Cannabis use, retail availability and legal sanctions in Canada: Differences by neighbourhood deprivation, individual socioeconomic factors, and race/ethnicity.

by

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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.

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Statement of Contributions

Fathima Fataar was the sole author for Chapters 1, 2, and 6, 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 prepared for publication. Exceptions to sole authorship are as follows:

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As lead author of these three chapters, I was responsible for contributing to conceptualizing the research questions, 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.

Abstract

Background: Cannabis legalization in Canada represents one of the most significant changes in substance use policy over the past century. One of the primary objectives of cannabis legalization is to reduce illicit trade and the disproportionate negative impact of criminalization on racialized individuals and those with lower socioeconomic position. The extent to which legalization of non-medical cannabis redresses these disparities has yet to be assessed. In particular, there is little evidence on the impact of different regulatory policies, such as the distribution of legal retail outlets, as well as community-level factors such as neighbourhood deprivation.

Objectives: This dissertation examined three primary research questions: 1) Are there differences in cannabis-related legal sanctions based on race/ethnicity, individual socioeconomic factors and neighbourhood deprivation?; 2) Are there differences in problematic cannabis use pre- and post-cannabis legalization based on race/ethnicity, individual socioeconomic factors and neighbourhood deprivation?; and 3) What is the distribution of legal cannabis retail stores based on neighbourhood deprivation?

Methods: Studies 1 and 2 used repeat cross-sectional data from wave 2 and 3 and waves 1-3, respectively, of the International Cannabis Policy Study (ICPS). Wave 1 was conducted prior to cannabis legalization from August-October 2018, and Wave 2 and Wave 3 data were collected post-legalization in September-October 2019 and 2020, respectively. The ICPS is a web-based survey conducted annually in Canada among those aged 16 to 65. Respondents were recruited using non-probability sampling methods through the Nielsen Consumer Insights Global Panel and their partners' panels. Individual respondent postal code data was linked to the Institut National de Santé Publique du Québec (INSPQ) 2016 material and social deprivation index to obtain a measure of neighbourhood material and social deprivation for each participant. In Study 1, multinomial regression models were used to

examine the associations between individual-level socioeconomic indicators, race/ethnicity and neighbourhood deprivation and arrests and convictions for cannabis-related criminal offences. Similarly, in Study 2, multinomial regression models were used to examine the associations between individual-level socioeconomic indicators, race/ethnicity and neighbourhood deprivation and problematic cannabis use using the World Health Organization Alcohol, Smoking and Substance Use Screening Test (ASSIST) measure. In addition, interaction terms between survey year and predictor variables were included to examine pre- and post-legalization changes in problematic use.

In Study 3, data on physical cannabis retail outlet locations including postal code were collected from government websites which included all available locations up to September 2021. Postal code data was linked to the INSPQ 2016 material and social deprivation index. Descriptive statistics were used to characterize the distribution of stores by neighbourhood material and social deprivation in Canada overall and within each of the provinces and territories.

Results:

Study 1: Overall, 4.4% of respondents reported a lifetime arrest or conviction for a cannabis-related offence. Compared to respondents who identified as White, Black and Indigenous individuals had more than 3 times the odds of conviction (AOR=3.90 95%CI=2.07-7.35, p<0.01; AOR=3.24 95% CI=1.78-5.90, p<0.01, respectively). Differences remained after adjusting for cannabis use and socioeconomic factors however only the difference for Black individuals remained after adjusting for neighbourhood deprivation. Neighbourhood deprivation was associated with cannabis-related convictions: the odds of a conviction among the 'most privileged' and 'privileged' neighbourhoods were approximately half of those in the 'most deprived' neighbourhoods (AOR=0.50, 95%CI=0.29-0.86; p=0.01; AOR=0.50, 95% CI=0.27-0.92; p=0.03, respectively).

Study 2: There was little evidence in support of changes in 'high risk' problematic cannabis use among past 12-month cannabis consumers from before cannabis legalization (2018=5.7%) to 12- or 24-months after legalization (2019=4.5%, 2020=5.0%, all p>0.10). There was a decrease in 'moderate risk' between 2018-2019 (p=0.03) and between 2018 and 2020 (p=0.01). Problematic use differed by sociodemographic factors. For example, compared to those from more materially deprived neighbourhoods the odds of 'moderate risk' vs 'low risk' were lower for consumers from neighbourhoods which were 'neither deprived nor privileged' (AOR=0.78, 95%CI=0.64-0.95; p=0.01); 'privileged' (AOR 0.60, 95%CI=0.49-0.7, p<0.01); and 'most privileged' (AOR=0.70; 95%CI=0.57-0.86, p=0.01). However, there were few differences in 'high risk'. Black, Middle Eastern and South Asian individuals were more likely than White individuals to experience 'high risk' compared to 'low risk' (AOR=2.63, 95%CI=1.33-5.22, p=0.01; AOR=4.22, 95%CI=1.93-9.19, p<0.01; AOR=2.33, 95%CI=1.14-4.78, p=0.02, respectively). Differences across subgroups were consistent from 2018 to 2020.

Study 3: At the national level, there were approximately 8.0 retail cannabis stores per 100,000 individuals age 15+ as of September 2021. The distribution of stores was closely aligned with the expected distribution across levels of material deprivation: for example, 19.5% of stores were located in neighbourhoods with the lowest level of material deprivation versus 19.1% in the highest level. More cannabis stores were located in the 'most socially deprived' or 'socially deprived' neighbourhoods (37.2% and 22.1%, respectively), characterized by a higher proportion of residents who live alone, are unmarried, or in single-parent families. The distribution of stores in provinces and territories were generally consistent with national patterns with a few exceptions.

Conclusions: Cannabis legalization in Canada has presented the opportunity to redress some of the harms associated with cannabis use, particularly for racialized individuals and those in lower socioeconomic position. Lifetime arrests and conviction for cannabis-related offences

were disproportionately higher among racialized people, especially Black and Indigenous people, as well as those with lower socioeconomic position and those living in more deprived neighbourhoods. While the current work suggests few differences in problematic cannabis use in the early stages of legalization, the findings also highlight the greater burden of problematic use on racialized and marginalized people. However, the relatively even distribution of retail stores at all levels of material neighbourhood deprivation is encouraging. Continued monitoring will be needed to determine if this continues in the rapidly evolving legal cannabis retail market to ensure that those in more materially deprived neighbourhoods are not disproportionately impacted. Going forward guidelines and policies to minimize harms associated with cannabis use and increase inclusion in the legal cannabis industry for racialized and marginalized people are needed.

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List of Abbreviations

AAPOR	American Association for Public Opinion Research
AOR	Adjusted odds ratio
ASSIST	Alcohol, Smoking and Substance Involvement Screening Test
AB	Alberta
BC	British Columbia
CAMH	Centre for Addiction and Mental Health
CAST	Cannabis Abuse Screening Test
CCS	Canadian Cannabis Survey
CCSA	Canadian Centre on Substance Use and Addiction
CI	Confidence interval
CUDIT-R	Cannabis Use Disorder Identification Test-Revised
DSM	Diagnostic and Statistical Manual of Mental Disorders
ICPS	International Cannabis Policy Study
INSPQ	Institut National de Santé Publique du Québec
m	Metres
MB	Manitoba
ON	Ontario
QC	Québec
NB	New Brunswick
NCS	National Cannabis Survey
NL	Newfoundland and Labrador
NS	Nova Scotia
NT	Northwest Territories
NU	Nunavut
PE	Prince Edward Island
SEP	Socioeconomic position
SK	Saskatchewan
US	United States
VIF	Variance inflation factor
WHO	World Health Organization
YK	Yukon

Chapter 1: Introduction

1.1 Cannabis

Cannabis is one of the most widely used substances globally.[1] There is a long history of cannabis use for both medical purposes, as well as for recreational purposes, such as relaxation. Cannabis is available in a variety of forms including dried herb, oils and wax for vaping, edibles and shatter. With the legalization of recreational cannabis in Canada and many states across the United States (US), it is expected that more products with varying potency will become available.[2] Canada and the US are among the nations with highest reported cannabis prevalence with national estimates of past 12-month use at 25% in Canada, and 18% in the US.[3,4] As the prevalence of cannabis use is high, there is the potential for it to have a substantial impact on public health.

There is some evidence that medical cannabis can be used to alleviate symptoms of some symptoms associated with medical conditions such as chronic pain and spasticity associated with multiple sclerosis,[5] however, cannabis use can have both acute and chronic adverse health effects.[5] Acute conditions can include severe vomiting, impaired coordination, anxiety and psychosis.[6] Frequent and heavy use of cannabis has been associated with mood disorders, neurocognitive dysfunction and cardiovascular disease among others.[6] Early age of initiation and use during adolescence are associated with greater risk of negative outcomes, both physical and socioeconomic, in adulthood. In particular, research suggests that those who begin using cannabis in their teens are more likely to continue to use into adulthood and this is associated with greater reports of dependency and health problems, as well as achieving lower levels of education and income.[7,8]

Aggregate measures of problematic cannabis use, those which include questions about heavy and frequent use, and use interfering with employment and family life, are often used to assess the harms associated with use. Researchers have often used the Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria for cannabis dependence and abuse, however some have used the Cannabis Abuse Screening Test (CAST),[9] the Cannabis Use

Disorder Identification Test-Revised (CUDIT-R)[10] and the Alcohol, Smoking and Substance Involvement Screening Test (ASSIST)[11] to assess problematic use. While the CAST tool asks about cannabis use in the past 12 months, the CUDIT-R focuses on past 6-month use and ASSIST on past 3-month use. The ASSIST tool was originally designed to be used in the clinical setting, but is now also used in population-based surveys. Each of the tests generates a score, for which there is a threshold for what is considered problematic use. There has been much debate about the use of these measures to assess prevalence of problematic use as most were originally designed for use by clinicians as diagnostic tools, and it is unclear where the thresholds should lie to accurately characterize problematic use prevalence.[12] Nonetheless, when used in population surveys these measures allow researchers to generate estimates of problematic use, as well as to monitor changes across time. Beyond aggregate measures of problematic use, other indicators of problematic use such as cannabis impaired driving, occupational injuries and emergency room admissions, are also relevant to understanding the public health impact of recreational cannabis use.

1.2 Cannabis Legalization

In Canada, cannabis use for medical purposes was deemed a constitutional right in 2000, and in 2001 medical cannabis became available for patients with certain illnesses. Authorized patients were able to grow their own cannabis or obtain it from authorized producers or Health Canada. In October 2018, non-medical cannabis was legalized across Canada, with individuals over 18 being able to grow their own cannabis or purchase cannabis from government authorized retailers.

In the US, cannabis is still an illegal substance at the federal level; however, as of May 2022, 19 states, two territories and the District of Columbia have legalized recreational cannabis, beginning with Colorado and Washington in 2012.[13] Thirty-seven states, three territories and the District of Columbia have legalized use of medical cannabis, although the regulations vary across states.[13]

1.3 Cannabis Legalization and Social Justice

One of the main arguments in favour of cannabis legalization has been that the costs of prohibition outweigh the potential harms associated with legalization.[14] Not only are there costs associated with police enforcement, court proceedings and imprisonment, but individuals enter the criminal justice system and can be left with permanent criminal records as a result of cannabis possession charges.[15] The impact of arrests and prosecution for cannabis possession extend beyond legal repercussions, and can impact an individual's employment, housing and educational opportunities, among others.[14] In addition, Black, Hispanic, and Indigenous populations have borne the brunt of the legal repercussions of cannabis prohibition in both Canada and the US.[14,16,17]

Prior to the legalization of cannabis in Canada, research found that those who used cannabis more frequently were less likely to have confidence in the police and the justice system.[18] While there are many possible explanations for this finding, it is possible that as cannabis consumers within an environment where cannabis was illegal, these individuals were more keenly aware of the potential to be arrested for use. It may also be that they felt that the police and justice system were enforcing unjust laws, reducing perceptions of legitimacy of the legal system. In addition, these individuals may lack the resources to fight for a fair outcome. In both Canada and the US, racialized and Indigenous individuals have been disproportionately targeted and incarcerated for drug-related offences, despite similar prevalence of cannabis use.[16,17] In Canada, despite little publicly available information on the race of those arrested for cannabis use, recent investigations have reported that in the large city of Toronto, Ontario, Black communities were overpoliced for cannabis offenses.[19] Similarly, a recent report suggests that between 2015 and 2017, Indigenous individuals in Regina, Saskatchewan, were nine times more likely to be arrested for cannabis possession than Whites.[20] A recent study reported that in 2015 across Vancouver, Calgary, Regina, Ottawa, Halifax, Black and Indigenous individuals were more likely to be arrested for

cannabis possession than White individuals.[21] Similarly, in the US, several studies have found that the arrest rates for Black and Hispanics for cannabis possession charges are at least double that of Whites.[17,22,23] Furthermore, in the US, while similar prevalence rates for cannabis use among adults has been reported in Washington State, racial disparities in cannabis related arrests have persisted despite legalization in 2012.[24]

Some have argued that while one of the goals of legalization is to reduce prosecution for possession, it does not do enough to address the social justice issues faced by Black and Indigenous communities, such as opportunities to enter the legal cannabis industry or to have profits reinvested in communities which have been disproportionately affected by cannabis prohibition.[25] In Canada, research has found that 84% of cannabis industry leaders were white, and that Black and Indigenous people were underrepresented relative to their representation in the general population.[26] Similarly, in the US, while data on the racial/ethnic diversity among licensed cannabis producers are limited, it was found that in Massachusetts only 3% of all cannabis business applications were made by an individual who self-identified as Black or Hispanic, while Black and Hispanic individuals make up about 20% of the state's population.[14] In addition, a 2017 survey of cannabis business owners and founders found that only about 6% identified as Hispanic or Latino, and 4% as Black.[27] Clearly, the development of policy guidelines to address the disparities need to be prioritized moving forward.

1.4 Impact of Legalization on Cannabis Use

Legalization of cannabis has the potential to increase heavy use as a result of reduced cost, as well as making it easier and safer to access.[28] Initial evidence from Canada suggests that the prevalence of past 3-month cannabis use increased from 14% in the first quarter of 2018, prior to legalization, to 17% in the first quarter of 2019, following legalization in October 2018, to 20% in the fourth quarter of 2020.[29] Data from the Canadian Cannabis Survey found that past 12-month cannabis use decreased slightly from 27% in 2020 to 25% in 2021.[30]

However, research comparing pre- and post-legalization data from several population-level surveys in Canada found that among current cannabis consumers, frequency of cannabis use and driving after cannabis use have not increased following legalization.[31] In addition, longitudinal data with high school students found no significant increase in 'ever' cannabis use between 2016 and 2018.[32] In the US, recent research on the impact of cannabis legalization on cannabis use among youth found that while legalization of medical cannabis did not appear to increase use, early data suggests that the legalization of recreational cannabis may be associated with increased cannabis use.[33,34] Among adults, in states where medical cannabis was legal, prevalence of use was higher among adults, particularly among those over 45, compared to states where medical cannabis was not legally available.[35,36] In addition, there was a higher prevalence of almost daily and daily users in states where medical cannabis was legal.[35] Similarly, prevalence of use among adults was greater in states with legal recreational cannabis.[37]

1.5 Sociodemographic Indicators and Cannabis Use

Research has explored differences in cannabis use based on sociodemographic indicators such as age, sex, and socioeconomic indicators such as income and education.

1.5.1 Sex and Age

Sex has often been noted as a predictor of cannabis use, with males being more likely than females to be cannabis users, in all age groups.[29,30,38,39] Recent data from a nationally representative Canadian sample indicated that 29% of males reported using cannabis in the past 12 months compared to 22% of females.[40] Among consumers, 29% of males report using cannabis daily or almost daily compared to and 23% of females.[40] Similarly, data from a nationally representative sample of adults in the US reported that past month prevalence of cannabis use was 14% for males and 9% for female.[41] Indeed, data from the US suggests that

over time, the disparity of cannabis use between male and female adults appears to be increasing.[39,42]

Age has also been associated with cannabis use, with higher use among young adults, followed by youth, and a tapering off among older adults. Research has found that in Canada and the US, prevalence was higher among young adults compared to other age groups.[29,30,43] In both Canada and the US, those over 50 were more likely to report using cannabis for medical purposes while young adults were more likely to report recreational use.[44,45] Data from the National Cannabis Survey in 2020 indicated that past 3-month use was highest among those 18-24 at 36%, followed by 25-44 year-olds at 30%.[29] This is substantially greater than use among those 45 and older (11%). Similarly, in the US, past month prevalence in 2019 was highest among 18-25 year-olds at 23%, followed by 14% for those 26-49 and 8% for those over 50.[41] Age is an important consideration as early age of cannabis initiation has been associated with later problematic use.[46]

As with prevalence of cannabis use, problematic use of cannabis is more likely to be reported among males and young people.[47–49] Data from a nationally representative sample of Canadians found that 2% of cannabis users were at 'high risk' for problematic use according to ASSIST criteria.[47] Furthermore, males and those 15-29 were more likely to be at 'high risk' for problematic use compared to females and older individuals, respectively. In the US, 5% of those aged 12 or older had a cannabis use disorder in the past 12 months, with the highest prevalence among those 18-25 at 13%.[4] In addition, a US study of young people between the ages of 24 and 32, males were found to have 1.8 times the odds of cannabis use dependence and 1.4 times the odds of abuse compared to females.[48]

1.5.2 Race and Ethnicity

Race and ethnicity have also been explored as potential predictors of cannabis use. Historically, in the US, the prevalence of cannabis use among adults and adolescents has

been lower among Black and Hispanic people compared to White people.[50] However, US trends suggest that prevalence of use among adolescents increased among Black and Hispanic people but not among White people between 1999 and 2013 resulting in similar estimates of current use across groups.[50] Among those 12 years and older, US national data has reported similar past 12-month prevalence estimates for Black (19%) and White (19%) individuals, with slightly lower prevalence among Hispanic individuals (15%).[51] One study examining racial and ethnic differences in past-year cannabis use after recreational cannabis legalization reported an increase in use among those who identified as Hispanic, White and 'other'.[52] In Canada, few studies have examined differences in cannabis use based on race or ethnicity. In Ontario, a study using the data from the Centre for Addiction and Mental Health (CAMH) Monitor, found that compared to those of 'Canadian' background, past-year cannabis use was lower among those of 'East Asian' and 'West Asian' background, while it was higher among those of 'Caribbean' background.[53] These findings suggest that cultural differences and norms regarding cannabis may impact use.

A US study examining trends in cannabis use disorder between 2002 and 2013 found that Black individuals had greater increases in prevalence of problematic cannabis use compared to White individuals.[54] Similarly, national US data from 2005-2013 found that while cannabis use and dependence remained stable across race/ethnic groups over time, the odds of cannabis dependence were greater for Black, Indigenous and mixed-race adults compared to White people.[55] More recent research did not find increased odds of cannabis use disorder as defined by DSM-V criteria among cannabis consumers of any racial/ethnic group following enactment of recreational cannabis legalization.[52] In Ontario, research has found that those of 'Caribbean' or 'Northern European' background were more likely to report moderate/high problematic cannabis use compared to those who identified as 'Canadian' background.[53] The current published data in Canada which has focused on assessing problematic cannabis use based on race/ethnicity is limited. Examining potential differences

represents an important area for further research particularly to understand if legalization of cannabis differentially impacts subgroups of the population.

1.5.3 Income and Education

Some have expressed concern that cannabis use will follow alcohol and tobacco use trends, resulting in highest use and health and economic burden among the disadvantaged.[56] While higher cannabis prevalence has been reported among adolescents from low-income families,[57] young adults from high-income households have been found to have higher prevalence of use.[58] Among adults, in Canada and the US, greater cannabis use has been reported among those from lower income households.[18,36,39,45] Data from a nationally representative Canadian sample found that cannabis prevalence was highest among those with the lowest income.[18] In particular, after adjusting for age and sex, 9% of those with household income less than $40000 reported using cannabis in the past month compared to 7% of those who earned $40000 to $79,999, and 5% of those earning more than $120,000.[18] In addition, those who had less than a high school education were more likely than those who had a university education to use at least twice per month.[18] Data from the US suggest that between 2001 and 2014 cannabis use has substantially increased across all income and education groups.[39] Nonetheless, those in the lowest income group ($0-$19,000) and those with only a high school education saw the greatest increase in prevalence of use compared to other income groups and those with at least some college education, respectively.[39] Similarly, in Australia, an analysis of cannabis use data between 2001 and 2013 suggested higher use among those of lower socioeconomic position (SEP), measured by income and education, with the disparity widening over time.[59] It has been suggested that those with lower SEP may face more life stressors and use substances as a coping strategy.[39,59,60]

In Ontario, a survey of medically approved cannabis users found lower household income was associated with greater use of cannabis for medical purposes compared to recreational use.[61] However, in the US, research based on national data found no differences in the use of

cannabis for medical purposes based on race or education.[62] It is plausible that in situations where individuals are using cannabis for medical purposes, their income may be lower as a result of health issues that make it difficult to engage in regular, full-time employment.

Conversely, problematic use has the potential to impact the ability to obtain and maintain employment which in turn effects income. In Canada, problematic use has also been associated with income level, with those with lower household income being more likely to experience problematic use than those with household income greater than $80000.[49] In the US, however, between 2001 and 2014, cannabis use disorders increased across all income groups and among those who had less than high school education, high school education or some college education.[39] In France, problematic use of cannabis has been associated with lower occupational grade and unstable employment among young adults.[63] In this study, various demographic factors, family characteristics and socioeconomic position (SEP) were assessed in relation to substance use outcomes. The prevalence of problematic use was found to be about 6%, and those of lower SEP were more likely to experience problematic use than those of intermediate or high SEP.[63] Further research from France has found that among a national sample of 17 year-olds, higher rates of experimentation and low frequency use were reported among those from higher income families, but these respondents were also less likely to report frequent, problematic or heavy use when compared to other income groups.[64] As the existing research is cross-sectional the directionality of the relationship between income and problematic use is unclear.

1.6 Neighbourhood Characteristics and Cannabis Use

Examining the impact of neighbourhood or area-level socioeconomic factors on substance use involves looking beyond individual-level variables to consider how environmental factors may impact behaviour. Neighbourhoods are often delineated by administrative boundaries such as census tracts, where it is assumed that living conditions and the availability of various resources within the boundaries are relatively similar.[65]

Neighbourhood deprivation is of particular interest, as examining the impact of factors outside the individual on individual behaviour in marginalized communities in particular, may explain some of the observed patterns of substance use based on socioeconomic factors. Neighbourhood deprivation may consider factors related to social and material deprivation within a community, as well as other aspects such as neighbourhood crime and disorder.[65] Neighbourhood characteristics may influence cannabis use in four primary ways. First, material deprivation, such as lower educational attainment, low income and high unemployment within a neighbourhood, may create an environment where individuals experience greater psychological distress, coupled with the a lack of opportunity to change their current circumstances and fewer resources to manage their situation may result in substance use for relief.[60,66,67] Furthermore, physical or mental health issues which may have led to individual material deprivation may also impact use of cannabis as a therapeutic agent. Second, aspects of social deprivation, such as social isolation and lack of community, may exacerbate individual material deprivation, and are likely to involve additional stressors which may be associated with substance use. Third, those living in lower income and racialized neighbourhoods may experience greater police presence and more frequents stops and searches by police compared to more affluent neighbourhoods.[68] As a result, being arrested for cannabis use or possession in an illegal environment is likely more probable, particularly as individuals may meet outside and be more visible to police.[22] Finally, social norms within neighbourhoods, as well as the differential availability of cannabis within neighbourhoods may also impact use.[60] This is likely a reciprocal relationship where greater access and availability are met with more accepting norms and greater use which perpetuates greater demand and access as well as social acceptability of use.

