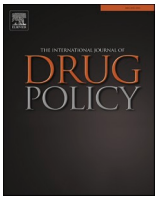
International Journal of Drug Policy 142 (2025) 104828

Contents lists available at ScienceDirect

International Journal of Drug Policy

journal homepage: www.elsevier.com/locate/drugpo



Transitions to legal cannabis markets: Legal market capture of cannabis expenditures in Canada following federal cannabis legalization

David Hammond [a,*], Daniel Hong [a], Samantha Rundle [a], Maryam Iraniparast [a], Beau Kilmer [b], Elle Wadsworth [c,d]

[a] School of Public Health Sciences, University of Waterloo, ON N2L 3G1, Canada
[b] RAND Drug Policy Research Center, Santa Monica, CA, United States
[c] RAND Europe, Cambridge CB2 8BF, United Kingdom
[d] Department of Psychology, University of Bath, Bath BA2 7AY, United Kingdom

ARTICLE INFO

Keywords:
Cannabis
Marijuana
Legalization
Substance use
Illegal market
Canada

ABSTRACT

Background: Canada legalized 'recreational' or 'non-medical' cannabis in 2018 with a primary objective of displacing illicit cannabis and transitioning consumers to a 'quality controlled' legal retail market. To date, there is limited research on legal market capture in jurisdictions with non-medical cannabis markets.
Methods: The current analysis used 'demand-side' methods to estimate the size of the Canadian cannabis market using data from two sources. First, data from the Canadian Community Health Survey were used to estimate the number of Canadians who use cannabis. Second, data on cannabis expenditures from legal versus illegal sources were analyzed from 5656 past 12-month consumers aged 16–100 who completed national surveys conducted in 2022 as part of the International Cannabis Policy Study.
Results: Total estimated expenditures from legal sources were within two percentage points of the 'actual' retail sales data from Government of Canada's tracking system. In the 12-month period ending in September 2022, total cannabis expenditures in Canada were estimated at $6.72 billion dollars, including $5.23 billion from legal sources and $1.49 billion from illegal sources for an estimated legal market capture of 78 %. In 2022, dried flower accounted for 55 % of total legal expenditures and an additional 2 % was spent on plants and seeds. Concentrates accounted for 12 % of legal expenditures, followed by oral liquids (11 %), vaping liquids (10 %), and edibles (8 %, excluding drinks).
Conclusions: The findings provide evidence of substantial transition in expenditures from the illegal to the legal market in the five years since legalization of non-medical cannabis in Canada.

Introduction

Estimating the size of cannabis markets is important for understanding trends in consumption and the scope of illegal sales. Estimates of market size are particularly important in jurisdictions that have legalized cannabis for understanding the 'market capture' of legal retail sources (Ritter, 2006). In Canada, reducing illegal cannabis activities and transitioning consumers to legal sources of "quality-controlled cannabis" is among the primary objectives of the Cannabis Act (Government of Canada, 2018). To date, there is little empirical evidence on transitions from the 'illegal' to legal cannabis market following legalization of non-medical cannabis. As described below, a primary barrier has been a lack of detailed data to support population-based estimates of cannabis consumption, expenditures, and retail sources.

There are two main approaches for estimating the size of drug markets: supply-side versus demand-side methods (Kilmer et al., 2011). Supply-side approaches typically rely on production-and/or seizure-based estimates, whereas demand-side approaches rely on either consumption-based or expenditure-based estimates. The accuracy of each of these approaches depends upon the quality of the data inputs, with greater challenges for some approaches versus others. For example, supply-side estimation strategies are often based on broad estimates of the amount of land used to grow drugs and estimates of yield. This type of approach is particularly problematic for production-based estimates of cannabis because cannabis can be grown both outdoors and indoors, and because of large differences in yields from different growing

* Corresponding author at: School of Public Health Sciences, University of Waterloo, 200 University Ave W, Waterloo, ON, Canada N2L 3G1.
E-mail address: dhammond@uwaterloo.ca (D. Hammond).

https://doi.org/10.1016/j.drugpo.2025.104828

0955-3959/© 2025 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

methods (Kilmer et al., 2011). There are also notable challenges with seizure-based estimates, including challenges in estimating the ratio of drugs that are seized versus sold, and accounting for differences in law enforcement (Reuter, 1995; Mawani et al., 2017).

Demand-side estimates provide significant advantages over supply-side estimates when sufficient data on population-level consumption or expenditures are available. Consumption-based estimates are typically calculated by estimating the number of cannabis consumers, their frequency of use (e.g., daily vs. non-daily), and the average amount of cannabis used on a daily basis (Kilmer et al., 2011). The main limitation of consumption-based approaches is the reliance on self-reported survey data, including cannabis prevalence data from population-level surveys which is used to determine the total number of cannabis consumers. Indeed, even probability-based 'gold standard' national surveillance surveys underestimate consumption by notable amounts, likely due to under-reporting (Kilmer et al., 2011; Cook, 2011), and non-coverage of populations with higher levels of substance use. Under-reporting is well-established for other legal substances, including alcohol and tobacco: self-reported estimates of consumption from leading national surveys are typically between 20–60 % lower than national data on retail sales (Midgette et al., 2019; Esser et al., 2022; Guindon et al., 2017; National Research Council, Institute of Medicine, 2015). Accordingly, previous demand-side estimates of cannabis consumption have sought to account for this phenomenon by applying a 'correction' factor to estimates from self-reported surveys (Midgette et al., 2019). The extent to which cannabis consumption is under-reported is largely unknown, although under-reporting is likely to diminish in jurisdictions that have legalized 'recreational' or non-medical cannabis use due to greater social norms and reduced social desirability bias. The accuracy of self-reported consumption amounts may also be enhanced through more detailed survey measures that provide detailed prompts and use images (Goodman et al., 2019). This is likely to be especially important for reporting consumption of cannabis products other than dried flower, such as beverage or vaping liquids, which use different 'units' when reporting amounts, as described below.

Demand-side estimates can also be based on expenditures, rather than the quantity of products consumed. Expenditure-based approaches calculate the amount of money spent on cannabis for a given period using population-level survey data. Like consumption, expenditures can be estimated for the 'overall cannabis market' or for individual product forms; however, expenditure estimates have the advantage of using the same 'unit' or 'metric' across all product forms (i.e., dollars). It is also plausible that self-reported expenditure data is more accurate because it avoids the complexity of reporting consumption amounts in grams and other units with which consumers may be unfamiliar (Kilmer et al., 2011; Abt Associates, 2001).

Considerations for estimating market size in juridictions with 'legal' cannabis markets

The emergence of legal cannabis markets provides both challenges and opportunities for estimating the size of cannabis markets. In terms of challenges, the vast majority of both supply- and demand-side estimates to date have focused almost exclusively on dried flower and hash, yet legal markets have increased the diversity of product forms that are consumed (Hammond et al., 2022; Fischer et al., 2021). Today, there are wide range of cannabis products on the market other than dried flower, which account for an increasing proportion of the market share since legalization (Hammond et al., 2022). The different 'units' or 'metrics' in which these products are sold and consumed complicate the ways in which self-reported data are collected. To capture non-flower products, demand-based estimates must also convert the various product forms to a common metric, either in terms of delta-9-THC levels or dried flower equivalencies (e.g., metric tons of dried flower). The latter requires conversion factors for various products to estimate the amount of dried flower required to produce vapes or edibles, which can vary widely in terms of THC content. Changes in the THC concentration of products over time must also be taken into account: a greater amount of flower may be required to produce higher THC products, which affects comparisons over time as both supply- and demand-side estimates are based on metric tons of dried flower or plants (Kilmer et al., 2011). Some of these challenges are alleviated when using expenditure-based demand estimates because they use the same unit over time (i.e., dollars spent).

