sample weights were constructed based on the Canadian and US Census estimates.[21-24] Respondents from Canada were classified into age-by-sex-by-province, education, and age-by-cigarette smoking status groups. Respondents from US legal states were classified into age-by-sex-by-legal state, education-by-legal state, region-by-race and age-by-cigarette smoking status groups, while those from illegal states were classified into age-by-sex, education, region-by-race and age-by-cigarette smoking status groups. Separately for Canada, US legal states, and US illegal states, a raking algorithm was applied to the cross-sectional analytic samples to compute weights that were calibrated to these groupings. The SAS macro "RAKE_AND_TRIM_G4_V5" was used for running the raking program with trimming set to 6 for 2019 data, and 5 for 2020 data.[25-27] Weights were rescaled to the sample size for each jurisdiction. All estimates are weighted unless specified.

Sample characteristics are provided in Chapters 3-6 for each study. Descriptive statistics were used to characterize outcome variables and key exposure variables and distributions were studied for violations from normality and transformed as necessary (i.e., self-reported price-per-gram, quantity purchased). Logistic regression models were conducted to examine binary outcome variables and multiple linear regression models were conducted to examine continuous variables. All models were reported with 95% confidence intervals (95% CI) and adjusted for age, sex at birth, highest level of education, ethnicity/race, perceived income adequacy, and cannabis use frequency. For analyses using 2019 and 2020 data, models were adjusted for survey year and device used to complete survey. Further details of analysis can be found in the chapters corresponding to the specific studies.

### 2.4.2 Cannabis use frequency cleaning

Respondents were asked about their current frequency of use in two ways: as a categorical variable ("How often do you use cannabis?" [Less than once per month/One or more times per month/One or more times per week/Every day or almost every day]) and also as an open-ended variable where respondents entered the number of days they use cannabis per week/month/in the past 12 months. Where large discrepancies between responses to these two variables existed (e.g., respondent selected "less than once per month" but indicated that they consumed cannabis on 365 days in the past 12 months), the frequency of cannabis consumption was reclassified. This affected 4.5% (n=729) of past 12-month cannabis consumers.

### 2.4.3 Price and quantity data cleaning

For studies using price data, quantity values were cleaned according to purchase limits in respective jurisdictions. If respondents last purchased dried flower from a legal retail non-medical store, quantities above 30 g in Canada (2019 and 2020) and 75 g in the US (all years) were excluded. Purchase limits vary across US states; however, the larger limit was used to account for any out-of-state purchasing. If respondents last purchased from a legal medical store and reported to have medical authorization, then quantities above 150 g in Canada (all years) and 75 g in the US (all years) were excluded. All quantities above 150 g purchased from other sources were excluded (all years).

*Study 1 (2018):* Price-per-gram values were cleaned based on the minimum and maximum price-per-gram identified in a retail scan of the Canadian illegal cannabis market pre-legalization in a separate study.[25] Respondents with a value less than $2.20 or greater than $30.00 per gram were deemed implausible and removed.

Study 3 (2019-2020): Implausible price-per-gram values were excluded at the 95th percentile and winsorized at the 1st percentile. This cleaning method was based on the distribution of price-per-gram values compared to a retail scan of the Canadian legal and illegal retail market in a separate study, including tens of thousands of prices for loose and pre-rolled dried flower to obtain plausible minimum and maximum price-per-gram values.[28-30] Respondents with an implausible price-per-gram (n=188) were those who had a calculated price-per-gram above the 95th percentile (Canada: $n_{2019}=100$; $n_{2020}=88$). Respondents with values below the 1st percentile were winsorized to the 1st percentile (Canada: $n_{2019}=20$; $n_{2020}=22$).

As a sensitivity analysis, additional cleaning methods were considered where instead of excluding values above the 95$^{th}$ percentile: respondents' values were winsorized at the 95$^{th}$ or 99$^{th}$ percentile. However, retaining these values above the 95$^{th}$ or 99$^{th}$ percentile skewed the means towards retaining less frequent consumers (who would arguably purchase less frequently) over more frequent consumers. In addition, it would retain implausible values (e.g., values greater than \$50/g). See Appendix D for alternative cleaning methods for Canadian respondents in 2019 and 2020.

Study 4 (2019-2020): Implausible price-per-gram values were excluded at the 95$^{th}$ percentile and winsorized at the 1$^{st}$ percentile. This cleaning method was based on the distribution of price-per-gram values compared to price estimates in the academic literature and industry reports to obtain plausible minimum and maximum price-per-gram values.[31-37] Respondents with an implausible price-per-gram (n=338) were those who had a calculated price-per-gram above the 95$^{th}$ percentile ($n_{2019}$=181; $n_{2020}$=157). Respondents with values below the 1$^{st}$ percentile were winsorized to the 1$^{st}$ percentile ($n_{2019}$=48; $n_{2020}$=40). See Appendix D for alternative cleaning methods for US respondents in 2019 and 2020.

### 2.4.4 Missing data

All analyses were based on subsamples of Canadian and US respondents who had reported consuming and purchasing dried flower in the past 12-months. In each study, missing data were removed using case-wise deletion for variables in regression analyses. Further details of missing data in specific studies can be found in Chapters 3-6 and Appendix E.

*Study 1 (2018):* The analysis for study 1 (see Chapter 3) was based on the sub-sample of 1,227 Canadian respondents who had consumed and purchased dried flower in the past 12-months. Missing data were removed using case-wise deletion for variables in regression analyses for: highest level of education (n=2), and price-per-gram at last purchase, either not providing a price or quantity variable to calculate price-per-gram (n=184) or an implausible value (n=152).

The proportion of cannabis consumers who had a plausible price-per-gram of dried flower were more likely to be male ($\chi^2$=4.3, p=0.039), report white ethnicity/race ($\chi^2$=13.4, p=0.020), and be daily cannabis consumers ($\chi^2$=15.0, p=0.002). For a full display of the differences between Canadian dried flower purchasers of who provided a plausible price-per-gram vs those who do not, see Appendix E1.

*Study 2 (2019):* The analysis for study 2 (see Chapter 4) was based on the sub-sample of 2,506 Canadian respondents who were of legal age to purchase cannabis and had consumed and purchased dried flower in the past 12-months. Missing data were removed using case-wise deletion for variables in regression analyses for: legality of purchase source at last purchase (n=101); self-reported proximity (n=19); ethnicity/race (n=35), highest level of education (n=12), and postal code of respondent's residence (n=355).

In 2019, the proportion of cannabis consumers purchased dried flower in the past 12 months and were of legal age to purchase dried flower who provided a valid postal code were more likely to be older ($\chi^2$=38.5, p<0.001), report difficult income adequacy ($\chi^2$=66.9, p<0.001), and have completed the survey on a computer ($\chi^2$=26.6, p<0.001). For a full display of the differences between Canadian dried flower purchasers of legal age who provide valid postal codes vs those who do not, see Appendix E2.

*Study 3 (2019 and 2020):* The analysis for study 3 (see Chapter 5) was based on the sub-sample of 4,923 ($n_{2019}$=2,506; $n_{2020}$=2,417) Canadian respondents who were of legal age to purchase cannabis, and had consumed and purchased dried flower in the past 12-months. Missing data were removed using case-wise deletion for variables in regression analyses for: legality of purchase source at last purchase (n=188); highest level of education (n=28); ethnicity/race (n=71) and price-per-gram at last purchase, either not providing a price or quantity variable to calculate price-per-gram (n=995) or an implausible value (n=188).

In 2019, the proportion of cannabis consumers who had a plausible price-per-gram of dried flower were more likely to report Indigenous, or Mixed/Other ethnicity/race ($\chi^2$=16.2, p=0.023), have a lower level of education ($\chi^2$=7.9, p=0.048), have a difficult income adequacy ($\chi^2$=13.6, p=0.018), and be more frequent cannabis consumers ($\chi^2$=27.6, p<0.001). In 2020, the proportion of cannabis consumers who had a plausible price-per-gram were more likely to be male ($\chi^2$=9.9, p=0.002), and be more frequent cannabis consumers ($\chi^2$=22.1, p<0.001). For a full display of the differences between Canadian dried flower purchasers who provided plausible price-per-gram values vs those who do not, see Appendix E1.

*Study 4 (2019 and 2020):* The analysis for study 4 (see Chapter 6) was based on the sub-sample of 5,792 respondents from US 'legal' states who were of legal age to purchase non-medical

cannabis and had consumed and purchased dried flower in the past 12-months. Missing data were removed using case-wise deletion for variables in regression analyses for: legality of purchase source (n=108), highest level of education (n=20), ethnicity/race (n=126), and price-per-gram at last purchase, either not providing a price or quantity variable to calculate price-per-gram (n=962) or an implausible value (n=180).

In 2019, the proportion of cannabis consumers in US 'legal' states who had a plausible price-per-gram of dried flower were more likely to have a lower level of education ($\chi^2$=8.6, p=0.035), have difficult income adequacy ($\chi^2$=29.3, p<0.001), and be more frequent cannabis consumers ($\chi^2$=53.8, p<0.001). In 2020 (W3), the proportion of cannabis consumers in US 'legal' states who had a plausible price-per-gram of dried flower were more likely to have a lower level of education ($\chi^2$=9.5, p=0.024), have difficult income adequacy ($\chi^2$=13.2, p=0.022), and be more frequent cannabis consumers ($\chi^2$=19.2, p<0.001).

For a full display of the differences between US 'legal' dried flower purchasers who provided plausible price-per-grams vs those who do not in 2019, and 2020, see Appendix E3.

# CHAPTER 3: DIFFERENCES IN SELF-REPORTED CANNABIS PRICES ACROSS PURCHASE SOURCE AND QUANTITY PURCHASED AMONG CANADIANS

Authors: Elle Wadsworth[a], Pete Driezen[ab], Samantha Goodman[a], David Hammond[a]

[a]School of Public Health Sciences, University of Waterloo, Waterloo, Ontario, Canada
[b]Department of Psychology, University of Waterloo, Waterloo, Ontario, Canada

## 3.1 Overview

**Background:** In October 2018, Canada legalized non-medical cannabis. A primary goal of legalization is to reduce illegal market transactions; however, there is little 'baseline' data on the price and purchase sources of cannabis prior to legalization in Canada. The current study examined the self-reported price of dried flower, quantity purchased, and sources used before retail stores opened.

**Methods:** Data come from the baseline wave of the International Cannabis Policy Study (ICPS), a repeat cross-sectional survey conducted in Aug-Oct 2018, immediately before legalization. Respondents were 1,227 Canadians aged 16–65 years who reported purchasing dried flower in the past 12 months. Respondents were recruited using the Nielsen Consumer Insights Global Panel. A linear regression model examined price-per-gram by quantity purchased, source used, and socio-demographics.

**Results:** Overall, the mean self-reported price-per-gram among cannabis consumers was $9.56 CAD (*SEM*=.2). The price-per-gram of cannabis significantly decreased as quantity purchased increased. For example, the mean price of cannabis purchased in smaller quantities (<3.5g) ($12.81/gram, *SEM*=.5) was more than double the price of cannabis purchased in larger quantities (>28g) ($5.60/gram, *SEM*=.2). The estimated quantity discount elasticity was -0.21 (95% CI: -0.25, -0.18). The most common purchase sources used were family member/friends (53.0%) and illegal street dealers (51.7%). Price-per-gram varied across sources; however, variation was largely accounted for by consumers purchasing different quantities at different sources.

**Conclusion:** Variations in the price of dried flower were largely determined by the quantity purchased. The findings highlight the importance of accounting for purchase quantity when assessing cannabis prices, particularly in illegal markets.

**Key words:** cannabis; marijuana; price; legalization; quantity discount; illegal market

## 3.2 Introduction

Cannabis is the most widely used illegal substance in the world, and Canada has one of the highest prevalence rates of use among developed countries.[1-2] In the 2018 Canadian Cannabis Survey, 22.4% of Canadians over 16 years reported cannabis use in the past 12 months, and 15.4% reported use in the past month.[3] Of those who used in the past 12 months, 19% reported daily cannabis use.[3] In Canada, medical cannabis has been legally available since 2001. Under the Access to Cannabis for Medical Purposes Regulations (ACMPR), those with authorization from a licensed physician could access cannabis from either a Health Canada registered licensed producer, grow a defined quantity or designate someone else to grow for them. During the same period, illegal cannabis was also widely available in Canada and could be accessed through illegal street dealers, 'dispensaries', and online retail sources.[4]

On October 17, 2018, Canada became the second country after Uruguay to legalize non-medical cannabis. Reducing the illegal cannabis market is one of the primary objectives of the federal Cannabis Act.[5] In 2017, Canadians spent on the order of $6 billion CAD on cannabis, of which 90% was estimated to be from illegal sources.[6] In an effort to minimize illegal sales, Canada set excise tax rates so that the price of legal cannabis products would be competitive with those in the illegal market. Cannabis is subject to a federal excise tax of $1 per gram of cannabis or 10% of a product's price, whichever is greater, as well as provincial sales taxes, which vary from 5% to 15%.[7] For example, one gram of dried flower costing $8 pre-tax (CAD) could cost between $9.45 and $10.35. The use of taxation to increase price is widely recognized as an effective public health measure for reducing tobacco and alcohol consumption.[8-10] Therefore, higher cannabis prices may be desirable. However, if the legal price exceeds that of illegal cannabis, higher prices may increase demand for and retain the illegal market. Indeed, the primary driver of illegal sales is the difference between legal and illegal prices.[11-13]

Price plays a central role in economic theories of consumer behavior.[13] 'Price elasticity of demand' is the economic concept that explains how sensitive consumers are to changes in price. Price elasticity of demand is usually negative, as an increase in price usually reflects a decrease in quantity demanded, including for addictive substances. For example, tobacco is an inelastic good, and its price elasticity of demand is estimated to be -0.4 in high-income countries.[13] This means that a 10% increase in price is expected to decrease consumption by 4%. Tobacco is inelastic because there are few substitutes, and nicotine, the main component of tobacco, is

highly addictive.[13] However, researchers argue that reliable price elasticities for cannabis do not yet exist; therefore, it is difficult to predict consumption.[14] Prior studies have calculated elasticities using prevalence data, which capture infrequent consumers.[14] Infrequent consumers account for the majority of cannabis consumers, but not the majority of cannabis consumed.[15] As a result, different types of consumers may be differentially sensitive to price. Two populations with particular relevance to public health outcomes – heavy consumers and youth – may have greater price sensitives and warrant special consideration.[14,16-21]

A reduction in price post-legalization could affect cannabis use rates among current consumers, as shown by evidence from other substances.[22-23] There is concern that this may increase the risk of cannabis-related problems and addiction.[24] Indeed, longitudinal research has shown that around 1 in 11 cannabis consumers will become dependent[25-26], and that this probability increases with daily use (1 in 2 consumers) and with initiation in adolescence (1 in 6 consumers).[26-27]

There is limited data on the price of illegal cannabis in Canada prior to legalization. Available estimates are drawn from three sources: 'crowdsourced' data collected online[28-29], self-reported data in population surveys[3], and objective price data collected directly from illegal retail sources.[4] The reliability of crowdsourced data remains highly uncertain and is particularly susceptible to self-selection bias and potential manipulation. Only one study to date has collected objective prices in Canada's illegal market. In a study investigating the price of cannabis in illegal retail and online dispensaries in the most populous city of each province and territory, the average price-per-gram of the most popular strain of cannabis was $10.02/g, somewhat higher than estimates from crowdsourced and self-reported data ($7.14/g - $8.62/g).[4]

Accurate price estimates of illegal cannabis are essential for assessing the potential impact of legalization. Knowing what Canadian cannabis consumers pay for their illegal cannabis is important as this helps to shape legal cannabis prices and tax rates, and whether legal prices are sufficient to encourage transition from illegal to legal sources as the market stabilizes post-legalization. Creating a legal market is predicted to reduce the cost of production, as certain costs associated with the illegal market are no longer required, such as paying workers a higher wage to compensate for illegal activity.[30] Legalization also has the potential to reduce monetary costs due to increased efficiency through innovation, expansion, and technology.[22,31] The price of legal cannabis is also expected to change over time as legal retail markets and supply chains

become established. In Canada, Statistics Canada reported crowdsourced price data between December 2018 and June 2019 that showed a 9% increase in the average price of dried flower from legal sources ($9.82/g to $10.65/g) and an 8% decrease in the price from illegal sources ($6.51/g to $5.93/g).[32] In a review of Colorado's cannabis market—one of the first legal non-medical retail markets—the price of cannabis declined 62% from 2014-2017.[33] In Oregon, the price of cannabis declined 50% from 2016-2018 due to increased supply.[34] Unfortunately, aside from legal non-medical cannabis prices post-legalization, US states that have legalized lack 'baseline' data and often have limited data on illegal sources following legalization.[30] The transition to a legal market in legal states has occured incrementally over many years; thus, data are just beginning to emerge from the first US states to legalize, such as Colorado and Washington.[29-30,35-36]

Few studies have examined self-reported price of dried flower in Canada before legalization.[3] The current study is timely given the importance of analyzing baseline or 'pre-implementation' measures before cannabis legalization in Canada to compare with post-legalization data. The current study examined Canadian results from the International Cannabis Policy Study (ICPS), immediately prior to legalization of non-medical cannabis in Canada. The aims of this study were to: 1) examine the self-reported price-per-gram of dried flower across Canada; 2) examine the effect of purchase source on price-per-gram; and 3) explore the associations between self-reported price-per-gram of dried flower, purchase source, and quantity purchased.

## 3.3 Methods

Data were from the baseline wave of the ICPS, a repeat cross-sectional survey conducted annually with participants aged 16–65 years living in Canada (n=10,057) and the US (n=17,112). The survey will be repeated annually at 12-, 24- and 36-months follow-up to monitor changes over time, as well as key mediators and moderators of use, in each of three jurisdictions: Canada (all provinces); US states that have legalized non-medical cannabis (US 'legal' states) and those that have not (US 'illegal' states). The current study reports data from the Canadian sample of Wave 1 of the ICPS Survey, conducted between August 27, 2018 and October 7, 2018. Respondents completed an online survey in English or French with a median survey time of 19.9 minutes.

Individuals were eligible to participate if they resided in a Canadian province, were 16–65 years of age at the time of recruitment and had access to the internet. Respondents were recruited using the Nielsen Consumer Insights Global Panel. The Nielsen panels use both probability and nonprobability sampling methods. For the current project, Nielsen drew stratified random samples from the online panels, based on known proportions in each age group. To account for differential response rates, Nielsen modified these sampling proportions to place greater weight on sub-groups with lower response rates. All the data provided by respondents were anonymous and kept strictly confidential. Respondents provided consent prior to completing the survey. Respondents received remuneration in accordance with their panel's usual incentive structure (e.g., points-based or monetary rewards, chances to win prizes). A full technical report for the study is available from http://cannabisproject.ca/methods/.

### 3.3.1 Measures

Survey measures were drawn or adapted from national surveys or selected based on previous research. In all cases, participants had the option of selecting 'Don't Know' or 'Refuse'.

#### 3.3.1.1 Socio-demographic measures

Socio-demographic measures included sex at birth, age in years, ethnicity/race, education, and province of residence. Cannabis use frequency was assessed through questions, "How often do you use cannabis?" and "When was the last time you used cannabis?" Responses were recoded into: ("Less than monthly consumer", "Monthly consumer", "Weekly consumer", "Daily/almost daily consumer").

#### 3.3.1.2 Self-reported price-per-gram of dried flower

Participant's price-per-gram was calculated from two questions. First, participants were asked, "The last time you purchased dried herb, how much did you buy…?" ("Less than 1/8 gram", "1/8 gram", "1/4 gram", "1/2 gram", "3/4 gram", "1 gram", "2 grams", "3 grams", "1/8 ounce", "1/4 ounce", "More than ¼ ounce", "1/2 ounce", "1 ounce", "More than 1 ounce"). Respondents had a choice of units in which to report. Units were standardized into grams (g) and responses were continuous. Second, participants were asked, "The last time you purchased dried herb, how much did you pay for the quantity you bought?" (Continuous variable). Participants who had a price-per-gram outside of the range $2.20-$30 were excluded (n=336).

This range was based on the minimum and maximum price-per-gram identified in a retail scan of the illegal cannabis market in a separate study.[4]

*3.3.1.3 Purchase source*
Participants were asked: "In the past 12 months, how did you get the dried herb you used?" ("I grew my own", "From a family member or friend", "From a dealer (in person)", "Health Canada medical marijuana licensed producer, by mail order", "Other internet delivery service", "From a store, co-operative or dispensary (in person)", "Other"). "Other" was recoded according to responses provided. Participants could select all that applied; however, only participants who purchased from only one source in the past 12 months were recoded to the respective source. It was assumed that those who purchased from only one source in the past 12 months would have used that source at their last purchase. Participants who purchased from more than one source in the past 12 months were recoded to 'Not reported'. For the current price analysis, "I grew my own" was excluded because price paid for seeds/plants might differ from price of dried flower (n=2). All purchases sources were illegal before legalization in Canada, except purchases from a Health Canada licensed producer.

**3.3.2 Data Analysis**
In Wave 1, 1,428,857 respondents were sent an email invitation to the survey, where 44,364 respondents accessed the survey link, of which 28,471 (2%) completed the entire survey. A total of 10,646 Canadian respondents completed the survey. Due to data integrity questions or ineligible location, 589 respondents were excluded. The final analytic sample included 10,057 respondents. For the current analysis, 8,824 participants were excluded for not having used and purchased dried flower in the past 12 months. An additional six were excluded for data quality because their postal code did not align with the province indicated. The final analytic sample for this study was 1,227 participants. A total of 336 respondents were excluded from analyses on a case-wise basis for measures with missing data in the price-per-gram calculation. Of those that were excluded, 184 respondents either refused or did not know the price and quantity of cannabis they purchased, and 152 respondents reported a quantity or price that was outside the plausible range of $2.20-$30.00. The proportion of respondents who had a price-per-gram within the plausible range differed by sociodemographic characteristics: more females were within range than males ($\chi2$=7.5, p=0.006); more respondents with Bachelors degrees or higher were within range than respondents with a high school diploma or some college degree ($\chi2$=14.1, p=0.003); more white respondents were within range than other respondents

($\chi$2=11.6, p<0.001); and more daily/almost daily consumers were within range than less frequent consumers ($\chi$2=27.0, p<0.001).

Post-stratification sample weights were constructed based on the Canadian Census estimates. Respondents from Canada were classified into age-by-sex-by-province and education groups. Correspondingly grouped population count and proportion estimates were obtained from Statistics Canada.[37-38] A raking algorithm was applied to the full analytic sample ($n$=10,057) to compute weights that were calibrated to these groupings. Weights were rescaled to the sample size for Canada. Estimates are weighted unless otherwise specified. First, the mean price-per-gram of dried flower with standard errors of the mean (*SEM*) were examined by quantity purchased, purchase source, and province. Second, a multiple linear regression was fitted to examine the relationship between the natural log of quantity purchased and purchase source and province of residence. Third, a multiple linear regression was fitted to examine the relationship between the natural log of price-per-gram and log-transformed quantity purchased, purchase source, and province of residence. The model estimates are reported with 95% confidence intervals (95% CIs) and adjusted for age, sex, ethnicity, education, and cannabis use frequency. Analyses were conducted using survey commands in SAS 9.4.

### 3.3.3 Ethics
The project was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#22392).

## 3.4 Results

Table 1 displays the weighted and unweighted sample characteristics among Canadians who had used and purchased dried flower in the past 12 months.

### 3.4.1 Cannabis quantity purchased and price paid
Table 2 displays the quantity of cannabis and the price paid at last purchase by frequency of cannabis use. Across all cannabis consumers, the mean total price paid for cannabis at last purchase was $81.30 (*SEM*=5.4). The price paid at last purchase differed by frequency of use ($\chi^2$=219.1, $p$<.001). In general, price paid at last purchase increased as frequency of use increased: daily/almost-daily consumers had the largest mean price paid at their last purchase, compared to monthly consumers with the smallest mean price, as shown in Table 2.

Across all cannabis consumers, the mean quantity of cannabis purchased at last purchase was 12.6 g (*SEM*=1.3). The quantity of dried flower purchased at last purchase differed by frequency of use ($\chi^2$=267.5, *p*<.001). In general, the quantity bought at last purchase increased as frequency of use increased: daily/almost-daily consumers bought the largest quantity of dried flower at their last purchase, compared to monthly consumers with the smallest mean quantity (Table 2).

### 3.4.2 Self-reported price-per-gram

Supplemental Table 1 displays the self-reported price-per-gram of dried flower at last purchase across the Canadian provinces. Across all quantities purchased, the average price-per-gram was the largest in Newfoundland and Labrador ($10.48/g, *SEM*=.9) and smallest in Prince Edward Island ($7.67/g, *SEM*=.6).

Table 3 displays the self-reported price-per-gram paid for three different purchase quantities. The mean price-per-gram of dried flower across consumers at all quantities purchased was $9.56/g (*SEM*=.2). The mean price-per-gram for all consumers purchasing in quantities under 3.5g was $12.81/g (*SEM*=.5) and decreased with increasing purchase quantity. Table 3 also shows self-reported prices among consumers who purchased cannabis from a single source versus multiple sources over the past 12 months. Across all quantities purchased, consumers that purchased from multiple sources over the past 12 months had a lower mean price-per-gram than those that only purchased from one source. In addition, consumers that purchased from multiple sources had a larger mean purchase quantity (16.4 g, *SEM*=2.9) compared to those that only purchased from one source (9.8 g, *SEM*=.9).

### 3.4.3 Cannabis purchase source

Figure 1 displays the sources used to purchase dried flower over the past 12 months. Across all consumers who had bought dried flower over the past 12 months (*n*=891), 53.0% purchased from a family member or friend, 51.7% purchased from an illegal dealer, 12.7% purchased from a Health Canada registered Licensed Producer, 15.5% purchased via another online source/mail order, and 21.9% purchased from a store, cooperative, or dispensary. Of consumers who had purchased from multiple sources, the majority had purchased from a family member or friend (74.6%) or an illegal dealer (74.4%). Fewer participants had purchased from Health Canada Licensed Producers, online, or stores and dispensaries.

Figure 2a displays the average self-reported quantity of dried flower purchased by consumers who purchased from only one purchase source over the past 12 months. Those who purchased online or via mail order purchased in larger quantities compared to those who purchased from stores, cooperatives or dispensaries.

A linear regression model was fitted to examine correlates of the log-transformed quantity purchased of dried flower at last purchase (Table 4). Purchase source was a significant predictor of quantity at last purchase. Purchasing online or via mail order was associated with a 6.5% increase in the average quantity purchased compared to those purchasing from family or friends. Cannabis use frequency was also a significant predictor of the quantity purchased at last purchase. Less than monthly, monthly, and weekly consumers were associated with a 12.7%, 12.0%, and 6.6% reduction, respectively, in the average quantity purchased compared to daily/almost-daily consumers. Province of residence, age, sex, ethnicity/race and education were not significantly associated with purchase quantity.

Figure 2b displays the average self-reported price-per-gram of dried flower among participants who purchased from only one source over the past 12 months. Across all quantities purchased, those who purchased from a store, coop, or dispensary had the largest mean price-per-gram, and those who purchased from another online source/mail order had the smallest mean price-per-gram.

A linear regression model was fitted to examine correlates of the log-transformed price-per-gram paid for dried flower at last purchase (Table 4). Purchase quantity was a significant predictor of price-per-gram. A 10% increase in the quantity purchased was associated with a 2.0% reduction in the average price-per-gram of dried flower. Purchase source was a significant predictor of price-per-gram. Purchasing from an illegal dealer, licensed producer, and online/mail order were associated with a 16.1%, 33.5% and 23.7% increase, respectively, in the average price-per-gram of dried flower compared to purchasing from a family member or friend. Cannabis use frequency was also a significant predictor of price-per-gram at last purchase. Monthly and weekly consumers were associated with a 14.9% and 14.6% increase, respectively, in the average price-per-gram of dried flower, compared to daily/almost-daily consumers. Province, age, sex, ethnicity/race and education were not significantly associated with the price-per-gram of dried flower.

## 3.5 Discussion

The current study presents self-reported cannabis prices of dried flower across Canada and sources used. Overall, the mean self-reported price among cannabis consumers was $9.56/g, and those who purchased from multiple sources had a lower average price-per-gram than those purchasing from only one source. The average price of $9.56/g across all consumers was higher than previous pre-legalization estimates that used crowdsourced data and self-reported data in population surveys.[3,28-29] The lower prices found in the crowdsourced data—ranging from $7.14/g to $7.69/g—may be attributed to the self-selected sample, where respondents submitting their data to crowdsourced websites may not be representative of all cannabis consumers, and/or may represent more frequent consumers. Indeed, in the current study daily/almost-daily consumers had a significantly lower price-per-gram of dried flower than less frequent consumers. However, $9.56/g was more similar to the price-per-gram (incl. tax) of legal cannabis that was predicted by the Canadian Government post-legalization, and the post-legalization crowdsourced price from StatsCannabis, $9.82/g.[7,32] The price of legal cannabis is expected to decrease post-legalization, albeit not immediately. While the benefit of prices being lower in the legal than the illegal market includes the incentive to transition, a reduction in price could also lead to increased consumption and adverse health outcomes, as seen with other substances.[14,23-24,39-41] Legal cannabis prices should aim to compete with illegal prices, yet not increase consumption or harms. The 'ideal' price of legal cannabis is difficult to quantify and is likely to change over time as legal markets evolve. Initially, cannabis prices may need to more aggressively compete with well-established illegal markets; however, evidence from tobacco control and other domains indicate that price and taxes can increases considerably with relatively modest impact on illegal purchasing depending on other factors.[42] Other factors are likely to moderate the influence of cannabis price on legal vs. illegal purchases, including access/proximity to legal retail outlets, as well as perceptions of product quality and safety. In addition, tax revenue from cannabis sales should feed into cannabis prevention, education, and treatment services.

The most important determinant of price was the quantity of cannabis purchased. The price-per-gram of cannabis significantly decreased as quantity purchased increased. For example, consumers purchasing in smaller quantities paid an average of $12.81/g, compared to $5.60/g when purchasing in larger quantities—a discount of 56.3%. The quantity discount observed in

this study is similar to objective prices found by a retail scan of Canadian illegal dispensaries.[4] Quantity discounts are also common in legal cannabis stores after legalization, such as the online Ontario Cannabis Store, albeit at a more modest discounted rate of 7.5% to 14.6%.[43] Quantity discounts are frequent in illegal drug markets.[44-46] The current study found a quantity discount elasticity of -0.21, which is within the range of what was found in previous studies in illegal cannabis markets[19,45-46], but higher than what found in a legal cannabis market.[47] As Smart and colleagues argued, their smaller estimate found within Washington State's legal market could be explained by the inclusion of potency within the models, which the previous studies on illegal cannabis markets did not include.[47]

To note, the current analysis did not include potency or THC content; therefore, the potential for potency differences to have contributed to the price-per-gram differences is unknown. Potency is important when discussing the price of cannabis, as prior studies have shown an association between price and perceived potency.[47-49] However, collecting and interpreting potency pre-legalization is difficult due to a lack of information in the illegal market and unreliable labelling on illegal products.[19,29] Overall, the findings suggest that reporting cannabis prices as a single mean based on 'price-per-gram' may obscure important differences in purchase price across different purchase quantities, and the potential importance of potency.

The most common source from which to purchase cannabis was a family member/friend or an illegal dealer, consistent with previous studies.[3,50-51] Purchase source was a significant predictor of price-per-gram at last purchase. Consumers purchasing from an illegal dealer, a licensed producer, and online all had a significant higher price-per-gram than those purchasing through family or friends. However, the variation across the sources was largely accounted for by the fact that consumers tended to purchase different quantities of cannabis from different sources, as purchase source was also a significant predictor of quantity purchased. For example, consumers purchasing from stores, cooperatives or dispensaries purchased in smaller quantities than those purchasing online, suggesting that consumers may be purchasing from stores in smaller quantities, perhaps due to the convenience or through purchasing 'premium' products in smaller quantities, such as 'pre-rolled' joints.[46] In contrast, consumers may be purchasing greater quantities from online sources to minimize shipping costs; indeed, some online suppliers provided free shipping for orders over a certain quantity.[4] In the current study, purchasing through family and friends on average reflected lower prices and smaller quantities purchased than other sources. However, family and friends may present a unique case, which

do not reflect actual retail prices. For example, family and friends may discount such small quantities due to their relationship with the consumer or the product may have been 'homegrown', reducing its initial cost. Future research should explore differences in cannabis purchasing across sources, with an emphasis on changes following legalization of non-medical cannabis and the transition from illegal to legal sources.[22,30,31]

In the current analysis, province of residence was not a significant predictor of the price of dried flower. The differences in price and quantity purchased across the provinces could be instead accounted for by the purchase source used. For example, in a retail scan conducted across the Canadian provinces in 2018, the availability of retail and online stores was found to vary across cities, ranging from 100 retail outlets in Vancouver, British Columbia, to zero in Calgary, Alberta.[4]

This study has several limitations. Respondents were asked to recall cannabis purchases over a 12-month time period, which may have introduced recall bias. Data collected for 'last purchase' may be less prone to memory errors. In addition, self-report data are subject to social desirability bias. At the time of study, non-medical cannabis use in Canada remained illegal; therefore, patterns of cannabis use may have been underreported or purchase sources misrepresented. However, the survey included a data integrity question wherein those who reported not answering all questions honestly were excluded[‡]. In addition, this survey was self-administered online, which compared to interviewer assisted surveys, can reduce social desirability bias by providing greater anonymity for sensitive topics.[52] As previously discussed, the current study did not include the potency of dried flower. Thus, a potency-adjusted price may be higher or lower than the prices reported in this study.[15,53] Another limitation is that respondents were not asked to identify the source they had used at last purchase; thus, information on last purchase source was only available for respondents with one cannabis source in the past 12 months. In addition, when reporting price paid from online sources or mail order, participants were not asked whether the price included shipping. Similarly, prices collected from licensed producers did not specify whether the final cost included tax. Thus, the aggregate prices reported for online sources and licensed producers may be higher or lower than prices reported in the current study. Finally, respondents were recruited from a commercial

---

[‡] Participants were asked: "Were you able to provide 'honest' answers about your marijuana use during the survey?" with response options: "No", "For some questions, but not all", "Yes, for all questions".

sample, rather than using probability-based methods only. However, Nielsen drew stratified random samples based on known proportions in each age group to account for differential response rates, and modified these sampling proportions to place greater weight on lower responding sub-groups. In addition, post-stratification survey weights were used to adjust for sociodemographic differences. The prevalence of cannabis use in the current study was close to national benchmark surveys.[54]

### 3.5.1 Conclusion

To our knowledge, the current study provides among the most comprehensive assessments of cannabis purchasing in illegal markets. The findings underscore the importance of purchase quantity when assessing cannabis pricing and purchasing patterns. Although price variations were observed across different purchase sources, these often mask differences in the quantity of cannabis that was purchased. Legalization of non-medical cannabis in Canada provides the opportunity to examine the transition from illegal to legal sources and the implications for prices and consumption. Accurate price estimates of cannabis in Canada post-legalization are important as the price of legal and illegal cannabis have direct implications for tax policies. In the US, all states that have legalized non-medical cannabis have adjusted their tax rates to minimize the price gap between illegal and legal cannabis.[55-58] After legalization, Colorado and Washington State have legal prices that are competitive to if not lower than illegal prices.[22,33] Future research is needed on price, potency, and purchasing patterns for other types of cannabis products, including cannabis edibles and concentrates, which account for greater market share in legal markets.

**Table 1: Sample characteristics** (*n*=1,227)

| | Unweighted % (*n*) | Weighted % (*n*) |
|---|---|---|
| **Age group** | | |
| 16-25 | 18.4 (226) | 18.9 (232) |
| 26-35 | 22.6 (277) | 31.4 (385) |
| 36-45 | 17.1 (210) | 21.0 (258) |
| 46-55 | 19.1 (234) | 16.1 (198) |
| 56-65 | 22.8 (280) | 12.6 (155) |
| **Sex** | | |
| Female | 48.8 (599) | 39.8 (488) |
| Male | 51.2 (628) | 60.3 (739) |
| **Race/Ethnicity** | | |
| White | 80.9 (993) | 79.4 (974) |
| Other | 19.1 (234) | 20.6 (253) |
| **Education** | | |
| Less than high school | 12.7 (156) | 19.4 (237) |
| High school diploma | 17.4 (213) | 29.5 (362) |
| Some college or technical vocation | 46.1 (566) | 34.5 (424) |
| Bachelor's degree or higher | 23.6 (290) | 16.4 (201) |
| **Province** | | |
| British Columbia | 11.9 (146) | 15.9 (195) |
| Alberta | 9.4 (115) | 12.8 (156) |
| Saskatchewan | 6.0 (74) | 2.8 (34) |
| Manitoba | 8.0 (98) | 3.5 (43) |
| Ontario | 28.2 (346) | 39.0 (479) |
| Quebec | 9.2 (113) | 19.1 (234) |
| New Brunswick | 8.8 (108) | 2.1 (26) |
| Nova Scotia | 10.2 (125) | 2.9 (36) |
| Prince Edward Island | 2.3 (28) | 0.5 (6) |
| Newfoundland & Labrador | 6.0 (74) | 1.4 (17) |
| **Cannabis Use Frequency** | | |
| Past year, but less than monthly | 14.4 (177) | 13.1 (161) |
| Monthly | 17.4 (213) | 18.9 (232) |
| Weekly | 21.6 (265) | 21.9 (268) |
| Daily/almost daily | 46.6 (572) | 46.1 (566) |

**Table 2: Cannabis quantity purchased, and price paid (CAD) by frequency of use** (*n*=891)

| | All consumers *n*=891 | Less than monthly *n*=102 | Monthly *n*=159 | Weekly *n*=180 | Daily/Almost Daily *n*=450 |
|---|---|---|---|---|---|
| **…How much did you pay for the quantity you bought?** | | | | | |
| Mean $ (*SEM*) | $81.30 (5.4) | $37.44 (5.7) | $37.83 (4.3) | $61.36 (5.2) | $114.49 (9.8) |
| Amount paid (%, *n*) | | | | | |
| Less than $25 | 28.1% (250) | 58.8% (60) | 54.4% (86) | 24.6% (44) | 13.2% (60) |
| $25-50 | 20.8% (185) | 10.9% (11) | 22.2% (35) | 24.0% (43) | 21.3% (96) |
| $50-100 | 22.2% (197) | 24.6% (25) | 9.1% (14) | 34.9% (63) | 21.1% (95) |
| Over $100 | 29.0% (258) | 5.7% (6) | 14.3% (23) | 16.4% (30) | 44.4% (200) |
| **…How much did you buy?** | | | | | |
| Mean grams (*SEM*) | 12.6g (1.3) | 4.2g (1.0) | 4.3g (.7) | 7.7g (.8) | 19.4g (2.5) |
| Quantity purchased (%, *n*) | | | | | |
| <1g | 4.5% (40) | 17.3% (18) | 10.6% (17) | 2.4% (4) | 0.2% (1) |
| 1g-3.5g | 29.4% (262) | 44.5% (45) | 57.9% (92) | 36.7% (66) | 13.1% (59) |
| 3.5g-28g | 48.7% (434) | 36.7% (37) | 26.3% (42) | 53.0% (95) | 57.6% (259) |
| >28g | 17.4% (155) | 1.5% (2) | 5.2% (8) | 7.9% (14) | 29.1% (131) |

**Table 3: Self-reported price-per-gram at different quantities among consumers who had purchased dried flower from one source vs. multiple sources in the past 12 months** (*n*=891).

| | All quantities purchased $/g (*SEM*) *n*=891 | <3.5g $/g (*SEM*) *n*=302 | 3.5g-28g $/g (*SEM*) *n*=434 | >28g $/g (*SEM*) *n*=155 |
|---|---|---|---|---|
| **All consumers** | **$9.56 (.2)** | **$12.81 (.5)** | **$8.71 (.3)** | **$5.60 (.2)** |
| **Multiple purchase sources** | $8.47 (.3) | $11.47 (.7) | $8.23 (.3) | $5.28 (.2) |
| **One purchase source** | $10.42 (.4) | $13.57 (.6) | $9.14 (.4) | $5.98 (.3) |

**Figure 1: Cannabis sources used by those who have purchased dried flower in the past 12-months from multiple sources and from one source only** (*n*=891).
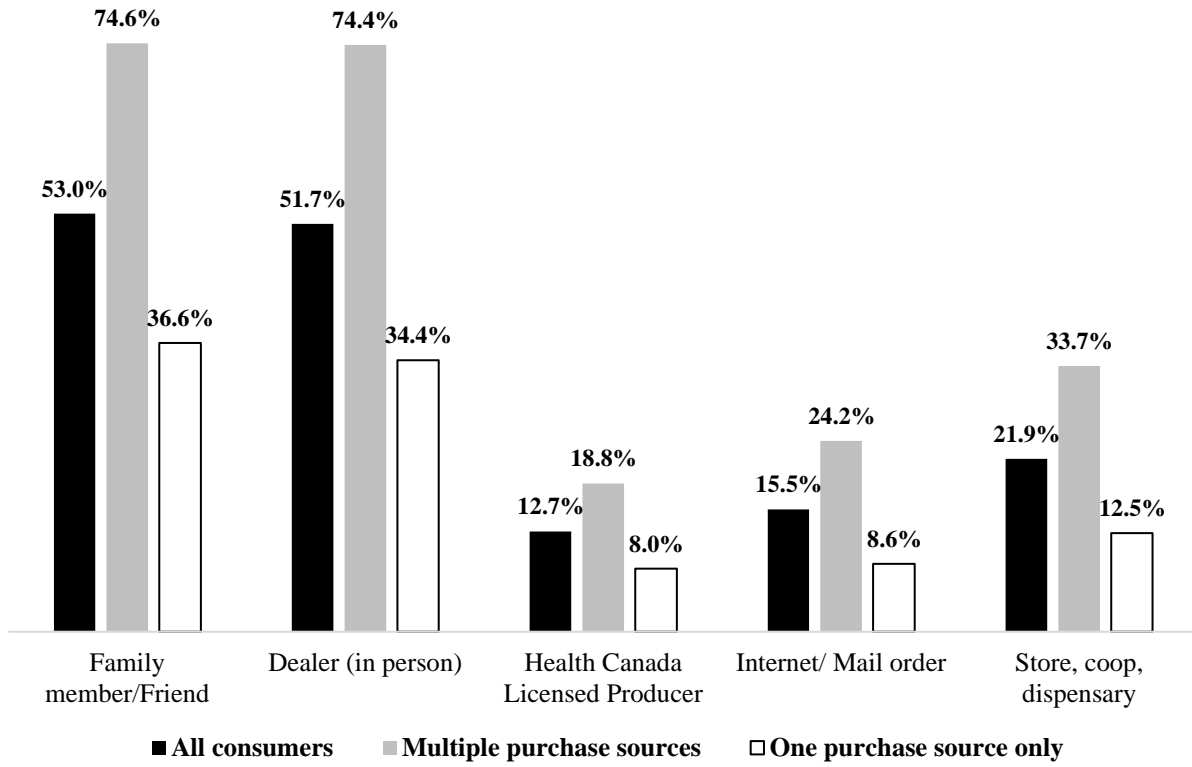
**Table 4: Weighted linear regression analysis for outcome variables by ln (quantity purchased) and ln (price-per-gram)** (*n*=891)

| | ln(Quantity purchased) | | ln(Price-per-gram) | |
|---|---|---|---|---|
| | *β* **(95% CI)** | *Sig.* (*p-value*) | *β* **(95% CI)** | *Sig.* (*p-value*) |
| **ln(Quantity purchased)** | - | - | -.21 (-0.25, -0.18) | <.001 |
| | | | | |
| **Source used last** | | | | |
| *(vs. family member/friend)* | | | | |
| Dealer | .18 (-.09, .45) | .188 | .15 (.02, .28) | .028 |
| Health Canada Licensed Producer | .25 (-.23, .72) | .305 | .29 (.13, .45) | <.001 |
| Internet/Mail order | .66 (.25, 1.07) | .002 | .21 (.02, .40) | .028 |
| Store, coop or dispensary | -.29 (-.59, .01) | .059 | .10 (-.09, .28) | .202 |
| Not specified | .23 (-.02, .48) | .067 | .02 (-.09, .13) | .764 |
| | | | | |
| **Cannabis use frequency** | | | | |
| *(vs. daily/almost daily)* | | | | |
| Past year, but less than monthly | -1.43 (-1.72, -1.13) | <.001 | .05 (-.08, .18) | .451 |
| Monthly | -1.35 (-1.64, -1.05) | <.001 | .14 (.01, .27) | .044 |
| Weekly | -.72 (-.96, -.48) | <.001 | .14 (.03, .24) | .010 |
| | | | | |
| **Province** | | | | |
| *(vs. Newfoundland & Labrador)* | | | | |
| British Columbia | -.12 (-.54, .31) | .596 | -.15 (-.30, .01) | .054 |
| Alberta | .23 (-.19, .65) | .280 | .12 (-.01, .26) | .072 |
| Saskatchewan | .01 (-.60, .58) | .981 | .09 (-.06, .26) | .229 |
| Manitoba | -.08 (-.54, .39) | .743 | .03 (-.12, .18) | .732 |
| Ontario | .07 (-.30, .43) | .727 | .01 (-.11, .13) | .868 |
| Quebec | -.20 (-.61, .22) | .347 | -.10 (-.25, .06) | .232 |
| New Brunswick | -.20 (-.62, .22) | .352 | -.10 (-.27, .07) | .258 |
| Nova Scotia | -.17 (-.68, .34) | .513 | -.08 (-.22, .06) | .271 |
| Prince Edward Island | .43 (-.37, 1.24) | .294 | -.03 (-.20, .14) | .745 |

**Figure 2a: Mean self-reported quantity of dried flower purchased by source, among those who purchased from only one source over the past 12 months** (*n*=501)
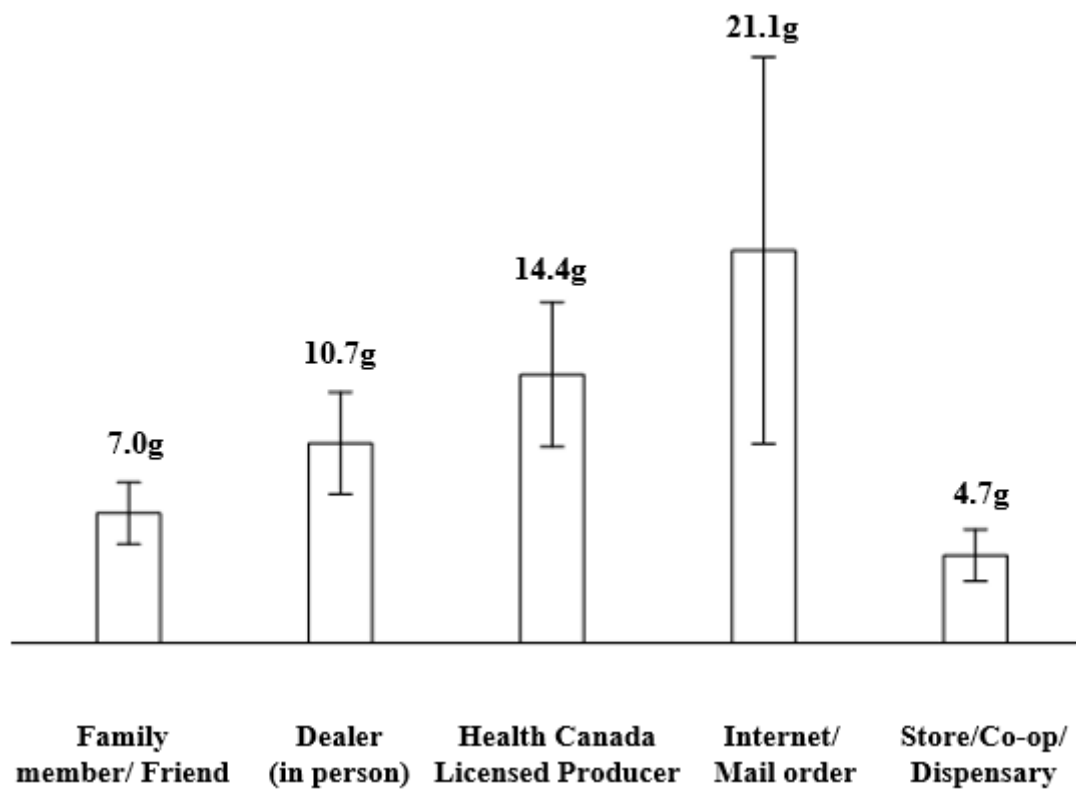


Whisker bars represent confidence intervals of the mean self-reported quantity of dried flower

**Figure 2b: Mean self-reported price-per-gram of dried flower purchased by source, among those who purchased from only one source over the past 12 months** (*n*=501)
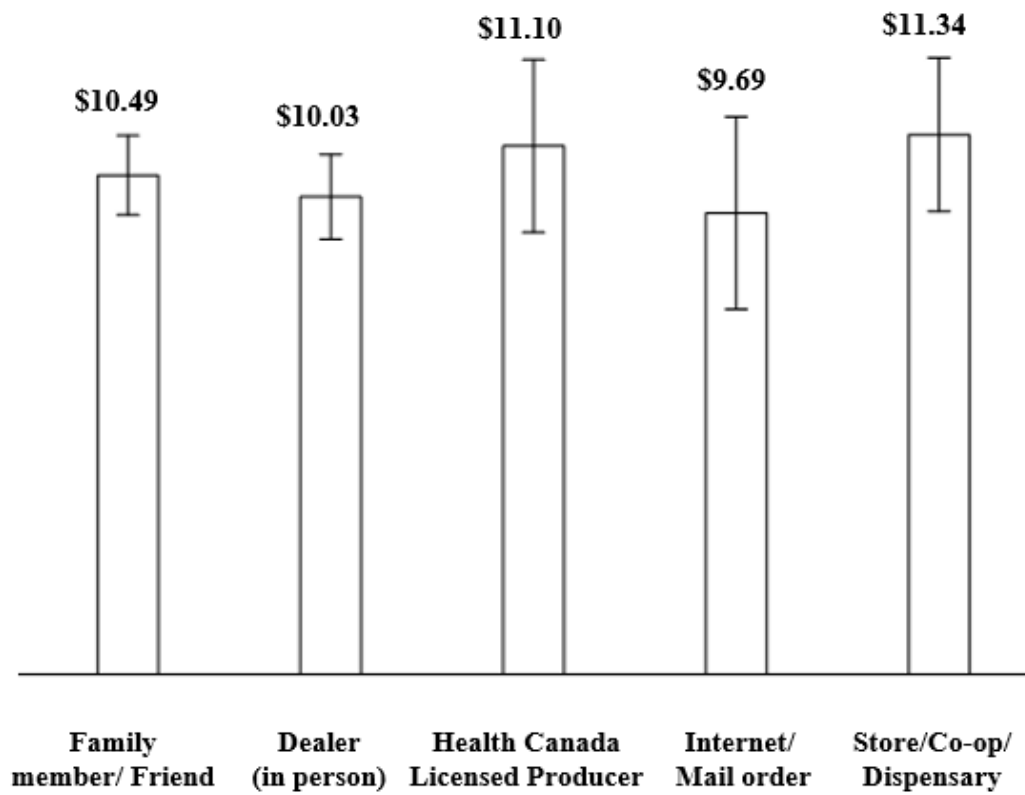


Whisker bars represent confidence intervals of the mean self-reported price-per-gram of dried flower

**Supplemental Table 1: Self-reported prices per gram of dried cannabis at last purchase by province in Canada** (n=891)

| Province | Price |
|---|---|
| British Columbia | $9.05 |
| Alberta | $10.25 |
| Saskatchewan | $10.18 |
| Manitoba | $9.61 |
| Ontario | $9.58 |
| Quebec | $9.57 |
| New Brunswick | $9.04 |
| Nova Scotia | $8.28 |
| Prince Edward Island | $7.67 |
| Newfoundland & Labrador | $10.48 |
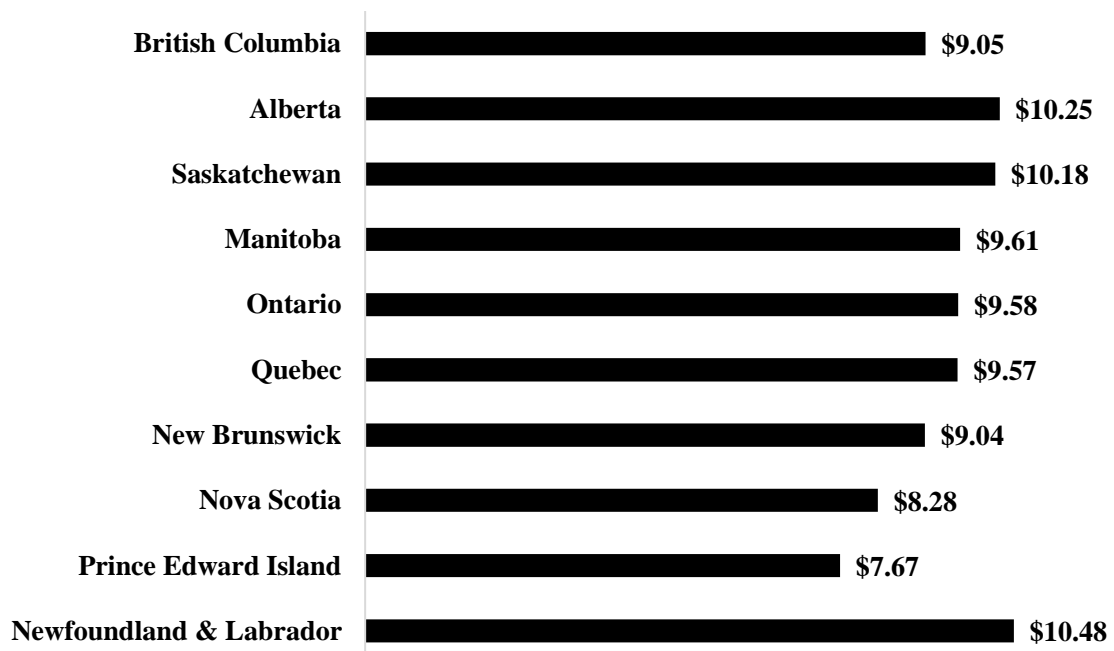
# CHAPTER 4: RETAIL AVAILABILITY AND LEGAL PURCHASES OF DRIED FLOWER IN CANADA POST-LEGALIZATION

Authors: Elle Wadsworth[a], Pete Driezen[ab], David Hammond[a]

[a]School of Public Health Sciences, University of Waterloo, Waterloo, ON, Canada
[b]Department of Psychology, University of Waterloo, Waterloo, ON, Canada

# 4.1 Overview

**Background:** Retail availability of cannabis has the potential to influence demand for both legal and illegal cannabis. The aims of the study were to: 1) estimate the percentage of consumers who report purchasing dried flower legally; and 2) examine the association between purchasing dried flower legally and retail availability, where retail availability was represented as: a) Canadian province; b) 'objective' retail proximity; and c) self-reported retail proximity.

