Cannabis legalization and cannabis use, daily cannabis use and cannabis-related problems among adults in Ontario, Canada (2001–2019)

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ABSTRACT

Background: In the context of cannabis legalization in Canada, we examined the effects on cannabis patterns of consumption, including cannabis use, daily cannabis use and cannabis-related problems. In addition, we examined differential effects of cannabis legalization by age and sex.
Methods: A pre-post design was operationalized by combining 19 iterations of the Centre for Addiction and Mental Health (CAMH) Monitor Surveys (N = 52,260; 2001–2019): repeated, population-based, cross-sectional surveys of adults in Ontario. Participants provided self-reports of cannabis use (past 12 months), daily cannabis use (past 12 months) and cannabis-related problems though telephone interviews. The effects of cannabis legalization on cannabis patterns of consumption were examined using logistic regression analyses, with testing of two-way interactions to determine differential effects by age and sex.
Results: Cannabis use prevalence increased from 11 % to 26 % (p < 0.0001), daily cannabis use prevalence increased from 1 % to 6 % (p < 0.0001) and cannabis-related problems prevalence increased from 6 % to 14 % (p < 0.0001) between 2001 and 2019. Cannabis legalization was associated with an increased likelihood of cannabis use (OR, 95 % CI: 1.62, 1.40–1.86), daily cannabis use (1.59, 1.21–2.07) and cannabis-related problems (1.53, 1.20–1.95). For cannabis-related problems, a significant two-way interaction was observed between cannabis legalization and age (p = 0.0001), suggesting differential effects among adults ≥55 years.
Conclusions: Cannabis legalization was associated with an increased likelihood of cannabis use, daily cannabis use and cannabis-related problems. Given increases in these cannabis patterns of consumption, broader dissemination and uptake of targeted prevention tools is indicated.

1. Introduction

The Cannabis Act (Bill C-45) became effective on October 17, 2018 in Canada, which outlines the legal and regulatory framework to control the legal production, distribution, sale and possession of cannabis (Government of Canada, 2021b). The theoretical underpinnings of cannabis legalization include prevention of youth access and displacement of the illegal market, with the ultimate goal to institute regulations to enable a public health approach to cannabis use (Government of Canada, 2021b). As part of this comprehensive legislation, adults are allowed to possess up to 30 g of cannabis, purchase cannabis from authorized retailers and grow up to four cannabis plants per residence for personal consumption (Government of Canada, 2021b). Importantly, provinces and territories are responsible for setting additional restrictions pertaining to minimum age, place of purchase, place of consumption and possession amounts (Government of Canada, 2021b). In the context of the most populous province of Ontario, adults 19 years and older can purchase up to 30 g of cannabis online from the provincial cannabis retailer and wholesaler or in-person from a government authorized private retailer (Government of Ontario, 2021).

Cannabis legalization may result in potential public health benefits, including reduction of social stigma and mitigation of the impacts of criminalization, as well as generation of a source of tax revenue that can be re-directed towards health promotion and education (Hajizadeh, 2016). However, the health and social outcomes of cannabis legalization remain unclear. As a range of cannabis-attributable adverse health outcomes have been documented (Campeny et al., 2020), large population shifts in cannabis use, especially frequent or intensive cannabis use, may result in increases in the cannabis-attributable burden of disease (Imtiaz et al., 2016), necessitating an assessment of the effect of cannabis legalization on cannabis patterns of consumption. Among states that have enacted cannabis legalization despite the federal prohibition in the United States, increases were found in cannabis use during the past month, frequent cannabis use during the past month and cannabis use disorder during the past year among adults 26 years and older, but not among adults between 18 and 25 years (Cerda et al., 2020; Hall and Lynskey, 2020). While there is limited evidence regarding the effects of cannabis legalization in Canada, previous research has shown that cannabis use increased among non-representative samples of women experiencing pelvic pain (Geoffrion et al., 2021), women in the pre-conception pregnancy period (Bayrampour and Asim, 2021) and patients of a primary care clinic (Steinberg, Meng, Kapanen, Reardon, and Yuen, 2021) in British Columbia and Ontario. Although these preliminary findings are insightful, further evidence is needed due to the limited generalizability.