Retail availability of substances within a neighbourhood may in part explain differences in patterns of use between neighbourhoods. Numerous studies have examined the density of tobacco and alcohol retailers within disadvantaged neighbourhoods compared to other neighbourhoods, as well as the association between retail density and the use of these

substances. For tobacco, many studies have reported more retail outlets in deprived neighbourhoods, with increased retail density also found to be associated with increased tobacco use among youth and adults.[69–71] In contrast, while alcohol outlet density has been found to be greater in deprived neighbourhoods[72], some studies have found that those in the least deprived neighbourhoods are more likely to consume more alcohol.[73,74]

Some studies have focused on retail availability of recreational cannabis in deprived neighbourhoods in jurisdictions where cannabis has been legalized. As medical dispensaries for cannabis were legal prior to the legalization of recreational cannabis, previous research has examined the distribution of medical dispensaries in some US states. For example, a 2009 study in California found that dispensaries were more likely to be found in areas with high cannabis demand, higher rates of poverty and more alcohol outlets.[75] In Colorado, more licensed retail outlets for medical and recreational cannabis were found in low income areas with a higher proportion of ethnic and racial minority groups.[76] Similarly, a study in Washington State found that between 2014 and 2017 the density of recreational retail cannabis outlets was greatest in the most deprived neighbourhoods at all time points, with significantly more outlets in the most deprived neighbourhoods compared to the least deprived neighbourhoods.[77] In Canada, in the first two years following cannabis legalization, it was found that the density of legal retail cannabis stores was greater within 1000m of the lowest income neighbourhoods compared to the highest income neighbourhoods.[78] Some have suggested that disadvantaged communities lack social and economic resources to resist establishment of outlets in their neighbourhoods.[75,76] One study in Washington State found increased retail access to legal cannabis was associated with current and frequent cannabis use.[79] Similarly, a study in Los Angeles county found that greater density of licensed retail outlets was associated with cannabis use and heavy use.[80] Research has yet to examine if the increased retail availability of legal recreational cannabis within deprived neighbourhoods in US states and Canada is associated with increased cannabis use or problematic use by individuals within those neighbourhoods.

Neighbourhood deprivation has been examined in relation to alcohol and tobacco use. Data support an association between neighbourhood deprivation and tobacco use, such that those in deprived neighbourhoods are more likely to report using tobacco products.[81–83] The studies on neighbourhood deprivation and alcohol use, however, have provided mixed results. A review of the research on the association of area-level deprivation with alcohol use revealed that of the 89 effects examined, 18% supported an association between increased alcohol use and area-level deprivation, 13% supported an association between increased alcohol use and area-level affluence, while 68% reported no association.[84]

To date, there have been relatively few published studies examining neighbourhood deprivation and cannabis use while controlling for individual-level SEP, particularly in the adult population. One US study used nationally representative from the National Alcohol Survey in 2000 and 2005 to examine the impact of neighbourhood deprivation and affluence compared to middle class neighbourhoods on the use of tobacco, alcohol, cannabis and other drugs.[82] Neighbourhood deprivation was measured as the proportion of adults without a high school diploma, males who were unemployed or not in the labor force, people with incomes below poverty, families with incomes below 50% of the US median, and households without access to a car. Results suggested that after controlling for a number of variables including age, sex, race/ethnicity, education, employment status and income, neighbourhood deprivation was not associated with using cannabis use 'once every month or two' for men or women.[82] This study included many variables to generate a neighbourhood deprivation index, although data on cannabis use frequency were insufficient.

Several studies have examined substance use in neighbourhoods within particular cities. For example, a study of adults in New York City which examined neighbourhood income and income distribution within neighbourhoods, found that neighbourhoods with the highest median income and areas where income was most unequally distributed, had the highest prevalence of past 30-day cannabis use, after adjusting for individual income.[60] This finding

suggests that factors other than neighbourhood income alone should be considered when examining neighbourhood effects on cannabis use, and that the relative distribution of income within a neighbourhood may provide insight into cannabis use patterns. An earlier study in Detroit sought to examine not only if neighbourhood deprivation was associated with substance use, but also the impact of social stress on substance use.[67] Substance use was characterized as past 12-month use of a number of drugs including cannabis. A measure of neighbourhood deprivation was generated using four variables: percent living below the poverty line, percent households headed by females, male unemployment rate, and percent of households receiving social assistance. The findings suggested that neighbourhood deprivation was associated with drug use, after controlling for individual income and other sociodemographic variables. Further, it found that the effect of neighbourhood deprivation on substance use was mediated by social stress and strain.[67]

One of the challenges with examining the effects of neighbourhood deprivation is that the measurement of socioeconomic deprivation at an area-level varies widely across studies. Many studies have relied on only one or some combination of median household income, employment rates, and households headed by a single parent. Use of comprehensive measures and census data have been found to provide more accurate estimates of neighbourhood deprivation.[85] Another limitation of past research has been that cannabis use has often been studied alongside other substance use so there was limited information about variations in cannabis use frequency or measures of problematic use. Examining whether an association exists between neighbourhood deprivation and these outcomes is key to understanding the role of area-level factors.

1.7 Study Rationale

The adverse effects of substance use are often higher among those of lower socioeconomic position. This is true when examining SEP as an individual-level variable, but also when examining the influence of deprivation within neighbourhoods. There are several reasons this

may apply to cannabis use as well, but there is relatively little research. To date, the prevalence of cannabis use differs by age, sex, education and income, with few differences by race and ethnicity. Nonetheless, the impacts of cannabis prohibition have disproportionately affected racialized communities. There is little research available which examines SEP or racial/ethnic differences in problematic cannabis use outcomes. Furthermore, among the few studies which have examined the impact of neighbourhood-level factors, the findings have been mixed and difficult to interpret given differences in the way SEP and cannabis use have been measured. Overall, there is a need for more studies which examine the relationship between the sociodemographic factors of SEP and race/ethnicity and the negative outcomes associated with cannabis use, and how these relationships may change following legalization. In addition, further research into the retail availability of legal cannabis by area-level socioeconomic factors is needed to determine if the Canadian market follows US trends which may put marginalized communities at greater risk for cannabis-related harms.

1.8 Research Questions

The current research project examined the following research questions:

1. Are there differences in cannabis-related legal sanctions based on race/ethnicity, individual socioeconomic factors and neighbourhood deprivation?

2. Are there differences in problematic cannabis use pre- and post-cannabis legalization based on race/ethnicity, individual socioeconomic factors and neighbourhood deprivation?

3. What is the distribution of legal cannabis retail stores based on neighbourhood deprivation?

Chapter 2: Methods

The proposed dissertation was comprised of three studies; specific methods for each study are presented in the respective papers in Chapters 3, 4, and 5. This chapter provides an overview of the methods.

2.1 Study design

The current project used three waves of data from the Canadian arm of the International Cannabis Policy Study (ICPS), a repeat cross-sectional survey, conducted in Canada and the United States.[86] Wave 1 was conducted between August 2018 and October 2018, wave 2 between September 2019 and October 2019 and wave 3 between September 2020 and November 2020. Wave 1 was conducted prior to cannabis legalization in Canada, while wave 2 and wave 3 were conducted post-legalization. The main purpose of the ICPS study is to evaluate the impact of cannabis legalization on cannabis use patterns, legal and illegal retail sales, and risk behaviours and perceptions. The survey questions cover numerous content areas, including prevalence and patterns of cannabis use, modes of use, sources of cannabis, types of products, and mental and physical health outcomes.

2.1.1 Participants and Recruitment

Data were collected via self-completed web-based surveys in 2018, 2019 and 2020 with respondents aged 16-65 in Canada. 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 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 or French. Respondents provided consent prior to completing the survey. Median time to complete the survey was 20 minutes in 2018, 25 minutes in 2019 and 21 minutes in 2020. 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, 17,157 respondents accessed the survey link, of whom 10,646

completed the entire survey for an AAPOR cooperation rate of 62.0%.[87,88] In 2019, 24,607 respondents accessed the survey link, of whom 17,513 completed the entire survey for an AAPOR cooperation rate of 71.2%.[87,88] In 2020, 25,827 respondents accessed the survey link, of whom 17,001 completed the entire survey for an AAPOR cooperation rate of 65.8%.[87,88] A full description of the study methods can be found in the ICPS Technical Reports (www.cannnabisproject.ca/methods). The study was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31330).

2.1.2 Study measures

The full survey for all three waves is available from www.cannabisproject.ca/methods. Survey measures were drawn or adapted from national surveys or selected based on previous research. Development included focus groups and cognitive interviewing with youth and young adults, as well as an extensive pilot study conducted in October 2017 with 1,045 Canadians aged 16– 30.[89] Cognitive interviewing was also conducted with cannabis users in January–February 2018[90] and August 2019 to evaluate and improve items tested in the pilot survey.

2.1.3 Cannabis use status

A 6-level 'cannabis use status' variable (never used; used >12 months ago; used in past 12 months; monthly use; weekly use; and daily or almost daily use) was derived from three survey questions: "Have you ever tried marijuana?" (yes/no); "When was the last time you used marijuana?" (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 marijuana?" (less than once per month; one or more times per month; one or more times per week; every day or almost every day).

2.1.4 Postal code

All survey respondents were asked "Please provide the postal code/zip code where you live for most of the year". A total of 1049 respondents at wave 1, 2900 respondents at Wave 2 and 2934 respondents at wave 3 either didn't know their postal code ($n_{2018}=287$; $n_{2019}=1,175$; $n_{2020}=1,241$), refused to provide their postal code ($n_{2018}=762$; $n_{2019}=1,676$; $n_{2020}=1,655$), or their postal code did not match their province ($n_{2018}=18$; $n_{2019}=49$; $n_{2020}=38$). 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' ($n_{2018}=170$; $n_{2019}=581$; $n_{2020}=616$) or 'Refuse to answer' ($n_{2018}=581$; $n_{2019}=1,189$; $n_{2020}=1,212$) for the intersection. Of those who provided their intersection ($n_{2018}=298$; $n_{2019}=1,081$; $n_{2020}=1,068$), 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 ($n_{2018}=61$; $n_{2019}=272$; $n_{2020}=336$). A total of 237 postal codes were retrieved for 2018, 809 for 2019 and 732 for 2020.

2.1.5 Legal retailer postal codes

Lists of legal retailers in each province were downloaded from government websites of licensed cannabis retailers in each province in September 2021; this information included complete physical addresses and postal codes for licensed retailers. These information sources represent 'census' lists of all legal retail stores in each province. The retailer list was cross-checked with lists displayed on Leafly, a website dedicated to cannabis and legal cannabis stores (www.leafly.ca). Unauthorized retail stores were not included.

2.1.6 Neighbourhood deprivation index

The Institut National de Santé Publique du Québec (INSPQ) 2016 material and social deprivation index was used to assess neighbourhood deprivation.[91] The index is based on the Canadian census dissemination areas, the smallest geographic unit for which census data are released. Dissemination areas were considered 'neighbourhoods' for the purposes of this project.

Through principal component analysis, socioeconomic indicators from 2016 census data were combined and two components were systematically identified: a material component and a social component.[91] The material deprivation component is comprised of 1) The proportion of the population aged 15 years and over without a high school diploma or equivalent; 2) The employment to population ratio for the population 15 years and over; and 3) The average income of the population aged 15 years and over. The social deprivation component is comprised of 1) The proportion of the population aged 15 and over living alone; 2) The proportion of the population aged 15 and over who are separated, divorced or widowed; and 3) The proportion of single-parent families. A factor score for the material and social component was generated for each dissemination area.[91] The dissemination areas were then ranked based on the factor score, and divided into quintiles.[91] Each of the material and social components were represented as a quintile (Q) with Q1 representing the most privileged and Q5 representing the most deprived area. As each dissemination area can be linked to postal codes, a material and social deprivation level (1-5) was assigned to ICPS respondents who provided postal codes.

2.1.7 Individual-level socioeconomic variables

2.1.7.1 Education

The highest level of formal education attained was assessed with the question: "What is the highest level of formal education that you have completed?" (Less than high school; High

school diploma or equivalent; Some college or technical/vocational training or certificate/diploma, or apprenticeship, or some university; Bachelor's degree or higher; Don't know; Refuse to answer).

2.1.7.2 Perceived income adequacy

Perceived income adequacy was measured with the question: "Thinking about your family's income, how difficult or easy is it to make ends meet? 'Making ends meet' means having enough money to pay for the things your family needs." (Very difficult; Difficult; Neither easy nor difficult; Easy; Very easy; Don't know; and Refuse to answer)

2.1.8 Race/ethnicity

Race/ethnicity was measured with the following question [92]: "In our society, people are often described by their race or racial background. For example, some people are considered "White" or "Black" or "East/Southeast Asian," etc. Which race category best describes you?" Respondents selected all that applied from the following options: "Black (e.g., African, Afro-Caribbean, African-Canadian descent); Southeast Asian (e.g., Chinese, Korean, Japanese, Taiwanese descent; Filipino, Vietnamese, Cambodian, Thai, Indonesian, other Southeast Asian descent); Indigenous (e.g., First Nations, Métis, Inuit descent); Latinx (e.g., Latin American, Hispanic descent); Middle Eastern (e.g., Arab, Persian, West Asian descent, e.g., Afghan, Egyptian, Iranian, Lebanese, Turkish, Kurdish, etc.); South Asian (e.g., South Asian descent, e.g., East Indian, Pakistani, Bangladeshi, Sri Lankan, Indo-Caribbean, etc.); White (e.g., European descent); Other (please specify); Don't know; and Refuse to answer).

2.1.9 Problematic cannabis use

Problematic cannabis use among past 12-month cannabis consumers was measured using 5 survey measures based on the WHO ASSIST measure for problematic substance use, and the cannabis use status variable, which provides a value based on frequency of cannabis use.[11]

The first three questions are, "In the past 3 months, how often have you had a strong desire or urge to use marijuana?"; "During the past 3 months, how often has your use of marijuana led to health, social, legal, or financial problems?" and "During the past 3 months, how often have you failed to do what was normally expected of you because of your use of marijuana?" (Never; Once or twice; Monthly; Weekly; Daily or almost daily; Don't know; Refuse to answer). The last two are: "Has a friend or relative or anyone else expressed concern about your use of marijuana?" and "Have you ever tried and failed to control, cut down or stop using marijuana?" (No, never; Yes, in the past 3 months; Yes, but not in the past 3 months; Don't know; Refuse to answer). An overall score was generated based on the responses to these five questions and the cannabis use status variable and was divided into three risk category groups: low risk for problematic use (0-6); moderate risk (7-26) and high risk (greater than 26).[93,94]

2.1.10 Legal sanctions

2.1.10.1 Arrests for cannabis offences

All respondents were asked about arrests for cannabis-related offences with the following questions: "Have you ever been arrested for any of the following cannabis offences…? a. Cannabis possession; b. Cannabis trafficking, cultivation or importation" (Yes/No/Don't know/Refuse to answer).

2.1.10.2 Convictions for cannabis offences

Respondents who indicated that they had been arrested for a cannabis possession were asked: "Did the arrest for cannabis possession result in a criminal conviction?" (Yes/No/Don't know/Refuse to answer). Respondents who reported being arrested for cannabis trafficking cultivation or importation were asked: "Did the arrest for cannabis trafficking, cultivation or importation result in a criminal conviction?" (Yes/No/Don't know/Refuse to answer).

2.1.11 Sociodemographic variables

Sociodemographic measures included age (16-25; 26-35; 36-45; 46-55; 56-65), sex at birth (female/male), region (rural/urban), device used to complete survey (smartphone, tablet, computer).

2.2 Data analysis

In 2018, 10,646 respondents in Canada completed the survey. After removing respondents due to dishonesty (n=77), poor data quality (n=507), ineligible country of residence (n=5), 10,057 respondents were retained in the analytical sample.

In 2019, 17,513 respondents in Canada completed the 2019 survey. After removing respondents due to dishonesty (n=247), poor data quality (n=805), those who identified as intersex and an 'other'/unstated gender identity (due to insufficient cell counts for weighting) (n=2), speeding (n=7) or duplicate entries (n=167), 16,285 respondents were retained. Of these, 1,029 returners from 2018 were excluded. The remaining 15,256 comprised the 2019 cross-sectional sample.

In 2020, 17,001 respondents in Canada completed the 2020 survey. After removing respondents due to dishonesty (n=222), poor data quality (n=974), those who identified as intersex and 'other'/unstated gender identity (due to insufficient cell counts for weighting) (n=4), speeding (n=20), duplicate entries (n=1), 15,780 respondents were retained in the analytical sample.

All analyses were conducted using SAS Studio statistical software (SAS version 9.4, SAS Institute Inc., Cary, NC, USA). For data from the ICPS survey, survey procedures were used for analyses.

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2.2.1 Survey weights

Post-stratification sample weights were constructed based on the Canadian census estimates. In 2018, respondents from Canada were classified into age-by-sex-by-province and education groups. In 2019 and 2020, respondents from Canada were classified into age-by-sex-by-province, education, and age-by-cigarette smoking status groups. Correspondingly grouped population count and proportion estimates were obtained from Statistics Canada.[95,96] The smoking status from ICPS 2018 was used for 2019 and 2020. A raking algorithm was applied to the cross-sectional analytic sample to compute weights that were calibrated to these groupings, and weights were rescaled to the sample size in each survey year for Canada.

2.2.2 Preliminary analysis

Pearson correlation coefficients for all pairs of the individual socioeconomic indicators and neighbourhood deprivation indices to be included in the modelling (education, perceived income adequacy, neighbourhood material deprivation, and neighbourhood social deprivation) were calculated to assess multicollinearity. No strong associations were observed so all variables were retained. In addition, multicollinearity was assessed in the final models for study 1 and study 2 using variance inflation factors (VIF). All variables met acceptable VIF cut-off values (<5) and were retained. Full details of the analyses are presented in Appendix A.

ICPS respondent postal codes and postal codes for legal retail cannabis stores were linked to the INSPQ deprivation indices to generate a neighbourhood material and social deprivation score for each. Postal code data from the ICPS respondents and legal retail cannabis store was linked to the corresponding postal code from the INSPQ deprivation index, such that each respondent and store, respectively, was assigned a material and social deprivation score which was associated with their neighbourhood.

2.2.3 Missing data

In study 1 and study 2, only ICPS respondents with valid postal code data were included in the analyses. Case-wise deletion was used to remove those with missing postal code data. More details about excluded cases are included in Chapters 3 and 4, as well as Appendix B.

Study 1: For this study all respondents from 2019 (n=15256) and 2020 (n=15780) were eligible for inclusion. Missing postal code data resulted in the removal of 2318 cases in 2019 and 2244 cases in 2020. Those respondents who provided a postal code were more likely to be older, of White race/ethnicity, report difficult (2019) or very easy perceived income adequacy, report higher education level and have consumed cannabis in their lifetime. The full list of differences with the associated Rao-Scott chi-square is presented in Appendix B, Table B1.

Study 2: This study included a subset of respondents from 2018 (n=2063), 2019 (n=4011) and 2020 (n=4059) who reported consuming cannabis is the past 12 months. Missing postal code data resulted in the removal of 213 cases in 2018, 814 cases in 2019 and 732 cases in 2020. Those respondents who provided a postal code were more likely to be older, of White race/ethnicity (2019 and 2020), and report difficult or very easy perceived income adequacy. Respondents providing postal code data were also more likely to have indicated their level of perceived income adequacy and level of education. The full list of differences with the associated Rao-Scott chi-square is presented in Appendix B, Table B2.

Chapter 3: Cannabis-related arrests and convictions in Canada: Differences by race/ethnicity, individual socioeconomic factors and neighbourhood deprivation.

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3.1 Overview

Introduction: Racialized individuals were disproportionately impacted by cannabis prohibition in Canada; however, the role of socioeconomic factors and neighbourhood deprivation are not well understood. The current study examined race/ethnicity, individual socioeconomic factors, and neighbourhood deprivation in relation to arrests and convictions for cannabis-related offences.

Methods: Repeat cross-sectional data were analyzed from two waves of the International Cannabis Policy Study (ICPS), a web-based survey conducted in 2019 (n=12,226) and 2020 (n=12,815) in Canada among those aged 16 to 65. Respondents were recruited through commercial online panels. Respondents' postal codes were linked to the INSPQ deprivation index. Multinomial regression models examined the association between race/ethnicity, individual socioeconomic factors, neighbourhood deprivation and lifetime arrest/conviction for cannabis offences.

Results: Overall, 4.4% of respondents reported a lifetime arrest or conviction for a cannabis-related offence. Black and Indigenous individuals had more than 3 times the odds of conviction than White individuals (AOR=3.90 95%CI=2.07-7.35, p<0.01; AOR=3.24 95% CI=1.78-5.90, p<0.01, respectively). Differences remained statistically significant after adjusting for cannabis use and socioeconomic factors, although only the difference for Black individuals remained after adjusting for neighbourhood deprivation. Neighbourhood deprivation was associated with cannabis-related convictions: the odds of a conviction among the 'most privileged' and 'privileged' neighbourhoods were approximately half of those in the 'most deprived' neighbourhoods (AOR=0.50, 95%CI=0.29-0.86; p=0.01; AOR=0.50, 95% CI=0.27-0.92; p=0.03, respectively).

Conclusion: Arrests and convictions for cannabis-related arrests were disproportionately higher among racialized individuals and those living in the most marginalized

neighbourhoods. Future research should examine if inequities have changed following legalization of recreational cannabis in Canada.

3.2 Highlights box

- In Canada, racialized people, those with lower socioeconomic position, and people living in marginalized neighbourhoods have been disproportionately arrested and convicted of cannabis-related offences.

- Black and Indigenous people reported more than double the convictions for cannabis-related offences than White people.

- Those living in the most deprived neighbourhoods were more likely to be convicted for a cannabis-related offence than those in more privileged neighbourhoods after controlling for individual-level socioeconomic factors and race/ethnicity.

- The findings support the continued monitoring of cannabis-related arrests/convictions by race/ethnicity as well as individual and neighbourhood level socioeconomic indicators to assess the impact of recreational cannabis legalization.

3.3 Introduction

In October 2018, Canada became the second country to legalize non-medical cannabis, after Uruguay. One of the main arguments in support of cannabis legalization has been that the costs of prohibition outweigh the potential harms associated with legalization.[14,15] The costs of prohibition include the economic costs associated with police enforcement, court proceedings and imprisonment, as well as costs to individuals who enter the criminal justice system and receive criminal records as a result of cannabis possession charges.[15] The impact of arrests and prosecution for cannabis possession extend beyond legal repercussions, and can impact an individual's employment, housing and educational opportunities, among others.[14]

The costs of cannabis prohibition have been disproportionately experienced by racialized individuals in both Canada and the US.[14,16,17] In both countries, Black and Indigenous individuals have been disproportionately targeted and incarcerated for drug-related offences, despite similar prevalence of cannabis use.[16,17] In Canada, despite little publicly available information on the race of those arrested for cannabis possession, a recent report found that in the city of Toronto, Ontario, Black individuals were overpoliced for cannabis offenses, and were four times more likely to be arrested for cannabis possession than their White counterparts.[97] Furthermore, a recent study using data sourced from police records where data were available found that in 2015, across Vancouver, Calgary, Regina and Ottawa, Black and Indigenous individuals were overrepresented in arrests for cannabis possession relative to their proportion in the population, while in Halifax only Black individuals were overrepresented.[21] Similarly, in the US, several studies have found that the arrest rates for cannabis possession charges for Black and Hispanic individuals were at least double that of White individuals.[17,98,99] Racial bias and targeted policing practices may result in more frequent street checks and police stops for Black and Indigenous individuals resulting in arrests for possession for small amounts of cannabis.[21,100]

Beyond racial differences, there is little evidence on the role of socioeconomic indicators, such as income and education, on arrests and convictions for cannabis offences. In general, individuals from lower income households are more likely to be arrested, convicted, and incarcerated for street-level crimes such as drug possession, than more affluent individuals.[101,102] Furthermore, arrestees are more likely to be unemployed or employed in low-paying jobs.[102] Socioeconomic differences in cannabis-related arrests and conviction may also reflect environmental differences, including the broader concept of neighbourhood deprivation. Neighbourhood deprivation may considers factors related to social and material deprivation within a community, as well as neighbourhood disorder, crime and limited access to resources.[65] More materially deprived neighbourhoods are often more racially diverse. For example, in Canada, racialized people and recent immigrants are over-represented among those living in low-income neighbourhoods.[103] Level of neighbourhood deprivation has the potential to contextualize factors such as race and education level, which are typically measured and interpreted at the individual level. For example, individuals living in lower income and racialized neighbourhoods may experience greater police presence and more stops compared to those in more affluent neighbourhoods.[68,104] Thus, being arrested for cannabis possession in this environment is likely more probable. To our knowledge, no previous work has examined the association between neighbourhood deprivation and arrests or convictions for cannabis-related offences while controlling for race/ethnicity and individual-level socioeconomic factors. While it has been acknowledged that vulnerable communities, those with low income and fewer resources, have been disproportionately impacted by cannabis prohibition in Canada,[105] it is unclear if this is independent of racial or socioeconomic factors.