International estimates of cannabis expenditures

Previous studies have estimated the size of cannabis markets in several countries using demand-based expenditure data. Analyses of data from the National Survey on Drug Use and Health (NSDUH) report two estimates on the size of the cannabis market in the US (Midgette et al., 2019). Cannabis expenditures (including from legal, illegal, and medical sources) were estimated at $40 billion USD in 2016, which increased to $52 billion USD after applying an adjustment to account for potential under-reporting of cannabis prevalence in NSDUH surveys. Another analysis of the US market used state reports and data from other economic groups to create a model of latent consumer demand across all states (Anderson, 2020). This report estimated that demand for cannabis products increased 40 % between 2016 and 2019. Analyses have also sought to estimate the size of cannabis markets for individual US states. For example, Washington State utilized their 'seed-to-sale' data from licensed cannabis stores to estimate that past-month consumers spent $1.66 billion USD annually on cannabis from 2015–2016 (Caulkins et al., 2019).

Demand-based estimates using expenditures have also estimated the size of cannabis markets in European countries (Abramsky & Drew, 2014; Trautmann et al., 2013). For example, a study conducted in France utilizing the Health Barometer survey and the European School Survey Project on Alcohol and other Drugs (ESPAD) estimated the value of the cannabis market between €746 and €832 million in 2005 (Legleye et al., 2008). In New Zealand, data from the 2001 New Zealand National Drug Survey was used to estimate the dollar value of the illegal cannabis market at $190 million NZD (Wilkins et al., 2005). Existing expenditure-based studies have several limitations, including the exclusion of less than monthly cannabis consumers, failure to account for different product forms, and inferred expenditures based on 'last' or 'usual' purchase prices and amounts.

Estimates of the illegal cannabis market in Canada

In October 2018, Canada legalized non-medical or 'recreational' cannabis at the federal level (Armstrong, 2021). Major changes in the legal retail market have occurred since legalization, including substantial increases in the number of licensed retail outlets and notable decreases in cannabis prices both from legal and illegal retail sources (Myran et al., 2022; Wadsworth et al., 2022; Mahamad et al., 2020).

Until recently, supply-side seizure-based estimates were the most commonly used approaches to estimating the size of the cannabis market in Canada (Mawani et al., 2017). Several demand-based estimates of the Canadian cannabis market were conducted prior to legalization using data on the frequency of cannabis use from national surveys along with assumptions about consumption amounts (Werb et al., 2012; Office of the Parliamentary Budget Officer, 2016; Macdonald & Rotermann, 2017; Sen & Wyonch, 2018). A more recent consumption-based approach using data from the Canadian government estimated that 24 % of cannabis consumed in Canada was from legal sources approximately one year after legalization (Armstrong, 2021).

Canada's legal market provides notable advantages in terms of estimating market size. Canada has mandatory guidelines that require reporting of legal cannabis sales as part of the federal Cannabis Tracking and Licensing System (CTLS) (Government of Canada, 2021). In addition, every provincial and territorial government serves as the wholesale distributor for all legal cannabis products sold in each jurisdiction. These

factors produce near 'census-level' data on legal cannabis retail sales. Legal retail sales data can serve as an objective 'anchor' or reference point to calibrate demand-based estimates, both at a single cross-sectional point in time and for estimated trends over time in the cannabis market (Kilmer et al., 2019). If demand-based estimates can be generated from population-level surveys in combination with data on retail sources (such as whether products were purchased from a legal or illegal source), survey-based estimates of legal cannabis expenditures can be directly compared and potentially calibrated using the legal retail sales data.

Overall, estimating the size of the illegal market is an important metric for evaluating the impact of legalization and for informing regulatory strategy, including fiscal policies, product restrictions, retail access and other regulatory measures with potential impact on legal market capture. To date, a variety of supply- and demand-based approaches have been used to estimate the size of cannabis markets in Canada. However, virtually all these efforts rely on important assumptions that limit the accuracy of the market estimates. There is little data on trends over time during the period in which the legal retail market has become established in Canada and virtually no studies account for the diversity of cannabis products other than dried flower, which account for a growing proportion of the legal cannabis market in Canada. The primary objective of the current report is to estimate the size of the Canadian cannabis market in terms of consumer expenditures, including the relative proportions from legal and illegal sources.

Methods

Data sources

The analysis relied upon three primary data sources: 1) data from the Canadian Community Health Survey to estimate the number of cannabis consumers in Canada; 2) data from the International Cannabis Policy Study to estimate use, expenditures and legal vs. illegal purchases for specific types of cannabis products; and 3) data on retail sales from legal sources reported to provincial and federal governments in Canada to compare 'objective' versus 'self-reported' estimates of legal market size. Each data source is described below.

Canadian community health survey

Cannabis prevalence data from Canada's national health survey, the Canadian Community Health Survey (CCHS), was used to derive estimates of the number of cannabis consumers in Canada. CCHS uses a probability-based sampling method and is Canada's leading national health surveillance survey, with an approximate sample size of 65,000 respondents per year (Statistics Canada, 2023). Individuals excluded from the CCHS sampling frame represent <3 % of the Canadian population aged 18 and over (Statistics Canada, 2023).

Data on cannabis use in the past 12-months and daily/almost daily (hereafter referred to as 'daily use') was extracted by sex-at-birth (male/female) and age (12–17/18–34/35–49/50–64/ ≥65 years of age). Data was accessed via Statistics Canada's online tool, which provides both prevalence rates (as percentages) and the corresponding population numbers, accounting for any changes in the Canadian population each year (Statistics Canada, 2022).

International cannabis policy study

Data from the International Cannabis Policy Survey (ICPS) is used to estimate the type and frequency of cannabis products used, expenditures on cannabis products, and the percentage of products purchased from legal versus illegal sources. The ICPS consists of national surveys using a repeat cross-sectional design. Data were collected via self-completed web-based surveys (Hammond et al., 2020). The current analysis includes data from the 2022 ICPS survey conducted between September 8 to October 31. Surveys were conducted in English and French, with a median survey time of 23 min. The cooperation rate, which was calculated based on AAPOR Cooperation Rate #2 as the percentage of respondents who completed the survey of eligible respondents who accessed the survey link, was 61 % in 2022 (Smith et al., 2015). Technical reports for the ICPS surveys provide additional methodological description and are publicly accessible at: www.cannabisproject.ca/methods/.

Sample—The current analysis included 5656 respondents who reported using cannabis in the past 12-months. Respondents were aged 16–100 at the time of recruitment (see Table 1 for a profile of participants). 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. Respondents were provided with information about the study and provided consent prior to completing the survey. Respondents received remuneration in accordance with their panel's usual incentive structure. The study was reviewed by and received ethics clearance through a University of Waterloo's Research Ethics Committee (omitted for review; ORE# 22392).

Measures—The full ICPS surveys are publicly available (see www.cannabisproject.ca). Survey measures were drawn or adapted from national surveys and developed through both quantitative and qualitative pre-testing and validation (Hammond et al., 2020; Goodman et al., 2019; Sikorski et al., 2021).

Types of cannabis products and frequency of use

Respondents were asked about their use of 10 cannabis products: dried flower (smoked or vaped), cannabis oils/liquids taken orally (e.g., drops or capsules), cannabis oil/liquid for vaping, edibles/foods, drinks, solid concentrates (e.g., wax, shatter), hash or kief, tinctures (e.g., concentrated amounts ingested orally or taken under the tongue), and topicals. Respondents reported whether they had used each of the product types in the past 12 months (No; Yes, but not in past 12 months; Yes, in past 12 months; Don't know). Frequency of use of each product

TABLE 1
ICPS sample characteristics of past 12-month cannabis consumers ($N = 5656$).