Findings from national surveys can provide useful insights regarding changes in cannabis patterns of consumption at the population level. Based on the National Cannabis Survey (NCS) from Statistics Canada, cannabis use during the past three months increased from 15 % in 2018 to 17 % in 2019, and daily cannabis use during the past three months remained unchanged between 2018 and 2019 (Rotermann, 2020). In Ontario, findings suggestive of a potential increase in both of these cannabis patterns of consumption were observed, but were non-significant (Rotermann, 2020). The Canadian Cannabis Survey (CCS) from Health Canada demonstrated that cannabis use during the past 12 months increased from 22 % in 2018 to 25 % in 2019, but the frequency of cannabis use during the past 12 months remained unchanged, with the majority of participants reporting consumption of up to three days per month (Government of Canada, 2019a). Less is known about cannabis-related problems. In a prospective cohort of community adults in Ontario, changes were not observed overall in the severity of cannabis misuse during the 12-month period following cannabis legalization (Turna et al., 2021). However, among those who used cannabis at baseline, the severity of cannabis misuse decreased, whereas among those who did not use cannabis at baseline, but used cannabis during the follow-up, the severity of cannabis misuse increased (Turna et al., 2021).

These findings were attributable to the rise in frequency of cannabis use, as supplementary analyses suggested that changes in cannabis misuse were largely driven by changes in frequency of cannabis use (Turna et al., 2021).

Both of the NCS and CCS were initiated a year prior to cannabis legalization (Government of Canada, 2019a; Rotermann, 2020), which precludes consideration of long-term trends in cannabis patterns of consumption. In addition, jurisdiction-specific estimates are not publicly available from the CCS. Furthermore, the differential effects of cannabis legalization on cannabis patterns of consumption by age and sex have not been adequately explored. As younger adults and males have demonstrated greater rates of cannabis consumption, consequences and impacts, it is important to understand if the effects of cannabis legalization are more pronounced in some demographic subgroups than others (Government of Canada, 2019b; Imtiaz et al., 2016; Jeffers, Glantz, Byers, and Keyhani, 2021; Lev-Ran et al., 2012). Accordingly, we addressed these knowledge gaps in a pre-post design using a repeated, population-based, cross-sectional survey of adults that has been conducted for more than four decades in Ontario. Our specific objectives were to: (1) examine the effects of cannabis legalization on cannabis use, daily cannabis use and cannabis-related problems; and (2) examine differential effects of cannabis legalization on cannabis patterns of consumption by age and sex.

2. Methods

2.1. Study design

A pre-post design was operationalized by aggregating together individual level observations from multiple iterations of a population-based survey into a pooled database.

2.2. Data source

Data were obtained from 19 iterations of the Centre for Addiction and Mental Health's (CAMH) Monitor Survey (2001–2019), a repeated, population-based, cross-sectional survey of adults 18 years and older in Ontario (Nigatu et al., 2020). Based on random-digit-dialing procedures, the sampling methodology entailed regional stratification by six geographical units with equal sample size allocation, and two-stage (telephone number, household respondent) probability selection of telephone numbers (Nigatu et al., 2020). The samples were drawn on a rolling basis each annual quarter, but the annual quarters were subsequently combined together to generate the annual samples (Nigatu et al., 2020). To address the increasing non-coverage due to households with cell phones only, a dual sampling frame comprised of a province-wide list-assisted random-digit-dialing sampling frame and a province-wide cell phone random-digit-dialing sampling frame was operationalized starting in 2017 (Nigatu et al., 2020). More than 52,000 respondents participated in the surveys between 2001 and 2019, with response rates ranging from 28 % (2019) to 61 % (2001) (see Table S1 in Supplementary Appendix for survey administration dates, sample sizes and response rates) (Nigatu et al., 2020). After obtaining informed consent for participation, computer-assisted telephone interviewing was used to collect anonymous responses to a questionnaire, which covered a range of topics related to substance use and mental health (Nigatu et al., 2020). Importantly, a mixed matrix interview design, comprising two-split ballot panels, was employed in the data collection to reduce response burden. As such, participants were randomly assigned to received one-of-two panel questionnaires, with some core items common between the two panel questionnaires (Nigatu et al., 2020). Further information regarding the surveys is available elsewhere (Nigatu et al., 2020).

2.3. Measures

2.3.1. Outcomes

Cannabis use (yes vs. no) and daily cannabis use (yes vs. no) were derived based on responses to the item, "How many times, if any, have you used cannabis, marijuana or hash during the past 12 months?": never, less than once a month, once a month, two to three times a month, once a week, two to three times a week, four to five times a week, about every day and more than once a day. These responses were dichotomized to reflect cannabis use (less than once a month to more than once a day) versus no cannabis use (never) during the past 12 months, and daily cannabis use (about every day and more than once a day) versus non-daily cannabis use (never to four to five times a week) during the past 12 months.