The objective of the current study was to explore differences in arrests and convictions for cannabis-related offences based on race/ethnicity, individual socioeconomic position, and neighbourhood deprivation in a population-based survey. The study addressed three main research questions: 1) Are Black and Indigenous people more likely to report legal sanctions

for cannabis-related offences than White consumers?; 2) Are there differences in legal sanctions experienced based on individual socioeconomic factors?; and 3) Are individuals from deprived neighbourhoods over-represented among those reporting arrests and convictions for cannabis offences? It was hypothesized that independent effects would be observed for differences in arrests and convictions by race, socioeconomic position and neighbourhood deprivation. More specifically, we hypothesized that arrests and convictions would be more common among Black and Indigenous individuals, while being less common among those with higher individual socioeconomic position, and respondents living in more privileged neighbourhoods.

3.4 Methods

Data are from Waves 2 and 3 of the International Cannabis Policy Study (ICPS), conducted in Canada. Data were collected via self-completed web-based surveys conducted in September/October 2019 and 2020 with 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 a random sample of panelists. Surveys were conducted in English or French. Respondents provided consent prior to completing the survey. Respondents received remuneration according to their panel's usual incentive structure. 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.[106,107]

3.4.1 Measures

Sociodemographic variables

Sociodemographic variables included age, sex at birth (female/male), and urbanicity (rural/urban). 'Ever' cannabis use was assessed with the question "Have you ever tried marijuana?" (Yes/No).

Legal sanctions

All respondents were asked about lifetime arrests for cannabis-related offences with the following questions: "Have you ever been arrested for any of the following cannabis offences…? a. Cannabis possession; b. Cannabis trafficking, cultivation or importation" (Yes/No/Don't know/Refuse to answer). Respondents who indicated that they had been arrested for cannabis possession were asked: "Did the arrest for cannabis possession result in a criminal conviction?" (Yes/No/Don't know/Refuse to answer). Respondents who reported being arrested for cannabis trafficking cultivation or importation were asked: "Did the arrest for cannabis trafficking, cultivation or importation result in a criminal conviction?" (Yes/No/Don't know/Refuse to answer). 'Don't know' and 'Refuse to answer' responses were recoded to 'Not reported'.

Race/ethnicity

Race/ethnicity was assessed with the question for race from the Government of Ontario Data Standards for the Identification and Monitoring of Systemic Racism.[92] Respondents were categorized into the following groups: Black; East/Southeast Asian; Indigenous; Latinx, Middle Eastern; Mixed race, South Asian; White; Other; Don't know; and Refuse to answer. Respondents who selected more than one category were recoded as 'Mixed race'.

Perceived income adequacy

Perceived income adequacy measured the extent to which family income was perceived as being sufficient make ends meet and was classified into five categories: Very difficult; Difficult; Neither easy nor difficult; Easy; Very easy.

Education

The highest level of formal education attained was assessed with the question: "What is the highest level of formal education that you have completed?" (Less than high school; High

school diploma or equivalent; Some college or technical/vocational training or certificate/diploma, or apprenticeship, or some university; Bachelor's degree or higher; Don't know; Refuse to answer).

For race/ethnicity, perceived income adequacy and education 'Don't know' and 'Refuse to answer' responses were recoded to 'Unstated'.

Postal code and neighbourhood deprivation index

All survey respondents were asked to provide their postal code which was used to link individual respondents to a national database of neighbourhood deprivation indices from the Institut National de Santé Publique du Québec (INSPQ).[91] The 2016 index is based on Canadian Census dissemination areas. Where data were available, each postal code in the country was assigned two scores: 1) a material deprivation score (based on the level of education, income and employment in the population 15 and over) and 2) a social deprivation score (based on the proportion of the population aged 15 and over living alone, who are separated, divorced or widowed as well as the proportion of single-parent families). Each index is represented in quintiles on a scale of 1-5 (most deprived/ deprived/ neither deprived nor privileged/privileged/most privileged).

3.4.2 Analysis

The final cross-sectional samples in Canada included 15,256 respondents in 2019 and 15,780 in 2020 after exclusions based on data quality checks and incomplete responses; complete details regarding exclusions can be found in the ICPS technical reports.[106,107] A sub-sample of 12,226 and 12,815 respondents in 2019 and 2020, respectively, were included in the current analysis after excluding respondents with missing data for postal code (n_{2019}=2318; n_{2020}=2244), neighbourhood deprivation index (n_{2019}=699; n_{2020}=708) and urban/rural designation (n_{2019}=13; n_{2020}=13).

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 full cross-sectional analytic samples to compute weights that were calibrated to these groupings. Weights were rescaled to the sample size for Canada. Estimates are weighted unless otherwise specified. Analyses were conducted using survey procedures in SAS version 9.4.

Four separate multinomial logistic regression models were estimated with 4 levels of the outcome variable: 1) Never arrested for cannabis possession, trafficking, cultivation or importation; 2) Arrested for cannabis possession, trafficking, cultivation or importation; 3) Arrested and convicted for cannabis possession, trafficking, cultivation or importation; 4) Arrest for cannabis possession, trafficking, cultivation or importation not reported. Given the current research which supports race/ethnicity as a predictor of arrests for cannabis possession, models were conducted in four steps to examine the association of race/ethnicity prior to and following adjustment for individual socioeconomic variables and neighbourhood deprivation. Respondents with 'Unstated' responses for race/ethnicity, perceived income adequacy and education were excluded from the analyses due to small cell counts and model convergence issues. Model 1 included only race/ethnicity, while model 2 included the race/ethnicity as well as cannabis use. Model 3 included the variables from model 2 as well as education and perceived income adequacy, the two individual socioeconomic indicators. Model 4, the final model, included material deprivation and social deprivation as independent variables. In addition, potential clustering based on dissemination area was accounted for using the cluster option in the survey routines analysis in all models. Models 3 and 4 also adjusted for age, sex at birth, urbanicity, survey year, and whether the survey was completed on smartphone, tablet, or computer. Multicollinearity was assessed using variance inflation factors; all VIFs were less than 5 so all variables were retained in the final model (See Appendix A, Table A1 for details). Parameter estimates for all covariates included in the final model are presented in Appendix C, Table C1.

3.5 Results

3.5.1 Sample characteristics

Table 1 presents the characteristics for respondents from the 2019 and 2020 survey years.

Table 1. Sample characteristics of 2019 and 2020 ICPS respondents

	2019 (n=12,226)		2020 (n=12,815)	
	Unweighted % (n)	Weighted % (n)	Unweighted % (n)	Weighted % (n)
Age				
16-25	12.8 (1565)	16.6 (2027)	15.1 (1847)	16.6 (2128)
26-35	17.5 (2144)	19.5 (2379)	15.4 (1969)	19.7 (2526)
36-45	20.3 (2487)	19.8 (2426)	19.0 (2428)	20.2 (2586)
46-55	21.7 (2558)	21.3 (2606)	21.2 (2719)	20.4 (2620)
56-65	27.6 (3372)	22.8 (2788)	30.1 (3852)	23.1 (2955)
Sex				
Female	61.5 (7520)	50.1 (6131)	61.7 (7909)	49.6 (6352)
Male	38.5 (4704)	49.9 (6095)	38.3 (4906)	50.4 (6463)
Race/ethnicity				
Black	2.6 (315)	3.3 (406)	2.4 (302)	3.0 (390)
East/Southeast Asian	6.9 (842)	7.3 (891)	8.1 (1033)	8.8 (1132)
Indigenous	2.1 (251)	2.2 (272)	2.0 (250)	1.9 (238)
Latinx	1.1 (141)	1.4 (167)	1.1 (141)	1.5 (188)
Middle Eastern	1.0 (120)	1.0 (126)	1.3 (173)	1.7 (211)
Mixed-race	2.5 (308)	2.9 (360)	3.0 (379)	3.0 (390)
South Asian	2.6 (317)	3.1 (377)	2.9 (368)	3.5 (443)
White	78.9 (9643)	76.1 (9303)	76.7 (9832)	73.8 (9454)
Other	1.1 (134)	1.3 (155)	1.2 (155)	1.3 (164)
Unstated	1.3 (155)	1.4 (167)	1.5 (182)	1.6 (204)
Perceived income adequacy				
Very difficult	9.1 (1114)	9.6 (1173)	7.1 (912)	7.6 (978)
Difficult	22.7 (2773)	23.1 (2822)	18.8 (2403)	18.8 (2404)
Not easy or difficult	35.1 (4293)	35.4 (4329)	37.5 (4800)	37.6 (4812)
Easy	21.0 (2567)	20.0 (2440)	23.1 (2958)	22.8 (2916)
Very easy	10.5 (1285)	10.0 (1217)	11.8 (1510)	11.3 (1446)
Unstated	1.6 (194)	2.0 (246)	1.2 (232)	2.0 (259)
Education				
Less than high school	8.2 (1002)	15.0 (1834)	9.5 (1214)	14.2 (1825)

High school diploma or equivalent	16.4 (2000)	26.5 (3244)	14.9 (1914)	26.2 (3363)
Some college or technical/vocational training[a]	42.7 (5226)	33.3 (4076)	40.8 (5231)	33.7 (4320)
Bachelor's degree or higher	32.7 (3998)	24.9 (3037)	34.4 (4409)	25.4 (3249)
Unstated	0.3 (37)	0.3 (35)	0.4 (47)	0.5 (58)
Neighbourhood material deprivation				
Most deprived	18.4 (2245)	20.5 (2512)	17.7 (2261)	19.9 (2547)
Deprived	20.4 (2491)	21.2 (2587)	19.8 (2533)	20.8 (2666)
Not deprived or privileged	20.4 (2500)	20.6 (2523)	20.4 (2613)	20.5 (2629)
Privileged	20.9 (2553)	19.5 (2389)	21.1 (2701)	19.8 (2534)
Most privileged	19.9 (2437)	18.1 (2216)	21.1 (2707)	19.0 (2439)
Neighbourhood social deprivation				
Most deprived	26.3 (3214)	27.6 (3373)	24.6 (3148)	26.8 (3438)
Deprived	22.3 (2721)	21.1 (2582)	21.8 (2794)	21.9 (2804)
Not deprived or privileged	19.8 (2421)	19.7 (2412)	19.7 (2527)	19.1 (2453)
Privileged	17.6 (2149)	17.2 (2101)	18.3 (2346)	16.6 (2121)
Most privileged	14.1 (1721)	14.4 (1759)	15.6 (2000)	15.6 (1998)
Cannabis use status				
Ever used	63.3 (7735)	63.1 (7718)	62.5 (8015)	61.8 (7918)
Never used	36.7 (4491)	36.9 (4509)	37.5 (4800)	38.2 (4897)

[a] This category includes some college, college certificate/diploma, technical/vocational training, apprenticeship, or some university.

3.5.2 Prevalence of arrest and conviction for cannabis offences

Overall, pooled data from 2019 and 2020 found that 94.4% of respondents reported never being arrested for any cannabis-related offence, with 4.4% reporting being arrested only or convicted for a cannabis-related offence in their lifetime, and 1.2% choosing not to respond. Table 2 shows frequency of arrests and convictions for cannabis possession and trafficking, cultivation or importation by race/ethnicity, individual socioeconomic factors and neighbourhood deprivation.

Table 2. Pooled 2019 and 2020 frequencies of arrests and convictions for cannabis possession, trafficking, cultivation or importation in Canada by race/ethnicity, individual socioeconomic indicators and neighbourhood deprivation (n=25,041)[a]

	n	Arrest-Possession			Conviction-Possession			Arrest-Trafficking			Conviction- Trafficking		
		Yes (%)	No (%)	Arrest not reported (%)	Yes (%)	No (%)	Arrest not reported (%)	Yes (%)	No (%)	Arrest not reported (%)	Yes (%)	No (%)	Arrest not reported (%)
Overall		3.8	95.0	1.2	1.5	98.3	0.2	2.6	96.2	1.2	1.0	98.8	0.2
Race/Ethnicity													
White	18479	3.6	95.7	0.8	1.4	98.4	0.2	2.2	97.0	0.8	0.9	99.0	0.1
Black	795	8.1	88.6	3.3	5.2	94.3	0.5*	6.0	90.7	3.3	3.3*	96.7	0
East/Southeast Asian	2023	3.0	95.0	2.0	0.7*	98.9	0.4*	3.5	94.5	2.0	0.8	98.3	0.9*
Indigenous	511	8.7	89.0	2.4*	4.4	95.2	0.4*	4.7	92.2	2.4*	2.4*	97.0	0.6*
Latinx	356	3.9	93.6	2.4*	1.5*	98.6	0	3.8*	93.7	2.4*	1.7*	98.3	0
Middle Eastern	337	3.3	94.0	2.7*	1.1*	98.9	0	4.7*	92.6	2.7*	2.6*	96.6	0.8*
Mixed-race	750	6.2	92.7	0.4*	2.1	97.7	0.3*	4.3	94.6	1.1*	1.7*	97.9	0.4*
South Asian	820	3.4	94.2	2.4	0.9*	98.9	0.1*	3.7	93.9	2.4	1.5*	98.2	0.3*
Other	319	1.7	98.0	0.3*	0.8*	99.2	0	0.8*	98.8	0.4*	0	100	0
Unstated	371	3.9	87.6	8.4	0	100	0	1.6*	89.9	8.5	0	100	0
Individual Socioeconomic Indicators													
Perceived Income Adequacy													
Very difficult	2150	6.3	92.3	1.4	3.1	96.4	0.5*	4.8	93.8	1.4	2.7	97.2	0.1*
Difficult	5226	4.9	94.3	0.9	1.8	98.0	0.2*	2.8	96.4	0.9	1.0	98.9	0.1*
Not easy or difficult	9140	3.4	96.2	1.4	1.2	98.7	0.1*	2.3	96.3	1.4	0.8	99.1	0.1*
Easy	5356	3.1	95.6	0.8	1.2	98.5	0.2*	2.1	97.1	0.8	0.8	99.0	0.3*
Very easy	2662	3.3	95.6	1.1	1.5	98.3	0.3*	3.0	96.0	1.1	1.4	98.1	0.5*
Unstated	505	1.7*	92.9	5.4	0.1*	98.4	1.5*	1.5*	93.1	5.4	0	98.5	1.5*
Education													
Less than high school	3658	5.0	93.6	1.4	2.0	97.9	0.2*	2.8	95.8	1.4	1.0	98.6	0.4*

	n	Arrest-Possession			Conviction-Possession			Arrest-Trafficking			Conviction- Trafficking		
		Yes (%)	No (%)	Arrest not reported (%)	Yes (%)	No (%)	Arrest not reported (%)	Yes (%)	No (%)	Arrest not reported (%)	Yes (%)	No (%)	Arrest not reported (%)
High school diploma or equivalent	6607	4.4	94.5	1.1	1.7	98.0	0.4*	2.7	96.2	1.1	1.2	98.6	0.2*
Some college/vocational training[b]	8396	3.8	95.3	0.9	1.5	98.2	0.3	2.6	96.5	0.9	0.9	98.9	0.2
Bachelor's degree or higher	6287	2.6	96.1	1.3	0.9	98.9	0.1*	2.5	96.2	1.3	1.1	98.9	0.1*
Unstated	93	2.2*	80.7	17.1	1.4*	98.6	0	2.8*	80.2	17.1	2.8*	97.2	0
Neighbourhood deprivation													
Material Deprivation													
Most deprived	5059	4.8	93.2	2.0	2.4	97.4	0.3*	3.3	94.7	2.0	1.6	98.1	0.3*
Deprived	5253	4.1	94.7	1.2	1.5	98.3	0.2*	2.7	96.1	1.2	1.0	98.9	0.1*
Not deprived or privileged	5151	4.0	94.9	1.1	1.6	98.2	0.2*	2.6	96.3	1.1	1.0	98.8	0.2*
Privileged	4923	3.2	96.1	0.7	0.9	98.9	0.3*	2.4	96.9	0.7	0.8	99.0	0.2*
Most privileged	4655	3.0	96.0	1.0	1.0	98.8	0.2*	2.0	97.0	1.0	0.9	98.9	0.2*
Social Deprivation													
Most deprived	6811	5.0	93.8	1.2	1.9	97.7	0.3*	3.4	95.3	1.2	1.5	98.3	0.3*
Deprived	5385	4.4	94.1	1.4	1.8	98.1	0.1*	2.8	95.8	1.4	1.2	98.7	0.2*
Not deprived or privileged	4865	3.0	95.9	1.0	1.4	98.5	0.1*	2.0	96.9	1.0	0.8	99.0	0.2*
Privileged	4222	2.8	96.2	1.0	0.9	98.9	0.2*	2.1	96.9	1.0	0.8	99.1	0.1*
Most privileged	3757	3.1	95.8	1.2	1.1	98.5	0.4*	2.4	96.5	1.2	0.7	99.0	0.3*

[a] All estimates are weighted sample sizes and percentages.
[b] This category includes some college, college certificate/diploma, technical/vocational training, apprenticeship, or some university.
[c] High sampling variability-coefficient of variation >0.30.

3.5.3 Model 1: Arrest and conviction by race/ethnicity

Figure 1 shows the proportions of arrests, convictions, and unreported arrests within each race/ethnicity category. Approximately 9% of Black and Indigenous individuals and 7% of mixed-race individuals reported being arrested or convicted for cannabis-related offences, compared to 4% of White individuals. As shown in Table 3, for Indigenous and mixed-race individuals, the odds of arrest were more than double that of White individuals. In addition, the odds of conviction were more than three times greater among Black and Indigenous respondents than White respondents.

Figure 1. Lifetime arrests and convictions for cannabis-related offences by race/ethnicity, individual socioeconomic factors and neighbourhood deprivation (n=25,041)

Table 3. Multinomial logistic regression models for arrests and convictions for cannabis offences in Canada by race/ethnicity and cannabis use (n=24,280)[a]

	Arrested only vs No arrest or conviction (Ref)	Convicted vs No arrest or conviction (Ref)	Unreported arrest vs No arrest or conviction (Ref)
	AOR (95%CI), p-value	AOR (95%CI), p-value	AOR (95%CI), p-value
Model 1: Race/ethnicity only[b]			
Race/ethnicity			
White	Ref	Ref	Ref
Black	1.65 (0.91-2.98), 0.10	3.90 (2.07-7.35), <0.01	5.11 (2.54-10.30), <0.01
East/Southeast Asian	1.32 (0.89-1.95), 0.17	0.79 (0.42-1.46), 0.45	2.72 (1.68-4.41), <0.01
Indigenous	2.07 (1.15-3.76), 0.02	3.24 (1.78-5.90), <0.01	3.83 (1.97-7.45), <0.01
Latinx	1.21 (0.54-2.70), 0.64	1.69 (0.61-4.64), 0.31	3.46 (1.17-10.24), 0.02
Middle Eastern	1.56 (0.66-3.72), 0.31	2.16 (0.77-6.09), 0.15	4.30 (1.68-11.05), <0.01
Mixed-race	2.01 (1.13-3.57), 0.02	1.78 (0.82-3.87), 0.14	1.78 (0.80-1.61), 0.16
South Asian	1.41 (0.72-2.74), 0.31	1.11 (0.53-2.32), 0.79	3.51 (1.97-6.27), <0.01
Other	0.37 (0.08-1.61), 0.16	0.53 (0.18-1.52), 0.18	0.41 (0.06-3.00), 0.24
Model 2: Race/ethnicity and cannabis use[c]			
Race/ethnicity			
White	Ref	Ref	Ref
Black	1.86 (1.03-3.38), 0.04	4.53 (2.40-8.56), <0.01	4.81 (2.51-10.51), <0.01
East/Southeast Asian	1.93 (1.26-2.75), <0.01	1.22 (0.67-2.23), 0.52	2.75 (1.72-4.42), <0.01
Indigenous	1.76 (0.97-3.19), 0.06	2.66 (1.44-4.93), <0.01	3.80 (1.95-7.39), <0.01
Latinx	1.19 (0.53-2.67), 0.67	1.66 (0.60-4.57), 0.33	3.47 (1.17-10.25), 0.02
Middle Eastern	1.94 (0.81-4.66), 0.14	2.84 (0.81-4.66), 0.05	4.34 (1.70-11.07), <0.01
Mixed-race	1.96 (1.11-3.47), 0.02	1.73 (0.80-3.75), 0.17	1.78 (0.80-3.94), 0.16
South Asian	1.78 (0.91-3.45), 0.09	1.48 (0.70-3.12), 0.30	3.55 (2.00-6.29), <0.01
Other	0.39 (0.09-1.69), 0.21	0.56 (0.20-1.62), 0.29	0.41 (0.06-3.00), 0.38
Cannabis use			
Never used	Ref	Ref	Ref
Ever used	3.42 (2.51-4.65), <0.01	5.52 (3.48-8.77), <0.01	1.04 (0.74-1.47), 0.81

[a] All estimates are weighted.
[b] Akaike information criterion: 12,890; Bayesian information criterion: 13,048.
[c] Akaike information criterion: 12,517; Bayesian information criterion: 12,759.

East/Southeast Asian reports of arrests and convictions were similar to that of White respondents, with slightly higher estimates of approximately 5% among Latinx and South Asian respondents and 6% of Middle Eastern respondents.

The odds of not reporting arrest status among respondents who did not identify as White were at least twice that of White respondents across all groups, with the exception of those identifying as 'mixed-race' or 'other' (Table 3).

3.5.4 Model 2: Arrest and conviction by race/ethnicity and cannabis use

Respondents who reported ever consuming cannabis had greater odds of being arrested and convicted for cannabis-related offences. As Table 3 shows, after adjusting for cannabis use status, the odds of arrest for a cannabis-related offence were greater not only for Indigenous individuals, but also for Black, East/Southeast Asian and mixed-race individuals compared to White individuals. The odds of conviction remained greater for both Indigenous and Black individuals. Black respondents also had greater odds of being convicted as opposed to arrested only (AOR=2.60, 95% CI=1.08-6.22; p=0.03).

