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RESEARCH ARTICLE

Lower-Risk Cannabis Use Guidelines: Adherence in Canada and the U.S.

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Introduction: This study examines the prevalence of risky cannabis use based on adherence to the Lower-Risk Cannabis Use Guidelines.

Methods: Respondents aged 16−65 years in Canada and the U.S. (N=27,024) completed the online 2018 International Cannabis Policy Study. Participants completed measures corresponding to the Lower-Risk Cannabis Use Guidelines and Alcohol, Smoking and Substance Involvement Screening Test. Analyses were conducted in 2019.

Results: More than half of the respondents (57.3%, *n*=15,489) had ever used cannabis, and 28.1% (*n*=7,584) had used it in the past 12 months (current use). The majority of current consumers (88.8%) reported nonadherence to ≥1 guideline other than ever use. These behaviors included smoking ≥50% of all cannabis consumed (69.8%), using high-tetrahydrocannabinol products (44.9%), initiating cannabis use before age 16 years (35.9%), daily/near-daily use (32.2%), driving after cannabis use (26.1%), cannabis use during pregnancy or with a history of psychosis or substance abuse (17.3%), and synthetic cannabis use (5.9%). More respondents in U.S. legal recreational cannabis states reported nonadherence than those in jurisdictions where recreational cannabis remained illegal. Specifically, consumers in U.S. legal states were significantly more likely to use high-tetrahydrocannabinol products than consumers in U.S. illegal states or Canada and more likely to drive after cannabis use than consumers in Canada ($p<0.001$ for all). Adherence to Lower-Risk Cannabis Use Guidelines was strongly associated with Alcohol, Smoking and Substance Involvement Screening Test scores.

Conclusions: Lower-Risk Cannabis Use Guideline adherence differed by jurisdiction and sociodemographic profile. As more jurisdictions legalize nonmedical cannabis, targeted interventions for key risk behaviors (e.g., using high-potency cannabis, early initiation age, driving after cannabis use) are warranted.

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INTRODUCTION

Nonmedical cannabis has been legalized at the federal level in both Canada and Uruguay.[1,2] In the U.S., 11 states have legalized the possession and sale of recreational cannabis: Alaska, California, Colorado, Illinois, Maine, Massachusetts, Michigan, Nevada, Oregon, Vermont, and Washington as well as the District of Columbia.[3] One of the primary objectives of cannabis legalization is to protect public health, including reducing problematic use.[1] Historically, basic measures of cannabis use prevalence have served as indicators of problematic use, such as ever trying cannabis or use in the past month. However, as an increasing number of jurisdictions legalize nonmedical cannabis, there is a need for more meaningful indicators of risky use,

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especially because primary/severe adverse outcomes occur only among a minority of users.[4,5]

Several tools have been developed to assess risky cannabis use. The Alcohol, Smoking and Substance Involvement Screening Test (ASSIST) was developed by WHO in 2010 to classify individuals according to their risk of dependence on various substances, including cannabis.[6] ASSIST was primarily intended as a screening and assessment measure for primary care settings. More recently, the Lower-Risk Cannabis Use Guidelines (LRCUGs), originally developed in a Canadian context and subsequently revised, were developed to "identify behaviors within a user's control that influence the risk of health consequences from cannabis use."[7,8] The LRCUGs (summarized in Table 1) are a set of 10 recommendations that caution individuals to avoid cannabis use and direct users to reduce or avoid early initiation of cannabis use, use of high-potency products, use of synthetic cannabis, inhalation of combusted cannabis, deep inhalation, daily/near-daily use, driving or operating machinery while impaired, use among high-risk groups, and combining these risk behaviors toward reducing overall risk for adverse outcomes when using cannabis.[8] The LRCUGs provide a template for evaluating the impact of cannabis control policies on minimizing problematic cannabis use. However, to the authors' knowledge, no studies have operationalized the LRCUGs to assess population-level adherence to the guidelines or examined their association with problematic cannabis use. Therefore, the objectives of this study are to (1) examine the prevalence of problematic cannabis use in Canada and the U.S., (2) characterize adherence to the LRCUGs in terms of the legality of nonmedical cannabis and sociodemographic factors, and (3) examine whether problematic cannabis use is associated with adherence to the LRCUGs.

