International Journal of Drug Policy 77 (2020) 102698

Contents lists available at ScienceDirect

International Journal of Drug Policy

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

Research methods

Evaluating the impacts of cannabis legalization: The International Cannabis Policy Study

David Hammond[a,*], Samantha Goodman[a], Elle Wadsworth[a], Vicki Rynard[a], Christian Boudreau[b], Wayne Hall[c]

[a] School of Public Health & Health Systems, University of Waterloo, 200 University Avenue West, Waterloo, ON N2L 3G1, Canada
[b] Department of Statistics and Actuarial Sciences, University of Waterloo, 200 University Avenue West, Waterloo, ON N2L 3G1, Canada
[c] Centre for Youth Substance Abuse, University of Queensland, 17 Upland Road, St Lucia, Queensland 4067, Australia

ARTICLE INFO

Keywords:
Cannabis
Marijuana
Survey
Methods
Measures
Legalization

ABSTRACT

An increasing number of jurisdictions have legalized non-medical cannabis use, including Canada in October 2018 and several US states starting in 2012. The policy measures implemented within these regulated markets differ with respect to product standards, labelling and warnings, public education, retail policies, marketing, and price/taxation. The International Cannabis Policy Study (ICPS) seeks to evaluate the impacts of these policy measures as well as the broader population-level impact of cannabis legalization using a quasi-experimental research design. The objective of this paper is to describe the ICPS conceptual framework, methods, and baseline estimates of cannabis use. The ICPS is a prospective cohort survey conducted with national samples of 16–65-year-olds in Canada and the US. Data are collected via an online survey using the Nielsen Consumer Insights Global Panel. Primary survey domains include: prevalence and patterns of cannabis use; purchasing and price; consumption and product types; commercial retail environment; problematic use and risk behaviours; cannabis knowledge and risk perceptions; and policy-relevant outcomes including exposure to health warnings, public educational campaigns, and advertising and promotion. The first annual wave was conducted in Aug-Oct 2018 with 27,169 respondents in three geographic 'conditions': Canada (n = 10,057), US states that had legalized non-medical cannabis (n = 7,398) and US states in which non-medical cannabis was prohibited (n = 9,714). The ICPS indicates substantial differences in cannabis use in jurisdictions with different regulatory frameworks for cannabis. Future waves of the study will examine changes over time in cannabis use and its effects associated with legalization in Canada and additional US states.

Introduction

On October 17 2018, Canada became the second country after Uruguay to legalize non-medical or 'recreational' cannabis use and retail sale (Government of Canada, 2018a; Parliament of Canada, 2018). Under the Cannabis Act, the federal government has primary responsibility for production, cultivation, processing, analytical testing, licensing, medical sales, advertising and marketing restrictions, labelling and health warnings, and shared taxation authority. Provinces and territories have primary responsibility for regulating retail sales (including online and 'brick-and-mortar' stores), as well as the ability to increase the minimum age, decrease possession amounts, and impose additional requirements on personal cultivation and zoning restrictions (Government of Canada, 2019). The federal government has also committed to using cannabis tax revenue to fund public education campaigns and increase funding for mental health and addiction services (Government of Canada, 2018b).

The Government of Canada has identified several objectives for legalizing cannabis. These include: (1) protecting the health of young people by restricting access to cannabis; (2) preventing illicit activities by allowing licit cannabis production and ensuring appropriate legal sanctions; (3) reducing the burden on the criminal justice system; (4) providing a quality-controlled cannabis supply; and (5) ensuring Canadians understand the risks of cannabis (Government of Canada, 2018a). Evaluating the impact of cannabis use is thus critically important to examining whether these public health objectives have been achieved.

Colorado (2012), Washington State (2012), Alaska (2014) and

* Corresponding author.
E-mail addresses: dhammond@uwaterloo.ca (D. Hammond), samantha.goodman@uwaterloo.ca (S. Goodman), ewadsworth@uwaterloo.ca (E. Wadsworth), vrynard@uwaterloo.ca (V. Rynard), cboudreau@uwaterloo.ca (C. Boudreau), w.hall@uq.edu.au (W. Hall).

https://doi.org/10.1016/j.drugpo.2020.102698

Oregon (2014) were the first US states to legalize cannabis production and sale, followed in subsequent years by California, Maine, Massachusetts, Nevada, Vermont and Michigan (National Conference of State Legislatures, 2019). State regulations share certain similarities—including a minimum purchase age of 21, a ban on public use, a retail distribution system, and excise taxes on retail sales—as well as some differences, such as restrictions on advertising and public consumption (National Conference of State Legislatures, 2019). However, the retail markets for recreational cannabis in these states are at different points of transition because it often takes several years after legalization for the legal retail market to become fully established.

Given that recreational cannabis has only recently been legalized in specific US states and Uruguay, there is relatively little robust evidence of its impacts, and the evidence that exists is inconclusive. Early evidence from the first states to legalize non-medical cannabis is somewhat mixed. Some studies suggest increased rates of adult cannabis use (Alaska Department of Health and Social Services, 2016; Colorado Department of Public Health & Environment, 2018; Kerr, Bae & Koval, 2018, 2017; Miller, Rosenman & Cowan, 2017; Parnes, Smith & Conner, 2018; Reed, 2018; Smart & Pacula, 2019; Substance Abuse and Mental Health Services Administration (SAMHSA), 2017a; Washington State Office of Financial Management, 2016); while other studies suggest little impact on adult cannabis use (Brooks-Russell et al., 2019; Cerda et al., 2017; Harpin, Brooks-Russell, Ma, James & Levinson, 2018; Jones, Jones & Peil, 2018; Mason et al., 2016). Importantly, evidence to date suggests little or no impact on cannabis prevalence among youth, although there is some evidence of increased frequency of use among youth who are already using cannabis (Smart & Pacula, 2019). Beyond prevalence of use, perceptions of risk appear to have decreased and cannabis-related driving incidents have increased, although at a rate comparable to that observed pre-legalization (Alaska Department of Health and Social Services, 2016; Couper & Peterson, 2014; Reed, 2018; Reuter & Mark, 1986). Adverse outcomes from overconsumption, such as unintentional ingestion of edible products, have increased since legalization (Cao, Srisuma, Bronstein & Hoyte, 2016; Wang et al., 2016) but plateaued in subsequent years (Colorado Department of Public Health & Environment, 2018). Further analyses are needed to determine the extent to which these changes are a result of legalization or the increased monitoring or reporting of adverse events (Azofeifa et al., 2016; Bull, Brooks-Russell, Davis, Roppolo & Corsi, 2017; Canadian Centre on Substance Abuse and Addiction, 2015). Overall, the impact of cannabis legalization has yet to be established, due to a lack of detailed longitudinal measures at the state level, and a lack of comparison groups to help distinguish between pre-existing secular trends and the impact of legalization.

The impact of cannabis legalization will be influenced by the specific policy measures that regulate the legal cannabis market. Research in other consumer domains—particularly tobacco—has demonstrated the impact of policy measures on social norms, prevalence and use (Glanz, Sallis, Saelens & Frank, 2005; Hall & Kozlowski, 2018; Pacula, Kilmer, Wagenaar, Chaloupka & Caulkins, 2014). For example, health warnings for cigarettes increase perceptions of risk, decrease tobacco use, and increase the use of smoking cessation services (Hammond, 2011). Restrictions on advertising and marketing tobacco products have also been influential in reducing use and social norms, particularly among young people (World Health Organization, 2013). The retail environment—including proximity to stores, in-store marketing and product displays—also impacts consumer behaviour (US Surgeon General, 2012). Taxation and price controls have a particularly strong influence on tobacco consumption, especially among youth, who are more price-sensitive (Davis, Geisler & Nichols, 2016). The taxation level and price of legal products will be critical factors in the extent to which consumers shift from illegal to legal retail sources (Pacula & Lundberg, 2014; Reuter & Mark, 1986).

To date, there is little evidence on the impact of specific cannabis policies. Evidence on specific regulatory measures is thus particularly important because of the variation in policies between legalized cannabis markets. Beyond the differences across US states, Canada has implemented more restrictive policy measures, such as greater restrictions on advertising and promotion, and more comprehensive labelling regulations. The retail market also differs across Canadian provinces in terms of government-run versus for-profit retail outlets, minimum purchase age, restrictions on retail location and density, as well as on whether home growth is allowed (Canadian Public Health Association, 2018). The variation in these policies represents a series of 'quasi-experiments' to examine the potential impact of different regulatory approaches.