3.5.5 Model 3: Arrest and conviction by race/ethnicity, cannabis use and individual-level socioeconomic indicators

More respondents who reported finding it 'very difficult' or 'difficult' to make ends meet reported being arrested for cannabis possession (Table 2). Figure 1 shows that a greater proportion of those whose perceived income adequacy was 'very difficult' or 'difficult' were arrested and convicted for a cannabis-related offence, with comparable proportions across other categories. Perceived income adequacy was associated with conviction for cannabis-related offences, with respondents who reported finding it 'difficult', 'not easy or difficult', 'easy' or 'very easy' to make ends meet being less likely to be convicted than those who found it 'very difficult' to make ends meet (Table 4).

Figure 1 shows an overall decreasing trend of arrest and conviction with higher education. The odds of arrest only and conviction for a cannabis-related offence were lower for those with those with some college/vocational training and those with a bachelor's degree compared to those with less than high school education (Table 4).

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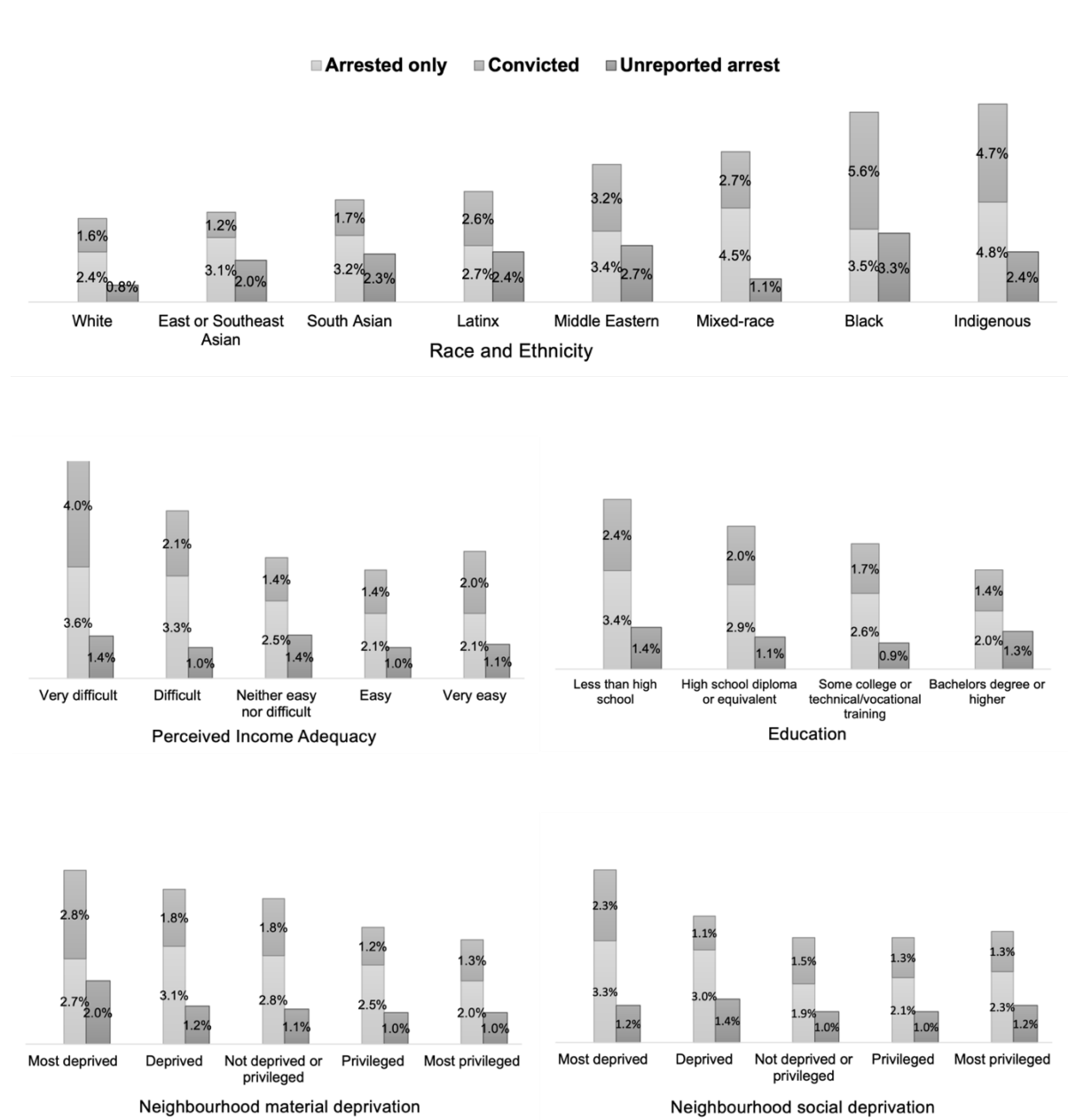**Table 4. Multinomial logistic regression model for arrests and convictions for cannabis offences in Canada by race/ethnicity and cannabis use and individual socioeconomic indicators (n=24,280)[a,b]**

	Arrested only vs No arrest or conviction (Ref)	Convicted vs No arrest or conviction (Ref)	Unreported arrest vs No arrest or conviction (Ref)
	AOR (95%CI), p-value	AOR (95%CI), p-value	AOR (95%CI), p-value
Akaike information criterion: 12,030 Bayesian information criterion: 12,661			
Race/Ethnicity			
White	Ref	Ref	Ref
Black	1.63 (0.90-2.98), 0.11	4.63 (2.43-8.83), <0.01	4.44 (2.12-9.30), <0.01
East/Southeast Asian	1.88 (1.23-2.87), <0.01	1.34 (0.72-2.52), 0.36	2.39 (1.39- 4.11), <0.01
Indigenous	1.24 (0.68-2.27), 0.48	2.00 (1.02-3.88), 0.04	3.34 (1.67-6.69), <0.01
Latinx	0.97 (0.41-2.27), 0.94	1.74 (0.62-4.88), 0.28	2.98 (0.98-9.11), 0.05
Middle Eastern	1.67 (0.68-4.08), 0.26	2.90 (1.05-7.99), 0.04	3.77 (1.45-9.79), 0.01
Mixed-race	1.75 (0.98-3.13), 0.06	1.85 (0.88-3.91), 0.11	1.49 (0.66-3.39), 0.34
South Asian	1.54 (0.78-3.06), 0.22	1.49 (0.69-3.20), 0.31	3.08 (1.68-5.65), <0.01
Other	0.38 (0.09-1.69), 0.20	0.57 (0.19-1.71), 0.31	0.38 (0.05-2.76), 0.34
Cannabis Use			
Never used	Ref	Ref	Ref
Ever used	2.88 (2.10-3.96), <0.01	4.81 (3.01-7.71), <0.01	1.07 (0.75-1.51), 0.72
Individual Socioeconomic Indicators			
Perceived Income Adequac			
Very difficult	Ref	Ref	Ref
Difficult	0.91 (0.61-1.35), 0.65	0.52 (0.33-0.82), <0.01	0.58 (0.31-1.08), 0.09
Not easy or difficult	0.76 (0.52-1.12), 0.17	0.38 (0.24-0.60), <0.01	0.91 (0.53-1.56), 0.73
Easy	0.69 (0.45-1.07), 0.10	0.38 (0.23-0.63), <0.01	0.49 (0.27-0.91), 0.02
Very easy	0.72 (0.41-1.28), 0.26	0.55 (0.33-0.92), 0.02	0.72 (0.36-1.43), 0.34
Education			
Less than high school	Ref	Ref	Ref
High school diploma or equivalent	0.68 (0.44-1.04), 0.08	0.66 (0.39-1.10), 0.11	0.81 (0.45-1.45), 0.49
Some college/vocational training[c]	0.56 (0.37-0.84), 0.01	0.47 (0.29-0.76), <0.01	0.79 (0.44-1.43), 0.44
Bachelor's degree or higher	0.42 (0.26-0.68), <0.01	0.41 (0.23-0.72), <0.01	0.92 (0.51-1.67), 0.78

[a] All estimates are weighted. [b] Model is adjusted for age, sex at birth, region, survey year and type of device used to complete survey.
[c] This category includes some college, college certificate/diploma, technical/vocational training, apprenticeship, or some university.

The addition of individual socioeconomic-level indicators modified the effect size for some race/ethnicity groups. For example, only East/Southeast Asian individuals were found to have greater odds of arrest than White individuals, while the odds of conviction for a

cannabis-related offence was greater for Black, Indigenous and Middle Eastern individuals than White individuals.

3.5.6 Model 4: Arrest and conviction by race/ethnicity, cannabis use, individual socioeconomic indicators and neighbourhood material and social deprivation level

Individuals living in material and socially 'privileged' and 'most privileged' neighbourhoods reported fewer arrests and convictions for cannabis-related offences than those in other neighbourhoods (Figure 1). While the evidence did not support an association between neighbourhood social deprivation and arrest or convictions, there was evidence of an association for neighbourhood material deprivation. As Table 5 shows, the odds of conviction for those in the 'privileged' and 'most privileged' neighbourhoods were approximately half that of those living in the most materially deprived neighbourhoods. Similarly, those from 'privileged' neighbourhoods had lower odds of conviction versus arrest only, compared to individuals from the 'most deprived' neighbourhoods (AOR=0.47, 95%CI=0.24-0.89; p=0.02). Those from the most materially deprived neighbourhoods were also less likely to report their arrest status than those in 'not privileged or deprived', 'privileged' and 'most privileged' neighbourhoods.

Table 5. Multinomial logistic regression model for arrests and convictions for cannabis offences in Canada by race/ethnicity and cannabis use, individual socioeconomic indicators and neighbourhood deprivation (n=24,280)[a,b]

	Arrested only vs No arrest or conviction (Ref)	Convicted vs No arrest or conviction (Ref)	Unreported arrest vs No arrest or conviction (Ref)
	AOR (95%CI), p-value	AOR (95%CI), p-value	AOR (95%CI), p-value
Akaike information criterion: 11,989 Bayesian information criterion: 12,814			
Race/Ethnicity			
White (Ref)	Ref	Ref	Ref
Black	1.60 (0.88-2.91), 0.12	4.15 (2.10-8.20), <0.01	3.83 (1.77-8.32), <0.01
East/Southeast Asian	1.89 (1.23-2.90), <0.01	1.35 (0.71-2.59), 0.36	2.31 (1.31-4.07), <0.01

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	Arrested only vs No arrest or conviction (Ref)	Convicted vs No arrest or conviction (Ref)	Unreported arrest vs No arrest or conviction (Ref)
	AOR (95%CI), p-value	AOR (95%CI), p-value	AOR (95%CI), p-value
Indigenous	1.25 (0.69-2.27), 0.47	1.88 (0.94-3.76), 0.07	3.00 (1.49-6.04), 0.02
Latinx	0.97 (0.41-2.28), 0.95	1.71 (0.63-4.62), 0.29	2.77 (0.92-8.37), 0.07
Middle Eastern	1.64 (0.67-4.01), 0.28	2.78 (1.00-7.72), 0.05	3.38 (1.31-8.69), 0.01
Mixed-race	1.74 (0.98-3.12), 0.06	1.79 (0.84-3.81), 0.13	1.39 (0.61-3.18), 0.44
South Asian	1.53 (0.77-3.04), 0.22	1.41 (0.64-3.11), 0.40	2.82 (1.48-5.37), <0.01
Other	0.38 (0.09-1.65), 0.19	0.55 (0.18-1.68), 0.30	0.37 (0.05-2.69), 0.80
Cannabis Use			
Never used	Ref	Ref	Ref
Ever used	2.87 (2.08-3.95), <0.01	4.80 (3.00-7.69), <0.01	1.05 (0.74-1.48), 0.80
Individual Socioeconomic Indicators			
Perceived Income Adequacy			
Very difficult	Ref	Ref	Ref
Difficult	0.93 (0.62-1.38), 0.71	0.54 (0.34-0.86), 0.01	0.61 (0.33-1.13), 0.12
Not easy or difficult	0.79 (0.53-1.16), 0.22	0.41 (0.26-0.65), <0.01	0.99 (0.57-1.70), 0.95
Easy	0.72 (0.46-1.11), 0.14	0.42 (0.25-0.71), <0.01	0.56 (0.30-1.05), 0.07
Very easy	0.76 (0.43-1.34), 0.34	0.63 (0.37-1.07), 0.09	0.84 (0.42-1.69), 0.62
Education			
Less than high school	Ref	Ref	Ref
High school diploma or equivalent	0.68 (0.44-1.04), 0.08	0.68 (0.40-1.15), 0.15	0.81 (0.45-1.44), 0.46
Some college/vocational training[c]	0.57 (0.37-0.86), 0.01	0.49 (0.30-0.82), 0.01	0.83 (0.47-1.49), 0.54
Bachelor's degree or higher	0.44 (0.27-0.71), <0.01	0.45 (0.25-0.84), 0.01	1.05 (0.58-1.89), 0.88
Neighbourhood deprivation			
Material Deprivation			
Most deprived	Ref	Ref	Ref
Deprived	1.20 (0.84-1.72), 0.31	0.75 (0.49-1.15), 0.19	0.70 (0.44-1.14), 0.14
Not deprived or privileged	1.22 (0.84-1.79), 0.30	0.79 (0.49-1.27), 0.32	0.53 (0.32-0.86), 0.01
Privileged	1.07 (0.74-1.54), 0.71	0.50 (0.29-0.86), 0.01	0.41 (0.24-0.71), <0.01
Most privileged	0.77 (0.52-1.12), 0.17	0.50 (0.27-0.92), 0.03	0.40 (0.22-0.72), <0.01
Social Deprivation			
Most deprived	Ref	Ref	Ref
Deprived	1.01 (0.74-1.39), 0.93	1.08 (0.70-1.69), 0.73	1.12 (0.70-1.80), 0.63
Not deprived or privileged	0.70 (0.48-1.01), 0.05	0.91 (0.58-1.42), 0.67	0.88 (0.53-1.45), 0.61
Privileged	0.79 (0.55-1.14), 0.21	0.83 (0.51-1.38), 0.48	0.95 (0.55-1.64), 0.84
Most privileged	0.90 (0.60-1.36), 0.62	0.83 (0.49-1.39), 0.48	0.75 (0.42-1.32), 0.32

[a] All estimates are weighted.
[b] Model is adjusted for age, sex at birth, region, survey year and type of device used to complete survey.
[c] This category includes some college, college certificate/diploma, technical/vocational training, apprenticeship, or some university.

In the models with material and social deprivation, few differences were observed by race/ethnicity, with the exception that the odds for conviction for a cannabis-related offence for Black individuals remained more than 4 times that of White individuals.

3.6 Discussion

In the current study, approximately 5% of respondents in Canada reported ever having been arrested or convicted for cannabis-related offences, with marked differences based on race/ethnicity. White respondents reported among the lowest reported arrests and convictions compared to those in all other race and ethnicity categories; by contrast, more than double the proportion of Black and Indigenous individuals reported arrests and convictions. This is generally consistent with the limited data which currently exists regarding arrests for cannabis possession in Canada and the US.[17,21,97-99] Substantially higher proportions of non-White race/ethnicity respondents chose not to answer the question on cannabis-related offences, which may reflect the greater stigma and sensitivity of such questions for racialized individuals. It is plausible that those who did not answer this question, may in fact have faced an arrest and/or conviction for a cannabis-related offence, which would underestimate racial differences.

The model building strategy used in the current study—which examined race/ethnicity, prior to adjusting for cannabis use, individual socioeconomic factors and neighbourhood deprivation—highlights the association between race and potential moderators. First, after adjusting for cannabis use, the effect for cannabis-related arrests for Black, East/Southeast Asian and mixed-race increased, suggesting that the racial differences in arrests are not explained by greater cannabis use in these racial/ethnic groups. Racial differences for convictions were somewhat attenuated, but generally persisted after adjusting for socioeconomic factors; however, adjusting for neighbourhood deprivation resulted in non-significant effects of race, with the notable exception of Black respondents. This pattern of findings underscores the broad impact of systematic racism on socioeconomic position and

neighbourhood-level factors. For example, in Canada, Black individuals have been found to be more likely to live in a low-income household than the rest of the population, as well as experience higher unemployment, and substantially lower median annual income for Black men.[108] Clearly, the impacts of racial bias are not limited to arrests and convictions but woven into many aspects of life including inequities in employment opportunities, income, and residential patterns.

The findings are consistent with previous research which suggests the existence of underlying systemic racism within policing practices and the criminal justice system, particularly towards Black and Indigenous people.[16,21,109] Although recreational cannabis is now legal in Canada, this does not mean that racial disparities in arrest and convictions for cannabis-related offences will be eliminated. While police-reported arrests for cannabis offences in Canada declined to 45 per 100,000 in 2019 from 99 per 100,000 in 2018, we are unaware of any data examining differences based on race.[110] Research in US states where cannabis has been legalized for several years suggests that while arrests for cannabis possession have decreased, racial disparities continue to exist.[111] For example, a Colorado report comparing arrests for cannabis-related offences found that the arrest rate for Black people was more than 2 times that of White people in 2010, before legalization, and remained the same in 2014, two years after legalization.[112] Similarly, while comparable prevalence rates for cannabis use have been reported among adults in Washington State, racial disparities in cannabis related arrests have persisted despite legalization in 2012.[24] Establishing guidelines to collect, and make accessible, data on police stops, searches and arrests by race/ethnicity will be a necessary next step in moving to change these entrenched practices.

Individual socioeconomic factors, namely perceived income adequacy and education, were negatively associated with cannabis-related arrests and convictions. This is not surprising given that those with greater financial resources may be better equipped to navigate the legal

system.[113] Neighbourhood deprivation was also associated with arrest and convictions, where individuals living in the most socially and materially deprived neighbourhoods reported higher cannabis arrests and convictions than those residing in neighbourhoods which are more privileged. Even after controlling for cannabis use, individual socioeconomic factors and race, those in the most materially privileged neighbourhoods were half as likely to report being convicted compared to those in the most deprived neighbourhoods. These findings are consistent with previous work which has found increased police presence within more deprived neighbourhoods, and more frequent stops and searches of those deemed suspicious.[114–116] The physical environment in which these individuals find themselves may put them at greater risk for arrests and convictions, despite the fact that their cannabis use may be similar to those in more privileged neighbourhoods.

3.6.1 Strengths and Limitations

While this study was able to examine the impact of race/ethnicity and neighbourhood deprivation in addition to individual socioeconomic factors associated with arrests/convictions for cannabis-related offences with a large national sample, it does have limitations. As the ICPS uses self-reported survey methodology, it is subject to limitations common to survey research such as social desirability and self-selection bias.[117] Respondents were recruited using non-probability-based sampling; therefore, the findings do not provide nationally representative estimates. Cannabis use estimates were within the range of national estimates for young adults, whereas estimates among the full ICPS sample were generally higher than national surveys in Canada.[106] This is likely due to the fact that the ICPS sampled individuals aged 16–65, whereas the national surveys included older adults, who are known to have lower rates of cannabis use.

Due to the cross-sectional nature of the ICPS design, this research cannot establish a temporal association between socioeconomic indicators or neighbourhood deprivation and the outcome of arrests and convictions. Similarly, it cannot be established if a respondent was

arrested in their own neighbourhood. Furthermore, the measures for arrest and convictions are for lifetime, and not specific to the period after legalization of non-medical cannabis. As a result, it is not possible to determine any impact that legalization may have on these outcomes. Finally, the measures do not allow assessment of the number of arrests for possession or other offences, which may impact conviction estimates.

The INSPQ material and social deprivation index is based on 2016 census data which may have changed over the course of the past several years. However, it is not expected that the distribution of socioeconomic indicators would shift dramatically in this time frame. An additional limitation is the assumption that the deprivation indices are representative of a neighbourhood. Postal code distribution may not align exactly with how neighbourhoods are viewed by those living in them. Furthermore, respondents with missing postal code data were excluded. The subset of those included differed on sociodemographic characteristics which may have introduced bias (see Appendix B, Table B1 for full comparisons).

3.6.2 Conclusion

The current study highlights the disproportionate burden of arrests and convictions for cannabis arrests among racialized individuals, those with lower socioeconomic position, as well as those living in the most materially deprived neighbourhoods. Legalization of cannabis is seen by many as an opportunity to change the outlook, particularly for marginalized and racialized groups. However, it is unlikely that issues rooted deeply in systemic racism will be swiftly eliminated. In Canada, continued efforts for transparency in arrests and convictions for cannabis-related offences will be crucial to determine if these policies are having the desired impact. Furthermore, policies focused on rectifying the disproportionate harms, such as expungement for cannabis possession offences, inclusion of racialized groups in the legal cannabis market, and giving back to communities most impacted by the harms of prohibition, are needed.

Chapter 4: Patterns of problematic cannabis use in Canada pre- and post-legalization: Differences by neighbourhood deprivation, individual socioeconomic factors and race/ethnicity.

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4.1 Overview

Aims The legalization of cannabis in Canada in 2018 has generated interest in understanding potential changes in problematic patterns of use. The current study sought to examine changes in problematic cannabis use following legalization including by sociodemographic factors, such as race/ethnicity and neighbourhood deprivation.

Design, Setting, Participants This study used repeat cross-sectional data from the Canadian arm of the International Cannabis Policy Study (ICPS) web-based survey conducted in 2018 (n=2063) prior to cannabis legalization, and post-legalization in 2019 (n=4005) and 2020 (n=4059), among past 12-month cannabis consumers aged 16 to 65.

Measurements The main outcome was the WHO Alcohol, Smoking and Substance Involvement Screening Test (ASSIST) risk group (low/moderate/high). Independent variables included race/ethnicity, perceived income adequacy, education, and neighbourhood deprivation. Neighbourhood deprivation scores were obtained by linking respondents' postal codes to the INSPQ neighbourhood deprivation index. Multinomial regression models examined differences in problematic use by sociodemographic and socioeconomic factors and over time.

Findings There were no significant changes in 'high risk' problematic cannabis use, from before cannabis legalization (2018=5.7%) to 12- or 24-months after legalization (2019=4.5%, 2020=5.0%, all p>0.10). There was a decrease in 'moderate risk' between 2018-2019 (p=0.03) and between 2018-2020 (p=0.01). Problematic use differed by sociodemographic factors. For example, compared to those from more materially deprived neighbourhoods, the odds of 'moderate risk' vs 'low risk' were lower for consumers living outside deprived neighbourhoods (p<0.01 for all); however, there were few differences in 'high risk'. Black, Middle Eastern and South Asian individuals were more likely than White individuals to experience 'high risk' compared to 'low risk' (all p<0.05). Differences across subgroups were consistent from 2018 to 2020.

Conclusions The risk of problematic cannabis use does not appear to have increased in the two years following cannabis legalization in Canada. Disparities in problematic use persisted, with racialized and marginalized groups experiencing higher risk.

Keywords: cannabis; marijuana; legalization; problematic use; neighbourhood deprivation; socioeconomic; race; ethnicity

4.2 Introduction

Legalization of non-medical cannabis in Canada in October 2018 was accompanied by many expectations and concerns. Proponents of legalization argued that reducing the illicit market, as well as safer and easier access to legal cannabis, would reduce the disproportionate negative legal implications for cannabis possession, particularly for Black and Indigenous communities.[16,21] However, there is also concern that increased accessibility and lower cost could increase cannabis use, resulting in higher incidence of problematic use.[28]

Under a framework of criminal prohibition, prevalence of 'any' cannabis use is often interpreted synonymously with problematic use. As an increasing number of jurisdictions legalize cannabis, there is a need for more meaningful indicators of problematic use.[118,119] Guidelines have been developed to identify individual indicators of problematic use, such as cannabis-impaired driving and adverse health events,[31,120] as well as aggregate measures of problematic use, that examine the impact of use on various aspects of life.[118,119] Widely-used aggregate measures of problematic use include the Diagnostic and Statistical Manual of Mental Disorders criteria for cannabis dependence and abuse,[121] the Cannabis Use Disorder Identification Test-Revised (CUDIT-R)[10] and the WHO Alcohol, Smoking and Substance Involvement Screening Test (ASSIST).[11] These scales typically assess a combination of frequent use as well as negative consequences on employment, social relationships, and health.