Cannabis-related problems (low risk vs. moderate to high risk; available from 2004 to 2019) were determined through the Cannabis Involvement Score from the World Health Organization's Alcohol, Smoking and Substance Involvement Screening Test (ASSIST Version 3.0), a screening instrument designed to assess the risk of experiencing problems due to substance use (WHO ASSIST Working Group, 2002). Based on responses to six items encompassing frequency of use, strong desire to use, legal or financial problems from use, lack of control over use, inability to meet expectations due to use and having someone express concerns about use, a protocol is used to derive scores ranging from 0 to 39 (see Table S2 in Supplementary Appendix for the items) (WHO ASSIST Working Group, 2002). These scores can be further categorized as low risk (0–3), moderate risk (4–26) and high risk ($\geq$27) of experiencing problems due to cannabis use (WHO ASSIST Working Group, 2002). As only 49 participants in the sample reported high risk of cannabis-related problems, meaningful assessments of change were not possible within this subgroup. Therefore, the scores were dichotomized to reflect low risk versus moderate to high risk of experiencing problems due to cannabis use.

2.3.2. Exposures

The main exposure was onset of cannabis legalization, which was coded as "post-cannabis legalization" for all observations from and after October 2018 and "pre-cannabis legalization" for all observations before October 2018. As the amplified public discourse potentially contributed to increases in cannabis patterns of consumption in the pre-cannabis legalization period, three-level cannabis legalization exposures were additionally tested in sensitivity analyses. The pre-cannabis legalization period was split based on one-of-two developments: 1) change in the leadership of the Liberal Party of Canada (April 13, 2013), when Justin Trudeau was elected as leader, the first leader of a major political party to support cannabis legalization in Canada (pre-cannabis legalization – before change in leadership of Liberal Party of Canada, pre-cannabis legalization – after change in leadership of Liberal Party of Canada, post-cannabis legalization) (Leblanc and Dhillon, 2013); and 2) announcement of the formation of the Task Force on Cannabis Legalization and Regulation (June 30, 2016), the first concrete step taken by the Government of Canada towards exploring the possibility of cannabis legalization (pre-cannabis legalization – before announcement of formation of task force, pre-cannabis legalization – after announcement of formation of task force, post-cannabis legalization) (Health Canada, 2016).

2.3.3. Covariates

Other covariates included survey year (continuous), sex at birth (male, female), age (18 – 34, 35 – 54, $\geq$ 55), marital status (never married, married or living with a partner, previously married [widowed, divorced or separated]), educational attainment (less than or completion of high-school, some or completion of post-secondary school) and income (< $50,000, $\geq$ $50,000, Not Stated).

2.4. Statistical analyses

Cross-tabulations between sex, age, marital status, educational attainment and income and cannabis legalization were generated to determine differences in characteristics of participants in the pre-cannabis legalization and post-cannabis legalization periods, with chi-square tests used to compare the distributions. Trends in cannabis use, daily cannabis use and cannabis-related problems were then characterized and tested using chi-square tests. Thereafter, associations between cannabis legalization and cannabis use, daily cannabis use and cannabis-related problems were tested using logistic regression analyses. For each of the three cannabis patterns of consumption, two separate models were constructed: 1) unadjusted model (including cannabis legalization and survey year); 2) adjusted model (including cannabis legalization, survey year, sex, age, marital status, educational attainment and income). Predicted probabilities in the pre-cannabis legalization period and post-cannabis legalization period for each of the cannabis patterns of consumption were generated along with the odds ratios (ORs) from the logistic regression analyses. Two-way interactions between cannabis legalization and sex and age were tested next to examine differential effects of cannabis legalization on each of the three cannabis patterns of consumption. However, given the number of simultaneous tests of interaction performed (N = 6), adjustments were made for multiple comparisons through the Bonferroni Correction, where the statistical threshold was altered (p $\leq$ 0.0083). To test the robustness of the findings, two sets of sensitivity analyses were conducted. In the first set of sensitivity analyses, three-level cannabis legalization exposures were modeled. In the second set of sensitivity analyses, ordinal logistic regression analyses were conducted, where cannabis patterns of consumption were modeled with ordered categories: cannabis use as never, less than monthly, monthly, weekly, daily; and cannabis-related problems as 0 – 3, 4 – 9, 10 – 15, 16 – 21, $\geq$22. A complete case analysis strategy was operationalized, as data missingness amounted to $\leq$2 % for all exposures other than income (23 %; missing data modeled as a separate category). All analyses accounted for the survey design and incorporated survey weights, with usage of Taylor series approximation in the variance estimation. Importantly, the survey weights accounted for selection probabilities and regional representation, as well as post-stratification adjustment to restore the age by sex distribution to the most recently available census figures (Nigatu et al., 2020). All analyses were conducted using STATA Software Version 16.0.