**Methods:** Data come from Canadian respondents in Wave 2 of the International Cannabis Policy Study (ICPS) conducted one year after non-medical cannabis legalization in September-October 2019. Respondents were 18+ years in Alberta/Quebec and 19+ years elsewhere and had purchased any dried flower in the past year (n=2,506). Respondents were recruited through commercial online panels. Weighted binary logistic regression models examined likelihood of purchasing dried flower legally.

**Results:** Overall, 47.7% of past-year dried flower purchasers reported last purchasing dried flower legally, with variation across provinces (range=40.5%-81.2%). Likelihood of purchasing dried flower legally was greater among those who lived closer to a legal retail store based on Euclidean distance (<3 km vs. 10+ km: AOR=1.56, 95% CI: 1.20, 2.02), and who had shorter self-reported travel time to a retail store (<5 mins vs. >15 mins: AOR=2.24, 95% CI: 1.56, 3.21).

**Conclusion:** One year after legalization, retail availability was associated with last purchasing dried flower legally among past-year dried flower purchasers. To our knowledge, the current study is among the first to examine the legality of purchase source used for dried flower and retail availability of cannabis in Canada post-legalization.

**Keywords:** Cannabis; Marijuana; Retail availability; Legalization; Proximity; Purchasing

## 4.2 Introduction

In October 2018, Canada legalized non-medical ('recreational') cannabis. In the first year, only dried flower and some oils were available to purchase legally, whereas all other products were available in December 2019.[1] Canada has among the highest global rates of cannabis use, with approximately 25% of adults reporting past 12-month cannabis use.[2] One of the primary objectives of legalization is to protect public health by establishing a legal retail framework.[3] Transitioning consumers into the legal market is critical to achieve this public health objective.[4] Before legalization, illegal cannabis was widely available in Canada and could be accessed through dispensaries, street dealers, and online retail sources.[5,6] Therefore, the well-developed illegal market in Canada is not expected to disappear immediately. Indeed, 30% of past 12-month cannabis consumers reported to "always", "mostly" or "sometimes" purchase cannabis from illegal sources in 2020.[7]

Self-reported data on the legality of purchase sources used by Canadians post-legalization are limited. In the annual 2019 Canadian Cannabis Survey (CCS), over half of past 12-month cannabis consumers reported purchasing cannabis from a legal source since legalization.[2] In the 2019 third quarter National Cannabis Survey (NCS), 28% of cannabis consumers reported receiving their cannabis products exclusively from legal sources.[8]

The retail availability of cannabis has the potential to influence demand for both legal and illegal cannabis. Research on other legal substances has shown that retail availability is associated with demand for illegal and legal substances. Indeed, differences in retail availability is a main reason for the regional differences in illegal tobacco sales across Canada.[9-11] Retail availability of cannabis captures many aspects of availability within the retail market such as availability of specific cannabis product, proximity to a cannabis retail store, or the number of retail stores in an area. In the alcohol literature, retail availability can be measured by retail store density, distance to the nearest store, minimum legal age, and retail store trading hours and days.[12-13] Under federal law, provinces have jurisdiction over retail policies.[3] Four provinces opted for a hybrid model of private and public retail sales (physical and online stores), four opted for a public-only model, and two opted for a private-only model.[14] The implementation of legal cannabis stores was not immediate, and both stores and websites experienced shortages in the initial months of legalization.[15] After the first year of legalization, Statistics Canada reported more than 400 legal physical retail stores[16]; however, the number of

legal cannabis stores varied widely across the provinces, ranging from one store for 2,375 past 3-month cannabis consumers in Alberta, to one store for 84,288 past 3-month consumers in Ontario.[8,17-18] In addition, the average distance to a physical legal retail store was estimated at 66 km for adults in March 2019, which decreased to 34 km in July 2019 as additional stores opened, with considerable variation across the provinces.[16] Proximity to legal stores will change over time as the legal retail market becomes more established.

Provinces and municipalities also implemented other retail policies that may affect availability. For example, some municipalities may prohibit stores altogether and some impose restrictions on proximity to schools.[14] Therefore, availability of stores may be dependent on policy rather than demand. This may influence who lives close to areas where retail stores are able to open. For example, research examining equity in the locations of illegal and legal retail cannabis stores in California concluded that vulnerable populations were disproportionately exposed to illegal retail stores.[19] Similar research exploring equity in location of retail stores in Portland, Oregon and Washington State concluded that retail stores were more likely to be located in poorer census tracts.[20-22]

Previous literature has explored the associations between availability of cannabis stores and cannabis use, with mixed conclusions.[23-27] However, retail availability can be defined and measured in various ways such as through retail density, retail proximity, or retail store opening times. For example, research in the Netherlands did not find a relationship between proximity to non-medical retail stores and cannabis use.[27] Research in Washington State observed a positive association between current cannabis use and access to non-medical retail stores, and research in Los Angeles observed an association between heavy cannabis use and greater retail density of medical and non-medical retail stores.[24,28]

To our knowledge, the current study is among the first to examine the legality of purchase source used for dried flower and retail availability of legal cannabis among dried flower purchasers in Canada post-legalization. The aims of the study were to 1) estimate the percentage of dried flower purchasers who report last purchasing dried flower legally overall and by province; and 2) examine the association between last purchasing dried flower at a legal source and the retail availability of cannabis at a provincial and individual level. In this study, retail availability will be represented in three ways: a) province of residence; b) 'objective' retail proximity; and c) self-reported retail proximity. This study offers a unique and timely

look at the relationship of retail availability in the transition to the legal cannabis market in Canada, one year after legalization.

## 4.3 Methods

Data are cross-sectional findings from the 2019 International Cannabis Policy Study (ICPS) conducted in Canada and the US. Data were collected via self-completed web-based surveys conducted in September/October 2019 with respondents aged 16-65. A non-probability sample of respondents was recruited through the Nielsen Consumer Insights Global Panel and their partners' panels. Email invitations with a unique link were sent to a random sample of panelists (after targeting for age and country criteria); panelists known to be ineligible were not invited. Surveys were conducted in English in the US and English or French in Canada. Median survey time was 25 minutes. Respondents provided consent prior to completing the survey. Respondents received remuneration in accordance with their panel's usual incentive structure. In total, 81,263 respondents accessed the survey link, of whom 51,087 completed the entire survey for an AAPOR cooperation rate of 62.9%.[29] The study was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31330). A full description of the study methods is described in the ICPS 2019 Technical Report and methodology paper.[30] The current study reports Canadian data.

### 4.3.1 Measures
*4.3.1.1 Socio-demographic measures*
Sex at birth, age (beginning at minimum legal age to purchase cannabis), ethnicity/race, highest education level, perceived income adequacy, suspected device type used to complete survey, and province of residence. Minimum legal age was taken from provincial laws in September 2019: 18 years in Alberta and Quebec, and 19 years elsewhere. See Table 1 for full coding of response options.

*4.3.1.2 Cannabis use frequency*
Cannabis use frequency was assessed through questions, "How often do you use cannabis?" and "When was the last time you used cannabis?" Responses were categorized into: ("Less than monthly consumer", "Monthly consumer", "Weekly consumer", "Daily or almost daily consumer").

*4.3.1.3 Legality of purchase source used at last purchase*
Respondents who purchased dried flower in the past 12 months were asked "The last time you bought dried herb, where did you buy it", with answers: "From a family member or friend", "From a dealer (in person)", "Internet delivery service or mail order", "From a store, co-operative or dispensary (in person)", "Other". Illegal and legal physical stores and online stores were determined by follow-up questions: "What type of physical store or dispensary did you buy the dried herb from?" with answers: "A legal/authorized store", "An illegal or unauthorized store/dispensary", "Other" and "Where did you buy the dried herb online?" with answers: "An authorized/legal website", "An unauthorized/illegal website, private delivery service or dealer", "Other". "Other" responses were re-categorized according to answers provided. All other sources were categorized according to Canadian regulations in September 2019 (Supplementary Table 1).

*4.3.1.4 Provincial retail density (stores per 100,000 residents aged 15 and over)*
Legal retailers in each province were identified and downloaded from provincial websites in September 2019 and cross-checked with lists displayed on Leafly, a website dedicated to cannabis and legal cannabis stores (www.leafly.ca). The number of stores in each province was divided by the provincial population aged 15 and over for 2019 and multiplied by 100,000.[31] Illegal retail stores were not included.

*4.3.1.5 Retail proximity (Euclidean distance)*
Respondents were asked "Please provide the postal code where you live for most of the year". If respondents did not provide their postal code (n=2,900), they were asked "Please name the 2 cross-streets of this intersection". Of those who provided their intersection (n=1,081), Google Maps was used to obtain postal codes, cross-referencing with the respondents' city and province. All intersections where Google Maps could not find a postal code were left blank (n=272). The postal codes of legal retailers were identified as described above. The Canadian respondents' postal codes and postal codes of legal retail stores were then linked to the Postal Code Conversion File Plus (PCCF+) version 7B, to obtain latitude and longitudes.[32] An open-source geographic information system (GIS) application (QGIS v3.6) was used to geocode the latitudes and longitudes of legal retail stores and respondents' postal codes. For respondents in urban areas, Canadian postal codes can cover a single house/apartment building, whereas postal codes in rural areas cover a larger landmass. In the current study, 86% of respondents live in urban areas and so a certain degree of accuracy can be assumed from postal codes as a proxy

for Canadian respondent locations.[33-34] The North American Equidistant Conic Projection (EPSG:102010) was used to minimize distance distortions. The Euclidean distance (in kilometers) between the postal code of the retail store and each respondent's address was computed. Distances were categorized into: "Under 3 km", "3-4.9 km", "5-9.9 km", "10 km or over" to mimic categories used by Statistics Canada.[16] A sensitivity analysis was conducted to examine the effect of distance as a categorical measure using breaks at the quartiles as well as a continuous measure (Supplemental Table 2).

*4.3.1.6 Retail proximity (self-reported time to retail store)*
Respondents were asked "How long would it take you to get to the nearest store that sells cannabis using your usual mode of transportation?" Responses began at "Less than five minutes" and increased in five-minute increments up to one hour and ended with "More than an hour" and "I don't know any store near to where I live". Responses were categorized into: "Under 5 mins", "5-15 mins", "Over 15 mins", "I don't know any stores where I live". To approximately match the time taken to travel 3 km and 10 km by car at 40-60 km per hour. This variable included both legal and illegal retail stores.

The full questionnaire is available in the ICPS 2019 survey (www.cannabisproject.ca/methods). All questions included "Don't know" and "Refuse to answer" options. Except "perceived income adequacy", all "Refuse to answer" options were set to missing. Except "perceived income adequacy" and "self-reported time to nearest retail store", all "Don't know" options were set to missing.

**4.3.2 Statistical analysis**
After exclusions due to poor data quality, such as speeding, dishonesty, or duplicate entries (n=1,228), the 2019 Canadian sample comprised 15,256 respondents. See 2019 Technical Report for more detail on exclusions (www.cannabisproject.ca/methods).

The current analysis was based on the sub-sample of 2,506 Canadian respondents who were of legal age to purchase cannabis and had consumed and purchased dried flower in the past 12-months. A total of 101 respondents were excluded where the legality of purchase source was unknown, and 355 were excluded where respondents did not provide a postal code or intersection.

Post-stratification sample weights were constructed based on the Canadian census estimates. Respondents were classified into age-by-sex-by-province, education, and age-by-smoking status groups. A raking algorithm was applied to the cross-sectional analytic sample to compute weights that were calibrated to these groupings and rescaled to the sample size for Canada. Statistical models were conducted with and without weights and similar patterns emerged. All estimates are weighted unless otherwise specified.

Descriptive statistics were used to describe legality of last purchase source, number of retail stores, and retail proximity across province. Binary logistic regression models were fitted to examine the association between the legality of last purchase source (1=Illegal vs. 2=Legal) and retail availability, where retail availability was represented in three ways: 1) province of residence; 2) objective retail proximity using the Euclidean distance to legal retail stores from a respondent's residence; and 3) self-reported retail proximity using time taken to nearest retail store. All models were adjusted for age, sex, education level, ethnicity/race, income adequacy, survey device type, and cannabis use frequency. Adjusted odds ratios (AORs) are reported with 95% confidence intervals (95% CI). Analyses were conducted using survey procedures in SAS (SAS version 9.4, SAS Institute Inc., Cary, NC, USA).

## 4.4 Results

Table 1 displays the weighted and unweighted sample characteristics among Canadian respondents who were of legal age to purchase legal cannabis and had consumed and purchased dried flower in the past 12 months.

Table 2 displays the percentage of dried flower purchasers who last purchased dried flower from a legal source, the number of stores per 100,000 residents aged 15 and over in September 2019, and retail proximity to the nearest store as an objective and self-reported measure in each province. As Table 2 shows, 47.7% of dried flower purchasers reported to last purchase dried flower from a legal source (range=40.5%-81.2% across the provinces). On average, there were 1.61 stores per 100,000 residents aged 15 and over in all provinces in September 2019 (range=0.20–7.87 stores per 100,000 residents aged 15 and over across the provinces). A total of 31.3% of dried flower purchasers live under 3 km from a legal retail store (range=12.2%-74.0% across the provinces). A total of 8.4% of dried flower purchasers reported living within five minutes from a retail store using their usual mode of transport (range=2.1%-20.7% across

the provinces). Of those who reported their usual mode of transport, 66.8% (n=1625) drove (car/taxi), 16.9% (n=372) used active transport (bike/walk), and 16.3% (n=325) used public transport (bus/train).

### 4.4.1 Province of residence
Three binary logistic regression models were used to examine the association of the legality of last purchase source used to purchase dried flower and retail availability (Table 3). In Model 1, province of residence was associated with legality of purchase source, adjusting for sociodemographic covariates. Dried flower purchasers residing in Prince Edward Island, Newfoundland and Labrador, Alberta, Nova Scotia, New Brunswick, Saskatchewan, and Quebec were more likely to last purchase dried flower from a legal source than residents of Ontario. No differences were found in the odds of last purchasing from a legal source between those residing in Manitoba or British Columbia and residents of Ontario.

### 4.4.2 Retail proximity (Euclidean distance)
In Model 2, objective retail proximity to the nearest legal retail store was associated with legality of purchase source, adjusting for sociodemographic covariates. Dried flower purchasers who lived under 3 km from a legal retail cannabis store were more likely to last purchase dried flower from a legal source than those who lived 10 km or more away. No differences were found in the odds of last purchasing from a legal source between dried flower purchasers who lived between 3 km and 4.9 km and 5 km and 9.9 km from a legal retail cannabis store and those who lived 10 km or more away.

### 4.4.3 Retail proximity (self-reported time taken to nearest retail store)
In Model 3, self-reported retail proximity to the nearest retail store was associated with legality of purchase source, adjusting for sociodemographic covariates. Dried flower purchasers who reported living over 15 minutes from their nearest retail store were less likely to last purchase dried flower from a legal source than those who reported living under five minutes or between five and 15 minutes, and more likely than those who did not know any stores near to where they lived.

### 4.4.4 Secondary covariates
After adjusting for retail availability and sociodemographic covariates, across all three models, daily cannabis consumers were less likely to last purchase dried flower at a legal source than

less than monthly consumers (all contrasts $p<0.001$). Dried flower purchasers with less than a high school diploma were less likely to last purchase dried flower at a legal source than those with a higher level of education (all contrasts $p<0.05$). Dried flower purchasers who found making ends meet neither difficult nor easy were more likely to last purchase dried flower at a legal source than those who found it difficult to make ends meet (all contrasts $p<0.05$).

After adjusting for retail availability and sociodemographic covariates, female dried flower purchasers were more likely to last purchase dried flower at a legal source than male purchasers in Models 1 and 3 (all contrasts $p<0.05$), with no association in Model 2. Age, ethnicity/race, and device used to complete survey were not associated with legality of last purchase source.

## 4.5 Discussion

The findings suggest that retail availability of legal cannabis is associated with purchasing dried flower from legal sources compared to illegal sources among Canadians who had consumed and purchased dried flower in the past 12-months; however, there is important variation across provinces. The proportion of Canadian dried flower purchasers who last purchased dried flower from a legal source varied from 41% in Ontario to 81% in Prince Edward Island. Indeed, residents in most provinces were more likely to purchase dried flower at a legal source than residents of Ontario. These results are consistent with a study using government data from federal and provincial agencies, which found a similar range of legal market share across the provinces, with Prince Edward Island having the greatest legal market share (70%) and Ontario having the smallest (13%).[35]

In the annual 2019 Canadian Cannabis Survey (CCS), 52% of consumers reported purchasing any cannabis legally in the past 12-months.[2] In addition, twice as many consumers reported their usual source to be legal physical stores (29%) than legal online stores (14%).[2] In the current study, 48% of all dried flower purchasers purchased dried flower legally at their last purchase. The proportion of those purchasing legally may be slightly lower in the current study due to potentially fewer people answering honestly about illegal purchases to a government survey. Moreover, the current survey removed respondents who reported being 'dishonest' in their answers.

The findings highlight marked discrepancies in retail availability in the first year after cannabis legalization. In September 2019, most dried flower purchasers in Alberta lived under 10 km from a legal cannabis store (92%), compared to only a third of those from Ontario (38%). Slightly lower proportions were reported by Statistics Canada in July 2019: 70% in Alberta lived within 10 km from a legal store and 33% in Ontario lived within 10 km.[16] The percentages from the current study across all provinces were slightly higher than those reported by Statistics Canada, potentially resulting from additional stores opening between July and September 2019.[16] The number of stores varied across the provinces in the first year of legalization and clear differences in physical availability of legal retail stores were seen across the provinces.[36] In the current study, Ontario – Canada's most populated province - had the lowest number of stores per 100,000 residents aged 15 and over. After a change of provincial government prior to legalization, Ontario's cannabis retail structure for physical stores changed from public to private; therefore, Ontario had no stores until April 2019. Comparatively, Alberta had a private retail structure for physical stores, and had 86 stores by April 2019. Ontario since increased its number of legal retail cannabis stores and therefore these patterns may change in the future as the legal market becomes more established. Documenting the evolution of the legal retail market is important for interpreting studies examining legalization in Canada and evaluating the impact of legalization in Canada.

The current study demonstrated a positive relationship between retail proximity, both objective and self-reported, and last purchasing dried flower from a legal source. Dried flower purchasers who lived under 3 km to a legal retail store were more likely to last purchase legally than those 10 km or more away. Self-reported time taken to get to the nearest store demonstrated a similar relationship, whereby those who reported living under 15 minutes from a store were more likely to purchase legally than those over 15 minutes. The relationship indicates that not only the distance to stores but the perceived time it takes to travel to stores is correlated to whether dried flower purchasers purchase from physical retail stores. Moreover, the self-reported measure considers travel time and reflects the awareness of retail stores in the local area. However, the importance of physical proximity and access may depend on the availability of delivery services.[37-38] Unlike most US states that have legalized non-medical cannabis, online sales are available in all Canadian provinces. The importance of physical access may also depend on access to the internet, access to a credit card, and patience for delivery. Indeed, although delivery times were longer than expected after legalization, the public online retail store (Ontario Cannabis Store) now provides same-day delivery in some regions of Ontario.[39-40]

Furthermore, since the COVID-19 pandemic and resulting reduced mobility, physical access to cannabis stores may matter less than before the pandemic.

Daily and almost daily cannabis consumers account for a significant proportion of the cannabis market share; therefore, they represent a priority group from transitioning to legal sources.[41-42] After adjusting for retail availability and sociodemographic covariates, daily cannabis consumers were less likely to last purchase dried flower from a legal source than less than monthly consumers. The legal purchase limit in Canada for dried flower is 30 g. Daily consumers may purchase in larger quantities; therefore, making illegal sources more desirable for bulk purchases. Indeed, quantity discounts are common in illegal drug markets.[43-45] Substantial quantity discounts were observed in a retail scan of objective prices in the Canadian illegal cannabis market.[5] Quantity discounts are present in the legal markets; although with smaller reductions.[46-47] Daily consumers may be retained in the illegal market due to the quantity discounts and the more generous purchase limits.

### 4.5.1 Limitations

This study is subject to limitations common to survey research. Respondents were recruited using non-probability-based sampling; therefore, the findings do not provide nationally representative estimates. The data were weighted by age group, sex, region, education, and smoking status. Cannabis use estimates were within the range of national estimates for young adults, whereas estimates among the entire ICPS sample were generally higher than national surveys in Canada. This is likely because the ICPS sampled individuals aged 16-65, whereas national surveys included older adults, who are known to have lower rates of cannabis use. In addition, a greater percentage of ICPS respondents reported poor self-rated general health than the national population, which is a feature of many non-probability samples and may be partly due to the use of web surveys, which provide greater perceived anonymity than in-person or telephone-assisted interviews often used in national surveys.[48-49]

To measure self-reported time taken to retail store, respondents were asked how long it would take them (in minutes) to get to their nearest store that sells cannabis. This question did not specify the legality of the retail store. In addition, self-reported time taken to retail store could vary by mode of transport; however, of those who reported their usual mode of transport, most used personal vehicle such as a taxi or car (66.8%). Sensitivity analyses examined the

association of 'usual mode of transport' as a covariate in the regression model, but comparable patterns emerged.

Euclidean distance to legal retail cannabis stores was treated as a categorical variable in the regression models, which assumes there are similar break points in distance travelled among respondents. A continuous measure would assume a monotonic linear relationship between distance and the likelihood of purchasing their dried flower at an illegal or legal source. Moreover, the geometric mean revealed skewness in the data and so a continuous measure was deemed inappropriate. A sensitivity analysis was conducted to examine the effect of distance as a categorical measure using different classification schemes as well as a continuous measure and similar patterns emerged (Supplementary Table 2).

Price of dried flower was not included in the current study. There are several estimates of legal prices for dried flower after the first year of legalization; however, provincial estimates are inconsistent, and the reliability is unclear.[46-47,50-51] Finally, the current study focused on dried flower only and therefore the findings may not be representative of all cannabis products in Canada. However, dried flower is the most used product among Canadians and so would capture a large proportion of expenditures in the legal market.[2,52-53] In addition, only dried flower and some oils were available in the legal market at the time of the survey; therefore, most products were only available in the illegal market.[1] Further research is needed on the association between proximity to legal stores and the legality of purchase source across different cannabis products, which are increasing in market share.

### 4.5.2 Conclusions

The findings demonstrate a strong association between retail availability and the proportion of past 12-month dried flower purchasers who reported purchasing dried flower from a legal source, where retail availability was represented by province of residence, 'objective' proximity to legal stores, and self-reported proximity to retail stores. This association was demonstrated both at the provincial level in terms of residence, as well as the individual level with respect to distance to legal stores and consumers' own perception of travel time to the nearest store. Achieving optimal retail availability, where consumers are encouraged to transition to the legal market without promoting increased initiation or problematic use, is paramount in a regulated market. The current study would suggest that more legal stores and accessible legal stores would increase legal purchases; however, too many stores may not only

increase consumption but if stores are unequally distributed, may increase consumption in some populations over others, such as vulnerable populations or those in low-income areas.[19-20,22] A balance must be achieved in the Canadian market to achieve the public health objectives set out in the Cannabis Act. Future research is needed on how retail proximity changes over time and its association with legal purchases as the market continues to stabilize post-legalization.

**Table 1: Sample characteristics of past 12-month cannabis consumers who purchased dried flower in the past 12 months** (n=2,506)

|  | Unweighted % (n) | Weighted % (n) |
|---|---|---|
| **Age group** | | |
| MLA-25* | 14.4 (361) | 14.0 (352) |
| 26-35 | 28.7 (720) | 33.5 (839) |
| 36-45 | 23.5 (590) | 22.2 (556) |
| 46-55 | 17.4 (435) | 17.6 (440) |
| 56-65 | 16.0 (400) | 12.7 (319) |
| | | |
| **Sex at birth** | | |
| Female | 53.6 (1343) | 40.2 (1008) |
| Male | 46.4 (1163) | 59.8 (1498) |
| | | |
| **Ethnicity/Race** | | |
| Black | 2.6 (66) | 3.3 (83) |
| East/Southeast Asian | 4.2 (105) | 4.4 (111) |
| Indigenous | 4.2 (104) | 4.4 (109) |
| Latinx | 1.5 (38) | 2.1 (52) |
| Middle Eastern | 0.6 (16) | 0.5 (13) |
| South Asian | 2.2 (55) | 2.6 (66) |
| White | 78.5 (1966) | 76.0 (1905) |
| Mixed/Other | 6.2 (156) | 6.7 (167) |
| | | |
| **Highest level of Education** | | |
| Less than high school | 6.9 (171) | 13.0 (324) |
| High school diploma | 19.4 (484) | 31.4 (783) |
| Some college or technical vocation | 47.8 (1192) | 35.4 (882) |
| Bachelor's degree or higher | 25.9 (647) | 20.2 (503) |
| | | |
| **Income adequacy** | | |
| Very difficult | 12.0 (301) | 12.1 (302) |
| Difficult | 25.5 (640) | 26.1 (653) |
| Neither easy nor difficult | 33.5 (840) | 33.7 (845) |
| Easy | 18.5 (464) | 17.9 (449) |
| Very easy | 8.4 (211) | 7.6 (191) |
| Not specified | 2.0 (50) | 2.6 (66) |
| | | |
| **Province** | | |
| British Columbia | 14.5 (363) | 13.9 (347) |
| Alberta | 16.4 (412) | 13.8 (346) |
| Saskatchewan | 5.4 (135) | 3.3 (83) |
| Manitoba | 6.3 (158) | 4.1 (103) |
| Ontario | 22.4 (562) | 40.1 (1005) |
| Quebec | 17.9 (448) | 17.2 (430) |
| New Brunswick | 5.3 (132) | 2.4 (60) |
| Nova Scotia | 6.7 (169) | 2.9 (73) |
| Prince Edward Island | 1.0 (24) | 0.5 (13) |
| Newfoundland and Labrador | 4.1 (103) | 1.8 (46) |

**Cannabis Use Frequency**

| | | |
|---|---|---|
| Past year, but less than monthly | 17.3 (433) | 15.4 (386) |
| Monthly | 18.4 (461) | 17.4 (436) |
| Weekly | 20.5 (513) | 20.8 (521) |
| Daily/almost daily | 43.9 (1099) | 46.4 (1162) |
| **Device used** | | |
| Smartphone | 49.1 (1230) | 48.7 (1220) |
| Tablet | 7.0 (176) | 6.7 (169) |
| Computer | 43.9 (1100) | 44.6 (1117) |

*MLA=minimum legal age.  Minimum legal age (MLA) was taken from provincial laws in September 2019: 18 years in Alberta and Quebec, and 19 years in all other provinces.

**Table 2: Legality of purchase source, the number of residents per store, and retail proximity across the provinces in Canada.**

| | Legal source used at last purchase (n=2,405) | Number of stores per 100,000 people aged 15+ in September 2019 | Objective retail proximity: Euclidean distance between postal code of respondents' residence and postal code of nearest <u>legal</u> retail store (km) (n=2,151) | | | | Self-reported retail proximity: Time taken to get to the nearest retail store in the town/city near to where you live (n=2,487) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Under 3 km | 3-4.9 km | 5-9.9 km | 10 km + | Under 5 minutes | 5–15 minutes | Over 15 minutes | I don't know any stores near to where I live |
| **All 10 provinces** | 47.7 (1278) | 1.61 | 31.3 (831) | 10.8 (259) | 16.4 (336) | 41.5 (725) | 8.4 (282) | 35.8 (1004) | 47.9 (1056) | 7.9 (145) |
| **Province** | | | | | | | | | | |
| Prince Edward Island | 81.2 (20) | 3.01 | 23.9 (7)* | 43.3 (7)* | 0.0 (0) | 32.8 (7)* | 9.4 (2)* | 65.5 (17) | 25.1 (5)* | 0.0 (0) |
| Newfoundland and Labrador | 73.8 (77) | 5.53 | 66.3 (58) | 10.7 (7)* | 4.9 (5)* | 18.2 (18) | 18.2 (20) | 58.0 (56) | 22.8 (26) | 1.0 (1)* |
| Nova Scotia | 66.6 (105) | 1.44 | 28.3 (38) | 13.3 (25) | 14.7 (25) | 43.6 (58) | 17.5 (26) | 40.9 (71) | 40.4 (68) | 1.1 (3)* |
| Alberta | 61.6 (251) | 7.87 | 74.0 (262) | 8.7 (33) | 9.0 (29) | 8.3 (34) | 20.3 (91) | 54.0 (208) | 22.3 (97) | 3.4 (14)* |
| New Brunswick | 58.0 (72) | 3.01 | 46.1 (45) | 11.5 (18) | 24.3 (23) | 18.1 (22) | 20.7 (21) | 51.1 (67) | 25.6 (40) | 2.6 (2)* |
| Saskatchewan | 54.8 (78) | 3.71 | 64.9 (75) | 7.9 (12)* | 7.6 (10)* | 19.7 (23) | 12.9 (20) | 47.3 (69) | 36.5 (40) | 3.4 (4)* |
| Quebec | 48.7 (223) | 0.27 | 23.6 (102) | 15.4 (64) | 24.6 (89) | 36.4 (133) | 2.1 (12)* | 32.7 (150) | 57.8 (253) | 7.4 (30) |
| Manitoba | 47.0 (79) | 2.07 | 49.4 (72) | 14.1 (18) | 13.4 (19) | 23.2 (26) | 13.0 (28) | 49.9 (79) | 33.5 (45) | 3.6 (5)* |
| British Columbia | 41.2 (154) | 1.53 | 33.7 (106) | 11.5 (35) | 16.3 (54) | 38.6 (119) | 11.6 (42) | 39.1 (143) | 45.4 (161) | 4.0 (16) |
| Ontario | 40.5 (219) | 0.20 | 12.2 (66) | 8.6 (40) | 16.9 (82) | 62.3 (285) | 3.2 (20) | 24.7 (144) | 59.2 (321) | 13.0 (70) |

Data are % (n). Weighted %, unweighted n. Missing values for legality of purchase source (n=101); Euclidean distance (n=355); and time taken to nearest store (n=19) are excluded (removed from the denominator). *High sampling variability – coefficient of variation is >30%

**Table 3: Weighted binary logistic regression analysis for outcome variables by legality of purchase source at last purchase of dried flower** (n=2,506).

| | % Legal (n) | MODEL 1 (n=2,368) Legal (vs. illegal) AOR (95% CI) | MODEL 2 (n=2,057) Legal (vs. illegal) AOR (95% CI) | MODEL 3 (n=2,356) Legal (vs. illegal) AOR (95% CI) |
|---|---|---|---|---|
| **Province of residence** | | | | |
| Prince Edward Island | 81.2 (20) | **5.66 (1.77, 18.13)** | - | - |
| Newfoundland and Labrador | 73.8 (77) | **4.25 (2.21, 8.19)** | - | - |
| Nova Scotia | 66.6 (105) | **2.82 (1.85, 4.31)** | - | - |
| Alberta | 61.6 (251) | **2.74 (1.98, 3.78)** | - | - |
| New Brunswick | 58.0 (72) | **2.26 (1.32, 3.88)** | - | - |
| Saskatchewan | 54.8 (78) | **1.83 (1.14, 2.94)** | - | - |
| Manitoba | 47.0 (79) | 1.47 (0.94, 2.31) | - | - |
| Quebec | 48.7 (223) | **1.41 (1.03, 1.92)** | - | - |
| British Columbia | 41.2 (154) | 1.04 (0.76, 1.43) | - | - |
| Ontario | 40.5 (219) | REF | - | - |
| | | | | |
| **Euclidean distance to legal retail store (km)** | | | | |
| Under 3 km | 53.9 (462) | | **1.56 (1.20, 2.02)** | - |
| 3 km – 4.9 km | 48.6 (133) | | 1.17 (0.80, 1.70) | |
| 5 km – 9.9 km | 43.5 (164) | - | 0.97 (0.70, 1.34) | - |
| 10 km + | 43.9 (337) | - | REF | - |
| | | | | |
| **Time taken to nearest retail store** | | | | |
| Under 5 minutes | 63.0 (173) | - | - | **2.24 (1.56, 3.21)** |
| 5 – 15 minutes | 53.5 (574) | - | - | **1.39 (1.11, 1.74)** |
| Over 15 minutes | 44.1 (491) | - | - | REF |
| I don't know any stores near to where I live | 29.9 (35) | - | - | **0.49 (0.30, 0.83)** |
| | | | | |
| **Cannabis Use Frequency** | | | | |
| Past year, but less than monthly | 57.6 (283) | REF | REF | REF |
| Monthly | 58.9 (276) | 1.11 (0.78, 1.58) | 1.19 (0.82, 1.72) | 1.02 (0.72, 1.45) |
| Weekly | 51.5 (283) | 0.93 (0.67, 1.31) | 0.96 (0.67, 1.38) | 0.85 (0.60, 1.19) |
| Daily/almost daily | 38.3 (436) | **0.51 (0.38, 0.70)** | **0.49 (0.35, 0.68)** | **0.47 (0.35, 0.64)** |
| | | | | |
| **Income adequacy** | | | | |
| Very difficult/Difficult | 42.1 (435) | REF | REF | REF |
| Neither difficult nor easy | 53.4 (465) | **1.54 (1.19, 2.00)** | **1.45 (1.11, 1.91)** | **1.51 (1.61, 1.95)** |
| Easy/Very easy | 48.2 (357) | 1.21 (0.93, 1.59) | 1.14 (0.86, 1.52) | 1.09 (0.83, 1.43) |
| Not specified | 49.1 (21) | 1.84 (0.62, 5.44) | 3.20 (0.57, 17.92) | 2.51 (0.84, 7.53) |
| | | | | |
| **Age group** | | | | |
| MLA-25 | 47.4 (190) | 0.93 (0.61, 1.41) | 1.14 (0.74, 1.76) | 0.98 (0.65, 1.47) |
| 26-35 | 51.2 (396) | 1.20 (0.84, 1.72) | 1.27 (0.88, 1.85) | 1.17 (0.81, 1.67) |
| 36-45 | 47.8 (302) | 1.04 (0.72, 1.50) | 1.14 (0.78, 1.67) | 1.05 (0.73, 1.50) |
| 46-55 | 41.9 (195) | 0.79 (0.54, 1.15) | 0.79 (0.54, 1.17) | 0.80 (0.55, 1.17) |
| 56-65 | 46.5 (195) | REF | REF | REF |
| | | | | |
| **Sex at birth** | | | | |
| Female | 50.2 (707) | **1.27 (1.02, 1.58)** | 1.15 (0.92, 1.45) | **1.26 (1.02, 1.57)** |
| Male | 46.0 (571) | REF | REF | REF |

| | | | | |
|---|---|---|---|---|
| **Ethnicity/Race** | | | | |
| Black | 38.9 (29) | 0.74 (0.40, 1.37) | 0.72 (0.36, 1.46) | 0.66 (0.37, 1.20) |
| East/Southeast Asian | 61.0 (58) | 1.47 (0.87, 2.49) | 1.08 (0.60, 1.95) | 1.23 (0.73, 2.08) |
| Indigenous | 41.6 (45) | 0.76 (0.46, 1.27) | 0.68 (0.39, 1.18) | 0.85 (0.51, 1.43) |
| Latinx | 42.3 (20) | 0.68 (0.27, 1.75) | 0.60 (0.23, 1.56) | 0.60 (0.23, 1.54) |
| Middle Eastern | 75.1 (11) | 2.93 (0.75, 11.48) | 4.87 (0.73, 32.65) | 2.27 (0.72, 10.85) |
| South Asian | 43.6 (24) | 0.65 (0.34, 1.25) | 0.59 (0.30, 1.18) | 0.58 (0.30, 1.10) |
| White | 48.2 (1013) | REF | REF | REF |
| Other/Mixed | 44.9 (64) | 0.96 (0.59, 1.57) | 0.77 (0.46, 1.30) | 0.88 (0.54, 1.44) |
| | | | | |
| **Highest level of Education** | | | | |
| Less than high school | 32.9 (55) | REF | REF | REF |
| High school diploma | 47.3 (230) | **1.80 (1.15, 2.81)** | **2.06 (1.27, 3.33)** | **1.74 (1.11, 2.73)** |
| Some college or technical vocation | 49.0 (607) | **1.78 (1.18, 2.00)** | **2.01 (1.29, 3.14)** | **1.65 (1.08, 2.51)** |
| Bachelor's degree or higher | 55.0 (380) | **1.97 (1.25, 3.11)** | **2.20 (1.35, 3.60)** | **1.84 (1.16, 2.91)** |
| | | | | |
| **Device used** | | | | |
| Computer | 47.7 (557) | REF | REF | REF |
| Smartphone | 47.7 (631) | 1.05 (0.83, 1.33) | 1.12 (0.88, 1.44) | 1.08 (0.86, 1.36) |
| Tablet | 48.0 (90) | 1.06 (0.68, 1.67) | 0.99 (0.62, 1.58) | 1.04 (0.66, 1.63) |

Weighted %, unweighted n. *MLA=minimum legal age. Minimum legal age (MLA) was taken from provincial laws in September 2019: 18 years in Alberta and Quebec, and 19 years in all other provinces. Missing values for legality of purchase source (n=101); Euclidean distance (n=355); time taken to nearest store (n=19); ethnicity/race (n=35); and education (n=12) are excluded.

**Supplemental Table 1: Illegal and legal purchase sources in Canada, September 2019**

| Illegal purchase sources | Legal purchase sources |
|---|---|
| Family/Friend | Licensed/legal store or dispensary |
| Dealer (in person) | Licensed/legal internet delivery service or mail order |
| Unlicensed/illegal store or dispensary | |
| Unlicensed/illegal internet delivery service or mail order | |
| Licensed/legal store or dispensary and under minimum legal age (MLA) | |
| Licensed/legal internet delivery service or mail order and under MLA | |

The source 'Family/Friend' in legal jurisdictions was classed as 'illegal' as it refers to dried flower that has been paid for, not gifted or shared.
MLA was taken from provincial laws in September 2019. In 2019, MLA was 18 years in Alberta and Quebec, and 19 years elsewhere.

**Supplementary Table 2: Weighted binary logistic regression analysis for legality of purchase source at last purchase of dried flower using Euclidean distance to legal retail store as a continuous and categorical variable** (n=2,057).

| | % Legal (n) | MODEL S1<br>Legal (vs. illegal)<br>AOR (95% CI) | MODEL S2<br>Legal (vs. illegal)<br>AOR (95% CI) |
|---|---|---|---|
| **Euclidean distance to legal retail store** | | | |
| 10km increase in distance | | **0.97 (0.95, 0.99)** | - |
| | | | |
| **Euclidean distance to legal retail store: four quartiles** | | | |
| Under 1.8 km | 52.9 (299) | - | **1.50 (1.09, 2.05)** |
| 1.8 km – 4.7 km | 52.1 (289) | - | 1.37 (0.99, 1.89) |
| 4.8 km – 14.8 km | 44.3 (258) | - | 0.95 (0.70, 1.30) |
| 14.9 km and over | 43.5 (250) | - | REF |
| | | | |
| **Cannabis Use Frequency** | | | |
| Past year, but less than monthly | 57.6 (283) | REF | REF |
| Monthly | 58.9 (276) | 1.18 (0.81, 1.72) | 1.18 (0.81, 1.71) |
| Weekly | 51.5 (283) | 0.96 (0.66, 1.38) | 0.95 (0.66, 1.37) |
| Daily/almost daily | 38.3 (436) | **0.49 (0.36, 0.68)** | **0.49 (0.35, 0.67)** |
| | | | |
| **Income adequacy** | | | |
| Very difficult/Difficult | 42.1 (435) | REF | REF |
| Neither difficult nor easy | 53.4 (465) | **1.38 (1.05, 1.81)** | **1.45 (1.10, 1.90)** |
| Easy/Very easy | 48.2 (357) | 1.07 (0.81, 1.42) | 1.14 (0.86, 1.52) |
| Not specified | 49.1 (21) | 3.37 (0.65, 17.48) | 3.21 (0.58, 17.92) |
| | | | |
| **Age group** | | | |
| MLA-25 | 47.4 (190) | 1.16 (0.75, 1.79) | 1.15 (0.74, 1.78) |
| 26-35 | 51.2 (396) | 1.28 (0.88, 1.86) | 1.27 (0.88, 1.85) |
| 36-45 | 47.8 (302) | 1.13 (0.77, 1.65) | 1.16 (0.79, 1.69) |
| 46-55 | 41.9 (195) | 0.80 (0.54, 1.19) | 0.79 (0.54, 1.17) |
| 56-65 | 46.5 (195) | REF | REF |
| | | | |
| **Sex at birth** | | | |
| Female | 50.2 (707) | 1.15 (0.91, 1.45) | 1.15 (0.91, 1.45) |
| Male | 46.0 (571) | REF | REF |
| | | | |
| **Ethnicity/Race** | | | |
| Black | 38.9 (29) | 0.65 (0.32, 1.30) | 0.72 (0.35, 1.45) |
| East/Southeast Asian | 61.0 (58) | 1.05 (0.58, 1.88) | 1.09 (0.60, 1.98) |
| Indigenous | 41.6 (45) | 0.76 (0.44, 1.31) | 0.69 (0.39, 1.19) |
| Latinx | 42.3 (20) | 0.60 (0.22, 1.59) | 0.61 (0.23, 1.59) |
| Middle Eastern | 75.1 (11) | 4.23 (0.71, 25.19) | 4.86 (0.73, 32.38) |
| South Asian | 43.6 (24) | 0.56 (0.28, 1.12) | 0.60 (0.30, 1.20) |
| White | 48.2 (1013) | REF | REF |
| Other/Mixed | 44.9 (64) | 0.75 (0.44, 1.26) | 0.77 (0.46, 1.29) |
| | | | |
| **Highest level of Education** | | | |
| Less than high school | 32.9 (55) | REF | REF |
| High school diploma | 47.3 (230) | **1.97 (1.21, 3.21)** | **2.04 (1.26, 3.31)** |

| | | | |
|---|---|---|---|
| Some college or technical vocation | 49.0 (607) | **2.00 (1.27, 3.15)** | **2.01 (1.28, 3.14)** |
| Bachelor's degree or higher | 55.0 (380) | **2.23 (1.35, 3.66)** | **2.19 (1.34, 3.58)** |
| **Device used** | | | |
| Computer | 47.7 (557) | REF | REF |
| Smartphone | 47.7 (631) | 1.13 (0.88, 1.45) | 1.13 (0.88, 1.44) |
| Tablet | 48.0 (90) | 1.01 (0.63, 1.61) | 0.98 (0.61, 1.57) |

Weighted %, unweighted n. *MLA=minimum legal age.  Minimum legal age (MLA) was taken from provincial laws in September 2019: 18 years in Alberta and Quebec, and 19 years in all other provinces.  Euclidean distance to legal retail store was categorized into four quartiles: 0-25th percentile, 25th-50th percentile, 50th-75th percentile, 75th-100th percentile. Missing values for legality of purchase source (n=101); Euclidean distance (n=355); ethnicity/race (n=35); and education (n=12) are excluded

# CHAPTER 5: TRENDS IN PRICE AND TRANSITIONS TO LEGAL PURCHASE SOURCES IN CANADA'S DRIED FLOWER CANNABIS MARKET IN THE TWO YEARS AFTER LEGALIZATION OF NON-MEDICAL CANNABIS

Status: Completed for submission, June 2021

PhD committee*: Elle Wadsworth[a], Pete Driezen[ab], Beau Kilmer[c], David Hammond[a]

[a]School of Public Health Sciences, University of Waterloo, Waterloo, Ontario, Canada

[b]Department of Psychology, University of Waterloo, Waterloo, Ontario, Canada

[c]RAND Drug Policy Research Center, RAND Corporation, Santa Monica, CA, USA

## 5.1 Overview

**Background:** The post-tax price of legal cannabis has the potential to influence whether consumers transition from the illegal to legal cannabis market. The aims of the study were to: 1) estimate the percentage who report purchasing dried flower at different sources and quantities; 2) estimate the unit price of dried flower; 3) examine the association between unit price of dried flower and legality of purchase source.

**Methods:** Repeat cross-sectional survey data come from Canadian respondents in Wave 2 and 3 of the International Cannabis Policy Study (ICPS) conducted in September-October 2019 and 2020, one and two years after non-medical cannabis legalization. Respondents were of legal age to purchase cannabis (up to 65 years) and had purchased dried flower in the past 12-months (n=4,923). Respondents were recruited through online commercial panels. Weighted binary logistic regression models examined the association between price and legality of source.

**Results:** The proportion of consumers last purchasing dried flower from legal sources increased from 2019 to 2020 (45.7% vs. 58.1%) and in the past 12-months, the average amount of dried flower consumers reported purchasing from legal sources increased from 2019 to 2020 (55.7% vs. 67.5%). The mean unit price of dried flower was $10.64 in 2019 and $10.41 in 2020, and when quantity was accounted for the unit price of dried flower was $7.09 in 2019 and $6.83 in 2020. The mean price of legal dried flower decreased in 2020 ($12.63 vs. $11.16; p<0.001), but remained more expensive than illegal dried flower in both years ($12.63 vs. $9.04 in 2019; p<0.001, $11.16 vs. $9.41 in 2020; p<0.001).

**Conclusion:** A greater percentage of consumers purchased dried flower from legal sources two years after legalization than one. The price of dried flower contributed to the legality of purchase source used, where higher prices were associated with legal purchasing.

**Key words:** cannabis; marijuana; price; legalization; Canada; quantity discount

## 5.2 Introduction

Canada legalized non-medical ("recreational") cannabis in October 2018. At the time of legalization, only dried flower and some oils were available to purchase from the non-medical market; all other products (e.g., edibles, vape pens) became available on the legal market in December 2019. In the non-medical market, Canadians are permitted to purchase up to 30 grams of dried flower in a single transaction, or the equivalent in non-flower form.[1] Indeed, quantity discounts are considerable in illegal markets, where purchasing in larger quantities tend to be cheaper per gram than smaller quantities.[2-7]

Canada had an established illegal and medical cannabis market prior to legalization.[8,9] Transitioning consumers from illegal to legal (medical or non-medical) sources is a primary objective of legalization; however, the timeline and the extent to which consumers shift to legal retail sources remains unclear. Indeed, Canada's national survey - the Canadian Cannabis Survey - found that just under half of consumers reported using the illegal market two years after legalization.[10] Price is among the primary reasons cited by cannabis consumers that influences where they sourced their cannabis.[10,11] This suggests that if the legal market is superior to the illegal market on price, then consumers may choose the legal market to source their cannabis.

The post-tax price of legal cannabis has the potential to influence whether consumers transition from the illegal to legal cannabis market.[12-14] Since legalization, studies have consistently reported illegal cannabis to be cheaper than legal cannabis in Canada. In a study using prices collected from illegal and legal retailers, legal cannabis was 19% more expensive than illegal cannabis at all quantities examined in the two months after legalization in Canada.[15] Crowdsourced data from Statistics Canada found a slightly greater price differential, where legal cannabis was 50% more expensive than illegal cannabis two months after legalization; however, results were not split by quantity purchased.[16] Moreover, in a self-reported study conducted pre-legalization, dried flower purchased from a legal source – government licensed medical retailers – was more expensive than dried flower purchased from an illegal source.[6] Canada's national cannabis survey reported a drop in the price-per-gram of dried flower prior to legalization among cannabis consumers, but an increase since legalization ($11.40/g, $8.62/g, $9.83/g, and $10.48/g in 2017, 2018, 2019, and

2020, respectively).[10,11,17,18] However, the Canadian Cannabis Survey did not separate price-per-gram by quantity purchased nor legality of source.

To our knowledge, the current study is among the first to examine the self-reported price-per-gram (hereafter: unit price) of dried flower and its relationship with purchase source used among cannabis dried flower purchasers in Canada post-legalization. The aims of the study were to 1) estimate the percentage of dried flower purchasers who report purchasing dried flower at different sources and quantities; 2) estimate the unit price of dried flower by source and cannabis use frequency and; 3) examine the association between unit price of dried flower and legality of purchase source. We hypothesized more consumers would purchase in the legal market and the average price paid would be lower in 2020 than 2019. We also hypothesized that it would be more expensive to purchase in the legal market than the illegal market. This study offers a timely exploration at the association of price of dried flower and legal purchases in a newly legal non-medical cannabis market in Canada.