In Canada, a 2013 report using a nationally representative sample estimated past 12-month prevalence of problematic cannabis use at 1.3%,[122] with another study estimating prevalence of 1.9% among past 3-month consumers.[47] The most recent nationally representative data from 2019 reported prevalence of problematic use among past 12-month consumers at 1.1%.[123] In the US, past 12-month national estimates of problematic use range between 1.4% and 5.1%.[4,54,124,125] To date, the impact of legalization on individual and aggregate indicators of problematic cannabis use remains unclear. Preliminary evidence on cannabis-impaired driving is mixed, with some research from the US suggesting increases post-legalization followed by a decreasing trend; other research suggests no difference between US states that have and have not legalized.[126–129] Adverse events and health care visits have increased in jurisdictions that have legalized cannabis, typically due to unintentional ingestion of edibles.[130–134] Further analysis is

needed to determine the extent to which these changes are a result of legalization or increased monitoring or reporting.[135] Consumers in US states that have legalized non-medical cannabis score higher on risk indices designed to measure differences in potential harms of use,[136] while prevalence of cannabis use disorder increased slightly among adolescents and adults 26 and older, but not those aged 18-25, following legalization.[37] The impact of cannabis legalization remains unclear due to a lack of detailed longitudinal data using sufficient measures to distinguish between pre-existing secular trends and the impact of legalization.[137]

Studies have also reported differences in socioeconomic and sociodemographic risk factors for problematic use. In Canada, lower household income has been associated with increased likelihood of problematic use.[49] Data from the US suggests that, between 2001 and 2014, cannabis use substantially increased across all income and education groups, while cannabis use disorders were more likely among those with low income and those who had not completed a college degree.[39,54] In terms of sociodemographic differences, previous work in both Canada and the US has found that males and young adults are at greater risk for problematic cannabis use.[39,47,54] Differences in prevalence of problematic use based on race/ethnicity have also been reported, with some studies in the US reporting increased odds of cannabis use disorders among Black, mixed-race and Indigenous individuals compared to White individuals.[138,139] One study that examined racial differences in cannabis use disorder over time found that prevalence increased to a greater extent among Black versus White individuals.[54] While studies examining racial/ethnic differences in problematic use in Canada are limited, a study in Ontario, Canada found that those of 'Caribbean' or 'Northern European' descent were more likely to report moderate/high problematic cannabis use compared to those who identified as 'Canadian'.[53] We are unaware of any work which looks at racial or ethnic differences in problematic cannabis use following legalization in Canada.

Beyond 'individual level' indicators of problematic use, there is limited research on 'environmental level' indicators, such as neighbourhood deprivation. In neighbourhoods with high levels of deprivation there are often fewer social and material resources for those in the community to rely on. Deprived environments also present more life stressors, leading to substance use as a coping strategy.[39,59,60] Limited research has focused on the association

between neighbourhood deprivation and cannabis use, and to our knowledge there is no work on problematic cannabis use and neighbourhood deprivation in Canada. Mixed results have been reported from the few US studies which have included cannabis when examining substance use within neighbourhoods, making it unclear whether neighbourhood deprivation is independently associated with problematic use after accounting for individual level socioeconomic factors.[60,67,82] An examination of potential differences in problematic use based on neighbourhood deprivation can provide insights into the unique challenges faced within communities and open the discussion on the need for policies to protect vulnerable populations. It is unclear if problematic use of cannabis has changed overall or by sociodemographic and socioeconomic factors following legalization.

The objective of the current study was to examine differences in problematic use, measured using the WHO ASSIST tool, by 1) material and social neighbourhood deprivation, 2) individual socioeconomic factors, and 3) race/ethnicity prior to and in the two years following legalization of adult non-medical cannabis in Canada. There were four main hypotheses: 1) neighbourhood deprivation is an independent predictor of problematic use, with lower odds of 'high risk' problematic use in more privileged neighbourhoods; 2) the odds of 'high risk' problematic use will be lower among those with higher perceived income adequacy and education; 3) there will be greater 'high risk' problematic use among Black and Indigenous individuals compared to White individuals; and 4) no changes will be observed in overall prevalence of problematic use in the two years following legalization in Canada.

4.3 Methods

Data are from waves 1 to 3 of the Canadian arm of the International Cannabis Policy Study (ICPS). Data were collected via self-completed web-based surveys conducted in September/October 2018, 2019 and 2020 with 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 a random sample of eligible panelists. Surveys were conducted in English or French. Respondents provided consent prior to completing the survey and received remuneration in accordance with their panel's usual incentive structure. The cooperation rate, which was calculated based on

AAPOR Cooperation Rate #2 as the number of respondents who completed the survey divided by the total number of respondents who accessed the survey link, was 64.2% in 2018, 62.9% in 2019, and 62.0% in 2020.[140] A full description of the study methods are available in the ICPS technical reports at http://cannabisproject.ca/methods.

The study was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31330).

4.3.1 Measures

Sociodemographic variables included age, sex at birth (female/male), and degree of urbanization (rural/urban).

Past 3-month cannabis use status. Past 12-month cannabis consumers were categorized into one of 5 mutually exclusive categories based on past 3-month cannabis use (derived from the ICPS most recent cannabis use and current cannabis use variables): Never; Once or twice; Monthly; Weekly; Daily/almost daily.

Problematic use. The WHO ASSIST tool assesses the level of risk for developing health and other problems from cannabis use based on past 3-month cannabis use as well as 5 additional questions which assess desire to use, health, social, legal, or financial problems, failure to meet expectations, as well as concerns from friends/family and failure to control use.[11] The ASSIST risk assessment score ranges from 0-39. Respondents were categorized to one of three problematic use risk groups: low risk (0-7); moderate risk (8-26) and high risk (greater than 26). Respondents with a missing ASSIST score were excluded from further analysis. The threshold for low risk was set to 7 in line with recommendations on using the ASSIST within population surveys to capture not only frequency of use, but also at least one harm associated with use.[93,94]

Race/Ethnicity. Race/Ethnicity was assessed with the question for race from the Government of Ontario Data Standards for the Identification and Monitoring of Systemic Racism.[92] Respondents were categorized into the following groups: Black; East/Southeast Asian; Indigenous; Middle

Eastern; South Asian; White; Other; Don't know; and Refuse to answer. Respondents who selected more than one category were recoded to 'Mixed race'.

Perceived income adequacy. Perceived income adequacy measured the extent to which family income was perceived as being sufficient make ends meet and was classified into five categories: Very difficult; Difficult; Neither easy nor difficult; Easy; Very easy.

Education. The highest level of formal education attained was classified into five categories: Less than high school; High school diploma or equivalent; Some college or technical/vocational training or certificate/diploma, or apprenticeship, or some university; Bachelor's degree or higher.

For race/ethnicity, perceived income adequacy and education 'Don't know' and 'Refuse to answer' responses were recoded to 'Unstated'.

Postal Code and Neighbourhood deprivation index. All survey respondents were asked to provide their postal code which was used to link individual respondents to a national database of neighbourhood deprivation indices from the Institut National de Santé Publique du Québec (INSPQ).[91] The 2016 index is based on Canadian Census dissemination areas. Where data were available, each postal code in the country was assigned two scores: 1) a material deprivation score (based on the level of education, income and employment in the population 15 and over) and 2) a social deprivation score (based on the proportion of the population aged 15 and over living alone, who are separated, divorced or widowed as well as the proportion of single-parent families). Scores for each index were derived through principal component analysis.[91] Each index is represented in quintiles on a scale of 1-5 (most deprived/ deprived/ neither deprived nor privileged/privileged/most privileged).

4.3.2 Analysis

The final cross-sectional samples in Canada consisted of 10,057 respondents in 2018, 15,256 respondents in 2019 and 15,780 in 2020 after exclusions based on data quality checks and incomplete responses; complete details regarding exclusions can be found in the ICPS technical

report.[106] The current study was based on respondents who reported consuming cannabis in the past 12 months. A sub-sample of 2063, 4011 and 4059 respondents in 2018, 2019 and 2020, respectively, were included in the current analysis after excluding respondents with missing data for postal code (n_{2018}=213; n_{2019}=814; n_{2020}=732), neighbourhood deprivation index (n_{2018}=110; n_{2019}=243; n_{2020}=218) and urban/rural designation (n_{2018}=27; n_{2019}=7; n_{2020}=2).

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-cigarette smoking status groups. A raking algorithm was applied to the full cross-sectional analytic samples to compute weights that were calibrated to these groupings. Weights were rescaled to the sample size for Canada. Estimates are weighted unless otherwise specified. Analyses were conducted using survey procedures in SAS version 9.4.

A main effects multinomial logistic regression model was estimated with 3 levels of the ASSIST score: 1) Low risk; 2) Moderate risk; 3) High risk. Respondents with 'Unstated' responses for race/ethnicity, perceived income adequacy and education were excluded from the analyses due to small cell counts and model convergence issues. Potential clustering based on dissemination area was accounted for using the cluster option in the survey routines analysis, and the model was adjusted for age, sex at birth, urbanicity, survey year and whether the survey was completed on a smartphone, tablet, or computer. Parameter estimates for all covariates included in the model are presented in Appendix C, Table C2. Multicollinearity was assessed using variance inflation factors; all VIFs were less than 5 so all variables were retained in the model (See Appendix A, Table A2 for details). Separate multinomial models were used to examine interactions between year and each of the main predictor variables (material and social neighbourhood deprivation, education, perceived income adequacy and race/ethnicity), to test for differences across time.

4.4 Results

4.4.1 Sample characteristics

Table 1 presents the characteristics of past 12-month cannabis consumers in 2018, 2019 and 2020.

4.4.2 Problematic cannabis use

Overall, less than 6% of past 12-month cannabis users were classified as 'high risk' for problematic use based on the ASSIST measure. Most respondents were 'low risk', with around a third considered 'moderate risk' (Figure 1). While the distribution of high-risk scores were consistent between 2018-2020 (all p>0.10), there was an increased odds of 'low risk' versus 'moderate risk' scores between 2018 and 2019, and 2018 and 2020, (AOR 95%CI=1.25 (1.07-1.46), p=0.03; AOR 95%CI=1.19 (1.02-1.40), p=0.01, respectively).

4.4.3 Neighbourhood deprivation

No consistent patterns in 'high risk' scores were noted based on level of neighbourhood deprivation (Table 2). As Table 3 shows, compared to those living in the *most materially deprived neighbourhoods*, those in 'not deprived or privileged', 'privileged', and 'most privileged' were less likely to be at 'moderate risk' compared to 'low risk'. Two-way interactions with *material deprivation* and year did not support any changes over time (F=1.04; p=0.41). The association between *neighbourhood social deprivation* and ASSIST scores was weak (F=1.92; p=0.05).

4.4.4 Individual socioeconomic indicators

The proportion of 'high risk' scores was consistently high among those respondents reporting finding it 'very difficult' to make ends meet. With only two exceptions, compared to respondents who found it 'very difficult' to make ends meet, those from all other categories had lower odds of reporting 'moderate risk' or 'high risk' compared to 'low risk', as well 'high risk' compared to 'moderate risk' (Table 3). The two-way interaction between perceived income adequacy and year suggested no changes in risk over time at any level of income adequacy (F=1.27, p=0.15).

For level of education, compared to those with 'less than high school', respondents with 'some college/vocational training' and those with a 'bachelor's degree or higher' were less likely to have 'moderate risk' compared to 'low risk' (Table 3). In addition, those with 'some college/vocational training' were also less likely to be 'high risk' compared to 'low risk'. Analysis of the education-by-year interaction did not suggest changes in ASSIST scores within each level of education over time (F=1.68; p=0.07).

4.4.5 Race and ethnicity

In 2020, all non-White racial/ethnic groups had a higher proportion of 'high risk' scores compared to White individuals (Table 2). In 2019, both Black and South Asian groups saw a sharp increase in the 'high risk' category, however, 2020 showed a return to proportions similar to 2018 for Black respondents, with a decrease among South Asian respondents as well, but still higher than 2018. Middle Eastern individuals had a notable increase in 'high risk' scores in 2020.

Overall, Black, Indigenous and East/Southeast Asian respondents were more likely to have moderate versus low risk compared to White respondents (Table 3). When comparing 'high risk' to 'low risk', Black, Middle Eastern and South Asian respondents had at least two times greater odds of 'high risk' compared to White respondents. Middle Eastern respondents also had more than 4 times the odds of 'high risk' compared to 'moderate risk' than White respondents. The race/ethnicity-by-year interaction suggests that ASSIST scores within racial/ethnic groups between 2018-2020 did not substantially change (F=1.27, p=0.15).

4.5 Discussion

The prevalence of high risk for problematic cannabis use overall was not marked by substantial change from 5.7% pre-legalization in 2018 to 4.5% and 5.0% in the 12- and 24-months following non-medical cannabis legalization in Canada. The estimates of high risk in the current study were somewhat higher than the 2019 national Canadian estimate of 1.1%,[123] however, it is similar to the 2020 US estimate of cannabis use disorder at 5.1%.[4] The cannabis use estimates among the full ICPS sample were generally higher than national surveys in Canada.[106] This is likely due to the fact that the ICPS sampled individuals aged 16–65, whereas the national surveys included older adults, who are known to have lower rates of cannabis use, and as a result lower rates of problematic use. In addition, as the national survey used telephone-assisted interviews to obtain data, it may be that there was underreporting of sensitive data, resulting in underestimates of risk.

Some differences in risk were noted based on race/ethnicity, as well as by individual and neighbourhood level socioeconomic factors. However, these differences have remained

relatively consistent pre- and post-legalization suggesting that increased potential for high-risk use does not seem to differ based on these factors, at least in the early stages of legalization.

Although cannabis use has increased moderately since legalization,[40,141] data on problematic use indicators from Canada post-legalization remain limited, with mixed findings. Research on cannabis-impaired driving suggests that self-reported rates have remained stable or decreased,[31,40] while there has been no significant increase in traffic-injury emergency department visits in Ontario and Québec post-legalization.[142] However, a recent report found that there was an 8% increase in cannabis-related emergency department visits and a 5% increase in hospitalizations across Canada, from 2019 to 2020, and 14% increase in both from 2020 to 2021.[143,144] This was attributed to the impact of the COVID-19 pandemic on substance use, including using as a coping mechanism, as well as changes in availability of services making it more challenging to receive assistance outside the hospital setting.[143] The current study adds to the literature by providing pre- and post-legalization estimates of risk of problematic use via an aggregate measure.

Looking more closely at the socioeconomic indicators of problematic use, some similar patterns emerged for material neighbourhood deprivation, perceived income adequacy and level of education. Within neighbourhood material deprivation categories, there was minimal change in patterns of risk scores across time. People from more deprived neighbourhoods were no more likely to report high risk, but they were more likely to report moderate risk compared to people from more privileged neighbourhoods. Similarly, those with 'less than high school' education were more likely to report moderate risk compared to those with at least some post-secondary education, as were those with the lowest perceived income adequacy. This is consistent with previous studies which have found an association between lower income and education and problematic cannabis use.[39,49,54] It may be the environmental and life stressors associated with financial hardship and limited opportunities to improve outcomes influence decisions to use cannabis, potentially as a form of relaxation or a coping mechanism, and negatively impact well-being and relationships.[39,60] Unlike neighbourhood deprivation and education, where differences were only noted in moderate risk, those who found it very difficult to make ends meet were also more likely to be at *high risk* for problematic use. Previous work has found that heavy cannabis

use is associated with long-term declines in socioeconomic outcomes and increased unemployment.[39] Thus, more frequent and disruptive use of cannabis may interfere with the ability to find and maintain employment.[8] Alternately, it may be that those suffering from physical or mental health issues may not be able to work, and cannabis may be used for medicinal purposes, increasing the likelihood of more frequent use.[18] The findings support the inclusion of neighbourhood material deprivation as an independent measure in addition to individual socioeconomic indicators when examining patterns of problematic cannabis use in future research.

While trends in high-risk scores were relatively stable within racial/ethnic groups across time, a higher proportion of respondents from all non-White racial/ethnic groups reported high risk scores compared to White individuals. This is consistent with previous research in the US which found stable levels of cannabis use within racial/ethnic groups between 2005-2013, with higher rates among Black, Indigenous and mixed-race individuals than White individuals.[138] The higher proportion of 'high risk' scores within particular racial/ethnic groups, including Middle Eastern, South Asian and mixed-race people, highlight the importance of collecting data at this level to be able to examine differences. Future research should examine if these trends continue and consider what factors may be accounting for these differences to determine if targeted interventions may be beneficial.

From 2018 to 2019, an increase in high-risk scores was noted for Black and South Asian individuals; however, it is unclear what may have caused these findings. Differences on individual ASSIST items within these two groups reflected more respondents in 2019 reporting friends/relatives expressing concern about use, as well as higher reported failed attempts to control use. When looking at differences between racial/ethnic groups, it was noted that while there were some differences in frequency of use, there were also differences in other indicators related to meeting expectations, friend/relative expressing concern as well as failure to control use. It may be that within varying cultural and ethnic backgrounds the expectations and perceived acceptability may influence a person's own perceptions about use and desire to change patterns of use. Similarly, the potential for legal ramifications of use as well as stigma and bias may influence views and expectations of both the person using as well as those of

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friends/relatives, particularly for racialized people who have faced inequitable outcomes for cannabis use.

4.5.1 Limitations

This study is subject to limitations common to survey research, such as social desirability and self-selection bias.[117] Respondents were recruited using non-probability-based sampling; therefore, the findings do not provide nationally representative estimates. Due to the cross-sectional nature of the design, this research cannot establish a temporal association between socioeconomic indicators and neighbourhood deprivation and problematic use. For example, it cannot be established whether a person's socioeconomic circumstances preceded problematic use or vice versa.

Respondents with missing postal code data and incomplete ASSIST questions were excluded from the current analyses. The subset of those included differed on sociodemographic characteristics which may have introduced bias (see Appendix B, Table B2 for full comparisons). The INSPQ material and social deprivation index also has some limitations. It is based on 2016 data which may have changed over the course of the past several years. However, it is not expected that the distribution of socioeconomic resources would shift dramatically in this time frame. An additional limitation is the assumption that the deprivation indices are representative of a neighbourhood. Dissemination areas may not align exactly with how neighbourhoods are viewed by those living in them.

4.5.2 Conclusion

Overall, in the initial period following legalization in Canada, levels of problematic use have changed very little at the population level. Modest differences in problematic use risk scores were observed based on various socioeconomic indicators as well as race/ethnicity. Future research should continue to monitor the prevalence of problematic cannabis use indicators keeping these factors in mind to ensure that any potential drawbacks of legalization are not disproportionately impacting marginalized and racialized populations.

Table 1: Sample characteristics of past 12-month cannabis consumers by survey wave (n=10,127)

	2018 (n=2,063)		2019 (n=4,011)		2020 (n=4,059)	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
Age						
16-25	16.8 (346)	19.3 (398)	16.1 (646)	17.8 (714)	16.1 (653)	16.8 (680)
26-35	20.4 (420)	28.0 (578)	24.3 (972)	27.1 (1085)	21.3 (865)	26.9 (1090
36-45	16.9 (348)	21.0 (434)	22.4 (898)	21.0 (843)	21.0 (851)	21.6 (878)
46-55	19.2 (398)	16.7 (345)	18.4 (736)	18.3 (735)	19.3 (782)	17.9 (727)
56-65	26.7 (551)	15.0 (309)	18.8 (753)	15.7 (629)	22.4 (908)	16.8 (683)
Sex						
Female	55.4 (1142)	45.7 (943)	58.6 (2346)	45.8 (1835)	61.0 (2476)	47.6 (1931)
Male	44.6 (921)	54.3 (1120)	41.4 (1659)	54.2 (2170)	39.9 (1583)	52.4 (2128)
Race/ethnicity						
Black	1.4 (28)	2.0 (42)	2.7 (110)	3.5 (142)	2.5 (101)	3.5 (142)
East/Southeast Asian	2.4 (49)	3.3 (68)	4.2 (170)	4.2 (170)	4.3 (174)	4.6 (1887)
Indigenous	7.2 (149)	6.8 (140)	3.5 (142)	3.7 (148)	3.0 (122)	2.7 (110)
Latinx	0.5 (10)	0.9 (19)	1.3 (52)	1.6 (66)	1.0 (41)	1.4 (57)
Middle Eastern	0.7 (14)	0.8 (17)	0.7 (28)	0.6 (23)	1.1 (44)	1.2 (49)
Mixed race	1.9 (40)	2.4 (50)	2.0 (82)	4.0 (161)	3.9 (159)	3.9 (157)
South Asian	1.3 (27)	2.0 (42)	3.7 (147)	2.6 (103)	2.2 (90)	2.8 (112)
White	83.9 (1731)	81.0 (1671)	79.8 (3195)	77.6 (3110)	79.4 (3222)	77.2 (3133)
Other	0.4 (9)	0.5 (9)	1.0 (42)	1.1 (42)	1.5 (62)	1.7 (68.0)
Unstated	0.3 (6)	0.2 (5)	0.9 (37)	1.0 (41)	1.1 (44)	1.1 (44)
Perceived income adequacy						
Very difficult	9.9 (205)	9.0 (186)	11.1 (445)	10.7 (428)	8.7 (355)	9.2 (375)
Difficult	22.2 (459)	22.4 (463)	24.9 (996)	25.6 (1025)	22.1 (899)	21.4 (871)
Not easy or difficult	37.0 (764)	36.7 (758)	33.5 (1342)	33.9 (1356)	35.6 (1444)	35.9 (1459)
Easy	18.8 (387)	19.0 (393)	19.6 (785)	18.7 (749)	22.0 (892)	21.8 (887)
Very easy	10.9 (224)	11.2 (231)	9.9 (396)	9.9 (396)	10.1 (408)	9.9 (401)
Unstated	1.2 (24)	1.5 (32)	1.0 (41)	1.3 (51)	1.5 (61)	1.6 (66)
Education						
Less than high school	10.8 (224)	18.0 (371)	8.1 (326)	15.5 (622)	9.1 (370)	13.4 (543)
High school diploma or equivalent	17.1 (353)	28.4 (585)	17.8 (716)	28.2 (1131)	16.5 (676)	29.3 (1188)
Some college or technical/vocational training*	46.7 (964)	35.5 (733)	46.1 (1847)	35.0 (1400)	43.6 (1771)	34.9 (1418)
Bachelor's degree or higher	25.2 (519)	18.0 (371)	27.8 (1112)	21.2 (849)	30.3 (1230)	22.1 (898)
Unstated	0.1 (3)	0.2 (4)	0.1 (4)	0.1 (3)	0.3 (12)	0.3 (12)
Neighbourhood material deprivation						
Most deprived	20.6 (425)	22.9 (473)	19.5 (781)	21.7 (867)	19.9 (806)	21.8 (885)
Deprived	21.0 (433)	20.7 (426)	22.1 (887)	22.4 (899)	20.5 (831)	21.9 (890)
Not deprived or privileged	19.7 (407)	19.8 (409)	19.6 (788)	19.3 (772)	20.3 (824)	19.8 (805)
Privileged	19.9 (411)	19.1 (394)	19.7 (789)	18.7 (751)	19.3 (786)	18.1 (735)
Most privileged	18.8 (387)	17.5 (361)	19.0 (760)	17.9 (715)	20.0 (812)	18.3 (745)
Neighbourhood social deprivation						
Most deprived	32.0 (661)	35.5 (733)	31.6 (1264)	32.2 (1290)	29.0 (1178)	31.7 (1286)

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	2018 (n=2,063)		2019 (n=4,011)		2020 (n=4,059)	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
Deprived	23.6 (487)	22.7 (469)	22.5 (900)	21.2 (850)	22.4 (908)	22.4 (908)
Not deprived or privileged	18.7 (385)	16.8 (347)	19.0 (761)	18.8 (755)	16.6 (797)	18.7 (759)
Privileged	15.0 (310)	14.3 (295)	15.4 (617)	15.9 (636)	16.1 (653)	14.2 (576)
Most privileged	10.7 (220)	10.7 (217)	11.6 (463)	11.9 (475)	12.9 (523)	13.1 (530)
Past 3-month cannabis use						
Never	21.8 (450)	20.5 (423)	21.9 (878)	20.3 (813)	20.6 (835)	19.2 (779)
Once or twice	16.5 (341)	14.0 (288)	18.0 (719)	16.8 (673)	17.0 (688)	14.9 (605)
At least monthly use	14.1 (291)	14.4 (297)	16.0 (641)	16.4 (658)	15.8 (641)	15.3 (622)
At least weekly use	16.2 (334)	18.0 (371)	15.1 (607)	15.2 (610)	15.8 (641)	16.2 (656)
Daily/almost daily use	31.4 (647)	33.2 (684)	29.0 (1160)	31.2 (1251)	30.9 (1254)	34.4 (1398)

*This category includes some college, college certificate/diploma, technical/vocational training, apprenticeship, or some university.