METHODS

Study Sample

Data were from Wave 1 of the International Cannabis Policy Study (ICPS),[9] conducted in Canada and the U.S. Data were collected through self-completed web-based surveys conducted from August 27, 2018, to October 7, 2018 (immediately before nonmedical cannabis legalization in Canada) with respondents aged 16−65 years. Respondents were recruited through the Nielsen Consumer Insights Global Panel and their partners' panels. E-mail invitations (with a unique link) were sent to a random sample of panelists (after targeting for age and country criteria); panelists known to be ineligible were not invited. Surveys were conducted in English in the U.S. and English or French in Canada. The median survey time was 19.9 minutes.

Respondents provided consent before completing the survey. Respondents received remuneration in accordance with their panel's usual incentive structure (e.g., points-based or monetary rewards and 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 technical report and methodology paper.[10,11]

Measures

Cannabis use was measured using 3 variables assessing (1) ever cannabis use, (2) most recent cannabis use, and (3) current frequency of cannabis use (described in ICPS 2018 survey).[9] Ever, past 12−month, and daily/almost daily use were assessed in this study. Medical cannabis authorization was assessed by asking the following 2 questions in Canada and the U.S., respectively: *Were you authorized to use medical marijuana at any time in the past 12 months?; Did you have a recommendation to use medical marijuana at any time in the past 12 months?* Response options were *yes, no, don't know*, and *refuse*.

Sociodemographic variables included sex, age group, education, and race/ethnicity. These variables were selected because of their known association with cannabis use.[12] Response categories used in analyses are shown in Table 2.

Problematic cannabis use was assessed using 7 questions on cannabis use adapted from ASSIST.[6] Briefly, these assess ever cannabis use, past 3−month use, desire to use, personal problems, failing to do what is expected, concern from others, and failing to quit. The ASSIST risk assessment score ranges from 0 to 42. Each respondent is categorized as having a "lower risk of problems related to their substance use" (scores 0−3); "moderate risk of health and other problems and may be experiencing some of these problems now" (scores 4−26); or "high risk of dependence or is dependent on that substance and is probably experiencing health, social, financial, legal, and relationship problems as a result of their substance use" (scores ≥27).[6]

Adherence to the LRCUGs was assessed using 7 survey items; Table 1 summarizes the question wording and scoring.[8] The LRCUG recommendation to avoid deep inhalation when smoking cannabis was not assessed because the ICPS does not assess level of inhalation. The LRCUGs also recommend against combining risk behaviors. Although combining behaviors was not assessed directly in the ICPS, it was assessed indirectly in this study. Additionally, although the LRCUGs were not designed as a scale, a simple index was created and mapped onto the LRCUG recommendations, whereby each individual risk behavior was assigned a score of 1, and the 7 items were summed so that higher scores indicated greater nonadherence (range=0−7).

Statistical Analysis

A total of 28,471 respondents completed the survey. After removing respondents with invalid responses to data quality questions, ineligible country of residence, smartphone use, or residence in District of Columbia (owing to inadequate sample size; n=1,302), a total of 27,169 respondents were retained in the main analytic sample. The final sample for this paper comprised 27,024 respondents after excluding 145 who had missing data on education.

Respondent jurisdiction was classified according to the legal status of nonmedical cannabis as of August 2018: Canada (illegal) and U.S. states that had and had not legalized nonmedical cannabis (legal and illegal states, respectively).

