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Perceptions of the health risks of cannabis: estimates from national surveys in Canada and the United States, 2018–2019

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Abstract

Few studies have compared knowledge of the specific health risks of cannabis across jurisdictions. This study aimed to examine perceptions of the health risks of cannabis in Canada and US states with and without legal non-medical cannabis. Cross-sectional data were collected from the 2018 and 2019 International Cannabis Policy Study online surveys. Respondents aged 16–65 ($n = 72\,459$) were recruited from Nielsen panels using non-probability methods. Respondents completed questions on nine health effects of cannabis (including two 'false' control items). Socio-demographic data were collected. Regression models tested differences in outcomes between jurisdictions and by frequency of cannabis use, adjusting for socio-demographic factors. Across jurisdictions, agreement with statements on the health risks of cannabis was highest for questions on driving after cannabis use (66–80%), use during pregnancy/breastfeeding (61–71%) and addiction (51–62%) and lowest for risk of psychosis and schizophrenia (23–37%). Additionally, 12–18% and 6–7% of respondents agreed with the 'false' assertions that cannabis could cure/prevent cancer and cause diabetes, respectively. Health knowledge was highest among Canadian respondents, followed by US states that had legalized non-medical cannabis and lowest in states that had not legalized non-medical cannabis ($P < 0.001$). Overall, the findings demonstrate a substantial deficit in knowledge of the health risks of cannabis, particularly among frequent consumers.

Introduction

Cannabis use is among the most commonly used substances in the United States and Canada [1, 2]. In addition to potential therapeutic effects, there is substantial evidence that frequent cannabis use can cause health effects, including worsened respiratory symptoms, increased risk of motor vehicle crash, pregnancy complications and lower infant birth weight, impairment to learning, memory and attention and increased risk of schizophrenia and psychosis among frequent consumers [3]. The likelihood of problematic cannabis use and long-term health effects is also associated with early initiation and frequent cannabis use in adolescence [3].

The perceived risk of cannabis among young people is inversely associated with future cannabis use: young people who perceive cannabis as less harmful are more likely to subsequently consume cannabis [4, 5]. Several studies also indicate that cannabis consumers have lower perceptions of risk and addiction than non-consumers [1, 5–10]. Lower perceived risk among consumers may reflect optimism bias, the belief that one's health risk is lower than that of others [11–13], and an effort to minimize cognitive dissonance, in which consumers alter their health beliefs when it conflicts with their behaviour [14, 15].

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US studies indicate decreasing cannabis risk perceptions over time among adolescents and adults [6, 7, 16–19]. The extent to which cannabis legalization has contributed to declining risk perceptions—particularly among young people—represents an important question, for which the evidence is mixed. A school-based study found that perceptions of harm increased among eighth-graders in states with medical cannabis laws [20], whereas another found no difference in perceptions of risk among youth in states without non-medical cannabis markets versus those with new or established markets [21]. In contrast, several other studies have found lower perceptions of risk from cannabis use in jurisdictions that have legalized cannabis [22–24]. However, these trends appear to predate legalization [24] and may reflect pre-existing differences between states that subsequently legalized non-medical cannabis (herein US 'legal' states). Overall, the impact of legalization on cannabis risk perceptions remains unclear.

Perceived risk of cannabis use has typically been assessed using a general question about 'overall' risk or risk compared to alcohol or other substances [4–8]. General indicators of risk can provide a useful overall measure of risk perception; however, perceptions of overall harm can obscure important deficits in health knowledge and beliefs [25]. For example, beginning in the 1950s, the majority of Americans agreed that smoking was harmful to health, while fewer than 10% could recall cancer as a health effect from smoking and less than half agreed that smoking caused lung cancer [26]. To date, few studies have assessed cannabis health risk using measures that test knowledge of specific health effects [10, 27]. A national Canadian monitoring survey found that most Canadians agreed that cannabis can be harmful to use during pregnancy or breastfeeding (87%), adolescents are at increased risk of harm from cannabis (84%), cannabis smoke is harmful (76%) and cannabis can harm mental health (75%) [27]. Studies also show higher risk perceptions of impaired driving in 'legal' versus 'illegal' US states [28], lower perceived risk of cannabis-impaired driving among frequent versus infrequent/non-cannabis consumers, as well as lower perceived risk of cannabis compared to alcohol-impaired driving [29, 30]. Knowledge of specific health effects may be particularly important in assessing the impact of public education campaigns and health warning labels, which often target specific outcomes or risks.

Abuse liability and dependence are central factors in substance use, with important implications for risk perceptions [31]. Although the risk of dependence is lower for cannabis than other legal drugs such as nicotine and alcohol, it is estimated that approximately 9% of cannabis consumers will become dependent on cannabis in their lifetime [27, 32]. Frequent cannabis use and higher consumption levels are important indicators of dependence, as well as more general measures of problematic cannabis use [33–35]. In addition, recent research suggests that the risk of dependence may increase with the use of high-potency cannabis, which has increased over time [36, 37].

Consumers may also hold false beliefs about the therapeutic effects of cannabis use. There is evidence for certain therapeutic effects of cannabis, including treating chronic pain, reducing chemotherapy-induced nausea and vomiting and multiple sclerosis spasticity [3, 38]. However, increased marketing and social media presence regarding cannabis and cannabidiol (CBD) products have the potential to promote false or exaggerated beliefs about the potential therapeutic use of these products [39]. A US survey found that respondents who considered social media or the internet, the cannabis industry, or family/friends as the most influential source of information about cannabis were most likely to believe misinformation about cannabis [40]. Another study among high-school students found that those who had previously consumed cannabis were more likely than never consumers to believe false assertions about cannabis, including that it cures mental illness [10].

To increase public awareness of specific health risks of cannabis, Canada mandated health warning labels on cannabis packages when non-medical cannabis legalization came into effect on 17 October 2018. The warnings described six

different health risks, and were revised in 2019 [41]. Similarly, all US 'legal' states have mandated warning labels on cannabis packages, as have some states with legal medical cannabis [42]. Health warning labels vary by state and often summarize multiple health risks in one paragraph.