Figure 1: Overall prevalence of ASSIST scores for problematic cannabis use among past 12-month cannabis consumers from 2018-2020[1]
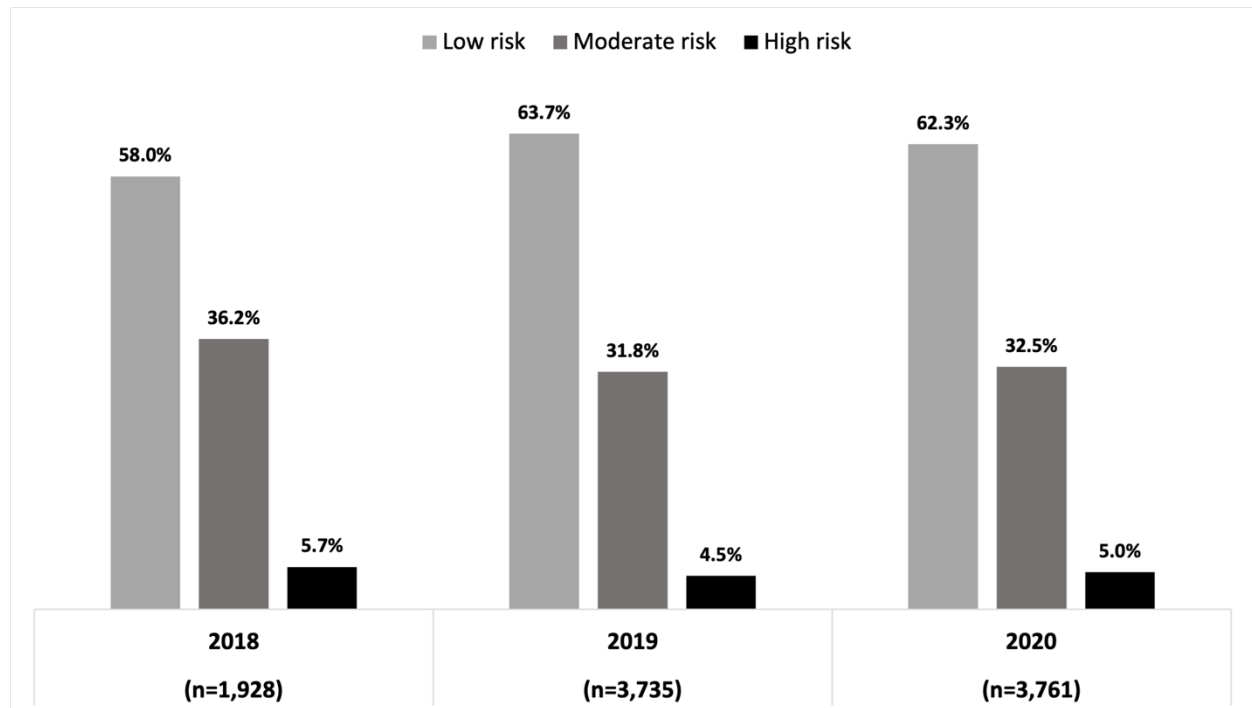
[1] All estimates are weighted frequencies and percentage

Table 2: ASSIST score distribution by neighbourhood deprivation, individual socioeconomic indicators, and race/ethnicity among past 12-month cannabis consumers from 2018-2020[1]

	2018 (n=1,928)			2019 (n=3,735)			2020 (n=3,761)		
	Low risk	Moderate risk	High risk	Low risk	Moderate risk	High risk	Low risk	Moderate risk	High risk
	(0-7)	(8-26)	(>=27)	(0-7)	(8-26)	(>=27)	(0-7)	(8-26)	(>=27)
Neighbourhood deprivation									
Material deprivation									
Most deprived	45.8 (203)	47.7 (211)	6.4 (29)	58.0 (464)	37.4 (299)	4.6 (37)	54.4 (428)	40.2 (316)	5.4 (42)
Deprived	52.9 (211)	41.5 (165)	5.6 (22)*	59.6 (488)	33.4 (276)	5.8 (48)	59.6 (490)	35.0 (288)	5.3 (44)
Not deprived or privileged	58.6 (221)	38.1 (143)	3.3 (13)*	66.9 (496)	30.3 (225)	2.8 (20)	64.5 (485)	30.5 (230)	5.0 (38)
Privileged	69.2 (255)	22.3 (82)	8.5 (31)*	69.9 (485)	26.0 (181)	4.1 (28)	70.2 (482)	26.6 (183)	3.2 (22)*
Most privileged	67.2 (229)	28.2 (96)	4.6 (16)*	65.4 (445)	29.5 (201)	5.1 (35)	64.5 (460)	29.4 (209)	6.2 (44)
Social deprivation									
Most deprived	55.7 (376)	40.4 (273)	3.9 (26)	59.4 (734)	36.7 (453)	4.0 (49)	57.7 (680)	37.8 (445)	4.5 (54)
Deprived	62.1 (273)	31.1 (137)	6.7 (29)	65.0 (521)	29.0 (33)	6.0 (48)	62.9 (527)	31.5 (264)	5.6 (47)
Not deprived or privileged	56.2 (187)	35.0 (117)	8.7 (29)*	63.4 (436)	32.2 (222)	4.4 (30)	67.8 (480)	27.1 (192)	5.1 (36)
Privileged	57.2 (155)	38.7 (105)	4.1 (11)*	68.7 (390)	27.8 (156)	3.5 (20)	63.4 (342)	30.7 (166)	5.9 (32)
Most privileged	61.1 (127)	31.9 (66)	7.1 (15)*	67.3 (298)	27.9 (124)	4.8 (21)	63.6 (317)	32.1 (160)	4.3 (22)
Individual socioeconomic indicators									
Perceived income adequacy									
Very difficult	55.5 (96)	35.6 (62)	8.8 (15)*	54.8 (214)	37.6 (147)	7.6 (29)	47.6 (154)	42.9 (139)	9.4 (31)
Difficult	54.2 (230)	42.2 (179)	3.5 (15)*	61.7 (585)	35.5 (337)	2.8 (27)	55.8 (447)	37.9 (304)	6.4 (51)
Not easy or difficult	56.4 (401)	39.3 (279)	4.3 (31)	64.9 (818)	32.2 (406)	2.9 (37)	64.8 (861)	31.4 (416)	3.8 (51)
Easy	63.4 (233)	30.0 (110)	6.6 (24)	67.7 (486)	26.4 (189)	6.0 (43)	67.1 (583)	28.7 (249)	4.2 (36)
Very easy	63.3 (143)	26.1 (59)	10.6 (24)*	66.2 (249)	25.9 (98)	7.9 (30)	69.0 (270)	26.2 (103)	4.8 (19)
Unstated	60.0 (15)	33.6 (9)*	6.4 (2)*	65.5 (27)	29.9 (12)*	4.6 (2)*	63.2 (29)	31.4 (14)	5.5 (2)*

	2018 (n=1,928)			2019 (n=3,735)			2020 (n=3,761)		
	Low risk	Moderate risk	High risk	Low risk	Moderate risk	High risk	Low risk	Moderate risk	High risk
	(0-7)	(8-26)	(>=27)	(0-7)	(8-26)	(>=27)	(0-7)	(8-26)	(>=27)
Education									
Less than high school	53.3 (177)	40.1 (133)	6.6 (22)	55.2 (309)	38.4 (215)	6.4 (36)	50.3 (233)	43.1 (200)	6.6 (31)
High school diploma or equivalent	53.3 (294)	37.9 (209)	8.7 (48)	58.8 (620)	37.7 (397)	3.4 (36)	58.8 (644)	36.4 (398)	4.8 (53)
Some college/vocational training [2]	58.3 (401)	37.3 (256)	4.3 (30)	67.8 (892)	28.4 (374)	3.7 (49)	65.5 (870)	31.4 (417)	3.1 (42)
Bachelor's degree or higher	69.0 (244)	28.0 (99)	3.0 (11)*	69.1 (556)	25.0 (201)	5.9 (47)	68.4 (870)	24.2 (210)	7.4 (64)
Unstated	100 (2)	0	0	60.6 (2)	39.4 (1)*	0	81.7 (4)	0	18.3 (1)*
Race/ethnicity									
Black	34.1 (14)*	59.2 (24)	6.7 (3)*	46.1 (64)	38.2 (53)	15.7 (22)	49.9 (60)	44.8 (54)	5.2 (6)*
East/Southeast Asian	60.5 (37)	19.2 (12)*	20.3 (12)*	63.4 (98)	34.5 (53)	2.1 (3)*	63.9 (114))	27.4 (49)	8.6 (15)*
Indigenous	49.7 (65)	45.3 (59)	5.0 (6)*	46.8 (66)	48.1 (68)	5.1 (7)*	47.0 (44)	45.5 (43)	7.1 (7)*
Latinx	52.0 (9)*	38.3 (7)*	9.7 (2)*	63.0 (41)	34.7 (22)	2.4 (2)*	57.0 (28)	38.6 (19)	4.4 (2)*
Middle Eastern	53.4 (9)*	32.7 (6)*	13.9 (2)*	74.1 (16)	11.1 (2)*	14.8 (3)*	41.0 (18)	34.5 (16)	22.6 (10)*
Mixed race	49.9 (22)	48.8 (21)	1.3 (1)*	56.0 (80)	37.8 (54)	6.2 (9)*	60.8 (83)	28.8 (39)	10.4 (14)*
South Asian	55.9 (23)	41.8 (17)	2.2 (1)*	53.3 (52)	30.0 (29)	16.7 (16)	49.5 (56)	37.4 (43)	13.1 (15)*
White	59.8 (935)	34.9 (546)	5.3 (84)	65.9 (1913)	30.5 (886)	3.6 (105)	64.2 (1882)	31.9 (934)	3.9 (116)
Other	45.6 (5)*	54.4 (6)*	0	67.1 (29)	32.9 (14)	0	54.3 (27)	37.4 (19)	8.4 (4)*
Unstated	0	100 (1)	0	73.5 (19)	22.6 (6)*	3.9 (1)*	75.7 (31)	24.3 (10)*	0

[1] All estimates are weighted frequencies and percentages. [2]This category includes some college, college certificate/diploma, technical/vocational training, apprenticeship, or some university. *High sampling variability-coefficient of variation >0.30.

Table 3: Multinomial regression main effects model of problematic cannabis use ASSIST score by neighbourhood deprivation, individual socioeconomic indicators, and race/ethnicity among past 12-month cannabis consumers (n=9,162)[1,2]

	ASSIST Moderate risk vs Low risk (Ref) AOR (95%CI), p-value	ASISIST High risk vs Low risk (Ref) AOR (95%CI), p-value	ASSIST High risk vs Moderate risk (Ref) AOR (95%CI), p-value
Neighbourhood deprivation			
Material deprivation			
Most deprived	Ref	Ref	Ref
Deprived	0.90 (0.74-1.10), 0.229	1.07 (0.68-1.68), 0.977	1.12 (0.70-1.79), 0.640
Not deprived or privileged	0.78 (0.64-0.95), 0.014	0.66 (0.41-1.07), 0.079	0.82 (0.50-1.36), 0.445
Privileged	0.60 (0.49-0.74), <0.001	0.80 (0.50-1.29), 0.371	1.34 (0.82-2.18), 0.225
Most privileged	0.70 (0.57-0.86), <0.001	0.87 (0.54-1.39), 0.645	1.31 (0.80-2.15), 0.279
Social deprivation			
Most deprived	Ref	Ref	Ref
Deprived	0.75 (0.63-0.90), 0.003	1.24 (0.84-1.82), 0.130	1.65 (1.11-2.44), 0.005
Not deprived or privileged	0.84 (0.70-1.02), 0.193	1.03 (0.65-1.64), 0.080	1.70 (1.07-2.70), 0.026
Privileged	0.86 (0.71-1.05), 0.160	1.03 (0.65-1.64), 0.674	1.20 (0.75-1.92), 0.318
Most privileged	0.84 (0.67-1.05), 0.144	1.04 (0.64-1.69), 0.716	1.24 (0.75-2.05), 0.328
Individual socioeconomic indicators			
Perceived income adequacy			
Very difficult	Ref	Ref	Ref
Difficult	0.85 (0.67-1.07), 0.155	0.39 (0.24-0.63), <0.001	0.46 (0.28-0.75), 0.002
Not easy or difficult	0.72 (0.58-0.90), 0.004	0.26 (0.16-0.41), <0.001	0.36 (0.22-0.58), <0.001
Easy	0.59 (0.46-0.76), <0.001	0.34 (0.21-0.55), <0.001	0.57 (0.35-0.94), 0.028
Very easy	0.58 (0.44-0.77), <0.001	0.47 (0.26-0.84), 0.011	0.80 (0.44-1.46), 0.468
Education			
Less than high school	Ref	Ref	Ref
High school diploma or equivalent	0.86 (0.68-1.08), 0.389	0.95 (0.59-1.53), 0.818	1.04 (0.64-1.71), 0.860
Some college/vocational training[3]	0.64 (0.52-0.80), <0.001	0.61 (0.40-0.95), 0.044	0.93 (0.59-1.47), 0.760
Bachelor's degree or higher	0.49 (0.39-0.62), <0.001	0.84 (0.51-1.38), 0.506	1.58 (0.94-2.67), 0.087
Race/ethnicity			
White	Ref	Ref	Ref
Black	1.75 (1.21-2.54), 0.003	2.63 (1.33-5.22), 0.006	1.50 (0.80-2.83), 0.209
East/Southeast Asian	0.93 (0.69-1.26), 0.641	1.42 (0.72-2.81), 0.317	1.52 (0.75-3.11),0.247
Indigenous	1.39 (1.04-1.87), 0.027	1.30 (0.68-2.47), 0.430	0.93 (0.49-1.78), 0.827
Latinx	1.05 (0.60-1.84), 0.873	0.75 (0.26-2.14), 0.592	0.72 (0.24-2.13), 0.549
Middle Eastern	0.98 (0.50-1.91), 0.944	4.22 (1.93-9.19), <0.001	4.32 (1.76-10.58), 0.001
Mixed race	1.12 (0.82-1.53), 0.485	1.59 (0.90-2.82), 0.111	1.34 (0.74-2.43), 0.245
South Asian	1.16 (0.77-1.74), 0.492	2.33 (1.14-4.78), 0.021	2.02 (1.00-4.09), 0.052

[1.]All estimates are weighted. [2.]Model is adjusted for age, sex at birth, region, survey year and type of device used to complete survey.
[3]This category includes some college, college certificate/diploma, technical/vocational training, apprenticeship, or some university

Chapter 5: Distribution of legal retail cannabis stores in Canada by neighbourhood deprivation.

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5.1 Overview

Background: In legal cannabis markets, the distribution of retail stores has the potential to influence transitions from illegal to legal sources, as well as consumer patterns of use. The current study examined the distribution of legal cannabis stores in Canada according to level of neighbourhood deprivation.

Methods: Postal code data were collected for all legal cannabis stores in Canada from October 2018 to September 2021 and linked to the INSPQ measures for material and social neighbourhood deprivation. Descriptive data are reported, including differences across provinces with different retail systems.

Results: At the national level, there were approximately 8.0 retail cannabis stores per 100,000 individuals age 15+ in September 2021. The distribution of stores was closely aligned with the expected distribution across levels of material deprivation: for example, 19.5% of stores were located in neighbourhoods with the lowest level of material deprivation versus 19.1% in the highest level. More cannabis stores were located in the 'most socially deprived' or 'socially deprived' neighbourhoods (37.2% and 22.1%, respectively), characterized by a higher proportion of residents who live alone, are unmarried, or in single-parent families. The distribution of stores in provinces and territories were generally consistent with national patterns with a few exceptions.

Conclusion: In the first three years following cannabis legalization in Canada, retail cannabis stores were evenly distributed across materially deprived neighbourhoods but were more common in socially deprived neighbourhoods. Future monitoring of retail store locations is required as the legal retail market evolves in Canada.

Keywords: cannabis; marijuana; retail availability; neighbourhood deprivation

5.2 Background

Canada legalized non-medical ('recreational') cannabis in October 2018 at the federal level. While the number of brick and mortar stores was initially limited, there has been substantial growth to more than 2400 stores by September 2021.[145] Although legalization occurred at the federal level, provinces and territories are responsible for retail distribution of cannabis, including licensing cannabis retailers and establishing guidelines. Six provinces and all three territories have opted for privately-run brick-and-mortar stores (Newfoundland and Labrador, Ontario, Manitoba, Saskatchewan, Alberta, Nunavut, Yukon, and Northwest territories), four provinces have opted for government-run stores (Prince Edward Island, Nova Scotia, New Brunswick, and Québec), while British Columbia has a hybrid model. Regulations surrounding the location of stores, such as distance from schools and distance from other cannabis stores, vary widely across provinces. In some jurisdictions, such as Ontario, a provincial regulation of 150m distance from a school boundary line is required for all stores, with no requirements for distances between stores.[146] In other cases, municipalities are allowed to set their own regulations on these matters.[146]

The number and location of retail cannabis stores has the potential to influence patterns of use and purchasing behaviour. This has been demonstrated for alcohol[147] and tobacco,[148,149] and more recently for cannabis.[79,80,150] With the changing landscape of legal cannabis retail stores, there is interest in understanding the distribution of stores based on neighbourhood deprivation. If stores are disproportionality located in deprived neighbourhoods, marginalized communities may be exposed to greater promotion of and access to cannabis, leading to greater use.[151,152] A recent study found that in Washington state, where non-medical cannabis is legally available, there was not only greater cannabis retail availability in disadvantaged neighbourhoods, but cannabis use and perceived acceptability of use were also higher.[152] Greater retail access to legal cannabis has been associated with current and frequent cannabis use.[79,153,154] In addition, the availability of retail stores also has the potential to shape social norms within communities, which may impact subsequent use.[152] Conversely, a lack of legal stores in more deprived neighbourhoods could suppress transitions to the legal market and increase the risk of criminal sanctions from illicit cannabis. This is a particular concern given that individuals living in

marginalized communities and racial minorities are disproportionately targeted by criminal sanctions for cannabis possession.[21,97]

Research has examined the distribution of both medical dispensaries and retail stores in some US states by neighbourhood deprivation. For example, a 2009 study in California found that dispensaries were more likely to be found in areas with high cannabis demand, higher rates of poverty and more alcohol outlets.[75] In Colorado, more licensed retail outlets for medical and recreational cannabis were found in low income areas with a higher proportion of ethnic and racial minority groups.[76] Similarly, a study in Washington State found that between 2014 and 2017 the density of recreational retail cannabis outlets was greatest in the most deprived neighbourhoods at all time points, with significantly more outlets in the most deprived neighbourhoods compared to the least deprived neighbourhoods.[77] Some have suggested that these communities lack social and economic resources to resist establishment of outlets in their neighbourhoods.[75,76] While there is little research on the distribution of retail stores in Canada since legalization in October 2018, one study found that, as of October 2020, there were almost 1.9 times the number of legal retail cannabis stores within 1000m of the lowest income neighbourhoods compared to the highest income neighbourhoods, which was down from 2.4 times in October 2019.[155] However, the retail market has more than doubled since this period, and it is unclear if this trend will continue.

The current study sought to examine the distribution of physical legal retail cannabis stores in Canada overall and within each province by neighbourhood deprivation using a comprehensive measure of deprivation which considers not only income, but also other aspects of material and social deprivation. It was hypothesized that more retail outlets would be located in more materially and socially deprived neighbourhoods.

5.3 Methods

Legal retail sources with storefronts

Official provincial and territorial government websites were used to identify a complete list of legal cannabis stores with storefronts in Canada beginning in November and December 2018 up to September 2021. The postal code for each store location was recorded.

Neighbourhood deprivation index

All store postal codes were linked to a national database of neighbourhood deprivation indices from the Institut National de Santé Publique du Québec (INSPQ).[91] The 2016 index is based on Canadian Census dissemination areas (DA), which served as a proxy for neighbourhoods. The DA is the smallest geographical unit of the census for which estimates are released, and include 400-700 people per DA. Where data were available, each postal code in the country was assigned two scores: 1) a material deprivation score (based on the level of education, income, and employment in the population 15 and over) and 2) a social deprivation score (based on the proportion of the population aged 15 and over living alone, who are separated, divorced or widowed as well as the proportion of single-parent families). Each index is represented by quintiles on a scale of 1-5, with each group representing 20% of the dissemination areas (most privileged/privileged/neither deprived nor privileged/deprived/most deprived).

5.3.1 Analysis

The proportion of stores within each level of material and social neighbourhood deprivation was estimated for Canada overall, and by province/territory. Scores for each deprivation index were based on regional data (BC, Prairie provinces, Ontario, Québec, Atlantic provinces).[91] Where regional scores were not available, national deprivation scores were imputed. Descriptive statistics were used to estimate the percentage of stores within each level of material and social deprivation using SAS version 9.4.

5.4 Results

At the national level there were approximately 8.0 retail cannabis stores per 100,00 individuals age 15+. The distribution varied from a low of 0.8 in Québec to a high of 19.7 in Alberta (Table 1). The distribution of retail cannabis stores was relatively evenly distributed across all levels of material deprivation, ranging from 16.1% in 'privileged' neighbourhoods to 19.8% in 'deprived' neighbourhoods (Figure 1). However, almost 60% of stores were in neighbourhoods which were characterized as 'most socially' and 'socially' deprived, i.e., neighbourhoods having higher proportions of people living alone, divorced/widowed, or single-parent families.

The prairie provinces (Alberta, Manitoba, and Saskatchewan), as well as the Yukon and Northwest Territories, had more stores per capita than other provinces (Table 1). Among provinces with at least 20 stores, the distribution of stores across levels of material and social deprivation tended to follow the overall national patterns, with some exceptions (Table 1). For example, in Manitoba, only 6.4% of stores were located in 'materially privileged' neighbourhoods, substantially lower than other provinces. In terms of social deprivation, Newfoundland was the only province that did not follow the national trend; specifically, fewer stores were located in the 'most socially deprived' neighbourhoods (9.1%), and a higher proportion of stores were in the 'most socially privileged' neighbourhoods (24.4%).

In two of the three largest census metropolitan areas in Canada, Toronto and Vancouver, more stores were located in the 'most materially privileged' neighbourhoods, and in the 'most socially deprived' and 'socially deprived' neighbourhoods (Table 2). In Montreal there were fewer stores in the 'most materially deprived' neighbourhoods, however, there were more stores in the 'most socially deprived' neighbourhoods.