Table 1. Assessment of Risk Behaviors Outlined in LRCUGs

Lower-risk cannabis use guideline	ICPS measures used to assess guideline	Risk behavior scoring
Abstain from cannabis use if possible (general precautionary principle).	Have you ever tried marijuana? 1=Yes 2=No	N/A (not included in index)
If you use cannabis, start later in life (particularly avoid use prior to age 16 years).	How old were you when you first used marijuana? Enter age in years: _____	1=Age of initiation <16 years 0=Age of initiation ≥16 years
Choose lower-strength products, such as those with a lower THC content or a higher ratio of CBD to THC.	Which of the following best describes the type of [product][a] you usually use? 1= High THC, Low CBD 2=High THC, High CBD 3=Low THC, Low CBD 4=Low THC, High CBD 5=Other	1=Uses high-THC products (reported 'High THC, Low CBD' or 'High THC, High CBD' ratio for any of 9 cannabis product types used) 0=Does not use high-THC products
Do not use synthetic cannabis products.	Have you ever used. . .? (List of 9 drugs, including: synthetic marijuana [e.g., spice, K2, K3, scene, herbal mixtures, herbal incense]) 1=Yes 2=No When was the last time you used. . .? (List of 9 drugs, including: synthetic marijuana [e.g., spice, K2, K3, scene, herbal mixtures, herbal incense]) 1=More than 12 months ago 2=Between 3 to 12 months ago 3=Between 1 to 3 months ago 4=Within the last month 5=Within the last week	1=Used synthetic cannabis in past 12 months 0=Did not use synthetic cannabis in past 12 months
Avoid smoking cannabis (choose other modes of use such as vaping or edibles).	Of all the dried herb that you used in the past 12 months, what percent (%) do you. . .? 1=Smoke without tobacco:____% 2=Smoke with tobacco:___% 3=Vape:___% 4=Other (please specify): ____% Of all the marijuana concentrate that you use, what percent (%) do you. . .? 1=Smoke: ___% 2=Vape: ___% 3=Other: ___%	1=At least 50% cannabis consumed by smoking (≥50% dried herb smoked with or without tobacco, or ≥50% concentrate smoked) 0 = Less than 50% of dried herb and/or concentrate consumed by smoking
Avoid deep inhalation when smoking cannabis.	Not assessed in survey	N/A
Try to limit your use as much as possible (avoid daily/near-daily use).	How often do you use marijuana? 1=Less than once per month 2=One or more times per month 3=One or more times per week 4=Every day or almost every day	1=Uses cannabis every day or almost every day 0=Uses cannabis less frequently
Don't drive or operate machinery after using cannabis.	Have you ever driven a vehicle (e.g., car, snowmobile, motor boat, or an off-road vehicle [ATV]) within 2 hours of using marijuana? 1=No, never 2=Yes, in the past 30 days 3=Yes, in the past 12 months 4=Yes, more than 12 months ago	1=Drove after using cannabis in the past 12 months 0=Did not drive after using cannabis in past 12 months
Avoid cannabis use if you are pregnant or have a personal predisposition toward or	When was the last time you used marijuana?	1=Used cannabis in past 30 days[b] and currently pregnant or has experienced or

(continued on next page)

Table 1. Assessment of Risk Behaviors Outlined in LRCUGs (*continued*)

Lower-risk cannabis use guideline	ICPS measures used to assess guideline	Risk behavior scoring
first-degree family history of psychosis or substance abuse.	1=More than 12 months ago 2=More than 3 months ago but less than 12 months ago 3=More than 30 days ago, but less than 3 months ago 4=Within the past 30 days Are you currently pregnant? 1=Yes 2=No Have you ever experienced any of the following mental health problems (regardless of whether you were diagnosed)? Psychosis (e.g., paranoia, disorganized thinking, hearing voices that others can't hear) Schizophrenia Drug or alcohol use Have you ever been diagnosed with any of the following? Psychotic disorder (including schizophrenia) Substance use disorder	used cannabis in past 12 months and has been diagnosed with psychosis, schizophrenia and/or substance abuse[c] 0=Not member of high-risk group described above or member of group but has not used cannabis in past 30 days
Avoid combining the risky behaviors listed above.	Not directly assessed in survey	Summed items 2–5 and 7–9 above to create an index of risky behavior (range=0–7)