The current study had two primary objectives. First, the study sought to examine whether knowledge of the health risks of cannabis differed in Canada pre- versus post-legalization, compared to respondents in US 'legal' and 'illegal' states. Second, the study examined potential differences in health knowledge by frequency of cannabis use and socio-demographics. It was hypothesized that due to exposure to mandatory health warnings on cannabis packaging, respondents in Canada would demonstrate greater knowledge of the tested health risks compared to US 'legal' and 'illegal' states. It was further hypothesized that frequent cannabis consumers would be less likely to endorse items relating to the health risks of cannabis, due to a combination of optimistic bias and personal positive experiences using cannabis.

Method

Cross-sectional findings from Waves 1 and 2 of the International Cannabis Policy Study (ICPS), conducted in Canada and the United States, are presented [43]. Data were collected via self-completed web-based surveys conducted in fall 2018 (immediately pre-cannabis legalization in Canada) and fall 2019 (1-year post-legalization). Respondents aged 16–65 were recruited through the Nielsen Consumer Insights Global Panel and their partners' panels. Email invitations (with a unique link) were sent to a random sample of panellists (after targeting for age and country criteria); panellists known to be ineligible were not invited. Surveys were conducted in English in the United States and in English or French in Canada. Median survey times were 20 and 25 min in 2018 and 2019, respectively. Respondents provided consent prior to completing the survey. Respondents received remuneration in accordance with their panel's usual incentive structure (e.g. points-based or monetary rewards, chances to win prizes). The study was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31330). A full description of the study methods can be found in the ICPS methodology paper [43] and technical reports (http://cannabisproject.ca/methods/).

Measures

Full question wording is available in the ICPS surveys (http://cannabisproject.ca/methods/).

Socio-demographic factors included sex, age group, ethnicity, highest education level and perceived income adequacy (categorical). The suspected device type used to complete the survey was also collected by Nielsen. See Table I for response options.

Cannabis use frequency was derived from questions on ever, most recent and current frequency of cannabis use. Consumers were then classified in to the following exclusive categories: Never user; Used more than 12 months ago; Past 12 months (but not more recent) user; Monthly user; Weekly user; or Daily/almost daily user.

Knowledge of the health risks of cannabis was assessed using measures of agreement with a list of health effects, for which respondents could select 'Yes', 'Maybe', 'No' or 'Don't know'. A total of seven health effects were assessed, with two additional items added in the 2019 survey (see Table II). Two 'false' effects were included for which there is no clear evidence: 'Can using marijuana cause diabetes?' (2018 and 2019 surveys) and 'Can marijuana or CBD help cure or prevent cancer?' (2019 survey only). An index was created by summing the number of correct responses across the seven items included in both years (range 0–7); the two items added in 2019 were excluded from the index score for consistency. Responses to 'true' health statements were coded as 'Correct' if respondents selected 'Yes'; responses to 'false' statements were coded as 'Correct' if respondents selected 'No'.

Table I. *Sample characteristics (n = 72 459)*

	Canada				US 'illegal' States				US 'legal' states			
	2018 (pre-legalization) (n = 9999)		2019 (post-legalization) (n = 15 134)		2018 (n = 9682)		2019 (n = 10 217)		2018 (n = 7351)		2019 (n = 20 076)	
	%	n	%	n	%	n	%	n	%	n	%	n
Sex												
Female	50.0%	4998	49.8%	7540	50.4%	4879	50.3%	5142	49.9%	3665	49.9%	10 012
Male	50.0%	5001	50.2%	7594	49.6%	4802	49.7%	5075	50.1%	3686	50.1%	10 064
Age												
16–25	18.9%	1894	18.6%	2818	19.9%	1932	19.9%	2029	19.4%	1429	19.7%	3952
26–35	20.6%	2062	20.8%	3153	21.4%	2069	21.5%	2196	22.9%	1679	22.6%	4537
36–45	19.5%	1948	19.8%	2997	18.9%	1827	19.0%	1943	17.4%	1279	19.3%	3883
46–55	20.9%	2087	20.0%	3022	20.2%	1954	19.8%	2027	21.8%	1605	19.5%	3911
56–65	20.1%	2007	20.8%	3143	19.6%	1899	19.8%	2022	18.5%	1360	18.9%	3792
Ethnicity												
White	77.4%	7744	73.4%	11 106	76.5%	7402	76.2%	7781	76.4%	5615	76.3%	15 318
Other/Mixed/Unstated	22.6%	2256	26.6%	4028	23.6%	2280	23.9%	2437	23.6%	1736	23.7%	4758
Highest education level												
Unstated	0.7%	73	1.0%	150	0.3%	27	0.4%	36	0.4%	32	0.4%	78
Less than high school	15.5%	1546	15.4%	2333	15.2%	1473	12.1%	1235	11.8%	865	5.0%	1015
High school diploma	26.6%	2655	26.5%	4017	19.4%	1880	22.5%	2300	15.8%	1164	20.2%	4056
Some college/technical training	32.4%	3239	32.4%	4911	38.3%	3712	36.4%	3718	42.0%	3084	41.7%	8380
Bachelor's degree or higher	24.9%	2488	24.7%	3740	26.8%	2591	28.7%	2928	30.0%	2206	32.6%	6550
Income adequacy (difficulty making ends meet)												
Unstated	3.4%	336	3.8%	568	2.0%	196	2.5%	256	2.9%	216	3.1%	612
Very difficult	8.2%	822	9.7%	1461	9.3%	901	10.6%	1084	8.9%	655	10.0%	2017
Difficult	20.0%	2002	22.2%	3365	22.2%	2153	23.3%	2376	19.5%	1438	22.7%	4549
Neither easy nor difficult	36.0%	3600	35.1%	5305	31.5%	3051	33.0%	3376	32.2%	2370	33.2%	6668
Easy	21.1%	2114	19.7%	2984	22.0%	2131	19.0%	1946	22.9%	1682	19.9%	4002
Very easy	11.3%	1125	9.6%	1451	12.9%	1249	11.5%	1180	13.6%	996	11.1%	2228
Suspected survey device type												
Smartphone[a]	0%	0	42.7%	6478	0%	0	51.9%	5299	0%	0	52.8%	10 593
Tablet	10.7%	1071	9.5%	1440	7.5%	730	6.2%	638	10.9%	801	5.9%	1182
Computer	89.3%	8929	47.8%	7226	92.5%	8951	41.9%	4280	89.1%	6550	41.4%	8301