Objectives

The overall objective of the International Cannabis Policy Study (ICPS) is to examine the impact of cannabis policies in five primary areas: (1) prevalence and patterns of cannabis use, including use among 'minors' (defined according to the minimum legal age in each state/province) and levels of dependence among users; (2) problematic use and risk behaviours, including driving after cannabis use and use in 'high risk' occupational settings; (3) the commercial retail environment, including the price and type of products used, the use of high potency products, and extent to which consumers shift from 'illegal' to 'legal' sources to obtain cannabis; (4) perceptions of risk and social norms; and (5) the effectiveness of specific regulatory policies—such as advertising restrictions, product labelling and warnings, and public education campaigns—on a diverse range of outcomes, including overall patterns of cannabis use, use in public spaces and workplaces, second-hand smoke exposure, and social norms. The objective of the present paper is to describe the ICPS conceptual framework, methods, and baseline estimates of cannabis use.

Conceptual model

The conceptual framework of the ICPS is based on theories of drug use that highlight the interaction of individual factors and broader environmental factors, including the social environment and the drug market environment (Jessor, 1985). These theories recognize the importance of individual risk factors, including biological and personality factors than influence susceptibility to substance use, as well as broader environmental factors, such as accessibility to drugs, and differences in social environments that can influence perceptions of risk and social norms. The study also draws on conceptual frameworks developed for evaluating population-level policies in the areas of food (Glanz et al., 2005) and tobacco (Fong et al., 2006), which highlight the importance of measuring 'upstream' policy measures to understand the impact on 'downstream' behaviour changes (International Agency for Research on Cancer, 2008). For example, 'upstream' policy factors could include regulations on advertising, which may influence exposure to advertising, social norms and 'downstream' indicators of substance use. The study design uses three major strategies to rigorously evaluate the effects of policies.

The first strategy is the use of a prospective cohort design, in which the same individuals are measured on the same key outcome variables, before and after policy implementation (Shadish, Cook, & Campbell, 2002). The first wave or pre-legalization 'baseline' for the ICPS was conducted from August to early October 2018, immediately before cannabis legalization in Canada, with at least three additional annual surveys planned for 12-, 24- and 36-month follow-up post-legalization. While most countries have national drug monitoring surveys, virtually all of these surveys use repeat cross-sectional designs, which are limited in their ability to reveal the underlying causal mechanisms (e.g., assess causal direction) of policies at the individual level (Shadish, Cook, & Campbell, 2002). In the ICPS, respondents lost to attrition are replenished over time to maintain the sample size across waves, with analytical models that account for time-in-sample effects and the

correlated nature of responses within individuals over time.

The second strategy is the use of a quasi-experimental design, in which outcomes in one group exposed to a policy are compared to outcomes in a group not exposed to the policy (Shadish, Cook, & Campbell, 2002). This is particularly important in the area of cannabis policy because of 'secular trends' in cannabis use; e.g. decreases in the perceived risks of cannabis use in many jurisdictions prior to legalization and increasing use in response to the rapidly evolving cannabis industry and the diversity of new cannabis products (Borodovsky et al., 2017; Carlini, Garrett, & Harwick, 2017; Cerda et al., 2017; Daniulaityte et al., 2018; Davenport & Caulkins, 2016; Macdonald & Rotermann, 2017; National Institute on Drug Abuse, 2018; Rocky Mountain High Intensity Drug Trafficking Area, 2017; Russell, Rueda, Room, Tyndall & Fischer, 2018; SAMHSA 2017a; Vigil et al., 2018; Zhang, Zheng, Zeng & Leischow, 2016). Research designs need to be able to distinguish between these secular trends and the effects of legalization. Unfortunately, it is not possible to conduct controlled experiments on drug policy or cannabis legalization because governments, not researchers, control how and when policies are implemented. In the ICPS, comparison groups are represented by US 'illegal' and 'legal' states. At the time of Wave 1, nine US states had legalized the use/possession of non-medical cannabis: Alaska, California, Colorado, Maine, Massachusetts, Nevada, Oregon, Vermont, and Washington, plus the District of Columbia (DC). Additional states are expected to legalize over the study period, as has already occurred (i.e., Michigan in 2018; Illinois in 2020). This will allow for pre-post comparisons in states that transition from 'illegal' to 'legal' status. It is worth noting that not all 'legal' states have legalized sales of non-medical cannabis (at the time of writing, Maine, Vermont, and DC have legalized use but not sales). Both the legal status of cannabis sales and date since legalization of use/possession and/or sales will be considered when analyzing the retail market and effects of specific regulatory policies. Combining a prospective cohort design and a quasi-experimental design in a single study yields a pre-post design with comparison groups, and a higher degree of internal validity than either feature alone (see Fig. 1) (Shadish, Cook, & Campbell, 2002). While some recent research in the Southern Cone is examining cannabis legalization in Uruguay (Schleimer et al., 2019), to our knowledge, there are few prospective cohort studies examining the impacts of changing drug policies across Canada and the US.

The third strategy is to measure policy-specific variables such as exposure to cannabis marketing, and proximity to retail outlets across the three 'conditions', as well as between US states and Canadian provinces. We refer to these as 'proximal' variables because they are conceptually close to the policy that is being evaluated, and thus are less likely to be affected by other factors. As described below, the ICPS survey includes measures in six primary policy domains. Fig. 2 illustrates the policy-specific variables with respect to advertising and promotion. For example, in the area of labelling, the policy-relevant variables include survey measures that assess awareness and knowledge of warning labels on products. The study also assesses measures of health knowledge and risk perceptions. Therefore, the study is capable of examining whether differences in health warnings across jurisdictions that have legalized cannabis translates into differences in use and health beliefs. The study will also be able to assess the impact of changes to health warnings within a jurisdiction over time, such as revisions to the health warning messages in Canada in 2019. This type of methodological approach has been widely used in tobacco control to evaluate specific regulatory policies, as noted in the paper. These three strategies, particularly when accompanied by the inclusion of other variables (covariates) that may explain differences between jurisdictions, allow for stronger inferences about the causal effects of policies.

Methods

Data for Wave 1 were collected from August 27—October 7, 2018. All data collection for the ICPS occurred online; respondents were discouraged from using smartphones due to small screen size and rendering of images, but not restricted from doing so. Online data collection provides several advantages in terms of automated skip logic and questionnaire routing to address complicated patterns of cannabis use and various product types (Groves et al., 2009; Johnson, 2016). Online surveys also permit the use of images, which are important in assessing cannabis consumption amounts (Goodman, Leos-Toro & Hammond, 2019). Compared to interviewer-assisted survey modes, self-administered surveys can reduce social desirability bias by providing greater anonymity for sensitive topics (Dodou & de Winter, 2014; Krumpal, 2013).

Respondents completed an online survey (median survey time: 19.9 min, or 22.8 and 16.6 min among 'ever' and 'never' cannabis users, respectively). The project was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31330).

Data integrity practices—The ICPS study incorporates best practices for online surveys to ensure data quality, including 'trap' questions to identify 'speeders' and disengaged respondents (American Association of Public Opinion Research 2010, 2019). As a data integrity check, respondents were asked near the end of the main survey to select the current month from a list. The month selected by the respondent was compared to the month the survey was submitted. Respondents with month discrepancies were excluded from the analytic sample, unless the selected month was within 2 days of the submission date. Overall, 1071 respondents were excluded from the analytic sample due to discrepancies with the month selected. At the end of the survey, respondents were asked, "Were you able to provide 'honest' answers about your marijuana use during the survey?" ('No', 'Yes to some questions', 'Yes to all Questions'). The 208 respondents who answered 'No' were excluded. The final analytic sample comprised 27,169 respondents.

ICPS Sample— Individuals were eligible to participate if they resided in a Canadian province or US state, were 16–65 years of age at the time of recruitment, and had access to the internet. Respondents were recruited using the *Nielsen Consumer Insights Global Panel*, which maintains panels in Canada and the US (http://www.nielsen.com/ca/en/about-us.html). The Nielsen panels are recruited using both probability and non-probability sampling methods in each country. For the current project, Nielsen drew stratified random samples from the online panels in each country, based on known proportions in each age group. To account for differential response rates, Nielsen modified these sampling proportions to place greater weight on sub-groups with lower response rates. Respondents from Canadian provinces and US states were provided with incentives according to Nielsen's regular remuneration structure. All respondents provided informed consent, and 16–17-year-

		Baseline	12-month Follow-up	24-month Follow-Up	36-month Follow-Up
Condition 1	Canada	O	X	X	X
Condition 2	'US illegal' states	O	O	O	O
Condition 3	'US legal' states*	X	X	X	X

O= illegal recreational cannabis; X=legal recreational cannabis

Fig. 1. International Cannabis Policy Study (ICPS) quasi-experimental design.