2.5. Ethics approval

Research ethics committee review and approval were obtained from the Research Ethics Board at the Centre for Addiction and Mental Health.

3. Results

The characteristics of the participants according to the pre-cannabis legalization and post-cannabis legalization periods are presented in Table 1. There were differences in characteristics of participants between the two periods in regards to age, education, marital status and income, but not in terms of sex. Trends in cannabis use, daily cannabis use and cannabis-related problems are presented in Fig. 1. The ORs from the logistic regression models examining the associations between cannabis legalization and cannabis use, daily cannabis use and cannabis-related problems are presented in Tables 2–4, respectively.

Cannabis use increased from 11 % in 2001 (95 % Confidence Interval [CI]: 10–13 %) to 26 % in 2019 (24–28 %) (P-Value < 0.0001; Fig. 1). Cannabis legalization was associated with an increased likelihood of cannabis use in the unadjusted model (OR, 95 % CI: 1.54, 1.36 – 1.74) and the adjusted model (1.62, 1.40 – 1.86) (Table 2), with the predicted probability increasing from 15 % (95 % CI: 14–15 %) in the pre-cannabis legalization period to 21 % (19–22 %) in the post-cannabis legalization

Table 1

Characteristics of participants according to pre-legalization and post-legalization periods in the CAMH Monitor.

	Pre-Cannabis Legalization		Post-Cannabis Legalization		P-Value
	%*	N ^	%*	N ^	
Sex					
Female	51.7	28,360	52.7	2040	0.3580
Male	48.3	20,371	47.3	1489	
Age					
18 – 34	27.4	8116	27.0	639	< 0.0001
35 – 54	39.1	17,551	30.1	833	
≥55	33.5	22,123	42.9	2034	
Marital Status					
Never married	22.7	8014	27.6	734	< 0.0001
Married or living with partner	65.4	29,886	58.7	1967	
Previously married (widowed, divorced or separated)	11.9	10,349	13.7	794	
Educational Attainment					
High school or less	32.0	17,030	27.9	1070	0.0001
Some post-secondary school or more	68.0	31,139	72.1	2429	
Income					
<$50,000	20.7	12,926	18.2	766	< 0.0001
≥$50,000	56.0	24,776	54.0	1817	
Not Stated	23.3	11,029	27.8	946	

^ The sample sizes are unweighted.

* The percentages are weighted.

period. Daily cannabis use increased from 1 % (95 % CI: 1–2 %) in 2001 to 6 % (5–7 %) in 2019 (P-Value < 0.0001; Fig. 1). Cannabis legalization was associated with daily cannabis use in the unadjusted model (OR, 95 % CI: 1.64, 1.27 – 2.11) and the adjusted model (1.59, 1.21 – 2.07) (Table 3), with the predicted probability increasing from 2 % (95 % CI: 2–3 %) in the pre-cannabis legalization period to 4 % (3–4 %) in the post-cannabis legalization period. For both cannabis use and daily cannabis use, two-way interactions between cannabis legalization and age and sex were not significant after the adjustment for multiple comparisons.

Cannabis-related problems increased from 6 % (95 % CI: 5–7 %) in 2004 to 14 % (12–16 %) in 2019 (p < 0.0001; Fig. 1). Cannabis legalization was associated with cannabis-related problems in the unadjusted model (OR, 95 % CI: 1.44, 1.15 – 1.79) and the adjusted model (1.53,

1.20 – 1.95) (Table 4). However, a significant two-way interaction was observed between cannabis legalization and age (Interaction Test Wald P-Value = 0.0001), suggesting that cannabis-related problems increased pre-post cannabis legalization among adults ≥ 55 years. The predicted probabilities of cannabis-related problems pre- and post-cannabis legalization by age are presented in Fig. 2 and Table S3 in the Supplementary Appendix. The absolute difference in predicted probabilities pre-cannabis legalization and post-cannabis legalization was 1 % among participants 18 – 34 years, 2 % among participants 35 – 54 years and 4 % among participants ≥55 years. This pattern of findings was sustained when the ≥55 years category was further divided into 55–64 years and ≥65 years (Table S4 in Supplementary Appendix).