5.5 Discussion

Overall, the number of cannabis stores in Canada more than doubled over a 12-month period, from 3.7 per 100,000 individuals age 15+ in October 2020[78] to 8.0 per 100,00 individuals 15+ in September 2021. In general, there were more stores per capita in provinces with a private or hybrid retail model than a public model.

When looking at the distribution of stores based on material and social deprivation, two trends emerged. Since the distribution of stores is based on quintiles for the dissemination areas, equitable distribution across deprivation levels would be equivalent to 20% of stores within each quintile. The pattern for material deprivation was very close to this, with a range of 16-20% within each of the five levels of deprivation. Data from Toronto and Vancouver, two of the three largest census metropolitan areas, revealed that in these areas more stores were located in the most materially privileged neighbourhoods. This is in contrast to previous work in Canada which reported that by October 2020 retail density of stores was greater in areas around low-income neighbourhoods.[78] As the current study used the INSPQ measures of deprivation which uses

several factors to establish material deprivation, rather than income alone, this may in part account for the differences noted in the distribution of stores across levels of material deprivation. Also, as we used retail data up to and including September 2021, the patterns of distribution may have changed during this period of substantial growth in retail availability.

The distribution of legal cannabis stores based on material deprivation of neighbourhoods in Canada contrasts with findings from legal markets in US states. Several studies have found that both medical cannabis dispensaries and recreational cannabis outlets were more likely to be located in low-income neighbourhoods.[77,151] It has been hypothesized that this may be attributable to zoning restrictions, demand for cannabis, co-location with alcohol outlets, as well differences in the availability to resources to deter the establishment of stores.[156] In Canada, zoning regulations in most provinces allow for brick-and-mortar stores to be located where any other retail outlet could be located, provided some jurisdictional guidelines are followed. These regulations may result in the more equitable distribution across neighbourhoods which is driven by factors such as market demand, visibility, and consumer convenience.

Approximately 60% of cannabis stores were located within socially deprived neighbourhoods, which are characterized by more people living alone. Although there are no clear data available on how retailers have decided where to establish a store, it is not surprising that more stores would be found in areas with more people living alone, particularly as these areas tend to have younger adults with higher levels of educational attainment and employment, as well as more individuals living in high density housing.[157] Large urban areas, such as Toronto, tend to have a greater proportion of people living alone than the national average, as well as higher levels of retail density.[158,159] The higher proportion of cannabis stores in these areas may be explained by higher rates of cannabis use among young people and higher levels of demand for cannabis stores in large urban centres. In addition, urban neighbourhoods may have more areas zoned for mixed commercial and residential land use. As stores would not be located in dissemination areas which are zoned for residential land use, and where couples and families with and without children may be more likely to reside, it is reasonable to find that there are fewer stores in more 'socially privileged' areas. Future research should examine whether there is higher demand for legal cannabis in more socially deprived neighbourhoods as well as the characteristics of these

neighbourhoods including the role of urbanization and population density. In addition, research should consider if those who reside in neighbourhoods which are more socially deprived are differentially impacted in terms of cannabis use and other potential harmful outcomes associated with exposure to cannabis retail stores. As one of the primary goals of legalization is to reduce the illicit market, ensuring that legal cannabis is available where demand is high must be considered against potential risks.

The current study has several limitations. First, approximately 9% of stores were not classified by neighbourhood deprivation because of unmatched postal codes. Postal codes for non-residential areas, those in dissemination areas with smaller populations where no census income data is available, and new postal codes in areas which were developed after 2016 and thus not included in the 2016 census are possible reasons for unmatched data. In addition, the area delineated by dissemination areas may not precisely represent the area residents consider their 'neighbourhood' and defining 'neighbourhood' differently could result in different deprivation scores. Lastly, the current study did not examine the distribution of unlicensed cannabis outlets, which also has the potential to impact outcomes, particularly for those in more deprived neighbourhoods.[80]

As the legal cannabis market in Canada continues to grow it will be important to continue to monitor the distribution of legal cannabis stores to determine if the patterns remain the same or change over time. Future research should also examine the impact of cannabis stores in terms of the balance between displacing the illicit market, without promoting greater consumption.

Figure 1: Overall distribution of retail cannabis stores by neighbourhood deprivation across Canada in September 2021 (n=2,477)*
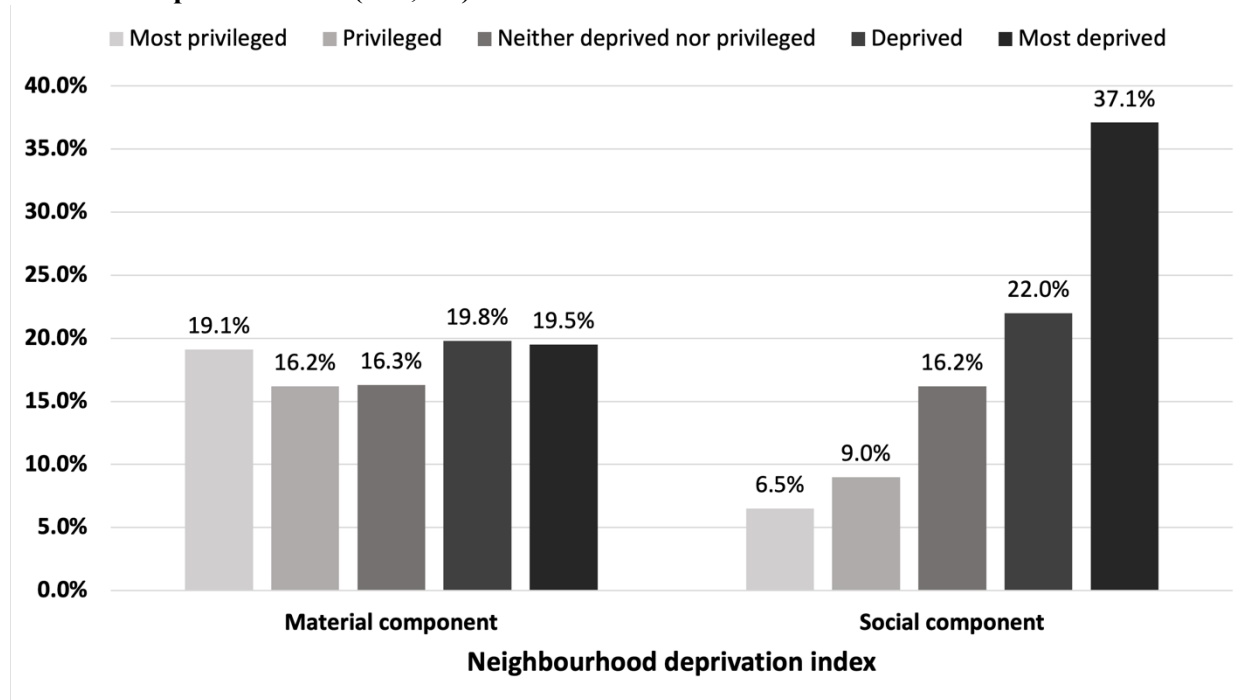
*Stores with unassigned neighbourhood deprivation not included in figure (n=226, 9.1%)

Table 1: Distribution of legal retail cannabis stores by neighbourhood deprivation in provinces and territories across Canada - September 2021 (n=2477)

Store model type	Private							Public					Hybrid
	ON	**AB**	**MB**	**SK**	**NL**	**YK**	**NU**	**QC**	**NS**	**NB**	**NWT**	**PE**	**BC**
Number of stores	1042	680	112	106	33	5	1	60	33	20	6	4	375
Stores per 100,000 individuals 15+	8.7	19.7	10.3	11.7	7.5	15.0	2.7	0.8	4.0	3.0	18.4	3.1	8.8
Percentage of stores by neighbourhood deprivation													
Material Deprivation	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**
Most privileged	21.1 (220)	19.1 (130)	6.3 (7)	14.2 (15)	18.2 (6)	20.0 (1)	0	21.7 (13)	15.2 (5)	20.0 (4)	16.7 (1)	0	18.9 (71)
Privileged	13.3 (139)	16.5 (112)	24.1 (27)	21.7 (23)	33.3 (11)	40.0 (2)	100 (1)	18.3 (11)	27.3 (9)	20.0 (4)	33.3 (2)	0	16.0 (60)
Not deprived or privileged	15.1 (157)	17.1 (116)	19.6 (22)	17.0 (18)	15.2 (5)	20.0 (1)	0	18.3(11)	18.2 (6)	15.0 (3)	16.7 (1)	50.0 (2)	16.5 (62)
Deprived	20.3 (211)	19.7 (134)	23.2 (26)	21.7 (23)	15.2 (5)	0	0	13.3 (8)	12.1 (4)	35.0 (7)	0	50.0 (2)	18.9 (71)
Most deprived	22.6 (235)	14.4 (98)	18.8 (21)	17.0 (18)	15.2 (5)	20.0 (1)	0	18.3 (11)	18.2 (6)	5.0 (1)	16.7 (1)	0	22.7 (85)
Social Deprivation													
Most privileged	5.4 (56)	7.2 (49)	8.9 (10)	7.6 (8)	24.4 (8)	0	0	6.7(4)	3.0 (1)	5.0 (1)	0	0	5.8 (22)
Privileged	7.9 (82)	10.9 (74)	12.5 (14)	8.5 (9)	18.2 (6)	0	100 (1)	6.7 (4)	6.1 (2)	15.0 (3)	16.7 (1)	25.0 (1)	7.2 (27)
Not deprived or privileged	15.7 (164)	16.6 (113)	15.2 (17)	16.0 (17)	21.2 (7)	0	0	21.7 (13)	12.1 (4)	15.0 (3)	50.0 (3)	0	16.3 (61)
Deprived	23.0 (240)	18.2 (124)	23.2 (26)	25.5 (27)	24.2 (8)	20.0 (1)	0	32.7 (19)	39.4 (13)	30.0 (6)	0	50.0 (2)	21.3 (80)
Most deprived	40.3 (420)	33.8 (230)	32.1 (36)	34.0 (36)	9.1 (3)	80.0 (4)	0	23.3 (13)	30.3 (10)	30.0 (6)	16.7 (1)	25.0 (1)	42.4 (159)
							0						
Deprivation score not assigned	7.7 (80)	13.2 (90)	8.0 (9)	8.5 (9)	3.0 (1)	0	0	10.0 (6)	9.1 (3)	5.0 (1)	16.7 (1)	0	6.9 (26)

Table 2: Distribution of legal retail cannabis stores by neighbourhood deprivation in the three largest census metropolitan areas* in Canada - September 2021 (n=442)

Store model type	Private	Public	Hybrid
	Toronto, Ontario	Montreal, Québec	Vancouver, British Columbia
Number of stores	352	22	68
Percentage of stores by neighbourhood deprivation			
Material Deprivation	% (n)	% (n)	% (n)
Most privileged	31.3 (110)	18.2 (4)	44.1 (30)
Privileged	17.6 (62)	18.2 (4)	13.2 (9)
Not privileged or deprived	12.8 (45)	27.3 (6)	16.2 (11)
Deprived	20.7 (73)	22.7 (5)	10.3 (7)
Most deprived	16.8 (59)	9.1 (2)	16.2 (11)
Social Deprivation			
Most privileged	4.6 (16)	4.6 (1)	4.4 (3)
Privileged	5.7 (20)	18.2 (4)	5.9 (4)
Not privileged or deprived	16.2 (57)	18.2 (4)	20.6 (14)
Deprived	35.5 (125)	13.6 (3)	33.9 (23)
Most deprived	37.2 (131)	40.9 (9)	35.3 (24)
Deprivation score not assigned	0.9 (1)	4.6 (1)	0

*Census metropolitan areas are based on 2016 census data

Chapter 6: Discussion

6.1 Overview

This dissertation focused on assessing the impact of race/ethnicity, individual socioeconomic indicators, and neighbourhood deprivation on two potential harms associated with cannabis use: legal sanctions for cannabis-related offences and problematic cannabis use. Whereas legal sanctions for cannabis-related offences represent a specific negative outcome associated with cannabis prohibition, the aggregate measures of problematic use provide a broader indicator of adverse outcomes from cannabis use, including the external consequences of use and the health and social impacts. As the focus of the work was on examining existing inequities, extending the project to consider the availability of legal cannabis based on level of neighbourhood deprivation sheds light on how the legal market may impact patterns of inequity going forward. In examining some of the potential harms of cannabis use and the early impact of legalization, several key themes emerged and are discussed in more detail in this section.

6.2 Key themes: Legalization and adverse outcomes

The potential adverse outcomes associated with cannabis use are many, including charges for cannabis possession and cultivation offences, driving under the influence of cannabis as well as negative health and social impacts. The current study adds to the emerging research on the effects of legalization on some of the potential adverse outcomes associated with cannabis use. Although the current study on legal sanctions for cannabis possession and trafficking/cultivation was not able to examine if arrests and convictions have changed post-legalization, the findings highlighted the importance of not only looking at overall arrests/convictions, but also examining the differential impacts based on race/ethnicity and socioeconomic factors. Nonetheless, recent research comparing arrests for cannabis possession among adults and youth have reported significant declines in arrests following

cannabis legalization in 2018.[160,161] This can be regarded as a positive effect of cannabis legalization in terms of reducing the burden on the criminal justice system as well as keeping youth from entering the criminal justice system.[15]

The use of the WHO ASSIST measure allowed us to broadly examine the health and social impact of cannabis use for individuals both pre- and post-legalization. The findings suggest that overall high risk for problematic cannabis use has not increased in the 2 years following cannabis legalization (2018=5.7 %, 2019: 4.5%; 2020: 5.0%). This is in line with early findings from the US.[37] Continued monitoring of adverse cannabis use outcomes across time are needed to determine if these trends remain.

6.3 Key themes: Racial inequities

The findings highlight the persistent racial inequities in the enforcement of cannabis prohibition, as well as indicators of problematic use. In terms of arrests and convictions for cannabis-related offences, Black and Indigenous individuals were more likely to be convicted even after adjusting for cannabis use and individual-level socioeconomic factors. The magnitude of these differences were large: compared to White individuals, Black individuals were more than four times more likely to be convicted after adjusting for cannabis use, individual-level socioeconomic factors and neighbourhood deprivation. This is consistent with findings from the US, and from limited data available in Canada.[17,21,97,162–164] Although there are several possible explanations for the findings, bias in policing and the criminal justice system is fundamental to racial differences in arrests and convictions. Black, Indigenous and minority populations are more likely to be targeted by police for stops and searches.[100] Furthermore, how cases of possession are handled by the police and criminal justice system differ based on the race of the accused.[162,165] While cannabis arrests and convictions have decreased since legalization of cannabis, the impacts on members of different racialized groups remains unknown. As evidence from the US suggests that racial

disparities in arrests and convictions continue despite legalization,[98,111,112] it cannot simply be assumed that legalization is all that is needed to address issues related to systemic racism.

Racialized individuals were also found to experience higher odds of risk for problematic cannabis use. For example, the odds of moderate and high-risk problematic use were higher not only for Black and Indigenous individuals, but also for all non-White racial/ethnic groups. The stress associated with racism may result in the use of substances such as cannabis as a coping mechanism.[166] Similarly, the potential for legal ramifications of use as well as stigma and bias may influence views and expectations of both the person using as well as those of friends/relatives. It may be that within varying cultural and ethnic backgrounds the expectations and perceived acceptability may influence a person's own perceptions about use and desire to change patterns of use.

In both studies there were also some unexpected findings around race/ethnicity. For example, individuals identifying as Middle Eastern had higher odds of problematic use, while East/Southeast Asian individuals were more likely than White individuals to be arrested for cannabis-related offences. The findings underscore the importance of collecting data on race and ethnicity to understand patterns of substance use and the systematic ways in which racialized Canadians may be at greater risk for adverse outcomes and institutional inequities.

The extent to which cannabis legalization can redress some of the racial inequities associated with cannabis use remains to be seen. One of the mandates of the *Cannabis Act* is to reduce the burden on the criminal justice system[167]; however, outlining specific goals and actions to address the issues of injustice faced by racialized communities is needed. Arrests for cannabis offences have decreased considerably since legalization[160,161] which should go some way to reducing the risk for legal sanctions for racialized individuals. However, consideration of how to address past harms, including expungement for previous possession charges, as well reinvestment of cannabis revenue in communities most impacted by

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prohibition, and opportunities to participate in the current legal market, are also needed. Currently, those with criminal records for simple cannabis possession can apply for a cannabis record suspension, however the system has been criticized as being inaccessible.[168] Between August 2019 and October 2021 only 484 record suspensions had been processed.[168] However, an amendment to Bill C-5 should see sequestration, a process which does not completely erase the criminal record but guarantees that it does not show on a criminal record check, for drug possession convictions within the next two years.[169] This has been projected to affect as many as 250,000 people with cannabis possession records.[169] This is certainly a step in the right direction towards redressing the harms of prohibition, especially considering the consequences associated with a criminal record including challenges in finding employment and housing. Nonetheless, the limited involvement of minority groups in the legal cannabis industry and ownership of retail stores suggests a perpetuation of the systems which have caused undue harm, and actions should be taken to develop greater inclusivity in the licensing processes.[26] Addressing issues related to stigma and racism and policies to ensure that equity is achieved going forward are needed for cannabis legalization to be successful.

6.4 Key themes: Social determinants associated with cannabis use outcomes

Social determinants of health at both the individual and neighbourhood or community level play an important role in substance use. While financial stability, influenced by income, education, and employment, are key individual-level considerations, neighbourhood-level factors, such as poverty, access to resources and social support and cohesion, also have the potential to impact substance use decisions. The association of poorer health and social outcomes for those with lower income and education is well documented. This has been found true for cannabis use as well as cannabis use disorder, although limited research has been done in Canada.[63,81,170] The current work has shown that this is also the case for both problematic cannabis use as well as cannabis offences. In particular, those with lower

perceived income adequacy were more likely to be convicted for a cannabis-related offence. Similarly, the odds of moderate and high risk for problematic use were greater for those with lower perceived income adequacy; however, in the two years following legalization risk has not increased. While access to financial resources is likely to be of benefit when faced with potential legal sanctions, it is also likely that financial resources mitigate stress to a certain extent as well as provide opportunities for alternative means to cope with physical and mental health concerns. As discussed in Chapter 1, for lower income individuals, cannabis use may provide a means of coping and stress relief. In addition, cannabis may also be used for medicinal purposes to deal with ongoing physical and mental health issues.[45] In terms of reducing the burden for those with lower socioeconomic position, facilitating transition to the legal market with access to legal cannabis that is affordable will be important. As these individuals may be particularly sensitive to price it is likely to be an important consideration. Research has found that while the price of legal cannabis decreased from 2019 to 2020, it is still more expensive than illegal cannabis,[171] thus those with fewer financial resources may be at greater risk of turning to the illicit market. Research to understand the potential impact of the legal markets on cannabis use among those with lower socioeconomic position is also needed to determine if patterns of risk change over time. Given that it is very early in legalization, it will take several more years before the assessment of changes in risk/harm associated with legalization can be fully assessed.

6.4.1 Area-based measures of deprivation

This study is among the first in Canada to move beyond individual measures of socioeconomic status to consider the impact of neighbourhood material and social deprivation on specific cannabis use outcomes as well as retail availability. While neighbourhood material deprivation was found to be associated with negative consequences over and above individual socioeconomic position, the role of neighbourhood social deprivation is less clear.

In more materially deprived neighbourhoods it was found that after controlling for race/ethnicity, cannabis use and individual socioeconomic factors, individuals were twice as likely to report being convicted compared to those in the most privileged neighbourhoods. These findings are consistent with previous work which has found increased police presence within more deprived neighbourhoods, and more frequent stops and searches of those deemed suspicious.[114,115] This additional scrutiny opens the door for being arrested for offences such as cannabis possession which may be overlooked in more privileged neighbourhoods. Additionally, in more deprived areas, people are more likely to be engaged in cannabis-related activities outdoors in public areas, increasing the potential for being apprehended.[22] This is supported by research in the US which found that those living in poor neighbourhoods were more likely to be arrested for a drug-related offence, and in fact, until recently there was federal support for police to target these neighbourhoods.[116] As previously noted, arrests have substantially decreased in Canada following cannabis legalization[110]; however, as little is known about who and where the charges are being laid, it is not known if those living in more deprived neighbourhoods remain at greater risk of being arrested. As public outdoor use is still a punishable offence in some parts of Canada such as Manitoba, Saskatchewan and Québec,[145] there is potential for those in more deprived neighbourhoods to be disproportionately impacted as they may have fewer opportunities to use inside, and thus be at greater risk of arrest is they use in an outdoor setting.

Problematic cannabis use has not increased in more deprived neighbourhoods in the early stages of cannabis legalization, however the odds of moderate risk for problematic use were still higher for individuals in these neighbourhoods. Living in a neighbourhood with greater material deprivation may add additional stress and cannabis may be used a coping mechanism. Research has shown that in more deprived neighbourhoods individuals have lower neighbourhood satisfaction, with lower perceived safety, aesthetic quality and place attachment, and is attributed with lower sense of well-being.[172] In addition, community resources and qualities such as the amount of green space and access to transport may be

limited in deprived neighbourhoods and contribute to lower well-being.[172] These factors, in addition to individual-level factors, may influence decisions to use substances such as cannabis.[173] Within deprived neighbourhoods there is also likely greater accessibility to illicit cannabis.[80] However, the findings from Chapter 5, that the distribution of retail stores was relatively even across all levels of material neighbourhood distribution, are encouraging. Given the potential increased risk for those living in more materially deprived neighbourhoods, having legal cannabis accessible, but not disproportionately located within these neighbourhoods is important.

The social component of the INSPQ neighbourhood deprivation combines measures of the proportion of people living alone, those who are divorced/widowed, and lone-parent families, which may not adequately capture elements of social isolation and sense of community or belonging, as intended. These measures may not reflect 'social disadvantage' particularly as individuals may have social connections and support despite living alone. Indeed, an examination of those living alone in Canada found that the majority of those surveyed reported strong social and community ties.[157] The findings from Chapters 3, 4 and 5 suggest that additional measures may be needed to get at issues of social deprivation at the neighbourhood level. In Chapters 3 and 4, neighbourhood social deprivation was weakly associated with the outcomes in the modeling. Previous research has found that greater neighbourhood cohesion was associated with lower cannabis use[174] so it may be that the current measures are insufficient to assess such aspects of 'social deprivation'. Future studies might consider including questions that ask how individuals perceive the social aspects of their neighbourhoods such as social supports within an area, safety, and community engagement. Conversely, the role of individual social support networks and connections within and outside of the neighbourhoods may be more relevant to cannabis use outcomes such as problematic use. If cannabis is used to deal with life stressors it may be exacerbated for those without the social support to help them cope through alternative means. Future research should include measures to assess social support and problematic use.

When considering the retail availability of cannabis by neighbourhood social deprivation, the findings suggested that many of the stores were located in 'socially deprived' neighbourhoods. Here again, it seems likely that further examination of other factors which more adequately capture elements of what social deprivation is intended to measure can provide insight into what the current findings reflect. Decisions on where to locate stores are likely driven by factors such as access for potential consumers and set-up costs, and the findings here suggest that this overlaps with areas with higher proportions of people living alone. Whether this also relates to other elements of social deprivation, such as isolation, should be considered in future research.