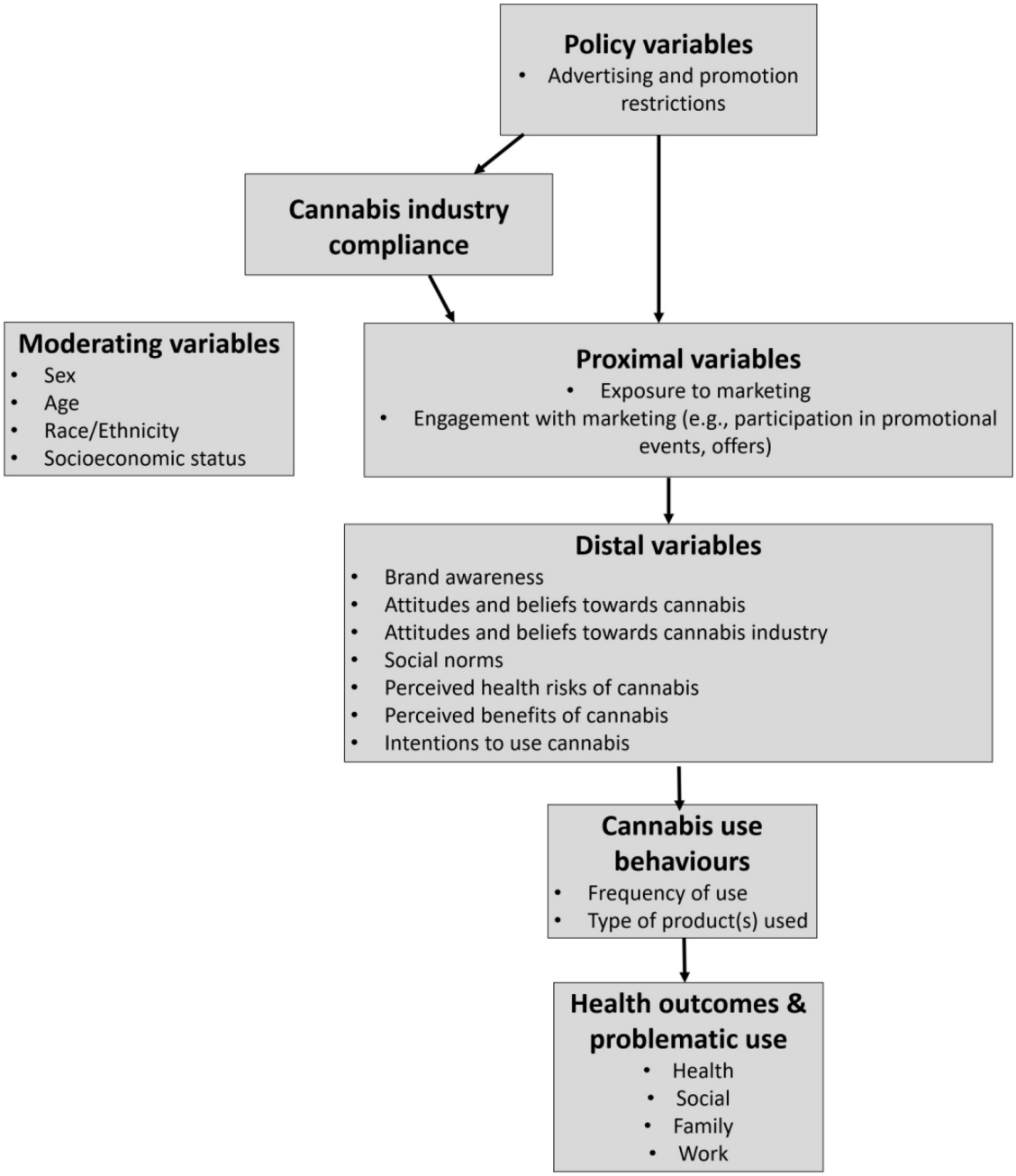

Fig. 2. Conceptual framework for cannabis marketing restriction policies.

olds were recruited through their parents, who also provided parental consent. Participation rates are provided in the Technical Report (Goodman & Hammond, 2019). Briefly, 44,364 respondents accessed the survey link, of whom 6722 (15.2%) partially completed the survey and 28,471 (64.2%) completed the survey. Only 'complete' surveys (i.e., in which the respondent reached the end of the survey) were included in the analytic sample. Overall, 2.8% of participants completed the survey in French; the remainder completed it in English. To maintain the cohort, Nielsen recontacts previous respondents at each wave using a unique subject ID. In order to ensure consistency in the number of completed surveys at each wave, respondents lost to attrition will be replaced at 12-, 24- and 36-month follow-up to ensure a consistent sample size at each wave. Note that only 14 participants from DC completed the Wave 1 survey; these respondents were excluded due to inadequate cell sizes for weighting (see Technical Report; Goodman & Hammond, 2019). The ICPS sample profile is compared with estimates from national benchmark surveys in Canada and the US, as shown in Supplemental Tables S1-S7, described below.

Survey content

Survey measures were drawn or adapted from national surveys or based on previous research. Development of new measures was informed by focus groups conducted with 35 cannabis users and non-users aged 16–24 (Leos-Toro, 2019a) and cognitive interviewing among 10 adult cannabis users (Goodman et al., 2019). An extensive pilot study was conducted in October 2017 with 870 Canadians aged 16–30 Leos-Toro, 2019a(Follow as above). The survey was available to respondents in English, as well as French in Canada.

The ICPS survey includes modules on the following content areas: prevalence and patterns of cannabis use; cannabis purchasing and price; cannabis consumption and product types; cannabis knowledge,

perceptions of risk and social norms; indicators of problematic use; substance use and other risk behaviours; demographic factors, postal code and socio-economic status; exposure to health warnings and public educational campaigns; and exposure to cannabis marketing and branding (Hammond et al., 2018).

Consumption—Prevalence of cannabis use (lifetime, past 12 months, past 30 days), frequency of use, age of initiation, and susceptibility among non-users are assessed. A 6-level 'cannabis use status' variable (Never user; Used >12 months ago; Used in past 12 months; Monthly user; Weekly user; Daily/almost daily user) was derived from three survey questions: ever use (Yes; No); most recent cannabis use (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 frequency of use (Less than once per month; One or more times per month; One or more times per week; Every day or almost every day).

Consumption quantity is assessed using reference images (e.g., Figs. 3 and 4) and the amounts for various cannabis product types used. Respondents were given a choice of units and timeframe (usual day, week, month or past 12 months) to report their consumption of each product type. Units and reference images for each product type are available in the survey document (Hammond et al., 2018).

Types of products—Respondents are asked to report consumption frequency, amounts and THC:CBD ratio for 10 types of cannabis products: dried herb (smoked or vaped); cannabis oils or liquids ingested orally (e.g., drops or capsules); vaped cannabis oils or liquids; cannabis edibles/foods; cannabis drinks (e.g., cola, tea or coffee); concentrates (e.g., wax, shatter, budder); hash or kief; tinctures; topical ointments (e.g., skin lotions); and 'Other' (open-ended).

Retail source, price, and products—Respondents who report purchasing cannabis in the past 12 months are asked to provide information about their purchases, including type of cannabis (dried herb, edible, concentrate, etc.), quantity, price paid, purchase source, and THC and CBD levels, if known.

Medical use—Respondents are asked about whether they had asked and/or received approval to use cannabis from a health professional; had used it to manage physical or mental health symptoms; and had a personal and/or family history of trauma or specific mental health issues.

Knowledge, attitudes, and beliefs—General risk perceptions and perceptions of specific risks are assessed (e.g., perceived consequences of impaired driving, use during pregnancy, and adverse mental health effects). Other attitudes and beliefs assessed include perceived ease of access, stigma, and social norms surrounding cannabis. These items assess respondents' level of comfort using cannabis around others, self-reported number of close friends who use cannabis, and perceived level of societal approval or disapproval of cannabis use.

Fig. 3. Reference image for dried herb reported as number of joints.

Problematic use and risk behaviours—Cannabis dependence and problematic use in the past 12 months is assessed using the established ASSIST measure for problematic use, which is used in the Canadian Tobacco, Alcohol and Drugs Survey (Statistics Canada, 2018b; World Health Organization, 2019). Measures also assess treatment seeking, polysubstance use and combining cannabis with tobacco, and self-reported adverse effects, including personal side effects and accidental ingestion by oneself or others. The ICPS survey measures also cover the indicators of problematic use outlined in the Lower-Risk Cannabis Use Guidelines, with the exception of 'avoiding deep inhalation when smoking cannabis' (Fischer et al., 2017).

Policy-specific measures—The ICPS includes a range of policy indicators in six primary domains. *Advertising and promotion* are assessed using an overall measure of self-reported exposure, as well as exposure through each of 16 specific channels, along with cannabis brand/company recognition. *Health warnings and product labelling* are assessed through health knowledge, exposure to warnings, recall of health warning messages, and knowledge of THC/CBD levels and 'standard serving' sizes. *Public education campaigns* are assessed based on exposure in each of 17 settings, including mass media, workplaces, and schools. *Retail access and settings* are assessed by examining interactions with online and 'brick-and-mortar' retail stores, proximity to stores, and perceptions of legal and illegal retail sources. *Taxation and price policies* are examined using data on purchasing patterns, price paid, and the prevalence of legal vs. illegal retail sales. *Medical cannabis policies* are evaluated through measures of medical cannabis use and consumption patterns.