Note: All questions included *Don't know* and *Refuse to answer* options.
[a]Asked for 9 product types (e.g., dried herb, edibles, concentrates. . .).
[b]Note that the time frame selected for pregnancy was past 30 days rather than past 12 months owing to lack of information on when respondents became pregnant.
[c]Family history of these mental health issues was not used in scoring because the survey did not specify first-degree relatives.
CBD, cannabidiol; ICPS, International Cannabis Policy Study; LRCUG, Lower-Risk Cannabis Use Guideline; N/A, not applicable; THC, tetrahydrocannabinol.

Poststratification sample weights were constructed on the basis of the Canadian and U.S. Census estimates.[13–16] Respondents from Canada were classified into age × sex × province and education groups. Respondents from U.S. legal states were classified into age × sex × legal state, education, and region × race groups, whereas those from illegal states were classified into age × sex, education, and region × race groups. A raking algorithm[17,18] was applied to the full analytic sample (N=27,169) to compute weights that were calibrated to these groupings. Weights were rescaled to the sample size for Canada, U.S. illegal states, and U.S. legal states. Estimates are weighted unless otherwise specified.

Separate binary logistic regression models were conducted to calculate the odds of engaging in each of the 7 risk behaviors discouraged in the LRCUGs among those who had consumed cannabis in the past 12 months. The following 6 covariates were entered into each model: jurisdiction, sex, age group, education, race/ethnicity, and medical authorization/recommendation in the past 12 months (Table 1 provides response categories). Tests of association were run to examine the association between the LRCUGs and ASSIST: (1) Pearson correlation to examine the association between mean scores on the LRCUG index and ASSIST and (2) 1-way ANOVA to examine the association between mean score on the LRCUG index and ASSIST score categorization (low, medium, or high). Analyses were conducted in 2019 using survey procedures in SAS release 9.4.

RESULTS

Table 2 shows the sample characteristics among all respondents and past 12–month cannabis consumers by jurisdiction. The majority of respondents in each jurisdiction had a low risk score on ASSIST.

More than half of the respondents (57.3%) had ever consumed cannabis; a total of 28.1% (n=7,584) had used cannabis in the past 12 months, including 27.6% (n=2,752) in Canada, 23.8% (n=2,303) in U.S. illegal states, and 34.4% (n=2,529) in U.S. legal states. Among the past 12–month consumers, 88.8% had engaged in ≥1 risk behavior (other than ever using cannabis) identified in the LRCUGs, including 88.3% in Canada, 90.1% in U.S. illegal states, and 88.1% in U.S. legal states. Figure 1A and B show the prevalence of nonadherence

Table 2. Sample Characteristics of Respondents in the 2018 ICPS (N=27,024)