(continued)

Table I. *(Continued)*

	Canada				US 'illegal' States				US 'legal' states			
	2018 (pre-legalization) ($n = 9999$)		2019 (post-legalization) ($n = 15\,134$)		2018 ($n = 9682$)		2019 ($n = 10\,217$)		2018 ($n = 7351$)		2019 ($n = 20\,076$)	
	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*
Frequency of cannabis use												
Never user	43.5%	4349	38.1%	5765	45.3%	4384	37.7%	31.9%	38.6%	2835	30.8%	6177
Used >12 months ago	29.1%	2910	26.9%	4067	31.0%	3000	3847	3254	27.4%	2016	30.4%	6105
Less than once per month	31.4%	862	32.4%	1715	29.2%	672	26.6%	830	27.4%	685	25.9%	2020
1+ times per month	17.7%	485	19.8%	1049	22.1%	507	20.0%	624	20.0%	499	16.3%	1272
1+ times per week	18.4%	505	16.0%	849	17.3%	397	15.5%	482	19.4%	484	16.1%	1252
Daily or almost daily	32.4%	889	31.9%	1688	31.4%	721	37.9%	1180	33.3%	833	41.7%	3251

[a]Use of smartphones to complete survey was prohibited in 2018 (Wave 1) survey.

Table II. *Mean number and frequency of correct responses to cannabis health risk questions by time, jurisdiction and frequency of cannabis use (n = 72 459)*

	Canada		US 'illegal' states		US 'legal' states	
	2018 (pre-legalization)	2019 (post-legalization)	2018	2019	2018	2019
Mean (SD) number correct (range = 0–7)[a]	4.1 (1.9)	4.0 (2.0)	3.4 (1.9)	3.2 (1.9)	3.5 (1.9)	3.4 (1.9)
Prevalence of correct responses % (*n*)						
1. Can it be dangerous to drive or operate machinery after using marijuana?	81.1% (8104)	79.1% (11 951)	68.4% (6618)	64.2% (6540)	73.3% (5387)	70.3% (14 105)
Never user	85.4% (3712)	82.4% (4746)	76.3% (3341)	71.9% (2757)	79.2% (2244)	76.1% (4693)
Used >12 months ago	86.8% (2524)	86.1% (3498)	72.0% (2157)	69.8% (2269)	80.0% (1609)	78.5% (4786)
Past 12 months user[b]	74.0% (1364)	75.5% (2725)	55.2% (869)	54.9% (1063)	67.0% (1116)	67.2% (3049)
Daily/almost daily user	56.6% (504)	58.2% (983)	34.9% (252)	38.4% (451)	50.2% (418)	48.5% (1576)
2. Can it be harmful to use marijuana when pregnant or breastfeeding?	72.8% (7275)	70.4% (10 646)	64.0% (6191)	58.9% (6009)	63.4% (4654)	59.7% (11 964)
Never user	77.6% (3372)	75.3% (4338)	71.9% (3148)	69.2% (2658)	72.9% (2059)	68.5% (4232)
Used >12 months ago	77.4% (2251)	76.1% (3092)	65.6% (1969)	62.8% (2043)	63.9% (1289)	66.6% (4059)
Past 12 months user	65.7% (1216)	64.2% (2315)	51.8% (815)	48.1% (932)	57.8% (964)	52.0% (2358)
Daily/almost daily user	49.3% (436)	53.5% (901)	36.0% (259)	32.0% (376)	41.0% (341)	40.6% (1316)
3. Can marijuana be addictive?	62.5% (6242)	61.6% (9297)	51.4% (4975)	49.6% (5065)	52.3% (3839)	49.9% (10 003)
Never user	72.9% (3170)	70.8% (4081)	64.6% (2826)	62.3% (2392)	66.1% (1870)	63.4% (3906)
Used >12 months ago	65.0% (1891)	66.1% (2683)	46.8% (1402)	49.4% (1608)	53.8% (1085)	54.7% (3332)
Past 12 months user	48.0% (886)	49.9% (1799)	35.6% (560)	35.6% (690)	37.0% (617)	38.2% (1731)
Daily/almost daily user	33.2% (295)	43.9% (734)	25.9% (187)	31.9% (375)	32.0% (266)	31.8% (1034)
4. Are teenagers at greater risk of harm from using marijuana than adults?	59.9% (5986)	59.7% (9025)	42.4% (4105)	42.2% (4300)	48.3% (3541)	49.2% (9863)
Never user	66.2% (2878)	64.6% (3717)	49.1% (2152)	48.5% (1857)	56.9% (1606)	56.8% (3504)
Used >12 months ago	60.7% (1765)	62.2% (2525)	41.4% (1239)	46.0% (1495)	48.7% (981)	52.4% (3189)
Past 12 months user	50.9% (940)	54.0% (1949)	34.3% (539)	32.0% (620)	40.5% (675)	43.6% (1980)
Daily/almost daily user	45.3% (403)	49.6% (834)	24.3% (175)	27.9% (327)	33.5% (279)	36.7% (1190)
5. Can marijuana smoke be harmful?	58.1% (5804)	56.2% (8500)	46.8% (4525)	41.1% (4189)	49.6% (3637)	44.3% (8883)
Never user	66.9% (2911)	64.5% (3716)	57.7% (2530)	53.8% (2064)	61.2% (1732)	57.7% (3563)
Used >12 months ago	61.3% (1781)	60.8% (2474)	46.0% (1379)	42.5% (1382)	52.0% (1044)	49.2% (2995)
Past 12 months user	44.1% (814)	47.4% (1711)	29.4% (460)	27.0% (523)	37.0% (615)	34.0% (1545)
Daily/almost daily user	33.4% (297)	35.5% (599)	21.7% (156)	18.7% (220)	29.5% (245)	24.1% (782)
6. Can regular use of marijuana increase the risk of psychosis and schizophrenia?	38.0% (3798)	36.7% (5550)	24.8% (2395)	22.3% (2272)	26.4% (1936)	21.5% (4311)
Never user	47.9% (2081)	44.3% (2552)	34.9% (1530)	30.7% (1178)	39.3% (1110)	30.8% (1898)
Used >12 months ago	37.1% (1079)	38.5% (1565)	19.0% (569)	20.6% (669)	23.8% (478)	21.9% (1333)
Past 12 months user	27.0% (499)	29.9% (1076)	14.9% (235)	13.8% (267)	15.2% (254)	15.2% (690)
Daily/almost daily user	15.7% (139)	21.2% (357)	8.5% (61)	13.3% (157)	11.4% (95)	12.0% (390)