Sociodemographic factors & disparities—The ICPS measures age, sex, gender, sexuality, race/ethnicity, household composition, and pregnancy status. In analytical models that assess 'minimum legal age', this variable will be constructed separately for each 'legal' jurisdiction to reflect differences across US states and provinces. Socioeconomic measures include education, income, and perceived income adequacy. The survey also collects postal/zip codes. In the 2018 survey, 94.3% of participants provided this information, which can be linked to neighbourhood or community level indicators of socio-economic status, such as Deprivation Index (Canadian Institute for Health Information, 2019; Institut national de santé publique, 2019).

Retail market data—As a complement to the survey data, the ICPS also collects information on the location of legal retail stores in Canada and US states that have legalized non-medical cannabis, using lists of licensed stores from state and provincial regulatory authorities, which are updated on a biannual basis (Mahamad & Hammond, 2019). Participants' zip/postal code will be used to calculate proximity to legal retail stores.

Analysis

Post-stratification sample weights were constructed based on Canadian and US Census estimates. Respondents from Canada were classified into age-by-sex-by-province and education groups. Respondents from US 'legal' states were classified into age-by-sex-by-legal state, education, and region-by-race groups. Those from 'illegal' states were classified into age-by-sex, education, and region-by-race groups. Corresponding grouped population counts and proportion estimates were obtained from Statistics Canada and the US Census Bureau (Statistics Canada, 2019a, 2019b; US Census Bureau, 2017a, 2017b). Separately for Canada, US 'legal' states and US 'illegal' states, a raking algorithm was applied to the full analytic sample (n = 27,169) to compute weights that were calibrated to these groupings. Weights were

a. Reference image for dried herb reported in standard units (e.g., g, oz)

Fig. 4. (a) Reference image for dried herb reported in standard units (e.g., g, oz). (b) Reference image for dried herb amounts above ¼ oz.

b. Reference image for dried herb amounts above ¼ oz

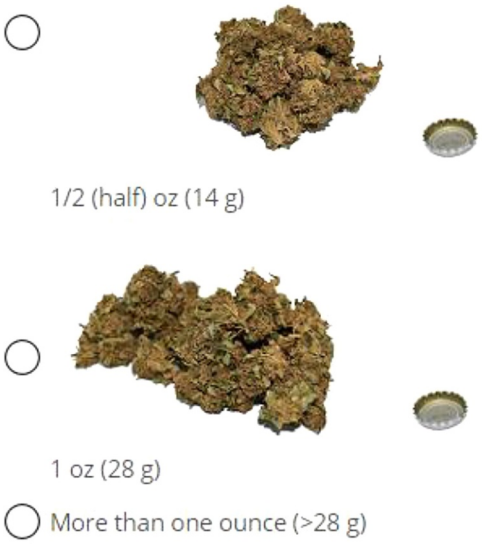

Fig. 4. (Continued)

then rescaled to sum to the sample sizes for Canada, US 'legal' states and US 'illegal' states.

Assuming retention rates are sufficient, weighted Generalized Estimating Equation (GEE) modelling will be the primary analytical approach used to compare jurisdictions over time. GEE models will include an indicator variable representing 'jurisdiction' (i.e., Canada, US 'legal' state, US 'illegal' state). Analyses at 12-, 24- and 36-month follow-ups will also include a 'wave' indicator variable (i.e., baseline vs. follow-up wave), which will be crossed with the jurisdiction variable. This analytical approach is similar to a 'difference-in-difference' approach but allows more precise modelling of differences across multiple survey waves. Models will also include a standard set of covariates (including age, sex, education, and race/ethnicity) to adjust for socio-demographic profiles across conditions and examine their association with outcomes.

Sample profile

Socio-demographic profile

Table 1 shows the unweighted and weighted sociodemographic characteristics for the sample in Canada, US legal states, and US illegal states. As outlined in the Supplementary Materials (Tables S1–S7), the Canadian sample aligned quite well with national estimates for education, on which the sample was weighted (Statistics Canada, 2019c). In the US sample, the proportion of respondents with a bachelor's degree or higher aligned with national estimates but considerably more respondents had a college/associate's degree and fewer had a high school education or less (US Census Bureau, 2017b). The proportions of individuals identifying as 'White/Caucasian' (Canada and US) and 'Black or African American' (US) corresponded closely with those of national surveys. In both countries, the proportions of other ethnicities were within 3% of national estimates; however, the ICPS had a lower proportion of respondents identifying as Hispanic compared to the US

Table 1
International Cannabis Policy Study (ICPS) 2018 sample characteristics by study condition[a] (n = 27,169).

	Canada n = 10,057		US 'illegal' states n = 9714		US 'legal' states n = 7398	
Characteristic	Unweighted % (n)	Weighted[b] % (n)	Unweighted	Weighted[b]	Unweighted	Weighted[b]
Sex (at birth)						
Female	58.1% (5845)	49.8% (5012)	61.4% (5968)	50.3% (4887)	66.1% (4887)	50.3% (3721)
Male	41.9% (4212)	50.2% (5045)	38.6% (3746)	49.7% (4827)	33.9% (2511)	49.7% (3677)
Gender identity						
Female	57.5% (5781)	49.1% (4937)	60.6% (5891)	49.7% (4829)	65.4% (4836)	49.0% (3628)
Male	41.5% (4178)	49.6% (4993)	38.5% (3738)	49.3% (4791)	33.6% (2488)	49.4% (3656)
Other	0.5% (53)	0.7% (69)	0.6% (63)	0.6% (61)	0.7% (52)	1.1% (78)
Unstated	0.4% (45)	0.6% (59)	0.2% (22)	0.3% (33)	0.3% (22)	0.5% (26)
Age (years)						
mean (SD)	45.9 (14.8)	40.6 (14.9)	41.9 (16.6)	40.0 (15.1)	45.9 (14.3)	40.0 (14.8)
Age group						
16–25	13.2% (1325)	18.9% (1902)	22.7% (2209)	19.9% (1938)	10.3% (762)	19.6% (1448)
26–35	14.2% (1424)	20.7% (2087)	13.6% (1317)	21.4% (2080)	17.2% (1270)	23.0% (1702)
36–45	15.3% (1538)	19.6% (1969)	15.3% (1484)	18.9% (1840)	17.1% (1268)	17.3% (1279)
46–55	21.7% (2185)	20.8% (2088)	19.4% (1883)	20.1% (1956)	21.2% (1570)	21.7% (1608)
56–65	35.6% (3585)	20.0% (2011)	29.0% (2821)	19.6% (1900)	34.2% (2528)	18.4% (1361)
Ethnicity						
White	81.5% (8195)	77.3% (7776)	85.5% (8301)	76.4% (7419)	85.2% (6304)	76.3% (5648)
Other/Mixed/Unstated	18.5% (1862)	22.7% (2281)	14.5% (1413)	23.6% (2295)	14.8% (1094)	23.7% (1750)
Education level						
Less than high school	8.7% (873)	15.4% (1552)	16.9% (1646)	15.2% (1474)	4.8% (358)	11.8% (870)
High school diploma or equivalent	15.4% (1548)	26.6% (2671)	16.1% (1567)	19.4% (1887)	13.6% (1003)	15.9% (1175)
Some college, associate degree, etc.[c]	42.4% (4268)	32.5% (3264)	30.1% (2925)	38.4% (3721)	34.7% (2567)	42.0% (3106)
Bachelor's degree or higher	32.9% (3309)	24.7% (2489)	36.6% (3551)	26.8% (2604)	46.7% (7384)	29.9% (2212)
Unstated	0.6% (59)	0.8% (81)	0.3% (25)	0.3% (28)	0.2% (14)	0.5% (36)
Income adequacy (ability to make ends meet)						
Very difficult	8.0% (806)	8.2% (822)	8.7% (847)	9.3% (901)	7.5% (554)	8.9% (656)
Difficult	19.9% (2000)	19.9% (2003)	21.7% (2107)	22.2% (2156)	19.2% (1423)	19.5% (1440)
Neither easy nor difficult	35.7% (3593)	35.9% (3612)	31.0% (3016)	31.6% (3066)	33.0% (2443)	32.1% (2375)
Easy	21.8% (2197)	21.3% (2145)	22.9% (2225)	12.9% (1251)	23.2% (1715)	22.8% (1689)
Very easy	11.8% (1183)	11.2% (1125)	13.7% (1330)	2.1% (202)	15.1% (1118)	13.6% (1009)
Unstated	2.8% (278)	3.5% (350)	1.9% (189)		2.0% (145)	3.1% (230)
Alcohol use						
Past 12 months	80.6% (8101)	77.9% (7837)	64.2% (6239)	64.0% (6220)	74.9% (5540)	67.5% (4991)
Tobacco cigarette use						
Past 12 months	21.2% (2134)	23.3% (2341)	19.5% (1897)	22.1% (2148)	17.9% (1324)	21.0% (1551)
Past 30 days	17.8% (1782)	19.5% (1947)	16.0% (1551)	18.2% (1761)	14.9% (1102)	17.2% (1266)
Cannabis use status (exclusive categories)						
Never user	41.8% (4205)	43.5% (4375)	47.0% (4568)	45.4% (4406)	34.0% (2513)	38.5% (2849)
Used >12 months ago	34.2% (3439)	29.0% (2914)	32.4% (3149)	30.9% (3000)	34.3% (2541)	27.3% (2017)
Used in past 12 months	8.5% (850)	8.6% (863)	6.8% (664)	7.0% (676)	10.1% (749)	9.4% (693)
Monthly user	4.0% (407)	4.9% (491)	4.4% (426)	5.2% (507)	5.8% (432)	6.8% (500)
Weekly user	4.0% (407)	5.2% (522)	3.4% (329)	4.1% (403)	5.2% (388)	6.8% (505)
Daily/almost daily user	7.4% (749)	8.9% (893)	6.0% (578)	7.4% (722)	10.5% (775)	11.3% (834)