## 5.3 Methods

Data are from Waves 2 and 3 of the International Cannabis Policy Study (ICPS), repeat cross-sectional surveys conducted in Canada and the United States. Wave 2 and 3 were conducted post-legalization in Canada. Data were collected via self-completed web-based surveys in September-October 2019 and 2020 from respondents aged 16-65. Respondents were recruited using non-probability sampling methods through the Nielsen Consumer Insights Global Panel and their partners' panels. Email invitations with a unique link were sent to panelists; ineligible panelists were not invited. Surveys were conducted in English or French in Canada. Median survey time was 25 minutes in 2019 and 21 minutes in 2020. Respondents provided consent prior to completing the survey. Respondents received remuneration in accordance with their panel's usual incentive structure. In 2019, 81,263 respondents accessed the survey link, of whom 51,087 completed the entire survey for an AAPOR cooperation rate of 63%. In 2020, 78,438 respondents accessed the survey link, of whom 48,633 completed the entire survey (62%).[19] The study was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee

(ORE#31330). A full description of the study methods can be found in the ICPS Technical Reports and methodology paper.[20-22]

The current study reports data on Canadian respondents who had consumed and purchased dried flower in the past 12-months and were of legal age to purchase cannabis. Minimum legal age to purchase cannabis (MLA) was taken from provincial laws in September 2019 and 2020. In 2019, MLA was 18 years in Alberta and Quebec, and 19 years elsewhere. In 2020, Quebec raised their MLA to 21 years.

**5.3.1 Measures**
*5.3.1.1 Socio-demographic measures*
Sociodemographic measures were sex at birth, age, ethnicity/race, education, perceived income adequacy, suspected device type used to complete survey, and province of residence. See Table 1 for full coding of response options.

*5.3.1.2 Cannabis use frequency*
Cannabis use frequency was assessed through questions, "How often do you use cannabis?" and "When was the last time you used cannabis?" Responses were categorized into: "Less than monthly consumer", "Monthly consumer", "Weekly consumer", "Daily/almost daily consumer".

*5.3.1.3 Legal purchases of dried flower in past 12-months*
Respondents who consumed dried flower in the past 12-months were asked "Overall, about what percentage of the dried herb that you used in the past 12-months came from legal/authorized sources?". Answers were open-ended from 0%-100%. Respondents were able to report both medical and non-medical legal/authorized sources.

*5.3.1.4 Source used to purchase dried flower at last purchase*
Respondents who purchased dried flower in the past 12 months were asked "The last time you bought dried flower, where did you buy it?", with answers: "From a family member or friend", "From a dealer (in person)", "Internet delivery service or mail order (delivered to me)", "From a store, co-operative or dispensary (in person/curbside pickup)", "Other". "Other" responses were re-categorized according to answers provided.

*5.3.1.5 Legality of last purchase source*

Respondents who purchased dried flower from a physical or online store were asked: "What type of physical store or dispensary did you buy the dried herb from?" with answers: "A legal/authorized store", "An illegal or unauthorized store/dispensary", "Other", and "Where did you buy the dried flower online?" with answers: "An authorized/legal website", "An unauthorized/illegal website, private delivery service or dealer", "Other". "Other" responses were re-categorized according to answers provided. "Don't know" responses were categorized into "Unknown". All other sources were categorized according to Canadian regulations in September 2019 and 2020 to "Illegal" and "Legal" (Supplemental Table 1).

*5.3.1.6 Unit price of dried flower at last purchase*

Respondent's unit price was calculated from two questions. First, respondents were asked, "The last time you purchased dried herb, how much did you buy…?" with answers "1/8 gram or less", "1/4 gram", "1/2 gram", "3/4 gram", "1 gram", "2 grams", "3 grams", "1/8 ounce", "1/4 ounce", "1/2 ounce", "3/4 ounce", "1 ounce" and "More than 1 ounce". Open-ended responses were provided to respondents who reported purchasing more than one ounce. Respondents also could answer in the number of joints and choose the weight that is closest to the size they purchased beginning at 0.2g and increasing in 0.2g increments to 1.2g. Units were standardized into grams (g) and responses were treated as continuous. Second, participants were asked, "How much did you spend the last time you bought dried herb?" and respondents could provide numeric responses in an open-ended field. To account for extreme values, unit prices above the 95th percentile were excluded ($n_{2019}=100$; $n_{2020}=88$) and values below the 1st percentile were winsorized to the 1st percentile ($n_{2019}=20$; $n_{2020}=22$). These limits were guided by the distribution and unit prices collected from the legal and illegal retail market in a different study.[23] All prices were in Canadian dollars (CAD). Prices in 2019 were inflated to 2020 prices using the 12-month change in Consumer Price Index from September 2019 to September 2020 (0.5%).[24]

*5.3.1.7 Quantity-adjusted price*

The unit price of dried flower adjusted for the quantity purchased for all respondents was computed as the ratio:

*Quantity-adjusted price = $\sum (P_r * QP_r)/ \sum(QP_r)$*


Where $P_r$ is the respondents' unit price and $QP_r$ is the respondent's quantity purchased.[25]


The full questionnaire is available in the ICPS 2019 and 2020 surveys. All questions included "Don't know" and "Refuse to answer" options. Except "perceived income adequacy", all "Refuse to answer" responses were set to missing. Except "perceived income adequacy" and "legality of last purchase source" all "Don't know" responses were set to missing.


### 5.3.2 Statistical analysis

After exclusions due to poor data quality or duplicate entries ($n_{2019}=1,228$; $n_{2020}=1,221$), the Canadian samples comprised 15,256 and 15,780 respondents in 2019 and 2020, respectively. See Technical Reports for more detail on exclusions.[21,22] The current analysis was based on the sub-sample of 4,923 ($n_{2019}=2,506$; $n_{2020}=2,417$) Canadian respondents who were of legal age to purchase cannabis, and had consumed and purchased dried flower in the past 12-months. Respondents who received dried flower for free or through non-monetary exchange were not included in the analysis. Missing data were removed using case-wise deletion for variables in regression analyses for: legality of purchase source at last purchase (n=188 [3.8%]); education (n=28 [0.6%]); ethnicity/race (n=71 [1.4%]); and unit price, either not providing a price or quantity variable to calculate a unit price (n=995 [20.2%]) or an implausible value (n=188 [3.8%]). The proportion of cannabis consumers who did not provide or had an implausible unit price were more likely to be female in 2020 ($\chi^2=9.9$, p=0.002), to be better educated in 2019 ($\chi^2=7.9$, p=0.048), report Black, East/Southeast Asian or Middle Eastern ethnicity/race in 2019 ($\chi^2=16.2$, p=0.023), report it was difficult to make ends meet in 2019 ($\chi^2=13.6$, p=0.018), and be less frequent cannabis consumers (2019: $\chi^2=27.6$, p<0.001; 2020: $\chi^2=22.1$, p<0.001).


Post-stratification sample weights were constructed based on the Canadian census estimates. Respondents were classified into age-by-sex-by-province, education, and age-by-smoking status groups. A raking algorithm was applied to the cross-sectional analytic sample to compute weights that were calibrated to these groupings and rescaled to the sample size for Canada for each year.[21,22] All estimates are weighted unless otherwise specified.

First, descriptive statistics were used to describe purchase sources and quantity purchased of dried flower at last purchase across province. Second, the percentage of legal purchases of dried flower in the past 12-months was examined among dried flower purchasers. Third, the mean unit price with standard errors of the mean (SEM) and quantity-adjusted price with standard errors (SE) were estimated by cannabis use frequency, purchase source, and quantity purchased. Fourth, a binary logistic regression model was fitted to examine the relationship between the legality of last purchase source and unit price, and tested a two-way interaction for survey wave and unit price. Sensitivity analyses were conducted where: 1) unit price of dried flower was removed as a covariate due to the bidirectionality of price also being dependent on purchase source and; 2) quantity purchased was included as a covariate as a categorical variable (<1 g, 1 g-3.49 g, 3.5 g-27.9 g, 28 g+) due to its relationship with purchase source, unit price, and cannabis use frequency. Models were adjusted for age, sex at birth, education, race/ethnicity, income adequacy, device type, and cannabis use frequency. Adjusted odds ratios (AORs) are reported with 95% confidence intervals (95%CI). Analyses were conducted using survey procedures in SAS (SAS version 9.4, SAS Institute Inc., Cary, NC, USA).

## 5.4 Results

Table 1 displays the weighted and unweighted sample characteristics of Canadian respondents who were of legal age to purchase cannabis and had consumed and purchased dried flower in the past 12 months in 2019 and 2020.

### 5.4.1 Legal dried flower purchases in the past 12-months

Figure 1a displays the average reported percentage of dried flower purchased from legal sources in the past 12-months in 2019 and 2020 overall and across the provinces. On average, consumers of legal age reported purchasing 55.7% and 67.5% of dried flower from legal sources in 2019 and 2020, respectively. Figure 1b displays the average reported percentage of dried flower purchased from legal sources among daily/almost-daily cannabis consumers. On average, daily cannabis consumers of legal age reported purchasing 44.7% and 58.8% of dried flower from legal sources in 2019 and 2020, respectively.

### 5.4.2 Purchase source and quantity of dried flower at last purchase

Table 2 displays the characteristics of consumers' last purchase of dried flower by province, in 2019 and 2020. As Table 2 shows, stores/dispensaries were the most commonly reported purchase source last used in both years. The percentage of dried flower purchasers who reported last purchasing dried flower online/mail order and in stores/dispensaries was greater in 2020. The mean quantity last purchased was greater in 2020 (10.3 g) than 2019 (8.7 g), and the median quantity last purchased was 3.4 g in both years. In both years, most consumers last purchased between 3.5 g and 27.9 g of dried flower. The percentage of those purchasing 28 g and over was greater in 2020.

Supplemental Figure 1 displays the percentage of consumers purchasing different quantities of dried flower at last purchase. On average, a greater percentage of consumers purchased larger quantities of illegal dried flower than legal (e.g., 18.9% purchased 28 g or more illegally vs 5.1% legally in 2019).

### 5.4.3 Unit price of dried flower at last purchase

Figure 2 displays the quantity-adjusted price of dried flower last purchased from illegal and legal sources in 2019 and 2020 by quantity purchased. On average, dried flower purchasers paid a higher unit price at all quantities from a legal source in both years.

Table 3 displays the mean and quantity-adjusted price of dried flower by cannabis frequency, purchase source, and quantity purchased. The mean unit price of dried flower was $10.64 in 2019 and $10.41 in 2020 ($t_{(3739)}=0.8$, $p=0.436$), and the quantity-adjusted price was $7.09 in 2019 and $6.83 in 2020. In general, the mean unit price of dried flower decreased as frequency of use increased (i.e., less than monthly consumers=$14.01 in 2019, daily consumers=$8.47 in 2019, $t_{(1928)}=-9.5$, $p<0.001$). In both years, purchases from stores/dispensaries had the highest mean and quantity-adjusted price at last purchase. In both years, legal dried flower was more expensive than illegal dried flower ($12.63 vs $9.04 in 2019 [$t_{(1869)}=8.9$, $p<0.001$]; $11.16 vs $9.41 in 2020 [$t_{(1755)}=3.8$, $p<0.001$]). Legal dried flower decreased in 2020 ($12.63 vs $11.16, $t_{(2085)}=-3.6$, $p<0.001$). As Table 3 indicates, the unit price of dried flower decreased as quantity purchased increased.

### 5.4.4 Legality of purchase source at last purchase

As Table 2 shows, 45.7% of consumers last purchased dried flower from legal sources in 2019 and increased to 58.1% in 2020. A total of 50.1% last purchased dried flower from illegal sources in 2019 and decreased to 38.2% in 2020.

A binary logistic regression model examined the correlates of the legality of last purchase source of dried flower (Table 4). An interaction test between unit price paid and survey year was significant ($F_{1,3579}$=4.3, p=0.039). Each additional dollar paid per gram in 2019 was associated with a 3% greater odds of purchasing legally and a 7% greater odds in 2020.

Consumers from Ontario were less likely to purchase dried flower from a legal source than consumers from all provinces except Manitoba. Daily cannabis consumers were less likely to purchase dried flower from a legal source than less than monthly consumers. Purchasing from legal sources was lower among those with less than a high school diploma. Respondents who reported finding it neither easy nor difficult or easy to make ends meet were more likely to purchase from a legal source than those who reported finding it difficult. When unit price was removed as a primary covariate, respondents in 2020 were more likely to purchase legally than respondents in 2019. All other patterns remained largely similar, except sex at birth, which after adjusting for covariates was associated with purchasing from a legal source.

As a sensitivity analysis, quantity purchased was included as a covariate. Similar patterns emerged in all variables, except the association between cannabis use frequency and legality of purchase source was attenuated. Respondents who purchased between 1 g and 3.49 g (AOR=2.60, 95%CI: 1.85, 3.65) and 3.5 g and 27.9 g (AOR=2.18, 95%CI: 1.62, 2.94) were more likely to purchase legally than respondents who purchased 28 g or more.

## 5.5 Discussion

The current study demonstrated a modest shift in purchase sources used to purchase dried flower between 12 and 24-months after cannabis legalization in Canada. Purchase sources typically used

in the illegal market (i.e., friends and family, dealers) decreased from 2019 to 2020. Conversely, more typical purchase sources used in a legal market (i.e., stores or online) increased from 2019 to 2020. The Canadian Cannabis Survey reported a similar increase in the use of legal retail stores among past 12-month consumers from 2019 to 2020 (29% to 41%, respectively), but no increase in the use of legal online services from 2019 to 2020 (14% to 13%).[10,11] The lower percentage of consumers reporting use of legal physical and online stores could be explained by the discrepancy in the questions: whereas the current study asked for last purchase, the Canadian Cannabis Survey asked for usual purchase. Furthermore, greater use of online purchasing in the current study may be reflective of the COVID-19 pandemic and increased online purchasing due to provincial lockdowns. The Canadian Cannabis Survey began in April 2020, only one month after all provinces declared a state of emergency.

Legal purchases of dried flower were greater in 2020 than 2019. At last purchase, 46% of consumers purchased dried flower from legal sources in 2019 and increased to 58% in 2020. Comparable increases were found in the past 12-months: cannabis consumers reported purchasing 56% of dried flower from legal sources in the past 12-months in 2019, which increased to 68% in 2020. Similar percentages were reported in Canada's national cannabis survey, where 52% of past 12-month consumers reported purchasing from a legal source in 2019 and 79% in 2020.[10,11]

Legal dried flower purchases varied across the provinces. Ontarians were less likely to purchase dried flower legally than dried flower purchasers of all provinces except Manitoba, after adjusting for price and other covariates. Ontario was slower to open a physical retail market due to a new provincial government that changed the proposed public retail structure to private months before legalization. Indeed, by September 2019 the legal non-medical market had only 13% of the total cannabis market share in Ontario, the lowest across the provinces.[26] However, by February 2021, Ontario authorized 30 store applications per week, so Ontarians could see a change to legal retail access over the years.[27,28]

The price of dried flower remained stable in 2019 and 2020. The mean unit price of dried flower was $10.64 in 2019 and $10.41 in 2020. These estimates are similar to the Canadian Cannabis Survey's estimates of dried flower among past 30-day consumers in 2019 ($9.83) and 2020

($10.48), where the change in price was not statistically significant.[10] In the current study, the price paid by consumers was also presented by a 'quantity-adjusted' price, which accounted for how much cannabis each consumer purchased: $7.09 in 2019 and $6.83 in 2020. The two approaches yield markedly different estimates of price due to quantity discounts. Researchers using self-reported data from population surveys should clarify which approach is being used to calculate price estimates, recognizing that the quantity-adjusted approach is likely to show better correspondence with actual data from retailers.

Study findings suggest that a higher unit price was associated with a higher likelihood of purchasing from a legal source in 2019 and to a greater extent in 2020. However, it is plausible that the relationship between price and legality of source is bidirectional: purchase source may determine the price paid, and the price may determine the purchase source chosen to obtain dried flower. Since legalization, reports demonstrate the price of legal cannabis has been more expensive than illegal cannabis, and the price differential is growing.[15,16] Indeed, legal dried flower was more expensive than illegal at all quantities in the current study; however, the price differential seems to be converging. In 2019, legal dried flower was 12%-41% more expensive than illegal, whereas in 2020, legal dried flower was only 5%-10% more expensive than illegal. In a legal market, the price of cannabis is expected to reduce over time, and reductions have already been observed in US states that have legalized non-medical cannabis.[29-33] It is argued that in order to transition consumers to the legal market, the price of legal cannabis needs to be competitive with illegal cannabis.[13] However, behavioural economic literature suggests that the price of legal cannabis may not need to be lower than illegal cannabis to encourage transition.[12,14]

Purchasing from legal sources increased between 2019 and 2020 among dried flower purchasers; however, more frequent consumers are transitioning slower than others. After adjusting for price and other covariates, daily cannabis consumers were less likely to purchase dried flower from a legal source than less than monthly consumers; however, when quantity purchased was included in the model as a sensitivity analysis, the association of cannabis use frequency was attenuated. Most of the relationship between cannabis use frequency and legality of purchase source was mediated by quantity purchased. Quantity discounts are frequent in both illegal and legal markets, but unlike the illegal market, the Canadian legal non-medical market has a purchase limit of 30 g

for dried flower.[3-5,8,15] In the current study, more consumers purchased greater quantities of illegal dried flower than legal dried flower in 2019 and 2020. If more frequent consumers purchase in greater quantities, it would suggest remaining in the illegal market may be financially beneficial due to quantity discounts.[3-5,8] Indeed, sensitivity analyses found consumers purchasing in quantities over an ounce were less likely to purchase legally than quantities between 1 g and 28 g. Daily consumers represent an important group of people to transition to the legal market due to their significant proportion of the cannabis market share.[34-37]

### 5.5.1 Limitations

This study is subject to limitations common to survey research. Respondents were recruited using non-probability-based sampling; therefore, the findings do not provide nationally representative estimates. The data were weighted by age group, sex, region, education and smoking status in Canada. Cannabis use estimates were generally lower than national estimates for young adults, and higher than national surveys in Canada. This is likely because the ICPS sampled individuals aged 16-65, whereas national surveys included older adults, who are known to have lower rates of cannabis use.

The current study is cross-sectional and cannot determine causality or direction; however, it is plausible that the relationship between unit price and the legality of purchase source used is bi-directional.

Respondents could include pre-rolls when reporting dried flower purchases. While pre-rolls contain dried flower, they are a premium product and would be priced as such.[38] Prices of dried flower in the current study could change if pre-roll and loose dried flower were separated. Future research should examine prices of dried flower and pre-rolls in Canada separately.

Implausible unit prices were excluded or modified, and so price estimates could vary if alternative cleaning methods were conducted. The Cannabis Retail Scan conducted in March 2020 was used as guidance for a minimum and maximum unit price in the illegal and legal retail markets.[23] The distribution of prices was also used to guide implausible values as physical and online retail stores do not cover all sources where respondents could purchase their dried flower (i.e., friends, dealers).

The potency, or tetrahydrocannabinol (THC) content, of dried flower was not included in the analysis. Research has shown positive associations between perceived potency and price.[7,30,39] Indeed, the potency of a product may contribute to both the price of the product and the purchase source used.[10,30,31] However, potency information is limited in the illegal market.[40] Moreover, research suggests that consumers typically lack understanding of potency, which promotes caution in using self-reported measures.[41,42]

Finally, the current study focused on dried flower and so the findings reported may not translate to other cannabis products. However, dried flower and some oils were the only products available until December 2019; therefore, other products would only have been available to purchase from the illegal market for the majority of the study period.[43] Furthermore, although the use of non-flower cannabis products is increasing among Canadians, dried flower is still the most used product and so would capture a large proportion of purchased cannabis.[10,11,17,18,44]

**5.5.2 Conclusion**
Findings indicate that the price of cannabis from legal sources decreased, along with an increasing percentage of consumers purchasing from legal cannabis retailers in the first two years after legalization in Canada. The most frequent consumers have transitioned to the legal market more slowly; however, purchasing from legal retail sources increased between 2019 and 2020 for all dried flower purchasers. Future research should examine price and purchase sources for cannabis products other than dried flower, which represent an increasing market share.

**Table 1: Sample characteristics of Canadian cannabis consumers who were of legal age to purchase cannabis and had reported purchasing dried flower in the past 12 months in 2019 and 2020** (n=4,923)

| | Unweighted % (n) | | Weighted % (n) | |
|---|---|---|---|---|
| | **2019** | **2020** | **2019** | **2020** |
| | n=2506 | n=2417 | n=2481 | n=2442 |
| **Age group** | | | | |
| MLA-25 | 14.4 (361) | 12.3 (298) | 14.0 (348) | 10.3 (250) |
| 26-35 | 28.7 (720) | 26.2 (632) | 33.5 (831) | 32.2 (785) |
| 36-45 | 23.5 (590) | 24.9 (602) | 22.2 (551) | 26.2 (640) |
| 46-55 | 17.4 (435) | 18.8 (455) | 17.6 (436) | 18.8 (458) |
| 56-65 | 16.0 (400) | 17.8 (430) | 12.7 (316) | 12.7 (309) |
| | | | | |
| **Sex** | | | | |
| Female | 53.6 (1343) | 56.0 (1354) | 40.2 (998) | 42.1 (1029) |
| Male | 46.4 (1163) | 44.0 (1063) | 59.8 (1483) | 57.9 (1413) |
| | | | | |
| **Ethnicity** | | | | |
| Black | 2.7 (66) | 2.5 (65) | 3.4 (83) | 3.2 (77) |
| East/Southeast Asian | 4.3 (105) | 3.3 (85) | 4.5 (110) | 4.0 (96) |
| Indigenous | 4.2 (104) | 3.7 (94) | 4.4 (108) | 3.2 (78) |
| Latinx | 1.5 (38) | 1.5 (39) | 2.1 (52) | 1.8 (43) |
| Middle Eastern | 0.7 (16) | 1.1 (28) | 0.5 (13) | 1.3 (32) |
| South Asian | 2.2 (55) | 2.5 (63) | 2.7 (65) | 3.1 (73) |
| White | 79.6 (1966) | 78.4 (2006) | 77.2 (1885) | 78.0 (1877) |
| Other/Mixed | 4.9 (121) | 7.0 (180) | 5.2 (127) | 5.4 (129) |
| | | | | |
| **Education** | | | | |
| Less than high school | 6.9 (171) | 6.6 (158) | 13.0 (321) | 9.7 (236) |
| High school diploma | 19.4 (484) | 18.2 (437) | 31.4 (775) | 31.9 (775) |
| Some college or technical vocation | 47.8 (1192) | 46.1 (1106) | 35.4 (873) | 36.8 (893) |
| Bachelor's degree or higher | 25.9 (647) | 29.2 (700) | 20.2 (498) | 21.6 (524) |
| | | | | |
| **Income adequacy** | | | | |
| Very difficult | 12.0 (301) | 10.3 (248) | 12.1 (299) | 10.2 (249) |
| Difficult | 25.5 (640) | 23.1 (558) | 26.1 (647) | 21.7 (529) |
| Neither easy nor difficult | 33.5 (840) | 35.0 (846) | 33.7 (836) | 35.9 (877) |
| Easy | 18.5 (464) | 20.9 (506) | 17.9 (444) | 21.2 (517) |
| Very Easy | 8.4 (211) | 8.9 (214) | 7.6 (189) | 9.4 (228) |
| Not stated | 2.0 (50) | 1.9 (45) | 2.6 (65) | 1.7 (43) |
| | | | | |
| **Cannabis use frequency** | | | | |
| Past-year but less than monthly | 17.3 (433) | 18.0 (436) | 15.4 (382) | 15.4 (376) |
| Monthly | 18.4 (461) | 16.8 (406) | 17.4 (432) | 15.9 (388) |
| Weekly | 20.5 (513) | 19.4 (469) | 20.8 (516) | 19.8 (483) |
| Daily/almost daily | 43.9 (1099) | 45.8 (1106) | 46.4 (1150) | 48.9 (1194) |
| | | | | |
| **Province of residence** | | | | |
| British Columbia | 14.5 (363) | 16.5 (398) | 13.9 (344) | 15.2 (371) |

| | | | | |
|---|---|---|---|---|
| Alberta | 16.4 (412) | 16.6 (402) | 13.8 (343) | 13.6 (333) |
| Saskatchewan | 5.4 (135) | 6.8 (165) | 3.3 (82) | 4.1 (101) |
| Manitoba | 6.3 (158) | 5.8 (141) | 4.1 (102) | 3.7 (89) |
| Ontario | 22.4 (562) | 19.2 (464) | 40.1 (995) | 38.1 (931) |
| Quebec | 17.9 (448) | 13.8 (334) | 17.2 (426) | 17.9 (438) |
| New Brunswick | 5.3 (132) | 7.1 (171) | 2.4 (59) | 2.4 (57) |
| Nova Scotia | 6.7 (169) | 7.1 (172) | 2.9 (72) | 3.0 (73) |
| Prince Edward Island | 1.0 (24) | 1.2 (28) | 0.5 (12) | 0.4 (11) |
| Newfoundland & Labrador | 4.1 (103) | 5.9 (142) | 1.8 (46) | 1.6 (39) |
| | | | | |
| **Device used** | | | | |
| Smartphone | 49.1 (1230) | 51.8 (1252) | 48.7 (1208) | 50.8 (1240) |
| Tablet | 7.0 (176) | 4.5 (109) | 6.7 (167) | 5.1 (124) |
| Computer | 43.9 (1100) | 43.7 (1056) | 44.6 (1106) | 44.1 (1078) |

Income adequacy is assessed by the question: "Thinking about your family's income, how difficult or easy is it to make ends meet?", where 'making ends meet' means having enough money to pay for the things your family needs.

MLA = minimum legal age. Minimum legal age to purchase cannabis (MLA) was taken from provincial laws in September 2019 and 2020. In 2019, MLA was 18 years in Alberta and Quebec, and 19 years elsewhere. In 2020, Quebec raised their MLA to 21 years.

**Table 2: Purchase source and quantity of dried flower among past 12-month cannabis consumers in Canada and the provinces, 2019-2020** (n=4,923)

| | Canada | | British Columbia | | Alberta | | Saskatchewan | | Manitoba | | Ontario | | Quebec | | New Brunswick | | Nova Scotia | | Newfoundland and Labrador | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 n=2506 | 2020 n=2417 | 2019 n=363 | 2020 n=398 | 2019 n=412 | 2020 n=402 | 2019 n=135 | 2020 n=165 | 2019 n=158 | 2020 n=141 | 2019 n=562 | 2020 n=464 | 2019 n=448 | 2020 n=334 | 2019 n=132 | 2020 n=171 | 2019 n=169 | 2020 n=172 | 2019 n=103 | 2020 n=142 |
| **Purchase source used at last purchase** | | | | | | | | | | | | | | | | | | | | |
| Friends or family member | 15.5% (377) | 14.8% (327) | 19.0% (73) | 15.0% (63) | 11.0% (49) | 8.4% (33) | 13.7% (20) | 6.5% (12) | 11.7% (25) | 19.0% (24) | 18.3% (102) | 17.9% (88) | 13.2% (59) | 15.4% (52) | 14.2% (18) | 12.9% (19) | 11.4% (23) | 12.8% (21) | 5.8% (6) | 5.4% (12) |
| Dealer (in person) | 25.4% (561) | 16.0% (343) | 25.0% (75) | 18.4% (57) | 21.3% (81) | 20.4% (81) | 25.3% (24) | 17.7% (22) | 37.3% (45) | 17.7% (20) | 25.1% (144) | 14.1% (61) | 31.3% (130) | 15.8% (51) | 18.9% (25) | 12.0% (21) | 13.3% (21) | 9.7% (13) | 18.1% (15) | 13.6% (16) |
| Online/mail order | 18.8% (400) | 22.9% (463) | 13.0% (43) | 16.4% (73) | 13.3% (56) | 13.1% (57) | 12.4% (23) | 16.2% (30) | 11.7% (18) | 16.3% (26) | 26.9% (148) | 35.0% (154) | 15.8% (64) | 16.8% (52) | 7.7% (12) | 6.9% (13) | 14.5% (25) | 14.8% (28) | 6.5% (9) | 15.5% (21) |
| Store/dispensary (in person) | 38.5% (1126) | 44.6% (1243) | 41.8% (166) | 48.2% (199) | 51.8% (218) | 57.0% (226) | 48.6% (68) | 57.5% (97) | 36.7% (69) | 42.2% (67) | 27.5% (156) | 31.3% (153) | 39.0% (191) | 50.9% (175) | 53.5% (70) | 64.8% (115) | 59.8% (97) | 60.3% (104) | 68.3% (72) | 64.2% (92) |
| Unknown | 1.8% (42) | 1.8% (41) | 1.2% (6) | 2.0% (6) | 2.7% (8) | 1.1% (5) | 0.0% (0) | 2.0% (4) | 2.6% (1) | 4.8% (4) | 2.2% (12) | 1.8% (8) | 0.8% (4) | 1.2% (4) | 5.7% (7) | 3.5% (3) | 0.9% (3) | 2.5% (6) | 1.3% (1) | 1.3% (1) |
| **Legality of purchase source used at last purchase** | | | | | | | | | | | | | | | | | | | | |
| Legal | 45.7% (1278) | 58.1% (1503) | 39.2% (154) | 53.1% (223) | 59.6% (251) | 66.4% (267) | 52.0% (78) | 68.6% (115) | 44.5% (79) | 49.5% (81) | 38.7% (219) | 52.2% (247) | 46.8% (223) | 65.0% (219) | 54.3% (72) | 63.4% (115) | 65.1% (105) | 62.3% (110) | 71.5% (77) | 72.3% (104) |
| Illegal | 50.1% (1127) | 38.2% (827) | 56.0% (188) | 42.3% (158) | 37.1% (149) | 31.2% (124) | 42.9% (52) | 27.7% (43) | 50.2% (73) | 44.5% (54) | 56.8% (318) | 43.5% (197) | 49.4% (211) | 33.5% (109) | 39.3% (51) | 30.6% (50) | 32.7% (59) | 32.6% (51) | 25.5% (22) | 24.8% (35) |
| Unknown | 4.2% (101) | 3.6% (87) | 4.8% (21) | 4.6% (17) | 3.3% (12) | 2.4% (11) | 5.1% (5) | 3.7% (7) | 5.3% (6) | 6.0% (6) | 4.5% (25) | 4.3% (20) | 3.8% (14) | 1.5% (6) | 6.4% (9) | 6.0% (6) | 2.2% (5) | 5.0% (11) | 3.1% (4) | 2.8% (3) |
| **Quantity purchased at last purchase** | | | | | | | | | | | | | | | | | | | | |
| Mean grams (SEM) | 8.7g (0.4) | 10.3g (0.6) | 9.1g (0.7) | 12.2g (1.0) | 8.0g (0.6) | 10.9g (1.3) | 8.9g (2.5) | 8.7g (1.4) | 6.8g (0.7) | 11.7g (2.5) | 10.2g (0.8) | 10.5g (0.6) | 6.6g (0.7) | 8.1g (0.9) | 7.6g (1.1) | 9.7g (1.0) | 6.8g (0.8) | 11.5g (1.2) | 5.1g (0.6) | 7.2g (0.9) |
| Geometric mean grams (SE) | 4.2g (0.1) | 5.0g (0.2) | 4.6g (0.3) | 5.7g (0.4) | 4.4g (0.3) | 5.3g (0.4) | 3.2g (0.4) | 4.1g (0.5) | 3.9g (0.4) | 5.0g (0.7) | 4.8g (0.3) | 5.3g (0.4) | 3.3g (0.2) | 3.9g (0.3) | 3.4g (0.4) | 5.0g (0.6) | 3.6g (0.4) | 5.8g (0.6) | 3.0g (0.3) | 4.1g (0.4) |
| Median grams (SE) | 3.4g (0.1) | 3.4g (0.1) | 3.4g (0.2) | 3.4g (0.2) | 3.5g (0.2) | 3.5g (0.1) | 3.0g (0.3) | 3.0g (0.3) | 3.5g (0.3) | 3.5g (0.3) | 3.5g (0.4) | 3.5g (0.4) | 2.9g (0.2) | 2.9g (0.2) | 2.9g (0.4) | 2.9g (0.4) | 2.9g (0.2) | 2.9g (0.2) | 3.2g (0.2) | 3.2g (0.3) |
| <1g | 7.8% (200) | 6.2% (139) | 4.5% (20) | 5.4% (25) | 5.3% (23) | 3.7% (16) | 10.8% (13) | 3.2% (8) | 8.8% (10) | 5.9% (9) | 7.4% (47) | 7.3% (28) | 11.5% (51) | 7.9% (29) | 11.8% (13) | 7.6% (9) | 8.0% (11) | 2.5% (5) | 7.2% (9) | 3.5% (7) |
| 1g-3.49g | 35.5% (884) | 32.1% (796) | 34.7% (125) | 28.6% (119) | 32.5% (123) | 28.2% (111) | 37.9% (50) | 44.7% (63) | 27.2% (49) | 29.7% (46) | 32.5% (182) | 28.3% (134) | 44.3% (188) | 42.1% (142) | 39.4% (43) | 31.4% (55) | 45.3% (61) | 33.7% (71) | 41.1% (43) | 47.7% (56) |
| 3.5-27.9g | 44.4% (1071) | 44.3% (1026) | 43.8% (146) | 43.0% (164) | 51.6% (200) | 51.4% (201) | 41.9% (56) | 38.1% (65) | 57.1% (82) | 46.9% (60) | 45.7% (256) | 45.2% (212) | 36.3% (163) | 41.2% (126) | 37.2% (54) | 41.0% (63) | 37.0% (64) | 39.2% (63) | 48.0% (43) | 36.2% (60) |
| =>28g | 12.2% (265) | 17.4% (380) | 17.0% (59) | 23.0% (77) | 10.6% (45) | 16.7% (60) | 9.4% (11) | 14.1% (25) | 6.9% (10) | 17.5% (20) | 14.4% (64) | 19.2% (77) | 8.0% (32) | 8.8% (31) | 11.7% (18) | 20.0% (34) | 9.7% (18) | 24.6% (36) | 3.7% (6) | 12.6% (16) |

Data are among consumers who were of legal age to purchase cannabis and who reported purchasing dried flower in the past 12-months.

Data are % (n). Weighted %, unweighted n. Respondents from Prince Edward Island are not included due to low sample size (n2019=24; n2020=28).

**Table 3: Unit price and quantity-adjusted price of dried flower at last purchase by cannabis use frequency, purchase source, and quantity purchased** (n=3,740)

| | Mean $/g (SEM) | | Quantity-adjusted* $/g (SE) | |
|---|---|---|---|---|
| | **2019**<br>n=1929 | **2020**<br>n=1811 | **2019**<br>n=1929 | **2020**<br>n=1811 |
| **All participants** | $10.64 (0.2) | $10.41 (0.2) | $7.09 (0.2) | $6.83 (0.2) |
| **Cannabis use frequency** | | | | |
| Past year, but less than monthly | $14.01 (0.5) | $14.13 (0.7) | $10.98 (0.7) | $9.73 (1.0) |
| Monthly | $13.78 (0.7) | $12.75 (0.6) | $10.76 (0.6) | $8.77 (0.7) |
| Weekly | $11.15 (0.4) | $10.60 (0.3) | $8.06 (0.7) | $7.96 (0.5) |
| Daily/almost daily | $8.47 (0.2) | $8.68 (0.3) | $6.29 (0.1) | $6.28 (0.2) |
| **Purchase source** | | | | |
| Friends or family | $9.73 (0.5) | $9.60 (0.6) | $6.60 (0.3) | $5.93 (0.3) |
| Dealer (in person) | $9.10 (0.4) | $10.07 (0.6) | $6.34 (0.2) | $6.91 (0.5) |
| Online/mail order | $10.14 (0.5) | $9.73 (0.5) | $6.46 (0.3) | $6.50 (0.3) |
| Store/dispensary | $12.34 (0.3) | $11.16 (0.3) | $9.37 (0.4) | $7.66 (0.2) |
| **Legality of purchase source** | | | | |
| Illegal | $9.04 (0.3) | $9.41 (0.4) | $6.07 (0.2) | $6.16 (0.2) |
| Legal | $12.63 (0.3) | $11.16 (0.3) | $9.59 (0.3) | $7.70 (0.2) |
| Unknown | $9.44 (0.7) | $9.15 (0.9) | $7.61 (0.6) | $6.75 (0.4) |
| **Quantity purchased** | | | | |
| <1g | $20.40 (1.6) | $21.27 (1.3) | $20.27 (1.6) | $20.99 (1.5) |
| 1g-3.49g | $13.37 (0.4) | $14.02 (0.4) | $13.02 (0.4) | $13.45 (0.4) |
| 3.5-27.9g | $9.48 (0.2) | $9.76 (0.2) | $8.63 (0.2) | $8.97 (0.3) |
| ≥ 28g | $5.25 (0.1) | $5.19 (0.1) | $5.11 (0.1) | $5.08 (0.1) |

*Quantity-adjusted price is the unit price of dried flower adjusted for the quantity purchased.
Values suppressed for "Other" category of purchase source due to cell counts below n=30.

**Table 4: Weighted binary logistic regression analysis for correlates of legality of purchase source used at last purchase among dried flower purchasers with and without unit price**

| | Odds of purchasing dried flower from a legal source (vs. illegal) n=3,580 | Odds of purchasing dried flower from a legal source (vs. illegal) n=4,657 |
|---|---|---|
| | **AOR (95% CI)** | **AOR (95% CI)** |
| **Unit price x Survey year** | | |
| Unit price x 2019 | **1.03 (1.01, 1.05)** | - |
| Unit price x 2020 | **1.07 (1.04, 1.09)** | - |
| | | |
| **Survey year** | | |
| 2019 | - | REF |
| 2020 | - | **1.66 (1.42, 1.95)** |
| | | |
| **Province of residence** | | |
| NL | **4.13 (2.56, 6.70)** | **3.25 (2.11, 4.99)** |
| PEI | **2.77 (1.24, 6.22)** | **3.91 (1.75, 8.74)** |
| AB | **2.60 (1.97, 3.43)** | **2.29 (1.81, 2.90)** |
| SK | **2.54 (1.66, 3.87)** | **2.04 (1.43, 2.92)** |
| NB | **2.78 (1.82, 4.24)** | **2.06 (1.43, 2.97)** |
| NS | **2.41 (1.68, 3.46)** | **2.15 (1.56, 2.96)** |
| QC | **1.93 (1.46, 2.54)** | **1.51 (1.20, 1.91)** |
| BC | **1.31 (1.00, 1.71)** | 1.07 (0.85, 1.34) |
| MB | 1.25 (0.86, 1.82) | 1.14 (0.82, 1.58) |
| ON | REF | REF |
| | | |
| **Cannabis use frequency** | | |
| Past year, but less than monthly | REF | REF |
| Monthly | 1.03 (0.75, 1.42) | 1.04 (0.80, 1.35) |
| Weekly | 1.04 (0.77, 1.41) | 0.99 (0.77, 1.27) |
| Daily/almost daily | **0.64 (0.49, 0.84)** | **0.56 (0.45, 0.70)** |
| | | |
| **Sex** | | |
| Male | REF | REF |
| Female | 1.05 (0.88, 1.26) | **1.18 (1.01, 1.38)** |
| | | |
| **Age** | | |
| MLA-25 | 1.21 (0.86, 1.71) | 1.15 (0.85, 1.55) |
| 26-35 | 1.06 (0.78, 1.42) | 1.23 (0.95, 1.59) |
| 36-45 | 0.97 (0.72, 1.31) | 1.07 (0.83, 1.39) |
| 46-55 | 0.79 (0.58, 1.08) | 0.88 (0.67, 1.16) |
| 56-65 | REF | REF |
| | | |
| **Ethnicity/race** | | |
| Black | 0.67 (0.39, 1.14) | 0.75 (0.48, 1.17) |
| East/Southeast Asian | 0.90 (0.54, 1.50) | 1.05 (0.70, 1.59) |
| Indigenous | 0.66 (0.42, 1.03) | 0.69 (0.47, 1.02) |
| Latinx | 0.80 (0.40, 1.59) | 0.76 (0.41, 1.41) |
| Middle Eastern | 2.35 (0.80, 6.90) | 1.16 (0.54, 2.51) |
| South Asian | 0.60 (0.35, 1.09) | 0.64 (0.40, 1.01) |
| White | REF | REF |
| Other/Mixed | 0.94 (0.63, 1.40) | 0.87 (0.61, 1.23) |
| | | |
| **Education** | | |
| Less than high school | REF | REF |
| High school diploma | 1.38 (0.96, 1.98) | **1.40 (1.01, 1.93)** |

| | | |
|---|---|---|
| Some college or technical vocation | **1.67 (1.20, 2.33)** | **1.55 (1.15, 2.10)** |
| Bachelor's degree or higher | **1.58 (1.09, 2.29)** | **1.63 (1.17, 2.27)** |
| | | |
| **Income adequacy** | | |
| Very difficult/Difficult | REF | REF |
| Neither easy nor difficult | **1.54 (1.24, 1.92)** | **1.37 (1.13, 1.65)** |
| Easy/Very easy | **1.39 (1.09, 1.76)** | **1.26 (1.03, 1.54)** |
| Not stated | 1.69 (0.60, 4.72) | 1.15 (0.51, 2.57) |
| | | |
| **Device used** | | |
| Computer | REF | REF |
| Smartphone | 1.14 (0.94, 1.40) | 1.10 (0.93, 1.31) |
| Tablet | 0.96 (0.64, 1.44) | 1.16 (0.81, 1.65) |

**Figure 1a: Average percentage of dried flower purchased from legal sources in the past 12-months by province in 2019 and 2020** (n=4,923)
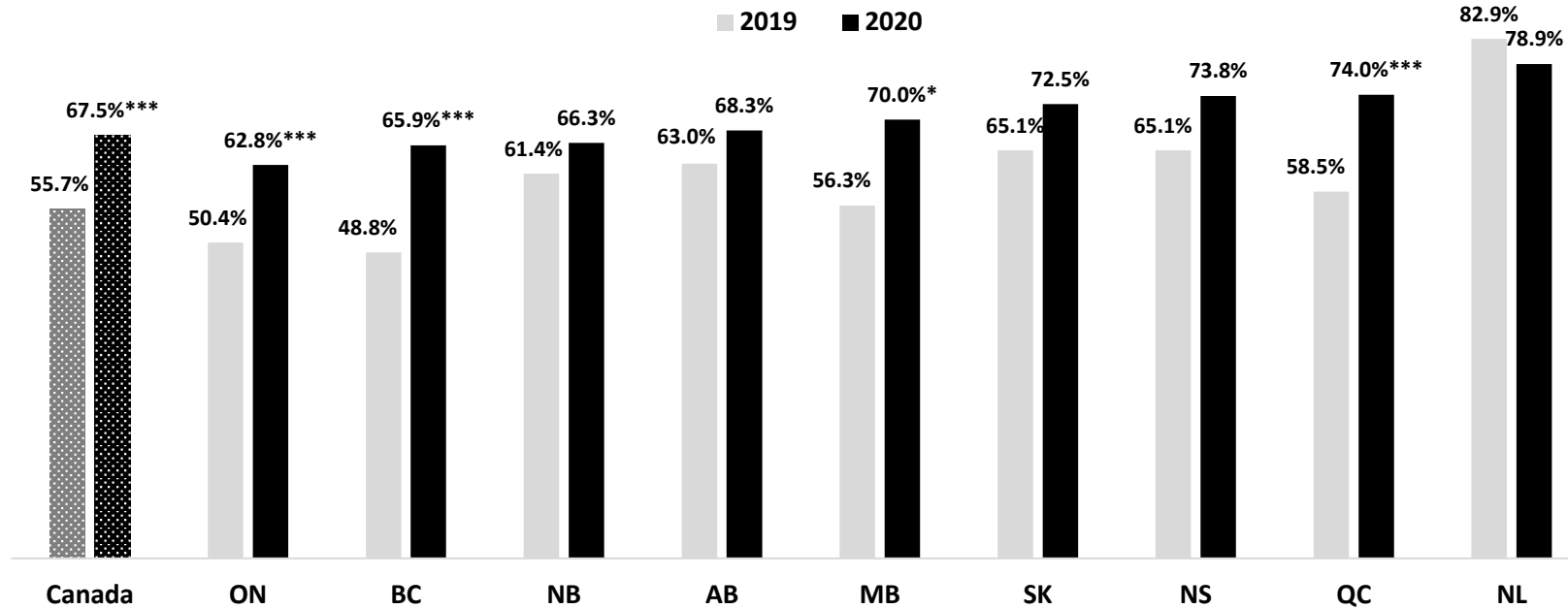


T-test between years: *<0.05; **<0.01; **<0.001
ON=Ontario; NB=New Brunswick; BC=British Columbia; MB=Manitoba; AB=Alberta; NS=Nova Scotia; QC=Quebec; SK=Saskatchewan; NL=Newfoundland and Labrador
Respondents from Prince Edward Island are not included due to low sample size (n$_{2019}$=24; n$_{2020}$=28).

**Figure 1b: Average percentage of dried flower purchased from legal sources in the past 12-months by province among daily/almost daily consumers in 2019 and 2020** (n=1,867)
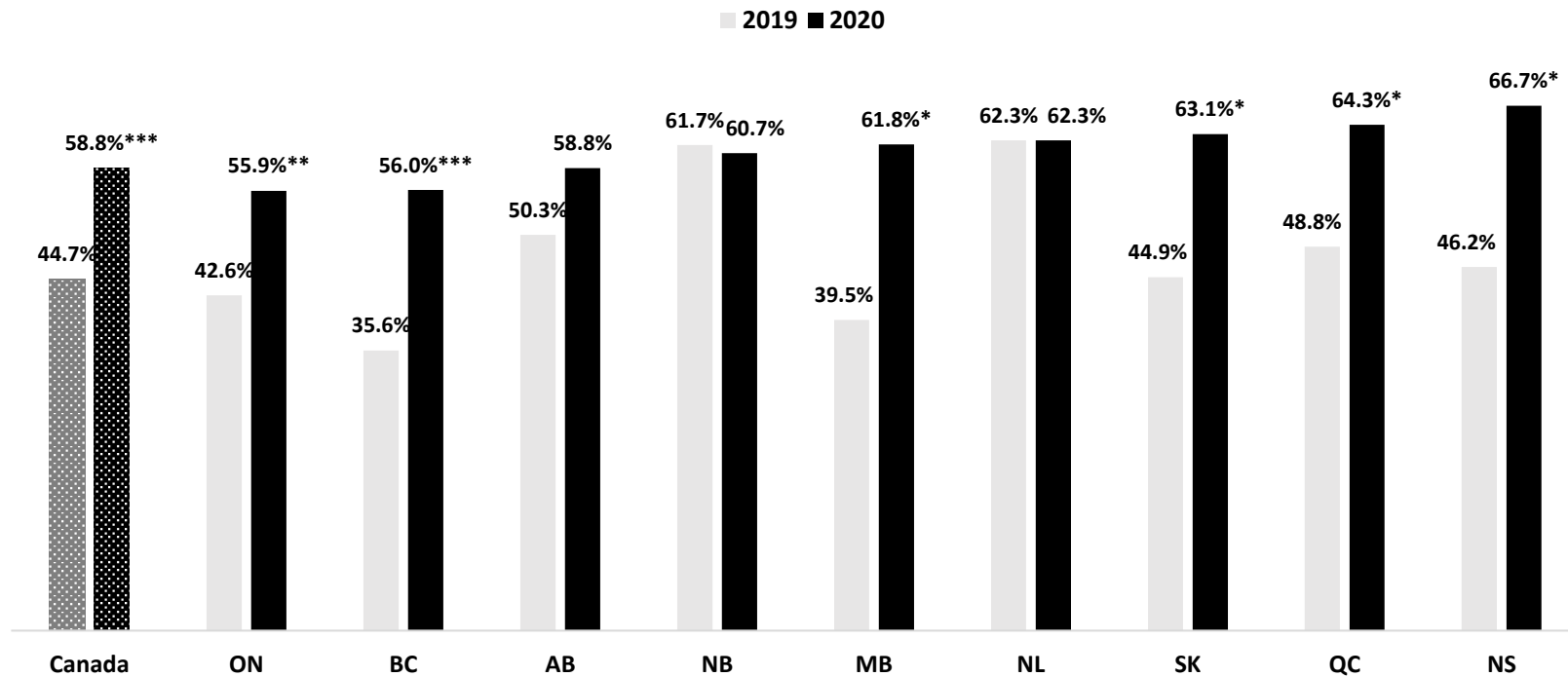


T-test between years: *<0.05; **<0.01; **<0.001

ON=Ontario; NB=New Brunswick; BC=British Columbia; MB=Manitoba; AB=Alberta; NS=Nova Scotia; QC=Quebec; SK=Saskatchewan; NL=Newfoundland and Labrador

Respondents from Prince Edward Island are not included due to low sample size (n$_{2019}$=4; n$_{2020}$=14).

**Figure 2: Quantity-adjusted price of dried flower purchased from illegal and legal sources in 2019 and 2020 by quantity purchased at last purchase** (n=3,740)
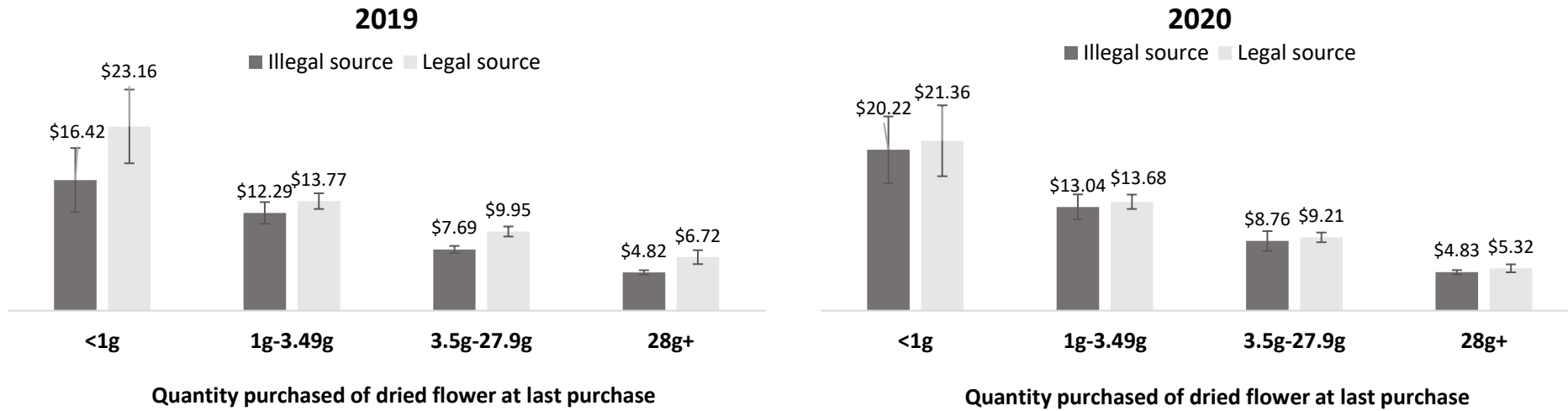


*Quantity-adjusted price is the unit price of dried flower adjusted for the quantity purchased.
Values with cell counts below n=30 were suppressed.

**Supplemental Table 1: Illegal and legal purchase sources in Canada, September 2019 and 2020**

| Illegal purchase sources | Legal purchase sources |
|---|---|
| Family/Friend | Authorized/legal store or dispensary |
| Dealer (in person) | Authorized/legal internet delivery service or mail order |
| Unlicensed/illegal store or dispensary | |
| Unlicensed/illegal internet delivery service or mail order | |
| Authorized/legal store or dispensary and under minimum legal age (MLA) | |
| Authorized/legal internet delivery service or mail order and under MLA | |

The source 'Family/Friend' in legal jurisdictions was classed as 'illegal' as it refers to dried flower that has been paid for, not gifted or shared.

Stores or online sources included both medical and non-medical sources.

MLA= Minimum Legal Age. MLA was taken from provincial laws in September 2019 and 2020. In 2019, MLA was 18 years in Alberta and Quebec, and 19 years elsewhere. In 2020, MLA was 18 years in Alberta, 21 years in Quebec, and 19 years elsewhere.