(continued)

Table II. *(Continued)*

	Canada		US 'illegal' states		US 'legal' states	
	2018 (pre-legalization)	2019 (post-legalization)	2018	2019	2018	2019
7. Can using marijuana cause diabetes?[c]	36.1% (3608)	38.4% (5806)	39.9% (3863)	45.2% (4609)	38.3% (2805)	44.6% (8937)
Never user	24.8% (1080)	26.2% (1509)	26.2% (1147)	29.0% (1112)	23.3% (657)	29.0% (1787)
Used >12 months ago	35.0% (1016)	38.9% (1580)	45.3% (1358)	49.3% (1602)	39.2% (788)	42.5% (2583)
Past 12 months user	49.7% (918)	47.9% (1726)	55.7% (876)	57.3% (1107)	47.1% (785)	54.2% (2458)
Daily/almost daily user	66.9% (594)	58.9% (991)	66.8% (481)	67.0% (788)	69.7% (575)	65.0% (2110)
8. Can high-THC marijuana products negatively affect memory and concentration? *(not included in index)*	*n/a*	53.9% (8148)	*n/a*	43.6% (4449)	*n/a*	44.6% (8930)
Never user	–	60.2% (3469)	–	51.0% (1958)	–	52.6% (3242)
Used >12 months ago	–	58.6% (2379)	–	47.7% (1549)	–	50.6% (3084)
Past 12 months user	–	46.1% (1663)	–	33.1% (640)	–	37.4% (1698)
Daily/almost daily user		37.9% (638)		25.8% (303)		27.9% (906)
9. Can marijuana or CBD help cure or prevent cancer?[c] *(not included in index)*	*n/a*	33.6% (5082)	*n/a*	26.8% (2737)	*n/a*	28.5% (5702)
Never user	–	37.5% (2161)	–	28.8% (1106)	–	33.2% (2047)
Used >12 months ago	–	37.3% (1516)	–	29.4% (955)	–	32.0% (1952)
Past 12 months user	–	30.4% (1094)	–	23.2% (448)	–	25.7% (1164)
Daily/almost daily user		18.5% (310)		19.4% (228)		16.7% (540)

[a]Items 1–7 were summed to calculate mean score (items 8–9 were added in 2019 and therefore not included in knowledge score).
[b]In all models, past 12 months consumers include less than once per month, monthly and weekly consumers.
[c]Correct response to all items was 'Yes' (incorrect = No/Maybe/Don't know) with the exception of the items on diabetes and curing/preventing cancer (Correct = 'No'; Incorrect = Yes/Maybe/Don't know).

Health statements were selected based on those featured in the health warnings mandated to appear on legal non-medical cannabis products in Canada [41, 44].

Noticing health warning messages was assessed using the question 'In the past 12 months, have you seen health warnings on marijuana products or packages?' (Yes, No, Not applicable—I have not seen any marijuana products or packages, Don't know, Refuse). These questions were asked later in the survey in order to discourage respondents from drawing associations with health risks questions.

Data analysis

The final 2018 and 2019 repeat cross-sectional samples comprised 27 169 and 45 735 respondents, respectively. The current analysis comprised a sub-sample of 72 459 after excluding respondents who refused the question on noticing cannabis health warning labels and all health risks questions. Post-stratification sample weights based on sex, age, region, education, race and smoking status (in 2019) were constructed based on the Canadian and US Census estimates and a raking algorithm applied to the original samples; see the Technical Reports for details (http://cannabisproject.ca/methods/). Weights were rescaled to the sample size for Canada and US 'legal' and 'illegal' states. Estimates are weighted.

Linear regression was used to test for differences between jurisdictions and frequency of cannabis use in knowledge of the health risks of cannabis asked in both survey years (range = 0–7; higher scores indicate more correct responses), adjusted for survey year, noticing health warnings, age, sex, education, ethnicity, income adequacy and device type. A sensitivity analysis indicated that a secondary model among past 12 months cannabis consumers only had the same general pattern of significance as the main model, except that the main effect of survey year and survey device became non-significant (data not shown).

Nine binary logistic models were used to test for differences in the odds of correctly responding to each health risk question (1 = Correct; 0 = Incorrect, including Maybe/Don't know) by jurisdiction and frequency of cannabis use (recoded for models as: Never user; Used >12 months ago; Past 12 months user [including less than once per month, monthly and weekly consumers]; and Daily/almost daily user), adjusted for the same covariates as above. Two-way interactions between jurisdiction and survey year were tested in subsequent models. Adjusted odds ratios (AORs) and 95% confidence intervals are shown. Analyses were conducted using survey procedures in SAS 9.4.

Results

Sample characteristics are shown in Table I. Approximately half of respondents were female, and the majority had at least some college or university education.

Knowledge of specific health risks

Figure 1 shows the frequency of responses to each health risk question in the two survey years combined. Table II shows the prevalence of correct responses to each health risk question by survey year, jurisdiction and frequency of cannabis use. Across jurisdictions, the highest prevalence of correct responses was observed for driving or operating machinery after cannabis use (66–80%), use during pregnancy/breastfeeding (61–71%) and risk of addiction (51–62%). Approximately half of the respondents (44–54%) agreed that high-THC products could affect memory and concentration. Of the 'true' items, the agreement was lowest for risk of developing schizophrenia and psychosis with regular use (23–37%). Of the two 'false' items, the agreement was higher for the question on curing/preventing cancer (12–18%) than causing diabetes (6–7%).