SD = standard deviation.

[a] Nine US states (Alaska, California, Colorado, Maine, Massachusetts, Nevada, Oregon, Vermont, and Washington) were considered 'legal' states because they had legalized non-medical cannabis at the time of the study.

[b] Weighted to Canadian and US national populations and rescaled to sample size.

[c] This category includes: some college, technical/vocational training or college certificate/diploma; apprenticeship; and some university.

population (Statistics Canada, 2018a; US Census Bureau, 2019). The ICPS sample had lower self-reported general health than national sample estimates (Blackwell & Villarroel, 2017; Statistics Canada, 2019). This is a feature of many non-probability samples (Fahimi, Barlas, & Thomas, 2018), and may be partly due to the use of web surveys, which provide greater perceived anonymity than the in-person or telephone-assisted interviews often used in national surveys (Hays, Liu & Kapteyn, 2015).

Cannabis, alcohol, and tobacco use

Supplemental Table S8 summarizes the primary data sources for national estimates of cannabis prevalence in Canada and the US. As shown in Table S2, ICPS estimates for lifetime, monthly, and daily cannabis use in Canada were between the range of estimates from Canada's two national surveys, the Canadian Cannabis Survey (CCS), and the National Cannabis Survey (NCS), although much closer to the NCS estimates for comparable age ranges (Government of Canada, 2018c; Statistics Canada, 2018b). Mean age of first trying cannabis (19.3 years) was close to national estimates (18.6–18.9 years) (Government of Canada, 2018c; Statistics Canada, 2018c). Estimates of prevalence for types of cannabis products that were directly comparable to those measured in national surveys (e.g., dried herb, hash, edibles, concentrates) were consistent with national estimates, and any differences were likely due to differences in response options (Government of Canada, 2018c; Statistics Canada, 2018b).

In the US, prevalence estimates for cannabis use were higher than those reported by the National Survey on Drug Use and Health (NSDUH) (SAMHSA, 2019a). Reasons for the higher estimates in the ICPS may be due to sampling or differences in survey modes: whereas the NSDUH is a household survey completed with in-person interviews, the ICPS is conducted online, which provides greater anonymity and

promotes more truthful reporting on sensitive topics, such as substance use (Dodou & de Winter, 2014; Krumpal, 2013). It should also be noted that the different national surveys also provide different prevalence estimates for cannabis and other substance uses. For example, the NHANES survey provides estimates 20–30% higher than NSDUH (Alshaarawy and Anthony, 2017), similar to the current study. Therefore, while the ICPS estimates of cannabis use are higher than those of NSDUH, they are within the range of variability across benchmark surveys.

Overall, past 12-month alcohol use aligned with national estimates in all three jurisdictions (SAMHSA, 2019a; Statistics Canada, 2018b). In Canada, past 30-day and lifetime tobacco cigarette use were about 4–7% higher than national estimates, whereas e-cigarette use was similar to national estimates (Statistics Canada, 2018b). In the US, cigarette use was lower than national estimates, with the exception of past 30-day use among young people aged 18–25 years (SAMHSA, 2019a). This is likely due to differences in question wording: while NSDUH asked explicitly about cigarette use ('Have you ever smoked all or part of a cigarette?'), lifetime cigarette use in the ICPS was based on the question, 'Have you ever used any of the following drugs?' (followed by a list of drugs, including 'tobacco cigarettes') (Hammond et al., 2018; SAMHSA, 2019b). ICPS respondents may therefore have failed to report cigarette use if they had not used other drugs on the list.

Discussion

The rapid evolution of the cannabis market highlights the need for comprehensive, sustained monitoring of cannabis use in greater detail than is assessed in existing population-level surveys. The ICPS study provides detailed assessments of cannabis consumption, including the types of products being used, how they are sourced, and associations with problematic patterns of use.

Ultimately, the impact of cannabis legalization will not be determined simply by *whether* cannabis is legalized, but *how* it is regulated in a legal framework. Therefore, a primary objective of the ICPS is to examine differences in the emerging cannabis control frameworks by comparing Canadian provinces and US states that have legalized non-medical cannabis. The variation in policies between these 'legal' jurisdictions—including taxation levels, retail access, minimum age restrictions, and marketing restrictions—provides an opportunity to evaluate potential differences in effectiveness. Variables will be created to represent presence/absence or level of restrictiveness of specific policies and to examine these across jurisdictions.

To date, most of the literature examining the impact of legalization has relied upon cross-sectional surveys that are unable to distinguish between secular changes and those attributable to legalization. This is particularly problematic because jurisdictions with historically higher cannabis use prevalence may also be those more likely to legalize cannabis. The longitudinal design of the ICPS is better able to characterize secular trends in legal and illegal markets, and to account for potential state differences when assessing the impact of legalization. The longitudinal nature of the ICPS will also help to characterize the transition from illegal to legal markets. In most jurisdictions, it takes several years after legalization for the retail market to stabilize in terms of the number of stores and sufficient cannabis supply to meet demand. The ICPS will examine how quickly and to what extent consumers transition to legal cannabis sources, with the possibility that both the pace of this transition and the ultimate 'settling point' may differ across jurisdictions.

Limitations

It is becoming increasingly difficult for surveys to recruit representative population samples and the non-probability sampling used for the ICPS represents an important limitation. Declining response rates represent a challenge for population-based surveys (Groves, 2011). Random-digit-dialled phone surveys—the traditional methodology used for generating probability-based samples—suffer from response rates below 10%. Moreover, they are no longer suitable for surveying young people (Dennis & Li, 2007) because in Canada and the US, significantly less than half of 18–34-year-olds have a landline telephone (Blumberg & Luke, 2009; Blumberg et al., 2011; Statistics Canada, 2016). Including unlisted cell phone numbers in a sampling frame further reduces response rates, typically to under 5% (Blumberg & Luke, 2009).

Online survey methods are a well established, emerging mode of population-based survey research (Braunsberger, Wybenga & Gates, 2007). Until recently, online surveys were constrained by limited internet penetration. However, internet penetration now exceeds that of landlines, even among lower socioeconomic groups: in the US and Canada, the prevalence of internet use for personal use ranges from 96% – 98% among young adults, and daily usage rates exceed 90% (PEW Research Center, 2018; US Census Bureau, 2012). The use of the Nielsen panel provides a reliable form of online recruitment and a representative sample within each of the conditions, using the same mix of probability and non-probability sampling in Canada and the US. As indicated in the Supplementary Materials, the weighted ICPS sample profile is broadly representative with respect to national benchmark surveys although somewhat more educated in the US, with moderately higher prevalence of cannabis use in the US compared to national estimates. One notable exception is that the ICPS does not include respondents over the age of 65 due to very low prevalence levels in this age group Statistics Canada, 2019. In addition, the ICPS survey was only available to US respondents in English and not Spanish, which may have contributed to the under-representation of Hispanic respondents.

The overall study design emphasises comparisons over time between jurisdictions. Point estimates in any one survey wave may be biased in comparison with the 'true' population value but differences in trends between jurisdictions should not be attributable to the sampling design because the same methods are used across jurisdictions and over time to replenish respondents lost to attrition. Finally, the inclusion of sociodemographic variables—such as age, sex, education, and ethnicity—in all analytical models will help to control for potential sociodemographic differences across jurisdictions.