Sensitivity analyses of additional pre-cannabis legalization exposures that reflected the change in the leadership of the Liberal Party of Canada and the announcement of formation of the task force are presented in Tables S5 and S6 in the Supplementary Appendix, respectively. These analyses indicated increases in all cannabis patterns of consumption in the period after the announcement of the formation of the taskforce compared with the period before the announcement of the formation of the taskforce. Similar impacts were not observed in regards to change in leadership. The overall pattern of findings in these sensitivity analyses remained consistent, as cannabis legalization was associated with an increased likelihood of cannabis use, daily cannabis use and cannabis-related problems. The lone exception was the null association observed for daily cannabis use when the period post-cannabis legalization was compared to the period after the announcement of formation of the task force. Sensitivity analyses incorporating ordered categories of cannabis use and cannabis-related problems in ordinal logistic regression are presented in Table S8 (see Table S7 for the frequency distributions of the cannabis patterns of consumption). These sensitivity analyses indicated that cannabis legalization was associated with higher frequency of cannabis use and higher scores of cannabis-related problems.

4. Discussion

The effects of cannabis legalization on cannabis patterns of consumption were examined in a pre-post design using a population-based survey of adults in Ontario. Cannabis legalization was associated with an increased likelihood of cannabis use, daily cannabis use and cannabis-related problems. In addition, differential effects of cannabis legalization by age were observed in the context of cannabis-related problems.

The present findings are consistent with previous research showing that cannabis use during the past three months increased from 15 % in
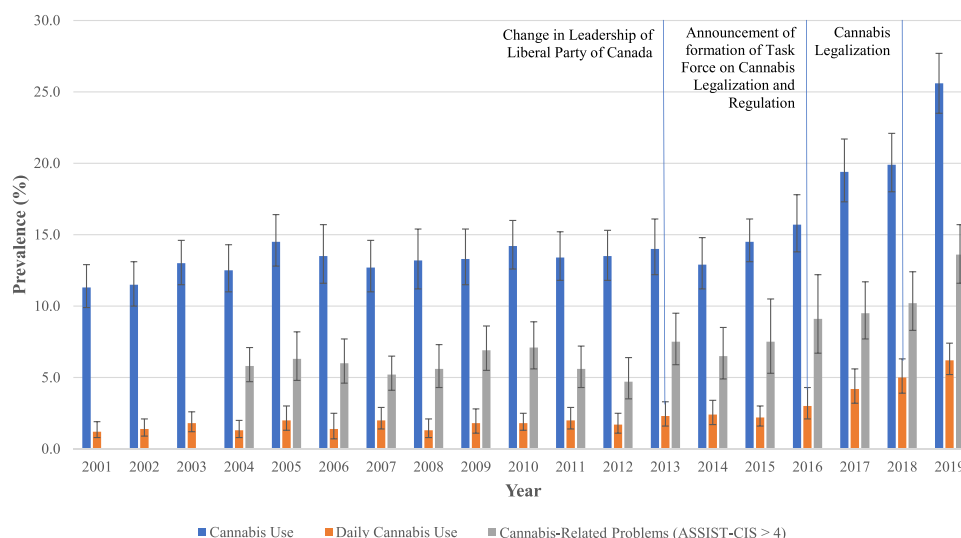

Fig. 1. Prevalence of cannabis use, daily cannabis use and cannabis-related problems in the CAMH Monitor.

Table 2

Associations between cannabis legalization and cannabis use in the CAMH Monitor.

	Cannabis Use	
	Unadjusted Model* (N = 51,378)	Adjusted Model^ (N = 50,158)
	OR (95 % CI)	OR (95 % CI)
Cannabis Legalization		
Pre-cannabis legalization (Reference)		
Post-cannabis legalization	1.54 (1.36–1.74)	1.62 (1.40–1.86)
Survey Year	1.03 (1.03–1.05)	1.04 (1.03–1.05)
Sex		
Male (Reference)		
Female		0.52 (0.48–0.56)
Age		
18 – 34 (Reference)		
35 – 54		0.40 (0.36–0.44)
≥55		0.16 (0.14–0.18)
Marital Status		
Never married (Reference)		
Married or living with a partner		0.47 (0.43–0.52)
Previously married (widowed, divorced or separated)		0.87 (0.76 – 0.99)
Educational Attainment		
High school or less (Reference)		
Some post-secondary school or more		0.81 (0.74–0.88)
Income		
<$50,000 (Reference)		
≥$50,000		1.12 (1.03–1.23)
Not stated		0.58 (0.51–0.65)

Abbreviations: CI, Confidence Interval; OR, Odds Ratio.

* Model includes survey year.

^ Model includes survey year, sex, age, marital status, educational attainment and income.

Table 3

Associations between cannabis legalization and daily cannabis use in the CAMH Monitor.