	Unweighted	Weighted
Province		
British Columbia	13.0 % (737)	15.4 % (872)
Alberta	17.3 % (980)	11.3 % (638)
Saskatchewan	4.2 % (240)	3.0 % (169)
Manitoba	4.7 % (264)	3.7 % (210)
Ontario	30.4 % (1718)	41.1 % (2325)
Quebec	12.9 % (730)	18.2 % (1032)
New Brunswick	5.3 % (299)	2.1 % (121)
Nova Scotia	6.2 % (349)	3.2 % (184)
Prince Edward Island	1.4 % (77)	0.4 % (25)
Newfoundland & Labrador	4.6 % (262)	1.4 % (81)
Frequency of cannabis use[a]		
Past 12-months (<monthly)	31.5 % (1784)	29.0 % (1638)
Monthly	19.5 % (1105)	19.4 % (1097)
Weekly	16.4 % (930)	17.6 % (997)
Daily[b]	32.5 % (1837)	34.0 % (1924)
Sex-at birth		
Female	60.8 % (3438)	46.5 % (2630)
Male	39.2 % (2218)	53.5 % (3026)
Age[3]		
16–17	3.1 % (173)	4.9 % (278)
18–34	33.4 % (1887)	37.4 % (2118)
35–49	32.5 % (1841)	31.6 % (1787)
50–64	26.0 % (1470)	21.9 % (1236)
65+	5.0 % (285)	4.2 % (237)

[a] Mutually exclusive categories among past 12-month consumers.
[b] Daily consumption = consumption ≥5 days per week.

was assessed with the following response options: "Less than once a month", "Monthly", "Weekly", and "Daily".

Total number of Canadians consuming each product type

The total number of past 12-month consumers of each individual product category were estimated by multiplying the actual CCHS frequencies of past 12-month consumers by the proportion of ICPS past 12-month consumers that reported using each product category.

Expenditures on cannabis by product category

In ICPS surveys conducted from 2022 onwards, the same expenditure questions were also asked for each of the ten product categories. For example, participants who used dried flower in the past 12-months were asked, "In total, how much money did you spend on all dried herb in the past 12 months?". After entering their response, respondents were asked to confirm their answer. Only respondents who reported purchasing a specific product type were asked the question on money spent for the corresponding product.

In addition, participants who reported that they grew cannabis plants or seeds and bought or paid for the cannabis plants or seeds they grew in the past 12 months, were asked to report the total money spent on plants and seeds in the last 12 months.

Data on expenditures for 'all' cannabis were cleaned across all survey waves by excluding responses above the 99th percentile for all responses and the 95th percentile for responses among non-daily consumers, respectively. Data on expenditures by product category were cleaned for the 2022 survey wave by applying a 99 % winsorization on all product categories.

Cannabis purchases from legal vs. illegal retail sources

Respondents who reported using cannabis in the past 12 months were asked, "Overall, how much of the marijuana that you used in the past 12 months was purchased from LEGAL / AUTHORIZED sources". Respondents could enter any numeric value between 0 and 100 or select "I did not buy or pay for any marijuana in the past 12 months". The same question was asked for past 12-month consumers for each of the ten product types individually.

Total expenditures for legal vs. illegal sources

Total expenditures from both legal and illegal sources were estimated by multiplying the mean expenditures by the total number of past 12-month consumers for each category of cannabis products. Legal expenditures were estimated by multiplying the mean percentage of cannabis products obtained from legal sources by the total expenditures. Expenditures from illegal sources were calculated as the difference between total expenditures and legal expenditures.

Data on percentage of purchases of cannabis from legal sources were cleaned by excluding inconsistent responses. Among respondents who reported only using one product category, responses were excluded where the percentage of legal purchases on 'all' cannabis did not equal the percentage of legal purchases on the sole product category. Missing data was excluded on a 'list-wise' basis.

Data sources for legal cannabis retail sales

Data on cannabis sales from licensed retailers (hereafter referred to as 'legal retail sales') was used to compare with self-reported cannabis expenditures. The federal Cannabis Act requires reporting of legal cannabis sales as part of the federal tracking system (Government of Canada, 2021). Sales data is reported to Health Canada from provinces and territories, who receive sales data from all licensed producers and retailers within their jurisdiction. Sales of medical cannabis directly from license holders to clients is reported directly to Health Canada. The sales data represents the closest estimate to 'census level' data on legal cannabis sales in Canada; however, the data may underestimate actual sales due to modest under-reporting from license holders. The current analysis used sales data released by Statistics Canada at the provincial and territorial level (Statistics Canada, 2023). Sales data for legal cannabis for non-medical use and medical use were combined to produce total retail sales for Canada and the four most populous provinces. While quarterly data for both types of cannabis were available for Canada, only annual data were available for 'cannabis for medical use' amongst the provinces.

Analysis

Analyses of ICPS data were conducted using post-stratification weights. Post-stratification survey weights were created using age-by-sex-by province, education, and age-by-smoking status groups. A raking algorithm was applied to compute weights that were calibrated to these groupings. Weights were rescaled to the sample size. See the ICPS Technical Reports for further detail (www.cannabisproject.ca/methods).

The total ICPS sample size for Canada in 2022 was 15,942. The current analyses only included the 5656 respondents that had consumed cannabis in the past 12-months. Table 1 summarizes the frequency of cannabis use among past 12-month consumers and other characteristics of the analytic sample.

All ICPS estimates related to cannabis expenditures—the proportion of consumers using each product form, expenditures, and the proportion of legal vs. illegal expenditures—were calculated separately by sex-at-birth and age. These estimates were then multiplied to the number of past 12-month consumers estimated from CCHS in the corresponding categories for sex-at-birth and age.

Participants with missing data were excluded on a 'list wise' basis, such that all valid responses for each outcome were included, where possible. 'Don't know' and 'refusals' were treated as missing in all cases. Due to small sample sizes in the male and female 16–17 and 65+ sex-age groups, mean expenditures for individual product categories for these groups were estimated by multiplying the mean expenditures of the next/previous age group by the ratio of 16–17/18–34 and 65+/50–64 mean expenditures on all cannabis types. Mean percentages of cannabis obtained from legal sources were retained for these sex-age groups. In cases where estimates of legal sourcing were missing because no respondents reported using a specific product type, estimates from the same age but in the other sex group were used instead (e.g., the estimates for 16–17-year-old males were imputed for 16–17-year-old females). If those estimates were also missing, estimates from the adjacent age group within the same sex-at-birth group were used.

Frequencies and descriptive statistics are reported with 95 % confidence intervals. All analyses were conducted using survey procedures in SAS (SAS version 9.4, SAS Institute Inc., Cary, NC, USA).

'Expenditure-weighted' estimates

In most cases, estimates derived from population-based surveys are based on averages across individual respondents. We will refer to this as the 'consumer-weighted' average. For example, some studies calculate an 'average' price paid for cannabis products and then multiply this number by the number of past 12-month consumers. However, individuals have very different consumption levels for cannabis and contribute different amounts to the overall market share of cannabis products. This approach incorrectly assumes that more frequent and less frequent consumers pay the same price for cannabis products; in fact, more frequent consumers generally pay less for their products due to quantity discounts, as well as a greater likelihood of purchasing their products from illegal versus legal sources, which has lower prices than legal markets.

In the case of estimating the expenditures from legal versus illegal sources, consumers contribute different amounts to the legal and illegal markets based on differences in their purchase or consumption amounts. For example, Consumer A may purchase 1 *g* of dried flower per year all of which was purchased from a legal retail source, whereas Consumer B may purchase 1000 *g* of dried flower per year, 50.0 % of which was purchased from a legal retail source. The consumer average of dried flower per year would be 75.0 %; however, the 'expenditure weighted' average would be 50.1 %. To be consistent with 'sales-weighted' market data, estimates of legal purchasing were weighted based on individual expenditure amounts. This was accomplished by calculating outcomes in the following sequence: 1) determining the total expenditures from all respondents for a particular product (e.g., dried flower); 2) dividing the individual participant's expenditure amount by the total expenditure amount; 3) multiplying this number by the proportion of expenditures from legal sources; 4) summing the totals across all respondents.

Results

Sample characteristics

Table 1 shows the unweighted and weighted profile of past 12-month cannabis consumers included in the 2022 ICPS dataset.