Knowledge index

Table II shows the mean number of correct responses to the seven questions included in both survey waves, and Table III shows the results of the linear regression model. Scores on the knowledge

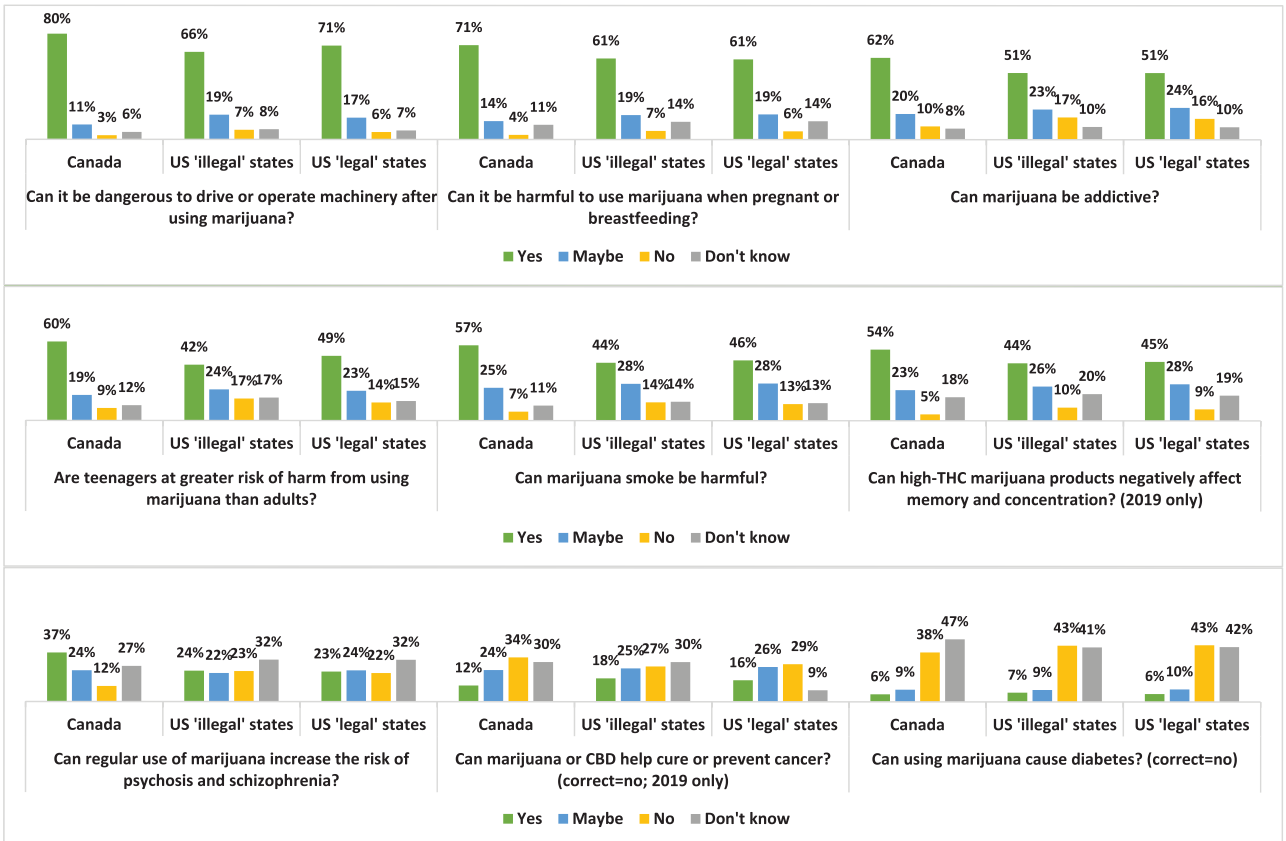

Fig. 1. Frequency of responses to questions on the health risks of cannabis by jurisdiction, 2018 and 2019 data ($n = 72\,459$).

index were significantly higher among respondents in Canada versus US jurisdictions, as well as respondents in US 'legal' versus 'illegal' states (Table III). Knowledge scores were significantly higher in 2018 compared to 2019. Scores on the knowledge index were significantly higher among those who never consumed cannabis or consumed cannabis less recently compared to daily/almost daily consumers, as well as those who reported noticing health warning labels versus those who did not. There were significant main effects of all socio-demographic covariates. Briefly, knowledge scores were higher among the following groups: 16–25-year-olds versus 26–35 and 36–45-year-olds; females versus males; White versus other/mixed/unstated ethnicity; all education levels versus unstated education and all levels of income adequacy versus unstated. There was no interaction between survey year and jurisdiction in the subsequent model ($P = 0.469$).

Finally, sensitivity analyses in the form of separate binary regression models were conducted for each health effect. This revealed a similar pattern of results in terms of the effect of jurisdiction and frequency of cannabis use. As shown in Table IV, those living in Canada were significantly more likely to respond correctly than those in both US 'illegal' and 'legal' states for all except the 'false' diabetes item, as were those in US 'legal' states compared to 'illegal' states (with the exception of the item on psychosis/schizophrenia).

Discussion

Results of the current study suggest varying levels of knowledge of the various health risks of cannabis. With the exception of the risk of psychosis and schizophrenia, approximately half or more respondents agreed which each 'true' health risk, with the highest level of agreement observed among Canadian respondents for the item on driving after cannabis use (81%). In the United States, agreement with the risk of driving impaired was lower, at approximately two-thirds to 70%. Agreement with this item decreased with the frequency of cannabis consumption; across jurisdictions, approximately one-third to one-half of daily cannabis consumers recognized the dangers of cannabis-impaired driving. This is problematic given that motor vehicle crashes are a leading cause of mortality attributable to cannabis [3, 45]. Cannabis use is also known to worsen respiratory symptoms [3], yet agreement with the harms of cannabis smoke was even lower, with only one-fifth to one-third of daily consumers and approximately half of the general population in each jurisdiction endorsing this item.

The agreement was notably lower overall for the risk of psychosis and schizophrenia, at approximately 22–38% of the general population, and only 9–22% of daily cannabis consumers. A 2017 survey found higher agreement among Canadian young adults, with 49% believing that people had a moderate or great risk of 'harming their mental health' with regular cannabis use [9]. This lower agreement is perhaps unsurprising given that psychosis and schizophrenia suggest greater disease severity compared to 'harming mental health'. Indeed, when a national Canadian survey asked whether frequent cannabis can 'increase the risk of mental health problems', 75% of all respondents and 65% of past 12-month cannabis consumers agreed—much higher than the agreement observed among Canadians in the current study [27]. Lower awareness of the risk of schizophrenia and psychosis from cannabis use also may reflect the lower prevalence of these conditions in the general population relative to other health effects. Therefore, even meaningful increases in risk may not be apparent or particularly salient to the general population, including cannabis consumers with no experience with schizophrenia or psychosis.