Social desirability bias represents a general limitation of self-reported survey measures. However, survey research is the only feasible method for estimating the prevalence of cannabis use, and is the method used in all national benchmark surveys (Government of Canada, 2018c; SAMHSA, 2019b; Statistics Canada, 2018b; US Census Bureau, 2018). As noted above, in an effort to mitigate any potential social desirability bias, the ICPS stresses the importance of honest reporting and the confidential nature of the survey. Respondents who report that they are unable to provide honest answers are excluded from analyses.

Longitudinal pre-post measurement of cannabis prevalence may include other biases. For example, prevalence of cannabis use prior to legalization was likely underreported due to the illegality of cannabis. Post-legalization data may be more reflective of truthful reporting. This idea is supported by the 2018 CCS, in which 31.4% of respondents indicated that they would be more willing to publicly report their cannabis use once legalized (Government of Canada, 2018c). For example, self-reporting of hospital visits may seem inflated post-legalization, particularly since public education messaging about overconsumption advises cannabis users to seek medical attention when needed. To overcome these biases, more attention should be placed on the differences between post-legalization years and between legal markets, to better determine changes in public health outcomes since legalization. These limitations highlight the importance and necessity of continued surveillance/monitoring in the years following legalization.

Conclusion

Legalization of cannabis production and sale for non-medical use represents one of the most significant developments in substance use policy over the past century. As the history of tobacco control has demonstrated, the impact of legalization is a process rather than a single event and its impact on public health will be affected by how the legal market is regulated (US Department of Health and Human Services, 2014). Considering that major tobacco control policies continue to evolve after more than 60 years of regulatory history, evidence on the effectiveness of specific cannabis policies will be important to inform the future evolution of cannabis policies and assess the overall public health impact of legalization.

CRediT authorship contribution statement

David Hammond: Conceptualization, Methodology, Investigation, Writing - original draft, Supervision, Funding acquisition. **Samantha Goodman:** Investigation, Formal analysis, Writing - original draft, Writing - review & editing, Project administration. **Elle Wadsworth:** Investigation, Writing - review & editing. **Vicki Rynard:** Formal analysis, Writing - review & editing. **Christian Boudreau:** Formal analysis, Writing - review & editing. **Wayne Hall:** Writing - review & editing.

Declarations of Competing Interest

None.

Acknowledgments

Funding for this study was provided by a Canadian Institutes of Health Research (CIHR) Project Bridge Grant (PJT-153342) and a CIHR Project Grant. Additional support was provided by a Public Health Agency of Canada-CIHR Chair in Applied Public Health (Hammond). We would also like to thank Hanan Abramovici, George Mammen, Lily Fang, Anton Maslov and Sailly Dave for their feedback on a draft of the manuscript.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.drugpo.2020.102698.

References

Alaska Department of Health and Social Services. (2016). Data statistics: Marijuana use in Alaska and the United States. Office of Substance Misuse and Addiction Prevention. From http://dhss.alaska.gov/dph/Director/Documents/marijuana/MJ_AKandUS_DataSurveySummary.pdf.

Alshaarawy, O., & Anthony, J. C. (2017). The replicability of cannabis use prevalence estimates in the United States. *International Journal of Methods in Psychiatric Research, 26*(2), https://doi.org/10.1002/mpr.1524 10.1002/mpr.1524.

American Association of Public Opinion Research (AAPOR), (2010). Report on online panels. From https://www.aapor.org/Education-Resources/Reports/Report-on-Online-Panels.

American Association of Public Opinion Research (AAPOR). (2019). Online panels. From https://www.aapor.org/Education-Resources/Election-Polling-Resources/Online-Panels.aspx.

Azofeifa, A., Mattson, M., Schauer, G., MCAfee, T., Grant, A., & Lyerla, R. (2016). National estimates of marijuana use and related indicators—National Survey on Drug Use and Health, United States, 2002–2014. *Morbidity and Mortality Weekly Report: Surveillance Summaries, 65*, 1–25 From http://dx.doi.org/10.15585/mmwr.ss6511a1.

Blackwell, D., & Villarroel, M. (2017). Tables of summary health statistics for U.S. Adults: 2017 National Health Interview Survey. National Center for Health Statistics. Table A-11a. Age-adjusted percent distribution (with standard errors) of respondent-assessed health status among adults aged 18 and over, by selected characteristics. From https://ftp.cdc.gov/pub/Health_Statistics/NCHS/NHIS/SHS/2017_SHS_Table_A-11.pdf.

Blumberg, S., & Luke, J. (2009). Reevaluating the need for concern regarding noncoverage bias in landline surveys. *American Journal of Public Health, 99*(10), 1806–1810. https://doi.org/10.2105/ajph.2008.152835.

Blumberg, S., Luke, J., Ganesh, N., Davern, M., Boudreaux, M., & Soderberg, K. (2011). Wireless substitution: state-level estimates from the National Health Interview Survey, January 2007-June 2010. *National Health Statistics Reports, 39*, 1–26 28. From https://www.ncbi.nlm.nih.gov/pubmed/21568134.

Borodovsky, J., Lee, D., Crosier, B., Gabrielli, J., Sargent, J., & Budney, A. (2017). U.S. cannabis legalization and use of vaping and edible products among youth. *Drug and Alcohol Dependence, 177*, 299–306. https://doi.org/10.1016/j.drugalcdep.2017.02.017.

Braunsberger, K., Wybenga, H., & Gates, R. (2007). A comparison of reliability between telephone and web-based surveys. *Journal of Business Research, 60*(7), 758–764. https://doi.org/10.1016/j.jbusres.2007.02.015.

Brooks-Russell, A., Ma, M., Levinson, A. H., Kattari, L., Kirchner, T., Anderson Goodell, E. M., et al. (2019). Adolescent marijuana use, marijuana-related perceptions, and use of other substances before and after initiation of retail marijuana sales in Colorado (2013-2015). *Prevention Science, 20*(2), 185–193. https://doi.org/10.1007/s11121-018-0933-2.

Bull, S. S., Brooks-Russell, A., Davis, J. M., Roppolo, R., & Corsi, K. (2017). Awareness, perception of risk and behaviors related to retail marijuana among a sample of Colorado youth. *Journal of Community Health, 42*(2), 278–286. https://doi.org/10.1007/s10900-016-0253-z.

Canadian Centre on Substance Abuse and Addiction. (2015). *Cannabis regulation: lessons learned in Colorado and Washington State.* Canadian Centre on Substance Abuse and Addiction From http://www.ccsa.ca/Resource%20Library/CCSA-Cannabis-Regulation-Lessons-Learned-Report-2015-en.pdf.

Canadian Institute for Health Information. (2019). *Deprivation in Canadian cities: an analytical tool.* From https://www.cihi.ca/en/deprivation-in-canadian-cities-an-analytical-tool.

Canadian Public Health Association. (2018). *Provincial and territorial cannabis regulations summaries.* From https://www.cpha.ca/provincial-and-territorial-cannabis-regulations-summaries.

Cao, D., Srisuma, S., Bronstein, A. C., & Hoyte, C. O. (2016). Characterization of edible marijuana product exposures reported to United States poison centers. *Clinical Toxicology, 54*(9), 840–846. https://doi.org/10.1080/15563650.2016.1209761.

Carlini, B. H., Garrett, S. B., & Harwick, R. M. (2017). Beyond joints and brownies: marijuana concentrates in the legal landscape of WA State. *International Journal of Drug Policy, 42*, 26–29. https://doi.org/10.1016/j.drugpo.2017.01.004.

Cerda, M., Wall, M., Feng, T., Keyes, K. M., Sarvet, A., Schulenberg, J., et al. (2017). Association of state recreational marijuana laws with adolescent marijuana use. *JAMA Pediatrics, 171*(2), 142–149. https://doi.org/10.1001/jamapediatrics.2016.3624.

Colorado Department of Public Health & Environment. (2018). *Monitoring health concerns related to marijuana in Colorado: 2018.* From https://drive.google.com/file/d/1cyaRNiT7fUVD2VMb91ma5bLMuvtc9jZy/view?usp=sharing.

Couper, F. J., & Peterson, B. L. (2014). The prevalence of marijuana in suspected impaired driving cases in Washington State. *Journal of Analytical Toxicology, 38*(8), 569–574. https://doi.org/10.1093/jat/bku090.

Daniulaityte, R., Zatreh, M. Y., Lamy, F. R., Nahhas, R. W., Martins, S. S., Sheth, A., et al. (2018). A Twitter-based survey on marijuana concentrate use. *Drug and Alcohol Dependence, 187*, 155–159. https://doi.org/10.1016/j.drugalcdep.2018.02.033.

Davenport, S. S., & Caulkins, J. P. (2016). Evolution of the United States marijuana market in the decade of liberalization before full legalization. *Journal of Drug Issues, 46*(4), 411–427. https://doi.org/10.1177/0022042616659759.