Numbers of consumers and expenditures by type of cannabis product

Use of specific types of cannabis products

According to the CCHS, in 2022, a total of 22.4 % (21.9 % - 22.9 %) or 7248,000 Canadians aged 12 and older reported cannabis use in the past 12-months. Table 2 shows the past 12-month prevalence calculated for each of the 11 categories of cannabis products using ICPS data. As shown in Table 2, past 12-month cannabis consumers were most likely to report using dried flower, followed by edibles, liquid vapes, and hash/kief. Prevalence estimates for each product type were multiplied by the number Canadians who reported using cannabis in the past 12-month according to the 2022 CCHS, within each of the age x sex categories (see Supplemental Table 1).

Cannabis expenditures

Table 2 shows the average cannabis expenditures in CAD among past 12-month consumers of each product form. Among past 12-month consumers for each product, the highest mean expenditures were reported by dried flower consumers, followed by consumers of concentrates, liquid drops, and liquid vapes.

Legal source of cannabis products and expenditures

ICPS participants reported the percentage of cannabis sourced from legal versus illegal sources for each of the 10 product categories, as well as plants and seeds. As Table 2 shows, in 2022, past 12-month consumers of liquid caps reported the highest percentage of purchasing from legal sources, followed by drinks, topicals, and tinctures. Dried herb, edibles, and hash consumers were least likely to report purchasing their products from legal sources.

Table 2 also shows the percentage of cannabis expenditures from legal versus illegal sources, calculated based on the proportion of each product type that was sourced from legal sources multiplied by the expenditures for each product type. As Table 2 indicates, proportions of legal expenditures were moderately higher than the proportions of legal product purchased due to higher prices in legal retail sources. Total expenditures across all product forms were $6720,991,456 CAD, including $5228,419,252 CAD from legal sources and $1492,572,204 CAD from illegal sources, equivalent to an overall legal market capture 77.8 %.

TABLE 2
Prevalence of use, expenditures and legal market source by type of cannabis product among past 12-month consumers (ICPS, 2022).

	Percentage of past 12-month consumers using each product type	Mean reported cannabis expenditures per product type[a]	Mean percent of cannabis products obtained from legal sources	Mean percent of cannabis expenditures obtained from legal sources
Dried herb	67.2 % (3802) (65.7 % - 68.7 %)	$787.19 (1627) ($714.60 - $859.77)	78.6 % (1627) (70.3 % - 86.9 %)	78.7 %
Edibles	51.5 % (2911) (49.8 % - 53.1 %)	$156.79 (1018) ($139.75 - $173.83)	78.2 % (1018) (68.5 % - 88.0 %)	77.7 %
Liquid vapes	30.8 % (1743) (29.3 % - 32.3 %)	$291.57 (624) ($246.34 - $336.79)	80.8 % (624) (67.0 % - 94.6 %)	80.5 %
Hash	20.9 % (1181) (19.5 % - 22.2 %)	$188.77 (269) ($130.62 - $246.92)	63.1 % (269) (40.1 % - 86.1 %)	62.5 %
Drinks	20.5 % (1159) (19.2 % - 21.8 %)	$79.86 (418) ($62.43 - $97.28)	84.4 % (418) (63.9 % - 105.0 %)	82.9 %
Concentrates	17.7 % (999) (16.4 % - 18.9 %)	$401.40 (271) ($274.18 - $528.62)	79.0 % (271) (47.6 % - 110.3 %)	72.6 %
Liquid drops	17.4 % (982) (16.2 % - 18.5 %)	$328.53 (482) ($265.95 - $391.11)	79.2 % (482) (64.0 % - 94.4 %)	77.1 %
Topicals	16.6 % (937) (15.4 % - 17.7 %)	$102.10 (256) ($77.17 - $127.02)	82.3 % (256) (57.0 % - 107.7 %)	80.8 %
Tinctures	12.1 % (684) (11.0 % - 13.2 %)	$167.19 (198) ($130.53 - $203.86)	81.2 % (198) (59.4 % - 103.0 %)	80.3 %
Liquid caps	9.1 % (513) (8.1 % - 10.0 %)	$288.47 (236) ($228.28 - $348.67)	85.3 % (236) (64.7 % - 105.8 %)	78.9 %
Plants or seeds[b]	14.3 % (805) (13.1 % - 15.5 %)	$130.03 (413) ($106.87 - $153.20)	78.6 % (N/A) (N/A)	79.3 %

[a] Among respondents who reported consuming each product type in the past 12-months.

[b] Respondents were not asked what percentage of plants or seeds were obtained from legal sources; therefore, percentages for dried herb applied to plants and seeds.

Comparison between self-reported cannabis expenditures and 'objective' sales data from legal retail sources

Supplemental Figure 1 shows the value of cannabis sales from legal retail sources between October 2018 and October 2023 from Statistics Canada, overall and for Canada's four most populous provinces. As Table 3 indicates, there was a high correspondence between the self-reported expenditures and actual legal sales: self-reported expenditures for Canada were within two percentage points of actual legal retail sales in Canada, and within 5 percentage points across each of the four provinces. As previously mentioned, the 'objective' sales data for 'cannabis for medical use' amongst the provinces were available only on an annual basis, so 'objective' sales data and self-reported cannabis expenditures for the provinces could not be mapped to exactly the same time period. However, sales for 'cannabis for medical use' accounted for

TABLE 3
Comparison between self-reported legal expenditures versus 'objective' legal retail sales data, 2021–2022.

	Canada	Ontario	British Columbia	Alberta	Quebec
ICPS Self-reported 'Sum of all products' legal expenditures (millions)	**$5228**	$2083	$736	$859	$730
Statistics Canada legal sales data (millions)[1,2]	**$5325**	$2165	$751	$859	$726
Difference between ICPS legal expenditures and Statistics Canada legal retail sales (%)	**−2 %**	−4 %	−2 %	+0 %	+1 %

[1] Including sales tax.
[2]]egal sales data comprised of sales for cannabis products for non-medical use and 'cannabis products for medical use'. Provincial data for the medical component were available only annually. Provincial data for self-reported legal expenditures and Statistics Canada legal sales data for cannabis for non-medical use were between October 2021 and September 2022, but provincial data for the medical component included only the entirety of 2022.

<10 % of total licensed cannabis sales within each province.

Discussion

The current report presents a comprehensive analysis of the size of the Canadian cannabis market in 2022, including the proportion of cannabis expenditures from legal and illegal sources. To date, virtually all demand-based analyses have been constrained by a lack of detailed population-level data to support demand-side estimates. The current analysis used novel data from the ICPS study to address data gaps in consumer consumption patterns, cannabis expenditures, and purchase sources (Ritter, 2006; Kilmer et al., 2011; Reuter, 1995).

Total size of cannabis market

In the 12-month period ending in September 2022, the current analysis estimated total cannabis expenditures in Canada to be $6.721 billion CAD, approximately half of the legal sales revenue from both tobacco ($11.8 billion CAD) (Statistics Canada, 2023) and alcohol ($13.6 billion CAD) (Statistics Canada, 2024). On a per capita basis, the current estimates suggest that past 12-month cannabis consumers in Canada spent an average of $927 CAD on cannabis between October 2021 and September 2022. There are little data from other studies available for comparison, although previous estimates range from yearly expenditures of €202 in France and $362 USD in the US in 2005 (Legleye et al., 2008), and past-month expenditures of $1538 USD per US consumer in 2014 (Midgette et al., 2019), to $2199 USD per consumer in Washington State in 2016/17 (Caulkins et al., 2019). Most previous estimates have inferred expenditures indirectly through assumptions based on cannabis prices and consumption amounts, rather than assessing expenditures directly.

In the current analysis, males accounted for a greater proportion of expenditures than females (60 % of all expenditures), including for each of the individual product categories, except for topicals, for which females reported greater expenditures. Cannabis expenditures were also highest for respondents aged 18–34 due to high prevalence of use and high expenditure amounts per consumer. The pattern of expenditures by age is consistent with previous studies (Rotermann, 2019; Health Canada, 2022). A substantial percentage of cannabis consumers—approximately 12 % in 2022—did not report spending any money on cannabis, which is consistent with findings from the 2023 National Cannabis Survey (NCS), which found that 19 % of past 12-month consumers did not report purchasing any cannabis (Statistics Canada, 2024).