**Supplemental Figure 1: Percentage of quantity purchased of dried flower at last purchase among Canadian consumers of legal age (n=4,591)**



## 2019

■ Illegal source    □ Legal source

7.3%  8.7%    28.8%  42.7%    45.0% 43.4%    18.9%  5.1%

<1g        1g-3.49g        3.5g-27.9g        28g+

**Quantity purchased of dried flower at last purchase**



## 2020

■ Illegal source    □ Legal source

6.0%  6.2%    25.4%  37.0%    43.8% 45.1%    24.8%  11.7%

<1g        1g-3.49g        3.5g-27.9g        28g+

**Quantity purchased of dried flower at last purchase**
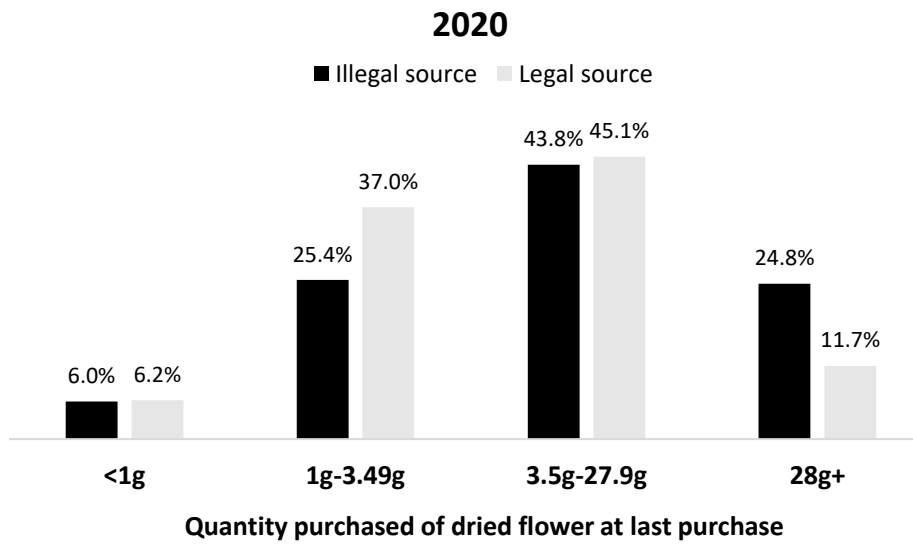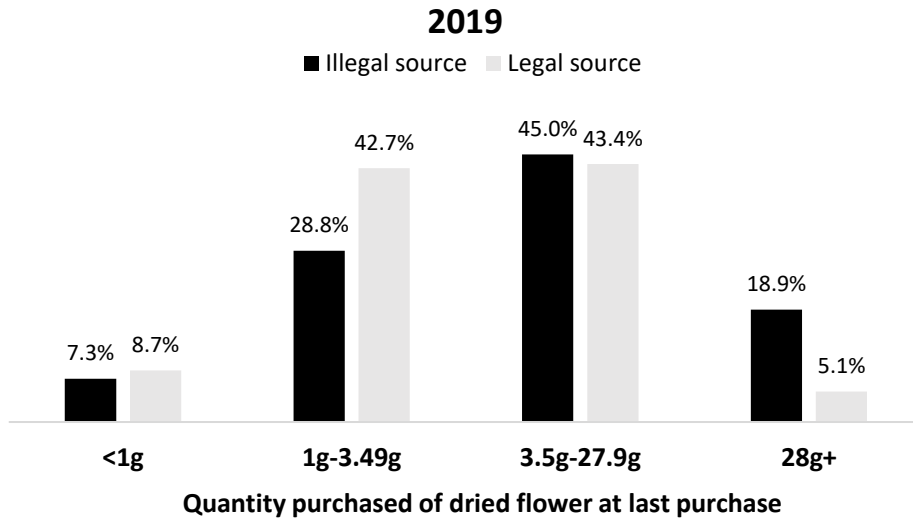
# CHAPTER 6: TRENDS IN PRICE AND PURCHASE SOURCES IN THE DRIED FLOWER CANNABIS MARKET IN THE UNITED STATES, 2019-2020

Status: Completed for submission, June 2021

PhD committee*: Elle Wadsworth[a], Pete Driezen[ab], Beau Kilmer[c], David Hammond[a]

[a]School of Public Health Sciences, University of Waterloo, Waterloo, Ontario, Canada
[b]Department of Psychology, University of Waterloo, Waterloo, Ontario, Canada
[c]RAND Drug Policy Research Center, RAND Corporation, Santa Monica, CA, USA

*Author list currently PhD committee, final author list to be confirmed.

## 6.1 Overview

**Background:** Cannabis prices and retail availability have a strong influence on consumption patterns. The current study examined the price and sources used to purchase dried flower among consumers in US states with differing cannabis laws, with an additional focus on legal vs illegal purchasing in US states that have legalized recreational cannabis.

**Methods:** Repeat cross-sectional survey data were collected from US respondents in 2019 and 2020 as part of the International Cannabis Policy Study (ICPS). Respondents were recruited through online commercial panels, were aged 16-65, and had purchased dried flower in the past 12-months (n=9,910). Weighted binary logistic regression models examined legal purchasing of dried flower in states that had a legal recreational retail market.

**Results:** The most common purchase source in 'illegal' and 'medical' states was dealers (2019: 48.8% and 43.5%; 2020: 50.6% and 39.3%, respectively) compared to stores/dispensaries in 'recreational' states (2019: 58.7%; 2020: 57.9%). The mean unit price of dried flower in US 'recreational' states increased in 2020 ($11.44 vs $12.24 USD; p=0.044), and when quantity was accounted for the unit price was $7.34 in 2019 and $7.95 in 2020. Consumers in 'recreational' states reported purchasing 74.0% and 77.0% of their dried flower from legal retail sources in 2019 and 2020. The odds of purchasing from legal sources was greater with each additional year with a legal retail recreational market (AOR=1.68, 95%CI: 1.58, 1.77), with few other sociodemographic differences.

**Conclusion:** Sources used to purchase dried flower reflect different cannabis regulations across US jurisdictions. The findings suggest legal purchasing of dried flower was greater in 'recreational' states that had a recreational market for longer.

**Keywords:** Marijuana; Cannabis; Price; United States; Legalization

## 6.2 Introduction

Although cannabis remains illegal at the federal level in the United States (US), cannabis policy has been liberalizing at the state-level for several decades. As of 2021, 18 states and the District of Columbia had legalized or passed laws to legalize non-medical (hereafter 'recreational') cannabis, eight states had criminal laws for possession and use, and the remaining states had some form of liberalization of cannabis, such as medical laws, decriminalization, or cannabidiol (CBD) laws.[1] More states are expected to liberalize recreational cannabis laws in the near future.

State laws vary among those that have legalized recreational cannabis. For example, laws differ on personal possession limits, cultivation, taxes, permitting retail sales, and permitting delivery services. In most jurisdictions, consumers can access recreational cannabis through home grow (except Washington State), friends and family, retail stores (with exceptions, e.g., District of Columbia), and online delivery (with exceptions, e.g., Alaska). Some level of illegal cannabis sales persists in states that have legalized recreational cannabis.[2-7] For example, when triangulating findings from sales data and self-reported data in Washington State 2016-2017, researchers demonstrated that consumption outweighed legal sales.[3] Moreover, in a recent study examining the association between retail density and cannabis outcomes in Los Angeles, California post-legalization of non-medical cannabis, there were a greater number of unlicensed cannabis retail stores than licensed within four miles of participants' home address.[8] However, the size of the illegal market and potential differences between states has yet to be examined.

The price of legal cannabis may influence the demand of both illegal and legal cannabis. Through increased production, efficiency, and reduced risks, the price of cannabis is hypothesized to decline in a legal recreational market, and there is evidence to suggest prices have declined in states with 'older' recreational markets.[6,9-13] For example, the retail price of cannabis declined in the initial years of retail market opening in Colorado, Washington, and Oregon.[5,6,9-11] Moreover, Smart and colleagues demonstrated that quantity discounts were present for quantities over 5g with larger discounts for quantities over one ounce in Washington State. Regardless of these discounts, purchases below 5g accounted for the majority of dried flower sales in 2016.[11] To date, Oregon still reports some of the lowest average prices of cannabis across the legalized states due to high

supply.[5,13-15] Although lower prices may encourage consumers to transition to the legal market, prices that are too low may encourage initiation, encourage more frequent use, reduce tax revenue (depending on the tax base), or discourage small businesses from entering or remaining in the market due to smaller profits.[16-18] Little research exists on the direct comparison of self-reported prices of cannabis in states that have legalized recreational cannabis.

Previous research has examined the price of dried flower in US states that have legalized recreational cannabis using self-reported data, objective data taken directly from retailers, and legal sales data, predominantly in Washington State.[9,11,12,19] However, little research has examined the price of dried flower and its relationship with legal purchasing across multiple legal markets. Evidence is needed on who is accessing legal and illegal markets and the factors which contribute to legal purchasing in order to encourage and retain consumers in the legal market. The aims of the study were to: 1) estimate dried flower purchases by source and quantities purchased; 2) describe the price of dried flower; 3) examine the association between price, time since legal retail sales, and legal purchasing in US 'recreational' states with non-medical retail markets in 2020 (Alaska, California, Colorado, Massachusetts, Michigan, Nevada, Oregon, Washington State).

## 6.3 Methods

Repeat cross-sectional data are from Waves 2 and 3 of the International Cannabis Policy Study (ICPS), conducted in Canada and the United States. Data were collected via self-completed web-based surveys conducted in September-October 2019 and 2020 with respondents aged 16-65. Wave 1 data was not included due to changes in key measures used in this study. Respondents were recruited using non-probability sampling methods through the Nielsen Consumer Insights Global Panel and their partners' panels. US 'recreational' states were oversampled in 2019 and 2020 to ensure sufficient representation. The current study reports data only from US respondents who had consumed and purchased dried flower in the past 12-months. Email invitations with a unique link were sent to eligible panelists. Surveys were conducted in English in the United States. Median survey time was 25 minutes in 2019 and 21 minutes in 2020. Respondents provided consent prior to completing the survey. Respondents received remuneration in accordance with their panel's usual incentive structure. In 2019, 81,263 respondents accessed the survey link, of

114

whom 51,087 completed the entire survey for an AAPOR cooperation rate of 62.9%.[20] In 2020, 78,438 respondents accessed the survey link, of whom 48,633 completed the entire survey for an AAPOR cooperation rate of 62.0%.[20] The study was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31330). A full description of the study methods can be found in the ICPS Technical Reports and methodology paper.[21-23]

### 6.3.1 Measures

*6.3.1.1 Socio-demographic measures*
Sociodemographic measures were sex at birth, age group, ethnicity/race, highest education level, perceived income adequacy, and suspected device type used to complete survey. See Table 1 for full coding of response options.

*6.3.1.2 Cannabis use frequency*
Cannabis use frequency was assessed through questions, "How often do you use cannabis?" and "When was the last time you used cannabis?" Responses were categorized into: "Less than monthly consumer", "Monthly consumer", "Weekly consumer", "Daily/almost daily consumer".

*6.3.1.3 US cannabis laws*
US 'recreational' states were defined as those with recreational cannabis laws in place on or before the time of the survey in each year. US 'medical' states were defined as those with medical cannabis laws in place on or before the time of survey in each year. US 'illegal' states were defined as states without medical or recreational cannabis laws at the time of survey.

*6.3.1.4 Time since legal recreational sales*
US 'recreational' states with retail recreational markets in 2020 were recorded to a continuous variable according to the time (in years) since their state began recreational retail sales to the time of the survey.

*6.3.1.5 Legal purchases of dried flower in past 12-months*
Respondents were asked "Overall, about what percentage of the dried herb that you used in the past 12-months came from LEGAL/AUTHORIZED sources?". Answers were open-ended from 0%-100%. Respondents were able to report both medical and non-medical legal/authorized sources.

*6.3.1.6 Source used to purchase dried flower at last purchase*
Respondents were asked "The last time you bought dried herb, where did you buy it", with answers: "From a family member or friend", "From a dealer (in person)", "Internet delivery service or mail order (delivered to me)", "From a store, co-operative or dispensary (in person/curbside pickup)", "Other". "Other" responses were re-categorized according to answers provided.

*6.3.1.7 Legality of last purchase source*
Respondents in US 'recreational' states who purchased dried flower from a physical store or online stores were asked: "What type of physical store or dispensary did you buy the dried herb from?" with answers: "A legal/authorized store", "An illegal or unauthorized store/dispensary", "Other", and "Where did you buy the dried herb online?" with answers: "An authorized/legal website", "An unauthorized/illegal website, private delivery service or dealer", "Other". "Other" responses were re-categorized according to answers provided. "Don't know" responses were categorized into "Unknown". All other sources were categorized according to US state regulations in September 2019 and 2020 to "Illegal" or "Legal" (Supplemental Table 1).

*6.3.1.8 Unit price of dried flower at last purchase*
Respondent's price-per-gram (hereafter 'unit price') was calculated from two questions. First, respondents were asked, "The last time you purchased dried herb, how much did you buy...?" with answers "1/8 gram or less", "1/4 gram", "1/2 gram", "3/4 gram", "1 gram", "2 grams", "3 grams", "1/8 ounce", "1/4 ounce", "1/2 ounce", "3/4 ounce", "1 ounce" and "More than 1 ounce". Open-ended responses were provided to respondents who reported purchasing more than one ounce. Respondents also could answer in the number of joints and choose the weight that was closest to the size they purchased beginning at 0.2g and increasing in 0.2g increments to 1.2g. Units were standardized into grams (g) and responses were treated as continuous. Second, participants were asked, "How much did you spend the last time you bought dried herb?" and respondents could provide numeric responses in an open-ended field. To account for extreme values, respondent's unit prices above the 95$^{th}$ percentile were excluded ($n_{2019}=181$; $n_{2020}=157$) and values below the 1$^{st}$ percentile were winsorized to the 1$^{st}$ percentile ($n_{2019}=48$; $n_{2020}=40$). Prices in 2019 were inflated to 2020 prices using the 12-month change in Consumer Price Index from September 2019 to September 2020 (1.4%).[24]

116

*6.3.1.9 Quantity-adjusted price*

The unit price of dried flower adjusted for the quantity purchased for all respondents was computed as the ratio:

$$Quantity\text{-}adjusted\ price = \sum (P_r * QP_r)/\sum(QP_r)$$

Where $P_r$ is the respondents' unit price and $QP_r$ is the respondent's quantity purchased

The full questionnaire is available in the ICPS 2019 and 2020 surveys (www.cannabisproject.ca/methods). All questions included "Don't know" and "Refuse to answer" options. Except "perceived income adequacy", all "Refuse to answer" responses were set to missing. Except "perceived income adequacy" and "legality of last purchase source" all "Don't know" responses were set to missing.

## 6.3.2 Statistical analysis

After exclusions due to poor data quality or duplicate entries ($n_{2019}$=3,095; $n_{2020}$=2,287), the US samples comprised 30,479 and 29,345 respondents in 2019 and 2020, respectively. See Technical Reports for more detail on exclusions.[21-23] The current analysis was based on the sub-sample of 9,910 respondents who had consumed and purchased dried flower in the past 12-months. Respondents who only obtained their dried flower for free or through non-monetary exchange were excluded (n=4,097). Respondents from Illinois were removed due to a change in cannabis legislation across 2019 to 2020.

The sample for regression analysis was restricted to respondents from US 'recreational' states with legal recreational retail sales in September 2020, and who were of legal age to purchase cannabis (21+ years): Alaska, California, Colorado, Maine, Massachusetts, Michigan, Nevada, Oregon, and Washington State. Missing data were removed using case-wise deletion for variables in regression analyses for: legality of purchase source (n=108 [1.8%]); highest level of education (n=20 [0.3%]); ethnicity/race (n=126 [2.1%]); and unit price, either not providing a price or quantity variable to calculate unit price (n=962 [16.1%]) or an implausible value (n=180 [3.0%]). The proportion of dried flower purchasers who did not provide or had an implausible unit price were more likely to

be better educated (2019: $\chi^2$=8.6, p=0.035; 2020: $\chi^2$=9.5, p=0.024), not report their income adequacy (2019: $\chi^2$=29.3, p<0.001; 2020: $\chi^2$=13.2, p=0.022), and be less frequent cannabis consumers (2019: $\chi^2$=53.8, p<0.001; 2020: $\chi^2$=19.2, p<0.001).

Post-stratification sample weights were constructed based on the US census estimates. Respondents from US 'recreational' states were classified into age-by-sex-by-state, education-by-state, region-by-race, and age-by-tobacco smoking status groups, while those from 'medical' and 'illegal' states were classified into age-by-sex, education, region-by-race, and age-by-smoking status groups. Separately for jurisdiction, a raking algorithm was applied to the cross-sectional analytic samples to compute weights that were calibrated to these groupings and rescaled to the sample size for each jurisdiction for each year.[21-22] All estimates are weighted unless otherwise specified.

First, descriptive statistics described purchase sources and quantity purchased of dried flower at last purchase by cannabis laws: 'recreational' vs. 'medical' vs. 'illegal'. Second, mean unit price of dried flower with standard errors of the mean (SEM) and quantity-adjusted price of dried flower with standard errors (SE) were estimated by jurisdiction, cannabis frequency, source used, and quantity purchased. Third, a binary logistic regression model was fitted among respondents in US 'recreational' states with recreational markets who were of legal age to purchase cannabis (21+ years) to examine the relationship between the legality of purchase source and the time since legal retail sales began and unit price of dried flower. The model was conducted across both survey years together (Model 1) and separately in 2019 (Model 3) and 2020 (Model 4). Sensitivity analyses were conducted where 1) unit price of dried flower was removed as a covariate due to the bidirectionality of price also being dependent on purchase source (Model 2), and; 2) quantity purchased as a categorical variable (<1 g, 1 g-3.49 g, 3.5 g-27.9 g, 28 g+) was included as a covariate due to its relationship with purchase source, unit price, and cannabis use frequency. Models were adjusted for age, sex at birth, education, race/ethnicity, income adequacy, device type, and cannabis frequency. Adjusted odds ratios (AORs) are reported with 95% confidence intervals (95%CI). Analyses were conducted using survey procedures in SAS (SAS version 9.4, SAS Institute Inc., Cary, NC, USA).

## 6.4 Results

Table 1 displays the weighted and unweighted sample characteristics of respondents in US 'illegal', 'medical' and 'recreational' states who had consumed and purchased dried flower in the past 12 months in 2019 and 2020.

### 6.4.1 Purchase source and quantity of dried flower at last purchase

Table 2 displays the characteristics of respondents who last purchased dried flower by cannabis laws in 2019 and 2020. Purchase source differed between jurisdictions in both years (2019: $\chi^2$=733.0, p<0.001; 2020: $\chi^2$=466.2, p<0.001). In US 'illegal' and 'medical' states, dealers were the most commonly reported purchase source used in both years. In US 'recreational' states, stores/dispensaries were the most commonly reported purchase source used in both years. Quantity purchased differed in 'recreational' and 'medical' states between years: more respondents purchased larger quantities in 2020 than 2019 (recreational: $\chi^2$=9.0, p=0.029; medical: $\chi^2$=13.5, p=0.004). The mean amount of dried flower purchased ranged from 6.2 g to 8.2 g across year and jurisdiction. The median purchase amount of dried flower was between 3.3 g and 3.5 g in all jurisdictions and years.

### 6.4.2 Unit price of dried flower at last purchase

Table 3a and 3b display the mean unit price and quantity-adjusted price of dried flower by cannabis laws, cannabis frequency, purchase source and quantity purchased. The mean unit price of dried flower in US 'recreational' states increased in 2020 ($11.44 vs $12.24: t(5369)=4.1, p=0.044). The quantity-adjusted price in US 'recreational' states was $7.34 in 2019 and $7.95 in 2020. For US 'illegal' and 'medical' states, the quantity-adjusted price of dried flower was $8.88 and $9.07 in 2019 and $9.19 and $8.61 in 2020. The mean unit price of dried flower was higher in US 'medical' states than in US 'recreational' states in 2019 (t(4572)=3.5, p<0.001). Daily consumers had the lowest mean unit price and quantity adjusted price in all jurisdictions and years. In US 'recreational' states, consumers purchasing online/mail order had the highest prices in both years. The unit price of dried flower decreased as quantity purchased increased.

### 6.4.3 Legal purchases in US 'recreational' states in the past 12-month

Figure 1 displays the average reported percentage of dried flower purchased from legal sources in the past 12-months in 2019 and 2020 in US 'recreational' states. On average, dried flower purchasers in US 'recreational' states reported purchasing 74.0% and 77.0% of dried flower from legal sources in 2019 and 2020, respectively.

### 6.4.4 Last purchase of dried flower in US 'recreational' states

Supplemental Table 2 displays last purchase of dried flower within each US 'recreational' state in 2019 and 2020. Across all states, stores/dispensaries were the most commonly reported purchase source in both years. California had the greatest percentage of respondents purchasing from online/mail order services. In all US 'recreational' states except respondents in Maine, Massachusetts, and Michigan, the majority reported purchasing dried flower from a legal source in both years.

Figure 2 displays the quantity-adjusted price of dried flower from illegal and legal sources in 2019 and 2020 by quantity in US 'recreational' states only. On average, respondents paid a higher unit price at quantities below 28 grams when purchasing from a legal source.

Supplemental Figure 1 displays the quantity-adjusted price of dried flower in each US 'recreational' state. In all states, the unit price was higher in 2020 than 2019. Michigan dried flower purchasers reported the highest unit price in 2020 ($9.81) and Oregon the lowest ($5.90).

Binary logistic regression models examined the correlates of the legality of purchase source of dried flower among respondents aged 21 and over in US 'recreational' states with legal recreational retail markets (Table 4). In Model 1 including both survey years, each additional dollar paid per gram of dried flower was associated with 3% greater odds of purchasing dried flower from a legal source. Each additional year with a legal retail recreational market was associated with a 68% increase in the odds of purchasing dried flower from a legal source. After adjusting for price, time since legal sales, and sociodemographic covariates, daily and weekly cannabis consumers were more likely to purchase dried flower from a legal source than less than monthly consumers. Purchasing from legal sources was higher among those over 35 years old and those who reported finding it neither easy nor difficult to make ends meet.

In Model 2, unit price was removed as a primary covariate. Similar patterns emerged as Model 1 except cannabis use frequency was no longer associated with legality of purchase source. In Model 3 and 4, 2019 and 2020 were modelled separately, respectively. Similar patterns emerged as Model 1, except in Model 4 where cannabis use frequency and unit price of dried flower was no longer associated with purchasing from a legal source. As a sensitivity analysis, quantity purchased as a categorical variable was included as a covariate; similar patterns emerged in all models, except in Model 1 where cannabis use frequency was no longer associated with legality of purchase source.

## 6.5 Discussion

The current study provides a comprehensive assessment of consumer purchasing behaviours in legal and illegal cannabis markets. Distinct differences in the purchase sources were observed across US jurisdictions. Consumers from 'illegal' and 'medical' states were substantially more likely to purchase dried flower from traditional illegal sources, such as dealers. A greater percentage of consumers in 'medical' states purchased from stores/dispensaries than those in 'illegal' states, as expected.

Among 'recreational' states, consumers reported purchasing approximately three quarters of dried flower from legal retail sources in the past 12-months. Substantial differences were observed across states, with higher levels of legal purchases in states with 'older' recreational markets. For example, in Washington State and Colorado, where recreational stores opened in 2014, consumers reported purchasing close to 90% of dried flower from legal retail sources. In contrast, 68% and 58% reported purchasing dried flower legally in Massachusetts and Michigan in 2020, where recreational stores opened in 2018 and 2019, respectively. Moreover, the proportion of consumers purchasing dried flower from legal sources at last purchase increased in Maine, Massachusetts, and Michigan between 2019 and 2020, which illustrates the shift towards legal sources after legalization. This likely reflects the time it takes to open recreational markets and expand access following legalization. Purchase sources also reflected differences in how retail sales are regulated across legal markets. California and Nevada, two of the few states to allow online delivery services for recreational cannabis, had higher percentages of respondents purchasing dried flower

online.[25,26] Among respondents in states with a recreational market, there were modest differences among individual characteristics of consumers regarding the likelihood of legal purchasing, most notably that daily and weekly consumers were more likely to purchase legally than less than monthly consumers, but only after adjusting for price. The current findings demonstrate that infrequent and frequent consumers use sources that they are legally allowed to access, suggesting increased physical retail stores and online delivery services could expand uptake of legal cannabis sources.

Consumers paid more for dried flower in 'medical' states than 'recreational' states in 2019. Research has documented price declines in states that have opened legal recreational markets.[5,6,10,11,27] In the current study, prices varied across 'recreational' states: Michigan and Massachusetts had the highest quantity-adjusted prices in 2020, and Oregon and Colorado had the lowest. This is a similar order to what was found in an 2020 industry report documenting wholesale prices.[14] For dried flower, Michigan had one of the highest wholesale price, explained by a new recreational retail market, whereas Colorado and Oregon are among the oldest, most well-established legal recreational markets.[14] From a public health perspective, although lower prices are expected as legal markets establish, prices should not fall too low so that initiation or more frequent consumption is encouraged.[27]

The price of dried flower in 'recreational' states was more expensive in 2020 than 2019. Potential reasons for the price increases include the COVID-19 pandemic.[4,5,14,28] The current study in 2020 was conducted approximately 6-7 months after the World Health Organization declared COVID-19 a global pandemic.[29] In Oregon, price increases were explained by an increase in demand during Oregon's "stay home" measures during the early months of the pandemic.[6] Other reasons suggested by the industry for price increases in 2020 include wildfires in cannabis farming regions,[4,14,30] cannabis cultivators pivoting to hemp,[31,32] and supply shortages.[14,33-35] Future research should continue to monitor trends in US dried flower prices, and examine whether the increased demand seen in some states during the pandemic represents a long or short-term effect.

The findings highlight the large price discounts when dried flower is purchased in bulk, and the importance of considering purchase amounts when reporting price estimates. Indeed, when prices

were adjusted for quantity purchased, the current study reported substantially lower price estimates. For example, the mean unit price in 'recreational' states was $11.44 in 2019; comparatively, the 'quantity-adjusted' price was $7.34. Regardless of jurisdiction, buying dried flower by the ounce was approximately five times less expensive than buying under a gram of dried flower. Research has shown discounts in legal markets tend to be more modest than those in illegal markets.[11,36-39] However, quantity discounts were marginally greater from legal sources than illegal sources in 'recreational' states in the current study. Indeed, the price of dried flower purchased from illegal and legal sources was similar in 'recreational' states: in 2019 and 2020, prices from legal sources were 3-37% higher than illegal sources for amounts less than an ounce and less expensive than illegal sources for amounts larger than an ounce. In a study examining perceptions of legal cannabis compared to illegal cannabis in US 'recreational states' in 2018, close to a third of respondents reported perceiving legal cannabis as more expensive than illegal cannabis. The same study demonstrated that respondents from 'older' retail markets had more favourable opinions of legal cannabis, i.e., lower prices.[40] The continued comparison between the price of legal and illegal cannabis is important to ensure consumers are retained in the legal market without compromising public health objectives.

### 6.5.1 Limitations

This study is subject to limitations common to survey research. Respondents were recruited using non-probability-based sampling; therefore, the findings do not provide nationally representative estimates. The data were weighted by age group, sex, region, education, smoking status, and region-by-race in the US. However, compared to the national population, the US sample had fewer respondents with low education levels and Hispanic ethnicity. Cannabis use estimates were generally lower than national estimates for young adults, and higher than national surveys. National data for 2020 were unavailable at the time of writing; comparisons to 2019 data may not reflect secular increases in cannabis use from 2019-2020.

The current study did not distinguish between loose dried flower and dried flower in pre-manufactured cannabis cigarettes ("pre-rolls"). Pre-rolls are typically more expensive than loose dried flower, especially if pre-rolls also contain other cannabis products, such as concentrates.[14] Prices reported in this study may therefore vary if pre-rolls were separated from loose dried flower.

Potency was not included in the current study. Previous research has demonstrated an association between price and potency, and there has been recommendations to quantify price as a measure of tetrahydrocannabinol (THC) rather than grams or units.[12] However, the validity of self-reported THC data collected in population-level surveys have not been established.[41-43]

The current study examined dried flower purchases only. While dried flower remains the most consumed cannabis product and contributes to the largest proportion of sales in US recreational states, evidence shows that dried flower consumption and sales are declining in favour of non-flower products.[11,12,19,44] Future research should explore the association between non-flower purchases and legality of purchase source.

Finally, cannabis laws vary across the US, including variation in recreational cannabis laws, medical cannabis laws, decriminalization, and CBD laws. Indeed, grouping states together may lose some of the nuance of the individual situation within each state, including the influence of neighbouring states. The current study focused on recreational cannabis laws, with additional analyses on medical cannabis laws and individual US 'recreational' states in order to capture added detail across the states.

**6.5.2 Conclusion**

The findings suggest that purchase behaviours are strongly influenced by the legal status of cannabis and how it is regulated in legal markets. The findings also indicate that the transition to legal retail sources does not occur immediately following legalization; rather, the legal retail market takes several years to become established, as the number of retail stores increase and cannabis prices typically decrease. As of 2020, differences in the price of dried flower from legal and illegal sources has narrowed. Notably, dried flower prices appear to have increased in 2020 in legal markets, possibly due to the unique impact of COVID-19, combined with reduction in supply. Future research should examine the relationship between price and purchase sources for non-flower products, which account for an increasing proportion of the cannabis market share.

**Table 1: Sample characteristics of US cannabis consumers who reported purchasing dried flower in the past 12 months in 2019 and 2020** (N=9,910)

| | Unweighted % (n) | | | | | | Weighted % (n) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | US 'illegal' states | | US 'medical' states | | US 'recreational' states | | US 'illegal' states | | US 'medical' states | | US 'recreational' states | |
| | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** |
| | n=653 | n=657 | n=1020 | n=940 | n=3,970 | n=2,670 | n=630 | n=735 | n=993 | n=1023 | n=3,857 | n=2,672 |
| **Age group** | | | | | | | | | | | | |
| 16-20 | 14.2 (93) | 14.9 (98) | 12.9 (132) | 12.8 (120) | 5.1 (202) | 4.6 (122) | 13.0 (82) | 10.7 (78) | 12.1 (120) | 9.9 (101) | 6.8 (260) | 6.0 (161) |
| 21-35 | 37.0 (259) | 28.3 (186) | 38.0 (388) | 25.2 (237) | 41.4 (1643) | 33.9 (905) | 40.2 (253) | 38.0 (279) | 36.7 (364) | 34.0 (348) | 41.4 (1597) | 40.7 (1086) |
| 36-50 | 27.4 (179) | 31.4 (206) | 30.2 (308) | 30.1 (283) | 30.4 (1205) | 33.3 (890) | 27.5 (173) | 31.3 (230) | 30.3 (301) | 31.9 (326) | 31.1 (1200) | 32.6 (872) |
| 51-65 | 18.7 (122) | 25.4 (167) | 18.8 (192) | 31.9 (300) | 23.2 (920) | 28.2 (753) | 19.3 (122) | 20.0 (147) | 20.9 (208) | 24.3 (248) | 20.7 (800) | 20.7 (553) |
| **Sex** | | | | | | | | | | | | |
| Female | 68.6 (448) | 64.5 (424) | 61.9 (631) | 59.2 (556) | 69.9 (2776) | 62.0 (1656) | 42.2 (266) | 44.3 (325) | 37.0 (368) | 41.2 (421) | 42.8 (1651) | 44.2 (1182) |
| Male | 31.4 (205) | 35.5 (233) | 38.1 (389) | 40.9 (384) | 30.1 (1194) | 38.0 (1014) | 57.8 (364) | 55.7 (409) | 63.0 (626) | 58.8 (601) | 57.2 (2205) | 55.8 (1491) |
| **Ethnicity** | | | | | | | | | | | | |
| Non-Hispanic White | 68.2 (444) | 72.7 (471) | 69.2 (700) | 77.3 (714) | 67.7 (2687) | 71.2 (1900) | 65.0 (409) | 67.9 (494) | 63.7 (629) | 72.4 (730) | 63.7 (2458) | 65.0 (1737) |
| Hispanic White | 9.4 (61) | 8.3 (54) | 7.8 (79) | 7.3 (67) | 11.9 (472) | 8.1 (216) | 9.7 (61) | 9.0 (65) | 7.5 (74) | 7.4 (75) | 14.8 (570) | 12.5 (333) |
| American Indian or Alaskan Native | 0.6 (4) | 1.2 (8) | 1.3 (13) | 1.2 (11) | 2.1 (85) | 2.1 (56) | 0.3 (2) | 1.1 (8) | 1.5 (15) | 0.8 (8) | 2.2 (85) | 1.7 (45) |
| Asian | 0.9 (6) | 0.9 (6) | 2.0 (20) | 1.6 (15) | 2.5 (99) | 2.1 (57) | 0.6 (4) | 0.7 (5) | 2.2 (22) | 1.2 (12) | 2.6 (101) | 2.7 (73) |
| Black or African American | 16.0 (104) | 11.1 (72) | 14.6 (148) | 8.8 (81) | 7.7 (306) | 7.4 (198) | 21.4 (134) | 18.3 (133) | 20.4 (201) | 15.4 (155) | 9.6 (369) | 10.5 (280) |
| Native Hawaiian or Pacific Islander | 0.2 (1) | 0.3 (2) | 0.4 (4) | 0.4 (4) | 0.3 (12) | 0.5 (12) | 0.1 (1) | 0.2 (1) | 0.4 (4) | 0.4 (4) | 0.4 (15) | 1.0 (25) |
| Other/Multiracial | 4.8 (31) | 5.4 (35) | 4.7 (47) | 3.5 (32) | 5.9 (234) | 6.4 (170) | 3.0 (19) | 3.0 (22) | 4.2 (42) | 2.3 (24) | 4.9 (190) | 4.8 (129) |
| **Education** | | | | | | | | | | | | |
| Less than high school | 13.0 (85) | 10.5 (69) | 11.3 (115) | 8.4 (79) | 4.7 (184) | 4.9 (129) | 12.9 (81) | 8.5 (62) | 11.1 (110) | 7.5 (77) | 5.6 (214) | 5.8 (153) |
| High school diploma | 24.4 (159) | 29.0 (190) | 24.5 (249) | 25.3 (237) | 22.1 (874) | 21.4 (568) | 22.9 (144) | 31.4 (230) | 25.0 (247) | 27.0 (276) | 23.1 (890) | 22.7 (605) |
| Some college or technical vocation | 41.8 (273) | 40.1 (263) | 39.5 (402) | 39.0 (365) | 48.0 (1900) | 42.5 (1130) | 41.5 (261) | 40.0 (293) | 39.3 (389) | 42.3 (432) | 47.9 (1842) | 44.5 (1185) |
| Bachelor's degree or higher | 20.8 (136) | 20.4 (134) | 24.8 (252) | 27.2 (255) | 25.3 (1002) | 31.3 (831) | 22.8 (143) | 20.1 (148) | 24.6 (244) | 23.1 (236) | 23.4 (902) | 27.1 (721) |
| **Income adequacy** | | | | | | | | | | | | |
| Very difficult | 8.9 (58) | 13.2 (87) | 11.0 (112) | 12.2 (115) | 12.3 (489) | 11.2 (300) | 7.5 (47) | 12.6 (93) | 10.0 (100) | 12.0 (122) | 10.6 (409) | 9.6 (256) |
| Difficult | 25.9 (169) | 25.7 (169) | 27.3 (278) | 25.3 (238) | 26.5 (1050) | 24.2 (645) | 21.6 (136) | 23.5 (173) | 24.8 (246) | 22.3 (228) | 24.7 (954) | 22.0 (587) |
| Neither easy nor difficult | 30.9 (202) | 30.0 (197) | 32.8 (335) | 32.1 (302) | 34.5 (1368) | 34.5 (920) | 30.5 (192) | 29.6 (217) | 32.9 (327) | 32.4 (331) | 34.3 (1323) | 34.7 (927) |
| Easy | 21.8 (142) | 19.8 (130) | 18.4 (188) | 17.6 (165) | 16.5 (653) | 17.3 (463) | 23.2 (146) | 20.7 (152) | 19.6 (194) | 19.1 (196) | 18.2 (701) | 18.0 (480) |
| Very Easy | 11.2 (73) | 9.3 (61) | 9.4 (96) | 11.0 (103) | 8.5 (337) | 10.4 (277) | 15.5 (97) | 11.6 (85) | 11.3 (112) | 11.7 (120) | 9.9 (381) | 13.7 (365) |
| Not stated | 1.4 (9) | 2.0 (13) | 1.1 (11) | 1.8 (17) | 1.8 (73) | 2.4 (65) | 1.8 (11) | 2.1 (15) | 1.4 (14) | 2.6 (26) | 2.3 (89) | 2.2 (58) |
| **Cannabis use frequency** | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Past-year but less than monthly | 14.9 (97) | 15.7 (103) | 13.6 (139) | 11.6 (109) | 11.8 (470) | 12.1 (322) | 14.6 (92) | 12.7 (93) | 13.1 (130) | 10.8 (111) | 11.6 (446) | 11.8 (316) |
| Monthly | 18.1 (118) | 16.3 (107) | 20.8 (212) | 16.5 (155) | 12.7 (504) | 16.5 (441) | 18.5 (117) | 17.1 (126) | 21.1 (210) | 16.8 (172) | 12.9 (498) | 16.7 (447) |
| Weekly | 14.9 (97) | 20.2 (133) | 16.2 (165) | 18.1 (170) | 17.4 (691) | 17.2 (458) | 15.8 (100) | 22.0 (161) | 16.9 (168) | 17.4 (178) | 18.0 (694) | 17.7 (473) |
| Daily/almost daily | 52.2 (341) | 47.8 (314) | 49.4 (504) | 53.8 (506) | 58.1 (2305) | 54.3 (1449) | 51..0 (321) | 48.3 (355) | 48.9 (486) | 55.0 (563) | 57.5 (2218) | 53.8 (1436) |
| **Device used** | | | | | | | | | | | | |
| Smartphone | 64.2 (419) | 63.3 (416) | 60.6 (618) | 56.3 (529) | 61.5 (2442) | 63.3 (1690) | 60.4 (380) | 61.8 (454) | 56.3 (559) | 57.2 (585) | 58.3 (2247) | 61.9 (1655) |
| Tablet | 4.3 (28) | 3.8 (25) | 4.1 (42) | 5.4 (51) | 5.4 (216) | 4.0 (107) | 3.7 (23) | 3.7 (27) | 4.4 (43) | 5.5 (56) | 5.1 (195) | 4.1 (110) |
| Computer | 31.6 (206) | 32.9 (216) | 35.3 (360) | 38.3 (360) | 33.1 (1312) | 32.7 (873) | 35.9 (226) | 34.5 (253) | 39.3 (391) | 37.4 (382) | 36.7 (1414) | 34.0 (907) |

**Table 2: Purchase source and quantity of dried flower at last purchase among past 12-month cannabis consumers in US 'illegal', US 'medical', and US 'recreational' states 2019 and 2020** (n=9,910)

| | US 'illegal' states | | US 'medical' states | | US 'recreational' states | |
|---|---|---|---|---|---|---|
| | **2019**<br>n=653 | **2020**<br>n=657 | **2019**<br>n=1,020 | **2020**<br>n=940 | **2019**<br>n=3970 | **2020**<br>n=2670 |
| **Purchase source used** | | | | | | |
| Friends or family member | 36.3% (263) | 32.0% (237) | 36.0% (390) | 32.0% (320) | 17.5% (691) | 17.3% (420) |
| Dealer (in person) | 48.8% (316) | 50.6% (312) | 43.4% (433) | 39.3% (354) | 16.4% (579) | 16.2% (326) |
| Online/mail order | 2.7% (12) | 2.9% (14) | 2.7% (19) | 4.1% (38) | 6.4% (178) | 7.5% (107) |
| Store/dispensary (in person) | 8.5% (43) | 10.9% (65) | 15.6% (157) | 22.8% (209) | 58.7% (2481) | 57.9% (1784) |
| Unknown | 3.6% (19) | 3.6% (26) | 2.2% (21) | 1.8% (19) | 1.0% (39) | 1.1% (26) |
| | | | | | | |
| **Quantity purchased** | | | | | | |
| Mean grams (SEM) | 6.7g (0.4) | 7.4g (0.5) | 6.2g (0.3) | 8.2g (0.5) | 7.0g (0.2) | 7.7g (0.4) |
| Geometric mean grams (SE) | 3.9g (0.2) | 3.9g (0.2) | 3.9g (0.1) | 4.5g (0.2) | 3.9g (0.1) | 4.2g (0.1) |
| Median grams (SE) | 3.4g (0.1) | 3.3g (0.1) | 3.3g (0.1) | 3.5g (0.1) | 3.4g (0.1) | 3.4g (0.1) |
| | | | | | | |
| <1g | 5.4% (39) | 6.1% (45) | 6.3% (76) | 4.6% (49) | 6.9% (262) | 4.5% (136) |
| 1g-3.49g | 36.9% (224) | 37.3% (238) | 37.0% (354) | 29.9% (270) | 30.9% (1246) | 33.2% (823) |
| 3.5-27.9g | 49.3% (322) | 48.9% (306) | 50.3% (515) | 55.9% (503) | 53.2% (2008) | 52.5% (1390) |
| =>28g | 8.4% (51) | 7.8% (48) | 6.5% (58) | 9.6% (88) | 9.0% (354) | 9.8% (262) |

Data are among consumers who reported purchasing dried flower in the past 12-months.

Data are % (n). Weighted %, unweighted n. Difference in unweighted sample sizes are due to missing data in purchase source (US 'illegal' states: $n_{2020}$=3; US 'recreational' states: $n_{2019}$=2, $n_{2020}$=7), and quantity purchased at last purchase (US 'illegal' states: $n_{2019}$=17, $n_{2020}$=41; US 'medical' states: $n_{2019}$=17, $n_{2020}$=50; US 'recreational' states: $n_{2019}$=100, $n_{2020}$=111).

**Table 3a: Unit price of dried flower by cannabis use frequency, and purchase source, and quantity purchased at last purchase** (n=8,023)

| | Mean $/g (SEM) | | | | | |
|---|---|---|---|---|---|---|
| | US 'illegal' 2019 n=544 | US 'illegal' 2020 n=525 | US 'medical' 2019 n=824 | US 'medical' 2020 n=760 | US 'recreational' 2019 n=3205 | US 'recreational' 2020 n=2165 |
| **All participants** | $11.95 (0.5) | $13.09 (0.6) | $13.01 (0.4) | $12.59 (0.4) | $11.44 (0.2) | $12.24 (0.3) |
| **Cannabis use frequency** | | | | | | |
| Past year, but less than monthly | $14.34 (1.5) | $16.10 (2.0) | $14.81 (1.2) | $14.55 (1.2) | $15.22 (0.8) | $16.92 (1.2) |
| Monthly | $14.53 (1.4) | $15.00 (1.2) | $15.12 (0.9) | $15.22 (1.1) | $14.37 (0.8) | $16.45 (1.1) |
| Weekly | $10.57 (0.9) | $13.15 (1.3) | $13.38 (0.8) | $13.27 (1.2) | $13.50 (0.6) | $13.71 (0.8) |
| Daily/almost daily | $10.78 (0.6) | $11.63 (0.8) | $11.55 (0.5) | $11.27 (0.5) | $9.66 (0.2) | $9.86 (0.3) |
| **Purchase source** | | | | | | |
| Friends or family | $11.85 (0.8) | $13.41 (0.8) | $12.80 (0.6) | $13.45 (0.9) | $10.84 (0.5) | $11.75 (0.8) |
| Dealer (in person) | $11.05 (0.6) | $11.12 (0.6) | $12.50 (0.6) | $11.36 (0.6) | $10.44 (0.5) | $11.17 (0.7) |
| Online/mail order | - | - | - | - | $12.51 (0.9) | $14.13 (1.8) |
| Store/dispensary | - | $20.04 (2.7) | $15.23 (1.3) | $13.48 (0.7) | $11.83 (0.3) | $12.46 (0.4) |
| **Quantity purchased** | | | | | | |
| <1g | - | - | $26.90 (2.0) | - | $26.14 (1.6) | $25.28 (2.6) |
| 1g-3.49g | $14.15 (0.8) | $15.94 (1.1) | $16.79 (0.8) | $16.95 (0.8) | $15.03 (0.4) | $16.49 (0.7) |
| 3.5-27.9g | $10.33 (0.6) | $11.09 (0.7) | $10.47 (0.3) | $10.97 (0.5) | $9.76 (0.2) | $10.65 (0.3) |
| =>28g | $6.83 (0.7) | $7.71 (1.0) | $6.28 (0.5) | $6.07 (0.5) | $4.55 (0.2) | $5.33 (0.3) |

Data are among dried flower purchasers who provided a plausible unit price of dried flower at last purchase.
Values suppressed for instances where cell counts are below n=30.

**Table 3b: Quantity-adjusted price of dried flower by cannabis use frequency, and purchase source, and quantity purchased at last purchase** (n=8,023)

| | Quantity-adjusted price* (SE) | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | US 'illegal' 2019 n=544 | US 'illegal' 2020 n=525 | US 'medical' 2019 n=824 | US 'medical' 2020 n=760 | US 'recreational' 2019 n=3205 | US 'recreational' 2020 n=2165 |
| **All participants** | $8.88 (0.5) | $9.19 (0.5) | $9.07 (0.3) | $8.61 (0.4) | $7.34 (0.2) | $7.95 (0.3) |
| **Cannabis use frequency** | | | | | | |
| Past year, but less than monthly | $11.68 (1.9) | $9.81 (2.4) | $10.44 (1.7) | $11.08 (0.9) | $9.61 (0.8) | $9.63 (2.7) |
| Monthly | $12.27 (2.3) | $13.00 (1.5) | $11.05 (1.0) | $10.98 (1.2) | $10.23 (0.7) | $12.38 (0.8) |
| Weekly | $7.64 (0.9) | $9.05 (0.9) | $10.76 (0.7) | $8.93 (0.7) | $9.47 (0.5) | $10.64 (0.8) |
| Daily/almost daily | $8.26 (0.5) | $8.73 (0.7) | $8.10 (0.4) | $8.14 (0.5) | $6.61 (0.2) | $7.10 (0.3) |
| **Purchase source** | | | | | | |
| Friends or family | $8.43 (0.9) | $9.07 (1.1) | $8.98 (0.5) | $9.12 (1.1) | $6.48 (0.4) | $7.07 (0.7) |
| Dealer (in person) | $8.80 (0.6) | $8.18 (0.5) | $8.59 (0.5) | $7.88 (0.5) | $6.85 (0.4) | $7.45 (0.5) |
| Online/mail order | - | - | - | - | $7.62 (0.5) | $10.03 (1.5) |
| Store/dispensary | - | $13.17 (1.5) | $10.89 (1.1) | $9.65 (0.9) | $7.81 (0.2) | $8.12 (0.4) |
| **Quantity purchased** | | | | | | |
| <1g | - | $24.16 (3.5) | $27.15 (2.3) | $23.88 (3.6) | $24.51 (1.6) | $25.19 (2.7) |
| 1g-3.49g | $13.17 (0.8) | $15.11 (1.1) | $16.03 (0.9) | $16.24 (0.8) | $14.63 (0.5) | $15.72 (0.7) |
| 3.5-27.9g | $9.62 (0.7) | $9.76 (0.7) | $9.70 (0.3) | $10.05 (0.6) | $8.67 (0.2) | $9.72 (0.4) |
| =>28g | $6.83 (0.7) | $7.20 (0.9) | $5.99 (0.5) | $5.92 (0.6) | $4.47 (0.2) | $5.05 (0.3) |

Data are among dried flower purchasers who provided a plausible unit price of dried flower at last purchase.
*Quantity-adjusted price is the unit price of dried flower adjusted for the quantity purchased.
Values suppressed for instances where cell counts are below n=30.

**Table 4: Weighted binary logistic regression analysis for correlates of legality of purchase source used at last purchase in US 'recreational' states among dried flower purchasers over 21 years.**

| | Odds of purchasing dried flower from a legal source (vs. illegal source) AOR (95% CI) | | | |
|---|---|---|---|---|
| | **MODEL 1** | **MODEL 2** | **MODEL 3** | **MODEL 4** |
| | **Both years** | **Both years without unit price** | **2019 only** | **2020 only** |
| | n=4,682 | n=5,736 | n=2,812 | n=1,870 |
| **Unit price** (per $1 increase in price) | **1.03 (1.02, 1.04)** | - | **1.03 (1.02, 1.05)** | 1.02 (0.99, 1.04) |
| **Survey year** | | | | |
| 2019 | REF | REF | - | - |
| 2020 | 1.10 (0.90, 1.36) | 0.98 (0.81, 1.17) | - | - |
| **Time with legal retail sales*** | **1.68 (1.58, 1.77)** | **1.59 (1.52, 1.67)** | **1.74 (1.60, 1.88)** | **1.61 (1.48, 1.75)** |
| **Cannabis use frequency** | | | | |
| Past year, but less than monthly | REF | REF | REF | REF |
| Monthly | 1.38 (0.93, 2.06) | 1.11 (0.80, 1.56) | 1.46 (0.91, 2.34) | 1.33 (0.67, 2.62) |
| Weekly | **1.65 (1.11, 2.45)** | 1.32 (0.95, 1.84) | **2.42 (1.56, 3.78)** | 1.03 (0.51, 2.08) |
| Daily/almost daily | **1.56 (1.12, 2.17)** | 1.14 (0.86, 1.51) | **1.82 (1.24, 2.67)** | 1.27 (0.70, 2.31) |
| **Sex** | | | | |
| Male | REF | REF | REF | REF |
| Female | 1.10 (0.92, 1.33) | 1.17 (0.99, 1.39) | 1.06 (0.86, 1.31) | 1.18 (0.83, 1.67) |
| **Age** | | | | |
| 21-35 | **0.77 (0.60, 0.99)** | 0.82 (0.66, 1.02) | 0.85 (0.64, 1.12) | 0.72 (0.46, 1.14) |
| 36-50 | 0.88 (0.69, 1.13) | 0.89 (0.71, 1.11) | 0.87 (0.66, 1.16) | 0.91 (0.57, 1.43) |
| 51-65 | REF | REF | REF | REF |
| **Ethnicity** | | | | |
| Non-Hispanic White | REF | REF | REF | REF |
| Hispanic White | 1.06 (0.78, 1.43) | 1.00 (0.77, 1.30) | 1.19 (0.86, 1.65) | 0.89 (0.48, 1.64) |
| American Indian or Alaskan Native | 0.84 (0.42, 1.69) | 0.80 (0.44, 1.48) | 0.61 (0.31, 1.23) | 1.64 (0.29, 9.16) |
| Asian | 1.15 (0.63, 2.13) | 1.08 (0.61, 1.89) | 1.44 (0.67, 3.12) | 0.83 (0.31, 2.23) |
| Black or African American | 0.73 (0.52, 1.03) | **0.67 (0.49, 0.91)** | 0.86 (0.58, 1.27) | 0.61 (0.33, 1.12) |

| | | | | |
|---|---|---|---|---|
| Native Hawaiian or Pacific Islander | 1.70 (0.33, 8.88) | 1.21 (0.32, 4.59) | 4.88 (0.50, 47.34) | 0.94 (0.12, 7.37) |
| Other/Multiracial | 1.02 (0.69, 1.50) | 0.95 (0.66, 1.35) | 1.03 (0.65, 1.62) | 0.97 (0.49, 1.93) |
| **Education** | | | | |
| Less than high school | REF | REF | REF | REF |
| High school diploma | 1.42 (0.84, 2.42) | 1.25 (0.77, 2.02) | 1.30 (0.70, 2.41) | 1.47 (0.57, 3.80) |
| Some college or technical vocation | 1.60 (0.96, 2.66) | 1.53 (0.96, 2.43) | 1.39 (0.78, 2.49) | 1.79 (0.72, 4.46) |
| Bachelor's degree or higher | 1.24 (0.73, 2.11) | 1.12 (0.69, 1.82) | 1.17 (0.63, 2.15) | 1.24 (0.48, 3.17) |
| **Income adequacy** | | | | |
| Very difficult/Difficult | REF | REF | REF | REF |
| Neither easy nor difficult | **1.42 (1.13, 1.79)** | **1.33 (1.09, 1.63)** | **1.32 (1.02, 1.70)** | 1.50 (0.98, 2.31) |
| Easy/Very easy | 1.27 (0.99, 1.62) | 1.22 (0.98, 1.52) | 1.20 (0.90, 1.60) | 1.31 (0.84, 2.05) |
| Not stated | 1.96 (0.67, 5.76) | 1.08 (0.48, 2.40) | 2.59 (0.63, 10.63) | 1.11 (0.27, 4.62) |
| **Device used** | | | | |
| Computer | REF | REF | REF | REF |
| Smartphone | 1.14 (0.92, 1.41) | **1.24 (1.02, 1.50)** | 1.12 (0.88, 1.43) | 1.14 (0.77, 1.68) |
| Tablet | 1.08 (0.64, 1.81) | 1.20 (0.79, 1.84) | 0.97 (0.55, 1.70) | 1.17 (0.41, 3.32) |

Data are from respondents aged 21 and over in US legal states with legal retail sales in September 2020. States Maine, Vermont, and the District of Columbia were removed due to no legal retail sales in September 2020.