Davis, A. J., Geisler, K. R., & Nichols, M. W. (2016). The price elasticity of marijuana demand: evidence from crowd-sourced transaction data. *Empirical Economics, 50*(4), 1171–1192. https://doi.org/10.1007/s00181-015-0992-1.

Dennis, M., & Li, R. (2007). More honest answers to surveys? A study of data collection mode effects. *Journal of Online Research, 10*(7), 1–15.

Dodou, D., & de Winter, J. (2014). Social desirability is the same in offline, online, and paper surveys: a meta-analysis. *Computers in Human Behavior, 36*, 487–495. https://doi.org/10.1016/j.chb.2014.04.005.

Fahimi, M., FM&, Barlas, F. M., & Thomas, R. K. (2018). A practical guide for surveys based on nonprobability samples [Webinar]. *American Association for Public Opinion Research (AAPOR)*. https://www.gfk.com/fileadmin/user_upload/dyna_content/US/documents/A_practical_guide_for_surveys_based_on_nonprobability_samples_webinar.pdf.

Fischer, B., Russell, C., Sabioni, P., van den Brink, W., Le Foll, B., Hall, W., et al. (2017). Lower-Risk Cannabis Use Guidelines: a comprehensive update of evidence and recommendations. *American Journal of Public Health, 107*(8), e1–e12. https://doi.org/10.2105/ajph.2017.303818.

Fong, G. T., Cummings, K. M., Borland, R., Hastings, G., Hyland, A., Giovino, G. A., et al. (2006). The conceptual framework of the International Tobacco Control (ITC) Policy Evaluation Project. *Tobacco Control, 15*(suppl 3), iii3–iii11. https://doi.org/10.1136/tc.2005.015438.

Glanz, K., Sallis, J. F., Saelens, B. E., & Frank, L. D. (2005). Healthy nutrition environments: concepts and measures. *American Journal of Health Promotion, 19*(5), 330–333. https://doi.org/10.4278/0890-1171-19.5.330.

Goodman, S., & Hammond, D. (2019). *International Cannabis Policy Study: Technical report – Wave 1 (2018).* University of Waterloo From http://cannabisproject.ca/methods/.

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. https://doi.org/10.1177/1049732318820523.

Government of Canada. (2018). *Cannabis regulations (SOR/2018-144).* Cannabis Act From https://laws-lois.justice.gc.ca/eng/regulations/SOR-2018-144/FullText.html.

Government of Canada. (2018). *Budget 2018. Equality + growth: a strong middle class.* Ottawa, ON: Department of Finance From https://www.budget.gc.ca/2018/docs/plan/budget-2018-en.pdf.

Government of Canada. (2018). *Canadian Cannabis Survey 2018 summary.* Health Canada