Cannabis expenditures by product

To our knowledge, the current analysis is the first to estimate consumption and expenditures for the diversity of products that characterize 'modern' cannabis markets. In 2022, dried flower accounted for 55 % of total legal expenditures and an additional 2 % was spent on plants and seeds. Concentrates (including hash) accounted for 12 % of expenditures, followed by oral liquids (11 %), vaping liquids (10 %), and edibles (8 %, excluding drinks). The self-reported expenditures for specific product categories are generally consistent with Health Canada data on legal retail sales in the same 12-month period, in which dried flower accounted for approximately 67 % of all sales from legal sources, ingested extracts (including vaping liquids and 'solid' concentrates) accounted for 21 % of legal sales, and edibles (excluding drinks) accounted for 5 % of legal sales (Government of Canada, 2024). Overall, while dried flower remains the dominant type of cannabis product in the Canadian market, products other than dried flower accounted for close to half of all cannabis expenditures as of 2022.

Comparisons with other literature estimating cannabis market size

There are few estimates of the size of the Canadian cannabis market with which to compare the current findings. Statistics Canada estimated household expenditures on cannabis at $7.821 billion for the 2021–2022 time period corresponding to the current analysis (4th quarter of 2021 and 3rd quarter of 2022—see Supplemental Figure 2) (Statistics Canada, 2024). Statistics Canada's methods for calculating household expenditures are not publicly available, which precludes a detailed comparison. However, the higher market estimate from Statistics Canada is most likely due to the use of prevalence and expenditure data from the Canadian Cannabis Survey (CCS). The CCS yields substantially higher national estimates of cannabis prevalence compared to the CCHS, which was used in the current analysis. In 2022, the prevalence of past 12-month cannabis use in the CCS was estimated at 33 % versus 22 % in the CCHS (Statistics Canada, 2022; Canadian Cannabis Survey, 2024). Thus, the CCS estimates 36.2 % more cannabis consumers in Canada than CCHS in 2022 (9873,996 vs. 7248,000 consumers). If the current analysis relied on CCS rather than CCHS estimates, total estimated consumption would have been $9.153 billion dollars.

In regard to methodology, the CCHS is Canada's largest health surveillance survey and has superior sampling methodology to CCS (Statistics Canada, 2023). The CCS also used an atypical approach to assess prevalence: the main prevalence questions are asked separately for cannabis used for medical and non-medical reasons. In 2022, the CCS prevalence of use for 'non-medical' cannabis is reported at 27 %, but the overall prevalence of cannabis use increases to 34 % after including respondents who report only using cannabis for medical reasons. The CCS methodology used to assess cannabis use is problematic, not simply because it can't be directly compared with other surveys, but also because use of cannabis non-medical and medical reasons is not distinct (Rotermann, 2019): indeed, approximately one-third-of all past 12-month consumers in Canada report using cannabis for both medical and non-medical reasons (Hammond et al., 2023). It is unclear how CCS respondents who report using cannabis for both medical and non-medical reasons 'separate' their consumption and expenditures between the medical and non-medical sections, raising the possibility that some consumers may 'double-report' the same consumption and expenditures in both the medical and non-medical sections. In short, it is highly likely that the CCS approach to recording consumption and expenditures for medical and non-medical cannabis use separately leads to greater measurement error for several of the key inputs used by Statistics Canada.

Differences in market estimates between the current analysis and

Statistics Canada's may also reflect differences in per capita cannabis expenditures between the ICPS study and the CCS. Expenditure data from the CCS are challenging to interpret for several reasons. In the 2022 CCS, past 12-month consumers reported cannabis expenditures of $2076 among males and $1596 among females; however, consumers reported substantially higher total expenditures when subsequently asked to report expenditures from legal and illegal sources separately. In addition, there are implausibly large discrepancies between the expenditures reported in an 'overall' question for all cannabis products and questions that are asked of individual products: total expenditures reported are approximately four times higher when summed across individual products. Overall, the inconsistent, and implausible patterns of self-reported expenditure data in the CCS suggest fundamental issues in the construction and sequence of questions, such that they may not be suitable for use without substantial data cleaning and checking.

Cannabis expenditures and legal market capture

In the 12 months ending September 2022, the current analysis estimated the legal market capture at 78 %, with a total of $5.228 billion spent on cannabis from legal sources and $1.493 billion (or 22 %) from illegal sources. Cannabis expenditures based on self-reported data from the ICPS and CCHS surveys were within two percentage points of the 'actual' retail sales data for the same period between 2021 and 2022. In addition, at the provincial level, self-reported expenditures were within 5 percentage points of retail sales in each of Ontario, Alberta, Quebec and British Columbia. These results suggest that population surveys with detailed questions on cannabis expenditures can yield estimates that are highly consistent with 'objective' sales data. This represents a potentially important methodological contribution that could lead to more accurate demand-based estimates of cannabis markets. However, analyses over a longer time period will be important for examining whether self-reported expenditures can track changes in legal sales data. In addition, as discussed under Limitations, it is possible that expenditures from illegal sources are under-reported, such that both the estimate of legal market capture and overall market size would be under-estimated. It should also be noted that estimates of legal market capture based on expenditures will be different than estimates based on product amounts, such as THC equivalencies. Setting aside the broader number of inputs and assumptions required to estimate consumption based on THC equivalencies, if the price of products from illegal sources is lower than legal sources, legal market capture will be higher for expenditure-based estimates than product/consumption-based estimates.

In regard to other studies, the legal market capture estimates from Statistics Canada are generally consistent with the current analysis, equivalent to 68 % in 2021/22 (see Supplemental Figure 2). Despite similarities in the proportion of legal market capture, Statistics Canada's estimate of $2.500 billion in illegal expenditures over the same 12-month period (4th quarter of 2021 to the 3rd quarter of 2022) was higher than our estimates. This is largely attributable to the use of CCS prevalence data in the Statistics Canada methodology, as described above.

Self-reported legal sourcing and legal market capture

In the current analysis and Statistics Canada analyses, legal market capture is determined by the percentage of products sourced from legal versus illegal sources as self-reported by survey respondents. Despite methodological differences in sampling and question wording, the three national surveys yield very similar estimates, particularly for trends over time. In the ICPS surveys, respondents reported sourcing approximately 78 % of 'all cannabis' from a legal source in 2022. By comparison, in the 2022 CCS survey, 69 % of past 12-month consumers reported a legal store as their 'usual source' of cannabis, with other consumers citing 'social sources', which may also include products purchased from legal stores. Data from the 2023 NCS indicate that 72 % of past 12-month consumers reported purchasing cannabis 'from legal sources only' (including the 19 % of consumers who did not purchase cannabis in the denominator) (Statistics Canada, 2024). As shown in Supplemental Table 2, consistent trends over time in self-reporting legal sources are also observed across the NCS, CCS, and ICPS surveys.

Transitions from illegal to legal cannabis markets in Canada have been driven by two key factors: access to legal stores and price (Hammond et al., 2021). The primary reasons for purchasing cannabis from illegal sources among both Canadian and US consumers is price and convenience (Wadsworth et al., 2022; Goodman et al., 2022; Donnan et al., 2022; Donnan et al., 2022). Both of these factors underwent significant change in the first five years of the legal non-medical market. The number of licensed retail stores in Canada increased more than 18-fold between the last quarter of 2018 and the third quarter of 2023, from 182 to 3332 licensed stores (Statistics Canada, 2023). This reflects the time it takes to license, build and open retail stores for a novel commercial market (Health Canada, 2022). Accordingly, there have been substantial increases in the number of legal cannabis stores per capita and geographic proximity to a legal store (Myran et al., 2022; Wadsworth et al., 2021; Myran et al., 2019), both of which increase the likelihood that consumers will purchase their cannabis from legal sources (Wadsworth et al., 2023).