An interaction between survey year and unit price was not significant ($F_{1,4681}=0.4$, p=0.505).

Predictor 'time with legal retail sales' is a proxy for legal state.

**Figure 1: Average percentage of dried flower purchased from legal sources in the past 12-months by jurisdiction, positioned in order of length of time with legal retail sales, in 2019 and 2020** (n=5,947)

**Figure 2: Quantity-adjusted price of dried flower purchased from illegal and legal sources at last purchase in US 'recreational' states** (n=5,324)



Graphs include 95% confidence intervals
*Quantity-adjusted price is the unit price of dried flower adjusted for the quantity purchased.

**Supplemental Table 1: Illegal and legal sources of dried flower in 2019 and 2020 in US states that have legalized recreational cannabis**

|  | **Illegal sources** | **Legal sources** |
| --- | --- | --- |
| **2019** | Family/Friend | Licensed Store/Dispensary |
|  | Dealer | Internet/Mail order in a state that allows delivery |
|  | Unlicensed Store/Dispensary |  |
|  | Internet/Mail order in a state that does not allow delivery |  |
|  | Licensed Store/Dispensary and under MLA or in a state without legal retail sales |  |
| **2020** | Family/Friend | Licensed Store/Dispensary |
|  | Dealer | Internet/Mail order and in a state that allows delivery |
|  | Unlicensed Store/Dispensary |  |
|  | Internet/Mail order and in a state that does not allow delivery |  |
|  | Licensed Store/Dispensary and under MLA or in a state without legal retail sales |  |

MLA = Minimum Legal Age to purchase cannabis. MLA is 21 years to purchase recreational cannabis; MLA is 21 to purchase medical cannabis in Alaska, Maine, Massachusetts, Michigan, and Washington State; and MLA is 18 years to purchase medical cannabis in California, Colorado, Nevada, Oregon, Vermont, and Washington DC.

The source 'Family/Friend' in legal jurisdictions was classed as 'illegal' as it refers to dried flower that has been paid for, not gifted or shared.

**Supplemental Table 2: Purchase source at last purchase among past 12-month cannabis consumers in US 'recreational' states, positioned in order of length of time with legal retail sales, 2019 and 2020** (n=6,488)

| | Maine | | Michigan | | Massachusetts | | California | | Nevada | | Alaska | | Oregon | | Washington State | | Colorado | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2019** n=107 | **2020** n=107 | **2019** n=339 | **2020** n=273 | **2019** n=441 | **2020** n=369 | **2019** n=1261 | **2020** n=349 | **2019** n=252 | **2020** n=279 | **2019** n=32 | **2020** n=140 | **2019** n=418 | **2020** n=313 | **2019** n=568 | **2020** n=377 | **2019** n=483 | **2020** n=380 |
| **Purchase source used** | | | | | | | | | | | | | | | | | | |
| Friends or family member | 45.4% | 28.5% | 35.5% | 29.9% | 30.7% | 29.9% | 15.5% | 19.0% | 10.3% | 9.4% | 5.6% | 4.5% | 7.6% | 4.9% | 11.5% | 5.4% | 8.9% | 8.3% |
| | (45) | (30) | (134) | (91) | (138) | (112) | (202) | (66) | (21) | (26) | (3)* | (9)* | (28) | (17) | (55) | (21) | (37) | (26) |
| Dealer (in person) | 25.3% | 9.3% | 32.2% | 21.2% | 32.7% | 23.5% | 16.2% | 18.9% | 13.8% | 14.3% | 25.1% | 6.2% | 2.6% | 7.3% | 5.7% | 5.4% | 5.9% | 8.3% |
| | (27) | (10)* | (96) | (50) | (142) | (75) | (186) | (58) | (31) | (35) | (8)* | (7)* | (11)* | (14)* | (31) | (16) | (21) | (27) |
| Online or mail order | 1.7% | 0.6% | 3.6% | 4.4% | 1.9% | 2.7% | 12.0% | 12.8% | 1.1% | 5.6% | 0.0% | 0.0% | 0.0% | 1.4% | 0.8% | 2.8% | 0.6% | 2.3% |
| | (2)* | (1)* | (7)* | (9)* | (11)* | (8)* | (147) | (45) | (4)* | (17) | (0) | (0)* | (0)* | (6)* | (3)* | (8)* | (1)* | (7)* |
| Store or dispensary (in person) | 26.7% | 60.0% | 26.4% | 42.3% | 33.5% | 42.7% | 55.6% | 48.2% | 73.4% | 69.3% | 69.3% | 87.6% | 88.0% | 86.2% | 81.1% | 86.0% | 84.7% | 80.9% |
| | (31) | (61) | (89) | (117) | (145) | (171) | (717) | (176) | (194) | (197) | (21) | (123) | (375) | (275) | (476) | (330) | (424) | (319) |
| Unknown | 0.9% | 1.5% | 2.3% | 2.1% | 1.2% | 1.2% | 0.7% | 1.1% | 1.5% | 1.4% | 0.0% | 1.7% | 1.8% | 0.2% | 0.9% | 0.4% | 0.0% | 0.2% |
| | (2)* | (2)* | (13) | (6)* | (5)* | (3)* | (9)* | (4)* | (2)* | (4)* | (0)* | (1)* | (4)* | (1)* | (3)* | (2)* | (0)* | (1)* |
| | | | | | | | | | | | | | | | | | | |
| **Legality of purchase source** | | | | | | | | | | | | | | | | | | |
| Illegal | 71.9% | 37.9% | 70.8% | 54.4% | 64.8% | 53.7% | 35.5% | 41.5% | 25.4% | 24.3% | 30.7% | 10.7% | 12.7% | 14.7% | 19.0% | 12.1% | 17.6% | 18.4% |
| | (73) | (40) | (235) | (147) | (286) | (188) | (436) | (138) | (55) | (63) | (11)* | (16) | (45) | (38) | (97) | (43) | (65) | (60) |
| Legal | 25.5% | 60.6% | 26.8% | 41.8% | 33.8% | 43.9% | 62.0% | 55.2% | 72.6% | 74.3% | 69.3% | 87.6% | 85.1% | 84.8% | 79.1% | 86.3% | 81.5% | 79.2% |
| | (29) | (62) | (90) | (118) | (148) | (175) | (795) | (203) | (194) | (212) | (21) | (123) | (367) | (273) | (464) | (328) | (415) | (315) |
| Unknown | 2.7% | 1.5% | 2.4% | 3.8% | 1.4% | 2.5% | 2.5% | 3.3% | 2.0% | 1.4% | 0.0% | 1.7% | 2.2% | 0.4% | 1.9% | 1.6% | 1.0% | 2.4% |
| | (5)* | (2)* | (14) | (9)* | (7)* | (7)* | (31) | (10)* | (3)* | (4)* | (0)* | (1)* | (7)* | (2)* | (7)* | (6)* | (3)* | (8)* |

Data are among consumers who reported purchasing dried flower in the past 12-months.

Data are % (n). Weighted %, unweighted n. Respondents from District of Columbia (n$_{2019}$=26; n$_{2020}$=47) and Vermont (n$_{2019}$=39; n$_{2020}$=26) are not included due to low sample size.

*High sampling variability – coefficient of variation is >30%

**Supplemental Figure 1: Quantity-adjusted price of dried flower at last purchase among US legal states in 2019 and 2020**
(n=5,370)
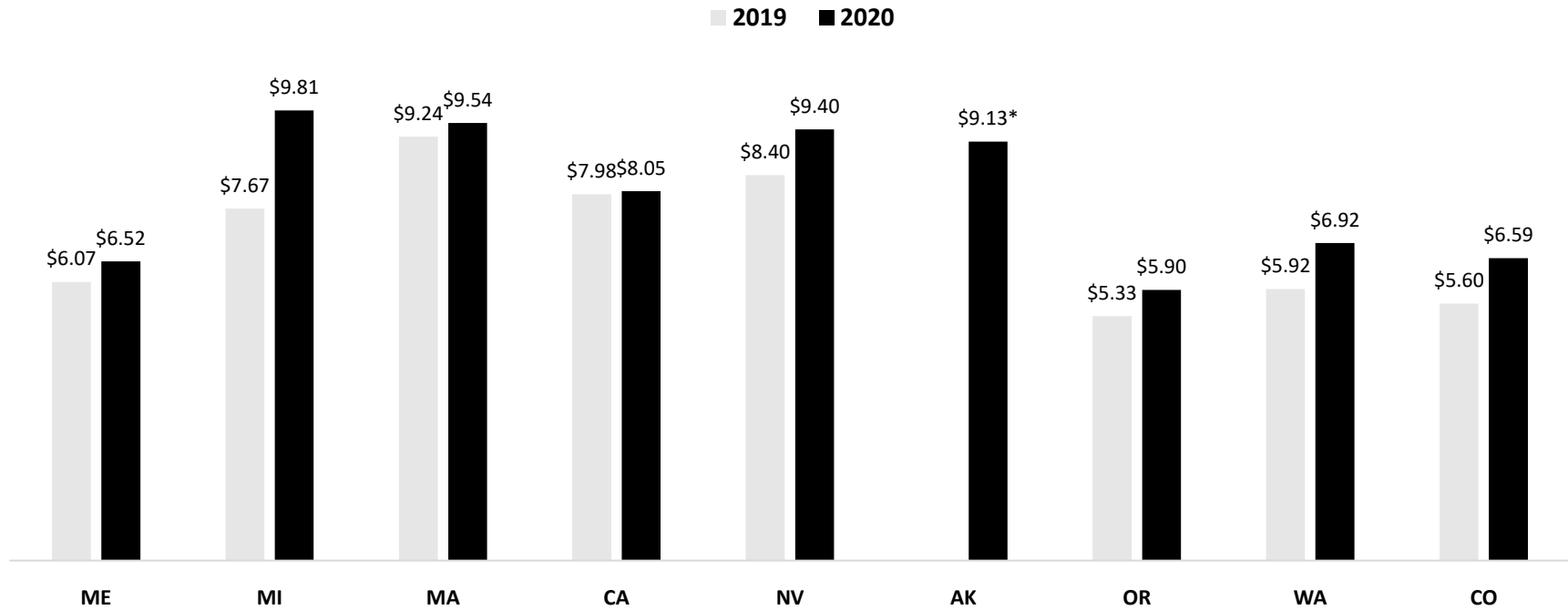


ME=Maine; MI=Michigan; MA=Massachusetts; CA=California; NV=Nevada; AK=Alaska; OR=Oregon; WA=Washington State; CO=Colorado
US States are positioned in order of length of time with legal retail sales.
*Respondents from District of Columbia ($n_{2019}$=23; $n_{2020}$=37), Vermont ($n_{2019}$=30; $n_{2020}$=23), and Alaska ($n_{2019}$=25) are not shown due to low sample size.

# CHAPTER 7 – GENERAL DISCUSSION

The current studies contribute to the emerging evidence on the effect of cannabis price and retail availability on consumer purchasing behaviour as consumers transition to a legal market. To our knowledge, these are among the first studies to examine the relationship between price, retail availability and legal purchasing of dried flower among consumers in Canada and the US. The key themes that emerged from the studies are discussed below.

## 7.1 Transition to the legal market

Differences in the sources used to purchase dried flower were observed across jurisdictions. Consumers predominantly purchased from illegal sources in jurisdictions that had not legalized non-medical cannabis, and purchased from legal sources in jurisdictions that had legalized non-medical cannabis (Chapters 3, 5, and 6). Canadian consumers show relatively quick uptake of the legal market in the first few years of legalization, with 46% purchasing from a legal source in the first year, increasing to 58% in the second year. The current findings are consistent with two national cannabis surveys in Canada – the Canadian Cannabis Survey and the National Cannabis Survey – which indicate an increase in consumer purchases from legal sources the first two years following legalization.[1-5] In the National Cannabis Survey, 23% of consumers purchased "at least some" of their cannabis in the past 3-months legally pre-legalization, and this increased to 47% in 2019 and 68% in 2020.[1] The current study observed the same pattern in US states that had legalized non-medical cannabis: the percentage of dried flower purchased from legal retail sources in the past 12-months increased with the 'age' of legal non-medical markets. For example, in the newest markets, such as Michigan and Massachusetts, consumers reported purchasing approximately 50% of their dried flower from legal sources in 2019; in contrast, consumers reported purchasing approximately 90% of dried flower from legal sources in 'older' markets such as Colorado and Washington State.

Collectively, the data suggest a general timeline for consumer transitions to legal markets. However, the findings also suggest that rates of transition to the legal market may not be fixed; rather, it may be influenced by factors such as retail availability, particularly in the initial period

of legalization. One year post-legalization in Canada, consumers with greater retail availability had a higher likelihood of purchasing legal dried flower. In Canada, retail stores are regulated at the provincial level, which resulted in substantially different retail access across the country, particularly in the first two years following legalization. Legal purchasing was higher in provinces with a greater number of stores. In 2019, Ontario had 0.2 stores per 100,000 people aged 15 and older, Saskatchewan had 3.7 stores, and Alberta had 7.9 stores per 100,000 people aged 15 and older (Chapter 4). Accordingly, the proportion of consumers who last purchased dried flower from a legal source in 2019 was 41% in Ontario, 55% in Saskatchewan, and 62% in Alberta. Legal purchasing across Canada increased from 2019 to 2020 (46% vs 58%), as certain provinces increased their number of stores. Ontario had 24 stores in September 2019, 112 stores in September 2020, and 754 stores as of May 2021.[6] Overall, retail availability has increased considerably in the 30 months since legalization in Canada, along with the proportion of consumers purchasing from legal stores. In March 2021, Canadian cannabis stores took $322 million in sales, compared to $181 million the previous March.[7]

Consumers in older retail markets still purchase dried flower illegally. Findings from Chapter 6 demonstrate that even seven to eight years after legalization, approximately one in ten consumers purchased dried flower illegally in Colorado and Washington State. From the current studies, US respondents purchasing illegally in states with legal markets were more likely to be less frequent cannabis consumers, aged 21-35, and report finding it difficult to make ends meet. Comparatively, among Canadian consumers, those purchasing illegally were more likely to be daily consumers, report lower education, and report finding it difficult to make ends meet. The apparent contradiction in the cannabis frequency of consumers purchasing illegally in Canada and the US could be explained by the difference in medical retail markets prior to legalization. It is plausible that US daily consumers had already 'transitioned' to a physical retail market prior to non-medical legalization through medical access and so the movement to legal purchasing was somewhat quicker than in Canada, where medical cannabis was only available legally online. Future research should examine why consumers remain in the illegal market across individual US legal states and in Canada. Results of which could aid governments to transition more resistant consumers to the legal market.

## 7.2 Price and quantity of dried flower

In the first year of legalization in Canada, the average price that consumers paid for dried flower increased as consumers began purchasing from the legal market, where prices were more expensive than the illegal market. In a newly regulated market, it is perhaps expected that there will be an initial increase in the price of cannabis prior to expected longer-term price decreases: initial increases were also observed in US states such as Washington State and Michigan.[8,9] In the current thesis, the mean price-per-gram in 2018 was $9.56 (Chapter 3), $10.64 in 2019, and $10.41 in 2020 (Chapter 5). The difference between the average price in 2019 and 2020 in the current study was not statistically significant; however, it may suggest the start of a decline in the average price of dried flower. These average prices of dried flower are within a dollar of prices found in the Canadian Cannabis Survey.[3-5]

The findings in Chapters 3 and 5 demonstrated that the average price of legal dried flower was higher than the average price of illegal dried flower. Price estimates from crowdsourced data and objective data taken from illegal and legal retailers demonstrate a similar price differential.[10-12] However, since legalization in Canada, cannabis prices in legal stores have decreased, which reduced the price differential between illegal and legal dried flower. For example, between 2019 and 2020, the Ontario Cannabis Store reduced the median price of dried flower by 25%.[13] In the 2020 annual report of Quebec's provincial store (SQDC), average prices were reportedly competitive with the illegal market.[14] Moreover, since the current thesis, cannabis prices in Canada declined considerably: as of May 2021, prices of dried flower between $3.00 and $5.00 per gram were common. In addition to price, other factors may contribute to the choice of purchasing legally, such as convenience, safe supply, quality, known potency levels, or product availability.[4,5,15] Indeed, research has shown that consumers will tolerate higher prices of legal cannabis compared to illegal cannabis before switching to the illegal cannabis.[16,17] Research should examine consumer preferences regarding price in the illegal and legal market to ensure consumers are encouraged to transition to the legal market and are retained.

Substantial quantity discounts were observed in Canadian and US dried flower markets. For example, the average price-per-gram of quantities under 3.5 g were more than twice the price-per-

gram of quantities over 28 g. Notably, quantity purchased was the most important determinant of price-per-gram paid at last purchase among Canadian cannabis consumers pre-legalization (Chapter 3). The findings highlight the importance of reporting and interpreting dried flower prices by purchase quantities, particularly if the average purchase amount differs from legal and illegal retail sources. In the current study, the price paid by consumers was presented using two different methods (Chapter 5 and 6). First, the average amount that was paid across consumers was calculated, for which all consumers were weighted equally, regardless of how they purchased. (For example, if a consumer purchased 1 g for $10.00/g and another consumer purchased 28 g for $100 or $3.57/g, the average across the two consumers would be $6.79). For the second method, a type of 'quantity-adjusted' estimate was calculated, which accounted for how much dried flower each consumer purchased. (In the example above, a total of 29 g of dried flower was purchased for a total of $110, for an average of $3.79/gram.) These two approaches yield markedly different estimates of the average purchase price due to the quantity discount for larger purchases: for example, the mean purchase price for 2020 in Canada was $10.41 using the first method and $6.83 using the 'quantity-adjusted' method. Researchers using self-reported data from population surveys should clarify which approach is being used to calculate price estimates, recognizing that the second approach is likely to show better correspondence with actual 'quantity-adjusted' data from retailers.

Cannabis use frequency and quantity purchased are closely related, such that more frequent consumers pay substantially lower prices due to greater quantity discounts. This has implications for comparing purchases between legal and illegal markets. In Canada, lower percentages of frequent cannabis consumers transitioned to the legal market in the early stages of legalization, potentially due to established relationships with illegal sources, or purchasing larger quantities than permitted in the legal market. In addition, frequent cannabis consumers will spend substantially more money on cannabis in total than infrequent consumers, and so price may be a more important factor in deciding where to purchase cannabis. Indeed, research has shown price elasticities of demand vary according to consumer groups, whereby youth and more frequent consumers may have greater price sensitivities to cannabis.[18] Frequent consumers are an important group to encourage and retain in the legal market due to their significant contribution to the total

cannabis market share.[19-22] Future research should examine other barriers to transition to the legal market among consumers other than price and retail availability.

## 7.4 Limitations and strengths

### 7.4.1. Survey data

The research presented in this thesis has several limitations. Respondents were recruited using non-probability-based sampling; therefore, the findings do not provide nationally representative estimates. The data were weighted by age group, sex, region in 2018 and age group, sex, region, education and cigarette smoking status in 2019 and 2020 in both countries. US data were also weighted by region-by-race in all years. Compared to the national population, the US sample had fewer respondents with low education levels and Hispanic ethnicity. Cannabis use estimates were generally lower than national estimates for young adults, and higher than national surveys. This is likely because the ICPS sampled individuals up to the age of 65, whereas national surveys include older adults, who are known to have lower rates of use. US National data for 2020 were unavailable at the time of writing; comparisons to 2019 data may not reflect secular increases in cannabis use from 2019-2020. In both countries, the ICPS sample also had poorer self-reported general health compared to the national population, which is a feature of many non-probability samples, and may be partly due to the use of web surveys, which provide greater perceived anonymity than in-person or telephone-assisted interviews often used in national surveys.[23,24]

Self-report data are subject to social desirability bias. Non-medical cannabis consumption in Canada (2018) and the US (2018-2020) remained illegal at the federal level; therefore, patterns of cannabis use may be underreported, or purchase sources misrepresented. However, the survey included a data integrity question wherein those who reported not answering questions honestly were excluded. In addition, this survey was self-administered online, which compared to interviewer assisted surveys, can reduce social desirability biases by providing anonymity.[24]

The Canadian sample in the current study only included respondents from the 10 Canadian provinces and not from the three Canadian territories. The territories contribute 0.3% of the entire

Canadian population, and so obtaining adequate sample sizes through the online commercial panels was unattainable.[25]

### 7.4.2. Dried flower

Respondents were asked to report their last purchase of dried flower, rather than their 'usual' purchase. While a respondent's last purchase may not be representative of their usual purchase at the individual level, 'last purchase' should provide a more representative estimate at the population level. In addition, 'last purchase' may be less prone to memory errors due to recalling over a shorter period of time. Further, research examining the comparison between consumers most recent cannabis purchase and all cannabis purchases demonstrated little difference between the two.[26]

Analyses did not examine the potency or THC content of dried flower. As discussed previously, collecting and interpreting potency pre-legalization is challenging due to a lack of information and unreliable labelling on illegal products.[12] Additionally, self-report, focus groups, and experimental data show self-reported potency is unreliable, even in legal markets.[27-29] Thus, a potency-adjusted price may be larger or smaller than the prices reported.[30,31]

In Chapters 3, 5, and 6, respondents could include pre-rolls when reporting dried flower purchases, which may be priced differently to loose dried flower. For example, while pre-rolls contain dried flower, they are a premium product and would be priced as such.[13,32] In addition, some pre-rolls contain concentrates in addition to dried flower and are sold at premium price level.[33] Alternatively, low quality dried flower could be used in pre-rolls and priced lower as a result. Average prices of dried flower in the current study could change if pre-roll and loose dried flower were analysed separately.

All studies focused on dried flower only; therefore, the findings may not be representative of all cannabis products. However, dried flower remains the most used product in Canada and the US and so would capture a large proportion of expenditures in the legal market.[2-5,34-37] In addition, only dried flower and some oils were available in the legal market at the start of legalization in Canada and all other products (i.e., edibles, concentrates) were available from December 2019; therefore, most products were only available in the illegal market.[38]

### 7.4.3. Purchase source

There were some limitations present in Chapter 3 that were explored in the subsequent studies. First, respondents were not asked to identify the purchase source they used at last purchase in Chapter 3; therefore, it was assumed that respondents who reported purchasing from only one source in the past 12-months would have used the same one source at last purchase. Respondents who reported purchasing from more than one source in the past 12-months were classed as 'unknown'. The purchase source used at last purchase was asked in Chapters 4-6. Second, when reporting price paid from online sources or mail order, respondents in Chapter 3 were not asked whether the price included shipping. Similarly, respondents were not asked whether the final cost included tax. Thus, the aggregate prices reported may be larger or smaller than prices that were reported in Chapter 3. In 2019 and 2020, respondents were asked to clarify the inclusion of tax and shipping. However, tax and shipping costs were not adjusted for in Chapters 5 and 6. The majority of participants (between 60-82%) reported including tax in their final cost after purchasing from stores or online at last purchase, and we aimed to report prices as consumers remembered/paid for it (see Appendix F). Further, some respondents who purchased from illegal sources also reported including tax in their final cost, where tax would not be included. Therefore, the reliability of these measure is questionable, and adjusting the price-per-gram according to an unreliable measure may add further errors to the estimates.

### 7.4.4. Price

As outlined in Chapter 2, the price data were cleaned differently in Chapter 3 to Chapters 5 and 6. In Chapter 3, the price data were cleaned according to limits found in a separate study examining the price of dried flower among Canadian illegal retailers.[39] In Chapters 5 and 6, the price data were also cleaned according to objective price data from legal and illegal retailers but also according to the distribution of prices.[11,40,41] Sensitivity analyses were conducted where the price data in Chapter 3 were retrospectively cleaned according to the methods used in Chapters 5 and 6, and similar patterns emerged. Furthermore, 2019 prices in Chapters 5 and 6 were inflated to 2020 prices according to the estimated inflation rate in Canada and the US, respectively.[42-44] For the current studies, the all-item Consumer Price Index was used, yet dried flower is both a legal and illegal good and so an overall inflation rate for legal products may not represent the inflation rate of dried flower accurately.

### 7.4.5 Retail availability

In Chapter 4, Euclidean distance to legal retail cannabis stores was treated as a categorical variable, which assumes there were similar break points in distance travelled among respondents. A continuous measure would assume a monotonic linear relationship between distance and the likelihood of purchasing their dried flower at an illegal or legal source. Moreover, the geometric mean revealed skewness in the data and so a continuous measure was deemed inappropriate. A sensitivity analysis was conducted to examine the effect of distance as a categorical measure using different classification schemes as well as a continuous measure and similar patterns emerged. Another limitation is that not all respondents provided valid postal code information; as a result, some cannabis consumers were excluded from the analyses. Nonetheless, 86% of respondents provided valid postal code information; therefore, any bias resulting from the exclusion of these respondents should be minimal. In addition, the respondent and retail store location based on postal code is only approximate. Canadian postal codes can cover a single house/apartment building in urban areas, whereas postal codes in rural areas cover a larger geographic area. In the current study, 86% of respondents lived in urban areas and so we can assume a certain degree of accuracy from postal codes as a proxy for Canadian respondent locations.[45,46] Finally, because Euclidean distance was categorized into three categories rather than a continuous variable, it arguably would result in groupings of rural versus urban and so the differences in accuracy would be minimized.

In Chapter 4, to measure self-reported time taken to retail store, respondents were asked how long it would take them (in minutes) to get to their nearest store that sells cannabis. This question did not specify the legality of the retail store, and so respondents could answer whether their nearest store was illegal or legal. In addition, self-reported time taken to retail store could vary by mode of transport; however, of those who reported their usual mode of transport, most used a personal vehicle such as a taxi or car (66.8%). Sensitivity analyses examined the contribution of 'usual mode of transport' as a covariate in the regression model, but comparable patterns emerged.

### 7.4.6 Strengths

The current thesis used self-reported data collected from a large population survey, and although there are limitations to self-reported data, there are key strengths. For example, self-reported surveys can provide individual-level data on *who* is using the illegal and legal market and *why*.

Previous research has triangulated multiple data sources in order to create a clearer picture of legal cannabis markets.[47,48] However, researchers and policymakers require consistent access to data sources. In the Canadian legal retail market, Health Canada discloses overall non-medical cannabis sales but it is down to the provinces to disclose provincial-level data, which is not disclosed equally nor consistently.[49] In the illegal market, researchers previously used Leafly and Weedmaps to collect data from retailers on price and location of stores.[11,39,50-53] However, Leafly changed focus to only legal stores in Canada since legalization, and Weedmaps reported stopping advertising known illegal retailers in certain US states.[54,55] Without 'objective' illegal retail data or consistent legal sales data, we are left with self-reported data to account for the illegal market.[56] Self-reported data make an important contribution to the evaluation of cannabis legalization in Canada and US states.

## 7.4 Future directions

Future studies should examine the array of cannabis products other than dried flower, which are increasing in popularity.[2-5,35-37] In fact, there is evidence to suggest that preference for cannabis products vary by sociodemographic characteristics, such as age or gender. For example, females report higher rates of edible use and males report higher rates of vaped product use.[4,5,57,58] The products available to purchase, such as vape oils or edibles, may influence who transitions to the legal market. Indeed, Quebec is the only province to introduce a THC limit on all cannabis products of 30%.[59] While 30% THC would not impact dried flower sales (30% is close to dried flowers' biological limit[60]), it may impact non-flower products such as vape oils that can reach over 90% THC. Quebec has a very different product offering compared to other provinces: vape oils, edibles, and solid concentrates were not available in Quebec at the time of the study, but when these products enter the market, they will be with lower THC concentrations than products in other provinces. Moreover, edibles in Quebec will not include most popular offerings such as chocolates, candies, or any food deemed to be appealing to children. The extent to which these product standards impact legal cannabis purchases for these product categories – and other categories not directly affected by the standards – should be examined.

Future research should examine the effect of tax rates on average prices of cannabis products across US states and Canada. US states have taxes based on price, weight, or potency, and Canada

has taxes based on price and potency. Differences in the final retail price of cannabis products will differ across jurisdictions due to provincial/state tax rates. For example, Alaska is reported to have some of the highest prices across states that have legalized non-medical cannabis due to high tax rates.[9] Tax rates could also influence the types of products sold. Canada and some US states tax by potency where higher potency products translate to higher prices. If manufacturers adapt products to contain less THC and thus lower taxes, consumers could access different products across jurisdictions. While a potency tax would encourage purchasing low potency products, low potency products would also reduce tax revenue to the respective governments.

Although the Canadian Cannabis Act did not explicitly include an objective regarding social justice measures, it is still critical to examine the effect of legalization on racialized groups who have historically borne the brunt of prohibition, namely Black and Indigenous people.[61-63] Future research should examine the relationships between retail access, legal purchasing and resulting consumption behaviours post-legalization in Canada across race/ethnicity. In addition, research should examine participation in the legal market among racialized groups and barriers to entry.[61,64] As of 2020, senior positions in Canada's legal cannabis industry were overwhelmingly white and male.[64] One explanation for the limited diversity in legal markets in Canada and US states were the high barriers to entry for cultivators, processors or retailers, through applications and costs.[65] Moreover, size and consolidation of the market are other considerations that may affect barriers to entry or to remain a participant in the legal market.[66-69]

Future research should examine local retail restrictions and how this influences consumer access to cannabis. Similar to provincial-level factors, local restrictions can determine retail availability at the individual-level. For example, in some provinces, municipalities are permitted to opt out of physical retail stores.[70] This creates an uneven distribution of access among residents. In Ontario, 69 municipalities opted out of retail stores as of May 2021, including densely-populated areas in the Greater Toronto Area.[71] Some provinces provide incentives to distribute retail stores, i.e., Saskatchewan set a lower annual license fee for physical retail stores located outside of a city than within.[72] The uneven distribution of cannabis retail stores due to local restrictions is also present in US states that have legalized, such as Oregon and Washington State.[73,74] Moreover, the distribution of cannabis stores may influence who lives in or near to areas with retail stores:

research conducted in US states with legal cannabis markets examining equity in the location of retail cannabis stores demonstrated that retail stores were located in areas with higher proportions of minority populations, alcohol retail stores, and people living in poverty.[74-78] In short, due to provincial and local retail structures and restrictions, retail availability will vary among consumers and likely change over time as number of retail stores increase.

On a similar theme, future research is needed on the impact of different retail structures on retail availability and resulting consumption behaviours. In US states that have legalized non-medical cannabis, all retail structures are privately run; however, in Canada, retail stores vary between private, public, or a hybrid of the two depending on the province.[70] Provincial retail market structure can influence not only the number of stores, but the rate of market expansion over time: provinces with a public retail market structure will likely not expand their number of stores to the same capacity as private retail markets. For instance, provinces with private physical retail markets show large increases in the number of stores: Alberta stores increased from 75 to 527 stores, and 0 to 112 in Ontario from March 2019 to September 2020, respectively.[70,79] Public retail markets, while predominantly in lower populated provinces, demonstrate smaller increases in the number of stores over the same period. Future research should continue to examine retail availability across provincial retail market structure and how it influences access to the legal market to help identify the 'ideal' number of stores where cannabis consumers have access to legal cannabis without promoting use or initiation.

Future research should examine the impact of COVID-19 and whether impacts of the pandemic on consumer purchasing behaviours are of short- or longer-term duration. In 2020, approximately 40% of Canadian cannabis consumers reported increasing their cannabis consumption during the pandemic.[80] Moreover, the pandemic may accelerate the transition from the illegal to the legal market for consumers. In an Oregon report, demand increased during the pandemic, and the authors predicted this demand to be driven by three groups, one of which were consumers transitioning to the legal non-medical market from the medical or illegal market.[81] In Canada, curbside pickup was made available for physical retail stores, which increased accessibility to cannabis during the pandemic. Indeed, in the ICPS 2020 survey, 28% of cannabis consumers reported they were more likely to source their cannabis legally compared to 9% who reported they

were more likely to source illegally.[82] The studies included in this thesis were conducted prior to or within the first year of COVID-19, which may only capture short-term changes to consumers habits. Research exploring purchase sources used, retail availability, and prices paid in the legal and illegal market will require data over multiple years of legalization to fully understand the impact of COVID-19 on consumer purchasing habits.

Future research should examine whether consumers in areas without retail stores have a higher uptake of legal online purchasing. Chapter 4 primarily focused on the retail availability of physical stores; however, online sales are an important aspect of the cannabis market, especially for those consumers who cannot or do not want to access physical stores. In an analysis of Canada's cannabis market, online sales contributed to 13% of the total non-medical retail sales in the first year of legalization.[79] The findings from Chapter 4 were prior to the COVID-19 pandemic where much of Canadian retail shopping moved online, and so location of physical stores may reduce the level of influence in legal purchasing during the pandemic.

In addition, future research should unpack the relationship between the price of cannabis and affordability. Price paid and income may be bidirectional. The amount spent on cannabis many determine income adequacy, and income adequacy may determine the amount consumers are willing to spend on cannabis.[83] There is a substantial literature on affordability of other substances such as tobacco and alcohol.[84-87] Future research should examine affordability of cannabis in Canada and the US.

Finally, future research is needed exploring the relationship between price, retail availability, and legal purchasing using longitudinal data. The ICPS uses repeat cross-sectional data; therefore, causation or direction of associations examined in the current thesis could not be determined. Longitudinal data would allow researchers to gain a clearer understanding of cannabis consumers transition to the legal market.

## 7.5 Conclusion

The legalization of non-medical cannabis in Canada and some US states represent a unique opportunity to evaluate a novel policy with public health implications. The current studies provide timely evidence on the Canadian and US legal cannabis markets with regards to price and retail availability, two primary factors in the decision to transition from the illegal market to the legal market. The findings suggest that, at least in the immediate post-legalization period, retail availability may be more important than price in encouraging consumers to purchase from the legal market. The current thesis demonstrated that consumers transition to the legal non-medical market relatively quickly in the first few years of legalization, with over half of Canadian consumers purchasing from legal sources within two years of a legal market. At the same time, legal purchasing in 'older' non-medical markets in the US still had a small percentage of consumers purchasing illegally, even after seven to eight years of legalization. At the time of writing, 18 states and the District of Columbia had legalized or passed laws to legalize non-medical cannabis, the equivalent of over 40% of the US population.[88] If this trend of state legalization accelerates, this may change the landscape of cannabis policy across the country. US states that have not legalized non-medical cannabis may be located closer to states that have, potentially creating 'spillover' effects, such as cross-border sales or increased law enforcement costs.[89-92] State legalization does not exist in a vacuum within one state, and so as more states legalize there may be fewer differences between those that have and those that have not legalized non-medical cannabis. Research should continue to monitor trends across states that have and have not legalized non-medical cannabis to capture the predicted movement towards increased cannabis liberalization in the US, potentially at a federal level.

# REFERENCES

## Chapter 1

1.     Pertwee RG. Handbook of Cannabis. 1st ed. New York, NY, US: Oxford University Press; 2014.

2.     Lafaye G, Karila L, Blecha L, Benyamina A. Cannabis, cannabinoids, and health. Dialogues Clin Neurosci. 2017;19(3):309-16.

3.     Niesink RJ, van Laar MW. Does Cannabidiol Protect Against Adverse Psychological Effects of THC? Front Psychiatry. 2013;4:130.

4.     United Nations Office on Drugs and Crime. Market analysis of plant-based drugs: opiates, cocaine, cannabis. In World Drug Report 2017. Sales No. E.17.XI.6. United Nations; 2017.

5.     European Monitoring Centre for Drugs and Drug Addiction. European Drug Report 2017: Trends and Developments. Publication Office of the European Union, Luxembourg; 2019.

6.     Statistics Canada. Canadian Tobacco, Alcohol and Drugs Survey (CTADS), 2017. [Internet] 2018. Available from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=4440.

7.     Government of Canada. Canadian Student Tobacco, Alcohol and Drugs Survey - Summary of Results for 2018 to 2019. [Internet] 2020. Available from: https://www.canada.ca/en/health-canada/services/canadian-student-tobacco-alcohol-drugs-survey/2018-2019-summary.html

8.     Canadian Institute for Health Information. How Canada compares: Results from the Commonwealth Fund's 2020 International Health Policy Survey of the General Population in 11 Countries. Ottawa, ON, Canada: CIHI; 2021.

9.     Government of Canada. Canadian Cannabis Survey 2018 Summary. [Internet] 2018. Available from: https://www.canada.ca/en/services/health/publications/drugs-health-products/canadian-cannabis-survey-2018-summary.html.

10.    Government of Canada. Canadian Cannabis Survey 2019 – Summary. [Internet] 2019. Available from: https://www.canada.ca/en/health-canada/services/publications/drugs-health-products/canadian-cannabis-survey-2019-summary.html.

11.     Government of Canada. Canadian Cannabis Survey 2020: Summary. [Internet] 2020.
        Available from: https://www.canada.ca/en/health-canada/services/drugs-
        medication/cannabis/research-data/canadian-cannabis-survey-2020-summary.html. .

12.     Substance Abuse and Mental Health Services Administration. Key Substance Use and
        Mental Health Indicators in the United States: Results from the 2019 National Survey on
        Drug Use and Health. [Internet] 2019.  Available from:
        https://www.samhsa.gov/data/sites/default/files/reports/rpt29393/2019NSDUHFFRPDF
        WHTML/2019NSDUHFFR1PDFW090120.pdf

13.     Substance Abuse and Mental Health Services Administration. Key substance use and
        mental health indicators in the United States: Results from the 2018 National Survey on
        Drug Use and Health. [Internet] 2018. Available from:
        https://www.samhsa.gov/data/sites/default/files/cbhsq-
        reports/NSDUHNationalFindingsReport2018/NSDUHNationalFindingsReport2018.pdf

14.     National Academies of Sciences Engineering and Medicine. The Health Effects of
        Cannabis and Cannabinoids: The Current State of Evidence and Recommendations for
        Research. . Washington DC, US: The National Academies Press; 2017.

15.     Stockings E, Campbell G, Hall WD, Nielsen S, Zagic D, Rahman R, et al. Cannabis and
        cannabinoids for the treatment of people with chronic noncancer pain conditions: a
        systematic review and meta-analysis of controlled and observational studies. Pain.
        2018;159(10):1932-54.

16.     Stockings E, Zagic D, Campbell G, Weier M, Hall WD, Nielsen S, et al. Evidence for
        cannabis and cannabinoids for epilepsy: a systematic review of controlled and
        observational evidence. J Neurol Neurosurg Psychiatry. 2018;89(7):741-53.

17.     Eurich DT, Hanlon JG, Boisvenue JJ, Meng H, Dyck JRB. A description of the medical
        cannabis use in Ontario, Canada. Cannabis and Cannabinoid Research. 2019;4:131-5.

18.     Corroon JM, Jr., Mischley LK, Sexton M. Cannabis as a substitute for prescription drugs
        - a cross-sectional study. J Pain Res. 2017;10:989-98.

19.     Lake S, Walsh Z, Kerr T, Cooper ZD, Buxton J, Wood E, et al. Frequency of cannabis
        and illicit opioid use among people who use drugs and report chronic pain: A longitudinal
        analysis. PLoS Med. 2019;16(11):e1002967.

20.     Lucas P, Walsh Z. Medical cannabis access, use, and substitution for prescription opioids and other substances: A survey of authorized medical cannabis patients. Int J Drug Policy. 2017;42:30-5.

21.     Vigil JM, Stith SS, Adams IM, Reeve AP. Associations between medical cannabis and prescription opioid use in chronic pain patients: A preliminary cohort study. PLoS One. 2017;12(11):e0187795.

22.     Walsh Z, Callaway R, Belle-Isle L, Capler R, Kay R, Lucas P, et al. Cannabis for therapeutic purposes: patient characteristics, access, and reasons for use. Int J Drug Policy. 2013;24(6):511-6.

23.     Walsh Z, Gonzalez R, Crosby K, M ST, Carroll C, Bonn-Miller MO. Medical cannabis and mental health: A guided systematic review. Clin Psychol Rev. 2017;51:15-29.

24.     Kosiba JD, Maisto SA, Ditre JW. Patient-reported use of medical cannabis for pain, anxiety, and depression symptoms: Systematic review and meta-analysis. Soc Sci Med. 2019;233:181-92.

25.     Black N, Stockings E, Campbell G, Tran LT, Zagic D, Hall WD, et al. Cannabinoids for the treatment of mental disorders and symptoms of mental disorders: a systematic review and meta-analysis. Lancet Psychiatry. 2019;6(12):995-1010.

26.     Hoch E, Niemann D, von Keller R, Schneider M, Friemel CM, Preuss UW, et al. How effective and safe is medical cannabis as a treatment of mental disorders? A systematic review. Eur Arch Psychiatry Clin Neurosci. 2019;269(1):87-105.

27.     Government of Canada. Justice Laws Website: Cannabis Act (S.C. 2018, c.16) 2018.

28.     Hall W. What has research over the past two decades revealed about the adverse health effects of recreational cannabis use? Addiction. 2015;110(1):19-35.

29.     Hindocha C, Freeman TP, Ferris JA, Lynskey MT, Winstock AR. No Smoke without Tobacco: A Global Overview of Cannabis and Tobacco Routes of Administration and Their Association with Intention to Quit. Front Psychiatry. 2016;7:104.

30.     Lopez-Quintero C, Perez de los Cobos J, Hasin DS, Okuda M, Wang S, Grant BF, et al. Probability and predictors of transition from first use to dependence on nicotine, alcohol, cannabis, and cocaine: results of the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). Drug Alcohol Depend. 2011;115(1-2):120-30.

31.    van der Pol P, Liebregts N, de Graaf R, Korf DJ, van den Brink W, van Laar M. Predicting the transition from frequent cannabis use to cannabis dependence: a three-year prospective study. Drug Alcohol Depend. 2013;133(2):352-9.

32.    Di Forti M, Marconi A, Carra E, Fraietta S, Trotta A, Bonomo M, et al. Proportion of patients in south London with first-episode psychosis attributable to use of high potency cannabis: a case-control study. Lancet Psychiatry. 2015;2(3):233-8.

33.    Di Forti M, Quattrone D, Freeman TP, Tripoli G, Gayer-Anderson C, Quigley H, et al. The contribution of cannabis use to variation in the incidence of psychotic disorder across Europe (EU-GEI): a multicentre case-control study. Lancet Psychiatry. 2019;6(5):427-36.

34.    Semple DM, McIntosh AM, Lawrie SM. Cannabis as a risk factor for psychosis: systematic review. J Psychopharmacol. 2005;19(2):187-94.

35.    Moore TH, Zammit S, Lingford-Hughes A, Barnes TR, Jones PB, Burke M, et al. Cannabis use and risk of psychotic or affective mental health outcomes: a systematic review. Lancet. 2007;370(9584):319-28.

36.    Lev-Ran S, Roerecke M, Le Foll B, George TP, McKenzie K, Rehm J. The association between cannabis use and depression: a systematic review and meta-analysis of longitudinal studies. Psychol Med. 2014;44(4):797-810.

37.    Degenhardt L, Coffey C, Romaniuk H, Swift W, Carlin JB, Hall WD, et al. The persistence of the association between adolescent cannabis use and common mental disorders into young adulthood. Addiction. 2013;108(1):124-33.

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

39.    World Health Organization. The health and social effects of nonmedical cannabis use. . Geneva, Switzerland: World Health Organization; 2018.

40.    Rogeberg O, Elvik R. The effects of cannabis intoxication on motor vehicle collision revisited and revised. Addiction. 2016;111(8):1348-59.

41.    Porath A, Kent P, Konefal S. Clearing the smoke on cannabis: Maternal cannabis use during pregnancy - an update. [Internet] 2018. Available from: https://ccsa.ca/sites/default/files/2019-04/CCSA-Cannabis-Maternal-Use-Pregnancy-Report-2018-en.pdf.

42.     Gunn JK, Rosales CB, Center KE, Nunez A, Gibson SJ, Christ C, et al. Prenatal exposure to cannabis and maternal and child health outcomes: a systematic review and meta-analysis. BMJ Open. 2016;6(4):e009986.

43.     Manrique-Garcia E, Zammit S, Dalman C, Hemmingsson T, Andreasson S, Allebeck P. Cannabis, schizophrenia and other non-affective psychoses: 35 years of follow-up of a population-based cohort. Psychol Med. 2012;42(6):1321-8.

44.     Hall W, Degenhardt L. The adverse health effects of chronic cannabis use. Drug Test Anal. 2014;6(1-2):39-45.

45.     Meier MH, Caspi A, Ambler A, Harrington H, Houts R, Keefe RS, et al. Persistent cannabis users show neuropsychological decline from childhood to midlife. Proc Natl Acad Sci USA. 2012;109(40):E2657-64.

46.     Shi Y, Lenzi M, An R. Cannabis Liberalization and Adolescent Cannabis Use: A Cross-National Study in 38 Countries. PLoS One. 2015;10(11):e0143562.

47.     Hopfer C. Implications of marijuana legalization for adolescent substance use. Subst Abus. 2014;35(4):331-5.

48.     Cerda M, Wall M, Feng T, Keyes KM, Sarvet A, Schulenberg J, et al. Association of State Recreational Marijuana Laws With Adolescent Marijuana Use. JAMA Pediatr. 2017;171(2):142-9.

49.     Smart R, Caulkins JP, Kilmer B, Davenport S, Midgette G. Variation in cannabis potency and prices in a newly legal market: evidence from 30 million cannabis sales in Washington state. Addiction. 2017;112(12):2167-77.

50.     Goodman S, Wadsworth E, Leos-Toro C, Hammond D, International Cannabis Policy Study t. Prevalence and forms of cannabis use in legal vs. illegal recreational cannabis markets. Int J Drug Policy. 2020;76:102658.

51.     Colizzi M, Bhattacharyya S. Does Cannabis Composition Matter? Differential Effects of Delta-9-tetrahydrocannabinol and Cannabidiol on Human Cognition. Curr Addict Rep. 2017;4(2):62-74.

52.     Parliament of Canada. Legislative Summary of Bill C-46: An Act to amend the Criminal Code (offences relating to conveyances) and to make consequential amendments to other Acts. [Internet] Publication No. 42-1-C46-E. 2017. Available from:

https://lop.parl.ca/sites/PublicWebsite/default/en_CA/ResearchPublications/LegislativeSummaries/421C46E.

53. Substance Abuse and Mental Health Services Administration. Results from the 2016 National Survey on Drug Use and Health. [Internet] 2016. Available from: https://www.samhsa.gov/data/sites/default/files/NSDUH-DetTabs-2016/NSDUH-DetTabs-2016.pdf

54. National Institute on Drug Abuse. Monitoring the Future Study: Trends in Prevalence of Various Drugs. [Internet] 2021. Available from: https://www.drugabuse.gov/drug-topics/trends-statistics/monitoring-future/monitoring-future-study-trends-in-prevalence-various-drugs

55. Colorado Department of Public Health and Environment. Monitoring health concerns related to marijuana in Colorado: 2016. [Internet] 2016. Available from: www.colorado.gov/cdphe/marijuana-health-report

56. Forecasting and Research Division: Washington State Office of Financial Management. Monitoring impacts of recreational marijuana legalization. 2016 Update Report. [Internet] 2016. Available from: https://www.ofm.wa.gov/sites/default/files/public/legacy/reports/marijuana_impacts_update_2016.pdf

57. Anderson DM, Hansen B, Rees DI, Sabia JJ. Association of Marijuana Laws With Teen Marijuana Use: New Estimates From the Youth Risk Behavior Surveys. JAMA Pediatr. 2019.

58. Dilley JA, Richardson SM, Kilmer B, Pacula RL, Segawa MB, Cerda M. Prevalence of Cannabis Use in Youths After Legalization in Washington State. JAMA Pediatr. 2019;173(2):192-3.

59. Melchior M, Nakamura A, Bolze C, Hausfater F, El Khoury F, Mary-Krause M, et al. Does liberalisation of cannabis policy influence levels of use in adolescents and young adults? A systematic review and meta-analysis. BMJ Open. 2019;9(7):e025880.

60. Cerda M, Mauro C, Hamilton A, Levy NS, Santaella-Tenorio J, Hasin D, et al. Association Between Recreational Marijuana Legalization in the United States and Changes in Marijuana Use and Cannabis Use Disorder From 2008 to 2016. JAMA Psychiatry. 2020;77(2):165-71.

61. Spindle TR, Bonn-Miller MO, Vandrey R. Changing landscape of cannabis: novel products, formulations, and methods of administration. Curr Opin Psychol. 2019;30:98-102.

62. Borodovsky JT, Crosier BS, Lee DC, Sargent JD, Budney AJ. Smoking, vaping, eating: Is legalization impacting the way people use cannabis? Int J Drug Policy. 2016;36:141-7.

63. Ueno LF, Mian MN, Altman BR, Giandelone E, Luce M, Earleywine M. Age-Related Differences in Cannabis Product Use. J Psychoactive Drugs. 2021:1-7.

64. Greaves L, Hemsing N. Sex and Gender Interactions on the Use and Impact of Recreational Cannabis. Int J Environ Res Public Health. 2020;17(2).

65. Cuttler C, Mischley LK, Sexton M. Sex Differences in Cannabis Use and Effects: A Cross-Sectional Survey of Cannabis Users. Cannabis Cannabinoid Res. 2016;1(1):166-75.

66. Cascini F, Aiello C, Di Tanna G. Increasing delta-9-tetrahydrocannabinol (Delta-9-THC) content in herbal cannabis over time: systematic review and meta-analysis. Curr Drug Abuse Rev. 2012;5(1):32-40.

67. Chandra S, Radwan MM, Majumdar CG, Church JC, Freeman TP, ElSohly MA. New trends in cannabis potency in USA and Europe during the last decade (2008-2017). Eur Arch Psychiatry Clin Neurosci. 2019;269(1):5-15.

68. Freeman TP, Craft S, Wilson J, Stylianou S, ElSohly M, Di Forti M, et al. Changes in delta-9-tetrahydrocannabinol (THC) and cannabidiol (CBD) concentrations in cannabis over time: systematic review and meta-analysis. Addiction. 2021;116(5):1000-10.

69. Mahamad S, Wadsworth E, Rynard V, Goodman S, Hammond D. Availability, retail price and potency of legal and illegal cannabis in Canada after recreational cannabis legalisation. Drug Alcohol Rev. 2020;39(4):337-46.

70. Corroon J, Phillips JA. A Cross-Sectional Study of Cannabidiol Users. Cannabis Cannabinoid Res. 2018;3(1):152-61.

71. Williams A. Why is CBD everywhere? [Internet] The New York Times. 2018 October 27. Available at: https://www.nytimes.com/2018/10/27/style/cbd-benefits.html

72. Government of Canada. Canadian Cannabis Survey 2017 Summary. [Internet] 2017. Available from: https://www.canada.ca/en/health-canada/services/publications/drugs-health-products/canadian-cannabis-survey-2017-summary.html.

73.     Orens A, Light M, Lewandowski B, Rowberry J, Saloga C. Market Size and Demand for Marijuana in Colorado 2017 Market Update. [Internet] 2018. Available from: https://www.colorado.gov/pacific/sites/default/files/MED-_Demand_and_Market_Study_082018.pdf.