	Daily Cannabis Use	
	Unadjusted Model* (N = 51,378) OR (95 % CI)	Adjusted Model^ (N = 50,158) OR (95 % CI)
Cannabis Legalization		
Pre-cannabis legalization (Reference)		
Post-cannabis legalization	1.64 (1.27–2.11)	1.59 (1.21–2.07)
Survey Year	1.07 (1.05–1.09)	1.09 (1.07–1.11)
Sex		
Male (Reference)		
Female		0.39 (0.32–0.46)
Age		
18 – 34 (Reference)		
35 – 54		0.46 (0.35–0.59)
≥55		0.17 (0.13–0.23)
Marital Status		
Never married (Reference)		
Married or living with a partner		0.60 (0.46–0.77)
Previously married (widowed, divorced or separated)		1.37 (0.95 – 1.97)
Educational Attainment		
High school or less (Reference)		
Some post-secondary school or more		0.41 (0.35–0.49)
Income		
<$50,000 (Reference)		
≥$50,000		0.73 (0.59–0.89)
Not stated		0.59 (0.46–0.77)

Abbreviations: CI, Confidence Interval; OR, Odds Ratio.

* Model includes survey year.

^ Model includes survey year, sex, age, marital status, educational attainment and income.

2018 to 17 % in 2019 across Canada in the NCS, and cannabis use during the past 12 months increased from 22 % in 2018 to 25 % in 2019 across Canada in the CCS (Government of Canada, 2019a; Rotermann, 2020). While the present findings appear to be inconsistent with previous research showing no changes in cannabis use during the past three months in Ontario based on the NCS (16 % in 2018 and 18 % in 2019) (Rotermann, 2020), their null findings may be due to smaller sample size available for the provincially stratified analyses in the NCS. Regarding daily cannabis use during the past three months or frequency of cannabis use during the past 12 months, both of the NCS and CCS demonstrated no changes pre-post cannabis legalization in Ontario or Canada (Government of Canada, 2019a; Rotermann, 2020), which is not in agreement with the present findings.

In regards to cannabis-related problems, directly comparable findings are not available. A prospective cohort of community adults in Ontario demonstrated significant increases in severity of cannabis misuse among those who did not use cannabis at baseline and decreases in severity of cannabis misuse among those who did use cannabis at baseline (Turna et al., 2021). However, unlike the present findings, no changes were observed when a distinction was not made by cannabis use at baseline, or when the outcome was dichotomized to reflect problematic cannabis use (Cannabis Use Disorder Identification Test Score ≥ 8) (Turna et al., 2021). The divergence of the present findings may be explained by the differences in the nature of the sample, as enrollment into the cohort was based on membership of an existing registry that was comprised of ambulatory community adults, who had previously

indicated willingness to participate in research studies (Turna et al., 2021).

In contrast to the previous research, the present findings do not suggest differential effects of cannabis legalization on cannabis use or daily cannabis use by age or sex. In age- and sex-stratified analyses from the NCS, cannabis use during the past three months increased among those 25–44 years old and among males pre-post cannabis legalization (Rotermann, 2020). In age- and sex-stratified analyses from the CCS, cannabis use during the past 12 months increased among all age and sex groups pre-post cannabis legalization (Government of Canada, 2019a). Furthermore, no changes were observed in regards to daily cannabis use pre-post cannabis legalization after stratification by age and sex in the NCS (Rotermann, 2020). The lone exception was the increase in daily cannabis use observed among those 65 years and older pre-post cannabis legalization (Rotermann, 2020). The differences between the present findings and the findings obtained from the NCS and CCS may stem from variations in methodology (i.e. stratification vs. interaction) or absence of sufficient statistical power to detect differences. In contrast to cannabis use and daily cannabis use, differential effects of cannabis legalization on cannabis-related problems by age and sex have not been previously examined.

The rise in cannabis use after cannabis legalization may reflect increased experimentation, which likely does not pose significant health risks. However, the same is not true of daily cannabis use and cannabis-related problems. In particular, government authorities need to ensure that frequent or intensive cannabis use remains minimized, as it is the

Table 4

Associations between cannabis legalization and cannabis-related problems in the CAMH Monitor.