The Canadian cannabis market has also experienced major reductions in price (Wadsworth et al., 2022). By 2022, dried flower could be purchased from legal stores in most provinces for as low as $3.00/gram—approximately one-quarter of the typical price at the time of legalization. Consumer perceptions of the legal market have also grown more positive over time, including perceptions that cannabis from legal sources is more convenient to purchase, higher quality, and safer than cannabis from illegal sources (Hammond et al., 2023; Wadsworth et al., 2022). Even in the case of price, fewer than half of respondents reported that illegal cannabis is less expensive than cannabis from legal sources. The findings underscore that establishing the legal retail market—and the corresponding shift of consumers from illegal to legal retail sources—does not occur immediately and requires several years to occur. Indeed, the most recent data suggests that legal market capture continues to increase more than five years after legalization.

Differences in legal market capture between cannabis product types

To our knowledge, the current analysis is the first to estimate differences in legal market capture by type of cannabis product. Previously published estimates from the ICPS study indicate that drinks, vapes, and capsules are the products most likely to be purchased from legal sources, whereas solid concentrates (e.g., hash) are least likely to be sourced from legal sources (Wadsworth et al., 2023). Differences in the legal market capture for each product may reflect differences in the extent of processing and manufacturing. Some products, such as drinks, vaping products, and edibles all require greater technology or manufacturing capacity to produce compared to solid extracts or concentrates, which are more easily produced. The differences in legal market capture across products may also reflect the ease of transporting or shipping products, particularly in the case of drinks, which are heavy and less cost-effective to ship relative to the retail price than solid concentrates. In the case of hash and other concentrates, these products are typically used by more frequent consumers, who may have more established contacts in the illegal market. Finally, differences in legal market capture could reflect differences in consumer preferences among those most likely to use each product. For example, solid concentrates such as hash are more likely to be used by more frequent consumers, who may have greater motivations to source lower priced products from the illegal market, and who may have more established contacts for sourcing illegal products.

Limitations

This study is subject to limitations common to survey research. In the ICPS, respondents were recruited using non-probability-based sampling; therefore, the findings do not necessarily provide nationally representative estimates for cannabis expenditures. However, post-stratification weights are applied to ensure the sample is proportional to the Canadian population using age-by-sex-by-province, education, and age-by-smoking groups. The ICPS survey yields prevalence trends that are between the CCHS and CCS estimates, with highly consistent trends over time. High levels of consistency between ICPS, CCS, and NCS are also observed for other key outcomes, such as the proportion of consumers that use various product types and source products from legal sources.

It is well established in the scientific literature that prevalence estimates for substance use behaviours differ across national surveys, even among 'benchmark' national monitoring surveys (Levy et al., 2019; Messeri et al., 2019; Delnevo & Bauer, 2009; Fahimi et al., 2008). This has also been documented with respect to estimates of cannabis use in Canada, which vary by up to 40 % across different national monitoring surveys (Rotermann, 2019; Rotermann & Macdonald, 2018). Differences in these point estimates will have a substantial impact on demand-side estimates of the cannabis market. Previous studies have applied a 'correction' or adjustment factor to account for under-estimates of consumption from population surveys due to a lack of coverage or under-reporting (Midgette et al., 2019; Kilmer et al., 2019). The CCHS methodology is estimated to exclude less than 3 % of Canadian residents; however, cannabis consumption and expenditures may be higher among this sample, including for residents of the territories.

Self-reported measures of purchasing cannabis from legal and illegal sources are subject to social desirability bias; however, the extent to which Canadian consumers over-report purchasing from legal sources or under-report from illegal sources is unclear. ICPS surveys include several measures to promote honest reporting, including assurances of confidentiality and impartiality statements. In addition, at the end of the survey, participants are asked, "Were you able to provide 'honest' answers about your marijuana use during the survey?" Respondents who select "No" or "For some questions, but not all" are removed from the sample. Social desirability bias is unlikely to account for trends over time in self-reported legal sourcing. Although social norms and acceptability of cannabis has increased somewhat since legalization of non-medical cannabis, these changes have been modest and Canadians report high levels of social acceptability, which is likely to be associated with more honest reporting (Winfield-Ward & Hammond, 2024; Blevins et al., 2018). Nevertheless, some level of 'over-reporting' the use of legal sources remains highly likely. Beyond social desirability bias, some consumers may misreport the legal status of their cannabis sources due to the difficulty in distinguishing licensed from unlicensed retail outlets. In the 2018 NCS—conducted prior to federal legalization—11 % of consumers reported accessing 'all' their cannabis from legal sources, while 23 % reported accessing at least 'some' of their cannabis from legal sources (Rotermann, 2020). Although Canadians could legally access medical cannabis prior to October 2018, these numbers are higher than would be expected based on the number of individuals authorized/registered for medical cannabis under federal regulations (Health Canada, 2019). Some misreporting during the pre-legalization period could be due to consumer confusion about the nature of 'legal' stores: in the years immediately preceding legalization of non-medical cannabis in Canada, cannabis stores, often called 'dispensaries', were operating in several cities (Mahamad & Hammond, 2019). Overall, under-reporting of illegal cannabis sources is highly likely and it is plausible that the current analysis either over-estimates or represents a 'maximum' of legal market capture. Future research should examine the validity of self-reported purchasing measures in greater detail.

The current method does not account for sales to tourists or other non-residents who would be excluded from CCS, CCHS, and ICPS survey frames, which would overestimate expenditures per consumer. However, this would likely account for a modest proportion of legal sales in Canada. Tourism and 'cross-border' sales are likely to be far less consequential in Canada compared to US where many states still prohibit non-medical cannabis. In addition, the current method does not clearly distinguish between legal and grey market expenditures, including sales at unlicensed stores operated on First Nation reserves.

Finally, imputation methods were used in two general cases. First, the profile of products used among 12–17 year olds was assumed to be the same as the 16–17 year old age group for which ICPS data was available. Second, in cases where estimates of legal sourcing were missing because no respondents reported using a specific product type, estimates from the same age but in the other sex group were used instead (e.g., the estimates for 16–17-year-old males were imputed for 16–17-year-old females). In both cases, the impact of these imputation methods on the overall estimates would be negligible given the very low expenditures that are accounted for by these groups.

Conclusion

The findings provide evidence of substantial transition from the illegal to the legal market in the five years since the legalization of non-medical cannabis in Canada. Since the opening of legal retail stores in Canada in October 2018, legal retail sales have increased in a linear fashion, with no indication of a 'plateau' up to five years after legalization. The results suggest Canada's legal cannabis market has displaced approximately three-quarters of domestic expenditures on the illegal cannabis market four years after federal legalization of non-medical cannabis. The current findings are generally consistent with other population-level estimates and support the conclusions in the 2024 Legislative Review of the Cannabis Act, which noted "substantial displacement of the illegal market" (Rosenberg et al., 2024). Collectively, the evidence suggests that Canada has made substantial progress in achieving one of the primary objectives of the Cannabis Act, reducing illegal cannabis and transitioning consumers to legal cannabis sources. Future research should consider differences by province, including the extent to which differences in provincial retail structures and regulations are associated with different rates of legal market capture and overall consumption levels.

CRediT authorship contribution statement

David Hammond: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Daniel Hong:** Writing – review & editing, Visualization, Formal analysis. **Samantha Rundle:** Writing – review & editing, Formal analysis. **Maryam Iraniparast:** Writing – review & editing, Formal analysis. **Beau Kilmer:** Writing – review & editing. **Elle Wadsworth:** Writing – review & editing.

Declaration of competing interest

DH has provided paid expert testimony on behalf of public health authorities in response to legal claims from the tobacco, vaping and cannabis industry. All remaining authors declare no conflicts of interest. The funders played no role in the conceptualization, analysis or interpretation of the study findings.

Funding acknowledgment

Funding for this project was provided by Public Safety Canada. Funding for the broader ICPS study was provided by a Canadian Institutes of Health Research Project Bridge Grant (PJT-153342) and a Canadian Institutes of Health Research Project Grant (PJT-153342).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.drugpo.2025.104828.