It is also concerning that the proportion of correct responses to the psychosis and schizophrenia item was lower than the item on diabetes, with approximately one-third to one-half of respondents across jurisdictions correctly recognizing this item as false. (Interestingly, non-consumers were more likely than consumers to incorrectly believe that cannabis use can cause diabetes, which

Table III. *Main effects model regressing jurisdiction, cannabis use status and socio-demographic variables on health knowledge index*[a] *(n = 72 459)*

Characteristic	Beta (95% CI)	*P*-value
Jurisdiction	F(272 588) = 713.00	<0.001
Canada versus US 'legal' states	0.61 (0.56, 0.66)	<0.001
Canada versus US 'illegal' states	0.81 (0.76, 0.85)	<0.001
US 'legal' states versus US 'illegal' states	0.20 (0.15, 0.24)	<0.001
Survey year	F(172 588) = 14.06	<0.001
2018	—ref—	—ref—
2019	−0.09 (−0.14, −0.04)	<0.001
Frequency of cannabis use	F(372 588) = 745.71	<0.001
Daily or almost daily user	—ref—	—ref—
Past 12 months user	0.45 (0.39, 0.52)	<0.001
Used >12 months ago	1.07 (1.00, 1.13)	<0.001
Never user	1.32 (1.25, 1.38)	<0.001
Noticing health warnings	F(172 588) = 212.67	<0.001
No	—ref—	—ref—
Yes	0.44 (0.38, 0.50)	<0.001
Sex	F(172 588) = 92.11	<0.001
Female	—ref—	—ref—
Male	−0.18 (−0.22, −0.14)	<0.001
Age	F(472 588) = 56.62	<0.001
16–25	—ref—	—ref—
26–35	−0.35 (−0.42, −0.29)	<0.001
36–45	−0.18 (−0.25, −0.12)	<0.001
46–55	0.05 (−0.02, 0.12)	0.132
56–65	−0.03 (−0.09, 0.03)	0.391
Ethnicity	F(172 588) = 39.82	<0.001
White	—ref—	—ref—
Other/Mixed/Unstated	−0.15 (−0.20, −0.10)	<0.001
Highest education level	F(472 588) = 55.27	<0.001
Unstated	—ref—	—ref—
Less than high school	0.72 (0.39, 1.05)	<0.001
High school diploma	0.57 (0.25, 0.90)	<0.001
Some college/technical training	0.78 (0.46, 1.11)	<0.001
Bachelor's degree or higher	0.96 (0.63, 1.28)	<0.001
Income adequacy (difficulty making ends meet)	F(572 588) = 44.15	<0.001
Unstated	—ref—	—ref—
Very difficult	0.81 (0.66, 0.95)	<0.001
Difficult	0.87 (0.73, 1.00)	<0.001
Neither easy nor difficult	0.72 (0.58, 0.86)	<0.001
Easy	0.92 (0.78, 1.06)	<0.001
Very easy	0.89 (0.75, 1.04)	<0.001
Suspected survey device type	F(272 588) = 7.81	<0.001
Computer	—ref—	—ref—
Smartphone	0.09 (0.05, 0.14)	<0.001
Tablet	0.05 (−0.02, 0.12)	0.145

[a]Items were summed to calculate index score (the two items added in 2019 were excluded).

Table IV. *Odds of responding correctly to each cannabis health risk question, by jurisdiction and frequency of cannabis use (72 459)*

Health risk	AOR (95% CI)	*P*-value
1. Can it be dangerous to drive or operate machinery after using marijuana? ($n = 72\,515$)		
Jurisdiction	F(272 513) = 412.84	<0.001
Canada versus US 'illegal' states	2.33 (2.20, 2.47)	<0.001
Canada versus US 'legal' states	1.62 (1.53, 1.72)	<0.001
US 'legal' versus US 'illegal' states	1.44 (1.36, 1.52)	<0.001
Frequency of cannabis use	F(372 512) = 503.72	<0.001
Never user	3.90 (3.62, 4.22)	<0.001
Used >12 months ago	3.76 (3.48, 4.06)	<0.001
Past 12 months user	2.07 (1.91, 2.23)	<0.001
Daily/almost daily user *(ref)*	*—ref—*	*—ref—*
2. Can it be harmful to use marijuana when pregnant or breastfeeding? ($n = 72\,516$)		
Jurisdiction	F(2, 72 514) = 235.57	<0.001
Canada versus US 'illegal' states	1.70 (1.62, 1.79)	<0.001
Canada versus US 'legal' states	1.57 (1.49, 166)	<0.001
US 'legal' versus US 'illegal' states	1.08 (1.03, 1.14)	0.003
Frequency of cannabis use	F(372 513) = 470.11	<0.001
Never user	3.55 (3.29, 3.82)	<0.001
Used >12 months ago	2.90 (2.69, 3.12)	<0.001
Past 12 months user	1.73 (1.61, 1.87)	<0.001
Daily/almost daily user *(ref)*	*—ref—*	*—ref—*
3. Can marijuana be addictive? ($n = 72\,522$)		
Jurisdiction	F(2, 72 520) = 271.00	<0.001
Canada versus US 'illegal' states	1.73 (1.64, 1.81)	<0.001
Canada versus US 'legal' states	1.55 (1.48, 1.63)	<0.001
US 'legal' versus US 'illegal' states	1.11 (1.06, 1.17)	<0.001
Frequency of cannabis use	F(2, 72 519) = 731.44	<0.001
Never user	4.22 (3.91, 4.55)	<0.001
Used >12 months ago	2.72 (2.53, 2.93)	<0.001
Past 12 months user	1.39 (1.29, 1.51)	<0.001
Daily/almost daily user *(ref)*	*—ref—*	*—ref—*
4. Are teenagers at greater risk of harm from using marijuana than adults? ($n = 72\,508$)		
Jurisdiction	F(272 506) = 509.60	<0.001
Canada versus US 'illegal' states	2.17 (2.07, 2.28)	<0.001
Canada versus US 'legal' states	1.64 (1.56, 1.72)	<0.001
US 'legal' versus US 'illegal' states	1.32 (1.26, 1.39)	<0.001
Frequency of cannabis use	F(372 505) = 268.13	<0.001
Never user	2.41 (2.24, 2.60)	<0.001
Used >12 months ago	1.91 (1.77, 2.05)	<0.001
Past 12 months user	1.29 (1.20, 1.40)	<0.001
Daily/almost daily user *(ref)*	*—ref—*	*—ref—*
5. Can marijuana smoke be harmful? ($n = 72\,524$)		
Jurisdiction	F(272 522) = 353.55	<0.001
Canada versus US 'illegal' states	1.89 (1.80, 1.99)	<0.001
Canada versus US 'legal' states	1.58 (1.50, 1.66)	<0.001
US 'legal' versus US 'illegal' states	1.20 (1.14, 1.26)	<0.001
Frequency of cannabis use	F(342 521) = 650.53	<0.001
Never user	4.26 (3.93, 4.61)	<0.001
Used >12 months ago	2.92 (2.70, 3.16)	<0.001
Past 12 months user	1.56 (1.43, 1.69)	<0.001
Daily/almost daily user *(ref)*	*—ref—*	*—ref—*