	Cannabis-Related Problems		
	Unadjusted Model* (N = 29,436)	Adjusted Model^ (N = 28,454)	Adjusted Model with Interaction# (N = 28,454)
	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)
Cannabis Legalization			
Pre-cannabis legalization (Reference)			
Post-cannabis legalization	**1.44 (1.15–1.79)**	**1.53 (1.20–1.95)**	1.13 (0.81–1.57)
Survey Year	**1.04 (1.03–1.06)**	**1.06 (1.04–1.07)**	**1.06 (1.04–1.08)**
Sex			
Male (Reference)			
Female		**0.42 (0.37–0.48)**	**0.42 (0.37–0.48)**
Age			
18 – 34 (Reference)			
35 – 54		**0.39 (0.33–0.46)**	**0.38 (0.32–0.45)**
≥55		**0.17 (0.14–0.21)**	**0.14 (0.11–0.18)**
Marital Status			
Never married (Reference)			
Married or living with a partner		**0.48 (0.40–0.57)**	**0.48 (0.40–0.57)**
Previously married (widowed, divorced or separated)		0.86 (0.67–1.10)	0.85 (0.66–1.10)
Educational Attainment			
High school or less (Reference)			
Some post-secondary school or more		**0.56 (0.48–0.64)**	**0.56 (0.48–0.64)**
Income			
<$50,000 (Reference)			
≥$50,000		0.94 (0.79–1.11)	0.93 (0.79–1.10)
Not stated		**0.51 (0.40–0.63)**	**0.50 (0.40–0.63)**
Cannabis Legalization * Age Interaction			
Post-cannabis legalization, 35 – 54			1.31 (0.83–2.05)
Post-cannabis legalization, ≥55			**2.58 (1.66–4.02)**

Abbreviations: CI, Confidence Interval; OR, Odds Ratio.

* Model includes survey year.

^ Model includes survey year, sex, age, marital status, educational attainment and income.

Model includes survey year, sex, age, marital status, educational attainment, income and cannabis legalization by age interaction.

main contributor to the cannabis-attributable burden of disease (Imtiaz et al., 2016). Targeted prevention tools can be drawn upon to this end, such as the evidence-based lower risk cannabis use guidelines, which provide scientific guidance to reduce the health risks associated with cannabis use (Fischer et al., 2022, 2017). Importantly, these guidelines recommend cannabis use not to exceed once per week or weekend use (Fischer et al., 2022, 2017). Despite the increases in these cannabis patterns of consumption, it is premature to declare cannabis legalization as a success or failure. As has been observed in the context of other legal substances, continued maturation of the retail cannabis market may further affect cannabis patterns of consumption. The total grams of cannabis sold increased by 182 % (from 35 million grams to 99 million grams) and total sales of cannabis increased by 118 % (from $385 million to $840 million) between the first fiscal year (2019/2020) and

the second fiscal year (2020/21) after cannabis legalization in Ontario (Ontario Cannabis Store, 2020, 2021). Indeed, growth in private cannabis retailers has been shown to be associated with growth in those who use cannabis in Canada (Armstrong, 2021). However, the association between growth in private cannabis retailers and growth in cannabis retail sales has been shown to be stronger, suggesting a potential shift in consumer access from the illicit market to the licit market (Armstrong, 2021). As such, long-term examinations of cannabis patterns of consumption are needed to adequately characterize the effects of cannabis legalization. Given the differential effects of cannabis legalization on cannabis-related problems by age, awareness, education and monitoring of cannabis consumption is needed. Although some older adults may have previously engaged in cannabis consumption, cannabis potency today has risen substantially over the past decades in North America, potentially placing older adults at risk for health risks and harms (World Health Organization, 2016). Primary care providers may be ideally situated to address cannabis consumption among older adults, given their regular contact with this population subgroup (Baumbusch and Sloan Yip, 2022).