References

Abramsky, J., & Drew, S. (2014). *Changes to national accounts: inclusion of illegal drugs and prostitution in the UK national accounts*. UK Office for National Statistics Working Paper. Available at: https://www.unsiap.or.jp/sites/default/files/pdf/e-learning_el_material_4_eco_4_1_eco_stat_1508_gdp_kor_reference_materialillegal_activities_in_the_uk_national_accounts.pdf.

Abt Associates. (2001). *What america's users spend on illegal drugs. executive office of the president*. Washington, D.C: Office of National Drug Control Policy.

Anderson, P. L. (2020). Blue smoke and seers: measuring latent demand for cannabis products in a partially criminalized market. *Business Economics, 55*(1), 26–40.

Armstrong, M. J. (2021). Legal cannabis market shares during Canada's first year of recreational legalisation. *International Journal of Drug Policy, 88*, Article 103028.

Armstrong, M. J. (2021). Legal cannabis market shares during Canada's first year of recreational legalisation. *International Journal of Drug Policy, 88*, Article 103028.

Blevins, ClaireE., Marsh, Eliza, Banes, KelseyE., Stephens, RobertS., Walker, DeniseD., & Roffman, RogerA. (2018). The implications of cannabis policy changes in Washington on adolescent perception of risk, norms, attitudes, and substance use. *Substance abuse: research and treatment, 12*, Article 1178221818815491.

Canadian Cannabis Survey. (2024). *Cannabis use for non-medical purposes among canadians (aged 16+)*. Ottawa: Health Canada. Available at: https://health-infobase.canada.ca/cannabis/technical-notes.html.

Caulkins, J. P., Davenport, S., Doanvo, A., Furlong, K., Siddique, A., Turner, M., & Kilmer, B. (2019). Triangulating web & general population surveys: do results match legal cannabis market sales? *International Journal of Drug Policy, 73*, 293–300.

Cook, P. J. (2011). *Paying the tab: the costs and benefits of alcohol control*. Princeton University Press.

Delnevo, C. D., & Bauer, U. E. (2009). Monitoring the tobacco use epidemic III: the host: data sources and methodological challenges. *Preventive medicine, 48*(1), S16–S23.

Donnan, Jennifer, Shogan, Omar, Bishop, Lisa, & Najafizada, Maisam (2022). Drivers of purchase decisions for cannabis products among consumers in a legalized market: a qualitative study. *BMC Public Health, 22*(1), 368.

Donnan, Jennifer, Shogan, Omar, Bishop, Lisa, Swab, Michelle, & Najafizada, Maisam (2022). Characteristics that influence purchase choice for cannabis products: a systematic review. *Journal of cannabis research, 4*(1), 9.

Esser, M. B., Sherk, A., Subbaraman, M. S., Martinez, P., Karriker-Jaffe, K. J., Sacks, J. J., & Naimi, T. S. (2022). Improving estimates of alcohol-attributable deaths in the United States: impact of adjusting for the underreporting of alcohol consumption. *Journal of studies on alcohol and drugs, 83*(1), 134–144.

Fahimi, M., Link, M., Mokdad, A., Schwartz, D. A., & Levy, P. (2008). Peer reviewed: Tracking chronic disease and risk behavior prevalence as survey participation declines: Statistics from the behavioral risk factor surveillance system and other national surveys. *Preventing chronic disease, 5*(3).

Fischer, Benedikt, Lee, Angelica, Robinson, Tessa, & Hall, Wayne (2021). An overview of select cannabis use and supply indicators pre-and post-legalization in Canada. *Substance Abuse Treatment, Prevention, and Policy, 16*, 1–7.

Goodman, S., Leos-Toro, C., & Hammond, D. (2019). Methods to assess cannabis consumption in population surveys: Results of cognitive interviewing. *Qualitative health research, 29*(10), 1474–1482.

Goodman, S., Leos-Toro, C., & Hammond, D. (2019). Methods to assess cannabis consumption in population surveys: Results of cognitive interviewing. *Qualitative health research, 29*(10), 1474–1482.

Goodman, S., Wadsworth, E., & Hammond, D. (2022). Reasons for purchasing cannabis from illegal sources in legal markets: findings among Cannabis Consumers in Canada and US States, 2019–2020. *Journal of studies on alcohol and drugs, 83*(3), 392–401.

Government of Canada. (2018). Cannabis Act (SC 2018, c. 16). Available at: https://laws-lois.justice.gc.ca/eng/acts/c-24.5/page-1.html#h-76969.

Government of Canada. (2021). Cannabis tracking system resources. Available at: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/tracking-system.html.

Government of Canada. (2021). Cannabis tracking system resources. Available at: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/tracking-system.html.

Government of Canada. (2024). Cannabis data overview: Inventory, sales and licensed area. Available at: https://www.canada.ca/en/health-canada/services/drugsmedication/cannabis/research-data/market.html.

Guindon, G. E., Burkhalter, R., & Brown, K. S. (2017). Levels and trends in cigarette contraband in Canada. *Tobacco Control, 26*(5), 518–525.

Hammond, D., Goodman, S., Wadsworth, E., Rynard, V., Boudreau, C., & Hall, W. (2020). Evaluating the impacts of cannabis legalization: the International Cannabis Policy Study. *International Journal of Drug Policy, 77*, Article 102698.

Hammond, D., Rynard, V., Wadsworth, E., & Goodman, S. (2021). Analysis of drivers of the illicit cannabis market: Findings from the International Cannabis policy study: 2019–2020. In *Prepared on behalf of Public Safety Canada*. University of Waterloo.

Hammond, D., Goodman, S., Wadsworth, E., Freeman, T. P., Kilmer, B., Schauer, G., … Hall, W. (2022). Trends in the use of cannabis products in Canada and the USA, 2018–2020: Findings from the International Cannabis Policy Study. *International Journal of Drug Policy, 105*, Article 103716.

Hammond, D., Corsetti, D., Fataar, F., Iraniparast, M., Danh Hong, D., & Burkhalter, R. (2023). International Cannabis Policy Study - Canada 2022 Summary. *Cannabis Project*. Available at: https://cannabisproject.ca/wp-content/uploads/2024/01/2022-Canada-Report-June-26.pdf.

Health Canada (2019). ARCHIVED – market data under the Access to Cannabis for Medical Purposes Regulations. Available at: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/licensed-producers/market-data.html.

Health Canada. (2022). *Canadian cannabis survey 2022: summary*. Government of Canada. Available at: https://www.canada.ca/en/health-canada/services/drugsmedication/cannabis/research-data/canadian-cannabis-survey-2022-summary.html#s2-5.

Health Canada. (2022). *Authorized cannabis retailers in the provinces and territories*. Government of Canada. Available at: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/laws-regulations/provinces-territories.html#a4.

Kilmer, B., Caulkins, J. P., Pacula, R. L., & Reuter, P. H. (2011). Bringing perspective to illicit markets: estimating the size of the US marijuana market. *Drug and alcohol dependence, 119*(1-2), 153–160.

Kilmer, B., Davenport, S., Smart, R., Caulkins, J., & Midgette, G. (2019). *After the grand opening: assessing cannabis supply and demand in washington state*. RAND Corporation.

Legleye, S., Lakhdar, C. B., & Spilka, S. (2008). Two ways of estimating the euro value of the illicit market for cannabis in France. *Drug and Alcohol Review, 27*(5), 466–472.

Levy, D. T., Yuan, Z., Li, Y., Mays, D., & Sanchez-Romero, L. M. (2019). An examination of the variation in estimates of e-cigarette prevalence among US adults. *International journal of environmental research and public health, 16*(17), 3164.

Macdonald, R., & Rotermann, M. (2017, December). Experimental estimates of cannabis consumption in Canada, 1960 to 2015. Available at: https://www150.statcan.gc.ca/n1/pub/11-626-x/11-626-x2017077-eng.htm.

Mahamad, S., & Hammond, D. (2019). Retail price and availability of illicit cannabis in Canada. *Addictive behaviors, 90*, 402–408.

Mahamad, S., Wadsworth, E., Rynard, V., Goodman, S., & Hammond, D. (2020). Availability, retail price and potency of legal and illegal cannabis in Canada after recreational cannabis legalisation. *Drug and alcohol review, 39*(4), 337–346.