74.     Oregon Liquor Control Commission. 2019 Recreational Marijuana Supply and Demand Legislative Report. [Internet] 2019. Available from: https://www.oregon.gov/olcc/marijuana/Documents/Bulletins/2019%20Supply%20and%20Demand%20Legislative%20Report%20FINAL%20for%20Publication(PDFA).pdf.

75.     Davenport S. Price and product variation in Washington's recreational cannabis market. Int J Drug Policy. 2019:102547.

76.     Ouellet ML, Macdonald M, Bouchard M, Morselli C, Frank R. The price of cannabis in Canada. Ottawa, ON, Canada: Public Safety Canada= Sécurité publique Canada.; 2017.

77.     Mahamad S, Hammond D. Retail price and availability of illicit cannabis in Canada. Addict Behav. 2019;90:402-8.

78.     Government of Canada. Data on cannabis for medical purposes. [Internet] 2020. Available from: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/research-data/medical-purpose.html?utm_source=Canadian+Public+Health+Assocation&utm_campaign=e77f4588ba-EMAIL_CAMPAIGN_2020_04_27_07_17&utm_medium=email&utm_term=0_1f88f45ba0-e77f4588ba-154369927

79.     Government of Canada. Cannabis for medical purposes under the Cannabis Act: information and improvements. [Internet] 2021. Available from: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/medical-use-cannabis.html.

80.     Canadian Centre on Substance Use and Addiction. Policy and Regulations (Cannabis). [Internet] 2020. Available from: https://www.ccsa.ca/policy-and-regulations-cannabis.

81.     Government of Canada. Backgrounder: Final regulations on new cannabis products. [Internet] 2019. Available from: https://www.canada.ca/en/health-canada/news/2019/06/backgrounder-final-regulations-on-new-cannabis-products.html. .

82.     Government of Quebec. The legislation on cannabis: The cannabis regulation act. [Internet] 2020. Available from: https://encadrementcannabis.gouv.qc.ca/en/loi/loi-encadrant-le-cannabis/.

83.     DISA. Map of marijuana legality by state. [Internet] 2021. Available from: https://disa.com/map-of-marijuana-legality-by-state

84.     ProCon. Legal recreational marijuana states and DC. [Internet] 2021. Available from: https://marijuana.procon.org/legal-recreational-marijuana-states-and-dc/.

85.     NORML. State Laws. [Internet] 2021. Available from: https://norml.org/laws.

86.     Pacula RL, Powell D, Heaton P, Sevigny EL. Assessing the effects of medical marijuana laws on marijuana use: the devil is in the details. J Policy Anal Manage. 2015;34(1):7-31.

87.     Williams AR, Olfson M, Kim JH, Martins SS, Kleber HD. Older, Less Regulated Medical Marijuana Programs Have Much Greater Enrollment Rates Than Newer 'Medicalized' Programs. Health Aff (Millwood). 2016;35(3):480-8.

88.     Williams AR, Santaella-Tenorio J, Mauro CM, Levin FR, Martins SS. Loose regulation of medical marijuana programs associated with higher rates of adult marijuana use but not cannabis use disorder. Addiction. 2017;112(11):1985-91.

89.     Wolf C. A week for the history books. [Internet] 2021. Available from: https://norml.org/blog/2021/04/02/a-week-for-the-history-books/

90.     Colorado General Assembly. Regulated Marijuana Delivery. [Internet] 2019. Available from: http://leg.colorado.gov/bills/HB19-1234

91.     Statistics Canada. Cannabis Economic Account, 1961 to 2017. [Internet] 2018. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/180125/dq180125c-eng.htm.

92.     Armstrong P. Canada's chronic shortage of legal cannabis expected to drag out for years. [Internet] CBC News. 2019 January 23. Available from: https://www.cbc.ca/news/business/canada-cannabis-shortage-years-1.4988195

93.     Statistics Canada. StatsCannabis data availability: Crowdsourced cannabis prices, fourth quarter 2019. [Internet] 2020. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/200123/dq200123c-eng.htm.

94.     Rotermann M. Looking back from 2020, how cannabis use and related behaviours changed in Canada. Health Reports. 2021;32(4):3-14.

95.    Oregon Liquor Control Commission. 2021 Recreational Marijuana Supply and Demand
       Legislative Report. [Internet] 2021. Available from:
       https://www.oregon.gov/olcc/Docs/Legislative_docs/2021-Supply-and-Demand-
       Report.pdf

96.    Caulkins JP, Davenport S, Doanvo A, Furlong K, Siddique A, Turner M, et al.
       Triangulating web & general population surveys: Do results match legal cannabis market
       sales? Int J Drug Policy. 2019;73:293-300.

97.    Bureau of Cannabis Control California. California Cannabis Advisory Committee 2020
       Annual Report. [Internet] 2020. Available from:
       https://www.bcc.ca.gov/about_us/documents/cac_annual_report_2020.pdf.

98.    Bureau of Cannabis Control California. California Cannabis Advisory Committee: 2019
       Annual Report. [Internet] 2019. Available from:
       https://bcc.ca.gov/about_us/documents/cac_annual_report_2019.pdf.

99.    Bureau of Cannabis Control California. California Cannabis Advisory Committee: 2018
       Annual Report. [Internet] 2018. Available from:
       https://www.bcc.ca.gov/about_us/documents/cac_annual_report_2018.pdf.

100.   Burgard DA, Williams J, Westerman D, Rushing R, Carpenter R, LaRock A, et al. Using
       wastewater-based analysis to monitor the effects of legalized retail sales on cannabis
       consumption in Washington State, USA. Addiction. 2019;114(9):1582-90.

101.   Guindon GE, Burkhalter R, Brown KS. Levels and trends in cigarette contraband in
       Canada. Tob Control. 2016;26(5):518-25.

102.   National Academies of Sciences Engineering and Medicine. Understanding the U.S.
       Illicit Tobacco Market. The National Academies Press; 2015.

103.   Stewart B. Why Colorado's black market for marijuana is booming 4 years after
       legalization. [Internet] CBC News. 2018 May 28. Available from:
       https://www.cbc.ca/news/world/colorado-marijuana-black-market-1.4647198

104.   Hughes T. Marijuana's legalization fuels black market in other states. [Internet] USA
       Today. 2017 July 31. Available from:
       https://www.usatoday.com/story/news/nation/2017/07/31/marijuana-black-
       market/507417001/

105. Martin N. Why most Mass. marijuana sales are on the black market, two years after legalization. [Internet] The Boston Globe. 2019 February 2. Available from: https://www.bostonglobe.com/news/marijuana/2019/02/02/illicit-pot-market-remains-stubbornly-robust/Fqq5baxLvgkrTB1ABJRbEL/story.html

106. Murphy K. Cannabis' Black Market Problem. [Internet] Forbes. 2019 April 4. Available from: https://www.forbes.com/sites/kevinmurphy/2019/04/04/cannabis-black-market-problem/?sh=349c99de134f

107. Kaste M. Despite Legalization, Marijuana Black Market Hides in Plain Sight. [Internet] National Public Radio. 2018 May 16. Available from: https://www.npr.org/2018/05/16/610579599/despite-legalization-marijuana-black-market-hides-in-plain-sight

108. Williams J, Banta-Green C, Burgard D. The need for better marijuana sales data. Addiction. 2017;112(12):2179-80.

109. Armstrong MJ. Canada's provinces and territories should disclose cannabis data to support research. CMAJ. 2021;193(10):E341-E2.

110. Adinoff B, Reiman A. Implementing social justice in the transition from illicit to legal cannabis. Am J Drug Alcohol Abuse. 2019;45(6):673-88.

111. Owusu-Bempah A, Luscombe A. Race, cannabis and the Canadian war on drugs: An examination of cannabis arrest data by race in five cities. Int J Drug Policy. 2020:102937.

112. Khenti A. The Canadian war on drugs: structural violence and unequal treatment of Black Canadians. Int J Drug Policy. 2014;25(2):190-5.

113. Nguyen H, Reuter P. How risky is marijuana possession? Considering the role of age, race, and gender. Crime & Delinquency. 2012;58(6).

114. Sabet K. A year after legalization, Illinois' pot industry is a mess. [Internet] Chicago Tribune. 2021 January 13. Available from: https://www.chicagotribune.com/opinion/commentary/ct-opinion-marijuana-dispensaries-legal-illinois-20210113-nex5c42565djtac65rk43dvm5m-story.html

115. Massie G. Illinois erases 500,000 low-level cannabis charges. [Internet] The Independent. 2021 January 02. Available from: https://www.independent.co.uk/news/world/americas/illinois-cannabis-drugs-charges-legalisation-b1781569.html

116. Firth CL, Maher JE, Dilley JA, Darnell A, Lovrich NP. Did marijuana legalization in Washington State reduce racial disparities in adult marijuana arrests? Subst Use Misuse. 2019;54(9):1582-7.

117. Massachusetts Cannabis Control Commission. A baseline review and assessment of the Massachusetts Adult-Use cannabis industry: Market data and Industry participation. [Internet] 2020. Available from: https://mass-cannabis-control.com/wp-content/uploads/2020/02/Market_Data_and_Industry_Participation_February_2020.pdf

118. Valleriani J, Lavalley J, McNeil R. A missed opportunity? Cannabis legalization and reparations in Canada. Can J Public Health. 2018;109(5-6):745-7.

119. Donovan J. Canada must respect Indigenous cannabis laws. [Internet] Policy Options. 2019 August 1. Available from: https://policyoptions.irpp.org/magazines/august-2019/canada-must-respect-indigenous-cannabis-laws/

120. NORML. Virginia: Legalization of adult-use marijuana takes effect July 1, 2021. [Internet] 2021. Available from: https://norml.org/blog/2021/04/07/virginia-legalization-of-adult-use-marijuana-to-take-effect-july-1-2021/

121. Adlin B. New Mexico marijuana legalization bill heads to governor's desk following house and senate votes. Marijuana Moment. 2021. Available from: https://www.marijuanamoment.net/new-mexico-marijuana-legalization-bill-heads-to-governors-desk/

122. Clukey K. New York to expunge convictions with marijuana legalization. [Internet] Bloomberg. 2021 March 28. Available from: https://www.bloomberg.com/news/articles/2021-03-28/new-york-to-expunge-convictions-with-marijuana-legalization

123. Maghsoudi N, Rammohan I, Bowra A, Sniderman R, Tanguay J, Bouck Z, et al. How diverse is Canada's Legal cannabis industry? [Internet] 2020. Available from: https://cdpe.org/wp-content/uploads/dlm_uploads/2020/10/How-Diverse-is-Canada%E2%80%99s-Legal-Cannabis-Industry_CDPE-UofT-Policy-Brief_Final.pdf

124. Hunt P, Pacula RL. Early Impacts of Marijuana Legalization: An Evaluation of Prices in Colorado and Washington. J Prim Prev. 2017;38(3):221-48.

125.    Kilmer B. How will cannabis legalization affect health, safety, and social equity outcomes? It largely depends on the 14 Ps. Am J Drug Alcohol Abuse. 2019;45(6):664-72.

126.    Hall W, Lynskey M. Evaluating the public health impacts of legalizing recreational cannabis use in the United States. Addiction. 2016;111(10):1764-73.

127.    Kilmer B, Caulkins JP, Pacula RL, MacCoun RJ, Reuter PH. Altered State? Assessing how marijuana legalization in California could influence marijuana consumption and public budgets. . Santa Monica, CA, US. RAND Corporation; 2010.

128.    Caulkins JP, Kilmer B, Kleiman M. Marijuana Legalization: What everyone needs to know. . 2nd ed. New York, NY, US.: Oxford University Press; 2016.

129.    Goudie AJ, Sumnall HR, Field M, Clayton H, Cole JC. The effects of price and perceived quality on the behavioural economics of alcohol, amphetamine, cannabis, cocaine, and ecstasy purchases. Drug Alcohol Depend. 2007;89(2-3):107-15.

130.    Kilmer B, Pacula RL. Understanding and learning from the diversification of cannabis supply laws. Addiction. 2017;112(7):1128-35.

131.    Childs J, Stevens J. The state must compete: Optimal pricing of legal cannabis. Canadian Public Administration. 2019;64(4):656-73.

132.    Childs J, Stevens J. A cannabis pricing mistake from California to Canada: government can't tax cannabis optimally. Applied Economic Letters. 2020;24:1-5.

133.    Amlung M, Reed DD, Morris V, Aston ER, Metrik J, MacKillop J. Price elasticity of illegal versus legal cannabis: a behavioral economic substitutability analysis. Addiction. 2019;114(1):112-8.

134.    Kilmer B, Everingham S, Caulkins JP, Midgette G, Pacula RL, Reuter P. What America's users spend on illegal drugs: 2000-2010. Santa Monica, CA, USA: RAND Corporation; 2014.

135.    Caulkins JP. Price and purity analysis for illicit drug: data and conceptual issues. Drug Alcohol Depend. 2007;90 Suppl 1:S61-8.

136.    Caulkins JP, Gurga B, Little C. Economic analysis of drug transaction "cycles" described by incarcerated UK drug dealers. . Glob Crime. 2009;10:94-112.

137.    Caulkins JP, Padman R. Quantity discounts and quality premia for illicit drugs. J Am Stat Assoc. 1993;88:748-57.

138. Clements KW. Pricing and packaging: the case of marijuana. J Business. 2006;79:2019-44.

139. Wadsworth E, Driezen P, Goodman S, Hammond D. Differences in self-reported cannabis prices across purchase source and quantity purchased among Canadians. Addiction Research & Theory. 2020;28(6):474-83.

140. Červený J, van Ours JC. Cannabis prices on the dark web. . European Economic Review. 2019;120.

141. Ontario Cannabis Store. Dried Flower. [Internet] 2021. Available from: https://ocs.ca/collections/dried-flower-cannabis.

142. Freeman TP, Groshkova T, Cunningham A, Sedefov R, Griffiths P, Lynskey MT. Increasing potency and price of cannabis in Europe, 2006-16. Addiction. 2019;114(6):1015-23.

143. Hansen B, Miller K, Seo B, Weber C. Taxing the potency of sin goods: Evidence from recreational cannabis and liquor markets. [Internet] National Tax Journal. 2020. Available from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3560967

144. Caulkins JP, Kilmer B, MacCoun RJ, Pacula RL, Reuter P. Design considerations for legalizing cannabis: lessons inspired by analysis of California's Proposition 19. Addiction. 2012;107(5):865-71.

145. Ben Lakhdar CG, Vaillant N, Wolff FC. Price elasticity of demand for cannabis: does potency matter? Addiction Research & Theory. 2016;24(4):300-12.

146. Davis AJ, Geisler KR, Nichols MW. The price elasticity of marijuana demand: Evidence from crowd-sourced transaction data. . Empirical Economics. 2016;50(4):1171-92.

147. Caulkins JP, Pacula RL. Marijuana Markets: Inferences from reports by the household population. . J Drug Issues. 2006;6(1):173-200.

148. Leos-Toro C, Fong GT, Meyer SB, Hammond D. Cannabis labelling and consumer understanding of THC levels and serving sizes. Drug Alcohol Depend. 2020;208:107843.

149. Vandrey R, Raber JC, Raber ME, Douglass B, Miller C, Bonn-Miller MO. Cannabinoid Dose and Label Accuracy in Edible Medical Cannabis Products. JAMA. 2015;313(24):2491-3.

150. Hammond D, Goodman S. Knowledge of Tetrahydrocannabinol and Cannabidiol Levels Among Cannabis Consumers in the United States and Canada. [Internet] Cannabis and Cannabinoid Research. 2020. https://doi.org/10.1089/can.2020.0092

151. van der Pol P, Liebregts N, de Graaf R, Korf DJ, van den Brink W, van Laar M. Validation of self-reported cannabis dose and potency: an ecological study. Addiction. 2013;108(10):1801-8.

152. Freeman TP, Morgan CJ, Hindocha C, Schafer G, Das RK, Curran HV. Just say 'know': how do cannabinoid concentrations influence users' estimates of cannabis potency and the amount they roll in joints? Addiction. 2014;109(10):1686-94.

153. Kosa KM, Giombi KC, Rains CB, Cates SC. Consumer use and understanding of labelling information on edible marijuana products sold for recreational use in the states of Colorado and Washington. Int J Drug Policy. 2017;43:57-66.

154. Ontario Cannabis Store. A quarterly review: April 1 - June 30, 2020. [Internet] 2020. Available from: https://cannabislaw.report/wp-content/uploads/2020/10/OCS-InsightsReport_Q1-2020-FINAL.pdf

155. Statistics Canada. StatsCannabis data availability: Crowdsourced cannabis prices, third quarter 2018. [Internet] 2018. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/181004/dq181004a-eng.htm.

156. Martin B. Price averages for Canadian cannabis by province. [Internet] Leafly. 2019. Available from: https://www.leafly.ca/news/strains-products/canada-price-averages. .

157. Amlung M, MacKillop J. Availability of legalized cannabis reduces demand for illegal cannabis among Canadian cannabis users: evidence from a behavioural economic substitution paradigm. Can J Public Health. 2019;110(2):216-21.

158. The Canadian Press. Affordable legal cannabis should be priority as illegal pot prices drop, experts say. [Internet] CBC News. 2020 January 24. Available from: https://www.cbc.ca/news/business/cannabis-price-gap-illegal-legal-1.5438899

159. Pacula RL, Sevigny EL. Marijuana liberalization policies: why we can't learn much from policy still in motion. J Policy Anal Manage. 2014;33(1):212-21.

160. Subritzky T, Pettigrew S, Lenton S. Issues in the implementation and evolution of the commercial recreational cannabis market in Colorado. Int J Drug Policy. 2015.

161. Caulkins JP, Bao Y, Davenport S, Fahli I, Guo Y, Kinnard K, et al. Big data on a big new market: Insights from Washington State's legal cannabis market. Int J Drug Policy. 2018;57:86-94.

162. Headset. Price Per Package or Price Per Gram ? A Closer Look at Pricing Data. [Internet] 2019. Available from: https://www.headset.io/blog/price-per-package-or-price-per-gram-a-closer-look-at-pricing-data

163. Anderson DM, Hansen B, Rees DI. Medical Marijuana Laws, Traffic Fatalities, and Alcohol Consumption. . J Law Econ. 2013;56(2):333-69.

164. Press Release. Leaflink Releases Annual Wholesale Cannabis Pricing Guide. [Internet] Marijuana Retail Report. 2021 January 25. Available from: https://marijuanaretailreport.com/leaflink-releases-annual-wholesale-cannabis-pricing-guide/

165. Leaflink. Wholesale Cannabis Pricing Guide 2020. Leaflink.com; 2020.

166. Downs D. US cannabis harvest price report 2020. [Internet] Leafly. 2020 October 21. Available from: https://www.leafly.ca/news/industry/us-marijuana-harvest-price-report-2020

167. Schaneman B. Premium flower demand drives Colorado wholesale marijuana prices to nearly five-year highs. [Internet] Marijuana Business Daily. 2021. Available from: https://mjbizdaily.com/premium-flower-demand-drives-colorado-wholesale-marijuana-prices-to-nearly-five-year-highs/

168. Schaneman B. Michigan wholesale marijuana flower prices soar on tight supply, lack of community approvals. [Internet] Marijuana Business Daily. 2020. Available from: https://mjbizdaily.com/michigan-wholesale-marijuana-flower-prices-soar-on-tight-supply-lack-of-community-approvals/

169. Schaneman B. Wholesale cannabis flower prices in Massachusetts climb on mounting demand, sluggish supply. [Internet] Marijuana Business Daily. 2020. Availabe from: https://mjbizdaily.com/wholesale-cannabis-flower-prices-massachusetts-climb-on-mounting-demand/

170. Schaneman B. Temporary uptick in Washington State wholesale cannabis flower prices on shuttered businesses, unused canopy. [Internet] Marijuana Business Daily. 2020. https://mjbizdaily.com/washington-state-wholesale-cannabis-flower-prices/

171. Schaneman B. Oregon wholesale marijuana flower prices rise after growers exit market, some pivot to hemp. [Internet] Marijuana Business Daily. 2020. https://mjbizdaily.com/oregon-wholesale-marijuana-flower-prices-rise-after-growers-exit-market-pivot-to-hemp/

172. Kush. Retail vs. Wholesale cannabis in 2020. [Internet] 2020. Available from: https://kush.com/blog/cannabis-pricing-wholesale-vs-retail-in-2020/

173. U.S. National Cancer Institute and World Health Organization. The Economics of Tobacco and Tobacco Control. National Cancer Institute Tobacco Control Monograph 21. NIH Publication No. 16-CA-8029A. . Bethesda, MD, US; Geneva, Switzerland: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute, World Health Organization; 2016.

174. International Agency for Research on Cancer. Effectiveness of tax and price policies for tobacco control: IARC Handbook of Cancer Prevention, Volume 14. . Geneva, Switzerland: International Agency for Research on Cancer 2011.

175. Pacula RL, Kilmer B, Wagenaar AC, Chaloupka FJ, Caulkins JP. Developing public health regulations for marijuana: lessons from alcohol and tobacco. Am J Public Health. 2014;104(6):1021-8.

176. Hajizadeh M. Legalizing and Regulating Marijuana in Canada: Review of Potential Economic, Social, and Health Impacts. Int J Health Policy Manag. 2016;5(8):453-6.

177. Pacula RL, Lundberg R. Why Changes in Price Matter When Thinking About Marijuana Policy: A Review of the Literature on the Elasticity of Demand. Public Health Rev. 2014;35(2):1-18.

178. Callaghan RC, Sanches M, Benny C, Stockwell T, Sherk A, Kish SJ. Who consumes most of the cannabis in Canada? Profiles of cannabis consumption by quantity. Drug Alcohol Depend. 2019;205:107587.

179. Midgette G, Davenport S, Caulkins JP, Kilmer B. What America's Users Spend on Illegal Drugs, 2006-2016. RAND Corporation; Santa Monica, California, USA: RAND Corporation; 2019.

180. Manning WG, Blumberg L, Moulton LH. The demand for alcohol: the differential response to price. J Health Econ. 1995;14(2):123-48.

181.    van Ours JC, Williams J. Cannabis prices and dynamics of cannabis use. J Health Econ. 2007;26(3):578-96.

182.    Pacula RL, Grossman M, Chaloupka FJ, O'Malley PM, Johnston LD, Farrelly MC. Marijuana and Youth. In: Gruber, editor. Risky Behavior among Youths: an economic analysis. University of Chicago, Chicago, IL, US2001. p. 271-326.

183.    Kilmer B, Caulkins J, Pacula R, Reuter P. Bringing perspective to illicit markets: estimating the size of the U.S. marijuana market. Drug Alcohol Depend. 2011;119(1-2):153-60.

184.    Hall W, Lynskey M. Assessing the public health impacts of legalizing recreational cannabis use: the US experience. World Psychiatry. 2020;19(2):179-86.

185.    Kilmer B, Kilmer Neel E. Being thoughtful about cannabis legalization and social equity. World Psychiatry. 2020;19(2):194-5.

186.    McLellan AA, Ware MA, Boyd S, Chow G, Jesso M, Kendall P, et al. A frameworkd for the legalization and regulation of cannabis in Canada: The final report of the task force on cannabis legalization and regulation. Government of Canada; 2016.

187.    Government of Canada. Cannabis duty – Calculate the exise duty on cannabis. [Internet] 2019. Available from: https://www.canada.ca/en/revenue-agency/services/tax/businesses/topics/excise-duties-levies/collecting-cannabis.html.

188.    Boesen U. A road map to recreational marijuana taxation. [Internet] The Tax Foundation. 2020. Available from: https://taxfoundation.org/recreational-marijuana-tax/

189.    Villeneuve M. New York legalizes recreational marijuana. [Internet] The Boston Globe. 2021 March 31. Available from: https://www.bostonglobe.com/2021/03/31/marijuana/new-york-legalizes-recreational-marijuana/

190.    Barcott B. Vermont finally Oks retail cannabis stores, years after legalizing. [Internet] Leafly. 2020. Available from: https://www.leafly.com/news/politics/vermont-finally-oks-retail-cannabis-stores-years-after-legalizing

191.    Kilmer B. Marijuana legalization, government revenues, and public budgets: Ten factors to consider. [Internet] 2016. Available from: https://www.rand.org/content/dam/rand/pubs/testimonies/CT400/CT449/RAND_CT449.pdf.

192.    Bellegarde B. Status First Nations to remain tax exempt on marijuana sales on reserve land. [Internet] CBC News. 2018 January 10. Available from: https://www.cbc.ca/news/indigenous/first-nations-tax-exempt-cannabis-1.4481386

193.    Loughead K, Scarboro M. How high are recreational marijuana taxes in your state? [Internet] Tax Foundation. 2018. Available from: https://taxfoundation.org/state-marijuana-taxes-2018/.

194.    Hansen B, Miller K, Weber C. The Taxation of Recreational Marijuana: Evidence from Washington State. The National Bureau of Economic Research: NBER Working Paper No. 23632. 2017.

195.    Washington State Liquor and Cannabis Board. FAQs on marijuana. [Internet] 2018. Available from: https://lcb.wa.gov/mj2015/faqs_i-502.

196.    Emery S, White MM, Gilpin EA, Pierce JP. Was there significant tax evasion after the 1999 50 cent per pack cigarette tax increase in California? Tob Control. 2002;11(2):130-4.

197.    Ontario Agency for Health Protection and Promotion (Public Health Ontario). Ontario tobacco monitoring report 2018. Toronto, ON, Canada: Ontario Agency for Health Protection and Promotion 2019.

198.    Statistics Canada. National Cannabis Survey, second quarter 2018. [Internet] 2018. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/180809/dq180809a-eng.htm.

199.    Statistics Canada. National Cannabis Survey, third quarter 2019. [Internet] 2019. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/191030/dq191030a-eng.htm. .

200.    Alcohol and Gaming Commission of Ontario. Private retail licensing and regulation 2020. [Internet] 2020. Available from: https://www.agco.ca/cannabis/private-retail-licensing-and-regulation. .

201.    Pardo B. Cannabis policy reforms in the Americas: a comparative analysis of Colorado, Washington, and Uruguay. Int J Drug Policy. 2014;25(4):727-35.

202.    Alcohol and Gaming Commission of Ontario. The AGCO now issuing 30 cannabis retail store authorizations per week. [Internet] 2021. Available from:

https://www.agco.ca/blog/cannabis/feb-2021/agco-now-issuing-30-cannabis-retail-store-authorizations-week.

203.    Alcohol and Gaming Commission of Ontario. Status of current cananbis retail store applications. [Internet] 2021. Available from: https://www.agco.ca/status-current-cannabis-retail-store-applications.

204.    Alberta Gaming Liquor Commission. Cannabis Licensee search. [Internet] 2021. Available from: https://aglc.ca/cannabis/retail-cannabis/cannabis-licensee-search

205.    Statistics Canada. The retail cannabis market in Canada: A portrait of the first year. [Internet] 2019. Available from: https://www150.statcan.gc.ca/n1/pub/11-621-m/11-621-m2019005-eng.htm.

206.    Brohl B, Kammerzell R, Koski L, Burack J. Colorado Department of Revenue Enforcement Division. MED 2015 Annual Update. [Internet] 2016. Available from: https://www.colorado.gov/pacific/sites/default/files/2015%20Annual%20Update%20FINAL%2009262016_1.pdf.

207.    Dilley JA, Hitchcock L, McGroder N, Greto LA, Richardson SM. Community-level policy responses to state marijuana legalization in Washington State. Int J Drug Policy. 2017;42:102-8.

208.    Rusby JC, Westling E, Crowley R, Light JM. Legalization of recreational marijuana and community sales policy in Oregon: Impact on adolescent willingness and intent to use, parent use, and adolescent use. Psychol Addict Behav. 2018;32(1):84-92.

209.    Unger JB, Vos RO, Wu JS, Hardaway K, Sarain AYL, Soto DW, et al. Locations of licensed and unlicensed cannabis retailers in California: A threat to health equity? Prev Med Rep. 2020;19:101165.

210.    Shi Y, Meseck K, Jankowska MM. Availability of Medical and Recreational Marijuana Stores and Neighborhood Characteristics in Colorado. J Addict. 2016;2016:7193740.

211.    Amiri S, Monsivais P, McDonell MG, Amram O. Availability of licensed cannabis businesses in relation to area deprivation in Washington state: A spatiotemporal analysis of cannabis business presence between 2014 and 2017. Drug Alcohol Rev. 2019;38(7):790-7.

212. Tabb LP, Fillmore C, Melly S. Location, location, location: Assessing the spatial patterning between marijuana licenses, alcohol outlets and neighborhood characteristics within Washington state. Drug Alcohol Depend. 2018;185:214-8.

213. Firth CL, Carlini BH, Dilley JA, Wakefield J, Hajat A. What About Equity? Neighborhood Deprivation and Cannabis Retailers in Portland, Oregon. Cannabis 2020;3(2):157-72.

214. Morrison C, Gruenewald PJ, Freisthler B, Ponicki WR, Remer LG. The economic geography of medical cannabis dispensaries in California. Int J Drug Policy. 2014;25(3):508-15.

215. Romley JA, Cohen D, Ringel J, Sturm R. Alcohol and environmental justice: the density of liquor stores and bars in urban neighborhoods in the United States. J Stud Alcohol Drugs. 2007;68(1):48-55.

216. Chaiton MO, Mecredy GC, Cohen JE, Tilson ML. Tobacco retail outlets and vulnerable populations in Ontario, Canada. Int J Environ Res Public Health. 2013;10(12):7299-309.

217. Berg CJ, Henriksen L, Cavazos-Rehg PA, Haardoerfer R, Freisthler B. The emerging marijuana retail environment: Key lessons learned from tobacco and alcohol retail research. Addict Behav. 2018;81:26-31.

218. Freisthler B, Gruenewald PJ. Examining the relationship between the physical availability of medical marijuana and marijuana use across fifty California cities. Drug Alcohol Depend. 2014;143:244-50.

219. Leafbuyer Writing Team. State-by-State Guide to Marijuana Delivery Services. [Internet] 2020. Available from: https://www.leafbuyer.com/blog/state-by-state-guide-to-marijuana-delivery-services/.

220. Helling B. Gigworker Marijuana Delivery. [Internet] 2021. Available from: https://gigworker.com/marijuana-delivery/.

221. Loriggio P. Delays in Ontario cannabis delivery could push consumers back to black markets. [Internet] The Canadian Press. 2018 October 25. Available from: https://www.theglobeandmail.com/cannabis/article-delays-in-cannabis-delivery-in-ontario-could-push-consumers-back-to/

222. Leafly Canada Staff. Ontario Cannabis Store launches same-day delivery. [Internet] 2019. Available from: https://www.leafly.com/news/industry/ocs-same-day-delivery

223. Freisthler B, Gruenewald PJ, Treno AJ, Lee J. Evaluating alcohol access and the alcohol environment in neighborhood areas. Alcohol Clin Exp Res. 2003;27(3):477-84.

224. Lipperman-Kreda S, Mair C, Grube JW, Friend KB, Jackson P, Watson D. Density and proximity of tobacco outlets to homes and schools: relations with youth cigarette smoking. Prev Sci. 2014;15(5):738-44.

225. Lipperman-Kreda S, Grube JW, Friend KB. Local tobacco policy and tobacco outlet density: associations with youth smoking. J Adolesc Health. 2012;50(6):547-52.

226. Everson EM, Dilley JA, Maher JE, Mack CE. Post-Legalization Opening of Retail Cannabis Stores and Adult Cannabis Use in Washington State, 2009-2016. Am J Public Health. 2019;109(9):1294-301.

227. Young-Wolff KC, Adams SR, Padon A, Silver LD, Alexeeff SE, Van Den Eeden SK, et al. Association of Cannabis Retailer Proximity and Density With Cannabis Use Among Pregnant Women in Northern California After Legalization of Cannabis for Recreational Use. JAMA Netw Open. 2021;4(3):e210694.

228. Pedersen ER, Firth CL, Rodriguez A, Shih RA, Seelam R, Kraus L, et al. Examining Associations Between Licensed and Unlicensed Outlet Density and Cannabis Outcomes From Preopening to Postopening of Recreational Cannabis Outlets. Am J Addict. 2021;30(2):122-30.

229. Shih RA, Rodriguez A, Parast L, Pedersen ER, Tucker JS, Troxel WM, et al. Associations between young adult marijuana outcomes and availability of medical marijuana dispensaries and storefront signage. Addiction. 2019;114(12):2162-70.

230. Wouters M, Benschop A, van Laar M, Korf DJ. Cannabis use and proximity to coffee shops in the Netherlands. European Journal of Criminology. 2012;9:337-53.

231. Harpin SB, Brooks-Russell A, Ma M, James KA, Levinson AH. Adolescent Marijuana Use and Perceived Ease of Access Before and After Recreational Marijuana Implementation in Colorado. Subst Use Misuse. 2018;53(3):451-6.

232. Sarvet AL, Wall MM, Fink DS, Greene E, Le A, Boustead AE, et al. Medical marijuana laws and adolescent marijuana use in the United States: a systematic review and meta-analysis. Addiction. 2018;113(6):1003-16.

233. Salas-Wright CP, Vaughn MG. Marijuana use among young people in an era of policy change: what does recent evidence tell us? Am J Drug Alcohol Abuse. 2017;43(3):231-3.

234. Paschall MJ, Grube JW. Recreational Marijuana Availability in Oregon and Use Among Adolescents. Am J Prev Med. 2020;58(2):e63-e9.

235. Shi Y. The availability of medical marijuana dispensary and adolescent marijuana use. Prev Med. 2016;91:1-7.

236. Shi Y, Cummins SE, Zhu SH. Medical Marijuana Availability, Price, and Product Variety, and Adolescents' Marijuana Use. J Adolesc Health. 2018;63(1):88-93.

237. Hust SJT, Willoughby JF, Li J, Couto L. Youth's Proximity to Marijuana Retailers and Advertisements: Factors Associated with Washington State Adolescents' Intentions to Use Marijuana. J Health Commun. 2020;25(7):594-603.

238. IARC Working Group on Methods for Evaluating Tobacco Control Polices. International Agency for Research on Cancer: Methods for evaluating tobacco control policies. [Internet] 2008. Available from: https://publications.iarc.fr/Book-And-Report-Series/Iarc-Handbooks-Of-Cancer-Prevention/Methods-For-Evaluating-Tobacco-Control-Policies-2008.

239. International Agency for Research on Cancer and World Health Organisation. IARC Handbooks of Cancer Prevention, Tobacco Control, Vol. 14: Effectiveness of Tax and Price Policies for Tobacco Control Lyon, France: International Agency for Research on Cancer and World Health Organisation; 2011.

240. Fong GT, Cummings KM, Borland R, Hastings G, Hyland A, Giovino GA, Hammond D, Thompson ME. The conceptual framework of the International Tobacco Control (ITC) Policy Evaluation Project. Tobacco Control. 2006;15(Suppl III):iii3-iii11.

## Chapter 2

1. Hammond D, Goodman S, Wadsworth E, Rynard V, Boudreau C, Hall W. Evaluating the impacts of cannabis legalization: The International Cannabis Policy Study. Int J Drug Policy. 2020;77:102698.

2. American Association for Public Opinion Research. Standard definitions: Final dispositions of case codes and outcome rates for surveys. [Internet] 2016. Available from: https://www.aapor.org/AAPOR_Main/media/publications/Standard-Definitions20169theditionfinal.pdf.

3. Goodman S, Hammond D. International Cannabis Policy Study Technical Report - Wave 1 (2018). University of Waterloo, Waterloo, ON, Canada: University of Waterloo; 2019.

4. Goodman S, Burkhalter R, Hammond D. International Cannabis Policy Study Technical Report - Wave 2 (2019). University of Waterloo, Waterloo, ON, Canada: University of Waterloo; 2020.

5. Goodman S, Burkhalter R, Hammond D. International Cannabis Policy Study Technical Report - Wave 3 (2020). University of Waterloo; Waterloo, ON, Canada: University of Waterloo; 2021.

6. Hammond D, Goodman S, Leos-Toro C, Wadsworth E, Reid JL, Hall W, Pacula R, Driezen P, George T, Rehm J, Werb D, Boudreau C, Porath A, Abramovici H, Elliot TR. International Cannabis Policy Study Wave 1 survey (2018). University of Waterloo, Waterloo, ON, Canada: University of Waterloo; 2018.

7. Hammond D, Goodman S, Wadsworth E, Abramovici H, Carnide N, Chaiton M, Driezen P, Greaves L, Hall W, Hemsing N, Kaufman P, Mahamad S, Owusu-Bempah A, Porath A. International Cannabis Policy Study Wave 2 (2019). University of Waterloo, Waterloo, ON, Canada: University of Waterloo; 2019.

8. Hammond D, Goodman S, Wadsworth E, Abramovici H, Acton R, Carnide N, Chaiton M, Driezen P, Freeman T, Greaves L, Hall W, Hemsing N, Hobin E, Kaufman P, Mahamad S, Owusu-Bempah A, Porath A. International Cannabis Policy Study Wave 3 (2020). University of Waterloo, Waterloo, ON, Canada: University of Waterloo; 2020.

9. Sikorski C, Leos-Toro C, Hammond D. Cannabis consumption, purchasing and sources among young Canadians: The Cannabis Purchase and Consumption Tool (CPCT). Substance use & Misuse, 2021;56(4):449-457.

10. Goodman S, Leos-Toro C, Hammond D. Methods to assess cannabis consumption in population surveys: Results of cognitive interviewing. Qualitative Health Research. 2019, 29 (10): 1474-1482. doi:10.1177/1049732318820523

11. Canadian Centre on Substance Use and Addiction. Policy and Regulations (Cannabis). [Internet] 2021. Available from: https://www.ccsa.ca/policy-and-regulations-cannabis

12. Ontario Cannabis Store. A quarterly review: April 1 - June 30, 2020. [Internet] 2020. Available from: https://cannabislaw.report/wp-content/uploads/2020/10/OCS-InsightsReport_Q1-2020-FINAL.pdf

13. Alberta Gaming Liquor Commission. Cannabis Licensee search. [Internet] 2021. Available from: https://aglc.ca/cannabis/retail-cannabis/cannabis-licensee-search

14. Alcohol and Gaming Commission of Ontario. Status of current cananbis retail store applications. [Internet]. 2021. Available from: https://www.agco.ca/status-current-cannabis-retail-store-applications

15. Statistics Canada. Estimates of population as of July 1st, by marital status or legal marital status, age and sex. Table 17-10-0060-01. [Internet] 2021. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710006001

16. Statistics Canada. Postal Code Conversion File Plus (PCCF+). [Internet] 2020. Available from: https://www150.statcan.gc.ca/n1/en/catalogue/82F0086X.

17. Pinault L, Khan S, Tjepkema M. Accuracy of matching residential postal codes to census geography. Health Reports. 2020;31:3-13

18. Bow CJD, Waters NM, Faris PD, Seidel JE, Galbraith D, Knudtson ML, et al. Accuracy of city postal code coordinates as a proxy for location of residence. Int J Health Geog. 2004;3:1-9.

19. Statistics Canada. Analysis in brief: The retail cannabis market in Canada: A portrait of the first year. [Internet] 2019. Available from: https://www150.statcan.gc.ca/n1/pub/11-621-m/11-621-m2019005-eng.htm

20. Statistics Canada. Table 17-10-0005-01 Population estimates on July 1st, by age and sex. [Internet] 2017. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501

21. Statistics Canada. Census of Population, Statistics Canada Catalogue no. 98-400-X2016242. Highest Certificate, Diploma or Degree. [Internet] 2016. Available at: https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/dt-td/Rp-eng.cfm?LANG=E&APATH=3&DETAIL=0&DIM=0&FL=A&FREE=0&GC=0&GID=0&GK=0&GRP=1&PID=110634&PRID=10&PTYPE=109445&S=0&SHOWALL=0&SUB=0&Temporal=2017&THEME=123&VID=0&VNAMEE=&VNAMEF

22. Statistics Canada. Table 17-10-0005-01 Population estimates on July 1st, by age and sex. [Internet] 2019. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501

23. U.S. Census Bureau, Population Division. Annual State Resident Population Estimates for 6 Race Groups (5 Race Alone Groups and Two or More Races) by Age, Sex, and Hispanic Origin: April 1, 2010 to July 1, 2018. File: 7/1/2018 State Characteristics Population Estimates Release Date: June 2019. [Internet] 2019. Available from: https://www.census.gov/data/datasets/time-series/demo/popest/2010s-state-detail.html

24. U.S. Census Bureau, American Community Survey. American Community Survey 1-Year Estimates, Table S1501 generated using data.census.gov. [Internet] 2018. Available from: https://data.census.gov/cedsci/table?q=Educational%20Attainment%20in%20the%20United%20States&g=0100000US.04000.001&hidePreview=true&tid=ACSST1Y2018.S1501&vintage=2018&cid=S1501_C01_001E&moe=false

25. Atb Associates. MACRO RAKE AND TRIM G4 V5. [Internet]. 2016. Available from: https://www.abtassociates.com/sites/default/files/files/Insights/Tools/rake_and_trim_G4_V5.sas

26. Battaglia MP, Izrael D, Ball SW. Tips and tricks for raking survey data with advanced weight trimming. [Internet]. 2017. Available from: https://www.abtassociates.com/sites/default/files/files/Insights/Tools/SD_62_2017.pdf

27. Atb Associates. Raking survey data (a.k.a. Sample balancing). [Internet]. 2021. Available from: https://www.abtassociates.com/raking-survey-data-aka-sample-balancing

28. Mahamad S, Hammond D. Retail price and availability of illicit cannabis in Canada. Addict Behav. 2019;90:402–8.

29. Mahamad S, Wadsworth E, Rynard V, Goodman S, Hammond D. Availability, retail price and potency of legal and illegal cannabis in Canada after recreational cannabis legalisation. Drug and alcohol review. 2020 May;39(4):337-46.

30. Mahamad S, Goodman S, Hammond D. Cannabis Retail Scan - March 2020. University of Waterloo, Waterloo, ON, Canada. [Internet] 2021. Available from: http://cannabisproject.ca/methods/.

31. Headset. Price per package or price per gram? A closer look at pricing data. [Internet] 2020. Available from: https://www.headset.io/industry-reports/price-per-package-or-price-per-gram-a-closer-look-at-pricing-data

32. Editorial Staff. The Average Cost of Marijuana by State. [Internet] Oxford Treatment Center. 2020. Available from: https://oxfordtreatment.com/substance-abuse/marijuana/average-cost-of-marijuana/

33. Buzdu. Weed Prices. [Internet] 2020. Available from: http://budzu.com/prices

34. Austin, K. Guide to Cannabis Prices in 2021. [Internet] Save on Cannabis. 2020. Available from: https://saveoncannabis.com/weed-price-guide/

35. Mikulic, M. U.S. high quality marijuana prices per ounce in 2020 by state. [Internet] 2020. Available from: https://www.statista.com/statistics/589688/medical-marijuana-prices-by-state/

36. Smart R, Caulkins JP, Kilmer B, Davenport S, Midgette G. Variation in cannabis potency and prices in a newly legal market: evidence from 30 million cannabis sales in Washington state. Addiction. 2017;112(12):2167–77.

37. Caulkins JP, Bao Y, Davenport S, Fahli I, Guo Y, Kinnard K, et al. Big data on a big new market: Insights from Washington State's legal cannabis market. Int J Drug Policy. 2018;57:86–94.

# Chapter 3

1. United Nations Office on Drugs and Crime. Market Analysis of Plant-Based Drugs: Opiates, cocaine, cannabis. In World Drug Report 2017. (ISBN: 978-92-1-148291-1, eISBN: 978-92-1-060623-3, United Nations publication, Sales No. E.17.XI.6

2. Statistics Canada. Canadian Tobacco, Alcohol and Drugs Survey (CTADS), 2017. [Internet] 2018. Available from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=4440

3. Government of Canada. Canadian Cannabis Survey 2018 Summary. [Internet] 2018. Available from: https://www.canada.ca/en/services/health/publications/drugs-health-products/canadian-cannabis-survey-2018-summary.html

4. Mahamad S, Hammond D. Retail price and availability of illicit cannabis in Canada. Addict Behav. 2019;90:402–408.

5. Parliament of Canada. Bill C-45: An Act respecting cannabis and to amend the Controlled Drugs and Substances Act, the Criminal Code and other Acts. [Internet]

Ottawa, ON. 2018 Available from: http://www.parl.ca/DocumentViewer/en/42-1/bill/C-45/royal-assent

6.  Statistics Canada. Cannabis Economic Account, 1961 to 2017. [Internet] 2018. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/180125/dq180125c-eng.htm

7.  Department of Finance Canada. Cannabis Excise Duty Rates in Provinces and Territories. [Internet] 2018. Available from: https://www.fin.gc.ca/n18/data/18-084_2-eng.asp

8.  Chaloupka FJ, Yurekli A, Fong GT. Tobacco taxes as a tobacco control strategy. Tob Control. 2012;21(2):172-80. doi: 10.1136/tobaccocontrol-2011-050417.

9.  Babor TF, Alcohol and Public Policy Group. 2010. Alcohol: No ordinary commodity – a summary of the second edition. Addiction. 105:769-779.

10. Wright A, Smith KE, Hellowell M. Policy lessons from health taxes: A systematic review of empirical studies. BMC Public Health. 2017;17: 583.

11. Clements K, Zhao X. Economics and marijuana consumption, pricing and legalisation. Cambridge, UK; New York: Cambridge University Press. 2019. ISBN: 9780521884952.

12. Maslov A, Lawrence J, Ferguson M. Cannabis Performance Metrics for Policy Consideration: What Do We Need to Measure? [Internet] Public Safety Canada. 2016. Available from: https://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/2016-r009/2016-r009-en.pdf

13. US National Cancer Institute and World Health Organization. The Economics of Tobacco and Tobacco Control. National Cancer Institute Tobacco Control Monograph 21. NIH Publication No. 16-CA-8029A. Bethesda, MD: US Department of Health and Human Services, National Institutes of Health, National Cancer Institute; and Geneva: World Health Organization. 2016.

14. Pacula RL, Lundberg R. Why Changes in Price Matter When Thinking About Marijuana Policy : A Review of the Literature on the Elasticity of Demand. Public Health Rev. 2015;35(2):1–15.

15. Kilmer B, Everingham SS, Caulkins JP, Midgette G, Pacula R, Reuter P, et al. 2014. What America's Users Spend on Illegal Drugs, 2000-2010. Santa Monica, CA: Rand Corporation

16. Manning WG, Blumberg L, Moulton LH. The demand for alcohol: The differential response to price. J Health Econ. 1995;14(2):123–48.

17. Pacula RL, Grossman M, Chaloupka FJ, O'Malley PM, Johnston LD, Farrelly MC. Marijuana and Youth. In: Gruber, editor. Risky Behavior among Youths: an economic analysis. 2001. University of Chicago Press; Chicago, IL: p271–326.

18. Williams J, Pacula RL, Chaloupka FJ, Wechsler H. Alcohol and Marijuana Use Among College Students: Economic Complements or Substitutes? Health Econ. 2004;13(9):825-43

19. Caulkins JP, Pacula RL. Marijuana markets: Inferences from reports by the household population. J Drug Issues. 2006;36(1):173-200.

20. van Ours JC, Williams J. Cannabis prices and dynamics of cannabis use. J Health Econ. 2007;26(3):578–96.

21. Davis AJ, Geisler KR, Nichols MW. The price elasticity of marijuana demand: evidence from crowd-sourced transaction data. Empir Econ. 2016;50(4):1171–92.

22. Hall W, Lynskey M. Evaluating the public health impacts of legalizing recreational cannabis use in the United States. Addiction. 2016;111(10):1764–1773.

23. Wagenaar AC, Salois MJ, Komro KA. Effects of beverage alcohol price and tax levels on drinking: a meta-analysis of 1003 estimates from 112 studies. Addiction. 2009;104(2): 179-190.

24. Caulkins J. Drug prices and emergency department mentions of cocain and heroin. Am J Public Health. 2001;91 (9): 1446-1448

25. Lopez-Quintero C, de los Cobos JP, Hasin DS, Okuda M, Wang S, Grant BF, et al. Probability and predictors of transition from first use to dependence on nicotine, alcohol, cannabis, and cocaine: Results of the National Epidemiologic Survey on Alcohol and related Conditions (NESARC). Drug Alcohol Depend. 2011;115(1-2):120-130.

26. Hall W. What has research over the past two decades revelaed about the adverse health effects of recreational cannabis use? Addiction. 2014;110(1):19-35.

27. van der Pol P, Liebregts N, de Graaf R, Korf DJ, van den Brink W, van Laar M. Predicting the transition from frequent cannabis use to cannabis dependence: A three-year prospective study. Drug Alcohol Depend. 2013;133(2):352-359.

28. Statistics Canada. StatsCannabis data availability: Crowdsourced cannabis prices, third quarter 2018. [Internet] 2018. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/181004/dq181004a-eng.htm

29.    Ouellet M, Macdonald M, Bouchard M, Morselli C, Frank R. The Price of Cannabis in Canada. [Internet] Public Safety Canada (Vol. 112). 2017. Available from: https://doi.org/10.1111/add.13623

30.    Hunt P, Pacula RL. Early Impacts of Marijuana Legalization: An Evaluation of Prices in Colorado and Washington. J Prim Prev. 2017;38(3):221–248.

31.    Kilmer B, Caulkins JP, Pacula RL, MacCoun RJ, Reuter PH. Altered State? Assessing how marijuana legalization in California could influence marijuana consumption and public budgets. Santa Monica, CA. 2010.

32.    Statistics Canada. StatsCannabis data availability: Crowdsourced cannabis prices, second quarter 2019. [Internet] 2019. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/190710/t001c-eng.htm

33.    Orens A, Light M, Lewandowski B, Rowberry J, Saloga C. Market Size and Demand for Marijuana in Colorado: 2017 Market Update. Prepared for the Colorado Department of Revenue. [Internet] 2018. Available from: https://www.colorado.gov/pacific/sites/default/files/MED%20Demand%20and%20Market%20%20Study%20%20082018.pdf

34.    Oregon Liquor Control Commission. 2019 Recreational Marijuana Supply and Demand Legislative Report. [Internet] 2019. Available from: https://www.oregon.gov/olcc/marijuana/Documents/Bulletins/2019%20Supply%20and%20Demand%20Legislative%20Report%20FINAL%20for%20Publication(PDFA).pdf

35.    Pacula RL, Sevigny EL. Marijuana Liberalization Policies: Why We Can't Learn Much from Policy Still in Motion. J Policy Anal Manag. 2014;33(1):212–221.

36.    Subritzky T, Pettigrew S, Lenton S. Issues in the implementation and evolution of the commercial recreational cannabis market in Colorado. Int J Drug Pol. 2016;27:1–12.

37.    Statistics Canada. 2016 Census of Population, Statistics Canada Catalogue no. 98-400-X2016242. Highest Certificate, Diploma or Degree. [Internet] 2016. Available from: https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/dt-td/Rp-eng.cfm?LANG=E&APATH=3&DETAIL=0&DIM=0&FL=A&FREE=0&GC=0&GID=0&GK=0&GRP=1&PID=110634&PRID=10&PTYPE=109445&S=0&SHOWALL=0&SUB=0&Temporal=2017&THEME=123&VID=0&VNAMEE=&VNAMEF

38.    Statistics Canada. Table  17-10-0005-01 Population estimates on July 1st, by age and sex,

2017. [Internet] 2017. Available from:
https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501

39.     Wagenaar AC, Tobler AL, Komro KA. Effects of Alcohol Tax and Price Policies on Morbidity and Mortality: A Systematic Review. Am J Public Health. 2010;100(11): 2270-2278.

40.     Stockwell T, Auld MC, Zhao J, Martin G. Does minimum pricing reduce alcohol consumption? The experience of a Canadian province. Addiction. 2011;107(5):912–920.