6.5 Limitations

6.5.1 International Cannabis Policy Study (ICPS)

The ICPS is subject to limitations common to survey research such as social desirability and non-response bias. Respondents were recruited using non-probability-based sampling; therefore, the findings do not necessarily provide nationally representative estimates. However, the data were weighted by age group, sex, region, education and smoking status. Cannabis use estimates were generally lower than national estimates for young adults, and higher than national surveys in Canada. This is likely due to the fact that the ICPS sampled individuals aged 16–65, whereas the national surveys included older adults, who are known to have lower rates of cannabis use. This may have impacted some of the findings reported in the current work. For example, it may be that the observed estimates of problematic use are slightly higher than would be expected if the study included older age groups as well. In addition, 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.[88]

As the ICPS uses a repeat cross-sectional design, the temporal order of outcomes cannot be established, which limits causal inferences. For example, while problematic use was associated with level of material neighbourhood deprivation and individual socioeconomic indicators, it is not known whether problematic use preceded, coincided with or followed these factors. The examination of the nature of temporal associations through longitudinal studies is important to understanding individual changes in problematic use over time, as well as where policy and intervention efforts would be best placed to have the greatest effect. However, the multiple time periods, including observations before and after legalization, represent a significant strength of the study design.

6.5.2 Institut National de Santé Publique du Québec (INSPQ) material and social deprivation index

While the INSPQ material and social deprivation index provides a unique opportunity to examine the impact of environmental level factors on health outcomes, it is not without limitations. The use of dissemination areas (DA) as a proxy for neighbourhood may not be capturing the exact nature of what is considered a neighbourhood by the residents or even policymakers. While an advantage of the DA is the relatively small population size each covers as well as the homogeneity of the socioeconomic conditions, some research has found that this does not align directly with community perceptions of 'neighbourhood'.[175] Future research may consider comparing outcomes based on community-based delineations of neighbourhood compared to the use of DAs to delineate neighbourhoods to determine the acceptability. However, given that the DA estimates are based on census data, and the challenge of being able to establish a national database of deprivation indices based on community-level delineations of neighbourhood, the current methods allow some insight into environmental factors which may otherwise be omitted.

The indicators used to derive the material and social components of the index are limited to information which is captured in the census. For the material component, education,

employment and income levels within each DA are considered. While this is likely to capture the socioeconomic environment, some factors which have been deemed relevant in other measures of neighbourhood deprivation, such as proportion of families receiving social assistance or living below the poverty line, are not included in the current index.[156] As previously discussed, a similar situation arises with the social component, where the measures included are limited to those available in the census but may not capture the exact nature of 'social deprivation'.

Finally, deprivation indices are not available for all dissemination areas (DA) for several reasons including DAs with hospitals or long-term care facilities, postal codes associated with post boxes, those with few residents as well as not having information for areas developed after the 2016 census. Therefore, cases were excluded if ICPS data or retail availability data were not matched to a deprivation index which may introduce bias.

6.5.3 WHO Alcohol, Smoking and Substance Involvement Screening Tool (ASSIST)

The ASSIST measure provides a concise tool to assess various aspects of problematic cannabis use and can be easily embedded within population surveys; however, the tool has some limitations. First, while the measure is intended for 'ever' consumers, many of the questions focus on past 3-month use. Adopting this measure in a population survey can result in an inflation of the denominator resulting in estimates which may underestimate risk for problematic use. Similarly, the scoring guide for cannabis and other substances has a lower threshold for moderate risk (4) compared to alcohol (11), which results in greater sensitivity of the measure to frequency of use for cannabis, and more consumers in the moderate vs low risk category. For example, an individual who reports using cannabis weekly in the past 3 months will receive a score of 4 and automatically be in the moderate risk group even if no other adverse issues are reported. Conversely, while reporting weekly alcohol use will also garner a score of 4, if no other issues are reported, this individual would be in the low-risk

group. The reasons for the lower threshold for cannabis are unclear and may reflect a bias against substances with more negative social norms or those that are illegal. The merit of using a lower threshold for cannabis in jurisdictions where it is legal is questionable, particularly given the greater health and economic costs of alcohol use in Canada relative to cannabis.[176] The current study included only past 12-month consumers as well as set the cut-off for low risk at 7, based on previous work,[93,94] as this method is intended to capture not only frequency of use but also at least one harm associated with use. Sensitivity analyses conducted using ever consumers and a threshold of 3 for low-risk use resulted in lower estimates of high-risk use (2.7% in 2018; 2.6% in 2019; 2.7% in 2020) with fewer differences observed for low and moderate risk.

6.6 Future Directions

More detailed data on race/ethnicity is needed to determine the effect of cannabis legalization on racialized people, including from police stops and arrests, as well as convictions from criminal proceedings. In addition, continuing to collect race/ethnicity in population-level surveys such as ICPS alongside other questions related to perceptions and experiences of unfair treatment, racism and stigma can provide the opportunity to explore the impact of these factors on cannabis use.

While general measures such as ASSIST are useful, it is also important to consider other individual indicators of problematic use. This may include using administrative health care data with emergency department admissions, as well as police records and blood analysis, that have been used in other studies.[142,161,177–182] Future research should continue to monitor various measures of problematic use to have a comprehensive understanding of the impact of cannabis legalization.

Future research should consider the association between measures of perceived social deprivation as well as neighbourhood specific resources and elements which contribute to

well-being, such as access to green space and transport, and cannabis use outcomes such as problematic use. In addition, research should extend the examination of retail availability to investigate the association with legal purchasing based on material and social neighbourhood deprivation. While the distribution of stores is currently relatively evenly distributed across level of neighbourhood material deprivation, research is needed to determine whether this is marked by similar rates of legal purchasing based on neighbourhood. As legalization is still in its early stages in Canada, and the number and location of stores is rapidly evolving, future research should examine changes in the market over a longer period of time.

More broadly, continuing to collect data as the legal cannabis market in Canada evolves can highlight changes and areas of concern. As cannabis use had increased in recent years,[31] it may be some time before some of the potential harms may be evident. For example, an increase in cannabis use among youth in these early years may result in greater prevalence of problematic use down the line. The complex interplay between the sociodemographic factors considered in this study as well as those not examined, such as age and gender, suggests that future work should examine not only the patterns but also consider the most appropriate way to understand the mechanisms that underly the associations.

6.7 Conclusion

Exploring differences in potential negative outcomes associated with cannabis use based on race/ethnicity, individual socioeconomic position and neighbourhood deprivation is an important first step in the process towards achieving social justice in this area. Legalization of cannabis has presented the opportunity to address existing disparities through policy, and the use of revenue generated through legal cannabis sales for programs to address the needs of racialized and marginalized communities. Given that problematic use has not changed based on race/ethnicity, individual socioeconomic position and material neighbourhood deprivation suggests that the existing disparities have not been exacerbated in the early stages of legalization. Policy and programming to address the existing disparities may be needed to

narrow disparities in the coming years. For example, by continuing to monitor the distribution of stores within neighbourhoods, provinces and municipalities may choose to enact zoning restrictions or engage communities in decisions about where potential cannabis stores are located to protect their interests and well-being. Learning from experiences with alcohol and tobacco, and the disproportionate harms that racialized and marginalized individuals continue to experience, awareness and action now may serve to benefit those who most need it.

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Appendix A: Variation Inflation Factors of key predictor variables for Study 1 and Study 2

Table A1: Study 1 linear regression model to assess multicollinearity of key predictor variables with variance inflation factors (VIF) (n=24,280).

Variable	VIF
Race/ethnicity	
ETHNICITY_CANADA_DV1_1	3.79
ETHNICITY_CANADA_DV1_2	1.80
ETHNICITY_CANADA_DV1_3	1.44
ETHNICITY_CANADA_DV1_4	1.46
ETHNICITY_CANADA_DV1_5	2.09
ETHNICITY_CANADA_DV1_6	4.82
ETHNICITY_CANADA_DV1_7	2.07
Education	
EDUCATION_CANADA_DV1_1	2.53
EDUCATION_CANADA_DV1_2	3.95
EDUCATION_CANADA_DV1_3	4.02
Perceived income adequacy	
INCOME_ADEQ1_1	2.86
INCOME_ADEQ1_2	3.59
INCOME_ADEQ1_3	3.07
INCOME_ADEQ1_4	2.25
Neighbourhood material deprivation	
NDmat_1	1.71
NDmat_2	1.76
NDmat_3	1.81
NDmat_4	1.85
Neighbourhood social deprivation	
NDsoc_1	1.48
NDsoc_2	1.48
NDsoc_3	1.46
NDsoc_4	1.40

Table A2: Study 2 linear regression model to assess multicollinearity of key predictor variables with variance inflation factors (VIF) (n=9162).

Variable	VIF
Race/ethnicity	
ETHNICITY_CANADA_DV1_1	2.58
ETHNICITY_CANADA_DV1_2	2.63
ETHNICITY_CANADA_DV1_3	1.41
ETHNICITY_CANADA_DV1_4	1.35
ETHNICITY_CANADA_DV1_5	1.85
ETHNICITY_CANADA_DV1_6	4.39
ETHNICITY_CANADA_DV1_7	2.33
Education	
EDUCATION_CANADA_DV1_1	2.61
EDUCATION_CANADA_DV1_2	3.82
EDUCATION_CANADA_DV1_3	3.66
Perceived income adequacy	
INCOME_ADEQ1_1	2.63
INCOME_ADEQ1_2	3.08
INCOME_ADEQ1_3	2.65
INCOME_ADEQ1_4	1.98
Neighbourhood material deprivation	
NDmat_1	1.71
NDmat_2	1.76
NDmat_3	1.81
NDmat_4	1.85
Neighbourhood social deprivation	
NDsoc_1	1.38
NDsoc_2	1.39
NDsoc_3	1.33
NDsoc_4	1.28

Appendix B: Sociodemographic comparisons of those respondents included versus excluded from analyses

Table B1: Differences between respondents who provided a valid postal code versus those who did not in 2019 and 2020 (Study 1).

	2019 (Wave 2)			2020 (Wave 3)		
	Postal code not provided (n=2318)	Valid postal code (n=12,938)	Rao-Scott χ² (P-value)	Postal code not provided (n=213)	Valid postal code (n=2200)	Rao-Scott χ² (P-value)
Age						
16-25	29.5 (582)	16.7 (1669)	**327.55**	30.2 (667)	16.5 (1940)	**293.79**
26-35	27.8 (590)	19.6 (2273)	**(<0.001)**	27.2 (502)	19.9 (2106)	**(<0.001)**
36-45	19.9 (491)	19.7 (2611)		18.6 (412)	20.3 (2560)	
46-55	13.5 (361)	21.2 (2804)		14.8 (343)	20.3 (2854)	
56-65	9.4 (294)	22.9 (3581)		9.2 (320)	23.0 (4076)	
Sex						
Female	48.5 (1443)	49.9 (7930)	1.05	50.9 (1434)	49.5 (8348)	0.927
Male	51.5 (875)	50.1 (5008)	(0.306)	49.1 (810)	50.5 (5188)	0.336
Race/ethnicity						
Black	5.6 (107)	3.3 (334)	**416.13**	6.1 (98)	3.1 (322)	**429.31**
East/Southeast Asian	10.1 (236)	7.3 (896)	**(<0.001)**	10.0 (224)	8.8 (1094)	**(<0.001)**
Indigenous	2.2 (59)	2.3 (279)		1.9 (58)	1.9 (267)	
Latinx	2.1 (41)	1.3 (143)		3.8 (61)	1.5 (149)	
Middle Eastern	2.6 (51)	1.0 (129)		2.7 (65)	1.6 (181)	
Mixed-race	3.2 (69)	2.9 (328)		3.1 (65)	3.0 (398)	
South Asian	4.3 (89)	3.0 (332)		5.4 (112)	3.4 (384)	
White	58.8 (1427)	76.0 (10190)		56.0 (1312)	73.9 (10388)	

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	2019 (Wave 2)			2020 (Wave 3)		
	Postal code not provided (n=2318)	Valid postal code (n=12,938)	Rao-Scott χ^2 (P-value)	Postal code not provided (n=213)	Valid postal code (n=2200)	Rao-Scott χ^2 (P-value)
Other	1.6 (34)	1.2 (142)		1.3 (28)	1.3 (163)	
Unstated	9.5 (205)	1.4 (165)		9.8 (221)	1.6 (190)	
Perceived income adequacy						
Very difficult	9.4 (195)	9.7 (1187)	**557.25**	7.5 (163)	7.6 (969)	**525.01**
Difficult	16.5 (381)	23.2 (2951)	**(<0.001)**	16.4 (372)	18.7 (2523)	**(<0.001)**
Not easy or difficult	34.2 (828)	35.1 (4505)		37.0 (857)	37.4 (5051)	
Easy	17.9 (438)	20.0 (2723)		17.1 (384)	22.8 (3135)	
Very easy	7.1 (175)	10.0 (1365)		7.1 (161)	11.3 (1609)	
Unstated	14.9 (301)	2.0 (207)		15.0 (307)	2.1 (249)	
Education						
Less than high school	17.0 (223)	15.1 (1018)	**308.91**	21.2 (350)	14.2 (1274)	**376.36**
High school diploma or equivalent	26.9 (408)	26.4 (2108)	**(<0.001)**	27.3 (404)	26.3 (2021)	**(<0.001)**
Some college or technical/vocational training[a]	27.8 (848)	33.3 (5534)		25.4 (747)	33.6 (5521)	
Bachelor's degree or higher	23.0 (732)	24.9 (4236)		20.0 (612)	25.5 (4672)	
Unstated	5.3 (107)	0.3 (42)		6.0 (131)	0.4 (48)	
Cannabis use status						
Ever used	56.0 (1308)	63.2 (8194)	**28.36**	53.8 (1207)	61.9 (8468)	**33.68**
Never used	44.0 (1010)	36.8 (4744)	**(<0.001)**	46.2 (1037)	38.1 (5068)	**(<0.001)**

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Table B2: Differences between past 12-month cannabis consumers who provided a valid postal code versus those who did not in 2018, 2019, and 2020 (Study 2).

	2018 (Wave 1)			2019 (Wave 2)			2020 (Wave 3)		
	Postal code not provided (n=213)	Valid postal code (n=2200)	Rao-Scott χ^2 (P-value)	Postal code not provided (n=814)	Valid postal code (n=4255)	Rao-Scott χ^2 (P-value)	Postal code not provided (n=732)	Valid postal code (n=4279)	Rao-Scott χ^2 (P-value)
	% (n)	% (n)		% (n)	% (n)		% (n)	% (n)	
Age									
16-25	31.3 (65)	19.4 (369)	**25.82**	27.9 (218)	18.1(696)	**85.25**	25.3 (210)	16.7 (689)	**53.80**
26-35	35.6 (48)	28.6 (460)	**(<0.001)**	34.7 (263)	27.0 (1030)	**(<0.001)**	34.0 (207)	27.2 (926)	**(<0.001)**
36-45	19.8 (41)	20.6 (364)		20.7 (174)	21.0 (947)		19.8 (135)	21.8 (898)	
46-55	8.3 (29)	16.7 (422)		11.5 (97)	18.3 (779)		14.2 (107)	17.7 (814)	
56-65	5.0 (30)	14.7 (585)		5.2 (62)	15.7 (803)		6.7 (73)	16.6 (952)	
Sex									
Female	39.7 (109)	45.7 (1216)	1.57	44.4 (480)	45.8 (2495)	0.383	44.7 (432)	47.2 (2600)	0.996
Male	60.3 (104)	54.3 (984)	(0.210)	55.6 (334)	54.2 (1760)	(0.536)	55.3 (300)	52.3 (1679)	(0.318)
Race/ethnicity									
Black	0.7 (2)	2.0 (31)	13.29	6.0 (42)	3.6 (119)	**155.42**	6.0 (28)	3.6 (106)	**87.29**
East/Southeast Asian	5.9 (8)	3.1 (49)	(0.150)	6.6 (50)	4.3 (184)	**(<0.001)**	4.4 (33)	4.6 (186)	**(<0.001)**
Indigenous	7.3 (18)	6.9 (159)		3.6 (34)	4.0 (161)		2.5 (27)	2.8 (130)	
Latinx	1.1 (1)	0.9 (11)		2.1 (15)	1.6 (53)		3.8 (23)	1.4 (44)	
Middle Eastern	0.3 (1)	0.8 (15)		1.2 (10)	0.6 (30)		1.3 (10)	1.3 (46	
Mixed race	0.9 (3)	2.5 (45)		3.3 (29)	4.2 (159)		4.0 (25)	3.8 (168)	
South Asian	3.1 (3)	2.1 (31)		3.1 (26)	2.5 (86)		4.0 (30)	2.7 (92)	
White	77.0 (167)	80.6 (1841)		63.5 (529)	77.1 (3379)		67.1 (504)	77.1 (3398)	
Other	1.9 (3)	0.5 (10)		1.2 (10)	1.1 (44)		0.8 (7)	1.7 (65)	
Unstated	1.9 (7)	0.5 (8)		9.2 (69)	1.1 (40)		6.2 (45)	1.0 (44)	
Perceived income adequacy									
Very difficult	10.1 (16)	9.0 (216)	**22.01**	10.4 (76)	10.6 (470)	**192.61**	7.8 (61)	9.1 (373)	**122.35**

	2018 (Wave 1)			2019 (Wave 2)			2020 (Wave 3)		
	Postal code not provided (n=213)	Valid postal code (n=2200)	Rao-Scott χ^2 (P-value)	Postal code not provided (n=814)	Valid postal code (n=4255)	Rao-Scott χ^2 (P-value)	Postal code not provided (n=732)	Valid postal code (n=4279)	Rao-Scott χ^2 (P-value)
Difficult	17.8 (45)	22.7 (489)	**(<0.001)**	19.2 (155)	25.6 (1060)	**(<0.001)**	16.9 (129)	21.2 (941)	**(<0.001)**
Not easy or difficult	31.4 (75)	36.5 (806)		33.4 (291)	33.6 (1417)		38.8 (286)	36.0 (1522)	
Easy	23.9 (42)	19.0 (420)		17.4 (150)	18.9 (837)		18.9 (127)	22.0 (942)	
Very easy	9.3 (16)	11.3 (242)		6.8 (58)	10.0 (426)		6.3 (52)	9.9 (436)	
Unstated	7.6 (19)	1.6 (27)		12.8 (84)	1.3 (45)		11.3 (77)	1.7 (65)	
Education									
Less than high school	15.7 (27)	17.9 (237)	**20.35 (<0.001)**	16.5 (75)	15.4 (340)	**150.80 (<0.001)**	19.5 (103)	13.5 (393)	**85.56 (<0.001)**
High school diploma or equivalent	27.1 (36)	28.0 (372)		26.7 (145)	28.0 (756)		29.1 (144)	29.3 (715)	
Some college or technical/vocational training*	36.0 (89)	35.5 (1025)		30.2 (325)	35.0 (1969)		27.1 (264)	34.8 (1863)	
Bachelor's degree or higher	17.8 (55)	18.4 (562)		20.7 (226)	21.4 (1184)		20.1 (191)	22.1 (1296)	
Unstated	3.4 (6)	0.3 (4)		1.0 (43)	0.1 (6)		4.1 (30)	0.3 (12)	
Past 3-month cannabis use									
Never	23.7 (47)	20.6 (475)	2.00 (0.737)	20.8 (174)	20.2 (925)	2.71 (0.608)	21.2 (159)	19.5 (888)	3.11 (0.540)
Once or twice	15.0 (31)	14.4 (380)		14.7 (136)	16.6 (762)		12.1 (98)	14.7 (722)	
At least monthly use	15.7 (35)	14.3 (308)		15.2 (136)	16.3 (676)		16.1 (119)	15.3 (678)	
At least weekly use	19.2 (39)	18.3 (359)		17.1 (142)	15.2 (646)		17.1 (118)	16.0 (667)	
Daily/almost daily use	26.3 (61)	32.4 (678)		32.1 (226)	31.6 (1246)		33.5 (238)	34.5 (1324)	

Appendix C: Parameter estimates for model covariates in Study 1 and Study 2

Table C1: Parameter estimates for all covariates in full model for Study 1 – Legal sanctions (n=24,280).

	Arrested only vs No arrest or conviction (Ref)	Convicted vs No arrest or conviction (Ref)	Unreported arrest vs No arrest or conviction (Ref)
	AOR (95%CI), p-value	AOR (95%CI), p-value	AOR (95%CI), p-value
Sex at birth			
Female	Ref	Ref	Ref
Male	2.03 (1.59-2.58), <0.001	5.03 (3.61-7.02), <0.001	1.03 (0.73-1.44), 0.869
Age			
16-25	0.67 (0.43-1.04), 0.071	0.32 (0.17-0.59), <0.001	2.08 (1.48-3.00), 0.025
26-35	2.11 (1.48-3.00), <0.001	0.81 (0.52-1.25), 0.340	1.80 (1.00-3.26), 0.050
36-45	1.08 (0.73-1.58), 0.706	0.72 (0.45-1.14), 0.161	1.67 (0.92-3.03), 0.090
46-55	1.01 (0.70-1.46), 0.949	0.84 (0.56-1.26), 0.395	1.03 (0.54-1.97), 0.937
56-65	Ref	Ref	Ref
Survey Year			
2019	Ref	Ref	Ref
2020	1.11 (0.89-1.40), 0.350	0.94 (0.72-1.24), 0.674	1.13 (0.80-1.58), 0.492
Region			
Urban	Ref	Ref	Ref
Rural	0.73 (0.49-1.07), 0.109	0.44 (0.28-0.71), <0.001	1.02 (0.62-1.67), 0.950
Device			
Smartphone	Ref	Ref	Ref
Tablet	0.98 (0.63-1.53), 0.939	0.49 (0.27-0.89), 0.019	0.98 (0.50-1.93), 0.951
Computer	0.62 (0.47-0.80), <0.001	0.67 (0.49-0.91), 0.010	1.14 (0.79-1.64), 0.494

Table C2: Parameter estimates for all covariates in full model for Study 2 – Problematic use (n=9,162).

	ASSIST Moderate risk vs Low risk (Ref)	ASISIST High risk vs Low risk (Ref)	ASSIST High risk vs Moderate risk (Ref)
	AOR (95%CI), p-value	AOR (95%CI), p-value	AOR (95%CI), p-value
Sex at birth			
Female	Ref	Ref	Ref
Male	1.46 (1.29-1.66), <0.001	2.17 (1.60-2.95), <0.001	1.49 (1.09-2.03), 0.014
Age			
16-25	1.69 (1.35-2.11), <0.001	14.87 (6.88-32.16), <0.001	8.79 (4.06-19.06), <0.001
26-35	2.22 (1.80-2.74), <0.001	10.15 (4.68-22.00), <0.001	4.57 (2.11-9.89), <0.001
36-45	1.61 (1.30-1.99), <0.001	8.23 (3.71-18.26), <0.001	5.11 (2.30-11.34), <0.001
46-55	1.42 (1.15-1.76), 0.001	3.32 (1.45-7.58), 0.004	2.33 (1.02-5.33), 0.045
56-65	Ref	Ref	Ref
Survey Year			
2018	Ref	Ref	Ref
2019	0.71 (0.59-0.84), <0.001	0.68 (0.45-1.03), 0.067	0.96 (0.63-1.46), 0.848
2020	0.80 (0.66-0.96), 0.014	0.81 (0.53-1.24), 0.340	1.02 (0.66-1.58), 0.918
Region			
Urban	Ref	Ref	Ref
Rural	0.83 (0.68-1.01), 0.068	0.62 (0.32-1.20), 0.156	0.75 (0.38-1.46), 0.394
Device			
Computer	Ref	Ref	Ref
Smartphone	1.30 (1.12-1.51), <0.001	0.98 (0.71-1.35), 0.910	0.76 (0.59-0.98), 0.091
Tablet	1.32 (1.02-1.71), 0.033	1.24 (0.67-2.31), 0.497	0.94 (0.50-1.78), 0.845