4.1. Limitations

The findings should be considered in the context of some limitations. First, the absence of temporality and lack of a comparison group due to the cross-sectional data in a pre-post design limits the inferences of causality. Second, the sampling frame of the surveys excluded certain segments of the target population, including those who were homeless, hospitalized, incarcerated or living on military establishments. On a similar note, adolescents (≤ 18 years) were excluded from the target population of the survey. Third, the response rates of the surveys averaged 50 % (range of 28–61 %), declining by 54 % between 2001 and 2019, which is consistent with other telephone surveys (Wright, 2015). Although adjustments were made to the survey weights, those who chose to participate versus those who chose not to participate may differ in relation to the cannabis patterns of consumption. Importantly, despite the potential linkage between nonresponse rates and nonresponse bias, the extent to which the former represents the latter is rarely known. As such, nonresponse rate is best viewed as an indicator of the potential rather than the presence of nonresponse bias (Biemer and Lyberg, 2003; Groves et al., 2004; Groves and Peytcheva, 2008). These limitations pertaining to the exclusion of some segments of the population and low response rates may have affected the generalizability of the findings. On a similar note, expansion of the sampling frame by the inclusion of cell phone only households to ensure population representativeness may have resulted in differences in characteristics of included participants between the survey iterations. Notably, 10 % of participants in 2017, 25 % in 2018 and 50 % in 2019 were sampled from the cell phone random-digit-dialing sampling frame. Although adjustments were made for characteristics of participants in the multivariable models, the changes to the sampling strategy may have resulted in changes to the population under examination, which may have affected the cannabis patterns of consumption. Fourth, social desirability and recall biases cannot be ruled out, given the self-reported nature of the data. As such, cannabis use, daily cannabis use and cannabis-related problems may have been underestimated. However, self-reports of drug use have previously been shown to be valid (Darke, 1998). Fifth, the propensity to engage in cannabis use or the willingness to report cannabis use may have changed over time due to ongoing cannabis normalization. Indeed, among those who used cannabis during the past 12 months, 55 % in 2019 indicated that they would be more willing to disclose cannabis use since it was legal (Government of Canada, 2021a). As measures capturing the extent of cannabis normalization were not available, they were not accounted for in the analyses, but they represent an important consideration in future studies. Sixth, a distinction between recreational cannabis use and therapeutic cannabis use was not made, given the absence of measures across survey iterations. Among those who used
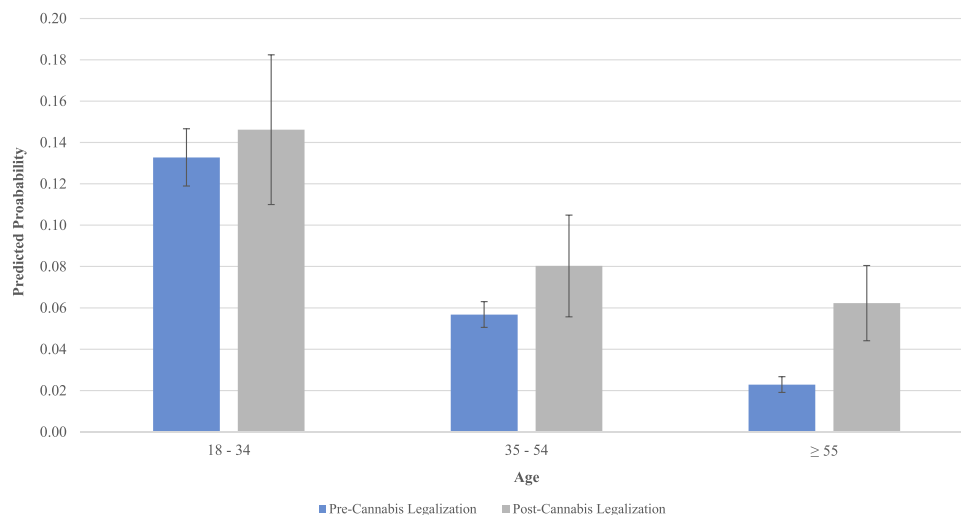
Fig. 2. Predicted probabilities of cannabis-related problems pre-cannabis legalization and post-cannabis legalization by age categories in the CAMH Monitor.

cannabis during the past 12 months between 2013 and 2014, about one-third reported therapeutic use, with 15 % further indicating medical authorization for cannabis use (Hamilton, Brands, Ialomiteanu, and Mann, 2017). As cannabis legalization continues to roll out, determination of the type of cannabis use will be an important consideration in future studies, as the public health responses required to address these two issues will vary. Seventh, adjustments were not made for chronic physical health or mental health conditions, as these measures were not available from the survey. Eighth, the nature of the design did not permit partitioning of age effects and cohort effects, which is relevant given the observed two-way interaction between age and cannabis legalization in the context of cannabis-related problems.

5. Conclusions

Cannabis legalization was associated with an increased likelihood of cannabis use, daily cannabis use and cannabis-related problems among adults in Ontario, Canada. Given the increases in these cannabis patterns of consumption, broader dissemination and uptake of targeted prevention tools is indicated to mitigate increases in the cannabis-attributable burden of disease. Importantly, long-term examinations of cannabis patterns of consumption are needed because the retail cannabis market continues to mature, which may necessitate additional policy adjustments in the future to minimize cannabis-attributable health risks.

Contributors

SI and T-EM conceived the research question and outlined the analytical design. HAH, YTN and T-EM managed the data acquisition. YTN conducted the data analyses, with input from SI, HAH, SR and T-EM. SI prepared the draft of the manuscript, with critical revisions for intellectual content made by all other authors. All authors approved the manuscript for submission to the journal.

Declaration of Competing Interest

No conflicts declared.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.drugalcdep.2023.109765.

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