From https://www.canada.ca/en/services/health/publications/drugs-health-products/canadian-cannabis-survey-2018-summary.html.
Government of Canada. (2019). *What you need to know about cannabis.* From https://www.canada.ca/en/services/health/campaigns/cannabis/canadians.html.
Groves, R. (2011). Three eras of survey research. *Public Opinion Quarterly, 75*(5), 861–871. https://doi.org/10.1093/poq/nfr057.
Groves, R., Fowler, F., Couper, M., Lepkowski, J., Singer, E., & Tourangeau, R. (2009). *Survey methodology* (2nd ed.). Hoboken, New Jersey: John Wiley & Sons.
Hall, W., & Kozlowski, L. T. (2018). The diverging trajectories of cannabis and tobacco policies in the United States: reasons and possible implications. *Addiction, 113*(4), 595–601. https://doi.org/10.1111/add.13845.
Hammond, D. (2011). Health warning messages on tobacco products: a review. *Tobacco Control, 20*(5), 327. https://doi.org/10.1136/tc.2010.037630.
Harpin, S. B., Brooks-Russell, A., Ma, M., James, K. A., & Levinson, A. H. (2018). Adolescent marijuana use and perceived ease of access before and after recreational marijuana implementation in Colorado. *Substance Use and Misuse, 53*(3), 451–456. https://doi.org/10.1080/10826084.2017.1334069.
Hays, R. D., Liu, H., & Kapteyn, A. (2015). Use of internet panels to conduct surveys. *Behavior Research Methods, 47*(3), 685–690. https://doi.org/10.3758/s1342.
Hammond, D., Goodman, S., Leos-Toro, C., Wadsworth, E., Reid, J. L., Hall, W., et al. https://cannabisproject.ca/methods/.
Institut national de santé publique. (2019). *Deprivation index.* From https://www.inspq.qc.ca/en/information-management-and-analysis/deprivation-index.
International Agency for Research on Cancer. (2008). *Methods for evaluating tobacco control policies. Handbooks of Cancer Prevention12*International Agency for Research on Cancerhttp://www.iarc.fr/en/publications/pdfs-online/prev/handbook12/index.php.
Jessor, R. (1985). *Bridging etiology and prevention in drug abuse research US Department of Health and Human Services*. Rockville, MD: National Institute on Drug Abuse (NIDAFrom. https://archives.drugabuse.gov/sites/default/files/monograph56.pdf.
Johnson, J. S. (2016). Improving online panel data usage in sales research. *Journal of Personal Selling & Sales Management, 36*(1), 74–85. https://doi.org/10.1080/08853134.2015.1111611.
Jones, J., Jones, N. K., & Peil, J. (2018). The impact of the legalization of recreational marijuana on college students. *Addictive Behaviors, 77*, 255–259. https://doi.org/10.1016/j.addbeh.2017.08.015.
Kerr, D. C. R., Bae, H., & Koval, A. L. (2018). Oregon recreational marijuana legalization: changes in undergraduates' marijuana use rates from 2008 to 2016. *Psychology of Addictive Behaviors, 32*(6), 670–678. https://doi.org/10.1037/adb0000385.
Kerr, D. C. R., Bae, H., Phibbs, S., & Kern, A. C. (2017). Changes in undergraduates' marijuana, heavy alcohol and cigarette use following legalization of recreational marijuana use in Oregon. *Addiction, 112*(11), 1992–2001. https://doi.org/10.1111/add.13906.
Krumpal, I. (2013). Determinants of social desirability bias in sensitive surveys: a literature review. *Quality & Quantity, 47*(4), 2025–2047. https://doi.org/10.1007/s11135-011-9640-9.
Leos-Toro, C. (2019a). *Health warnings, cannabis marketing and perceptions among youth and young adults in Canada.* Waterloo, ON: University of Waterloo (Doctoral Dissertation). From http://hdl.handle.net/10012/14544.
Macdonald, R., & Rotermann, M. (2017). *Experimental estimates of cannabis consumption in Canada, 1960 to 2015.* Ottawa, ON: Economic Analysis Division and Health Analysis Division From https://www150.statcan.gc.ca/n1/en/pub/11-626-x/11-626-x2017077-eng.pdf?st=Um9_wcgR.
Mahamad, S., & Hammond, D. (2019). Retail price and availability of illicit cannabis in Canada. *Addictive Behaviors, 90*, 402–408. https://doi.org/10.1016/j.addbeh.2018.12.001.
Mason, W. A., Fleming, C. B., Ringle, J. L., Hanson, K., Gross, T. J., & Haggerty, K. P. (2016). Prevalence of marijuana and other substance use before and after Washington State's change from legal medical marijuana to legal medical and non-medical marijuana: cohort comparisons in a sample of adolescents. *Substance Abuse, 37*(2), 330–335. https://doi.org/10.1080/08897077.2015.1071723.
Miller, A. M., Rosenman, R., & Cowan, B. W. (2017). Recreational marijuana legalization and college student use: early evidence. *SSM - Population Health, 3*, 649–657. https://doi.org/10.1016/j.ssmph.2017.08.001.
National Conference of State Legislatures. (2019). *State medical marijuana laws.* National Conference of State Legislatures From http://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx.
National Institute on Drug Abuse. (2018). *DrugFacts: Monitoring the Future Survey: high school and youth trends.* National Institute on Drug Abuse From https://d14rmgtrwzf5a.cloudfront.net/sites/default/files/drugfacts-mtf.pdf.
Pacula, R., Kilmer, B., Wagenaar, A., Chaloupka, F., & Caulkins, J. (2014). Developing public health regulations for marijuana: lessons from alcohol and tobacco. *American Journal of Public Health, 104*(6), 1021–1028. https://doi.org/10.2105/AJPH.2013.301766.
Pacula, R., & Lundberg, R. (2014). Why changes in price matter when thinking about marijuana policy: a review of the literature on the elasticity of demand. *Public Health Reviews, 35*(2), 1–18.
Parliament of Canada. (2018). *C-45: an Act respecting cannabis and to amend the Controlled Drugs and Substances Act, the Criminal Code and other Acts.* Ottawa, ON: LEGISinfo From http://www.parl.ca/LegisInfo/BillDetails.aspx?billId=8886269&Language=E&Mode=1.
Parnes, J. E., Smith, J. K., & Conner, B. T. (2018). Reefer madness or much ado about nothing? Cannabis legalization outcomes among young adults in the united states. *International Journal of Drug Policy, 56*, 116–120. https://doi.org/10.1016/j.drugpo.2018.03.011.
PEW Research Center. (2018). *Internet penetration rates are high in North America, Europe and parts of the Asia-Pacific.* From http://www.pewglobal.org/2018/06/19/social-media-use-continues-to-rise-in-developing-countries-but-plateaus-across-developed-ones/pg_2018-06-19_global-tech_0-01/.
Reed, J. (2018). *Impacts of marijuana legalization in Colorado: a report pursuant to Senate Bill 13-283*. Colorado Department of Public Safety, Colorado Division of Criminal Justice. Fromhttps://cdpsdocs.state.co.us/ors/docs/reports/2018-SB13-283_Rpt.pdf.
Reuter, P., & Mark, A. R. K. (1986). Risks and prices: an economic analysis of drug enforcement. *Crime and Justice, 7*, 289–340 From http://www.jstor.org/stable/1147520.
Rocky Mountain High Intensity Drug Trafficking Area. (2017). *The legalization of marijuana in Colorado: the impact.* Rocky Mountain High Intensity Drug Trafficking Area, Strategic Intelligence Unit From https://www.rmhidta.org/html/FINAL%202017%20Legalization%20of%20Marijuana%20in%20Colorado%20The%20Impact.pdf.
Russell, C., Rueda, S., Room, R., Tyndall, M., & Fischer, B. (2018). Routes of administration for cannabis use - basic prevalence and related health outcomes: a scoping review and synthesis. *International Journal of Drug Policy, 52*, 87–96. https://doi.org/10.1016/j.drugpo.2017.11.008.
Schleimer, J. P., Rivera-Aguirre, A. E., Castillo-Carniglia, A., Laqueur, H. S., Rudolph, K. E., Suárez, H., et al. (2019). Investigating how perceived risk and availability of marijuana relate to marijuana use among adolescents in Argentina, Chile, and Uruguay over time. *Drug and Alcohol Dependence, 201*, 115–126.
Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.
Smart, R., & Pacula, R. L. (2019). Early evidence of the impact of cannabis legalization on cannabis use, cannabis use disorder, and the use of other substances: findings from state policy evaluations. *American Journal of Drug and Alcohol Abuse,* 1–20. https://doi.org/10.1080/00952990.2019.1669626.
Statistics Canada. (2019). *Canadian Community Health Survey (CCHS) 2017 Annual Component.* Government of Canada Table 13-10-0096-02 Perceived health, by age group. From https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310009602.
Statistics Canada. (2018). *Canadian Tobacco, Acohol and Drugs Survey (CTADS), 2017.* Government of Canada From http://www23.statcan.gc.ca/imdb/p3Instr.pl?Function=assembleInstr&lang=en&Item_Id=337407.
Statistics Canada. (2019). *Education highlight tables, 2016 Census.* Government of Canada From https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/edu-sco/Table.cfm?Lang=E&T=11&Geo=00&SP=1&view=2&age=1&sex=1.
Statistics Canada. (2016). *Residential Telephone Service Survey*. Government of Canada From https://www.statcan.gc.ca/eng/survey/household/4426.
Statistics Canada. (2018). *Table 1. Prevalence of past-year cannabis use, by age group and sex, household population aged 15 or older, Canada excluding territories, 2015.* Government of Canada From https://www150.statcan.gc.ca/n1/pub/82-003-x/2018002/article/54908/tbl/tbl01-eng.htm.
Statistics Canada. (2019). *Table 17-10-0005-01. Population estimates on July 1st, by age and sex, 2017.* Government of Canada From https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501.
Statistics Canada. (2018). *2015 Canadian Community Health Survey (CCHS): Ethnic origin, 2015.* Government of Canada From http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3226.
Statistics Canada. (2019). *2016 Census.* From https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/dt-td/Rp-eng.cfm?LANG=E&APATH=3&DETAIL=0&DIM=0&FL=A&FREE=0&GC=0&GID=0&GK=0&GRP=1&PID=110634&PRID=10&PTYPE=109445&S=0&SHOWALL=0&SUB=0&Temporal=2017&THEME=123&VID=0&VNAMEE=&VNAMEF.
Statistics Canada. (2019). *National Cannabis Survey, second quarter 2019.* Government of Canada From https://www150.statcan.gc.ca/n1/daily-quotidien/190815/dq190815a-eng.htm.
Substance Abuse and Mental Health Services Administration (SAMHSA). (2017). *National Survey on Drug Use and Health: Comparison of 2008-2009 and 2016-2017 population percentages (50 states and the District of Columbia)*. Substance Abuse and Mental Health Services Administration From https://www.samhsa.gov/data/report/comparison-2008-2009-and-2016-2017-nsduh-state-prevalence-estimates.
Substance Abuse and Mental Health Services Administration (SAMHSA). (2019). *2018 National Survey on Drug Use and Health (NSDUH) Public Use Codebook.* Substance Abuse and Mental Health Services Administration From https://www.cdc.gov/rdc/data/b1/2018-FinalAnalytic-Codebook-RDC508.pdf.
Substance Abuse and Mental Health Services Administration (SAMHSA). (2019). *Key substance use and mental health indicators in the United States: results from the 2018 national survey on drug use and health (HHS publication no. PEP19-5068, NSDUH series H-54).* Rockville, MD: Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration From https://www.samhsa.gov/data/sites/default/files/cbhsq-reports/NSDUHNationalFindingsReport2018/NSDUHNationalFindingsReport2018.pdf.
US Census Bureau. (2017). *Current Population Survey, 2017 Annual Social and Economic Supplement. Table 1. Educational attainment of the population 18 years and over, sex, race, and Hispanic origin: 2017.* US Census Bureau From https://www2.census.gov/programs-surveys/demo/tables/educational-attainment/2017/cps-detailed-tables/table-1-1.xlsx.
US Census Bureau. (2018). *Current Population Survey 2018.* US Census Bureau From https://www.census.gov/cps/data/cpstablecreator.html.
US Census Bureau. (2017). *2013-2017 American Community Survey 5-Year estimates.* US Census Bureau From https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_17_5YR_S1501&src=pt.
US Census Bureau. (2012). *Calculated using penetration rate and population data from "Countries and areas ranked by population: 2012"* US Census Bureau From http://www.census.gov/population/international/data/idb/rank.php.
US Department of Health and Human Services. (2014). *The Health Consequences of*

Smoking: 50 Years of Progress A Report of the Surgeon General. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

US Census Bureau. (2019). *US Current Population Survey: Table 1. Population by age, sex, and race: 2018.* US Census Bureau From https://www.census.gov/data/tables/2018/demo/hispanic-origin/2018-cps.html.

US Surgeon General. (2012). *U.S. Department of Health and Human Services. Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion.* Atlanta, GA: Office on Smoking and Health1–899 From https://www.surgeongeneral.gov/library/reports/preventing-youth-tobacco-use/full-report.pdf.

Vigil, D. I., Van Dyke, M., Hall, K. E., Contreras, A. E., Ghosh, T. S., & Wolk, L. (2018). Marijuana use and related health care encounters in Colorado before and after retail legalization. *International Journal of Mental Health and Addiction, 16*(4), 806–812. https://doi.org/10.1007/s11469-018-9901-0.

Wang, G. S., Le Lait, M.-. C., Deakyne, S. J., Bronstein, A. C., Bajaj, L., & Roosevelt, G. (2016). Unintentional pediatric exposures to marijuana in Colorado, 2009-2015. *JAMA Pediatrics, 170*(9), https://doi.org/10.1001/jamapediatrics.2016.0971 e160971-e160971.

Washington State Office of Financial Management. (2016). *Monitoring impacts of recreational marijuana legalization: 2016 update report.* From https://www.ofm.wa.gov/sites/default/files/public/legacy/reports/marijuana_impacts_update_2016.pdf.

World Health Organization. (2013). *WHO report on the global tobacco epidemic, 2013: enforcing bans on tobacco advertising, promotion and sponsorship.* Geneva, Switzerland: World Health Organization From http://apps.who.int/iris/bitstream/handle/10665/85380/9789241505871_eng.pdf;jsessionid=8F859D52E050FB353233DFF6206D6138?sequence=1.

World Health Organization, (2019). WHO - ASSIST v.3.0. From https://www.who.int/substance_abuse/activities/assist_v3_english.pdf.

Zhang, Z., Zheng, X., Zeng, D. D., & Leischow, S. J. (2016). Tracking dabbing using search query surveillance: a case study in the United States. *Journal of Medical Internet Research, 18*(9), e252. https://doi.org/10.2196/jmir.5802.