(continued)

Table IV. *(Continued)*

Health risk	AOR (95% CI)	*P*-value
6. Can regular use of marijuana increase the risk of psychosis and schizophrenia? ($n = 72\,495$)		
Jurisdiction	F(272 493) = 497.15	<0.001
Canada versus US 'illegal' states	2.09 (1.98, 2.20)	<0.001
Canada versus US 'legal' states	2.02 (1.91, 2.13)	<0.001
US 'legal' versus US 'illegal' states	1.03 (0.97, 1.10)	0.301
Frequency of cannabis use	F(372 492) = 467.45	<0.001
Never user	4.14 (3.75, 4.57)	<0.001
Used >12 months ago	2.53 (2.29, 2.80)	<0.001
Past 12 months user	1.51 (1.36, 1.67)	<0.001
Daily/almost daily user *(ref)*	*—ref—*	*—ref—*
7. Can using marijuana cause diabetes? ($n = 72\,487$)		
Jurisdiction	F(272 485) = 47.29	<0.001
Canada versus US 'illegal' states	0.78 (0.74, 0.82)	<0.001
Canada versus US 'legal' states	0.89 (0.85, 0.94)	<0.001
US 'legal' versus US 'illegal' states	0.88 (0.84, 0.93)	<0.001
Frequency of cannabis use	F(372 484) = 797.57	<0.001
Never user	0.20 (0.18, 0.21)	<0.001
Used >12 months ago	0.38 (0.35, 0.41)	<0.001
Past 12 months user	0.58 (0.54, 0.63)	<0.001
Daily/almost daily user *(ref)*	*—ref—*	*—ref—*
8. Can high-THC marijuana products negatively affect memory and concentration? ($n = 45\,440$)		
Jurisdiction	F(245 438) = 140.66	<0.001
Canada versus US 'illegal' states	1.59 (1.50, 1.69)	<0.001
Canada versus US 'legal' states	1.48 (1.40, 1.56)	0.018
US 'legal' versus US 'illegal' states	1.08 (1.01, 1.14)	<0.001
Frequency of cannabis use	F(345 437) = 281.79	<0.001
Never user	2.89 (2.65, 3.15)	<0.001
Used >12 months ago	2.57 (2.35, 2.79)	<0.001
Past 12 months user	1.47 (1.34, 1.60)	<0.001
Daily/almost daily user *(ref)*	*—ref—*	*—ref—*
9. Can marijuana or CBD help cure or prevent cancer? ($n = 45\,437$)		
Jurisdiction	F(245 435) = 70.55	<0.001
Canada versus US 'illegal' states	1.46 (1.37, 1.56)	<0.001
Canada versus US 'legal' states	1.29 (1.22, 1.37)	<0.001
US 'legal' versus US 'illegal' states	1.13 (1.06, 1.21)	<0.001
Frequency of cannabis use	F(345 434) = 68.30	<0.001
Never user	1.96 (1.78, 2.16)	<0.001
Used >12 months ago	1.84 (1.67, 2.03)	<0.001
Past 12 months user	1.52 (1.37, 1.68)	<0.001
Daily/almost daily user *(ref)*	*—ref—*	*—ref—*

Models were adjusted for age group, sex, education, ethnicity, income adequacy, device type, noticing of health warnings and survey year (except for items 8 and 9, which were asked only in 2019). Sample sizes vary between health risk questions because models exclude those who selected 'Refuse to answer'. *F*-test refers to type III analysis of fixed effects.

suggests a non-specific effect towards greater agreement in general). Although many cannabis consumers self-report using cannabis for mental health concerns [46], there is continued evidence that regular consumers are at heightened risk of psychiatric disorders [47]. Enhanced public health messaging regarding this health risk of cannabis is needed.

Overall, agreement with the health effects of cannabis was somewhat lower than a Canadian

national survey, possibly due to lower social desirability bias associated with online versus in-person or telephone-based surveys [47, 48]. However, the ordering of perceived risk of health effects was the same, with a higher agreement for the item on pregnancy and breastfeeding, followed by harm to adolescents and harms of cannabis smoke [27].

In addition, a non-negligible proportion of respondents (12–18%) responded 'yes' to whether cannabis can prevent or cure cancer, suggesting that a reasonable number of people believe this to be true. Cannabis has demonstrated therapeutic effects, including as an anti-emetic that is commonly used to address the side effects of chemotherapy. However, there is insufficient evidence to date suggesting that it can cure or prevent cancer, and the research regarding its anti-tumour activity is in its infancy [3, 38]. The findings suggest that false beliefs about the medical benefits of cannabis are common and reflect widespread marketing of cannabis and CBD as natural health products, often based on dubious or incorrect claims [48]. Future research should examine potentially false beliefs about the health benefits of cannabis use, particularly if cannabis use supplants effective health care practices.

Across jurisdictions, agreement with health effects was generally highest in Canada, followed by US jurisdictions. Levels of agreement were moderately higher in US states that had legalized recreational cannabis compared to states that had not; however, the magnitude of difference was modest. Given that higher health knowledge was associated with noticing health warnings, the mandated warnings on cannabis products in 'legal' states are one potential explanation for the higher levels of health knowledge compared to 'illegal' states. Undoubtedly, some consumers in US 'illegal' states would have seen legal cannabis products with health warnings out of state, and some US 'illegal' states mandate health warnings on medical cannabis [42]. However, the reach of medical warnings would be lower compared to those on legal recreational cannabis products, which are designed to communicate risks to the general population. Overall, findings do not suggest lower levels of the perceived risk of cannabis in US states that had legalized compared to those that had not, as per some previous studies [22–24]. This contrasting finding may be attributable to several factors, including that this was a general population rather than a school-based survey [22, 24].