Mawani, F., Maslov, A., & Lawrence, A. (2017). *Measuring illicit cannabis seizures in canada*. Thompson, MB: Public Safety Canada.

Messeri, P., Cantrell, J., Mowery, P., Bennett, M., Hair, E., & Vallone, D. (2019). Examining differences in cigarette smoking prevalence among young adults across national surveillance surveys. *Plos one, 14*(12), Article e0225312.

Midgette, G., Davenport, S., Caulkins, J. P., & Kilmer, B. (2019). *What america's users spend on illegal drugs, 2006-2016*. Santa Monica, CA: Rand Corporation.

Myran, D. T., Brown, C. R., & Tanuseputro, P. (2019). Access to cannabis retail stores across Canada 6 months following legalization: a descriptive study. *Canadian Medical Association Open Access Journal, 7*(3), E454–E461.

Myran, D. T., Staykov, E., Cantor, N., Taljaard, M., Quach, B. I., Hawken, S., & Tanuseputro, P. (2022). How has access to legal cannabis changed over time? An analysis of the cannabis retail market in Canada 2 years following the legalisation of recreational cannabis. *Drug and alcohol review, 41*(2), 377–385.

National Research Council, Institute of Medicine. (2015). Understanding the U.S. Illicit Tobacco Market: characteristics, policy context, and lessons from international experiences. In P. Reuter (Ed.), *The illicit tobacco market: collection and analysis of the international experience*. Available at: https://www.nationalacademies.org/our-work/the-illicit-tobacco-market-collection-and-analysis-of-the-international-experience.

Office of the Parliamentary Budget Officer. (2016). Legalized Cannabis: Fiscal Considerations. Ottawa. Available at: http://www.pbo-dpb.gc.ca/web/default/files/Documents/Reports/2016/Legalized%20Cannabis%20Fiscal%20Considerations_EN.pdf.

Reuter, P. (1995). Seizure of drugs. *Encyclopedia of drugs and alcohol*. New York: MacMillan.

Ritter, A. (2006). Studying illicit drug markets: Disciplinary contributions. *International Journal of Drug Policy, 17*(6), 453–463.

Rosenberg, M., Ayonrinde, O., Conrod, P. J., Levesque, L. L., & Selby, P. (2024). Legislative review of the Cannabis Act. *Final report of the expert panel*. Available at: https://www.canada.ca/en/health-canada/services/publications/drugs-medication/legislative-review-cannabis-act-final-report-expert-panel.html#a10.

Rotermann, M., & Macdonald, R. (2018). Analysis of trends in the prevalence of cannabis use in Canada, 1985 to 2015. *Health reports, 29*(2), 10–20.

Rotermann, M. (2019). Analysis of trends in the prevalence of cannabis use and related metrics in Canada. *Health reports, 30*(6), 3–13.

Rotermann, M. (2020). What has changed since cannabis was legalized? *Health reports, 31*(2), 11–20.

Sen, A., & Wyonch, R. (2018). *Cannabis countdown: estimating the size of illegal markets and lost tax revenue post-legalization, 523*. CD Howe Institute Commentary. Available at: https://www.cdhowe.org/sites/default/files/2021-12/Final%20Final%20Commentary_523.pdf.

Sikorski, C., Leos-Toro, C., & Hammond, D. (2021). Cannabis consumption, purchasing and sources among young Canadians: The cannabis purchase and consumption tool (CPCT). *Substance Use & Misuse, 56*(4), 449–457.

Smith, T. W., Bailar, B., & Couper, M. (2015). Standard definitions: Final dispositions of case codes and outcome rates for surveys. *American association for public opinion research*. Oakbrook Terrace: AAPOR.

Statistics Canada. (2022). *Health characteristics, annual estimates – canadian community health survey (Table 13-10-0096-01)*. Statistics Canada. https://doi.org/10.25318/1310009601-eng

Statistics Canada. (2023). *Cigarette production, sales, smoking rates trending down*. Statistics Canada – StatsCAN Plus. Available at: https://www.statcan.gc.ca/o1/en/plus/3230-cigarette-production-sales-smoking-rates-trending-down.

Statistics Canada. (2023). *Research to insights: cannabis in canada*. Government of Canada. Available at: https://www150.statcan.gc.ca/n1/pub/11-631-x/11-631-x2023006-eng.htm.

Statistics Canada. (2023). Canadian Community Health Survey - Annual Component (CCHS). Available at: https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3226.

Statistics Canada. (2023). Monthly retail trade sales by province and territory (Table 20-10-0056-01). DOI: https://doi.org/10.25318/2010005601-eng.

Statistics Canada. (2024). *Control and sale of alcoholic beverages and cannabis, april 1, 2022, to march 31, 2023*. Statistics Canada – The Daily. Available at: https://www150.statcan.gc.ca/n1/daily-quotidien/240306/dq240306a-eng.htm.

Statistics Canada. (2024). National Cannabis Survey, 2023. Statistics Canada – The Daily. Available at: https://www150.statcan.gc.ca/n1/daily-quotidien/240318/dq240318e-eng.htm?utm_source=mstatcan&utm_medium=eml&utm_campaign=statcan-statcan-mstatcan.

Statistics Canada. (2024). Detailed household final consumption expenditure, Canada, quarterly (Table 36-10-0124-01). https://doi.org/10.25318/3610012401-eng.

Trautmann, F., Kilmer, B., & Turnbull, P. (2013). *Further insights into aspects of the EU illicit drugs market*. Brussels: European Union. Available at: https://op.europa.eu/en/publication-detail/-/publication/6b248f1a-8296-4aad-9271-53245a45a910/language-en.

Wadsworth, E., Driezen, P., & Hammond, D. (2021). Retail availability and legal purchases of dried flower in Canada post-legalization. *Drug and Alcohol Dependence, 225*, Article 108794.

Wadsworth, E., Driezen, P., Chan, G., Hall, W., & Hammond, D. (2022). Perceived access to cannabis and ease of purchasing cannabis in retail stores in Canada immediately before and one year after legalization. *The American Journal of Drug and Alcohol Abuse, 48*(2), 195–205.

Wadsworth, E., Driezen, P., Pacula, R. L., & Hammond, D. (2022). Cannabis flower prices and transitions to legal sources after legalization in Canada, 2019–2020. *Drug and Alcohol Dependence, 231*, Article 109262.

Wadsworth, E., Fataar, F., Goodman, S., Smith, D. M., Renard, J., Gabrys, R., … Hammond, D. (2022). Consumer perceptions of legal cannabis products in Canada, 2019–2021: a repeat cross-sectional study. *BMC public health, 22*(1), 2048.

Wadsworth, E., Driezen, P., Dilley, J. A., Gabrys, R., Jesseman, R., & Hammond, D. (2023). Proximity to legal cannabis stores in Canada and use of cannabis sources in the first three years of legalization, 2019–2021. *Journal of studies on alcohol and drugs, 84*(6), 852–862.

Wadsworth, E., Rynard, V., Driezen, P., Freeman, T. P., Rychert, M., Wilkins, C., … Hammond, D. (2023). Legal sourcing of ten cannabis products in the Canadian cannabis market, 2019–2021: a repeat cross-sectional study. *Harm reduction journal, 20*(1), 19.

Werb, D., Nosyk, B., Kerr, T., Fischer, B., Montaner, J., & Wood, E. (2012). Estimating the economic value of British Columbia's domestic cannabis market: Implications for provincial cannabis policy. *International journal of drug policy, 23*(6), 436–441.

Wilkins, C., Reilly, J. L., Pledger, M., & Casswell, S. (2005). Estimating the dollar value of the illicit market for cannabis in New Zealand. *Drug and Alcohol Review, 24*(3), 227–234.

Winfield-Ward, L., & Hammond, D. (2024). Social Norms for Cannabis Use After Nonmedical Legalization in Canada. *American journal of preventive medicine, 66*(5), 809–818.