41.     Hall W. Alcohol and cannabis: Comparing their adverse health effects and regulatory regimes. Int J Drug Policy. 2017;42:57-62.

42.     US Department of Health and Human Services. The health consequences of smoking: 50 years of progress. A Report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease  Prevention and Health Promotion, Office on Smoking and Health. 2014.

43.     Ontario Cannabis Store. Dried Cannabis. [Internet] 2019. Available from:
https://ocs.ca/collections/dried-cannabis-cannabis

44.     Caulkins JP, Gurga B, Little C. Economic analysis of drug transaction "cycles" described by incarcerated UK drug dealers. Global Crime. 2009;10(1–2):94–112.

45.     Caulkins JP, Padman R. Quantity Discounts and Quality Premia for Illicit Drugs. J Am Stat Assoc. 1993;88(423):748.

46.     Clements KW. Pricing and Packaging: The Case of Marijuana*. J Bus. 2006;79(4):2019–2044.

47.     Smart R, Caulkins JP, Kilmer B, Davenport S, Midgette G. Variation in cannabis potency and prices in a newly legal market: evidence from 30 million cannabis sales in Washington state. Addiction. 2017;112(12):2167–2177.

48.     Cole JC, Goudie AJ, Field M, Loverseed AC, Charlton S, Sumnall HR. The effects of perceived quality on the behavioural economics of alcohol, amphetamine, cannabis, cocaine, and ecstasy purchases. Drug Alcohol Depend. 2008; 94(1-3):183-190.

49.     Lakhdar C, Vaillant NG, Wolff FC. Price elasticity of demand for cannabis: Does potency matter? Addict Res Theory. 2016;24(4):300–312.

50.     Hathaway AD, Mostaghim A, Erickson PG, Kolar K, Osborne G. "It's Really No Big

Deal": The Role of Social Supply Networks in Normalizing Use of Cannabis by Students at Canadian Universities. Deviant Behav. 2018;39(12):1672–1680.

51.    Reinarman C. Cannabis policies and user practices: Market separation, price, potency, and accessibility in Amsterdam and San Francisco. Int J Drug Pol. 2009; 20(1):28–37.

52.    Krumpal I. Determinants of social desirability bias in sensitive surveys: A literature review. Qual Quant. 2013;47:2025-2047.

53.    Freeman TP, Groshkova T, Cunningham A, Sedefov R, Griffiths P, Lynskey MT. Increasing potency and price of cannabis in Europe, 2006–16. Addiction. 2018;114(6):1015-1023.

54.    Statistics Canada. National Cannabis Survey, third quarter 2018. [Internet] 2018. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/181011/dq181011b-eng.htm

55.    Canadian Centre on Substance Use and Addiction. Cannabis regulation: lessons learned in Colorado and Washington State. [Internet] Ottawa, ON: CCSA. 2015. Available from: http://www.ccsa.ca/Resource%20Library/CCSA-Cannabis-Regulation-Lessons-Learned-Report-2015-en.pdf

56.    Colorado Department of Revenue. Marijuana tax data. [Internet] 2018. Available from: https://www.colorado.gov/pacific/revenue/colorado-marijuana-tax-data

57.    State of Nevada. Marijuana in Nevada: Taxes. [Internet] 2017. Available from: http://marijuana.nv.gov/Businesses/Taxes/

58.    Washington State Liquor and Cannabis Board. FAQs on Marijuana. [Internet] 2018. Available from: https://lcb.wa.gov/mj2015/faqs_i-502

## Chapter 4

1.    Government of Canada. Backgrounder: Final regulations on new cannabis products. [Internet] 2019. Available from: https://www.canada.ca/en/health-canada/news/2019/06/backgrounder-final-regulations-on-new-cannabis-products.html

2.    Government of Canada. Canadian Cannabis Survey 2019 – Summary. [Internet] 2019. Available from: https://www.canada.ca/en/health-canada/services/publications/drugs-health-products/canadian-cannabis-survey-2019-summary.html

3.    Government of Canada. Justice Laws Website: Cannabis Act (S.C. 2018, c.16).

4.      McLellan A, Ware MA, Boyd S, Chow G, Jesso M, Kendall P. A Framework for the Legalization and Regulation of Cannabis in Canada: The Final Report of the Task Force on Cannabis Legalization and Regulation. [Internet] 2016. Available from: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/laws-regulations/task-force-cannabis-legalization-regulation/framework-legalization-regulation-cannabis-in-canada.html

5.      Mahamad S, Hammond D. Retail price and availability of illicit cannabis in Canada. Addict Behav. 2019;90, 402-8.

6.      Statistics Canada. Cannabis Economic Account, 1961 to 2017. [Internet] 2018. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/180125/dq180125c-eng.htm

7.      Government of Canada. Canadian Cannabis Survey 2020: Summary. [Internet] 2020. Available from: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/research-data/canadian-cannabis-survey-2020-summary.html

8.      Statistics Canada. National Cannabis Survey, third quarter 2019. [Internet] 2019. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/191030/dq191030a-eng.htm

9.      Driezen P, Gundon GE, Hammond D, Thompson ME, Quah ACK, Fong GF. Contraband cigarette purchasing from First Nation reserves in Ontario and Quebec: Findings from the 2020-2014 ITC Canada Survey. Int J Drug Policy. 2020;75,102612.

10.     Guindon, GE, Burkhalter R, Brown KS. Levels and trends in cigarette contraband in Canada. Tob Control. 2016;26:518-525.

11.     Tilson M. Reducing the availability of tobacco products at retail: policy analysis. [Internet] Non-Smokers Rights Association. 2011. Available from: https://www.nsra-adnf.ca/cms/file/files/Reducing_Retail_Availabilty_policy_analysis_final_2011.pdf

12.     Bryden A, Roberts B, McKee M, Petticrew M. A systematic review of the influence on alcohol use of community level availability and marketing of alcohol. Health Place. 2012;18, 349-357.

13.     Popova S, Giesbrecht N, Bekmuradov D, Patra J. Hours and Days of sale and density of alcohol outlets: Impacts on alcohol consumption and damage: A systematic review. Alcohol Alcohol. 2009; 44, 500-516.

14. Canadian Centre for Substance Use and Addiction. Policy and Regulations (Cannabis). [Internet] 2021. Available from: https://www.ccsa.ca/policy-and-regulations-cannabis

15. Armstrong P. Canada's chronic shortage of legal cannabis expected to drag out for years. [Internet] CBC News. 2019 January 23. Available from: https://www.cbc.ca/news/business/canada-cannabis-shortage-years-1.4988195.

16. Statistics Canada. Analysis in brief: The retail cannabis market in Canada: A portrait of the first year. [Internet] 2019. Available from: https://www150.statcan.gc.ca/n1/pub/11-621-m/11-621-m2019005-eng.htm

17. Alberta Gaming Liquor and Cannabis. Cannabis license search 2020. [Internet] 2020. Available from: https://aglc.ca/cannabis/retail-cannabis/cannabis-licensee-search.

18. Alcohol and Gaming Commission of Ontario. Private retail licensing and regulation 2020. [Internet] 2020. Available from: https://www.agco.ca/cannabis/private-retail-licensing-and-regulation.

19. Unger JB, Vos RO, Wu JS, Hardaway K, Sarain AYL, Soto DW. Locations of licensed and unlicensed cannabis retailers in California: A threat to health equity? Prev Med Reports. 2020;19, 101165.

20. Amiri S, Monsivais P, McDonell MG, Amram O. Availability of licensed cannabis businesses in relation to area deprivation in Washington state: A spatiotemporal analysis of cannabis business presence between 2014 and 2017. Drug Alcohol Rev. 2019;38, 790-7.

21. Firth CL, Carlini BH, Dilley JA, Wakefield J, Hajat A. What About Equity? Neighborhood Deprivation and Cannabis Retailers in Portland, Oregon. Cannabis. 2020; 3, 157-72.

22. Tabb LP, Fillmore C, Melly S. Location, location, location: assessing the spatial patterning between marijuana licenses, alcohol outlets and neighborhood characteristics within Washington state. Drug Alcohol Depend. 2010;185, 214-8.

23. Palali A, van Ours JC. Distance to cannabis shops and age of onset of cannabis use. Health Econ. 2015;24, 1483-501.

24. Pedersen ER, Firth CL, Rodriguez A, Shih RA, Seelam R, Kraus L. Examining associations between licensed and unlicensed outlet density and cannabis outcomes from

preopening to postopening of recreational cannabis outlets. Am J Addict. 2020. doi: 10.1111/ajad.13132.

25.  Rusby JC, Westling E, Crowley R, Light JM. Legalization of recreational marijuana and community sales policy in Oregon: Impact on adolescent willingness and intent to use, parent use, and adolescent use. Psychol Addict Behav. 2018;32, 84.

26.  Shi Y, Cummins SE, Zhu SH. Medical marijuana availability, price, and product variety, and adolescents' marijuana use. J Adol Health. 2018;63, 88-93.

27.  Wouters M, Benschop A, van Laar M, Korf DJ. Cannabis use and proximity to coffee shops in the Netherlands. Eur J Crim. 2012;9, 337-53.

28.  Everson EM, Dilley JA, Maher JE, Mack CE. Post-Legalization Opening of Retail Cannabis Stores and Adult Cannabis Use in Washington State, 2009–2016. Am J Public Health. 2019;109, 1294-301.

29.  American Association for Public Opinion Research. Standard definitions: Final dispositions of case codes and outcome rates for surveys. [Internet] 2016. Available from: https://www.aapor.org/AAPOR_Main/media/publications/Standard-Definitions20169theditionfinal.pdf.

30.  Hammond D Goodman S, Wadsworth E, Rynard V, Boudreau C, Hall W. Evaluating the impacts of cannabis legalization: The International Cannabis Policy Study. Int J Drug Policy. 2020;77, 102698.

31.  Statistics Canada. Estimates of population as of July 1st, by marital status or legal marital status, age and sex. Table: 17-10-0060-01 (formerly CANSIM 051-0042). [Internet] 2020. Available from:
https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710006001

32.  Statistics Canada. Postal Code Conversion File Pus (PCCF+). [Internet] 2020. Available from: https://www150.statcan.gc.ca/n1/en/catalogue/82F0086X.

33.  Bow CJD, Waters NM, Faris PD, Seidel JE, Galbraith D, Knudtson ML, et al. Accuracy of city postal code coordinates as a proxy for location of residence. Int J Health Geog. 2004;3:1-9.

34.  Pinault L, Khan S, Tjepkema M. Accuracy of matching residential postal codes to census geography. Health Reports. 2020;31:3-13

35. Armstrong MJ. Legal cannabis market shares during Canada's first year of recreational legalisation. Int J Drug Policy. 2020;88, 103028. Doi: 10.1016/j.drugpo.2020.103028

36. Myran DT, Brown CR, Tanuseputro P. Access to cannabis retail stores across Canada 6 months following legalization: a descriptive study. CMAJ open. 2019;7, E454. DOI: 10.9778/cmajo.20190012

37. Berg CJ, Henriksen L, Cavazos-Rehg PA, Haardoerfer R, Freisthler B. The emerging marijuana retail environment: Key lessons learned from tobacco and alcohol retail research. Addict Behav. 2018;81, 26-31.

38. Freisthler B, Gruenewald PJ. Examining the relationship between the physical availability of medical marijuana and marijuana use across fifty California cities. Drug Alcohol Depend. 2014;143, 244-50.

39. Loriggio P. Delays in Ontario cannabis delivery could push consumers back to black markets. [Internet] The Canadian Press. 2018 October 25. Available from: https://www.ctvnews.ca/business/delays-in-ontario-cannabis-delivery-could-push-consumers-back-to-black-market-critics-1.4149799.

40. Leafly Canada Staff. Ontario Cannabis Store launches same-day delivery. [Internet] Leafly. 2019. Available from: https://www.leafly.ca/news/industry/ocs-same-day-delivery.

41. Callaghan RC, Sanches M, Benny C, Stockwell T, Sherk A, Kish SJ. Who consumers most of the cannabis in Canada? Profiles of cannabis consumption by quantity. Drug Alcohol Depend. 2019;205, 107587. Doi: 10.1016/j.drugalcdep.2019.107587

42. Midgette G, Davenport S, Caulkins JP, Kilmer B. What America's Users Spend on Illegal Drugs, 2006-2016: Rand Corporation; 2019.

43. Caulkins JP, Padman R. Quantity discounts and quality premia for illicit drugs. J Am Stat Assoc. 1993;88, 748-57.

44. Caulkins JP. Price and purity analysis for illicit drug: Data and conceptual issues. Drug Alcohol Depend. 2007;90, S61-S8. Doi: 10.1016/j.drugalcdep.2006.08.014

45. Clements KW. Pricing and packaging: the case of marijuana. J Business. 2006;79, 2019-44.

46. Mahamad S, Wadsworth E, Rynard V, Goodman S, Hammond D. Availability, retail price and potency of legal and illegal cannabis in Canada after recreational cannabis legalisation. Drug Alcohol Rev. 2020;39, 337-46.

47. Ontario Cannabis Store. A quarterly review: April 1 - June 30, 2020. [Internet] 2020. Available from: https://cannabislaw.report/wp-content/uploads/2020/10/OCS-InsightsReport_Q1-2020-FINAL.pdf

48. Fahimi M, Barlas FM, Thomas RK. American Association for Public Opinion Research., 2018. A practical guide for surveys based on nonprobability samples. [Internet] Webinar. 2018. Available from: https://register.aapor.org/detail.aspx?id=WEB0218_REC.

49. Hays RD, Liu H, Kapteyn A. Use of Internet panels to conduct surveys. Behav Res Methods. 2015;47, 685-90. (ISSN: 1554-3528)

50. Martin B. Price averages for Canadian cannabis by province. [Internet] Leafly. 2019. Available from: https://www.leafly.ca/news/strains-products/canada-price-averages.

51. Statistics Canada. The Daily: Table 2 – Average price of cannabis, by province, 2019. [Internet] 2020. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/200123/t002c-eng.htm.

52. Goodman S, Wadsworth E, Leos-Toro C, Hammond D. Prevalence and forms of cannabis use in legal vs. illegal recreational cannabis markets. Int J Drug Policy. 2020;76, 102658. doi: 10.1016/j.drugpo.2019.10265

53. Government of Canada. Cananbis market data: overview. [Internet] 2020. Available from: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/research-data/market.html?utm_source=Canadian+Public+Health+Assocation&utm_campaign=5fa926fcc0-EMAIL_CAMPAIGN_2020_07_29_01_57&utm_medium=email&utm_term=0_1f88f45ba0-5fa926fcc0-154369927.

## Chapter 5

1. Government of Canada. Justice Laws Website: Cannabis Act (S.C. 2018, c.16) 2018

2. Červený J, van Ours JC. Cannabis prices on the dark web. Euro Econ Rev. 2019;120.

3.  Caulkins JP. Price and purity analysis for illicit drug: data and conceptual issues. Drug Alcohol Depend. 2007;90 Suppl 1:S61-8.

4.  Caulkins JP, Padman R. Quantity discounts and quality premia for illicit drugs. J Am Stat Assoc. 1993;88:748-57.

5.  Clements KW. Pricing and packaging: the case of marijuana. J Business. 2006;79:2019-44.

6.  Wadsworth E, Driezen P, Goodman S, Hammond D. Differences in self-reported cannabis prices across purchase source and quantity purchased among Canadians. Addiction Research & Theory. 2020;28(6):474-83.

7.  Ben Lakhdar CG, Vaillant N, Wolff FC. Price elasticity of demand for cannabis: does potency matter? Addiction Research & Theory. 2016;24(4):300-12.

8.  Mahamad S, Hammond D. Retail price and availability of illicit cannabis in Canada. Addict Behav. 2019;90:402-8.

9.  Capler R, Walsh Z, Crosby K, Belle-Isle L, Holtzman S, Lucas P, et al. Are dispensaries indispensable? Patient experiences of access to cannabis from medical cannabis dispensaries in Canada. Int J Drug Policy. 2017;47:1-8.

10. Government of Canada. Canadian Cannabis Survey 2020: Summary. [Internet] 2020. Available from: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/research-data/canadian-cannabis-survey-2020-summary.html. .

11. Government of Canada. Canadian Cannabis Survey 2019 – Summary. [Internet] 2019. Available from: https://www.canada.ca/en/health-canada/services/publications/drugs-health-products/canadian-cannabis-survey-2019-summary.html.

12. Amlung M, MacKillop J. Availability of legalized cannabis reduces demand for illegal cannabis among Canadian cannabis users: evidence from a behavioural economic substitution paradigm. Can J Public Health. 2019;110(2):216-21.

13. Childs J, Stevens J. The state must compete: Optimal pricing of legal cannabis. Can Pub Admin. 2019;64(4):656-73.

14. Amlung M, Reed DD, Morris V, Aston ER, Metrik J, MacKillop J. Price elasticity of illegal versus legal cannabis: a behavioral economic substitutability analysis. Addiction. 2019;114(1):112-8.

15. Mahamad S, Wadsworth E, Rynard V, Goodman S, Hammond D. Availability, retail price and potency of legal and illegal cannabis in Canada after recreational cannabis legalisation. Drug Alcohol Rev. 2020;39(4):337-46.

16. Statistics Canada. StatsCannabis data availability: Crowdsourced cannabis prices, fourth quarter 2019. [Internet] 2020. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/200123/dq200123c-eng.htm.

17. Government of Canada. Canadian Cannabis Survey 2017 Summary. [Internet] 2017. Available from: https://www.canada.ca/en/health-canada/services/publications/drugs-health-products/canadian-cannabis-survey-2017-summary.html.

18. Government of Canada. Canadian Cannabis Survey 2018 Summary. [Internet] 2018. Available from: https://www.canada.ca/en/services/health/publications/drugs-health-products/canadian-cannabis-survey-2018-summary.html.

19. American Association for Public Opinion Research. Standard definitions: Final dispositions of case codes and outcome rates for surveys. [Internet] 2016. Available from: https://www.aapor.org/AAPOR_Main/media/publications/Standard-Definitions20169theditionfinal.pdf.

20. Hammond D, Goodman S, Wadsworth E, Rynard V, Boudreau C, Hall W. Evaluating the impacts of cannabis legalization: The International Cannabis Policy Study. Int J Drug Policy. 2020;77:102698.

21. Goodman S, Burkhalter R, Hammond D. International Cannabis Policy Study Technical Report - Wave 2 (2019). University of Waterloo, Waterloo, ON, Canada: University of Waterloo; 2020.

22. Goodman S, Burkhalter R, Hammond D. International Cannabis Policy Study Technical Report - Wave 3 (2020). University of Waterloo; Waterloo, ON, Canada: University of Waterloo; 2021.

23. Mahamad S, Goodman S, Hammond D. Cannabis Retail Scan - March 2020. [Internet] University of Waterloo, Waterloo, ON, Canada: University of Waterloo; 2021. Available from: http://cannabisproject.ca/methods/.

24. Statistics Canada. Consumer Price Index, September 2020. [Internet] 2020. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/201021/dq201021a-eng.htm

25.    Ontario Cannabis Store. A quarterly review: April 1 - June 30, 2020. [Internet] 2020. Available from: https://cannabislaw.report/wp-content/uploads/2020/10/OCS-InsightsReport_Q1-2020-FINAL.pdf

26.    Armstrong MJ. Legal cannabis market shares during Canada's first year of recreational legalisation. Int J Drug Policy. 2021;88:103028.

27.    Alcohol and Gaming Commission of Ontario. The AGCO now issuing 30 cannabis retail store authorizations per week. [Internet] 2021. Available from: https://www.agco.ca/blog/cannabis/feb-2021/agco-now-issuing-30-cannabis-retail-store-authorizations-week.

28.    CBC News. Ontario removing cap on number of pot shops, opening up market for retailers. [Internet] CBC News. 2019 December 19. Available from: https://www.cbc.ca/news/canada/toronto/cannibis-store-cap-1.5394662

29.    Pacula RL, Kilmer B, Wagenaar AC, Chaloupka FJ, Caulkins JP. Developing public health regulations for marijuana: lessons from alcohol and tobacco. Am J Public Health. 2014;104(6):1021-8.

30.    Smart R, Caulkins JP, Kilmer B, Davenport S, Midgette G. Variation in cannabis potency and prices in a newly legal market: evidence from 30 million cannabis sales in Washington state. Addiction. 2017;112(12):2167-77.

31.    Caulkins JP, Bao Y, Davenport S, Fahli I, Guo Y, Kinnard K, et al. Big data on a big new market: Insights from Washington State's legal cannabis market. Int J Drug Policy. 2018;57:86-94.

32.    Oregon Liquor Control Commission. 2021 Recreational Marijuana Supply and Demand Legislative Report. [Internet] 2021. Available from: https://www.oregon.gov/olcc/Docs/Legislative_docs/2021-Supply-and-Demand-Report.pdf

33.    Oregon Liquor Control Commission. 2019 Recreational Marijuana Supply and Demand Legislative Report. [Internet] 2019. Available from: https://www.oregon.gov/olcc/marijuana/Documents/Bulletins/2019%20Supply%20and%20Demand%20Legislative%20Report%20FINAL%20for%20Publication(PDFA).pdf.

34. Callaghan RC, Sanches M, Benny C, Stockwell T, Sherk A, Kish SJ. Who consumes most of the cannabis in Canada? Profiles of cannabis consumption by quantity. Drug Alcohol Depend. 2019;205:107587.

35. Midgette G, Davenport S, Caulkins JP, Kilmer B. What America's Users Spend on Illegal Drugs, 2006-2016. RAND Corporation; Santa Monica, California, USA: RAND Corporation; 2019.

36. Caulkins JP, Pardo B, Kilmer B. Intensity of cannabis use: Findings from three online surveys. Int J Drug Policy. 2020;79:102740

37. Chan G, Hall W. Estimation of the proportion of population cannabis consumption accounted for by daily users using Monte Carlo simulation. Addiction. 2020;115:1182-1186

38. Ontario Cannabis Store. A Year in Review: 2019-2020. [Internet] 2020. Available from: https://cdn.shopify.com/s/files/1/2636/1928/files/OCS-InsightsReport_2019-2020_8f607a7b-21b0-4718-adb3-7cd60a2f08ea.pdf?v=1608224707.

39. Leos-Toro C, Fong GT, Meyer SB, Hammond D. Cannabis labelling and consumer understanding of THC levels and serving sizes. Drug Alcohol Depend. 2020;208:107843.

40. Freeman TP, Groshkova T, Cunningham A, Sedefov R, Griffiths P, Lynskey MT. Increasing potency and price of cannabis in Europe, 2006-16. Addiction. 2019;114(6):1015-23.

41. Ouellet ML, Macdonald M, Bouchard M, Morselli C, Frank R. The price of cannabis in Canada. Ottawa, ON, Canada: Public Safety Canada= Sécurité publique Canada.; 2017.

42. Hammond D, Goodman S. Knowledge of Tetrahydrocannabinol and Cannabidiol Levels Among Cannabis Consumers in the United States and Canada. Can Can Res. 2020. https://doi.org/10.1089/can.2020.0092

43. Government of Canada. Backgrounder: Final regulations on new cannabis products. [Internet] 2019. Available from: https://www.canada.ca/en/health-canada/news/2019/06/backgrounder-final-regulations-on-new-cannabis-products.html. .

44. Goodman S, Wadsworth E, Leos-Toro C, Hammond D, International Cannabis Policy Study t. Prevalence and forms of cannabis use in legal vs. illegal recreational cannabis markets. Int J Drug Policy. 2020;76:102658.

# Chapter 6

1.      DISA. Map of marijuana legality by state. [Internet] 2021. Available from:
        https://disa.com/map-of-marijuana-legality-by-state

2.      Burgard DA, Williams J, Westerman D, Rushing R, Carpenter R, LaRock A, et al. Using
        wastewater-based analysis to monitor the effects of legalized retail sales on cannabis
        consumption in Washington State, USA. Addiction. 2019;114(9):1582-90.

3.      Caulkins JP, Davenport S, Doanvo A, Furlong K, Siddique A, Turner M, et al.
        Triangulating web & general population surveys: Do results match legal cannabis market
        sales? Int J Drug Policy. 2019;73:293-300.

4.      Bureau of Cannabis Control California. California Cannabis Advisory Committee 2020
        Annual Report. [Internet] 2020. Available from:
        https://www.bcc.ca.gov/about_us/documents/cac_annual_report_2020.pdf.

5.      Oregon Liquor Control Commission. 2021 Recreational Marijuana Supply and Demand
        Legislative Report. [Internet] 2021. Available from:
        https://www.oregon.gov/olcc/Docs/Legislative_docs/2021-Supply-and-Demand-
        Report.pdf

6.      Oregon Liquor Control Commission. 2019 Recreational Marijuana Supply and Demand
        Legislative Report. [Internet] 2019. Available from:
        https://www.oregon.gov/olcc/marijuana/Documents/Bulletins/2019%20Supply%20and%
        20Demand%20Legislative%20Report%20FINAL%20for%20Publication(PDFA).pdf.

7.      Bureau of Cannabis Control California. California Cannabis Advisory Committee: 2019
        Annual Report. [Internet] 2019. Available from:
        https://bcc.ca.gov/about_us/documents/cac_annual_report_2019.pdf.

8.      Pedersen ER, Firth CL, Rodriguez A, Shih RA, Seelam R, Kraus L, et al. Examining
        Associations Between Licensed and Unlicensed Outlet Density and Cannabis Outcomes
        From Preopening to Postopening of Recreational Cannabis Outlets. Am J Addict.
        2021;30(2):122-30.

9.      Hunt P, Pacula RL. Early Impacts of Marijuana Legalization: An Evaluation of Prices in
        Colorado and Washington. J Prim Prev. 2017;38(3):221-48.

10.     Orens A, Light M, Lewandowski B, Rowberry J, Saloga C. Market Size and Demand for
        Marijuana in Colorado 2017 Market Update. [Internet] 2018. Available from:

https://www.colorado.gov/pacific/sites/default/files/MED-_Demand_and_Market_Study_082018.pdf.

11.     Smart R, Caulkins JP, Kilmer B, Davenport S, Midgette G. Variation in cannabis potency and prices in a newly legal market: evidence from 30 million cannabis sales in Washington state. Addiction. 2017;112(12):2167-77.

12.     Davenport S. Price and product variation in Washington's recreational cannabis market. Int J Drug Policy. 2019:102547.

13.     Dills A, Goffard S, Miron J, Partin E. The effect of state marijuana legalizations: 2021 update CATO Institute. [Internet] 2021. Available from: https://www.cato.org/policy-analysis/effect-state-marijuana-legalizations-2021-update.

14.     Leaflink. Wholesale Cannabis Pricing Guide 2020. Leaflink.com; 2020.

15.     Firth CL, Davenport S, Smart R, Dilley JA. How high: differences in the developments of cannabis markets in two legalized states. Int J Drug Policy. 2020;75:102611

16.     Kilmer B, Kilmer Neel E. Being thoughtful about cannabis legalization and social equity. World Psychiatry. 2020;19(2):194-5.

17.     Pacula RL, Lundberg R. Why Changes in Price Matter When Thinking About Marijuana Policy: A Review of the Literature on the Elasticity of Demand. Public Health Rev. 2014;35(2):1-18.

18.     Aston ER, Meshesha LZ. Assessing Cannabis Demand: A Comprehensive Review of the Marijuana Purchase Task. Neurotherapeutics. 2020;17(1):87-99.

19.     Caulkins JP, Bao Y, Davenport S, Fahli I, Guo Y, Kinnard K, et al. Big data on a big new market: Insights from Washington State's legal cannabis market. Int J Drug Policy. 2018;57:86-94.

20.     American Association for Public Opinion Research. Standard definitions: Final dispositions of case codes and outcome rates for surveys. [Internet] 2016. Available from: https://www.aapor.org/AAPOR_Main/media/publications/Standard-Definitions20169theditionfinal.pdf.

21.     Goodman S, Burkhalter R, Hammond D. International Cannabis Policy Study Technical Report - Wave 2 (2019). University of Waterloo, Waterloo, ON, Canada: University of Waterloo; 2020.

22. Goodman S, Burkhalter R, Hammond D. International Cannabis Policy Study Technical Report - Wave 3 (2020). University of Waterloo; Waterloo, ON, Canada: University of Waterloo; 2021.

23. Hammond D, Goodman S, Wadsworth E, Rynard V, Boudreau C, Hall W. Evaluating the impacts of cannabis legalization: The International Cannabis Policy Study. Int J Drug Policy. 2020;77:102698.

24. CPI Inflation Calculator. 2020 CPI and Inflation Rate for the United States. [Internet] 2020. Available from: https://cpiinflationcalculator.com/2020-cpi-and-inflation-rate-for-the-united-states/

25. Helling B. Gigworker Marijuana Delivery. [Internet] 2021. Available from: https://gigworker.com/marijuana-delivery/.

26. Leafbuyer Writing Team. State-by-State Guide to Marijuana Delivery Services. [Internet] 2020. Available from: https://www.leafbuyer.com/blog/state-by-state-guide-to-marijuana-delivery-services/.

27. Pacula RL, Kilmer B, Wagenaar AC, Chaloupka FJ, Caulkins JP. Developing public health regulations for marijuana: lessons from alcohol and tobacco. Am J Public Health. 2014;104(6):1021-8.

28. Press Release. Leaflink Releases Annual Wholesale Cannabis Pricing Guide. [Internet] Marijuana Retail Report. 2021 January 25. Available from: https://marijuanaretailreport.com/leaflink-releases-annual-wholesale-cannabis-pricing-guide/

29. World Health Organization. Timeline: WHO's COVID-19 response. [Internet] 2021. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!

30. Downs D. US cannabis harvest price report 2020. [Internet] Leafly. 2020. Available from: https://www.leafly.com/news/industry/us-marijuana-harvest-price-report-2020

31. Schaneman B. Oregon wholesale marijuana flower prices rise after growers exit market, some pivot to hemp. [Internet] Marijuana Business Daily. 2020. Available from: https://mjbizdaily.com/oregon-wholesale-marijuana-flower-prices-rise-after-growers-exit-market-pivot-to-hemp/

32. Kush. Retail vs. Wholesale cannabis in 2020. [Internet] 2020. Available from: https://kush.com/blog/cannabis-pricing-wholesale-vs-retail-in-2020/

33. Schaneman B. Premium flower demand drives Colorado wholesale marijuana prices to nearly five-year highs. [Internet] Marijuana Business Daily. 2021. Available from: https://mjbizdaily.com/premium-flower-demand-drives-colorado-wholesale-marijuana-prices-to-nearly-five-year-highs/

34. Schaneman B. Michigan wholesale marijuana flower prices soar on tight supply, lack of community approvals. [Internet] Marijuana Business Daily. 2020. Available from: https://mjbizdaily.com/michigan-wholesale-marijuana-flower-prices-soar-on-tight-supply-lack-of-community-approvals/

35. Schaneman B. Wholesale cannabis flower prices in Massachusetts climb on mounting demand, sluggish supply. [Internet] Marijuana Business Daily. 2020. Available from: https://mjbizdaily.com/wholesale-cannabis-flower-prices-massachusetts-climb-on-mounting-demand/

36. Mahamad S, Wadsworth E, Rynard V, Goodman S, Hammond D. Availability, retail price and potency of legal and illegal cannabis in Canada after recreational cannabis legalisation. Drug Alcohol Rev. 2020;39(4):337-46.

37. Caulkins JP. Price and purity analysis for illicit drug: data and conceptual issues. Drug Alcohol Depend. 2007;90 Suppl 1:S61-8.

38. Caulkins JP, Padman R. Quantity discounts and quality premia for illicit drugs. J Am Stat Assoc. 1993;88:748-57.

39. Ben Lakhdar CG, Vaillant N, Wolff FC. Price elasticity of demand for cannabis: does potency matter? Addict Res Theory. 2016;24(4):300-12.

40. Fataar F, Goodman S, Wadsworth E, Hammond D. Consumer perceptions of 'legal' and 'illegal' cannabis in US states with legal cannabis sales. Addict Behav. 2021;112:106563.

41. Hammond D. Communicating THC levels and 'dose' to consumers: Implications for product labelling and packaging of cannabis products in regulated markets. Int J Drug Policy. 2019:102509.

42. Hammond D, Goodman S. Knowledge of Tetrahydrocannabinol and Cannabidiol Levels Among Cannabis Consumers in the United States and Canada. Can Can Res. 2020. https://doi.org/10.1089/can.2020.0092

43.    Leos-Toro C, Fong GT, Meyer SB, Hammond D. Cannabis labelling and consumer understanding of THC levels and serving sizes. Drug Alcohol Depend. 2020;208:107843.

44.    Goodman S, Wadsworth E, Leos-Toro C, Hammond D, International Cannabis Policy Study t. Prevalence and forms of cannabis use in legal vs. illegal recreational cannabis markets. Int J Drug Policy. 2020;76:102658.

## Chapter 7

1.    Rotermann M. Looking back from 2020, how cannabis use and related behaviours changed in Canada. Health Reports. 2021;32(4):3-14.

2.    Government of Canada. Canadian Cannabis Survey 2017 Summary. [Internet] 2017. Available from: https://www.canada.ca/en/health-canada/services/publications/drugs-health-products/canadian-cannabis-survey-2017-summary.html.

3.    Government of Canada. Canadian Cannabis Survey 2018 Summary. [Internet] 2018. Available from: https://www.canada.ca/en/services/health/publications/drugs-health-products/canadian-cannabis-survey-2018-summary.html.

4.    Government of Canada. Canadian Cannabis Survey 2019 – Summary. [Internet] 2019. Available from: https://www.canada.ca/en/health-canada/services/publications/drugs-health-products/canadian-cannabis-survey-2019-summary.html.

5.    Government of Canada. Canadian Cannabis Survey 2020: Summary. [Internet] 2020. Available from: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/research-data/canadian-cannabis-survey-2020-summary.html. .

6.    Alcohol and Gaming Commission of Ontario. Status of current cananbis retail store applications. [Internet] 2021. Available from: https://www.agco.ca/status-current-cannabis-retail-store-applications.

7.    Statistics Canada. Retail sales, price, and volume, seasonally adjusted (x 1,000,000). Table 20-10-0078-01. [Internet] 2021. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2010007801

8.    Hunt P, Pacula RL. Early Impacts of Marijuana Legalization: An Evaluation of Prices in Colorado and Washington. J Prim Prev. 2017;38(3):221-48.

9.    Leaflink. Wholesale Cannabis Pricing Guide 2020. Leaflink.com; 2020.

10.    Statistics Canada. StatsCannabis data availability: Crowdsourced cannabis prices, fourth quarter 2019. [Internet] 2020. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/200123/dq200123c-eng.htm.

11.    Mahamad S, Wadsworth E, Rynard V, Goodman S, Hammond D. Availability, retail price and potency of legal and illegal cannabis in Canada after recreational cannabis legalisation. Drug Alcohol Rev. 2020;39(4):337-46.

12.    Ouellet ML, Macdonald M, Bouchard M, Morselli C, Frank R. The price of cannabis in Canada. Ottawa, ON, Canada: Public Safety Canada= Sécurité publique Canada.; 2017.

13.    Ontario Cannabis Store. A Year in Review: 2019-2020. [Internet] 2020. Available from: https://cdn.shopify.com/s/files/1/2636/1928/files/OCS-InsightsReport_2019-2020_8f607a7b-21b0-4718-adb3-7cd60a2f08ea.pdf?v=1608224707.

14.    Société québécoise du cannabis. Annual Report 2020. [Internet] 2020. Available from: https://www.sqdc.ca/en-CA/about-the-sqdc/acces-to-information/Publications

15.    Fataar F, Goodman S, Wadsworth E, Hammond D. Consumer perceptions of 'legal' and 'illegal' cannabis in US states with legal cannabis sales. Addict Behav. 2021;112:106563.

16.    Amlung M, MacKillop J. Availability of legalized cannabis reduces demand for illegal cannabis among Canadian cannabis users: evidence from a behavioural economic substitution paradigm. Can J Public Health. 2019;110(2):216-21.

17.    Amlung M, Reed DD, Morris V, Aston ER, Metrik J, MacKillop J. Price elasticity of illegal versus legal cannabis: a behavioral economic substitutability analysis. Addiction. 2019;114(1):112-8.

18.    Pacula RL, Lundberg R. Why Changes in Price Matter When Thinking About Marijuana Policy: A Review of the Literature on the Elasticity of Demand. Public Health Rev. 2014;35(2):1-18.

19.    Callaghan RC, Sanches M, Benny C, Stockwell T, Sherk A, Kish SJ. Who consumes most of the cannabis in Canada? Profiles of cannabis consumption by quantity. Drug Alcohol Depend. 2019;205:107587.

20.    Midgette G, Davenport S, Caulkins JP, Kilmer B. What America's Users Spend on Illegal Drugs, 2006-2016. RAND Corporation; Santa Monica, California, USA: RAND Corporation; 2019.

21.     Caulkins JP, Pardo B, Kilmer B. Intensity of cannabis use: Findings from three online surveys. Int J Drug Policy. 2020;79:102740.

22.     Hammond D, Goodman S, Wadsworth E, and the International Cannabis Policy Study Team. Trends in the use of cannabis products, 2018-2020: Findings from the International Cannabis Policy Study. In prep. 2021.

23.     Fahimi M, Barlas FM, Thomas RK, American Association for Public Opinion Research. A practical guide for surveys based on nonprobability samples. [Internet] Webinar. 2018. Available from: https://register.aapor.org/detail.aspx?id=WEB0218_REC. .

24.     Hays RD, Liu H, Kapteyn A. Use of Internet panels to conduct surveys. Behav Res Methods. 2015;47(3):685-90.

25.     Statistics Canada. Table 17-10-0009-01 Population estimates, quarterly. [Internet] 2021. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000901.

26.     Bond B, Caulkins JP, Scott N, Kilmer B, Dietze P. Are users' most recent drug purchases representative? Drug Alcohol Depend. 2014;142:133-8.

27.     Hammond D. Communicating THC levels and 'dose' to consumers: Implications for product labelling and packaging of cannabis products in regulated markets. Int J Drug Policy. 2019:102509.

28.     Leos-Toro C, Fong GT, Meyer SB, Hammond D. Cannabis labelling and consumer understanding of THC levels and serving sizes. Drug Alcohol Depend. 2020;208:107843.

29.     Kosa KM, Giombi KC, Rains CB, Cates SC. Consumer use and understanding of labelling information on edible marijuana products sold for recreational use in the states of Colorado and Washington. Int J Drug Policy. 2017;43:57-66.

30.     Freeman TP, Groshkova T, Cunningham A, Sedefov R, Griffiths P, Lynskey MT. Increasing potency and price of cannabis in Europe, 2006-16. Addiction. 2019;114(6):1015-23.

31.     Kilmer B, Everingham S, Caulkins JP, Midgette G, Pacula RL, Reuter P. What America's users spend on illegal drugs: 2000-2010. Santa Monica, CA, USA: RAND Corporation; 2014.

32.     Ontario Cannabis Store. A quarterly review: April 1 - June 30, 2020. [Internet] 2020. Available from: https://cannabislaw.report/wp-content/uploads/2020/10/OCS-InsightsReport_Q1-2020-FINAL.pdf

33. Weedmaps. Preroll. [Internet] 2021. Available from: https://weedmaps.com/learn/dictionary/preroll.

34. Goodman S, Wadsworth E, Leos-Toro C, Hammond D, International Cannabis Policy Study t. Prevalence and forms of cannabis use in legal vs. illegal recreational cannabis markets. Int J Drug Policy. 2020;76:102658.

35. Caulkins JP, Bao Y, Davenport S, Fahli I, Guo Y, Kinnard K, et al. Big data on a big new market: Insights from Washington State's legal cannabis market. Int J Drug Policy. 2018;57:86-94.

36. Davenport S. Price and product variation in Washington's recreational cannabis market. Int J Drug Policy. 2019:102547.

37. Smart R, Caulkins JP, Kilmer B, Davenport S, Midgette G. Variation in cannabis potency and prices in a newly legal market: evidence from 30 million cannabis sales in Washington state. Addiction. 2017;112(12):2167-77.

38. Government of Canada. Backgrounder: Final regulations on new cannabis products. [Internet] 2019. Available from: https://www.canada.ca/en/health-canada/news/2019/06/backgrounder-final-regulations-on-new-cannabis-products.html. .

39. Mahamad S, Hammond D. Retail price and availability of illicit cannabis in Canada. Addict Behav. 2019;90:402-8.

40. Mahamad S, Goodman S, Hammond D. Cannabis Retail Scan - March 2020. University of Waterloo: Waterloo, ON, Canada; 2021. Available from: http://cannabisproject.ca/methods/.

41. Headset. Price Per Package or Price Per Gram ? A Closer Look at Pricing Data. [Internet] 2019. Available from: https://www.headset.io/blog/price-per-package-or-price-per-gram-a-closer-look-at-pricing-data

42. Statistics Canada. Consumer Price Index, September 2020. [Internet] 2020. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/201021/dq201021a-eng.htm.

43. Turner HC, Lauer JA, Tran BX, Teerawattananon Y, Jit M. Adjusting for Inflation and Currency Changes Within Health Economic Studies. Value Health. 2019;22(9):1026-32.

44. CPI Inflation Calculator. 2020 CPI and Inflation Rate for the United States. [Internet] 2021. Available from: https://cpiinflationcalculator.com/2020-cpi-and-inflation-rate-for-the-united-states/.

45.    Bow CJ, Waters NM, Faris PD, Seidel JE, Galbraith PD, Knudtson ML, et al. Accuracy of city postal code coordinates as a proxy for location of residence. Int J Health Geogr. 2004;3(1):5.

46.    Pinault L, Khan S, Tjepkema M. Accuracy of matching residential postal codes to census geography. Health Rep. 2020;31(3):3-13.

47.    Caulkins JP, Davenport S, Doanvo A, Furlong K, Siddique A, Turner M, et al. Triangulating web & general population surveys: Do results match legal cannabis market sales? Int J Drug Policy. 2019;73:293-300.

48.    Armstrong MJ. Legal cannabis market shares during Canada's first year of recreational legalisation. Int J Drug Policy. 2021;88:103028.

49.    Armstrong MJ. Canada's provinces and territories should disclose cannabis data to support research. CMAJ. 2021;193(10):E341-E2.

50.    Pedersen ER, Firth CL, Rodriguez A, Shih RA, Seelam R, Kraus L, et al. Examining Associations Between Licensed and Unlicensed Outlet Density and Cannabis Outcomes From Preopening to Postopening of Recreational Cannabis Outlets. Am J Addict. 2021;30(2):122-30.

51.    Pedersen ER, Firth C, Parker J, Shih RA, Davenport S, Rodriguez A, et al. Locating Medical and Recreational Cannabis Outlets for Research Purposes: Online Methods and Observational Study. J Med Internet Res. 2020;22(2):e16853.

52.    Cao Y, Carrillo AS, Jankowska MM, Shi Y. Validation of secondary data sources for enumerating marijuana dispensaries in a state commercializing marijuana. Drug Alcohol Depend. 2020;215:108183.

53.    Unger JB, Vos RO, Wu JS, Hardaway K, Sarain AYL, Soto DW, et al. Locations of licensed and unlicensed cannabis retailers in California: A threat to health equity? Prev Med Rep. 2020;19:101165.

54.    Leafly. 30 days to legalization: Leafly to delist non-licensed retailers. [Internet] 2018. Available from: https://www.newswire.ca/news-releases/30-days-to-legalization-leafly-to-delist-non-licensed-retailers-693458501.html.

55.    Schroyer J. Weedmaps drops thousands of unlicensed cannabis ads, but some illegal shops remain. [Internet] 2020. Available from: https://mjbizdaily.com/weedmaps-drops-thousands-of-unlicensed-ads-but-some-illegal-shops-remain/.

56.    Meinhofer A, Rubli A. Illegal drug market responses to state recreational cannabis laws. Addiction. 2021.

57.    Greaves L, Hemsing N. Sex and Gender Interactions on the Use and Impact of Recreational Cannabis. Int J Environ Res Public Health. 2020;17(2).

58.    Cuttler C, Mischley LK, Sexton M. Sex Differences in Cannabis Use and Effects: A Cross-Sectional Survey of Cannabis Users. Cannabis Cannabinoid Res. 2016;1(1):166-75.

59.    Government of Quebec. The legislation on cannabis: The cannabis regulation act. [Internet] 2020. Available from: https://encadrementcannabis.gouv.qc.ca/en/loi/loi-encadrant-le-cannabis/.

60.    Pertwee RG. Handbook of Cannabis. 1st ed. New York, NY, US: Oxford University Press; 2014.

61.    Valleriani J, Lavalley J, McNeil R. A missed opportunity? Cannabis legalization and reparations in Canada. Can J Public Health. 2018;109(5-6):745-7.

62.    Government of Canada. Justice Laws Website: Cannabis Act (S.C. 2018, c.16) 2018

63.    Owusu-Bempah A, Luscombe A. Race, cannabis and the Canadian war on drugs: An examination of cannabis arrest data by race in five cities. Int J Drug Policy. 2020:102937.

64.    Maghsoudi N, Rammohan I, Bowra A, Sniderman R, Tanguay J, Bouck Z, et al. How diverse is Canada's Legal cannabis industry? [Internet] 2020. Available from: https://cdpe.org/wp-content/uploads/dlm_uploads/2020/10/How-Diverse-is-Canada%E2%80%99s-Legal-Cannabis-Industry_CDPE-UofT-Policy-Brief_Final.pdf

65.    Adinoff B, Reiman A. Implementing social justice in the transition from illicit to legal cannabis. Am J Drug Alcohol Abuse. 2019;45(6):673-88.

66.    Kilmer B. How will cannabis legalization affect health, safety, and social equity outcomes? It largely depends on the 14 Ps. Am J Drug Alcohol Abuse. 2019;45(6):664-72.

67.    Manskar N. Marijuana producers Tilray, Aphria merge to form world's largest cannabis firm. [Internet] New York Post. 2020 December 16. Available from: https://nypost.com/2020/12/16/aphria-tilray-merge-to-form-worlds-largest-cannabis-firm/

68. The Canadian Press. Tilray-Alphria merger closes, expanded company to control biggest share of Canadian pot market. [Internet] CBC News. 2021 May 3. Available from: https://www.cbc.ca/news/canada/windsor/tilray-aphria-deal-closes-1.6012291

69. MJBizDaily. Canopy, Loblaw among 8 hopefuls to take over New Brunswick cannabis sales. [Internet] 2020. Available from: https://mjbizdaily.com/loblaw-canopy-among-8-proposals-to-take-over-cannabis-sales-in-new-brunswick/.

70. Canadian Centre on Substance Use and Addiction. Policy and Regulations (Cannabis). [Internet] 2020. Available from: https://www.ccsa.ca/policy-and-regulations-cannabis.

71. Alcohol and Gaming Commission of Ontario. List of Ontario municipalities prohibiting or allowing cannabis retail stores. [Internet] 2021. Available from: https://www.agco.ca/cannabis/list-ontario-municipalities-prohibiting-or-allowing-cannabis-retail-stores?title_field_value=&field_opt_in_out_value_i18n=2&page=3.

72. Saskatchewan Liquor and Gaming Authority. Cannabis retail store permitting. [Internet] 2020. Available from: https://www.slga.com/permits-and-licences/cannabis-permits/cannabis-retailing/cannabis-retail-store-permitting.

73. Dilley JA, Hitchcock L, McGroder N, Greto LA, Richardson SM. Community-level policy responses to state marijuana legalization in Washington State. Int J Drug Policy. 2017;42:102-8.

74. Firth CL, Carlini BH, Dilley JA, Wakefield J, Hajat A. What About Equity? Neighborhood Deprivation and Cannabis Retailers in Portland, Oregon. Cannabis 2020;3(2):157-72.

75. Shi Y, Meseck K, Jankowska MM. Availability of Medical and Recreational Marijuana Stores and Neighborhood Characteristics in Colorado. J Addict. 2016;2016:7193740.

76. Amiri S, Monsivais P, McDonell MG, Amram O. Availability of licensed cannabis businesses in relation to area deprivation in Washington state: A spatiotemporal analysis of cannabis business presence between 2014 and 2017. Drug Alcohol Rev. 2019;38(7):790-7.

77. Tabb LP, Fillmore C, Melly S. Location, location, location: Assessing the spatial patterning between marijuana licenses, alcohol outlets and neighborhood characteristics within Washington state. Drug Alcohol Depend. 2018;185:214-8.

78.    Morrison C, Gruenewald PJ, Freisthler B, Ponicki WR, Remer LG. The economic geography of medical cannabis dispensaries in California. Int J Drug Policy. 2014;25(3):508-15.

79.    Statistics Canada. The retail cannabis market in Canada: A portrait of the first year. [Internet] 2019. Available from: https://www150.statcan.gc.ca/n1/pub/11-621-m/11-621-m2019005-eng.htm.

80.    Canadian Centre on Substance Use and Addiction and Mental Health Commission of Canada. Mental Health and Substance Use During COVID-19. [Internet] 2021. Available from: https://www.mentalhealthcommission.ca/sites/default/files/2021-02/mhcc_ccsa_covid_leger_poll_eng.pdf.

81.    Oregon Liquor Control Commission. 2021 Recreational Marijuana Supply and Demand Legislative Report. [Internet] 2021. Available from: https://www.oregon.gov/olcc/Docs/Legislative_docs/2021-Supply-and-Demand-Report.pdf

82.    Hammond D. Cannabis surveillance in population surveys. Centers for Disease Control and Prevention Cannabis Surveillance. [Internet] 2021 May 2, 2021; Online.

83.    Davenport S, Caulkins JP. Evolution of the United States marijuana market in the decade of liberalization before full legalization. Journal of Drug Issues. 2016;46(4):411-27.

84.    He Y, Shang C, Chaloupka FJ. The association between cigarette affordability and consumption: An update. PLoS One. 2018;13(12):e0200665.

85.    Kostova D, Chaloupka FJ, Yurekli A, Ross H, Cherukupalli R, Andes L, et al. A cross-country study of cigarette prices and affordability: evidence from the Global Adult Tobacco Survey. Tob Control. 2014;23(1):e3.

86.    Moore SC, Orpen B, Smith J, Sarkar C, Li C, Shepherd J, et al. Alcohol affordability: implications for alcohol price policies. A cross-sectional analysis in middle and older adults from UK Biobank. J Public Health (Oxf). 2021.

87.    Nargis N, Stoklosa M, Shang C, Drope J. Price, Income, and Affordability as the Determinants of Tobacco Consumption: A Practitioner's Guide to Tobacco Taxation. Nicotine Tob Res. 2021;23(1):40-7.

88.    Wolf C. A week for the history books. [Internet] 2021. Available from: https://norml.org/blog/2021/04/02/a-week-for-the-history-books/

89.     Hansen B, Miller K, Weber C. The grass is greener on the other side: how extensive is the interstate trafficking of recreational marijuana (No. 23762). NBER Working paper. 2017.

90.     Hansen B, Miller K, Weber C. Federalism, partial prohibition, and cross border sales: evidence from recreational marijuana. 8th Conference of the American Society of Health Economics; Washington, DC.2019.