There are several possible explanations for the higher level of health knowledge in Canada versus the United States. First, US jurisdictions had greater proportions of daily/almost daily cannabis consumers in 2019 compared to Canada (see Table I). Given that frequent consumers had lower risk perceptions overall, the different distribution of cannabis consumers may have been partially responsible for the lower risk perceptions observed in the United States. Second, survey questions were designed to test knowledge of the risks listed on mandated Canadian warning labels, and may therefore have been more familiar to Canadians [44]. This is consistent with the finding that noticing warnings were associated with greater health knowledge, as is the case for other consumer products, such as tobacco. In addition, previous experimental research demonstrated that the design of the Canadian warnings produces greater recall than the mandated warnings in US 'legal' states [49]. However, if the Canadian warnings were responsible for the higher levels of knowledge compared to the United States, one would expect greater knowledge post-legalization, after the warnings began appearing on products. This was not the case: levels of knowledge in Canada were modestly higher before legalization in 2018 compared to 2019. Lower overall levels of health knowledge in 2019 were largely driven by non-consumers, who account for a much greater proportion of the population than consumers; in contrast, levels of knowledge among daily/almost daily consumers in Canada increased between 2018 and 2019. Given that consumers are far more likely than non-consumers to be exposed to packaged-based warnings, this pattern of findings could be consistent with an effect of the new warnings. Nevertheless, a more plausible explanation for the higher levels of health knowledge in Canada compared to the United States in both 2018 and 2019

may be the public education campaigns implemented in Canada during the lead-up to legalization. In the year prior to legalization, several national mass media campaigns were conducted, along with extensive news coverage and discussion of the health effects of cannabis [50, 51]. These public education initiatives may account for both the higher levels of perceived risk in Canada versus the United States, as well as the moderately higher knowledge levels in 2018 and 2019 among Canadian respondents. Further research will be needed to examine the potential impact of health warnings on population-level health knowledge. This research will need to account for the complex association between frequency of use, exposure to product warnings and pre-existing differences between consumers and non-consumers. Future studies should also account for the gradual transition from illegal to legal retail sources, which directly affects exposure to mandated warnings. Shortly after legalization in Canada, exposure to warnings would have been attenuated by continuing use of products from illicit sources, none of which would display mandated warnings [52]. Legalization in Canada occurred in two phases, and product types other than dried herb and some oils did not become available for legal sale in Canada until 2020 [53]. Therefore, most consumers would still have been accessing the illegal market with little exposure to health warnings in the first year or two following legalization [54].

Finally, findings suggest individual-level differences in cannabis risk perceptions. Notably, higher risk perceptions were found among infrequent or never cannabis consumers, and lower risk perceptions were found among frequent consumers. This is consistent with hypotheses, research on optimistic bias [11–13] and previous studies showing lower risk perceptions—including lower risk of addiction—among those who have consumed cannabis compared to those who have not consumed cannabis [1, 5–9, 27]. This is also consistent with the concept of cognitive dissonance: frequent consumers may avoid regret over their cannabis use by adjusting their belief system (i.e. downplaying cannabis health risks). This phenomenon has been demonstrated in studies among tobacco smokers [15]. Future studies are needed to determine whether there are consistent socio-demographic differences in knowledge of cannabis-related health effects and whether they are different than for tobacco.

Limitations

This study is subject to limitations common to survey research. Respondents were recruited using non-probability-based sampling; therefore, the findings do not provide nationally representative estimates. The data were weighted by age group, sex, region, education and smoking status in both countries and region-by-race in the United States. However, compared to the national population, the US sample had fewer respondents with low education levels and Hispanic ethnicity. Cannabis use estimates were within the range of national estimates for young adults, whereas estimates among the full ICPS sample were generally higher than national surveys in the United States and Canada. This is likely due to the fact that the ICPS-sampled individuals aged 16–65, whereas the national surveys included older adults, who are known to have lower rates of cannabis use. In both countries, the ICPS sample also had poorer self-reported general health compared to the national population, which is a feature of many non-probability samples [55], and may be partly due to the use of web surveys, which provide greater perceived anonymity than in-person or telephone-assisted interviews often used in national surveys [56]. In addition, health risk questions were designed to test the risks listed on Canadian warning labels. Although many of these concepts are communicated by the mandatory labels in US ‘legal’ states [42], the labels use different wordings, and any supplementary information included on US warnings was not tested. Additionally, the measures of health knowledge used agreement questions and conditional causal wording such as ‘can’ when asking about health effects; both practices lead to higher estimates of health knowledge compared to open-ended or unprompted measures and statements featuring more definite causal

wording such as 'causes' [57]. Finally, the index was not previously validated as a measure of cannabis health knowledge. However, sensitivity analyses indicated a similar pattern of findings with respect to jurisdiction and cannabis use frequency when each risk item was modelled separately as opposed to as a linear measure (Table IV).

Conclusions

The current study suggests that population-level knowledge of the health effects of cannabis is relatively low, especially for specific health effects related to mental health. Frequent cannabis consumers had lower perceptions of the risks of cannabis use compared to infrequent consumers, likely due to optimistic bias and the desire to diminish cognitive dissonance. Given that more frequent consumption is associated with higher levels of risk to physical and mental health [3, 47], frequent consumers may benefit from education campaigns aiming to increase knowledge of the health risks of cannabis. As more consumers transition to the legal market in Canada and US 'legal' states, regular consumers will be frequently exposed to mandatory warning labels. Further research is required to determine whether this exposure increases knowledge of the health risks of cannabis in the same manner as has been established for tobacco products. Higher perceptions of health risk were also observed among respondents in Canada compared to those in US jurisdictions, which is consistent with increasing and decreasing risk perceptions of cannabis in Canada and the United States, respectively. US state health authorities should consider these findings when designing educational campaigns and health warning labels.

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Conflict of interest statement

None declared.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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