91.     Healy J. Nebraska and Oklahoma Sue Colorado over Marijuana Law. [Online] The New York Times. 2014 December 19. Available from: https://www.nytimes.com/2014/12/19/us/politics/nebraska-and-oklahoma-sue-colorado-over-marijuana-law.html

92.     Wadsworth E, Hammond D. Out-of-state cannabis purchases in the United States. Drug Alcohol Depend. 2020;207:107822

# APPENDICIES

## Appendix A - Summary of regulations for non-medical cannabis legalization

### Table A1 - Summary of federal and provincial regulations for non-medical cannabis legalization in Canada, as of May 2021

| | Age | Dried flower purchase limit | Sales model | Online sales | Home Grow | Excise Tax for dried flower (highest rate applies) | Sales Tax | Local retail opt-out option |
|---|---|---|---|---|---|---|---|---|
| **FEDERAL** | 18 | 30 g | Determined by provinces | Determined by provinces | 4 plants permitted | $0.25/gram Or 2.5% retail | Determined by provinces | Determined by provinces |
| **British Columbia** | 19 | 30 g | Hybrid | Public | 4 plants permitted | $0.75/gram Or 7.5% retail | 5% | Yes |
| **Alberta** | 18 | 30 g | Hybrid | Public | 4 plants permitted | $0.75/gram Or 7.5% retail | 5% | Yes |
| **Saskatchewan** | 19 | 30 g | Private | Private | 4 plants permitted | $0.75/gram Or 7.5% retail | 5% | Yes |
| **Manitoba** | 19 | 30 g | Private | Private | Prohibited | $0.75/gram Or 7.5% retail | 5% | Yes |
| **Ontario** | 19 | 30 g | Hybrid | Public | 4 plants permitted | $0.75/gram Or 7.5% retail | 13% | Yes |
| **Quebec** | 21 | 30 g | Public | Public | Prohibited | $0.75/gram Or 7.5% retail | 5% | No |
| **New Brunswick** | 19 | 30 g | Public | Public | 4 plants permitted | $0.75/gram Or 7.5% retail | 15% | No |
| **Nova Scotia** | 19 | 30 g | Public | Public | 4 plants permitted | $0.75/gram Or 7.5% retail | 15% | No |
| **Prince Edward Island** | 19 | 30 g | Public | Public | 4 plants permitted | $0.75/gram Or 7.5% retail | 15% | No |
| **Newfoundland & Labrador** | 19 | 30 g | Hybrid | Public | 4 plants permitted | $0.75/gram Or 7.5% retail | 15% | Yes |

Adapted from the Canadian Centre for Substance Use and Addiction (CCSA)'s summary of provincial and territorial cannabis regulations. Available at:
https://www.ccsa.ca/policy-and-regulations

**Table A2 - Summary of state regulations for non-medical cannabis legalization in the US, as of May 2021**

| | Date of approval | Date of legalization | Personal possession[*] | Home grow (individual limit) | Excise Tax* | Sales Tax (Local taxes may apply) | Retail sales | Delivery allowed? |
|---|---|---|---|---|---|---|---|---|
| **Alaska** | Nov 2014 | Feb 2015 | 1 oz | 6 plants | $50/oz of flower | 0% state | Yes, Oct 2016 | No |
| **Arizona** | Nov 2020 | Nov 2020 | 1 oz | 6 plants | 16% retail | 5.6% state | Yes, Mar 2021 | Yes |
| **California** | Nov 2016 | Nov 2016 | 1 oz | 6 plants | 15% retail | 7.25% state | Yes, Jan 2018 | Yes |
| **Colorado** | Nov 2012 | Dec 2012 | 1 oz | 6 plants | 15% wholesale 15% retail | 2.9% state | Yes, Jan 2014 | Yes |
| **Illinois** | Jun 2019 | Jan 2020 | 1 oz | None | 7% wholesale 10% retail[‡] | 6.3% state | Yes, Jan 2020 | No |
| **Maine** | Nov 2016 | Jan 2017 | 2.5 oz | 12 plants | 10% retail $335/lb of flower | 10% retail 5.5% state | Yes, Oct 2020 | No |
| **Massachusetts** | Nov 2016 | Dec 2016 | 1 oz | 6 plants | 10.75% retail | 6.25% state | Yes, Nov 2018 | No |
| **Michigan** | Nov 2018 | Dec 2018 | 2.5 oz | 12 plants | 10% at retail | 6% state | Yes, Dec 2019 | No |
| **Montana** | Nov 2020 | Jan 2021 | 1 oz | 4 plants | 20% at retail | 0% state | No, expected Jan 2022 | No |
| **Nevada** | Nov 2016 | Jan 2017 | 1 oz | 6 plants | 15% wholesale 10% retail | 6.85% state | Yes, Jul 2017 | Yes |
| **New Jersey** | Nov 2020 | Jan 2021 | 1 oz | TBC | TBC | 6.63% state | No, expected Aug 2021 | Yes |

| | Date of approval | Date of legalization | Personal possession* | Home grow (individual limit) | Excise Tax | Sales Tax (Local taxes may apply) | Retail sales | Delivery allowed? |
|---|---|---|---|---|---|---|---|---|
| **New Mexico** | March 2021 | Jun 2021 | 2 oz | 6 plants | 12% retail | 8% state | No, expected Apr 2022 | TBC |
| **New York** | March 2021 | March 2021 | 3 oz | 12 plants | 9% retail[Ψ] | 4% state | No, expected 2022 | Yes |
| **Oregon** | Nov 2014 | Jul 2015 Jan 2017[Φ] | 1 oz[φ] | 4 plants | 17% retail | 0% state | Yes, Oct 2015 | Yes |
| **South Dakota** | Nov 2020 | Jul 2021 | 1 oz | 3 plants | 15% at retail | 4.5% state | No, expected 2022 | TBC |
| **Vermont** | Jan 2018 | Jul 2018 | 1 oz | 6 plants | 14% retail | 6% state | No, expected 2022 | No |
| **Virginia** | April 2021 | Jul 2021 | 1 oz | 4 plants | 21% retail | 5.3% state | No, expected 2024 | TBC |
| **Washington, DC** | Nov 2014 | Feb 2015 | 2 oz | 6 plants | N/A | N/A | N/A | N/A |
| **Washington State** | Nov 2012 | Dec 2012 | 1 oz | None | 37% retail | 6.5% state | Yes, Jul 2014 | No |

Adapted from: a) NORML's state laws on legalization. Available at: https://norml.org/laws; b) National cannabis Industry Association's state-by-state marijuana policies. Available at: https://thecannabisindustry.org/ncia-news-resources/state-by-state-policies/ ; c) ProCon legal recreational marijuana states and DC website. Available at: https://marijuana.procon.org/legal-recreational-marijuana-states-and-dc/ ; d) Tax Foundation's election analysis. Available at: https://taxfoundation.org/legalize-marijuana-arizona-montana-new-jersey-south-dakota/ ; e) Leafly's guide to marijuana legalization. Available at: https://www.leafly.com/learn/legalization ; f) Leafbuyer's delivery information Available at: https://www.leafbuyer.com/blog/state-by-state-guide-to-marijuana-delivery-services/ ; g) Gig Workers delivery information. Available at: https://gigworker.com/marijuana-delivery/

*Dried flower only; [†]10% tax on cannabis products with less than 35% THC concentration, 25% tax on products above 35% THC concentration; [Φ]Official recreational only sales; [φ]Public limit; [Ψ]Dried flower is also taxed at $0.005 per mg of THC

# Appendix B – Price estimates of non-medical dried flower in Canada and the US

## Table B1 – Price estimates for dried flower by weight in Canada before and after legalization (CAD)

| Date | Source | Method | Type of dried flower | Price-per-gram $/g |
|------|--------|--------|----------------------|--------------------|
| 2010 | Statistics Canada[1] | Crowd-sourced | Not specified | $9.06 |
| 2011 | (Cannabis consumer prices) | | | $9.14 |
| 2012 | | | | $9.30 |
| 2013 | | | | $9.40 |
| 2014 | | | | $9.05 |
| 2015 | | | | $8.50 |
| 2016 | | | | $8.09 |
| 2017 | | | | $7.43 |
| | | | | |
| 2011-2015 | Public Safety Canada[2] | Crowdsourced | High quality | $7.69 |
| | (priceofweed.com) | | Medium quality | $7.14 |
| | | | Low quality | $7.26 |
| | | | | |
| 2015 | Statistics Canada[3] | Crowdsourced | Not specified | $8.06 |
| 2016 | (Cannabis consumer prices) | | | $7.70 |
| 2017 | | | | $7.15 |
| 2018 | | | | $7.00 |
| | | | | |
| Sep 2015 – Oct 2015 | Medical University of Vienna[4] (Alphabay, darknet) | Web-scraped retail scan | Not specified | $9.24* |
| | | | | |
| Oct 2017- May 2018 | University of Waterloo[5] (Weedmaps.com, Leafly.com, GoogleMaps.ca) | Objective retail scan | Most popular strain | $10.02 |
| | | | Least expensive strain | $7.80 |
| | | | Most expensive strain | $12.30 |
| | | | | |
| May 2018 – Jul 2018 | Government of Canada[6] (Canadian Cannabis Survey) | Self-reported | Not specified | $8.62 |

| Date | Source | Method | Type of dried flower | Price-per-gram $/g |
|---|---|---|---|---|
| Apr - June 2018 | Statistics Canada[7] (StatsCannabis) | Web-scraped | Up to 1.49 grams<br>1.5 – 6.99 grams<br>7 – 13.99 grams<br>14 – 27.99 grams<br>28 grams or more | $10.09<br>$9.09<br>$8.02<br>$7.27<br>$5.54 |
| Sep 2018 | Statistics Canada[8] (StatsCannabis) | Crowdsourced | Not specified | $7.20 |
| July - Sep 2018 | Statistics Canada[7] (StatsCannabis) | Web-scraped | Up to 1.49 grams<br>1.5 – 6.99 grams<br>7 – 13.99 grams<br>14 – 27.99 grams<br>28 grams or more | $9.75<br>$8.83<br>$7.98<br>$7.42<br>$4.94 |
| Oct - Dec 2018 | Statistics Canada[7] (StatsCannabis) | Web-scraped | Up to 1.49 grams<br>1.5 – 6.99 grams<br>7 – 13.99 grams<br>14 – 27.99 grams<br>28 grams or more | $9.58<br>$8.73<br>$7.87<br>$7.36<br>$4.83 |
| Nov – Dec 2018 | University of Waterloo[9] (Weedmaps.com, Leafly.com, online directories) | Web-scraped | 1 gram (illegal)<br>1 gram (legal)<br>1/8 ounce (illegal)<br>1/8 ounce (legal)<br>½ ounce (illegal)<br>½ ounce (legal) | $10.23<br>$11.08<br>$9.37<br>$10.88<br>$8.18<br>$8.85 |
| Dec 2018 | Statistics Canada[10] (StatsCannabis) | Crowdsourced | From legal sources<br>From illegal sources | $9.69<br>$6.44 |
| Mar 2019 | Statistics Canada[10] (StatsCannabis) | Crowdsourced | From legal sources<br>From illegal sources | $10.14<br>$6.24 |

| Date | Source | Method | Type of dried flower | Price-per-gram $/g |
|---|---|---|---|---|
| Jan - Mar 2019 | Statistics Canada[7] (StatsCannabis) | Web-scraped | Up to 1.49 grams<br>1.5 – 6.99 grams<br>7 – 13.99 grams<br>14 – 27.99 grams<br>28 grams or more | $9.32<br>$8.46<br>$7.77<br>$7.33<br>$5.41 |
| Apr - Jun 2019 | Government of Canada[11] (Canadian Cannabis Survey) | Self-reported | Not specified | $9.83 |
| Jun 2019 | Statistics Canada[9] (StatsCannabis) | Crowdsourced | From legal sources<br>From illegal sources | $10.65<br>$5.93 |
| Apr - Jun 2019 | Statistics Canada[7] (StatsCannabis) | Web-scraped | Up to 1.49 grams<br>1.5 – 6.99 grams<br>7 – 13.99 grams<br>14 – 27.99 grams<br>28 grams or more | $9.59<br>$8.60<br>$7.92<br>$7.36<br>$5.26 |
| Sep 2019 | Statistics Canada[9] (StatsCannabis) | Crowdsourced | From legal sources<br>From illegal sources | $10.12<br>$5.65 |
| Jul - Sep 2019 | Statistics Canada[7] (StatsCannabis) | Web-scraped | Up to 1.49 grams<br>1.5 – 6.99 grams<br>7 – 13.99 grams<br>14 – 27.99 grams<br>28 grams or more | $10.23<br>$9.04<br>$8.29<br>$7.72<br>$5.86 |
| Dec 2019 | Statistics Canada[9] (StatsCannabis) | Crowdsourced | From legal sources<br>From illegal sources | $10.30<br>$5.73 |
| Apr – Jun 2020 | Government of Canada[12] (Canadian Cannabis Survey) | Self-reported | Not specified | $10.48 |

*Originally reported in US dollars. Converted to Canadian dollars using the 2015 Purchasing Power Parity estimates from OECD: https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm

1.      Statistics Canada. Table 18-10-0211-01 Cannabis consumer prices. [Internet] 2021. Available from: https://doi.org/10.25318/1810021101-eng

2.      Ouellet M, Macdonald M, Bouchard M, Morselli C, Frank R. The Price of Cannabis in Canada [Internet]. Vol. 112, Public Safety Canada. 2017. 1128–1135 p. Available from: http://doi.wiley.com/10.1111/add.13623

3.      Statistics Canada. Table 36-10-0598-01 Cannabis consumer and producer prices. [Internet] 2021. Available from: https://doi.org/10.25318/3610059801-eng

4.      Červený J, van Ours JC. Cannabis prices on the dark web. European Economic Review. 2019 Nov 1;120:103306.Mahamad S, Hammond D. Retail price and availability of illicit cannabis in Canada. Addict Behav. 2019;90:402–8.

5.      Government of Canada. Canadian Cannabis Survey 2018 Summary [Internet]. 2018. Available from: https://www.canada.ca/en/services/health/publications/drugs-health-products/canadian-cannabis-survey-2018-summary.html

6.      Statistics Canada. Statscannabis data availability: Crowdsourced cannabis prices, third quarter 2019. Table 3 – Price per gram, by quantity purchased (web scraped data). [Internet] 2019. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/191009/t003a-eng.htm

7.      Statistics Canada. StatsCannabis data availability: Crowdsourced cannabis prices, third quarter 2018. [Internet]. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/181004/dq181004a-eng.htm

8.      Mahamad S, Wadsworth E, Rynard V, Goodman S, Hammond D. Availability, retail price and potency of legal and illegal cannabis in Canada after recreational cannabis legalization. Drug Alcohol Rev, 2020 DOI: 10.1111/dar.13069

9.      Statistics Canada. StatsCannabis data availability: Crowdsourced cannabis prices, second quarter 2019: Table 1. [Internet]. 2019. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/190710/dq190710c-eng.htm

10.     Government of Canada. Canadian Cannabis Survey 2019 – Summary. [Internet] 2019. Available from: https://www.canada.ca/en/health-canada/services/publications/drugs-health-products/canadian-cannabis-survey-2019-summary.html

11.     Government of Canada. Canadian Cannabis Survey 2020: Summary. [Internet] 2020. Available from: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/research-data/canadian-cannabis-survey-2020-summary.html

**Table B2- Brief summary of price estimates for dried flower by weight in US states after legalization (USD)**

| Date | Source | Method | State | Price-per-unit | Tax-inclusive? |
|---|---|---|---|---|---|
| Oct 2013-Oct 2014 | RAND West Coast States Survey[1] | Self-reported survey data | Washington | $10.40/g | Unknown |
| | | | | $9.04/g | Unknown |
| | | | | $12.21/g | Unknown |
| | | | Colorado | $9.94/g | Unknown |
| | | | | $9.26/g | Unknown |
| | | | | $9.20/g | Unknown |
| July 2014 – Sept 2016 | RAND corporation[2] (Washington States' cannabis traceability system) | Secondary data analysis of sales data | Washington | $11.06/g | Yes |
| Jul 2016 – Jun 2017 | Washington States' cannabis traceability system[3] | Secondary data analysis of sales data | Washington | $10.05/g | Yes |
| Sept 2016 | Marijuana Retail Surveillance Tool[4] | Convenience sampling | Colorado | $20.00-45.00/3.5g | Yes |
| Aug 2017 | McMaster University[5] (honestmarijuana.com, priceofweed.com, leafly.com) | Crowdsourced | Alaska | $14.09/g | Unknown |
| | | | California | $9.16/g | Unknown |
| | | | Colorado | $8.76/g | Unknown |
| | | | Maine | $10.43/g | Unknown |
| | | | Massachusetts | $10.16/g | Unknown |
| | | | Nevada | $11.42/g | Unknown |
| | | | Oregon | $8.87/g | Unknown |
| | | | Washington | $11.96/g | Unknown |
| Nov 2017 | Marijuana Policy Group[6] | Secondary data analysis of sales data | Colorado | $5.34/g | No |

| Date | Source | Method | State | Price-per-unit | Tax-inclusive? |
|------|--------|--------|-------|----------------|----------------|
| Jan 2018-Feb 2019 | Headset Cannabis Market Insights[7] | Secondary data analysis of sales data | California | $11.60/g | Yes |
| | | | Colorado | $4.60/g | Yes |
| | | | Nevada | $13.70/g | Yes |
| | | | Washington | $4.90/g | Yes |
| Dec 2018 | Oregon Liquor Control Commission[8] (Cannabis Tracking System) | Secondary data analysis of sales data | Oregon | < $5.00/g | Yes |
| May 2019 | Oxford Treatment Center[9] (priceofweed.com) | Crowdsourced | Alaska | $298/oz | Unknown |
| | | | California | $257/oz | Unknown |
| | | | Colorado | $242/oz | Unknown |
| | | | Maine | $288/oz | Unknown |
| | | | Massachusetts | $341/oz | Unknown |
| | | | Nevada | $270/oz | Unknown |
| | | | Oregon | $211/oz | Unknown |
| | | | Washington | $233/oz | Unknown |
| Jan 2019-Nov 2019 | Leaflink[10] (wholesale marketplace) | Analysis of Stock Keeping Units | Alaska | $3134/lb | No |
| | | | California | $1821/lb | No |
| | | | Colorado | $1285/lb | No |
| | | | Michigan | $2917/lb | No |
| | | | Nevada | $2572/lb | No |
| | | | Oregon | $915/lb | No |
| | | | Washington | $1148/lb | No |
| Jan 2020-Nov 2020 | Leaflink[11] (wholesale marketplace) | Analysis of Stock Keeping Units | Alaska | $3185/lb | No |
| | | | California | $2032/lb | No |
| | | | Colorado | $1495/lb | No |
| | | | Michigan | $3073/lb | No |
| | | | Nevada | $2238/lb | No |
| | | | Oregon | $1096/lb | No |
| | | | Washington | $1917/lb | No |

1. Hunt P, Pacula RL. Early impacts of marijuana legalization: An evaluation of prices in Colorado and Washington. J Prim Prev, 2017 38(3):221-248
2. Smart R, Caulkins JP, Kilmer B, Davenport S, Midgette G. Variation in cannabis potency and prices in a newly legal market: evidence from 30 million cannabis sales in Washington state. Addiction. 2017;112(12):2167–77
3. Hansen B, Miller K, Seo B, Weber C. Taxing the potency of sin goods: evidence from recreational cannabis and liquor markets. National Tax Journal, 2020, 73(2); 511-544
4. Berg C, Henriksen L, Cavazos-Rehg P, Schauer GL, Freisthler B. The development and pilot testing of the marijuana retail surveillance tool (MRST): assessing marketing and point-of-sale practices among recreational marijuana retailers. Health Education Research. 2017, 32(6): 465-472
5. Amlung M, Reed DD, Morris V, Aston ER, Metrik J, MacKillop J. Price elasticity of illegal versus legal cannabis: a behavioral economic substitutability analysis. Addiction. 2018;114:112-118.
6. Orens A, Light M, Lewandowski B, Rowberry J, Saloga C. Market Size and Demand for Marijuana in Colorado 2017 Market Update [Internet]. Denver, CO; 2018. Available from: https://www.colorado.gov/pacific/sites/default/files/MED Demand and Market Study 082018.pdf
7. Headset. Price Per Package or Price Per Gram? A Closer Look at Pricing Data. [Internet] 2019. Available from: https://www.headset.io/blog/price-per-package-or-price-per-gram-a-closer-look-at-pricing-data
8. Oregon Liquor Control Commission. 2019 Recreational Marijuana Supply and Demand Legislative Report. [Internet] 2019. Available from: https://www.oregon.gov/olcc/marijuana/Documents/Bulletins/2019%20Supply%20and%20Demand%20Legislative%20Report%20FINAL%20for%20Publication(PDFA).pdf
9. Lautieri A, Thomas S, Stein S. The Average Cost of Marijuana by State. Oxford Treatment Center. [Internet] 2019. Available from: https://www.oxfordtreatment.com/marijuana/average-cost-of-marijuana/
10. Leaflink. Wholesale Cannabis Pricing Guide 2019. [Internet] 2020. Available from: https://www.pricingguide.leaflink.com/
11. Leaflink. Wholesale Cannabis Pricing Guide 2020. [Internet] 2021. Available from: https://www.pricingguide.leaflink.com/

**Appendix C – Illegal and legal sources of dried flower in Canada and US states that have legalized non-medical cannabis, 2018-2020**

|  | CANADA | US 'LEGAL' STATES |
|---|---|---|
| **2018** | | |
| **ILLEGAL SOURCES** | Family/Friend*<br>Dealer<br>Internet/Mail order<br>Store/Dispensary | Family/Friend*<br>Dealer<br>Unlicensed/Illegal Store/Dispensary<br>Internet/Mail order and in a state that does not allow delivery<br>Licensed/Legal Store/Dispensary and under MLA or in a state without legal retail sales |
| **LEGAL SOURCES** | HC Licensed Producer | Licensed/Legal Store/Dispensary<br>Licensed/Legal Internet/Mail order and in a state that allows delivery |
| **2019** | | |
| **ILLEGAL SOURCES** | Family/Friend<br>Dealer<br>Unlicensed/Illegal Store/Dispensary<br>Unlicensed/Illegal Internet/Mail order<br><br>Licensed/Legal Store/Dispensary and under minimum legal age (MLA)<br>Licensed/Legal Internet/Mail order and under MLA | Family/Friend<br>Dealer<br>Unlicensed/Illegal Store/Dispensary<br>Internet/Mail order and in a state that does not allow delivery<br>Licensed/Legal Store/Dispensary and under MLA or in a state without legal retail sales |
| **LEGAL SOURCES** | Licensed/Legal Store/dispensary<br>Licensed/Legal Internet/Mail order | Licensed/Legal Store/Dispensary<br>Licensed/Legal Internet/Mail order and in a state that allows delivery |
| **2020** | | |
| **ILLEGAL SOURCES** | Family/Friend | Family/Friend |

|  | Dealer | Dealer |
| --- | --- | --- |
|  | Unlicensed/Illegal Store/Dispensary | Unlicensed/Illegal Store/Dispensary |
|  | Unlicensed/Illegal Internet/Mail order | Internet/Mail order and in a state that does not allow delivery |
|  | Licensed/Legal Store/Dispensary and under MLA | Licensed/Legal Store/Dispensary and under MLA or in a state without legal retail sales |
|  | Licensed/Legal Internet/Mail order and under MLA |  |
| **LEGAL SOURCES** | Licensed/Legal Store/Dispensary | Licensed/Legal Store/Dispensary |
|  | Licensed/Legal Internet/Mail order | Licensed/Legal Internet/Mail order and in a state that allows delivery |

The source 'Family/Friend' in legal jurisdictions was classed as 'illegal' as it refers to dried flower that has been paid for, not gifted or shared.

MLA was taken from provincial and state laws in September 2018, 2019 and 2020. In 2019, MLA in Canada was 18 years in Alberta and Quebec, and 19 years elsewhere. In 2020, MLA in Canada was 18 years in Alberta, 21 years in Quebec, and 19 years elsewhere. In US 'legal' states, MLA was 21 years in 2018, 2019, and 2020.

**Appendix D – Alternate cleaning methods for Canadian and US respondents of legal age who had consumed and purchased dried flower in the past 12-months and provided a price-per-gram of dried flower**

**Table D1 – Unit price and quantity-adjusted price of dried flower at last purchase by cannabis use frequency, purchase source, and quantity purchased where implausible values were winsorized at the 95th and 1st percentile, among Canadian respondents** (n=3,928)

| | Mean $/g (SEM) | | Quantity-adjusted $ (SE) | |
|---|---|---|---|---|
| | **2019** | **2020** | **2019** | **2020** |
| | n=2029 | n=1899 | n=2029 | n=1899 |
| **All participants** | $12.40 (0.3) | $11.71 (0.3) | $7.45 (0.2) | $7.07 (0.2) |
| **Cannabis use frequency** | | | | |
| Past year, but less than monthly | $17.38 (0.9) | $16.98 (0.8) | $12.29 (0.9) | $10.63 (1.1) |
| Monthly | $16.01 (0.8) | $14.41 (0.7) | $11.31 (0.6) | $9.45 (0.9) |
| Weekly | $12.60 (0.6) | $12.25 (0.6) | $8.58 (0.7) | $8.49 (0.6) |
| Daily/almost daily | $9.60 (0.3) | $9.13 (0.3) | $6.52 (0.2) | $6.37 (0.2) |
| **Purchase source** | | | | |
| Friends or family | $11.57 (0.7) | $12.37 (0.9) | $7.04 (0.3) | $6.48 (0.5) |
| Dealer (in person) | $11.07 (0.5) | $11.29 (0.7) | $6.79 (0.3) | $7.16 (0.5) |
| Online/mail order | $12.53 (0.8) | $10.82 (0.6) | $6.81 (0.4) | $6.67 (0.3) |
| Store/dispensary | $13.67 (0.4) | $12.05 (0.3) | $9.59 (0.4) | $7.83 (0.3) |
| **Legality of purchase source** | | | | |
| Illegal | $10.81 (0.4) | $10.97 (0.5) | $6.38 (0.2) | $6.40 (0.3) |
| Legal | $14.46 (0.4) | $12.25 (0.3) | $10.08 (0.3) | $7.94 (0.2) |
| Unknown | $10.00 (0.8) | $11.01 (1.9) | $7.68 (0.6) | $6.78 (0.4) |
| **Quantity purchased** | | | | |
| <1g | $29.47 (1.5) | $28.77 (1.5) | $27.32 (1.6) | $26.95 (1.6) |
| 1g-3.49g | $15.24 (0.5) | $15.42 (0.5) | $14.66 (0.5) | $14.49 (0.4) |
| 3.5-27.9g | $9.99 (0.2) | $10.33 (0.3) | $9.05 (0.2) | $9.36 (0.4) |
| ≥ 28g | $5.25 (0.1) | $5.19 (0.1) | $5.11 (0.1) | $5.08 (0.1) |

**Table D2 – Unit price and quantity-adjusted price of dried flower at last purchase by cannabis use frequency, purchase source, and quantity purchased where implausible values were winsorized at the 99th and 1st percentile, among Canadian respondents** (n=3,928)

| | Mean $/g (SEM) | | Quantity-adjusted $ (SE) | |
|---|---|---|---|---|
| | **2019** | **2020** | **2019** | **2020** |
| | n=2029 | n=1899 | n=2029 | n=1899 |
| **All participants** | $14.13 (0.5) | $13.06 (0.6) | $7.70 (0.2) | $7.31 (0.2) |
| **Cannabis use frequency** | | | | |
| Past year, but less than monthly | $20.58 (1.6) | $19.63 (1.3) | $13.01 (1.0) | $11.18 (1.2) |
| Monthly | $18.19 (1.2) | $16.25 (1.1) | $11.84 (0.7) | $10.18 (1.2) |
| Weekly | $13.60 (0.8) | $14.59 (1.4) | $8.90 (0.8) | $9.09 (0.8) |
| Daily/almost daily | $11.04 (0.7) | $9.56 (0.4) | $6.70 (0.2) | $6.48 (0.2) |
| **Purchase source** | | | | |
| Friends or family | $12.64 (0.9) | $15.76 (1.9) | $7.37 (0.5) | $7.09 (0.7) |
| Dealer (in person) | $13.37 (1.1) | $11.96 (0.9) | $7.13 (0.4) | $7.36 (0.6) |
| Online/mail order | $15.11 (1.5) | $11.97 (0.9) | $6.99 (0.4) | $6.88 (0.4) |
| Store/dispensary | $14.90 (0.6) | $13.09 (0.5) | $9.75 (0.4) | $7.96 (0.3) |
| **Legality of purchase source** | | | | |
| Illegal | $12.61 (0.7) | $12.52 (0.8) | $6.64 (0.2) | $6.64 (0.3) |
| Legal | $16.15 (0.7) | $13.50 (0.5) | $10.35 (0.4) | $8.21 (0.3) |
| Unknown | $11.07 (1.4) | $11.01 (1.9) | $7.81 (0.6) | $6.78 (0.4) |
| **Quantity purchased** | | | | |
| <1g | $44.05 (4.0) | $42.22 (3.9) | $37.37 (3.3) | $37.09 (3.5) |
| 1g-3.49g | $17.04 (0.8) | $16.73 (0.7) | $16.26 (0.8) | $15.41 (0.6) |
| 3.5-27.9g | $10.33 (0.3) | $11.03 (0.6) | $9.29 (0.3) | $9.85 (0.5) |
| ≥ 28g | $5.25 (0.1) | $5.19 (0.1) | $5.11 (0.1) | $5.08 (0.1) |

**Table D3 – Unit price and quantity-adjusted price of dried flower at last purchase by cannabis use frequency, purchase source, and quantity purchased where implausible values were winsorized at the 95th and 1st percentile, among US 'legal' respondents** (n=5,570)

| | Mean $/g (SEM) | | Quantity-adjusted $ (SE) | |
|---|---|---|---|---|
| | **2019** | **2020** | **2019** | **2020** |
| | n=3320 | n=2250 | n=3320 | n=2250 |
| **All participants** | $12.92 (0.3) | $14.28 (0.5) | $7.82 (0.2) | $8.63 (0.4) |
| **Cannabis use frequency** | | | | |
| Past year, but less than monthly | $17.43 (0.9) | $21.33 (1.7) | $10.54 (0.9) | $11.26 (2.9) |
| Monthly | $16.60 (1.0) | $19.80 (1.4) | $11.23 (0.8) | $14.54 (1.2) |
| Weekly | $15.23 (0.7) | $15.51 (1.0) | $10.17 (0.6) | $11.26 (0.8) |
| Daily/almost daily | $10.72 (0.3) | $10.91 (0.4) | $6.97 (0.2) | $7.57 (0.4) |
| **Purchase source** | | | | |
| Friends or family | $12.63 (0.7) | $16.19 (1.4) | $7.41 (0.5) | $9.35 (1.5) |
| Dealer (in person) | $12.15 (0.7) | $13.88 (1.2) | $7.28 (0.4) | $8.12 (0.6) |
| Online/mail order | $15.28 (1.3) | $18.03 (2.4) | $8.31 (0.7) | $10.78 (1.5) |
| Store/dispensary | $13.01 (0.3) | $13.43 (0.5) | $8.13 (0.2) | $8.29 (0.4) |
| **Quantity purchased** | | | | |
| <1g | $31.59 (1.6) | $31.64 (2.7) | $29.95 (1.8) | $30.32 (2.7) |
| 1g-3.49g | $17.13 (0.5) | $19.99 (1.0) | $16.44 (0.5) | $18.49 (0.9) |
| 3.5-27.9g | $10.38 (0.2) | $11.44 (0.4) | $9.22 (0.3) | $10.57 (0.6) |
| ≥ 28g | $4.55 (0.2) | $5.33 (0.3) | $4.47 (0.2) | $5.05 (0.3) |

**Table D4 – Unit price and quantity-adjusted price of dried flower at last purchase by cannabis use frequency, purchase source, and quantity purchased where implausible values were winsorized at the 99th and 1st percentile, among US 'legal' respondents** (n=5,570)

| | Mean $/g (SEM) | | Quantity-adjusted $ (SE) | |
|---|---|---|---|---|
| | **2019** | **2020** | **2019** | **2020** |
| | n=3320 | n=2250 | n=3320 | n=2250 |
| **All participants** | $14.99 (0.5) | $17.61 (1.0) | $8.41 (0.3) | $9.46 (0.6) |
| **Cannabis use frequency** | | | | |
| Past year, but less than monthly | $21.14 (1.8) | $29.71 (4.8) | $11.99 (1.4) | $14.40 (4.3) |
| Monthly | $20.32 (1.9) | $27.00 (4.0) | $12.81 (1.5) | $17.30 (1.9) |
| Weekly | $17.98 (1.2) | $18.04 (1.9) | $11.11 (0.7) | $11.88 (0.9) |
| Daily/almost daily | $11.97 (0.5) | $12.39 (0.8) | $7.36 (0.3) | $8.10 (0.6) |
| **Purchase source** | | | | |
| Friends or family | $15.04 (1.2) | $24.25 (3.7) | $8.65 (1.0) | $11.79 (2.6) |
| Dealer (in person) | $14.83 (1.4) | $18.00 (2.9) | $7.78 (0.6) | $9.13 (1.0) |
| Online/mail order | $19.87 (2.9) | $28.36 (7.3) | $9.29 (1.0) | $11.87 (1.9) |
| Store/dispensary | $14.53 (0.5) | $14.35 (0.6) | $8.48 (0.3) | $8.43 (0.4) |
| **Quantity purchased** | | | | |
| <1g | $44.50 (3.8) | $48.25 (8.7) | $41.47 (4.0) | $42.57 (6.9) |
| 1g-3.49g | $20.44 (1.0) | $26.90 (2.6) | $19.36 (1.0) | $23.80 (2.2) |
| 3.5-27.9g | $11.10 (0.4) | $12.36 (0.6) | $9.87 (0.5) | $11.43 (1.0) |
| ≥ 28g | $4.55 (0.2) | $5.35 (0.3) | $4.47 (0.2) | $5.08 (0.3) |

# Appendix E – Sociodemographic differences between respondents included and excluded in analyzes

**Table E1 - Differences between Canadian dried flower purchasers who provided a plausible price-per-gram vs those who do not in 2018, 2019, and 2020** (n=6,384).

| | STUDY 1 (2018) | | | STUDY 3 (2019) | | | STUDY 3 (2020) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Out of $2.20-$30 per gram range n=328 | Plausible price-per-gram n=899 | Rao-Scott χ² (sig.) | Did not provide or had invalid price-per-gram n=577 | Plausible price-per-gram n=1929 | Rao-Scott χ² (sig.) | Did not provide or had invalid price-per-gram n=606 | Plausible price-per-gram n=1811 | Rao-Scott χ² (sig.) |
| **Age group** | | | | | | | | | |
| 16-25 | 19.4 (64) | 18.7 (162) | 4.24 (p=0.375) | 14.0 (80) | 14.1 (281) | 5.45 (p=0.244) | 14.0 (75) | 14.1 (223) | 3.71 (p=0.447) |
| 26-35 | 34.6 (76) | 30.2 (201) | | 34.1 (168) | 33.3 (552) | | 34.1 (163) | 33.3 (469) | |
| 36-45 | 22.2 (61) | 20.5 (149) | | 22.2 (141) | 22.2 (449) | | 22.2 (155) | 22.2 (447) | |
| 46-55 | 12.0 (51) | 17.7 (183) | | 20.0 (110) | 16.8 (325) | | 20.0 (118) | 16.8 (337) | |
| 56-65 | 11.8 (76) | 12.9 (204) | | 9.7 (78) | 13.6 (322) | | 9.7 (95) | 13.6 (335) | |
| **Sex** | | | | | | | | | |
| Female | 46.0 (175) | 37.4 (424) | **4.26 (p=0.039)** | 43.9 (334) | 39.1 (1009) | 2.89 (p=0.089) | 49.3 (379) | 39.9 (975) | **9.88 (p=0.002)** |
| Male | 54.0 (153) | 62.6 (475) | | 56.1 (243) | 60.9 (920) | | 50.7 (277) | 60.1 (836) | |
| **Ethnicity** | | | | | | | | | |
| Black | 2.1 (8) | 2.6 (15) | **13.44 (p=0.020)** | 4.6 (18) | 3.0 (48) | **16.20 (p=0.023)** | 3.1 (12) | 3.2 (43) | 3.33 (p=0.853) |
| East/Southeast Asian | 4.5 (10) | 1.8 (10) | | 6.9 (32) | 3.8 (73) | | 4.0 (22) | 4.0 (63) | |
| Indigenous | 6.7 (26) | 7.4 (81) | | 3.3 (22) | 4.8 (82) | | 2.6 (19) | 3.4 (69) | |
| Latinx | - | - | | 1.9 (10) | 2.2 (28) | | 1.7 (8) | 1.8 (26) | |
| Middle Eastern | - | - | | 1.0 (8) | 0.4 (8) | | 1.6 (9) | 1.3 (18) | |
| South Asian | 3.6 (5) | 2.1 (17) | | 1.9 (11) | 2.9 (44) | | 4.0 (18) | 2.8 (41) | |
| White | 73.0 (256) | 81.8 (737) | | 76.7 (434) | 77.4 (1532) | | 78.8 (471) | 77.8 (1432) | |
| Other/Mixed | 10.1 (23) | 4.3 (39) | | 3.8 (27) | 5.6 (94) | | 4.3 (33) | 5.7 (97) | |
| **Education** | | | | | | | | | |
| Less than high school | 21.0 (40) | 18.8 (116) | 7.64 (p=0.054) | 9.1 (26) | 14.2 (145) | **7.92 (p=0.048)** | 8.8 (32) | 10.0 (126) | 3.30 (p=0.347) |
| High school diploma | 25.9 (52) | 30.9 (161) | | 34.8 (129) | 30.4 (355) | | 29.8 (106) | 32.6 (331) | |
| Some college or technical vocation | 30.9 (145) | 36.0 (421) | | 33.7 (259) | 35.9 (933) | | 36.4 (273) | 36.9 (833) | |
| Bachelor's degree or higher | 22.3 (90) | 14.2 (200) | | 22.3 (156) | 19.6 (491) | | 25.0 (187) | 20.5 (513) | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Income adequacy** | | | | | | | | | |
| Very difficult | 7.3 (34) | 9.2 (100) | 4.26 (p=0.642) | 12.8 (69) | 11.8 (232) | **13.63 (p=0.018)** | 9.9 (60) | 10.3 (188) | 9.03 (p=0.108) |
| Difficult | 23.2 (72) | 26.2 (235) | | 20.0 (123) | 28.0 (517) | | 19.8 (125) | 22.3 (433) | |
| Neither easy nor difficult | 38.0 (120) | 36.6 (328) | | 35.9 (197) | 33.1 (643) | | 33.3 (207) | 36.7 (639) | |
| Easy | 17.6 (58) | 18.1 (151) | | 18.3 (113) | 17.8 (351) | | 21.9 (131) | 20.9 (375) | |
| Very Easy | 11.5 (38) | 8.7 (73) | | 9.7 (57) | 7.0 (154) | | 12.6 (65) | 8.3 (149) | |
| Not stated | 9.7 (6) | 1.2 (12) | | 3.7 (18) | 2.3 (32) | | 2.6 (18) | 1.5 (27) | |
| **Cannabis use frequency** | | | | | | | | | |
| Past-year but less than monthly | 17.7 (66) | 11.4 (111) | **14.98 (p=0.002)** | 20.9 (134) | 13.8 (299) | **27.60 (p<0.001)** | 22.4 (168) | 13.2 (268) | **22.06 (p<0.001)** |
| Monthly | 21.8 (71) | 17.8 (142) | | 22.5 (132) | 15.9 (329) | | 16.8 (112) | 15.6 (294) | |
| Weekly | 26.2 (85) | 20.2 (180) | | 20.3 (119) | 21.0 (394) | | 20.0 (118) | 19.7 (351) | |
| Daily/almost daily | 34.4 (106) | 50.6 (466) | | 36.4 (192) | 49.4 (907) | | 40.8 (208) | 51.5 (898) | |
| **Device used** | | | | | | | | | |
| Smartphone | - | - | - | 44.6 (276) | 50.0 (954) | 4.46 (p=0.108) | 49.7 (317) | 51.1 (935) | 3.63 (p=0.163) |
| Tablet | - | - | - | 8.5 (45) | 6.2 (131) | | 7.2 (31) | 4.4 (78) | |
| Computer | - | - | - | 46.9 (256) | 43.9 (844) | | 43.1 (258) | 44.5 (798) | |

Weighted %, unweighted n.

For Study 1, data are among consumers who reported purchasing dried flower in the past 12-months.

For Study 3, data are among consumers who were of legal age to purchase cannabis and who reported purchasing dried flower in the past 12-months.

**Table E2 - Differences between Canadian dried flower purchasers who provide a valid postal code vs those who do not in 2019** (n=2,506).

| | STUDY 2 (2019) | | |
| --- | --- | --- | --- |
| | **Did not provide postal code**<br>**n=355** | **Valid postal code**<br>**n=2151** | **Rao-Scott χ²**<br>**(sig.)** |
| **Age group** | | | |
| 16-25 | 22.4 (83) | 12.6 (278) | **38.48 (p<0.001)** |
| 26-35 | 39.2 (117) | 32.5 (603) | |
| 36-45 | 20.4 (81) | 22.5 (509) | |
| 46-55 | 13.3 (46) | 18.3 (389) | |
| 56-65 | 4.7 (28) | 14.1 (372) | |
| | | | |
| **Sex** | | | |
| Female | 40.0 (197) | 40.3 (1146) | 0.01 (p=0.929) |
| Male | 60.0 (158) | 59.7 (1005) | |
| | | | |
| **Ethnicity** | | | |
| Black | 5.3 (19) | 3.1 (47) | 7.33 (p=0.395) |
| East/Southeast Asian | 5.9 (18) | 4.2 (87) | |
| Indigenous | 3.5 (14) | 4.6 (90) | |
| Latinx | 2.3 (5) | 2.1 (33) | |
| Middle Eastern | 1.0 (5) | 0.4 (11) | |
| South Asian | 2.9 (11) | 2.6 (44) | |
| White | 75.4 (249) | 77.5 (1717) | |
| Other/Mixed | 3.8 (15) | 5.4 (106) | |
| | | | |
| **Education** | | | |
| Less than high school | 13.2 (26) | 13.0 (145) | 0.25 (p=0.969) |
| High school diploma | 32.1 (72) | 31.3 (412) | |
| Some college or technical vocation | 33.9 (152) | 35.6 (1040) | |

| | | | |
|---|---|---|---|
| Bachelor's degree or higher | 20.8 (94) | 20.0 (553) | |
| | | | |
| **Income adequacy** | | | |
| Very difficult | 8.7 (32) | 12.6 (269) | **66.89 (p<0.001)** |
| Difficult | 23.1 (84) | 26.6 (556) | |
| Neither easy nor difficult | 33.7 (119) | 33.7 (721) | |
| Easy | 17.6 (61) | 18.0 (403) | |
| Very Easy | 6.3 (27) | 7.9 (184) | |
| Not stated | 10.6 (32) | 1.2 (18) | |
| | | | |
| **Cannabis use frequency** | | | |
| Past-year but less than monthly | 10.7 (48) | 16.3 (385) | 5.69 (p=0.128) |
| Monthly | 18.6 (74) | 17.2 (387) | |
| Weekly | 23.2 (84) | 20.4 (429) | |
| Daily/almost daily | 47.5 (149) | 46.2 (950) | |
| | | | |
| **Device used** | | | |
| Smartphone | 63.4 (218) | 46.1 (1012) | **26.62 (p<0.001)** |
| Tablet | 6.9 (23) | 6.7 (153) | |
| Computer | 29.7 (114) | 47.2 (986) | |

Weighted %, unweighted n.

Data were among Canadian respondents of legal age to purchase cannabis and had consumed and purchased dried flower in the past 12-months.

**Table E3 - Differences between dried flower purchasers in US 'legal' states who provided a plausible price-per-gram vs those who do not in 2019, and 2020** (n=5,972)**.**

| | STUDY 4 (2019) | | | STUDY 4 (2020) | | |
|---|---|---|---|---|---|---|
| | Did not provide or had invalid price-per-gram n=700 | Plausible price-per-gram n=2900 | Rao-Scott χ² (sig.) | Did not provide or had invalid price-per-gram n=442 | Plausible price-per-gram n=1930 | Rao-Scott χ² (sig.) |
| **Age group** | | | | | | |
| 21-35 | 43.3 (298) | 44.8 (1266) | 2.17 (p=0.337) | 44.0 (157) | 43.2 (686) | 1.95 (p=0.377) |
| 36-50 | 36.0 (231) | 32.6 (916) | | 37.5 (171) | 33.9 (645) | |
| 51-65 | 20.7 (171) | 22.7 (718) | | 18.5 (114) | 22.9 (599) | |
| **Sex** | | | | | | |
| Female | 46.2 (506) | 42.0 (2004) | 2.89 (p=0.089) | 48.5 (283) | 43.2 (1189) | 1.65 (p=0.199) |
| Male | 53.8 (194) | 58.0 (896) | | 51.5 (159) | 56.8 (741) | |
| **Ethnicity** | | | | | | |
| White Non-Hispanic | 63.1 (455) | 65.6 (1981) | 5.83 (p=0.443) | 63.2 (314) | 69.0 (1405) | 6.88 (p=0.332) |
| White Hispanic | 16.2 (92) | 15.0 (342) | | 16.0 (47) | 11.0 (138) | |
| American Indian or Alaskan Native | 2.4 (17) | 2.4 (61) | | 1.1 (8) | 1.9 (43) | |
| Asian | 4.0 (26) | 2.2 (61) | | 4.4 (10) | 1.9 (41) | |
| Black or African American | 8.5 (47) | 9.5 (228) | | 9.8 (30) | 10.5 (134) | |
| Native Hawaiian or Pacific Islander | 0.6 (4) | 0.3 (7) | | 1.1 (1) | 1.1 (11) | |
| Other/Mixed | 5.2 (36) | 5.0 (172) | | 4.5 (23) | 4.7 (122) | |
| **Education** | | | | | | |
| Less than high school | 4.1 (26) | 3.5 (100) | **8.60 (p=0.035)** | 1.5 (10) | 4.0 (75) | **9.45 (p=0.024)** |
| High school diploma | 19.8 (135) | 23.6 (632) | | 18.5 (82) | 22.6 (394) | |
| Some college or technical vocation | 46.8 (313) | 49.5 (1428) | | 44.1 (161) | 46.2 (860) | |
| Bachelor's degree or higher | 29.3 (219) | 23.4 (737) | | 35.9 (183) | 27.2 (597) | |
| **Income adequacy** | | | | | | |
| Very difficult | 8.1 (75) | 11.4 (376) | **29.28 (p<0.001)** | 7.3 (42) | 10.4 (226) | **13.19 (p=0.022)** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Difficult | 21.9 (151) | 25.6 (800) | | 17.5 (88) | 23.0 (489) | |
| Neither easy nor difficult | 37.0 (268) | 34.4 (983) | | 33.4 (161) | 34.6 (652) | |
| Easy | 15.7 (99) | 18.2 (483) | | 18.5 (73) | 17.8 (341) | |
| Very Easy | 12.9 (82) | 8.9 (221) | | 19.9 (59) | 12.7 (190) | |
| Not stated | 4.5 (25) | 1.5 (37) | | 3.5 (19) | 1.5 (32) | |
| | | | | | | |
| **Cannabis use frequency** | | | | | | |
| Past-year but less than monthly | 17.5 (126) | 10.0 (303) | **53.77 (p<0.001)** | 15.1 (86) | 10.5 (205) | **19.16 (p<0.001)** |
| Monthly | 16.9 (121) | 11.3 (325) | | 25.7 (97) | 14.6 (296) | |
| Weekly | 22.3 (157) | 17.3 (476) | | 16.6 (73) | 18.3 (338) | |
| Daily/almost daily | 43.3 (296) | 61.4 (1796) | | 42.6 (186) | 56.6 (1091) | |
| | | | | | | |
| **Device used** | | | | | | |
| Smartphone | 53.8 (405) | 59.2 (1801) | 5.10 (p=0.078) | 57.9 (273) | 61.4 (1199) | 0.77 (p=0.680) |
| Tablet | 6.4 (42) | 4.7 (158) | | 4.7 (18) | 4.4 (83) | |
| Computer | 39.8 (253) | 36.1 (941) | | 37.4 (151) | 34.2 (648) | |

Weighted %, unweighted n.

For Study 4, data are among consumers who were of legal age to purchase non-medical cannabis and who reported purchasing dried flower in the past 12-months.

## Appendix F: Inclusion and exclusion of tax in final prices of dried flower in Canada and the US, 2019-2020

**Table F1: The inclusion or exclusion of tax in final prices of dried flower among Canadian respondents in Chapter 4 and 5: 2019-2020** (n=2601)

| | Did the amount you spent at last purchase include tax? | | | | | |
| | 2019 n=1232 | | | 2020 n=1369 | | |
| | Yes | No | Don't know | Yes | No | Don't know |
|---|---|---|---|---|---|---|
| **The last time you bought dried flower, where did you buy it?** | | | | | | |
| Online/Mail order | 57.4 (198) | 30.6 (89) | 12.0 (35) | 65.2 (236) | 20.4 (83) | 14.4 (54) |
| Stores/Dispensaries | 63.0 (562) | 21.0 (183) | 16.0 (165) | 60.1 (593) | 25.2 (240) | 14.8 (163) |
| | | | | | | |
| **Where did you buy the dried flower online?** | | | | | | |
| Legal website | 58.9 (127) | 28.0 (52) | 13.1 (28) | 66.2 (170) | 21.9 (56) | 11.9 (31) |
| Illegal website | 55.0 (63) | 37.6 (36) | 7.4 (6) | 63.2 (57) | 18.5 (24) | 18.3 (19) |
| Other/Don't know | 53.6 (7) | 8.8 (1) | 37.7 (1) | 63.4 (8) | 8.8 (3) | 27.8 (3) |
| | | | | | | |
| **What type of physical store/dispensary did you buy the dried flower from?** | | | | | | |
| Legal store | 62.9 (510) | 20.4 (165) | 16.7 (152) | 60.1 (566) | 25.5 (226) | 14.4 (152) |
| Illegal store | 63.3 (40) | 24.4 (14) | 12.3 (11) | 59.0 (20) | 17.7 (11) | 23.4 (9) |
| Other/Don't know | 63.6 (12) | 27.4 (4) | 9.0 (2) | 62.7 (7) | 31.0 (3) | 6.3 (2) |

Weighted %, unweighted n

Question asked among respondents who reported last purchasing dried flower from a store/dispensary or online/mail order.

**Table F2: The inclusion and exclusion of tax in final prices of dried flower among US 'legal' respondents in Chapter 6: 2019-2020** (n=3,787)

| | Did the amount you spent at last purchase include tax? | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | **2019** n=2,193 | | | **2020** n=1,594 | | |
| | **Yes** | **No** | **Don't know** | **Yes** | **No** | **Don't know** |
| **The last time you bought dried flower, where did you buy it?** | | | | | | |
| Online/Mail order | 59.6 (81) | 32.6 (44) | 6.7 (12) | 82.3 (66) | 15.2 (16) | 2.5 (3) |
| Stores/Dispensaries | 65.6 (1352) | 25.8 (507) | 8.6 (196) | 68.0 (1004) | 24.1 (377) | 7.9 (127) |
| | | | | | | |
| **Where did you buy the dried flower online?** | | | | | | |
| Legal website | 58.8 (69) | 34.5 (40) | 6.7 (10) | 82.3 (62) | 16.5 (15) | 1.2 (1) |
| Illegal website | 77.9 (10) | 13.5 (3) | 8.6 (2) | 85.8 (2) | 9.0 (1) | 5.2 (1) |
| Other/Don't know | 29.6 (1) | 70.4 (1) | 0.0 (0) | 78.3 (2) | 0.0 (0) | 21.7 (1) |
| | | | | | | |
| **What type of physical store/dispensary did you buy the dried flower from?** | | | | | | |
| Legal medical store | 64.0 (663) | 28.5 (288) | 7.6 (86) | 65.4 (475) | 26.8 (207) | 7.9 (47) |
| Legal non-medical store | 69.9 (672) | 21.3 (203) | 8.8 (97) | 70.8 (520) | 21.1 (166) | 8.1 (78) |
| Illegal store | 29.6 (10) | 46.2 (11) | 24.2 (8) | 83.6 (5) | 16.4 (2) | 0.0 (0) |
| Other/Don't know | 27.7 (7) | 54.2 (5) | 18.1 (4) | 49.5 (3) | 33.6 (2) | 16.8 (1) |

Weighted %, unweighted n

Respondents from Illinois were not included

Question asked among respondents who reported last purchasing dried flower from a store/dispensary or online/mail order.