Characteristic	Canada		U.S. illegal states		U.S. legal states	
	All, % (*n*) (*n*=9,976)	Past 12–month cannabis consumers, % (*n*) (*n*=2,752)	All, % (*n*) (*n*=9,686)	Past 12–month cannabis consumers, % (*n*) (*n*=2,303)	All, % (*n*) (*n*=7,362)	Past 12–month cannabis consumers, % (*n*) (*n*=2,529)
Age group, years						
26–35	20.6 (2,059)	29.3 (806)	21.4 (2,074)	27.8 (641)	22.9 (1,685)	29.4 (743)
36–45	19.6 (1,956)	20.5 (564)	19.0 (1,837)	17.8 (409)	17.3 (1,276)	17.1 (432)
46–55	20.9 (2,082)	16.0 (441)	20.2 (1,953)	18.8 (432)	21.8 (1,604)	18.0 (456)
56–65	20.1 (2,008)	14.0 (384)	19.6 (1,898)	12.8 (295)	18.5 (1,361)	15.9 (401)
Sex						
Female	49.9 (4,974)	45.4 (1,249)	50.3 (4,874)	42.9 (988)	49.7 (3,661)	45.8 (1,157)
Male	50.1 (5,002)	54.6 (1,504)	49.7 (4,812)	57.1 (1,315)	50.3 (3,701)	54.2 (1,371)
Race/ethnicity						
White	77.6 (7,743)	80.4 (2,214)	76.5 (7,410)	74.5 (1,715)	76.6 (5,643)	79.6 (2,014)
Other/mixed/ unstated	22.4 (2,233)	19.6 (539)	23.5 (2,276)	25.5 (588)	23.4 (1,719)	20.4 (515)
Education						
Less than high school	15.6 (1,552)	17.8 (490)	15.2 (1,474)	15.1 (347)	11.8 (870)	10.7 (271)
High school diploma or equivalent	26.8 (2,671)	28.1 (772)	19.5 (1,887)	19.8 (455)	16.0 (1,175)	18.7 (473)
Some college[a]	32.7 (3,264)	35.7 (983)	38.4 (3,721)	42.6 (982)	42.2 (3,106)	46.0 (1,164)
Bachelor's degree or higher	24.9 (2,489)	18.4 (507)	26.9 (2,604)	22.5 (518)	30.0 (2,212)	24.6 (622)
Medical cannabis authorization						
Yes	3.7 (372)	11.9 (326)	3.7 (356)	10.1 (232)	7.4 (547)	15.9 (403)
No/unstated[b]	96.3 (9,604)	88.1 (2,426)	96.3 (9,300)	89.9 (2,071)	92.6 (6,815)	84.1 (2,126)
ASSIST risk category						
Low	72.5 (7,230)	0.2 (7)	76.2 (7,385)	0.1 (2)	65.8 (4,840)	0.3 (7)
Moderate	23.4 (2,337)	84.9 (2,337)	18.9 (1,832)	79.5 (1,832)	28.3 (2,082)	82.3 (2,082)
High	4.1 (409)	14.8 (409)	4.8 (469)	20.4 (469)	6.0 (439)	17.4 (439)

[a]Includes some college, college certificate/diploma, technical/vocational training, apprenticeship, or some university.
[b]Less than 2.5% of respondents in each jurisdiction had unstated responses for this variable; *unstated* was therefore collapsed with *no*.
ASSIST, Alcohol, Smoking and Substance Involvement Screening Test; ICPS, International Cannabis Policy Study.

to the LRCUG recommendations by jurisdiction among all respondents and past 12–month consumers, respectively. The most common risk behaviors among past 12–month cannabis consumers were smoking ≥50% of all cannabis consumed (69.8%) and using high-potency products (44.9%). Approximately a third of consumers began using cannabis before age 16 years (35.9%) or reported daily cannabis use (32.2%). More than a quarter of consumers (26.1%) reported driving after cannabis use in the past 12 months. Current use of cannabis among high-risk groups (17.3%) and use of synthetic cannabis (5.9%) were less common.

Table 3 shows the characteristics associated with engaging in each of the LRCUG risk behaviors among past 12–month cannabis consumers. Past 12–month consumers in U.S. legal states were significantly more likely to use high-potency cannabis than those in Canada and U.S. illegal states; they were also more likely to drive after cannabis use than consumers in Canada. Conversely, consumers in U.S. illegal states were more likely to consume their cannabis through smoking and to drive after cannabis use than those in U.S. legal states. The largest relative differences were in the use of high-potency products and driving after cannabis use in U.S. jurisdictions compared with Canada (Figure 1B). Male sex was a consistent predictor of engaging in LRCUG risk behaviors, with the exception of initiation age and daily cannabis use, which did not differ by sex. With the

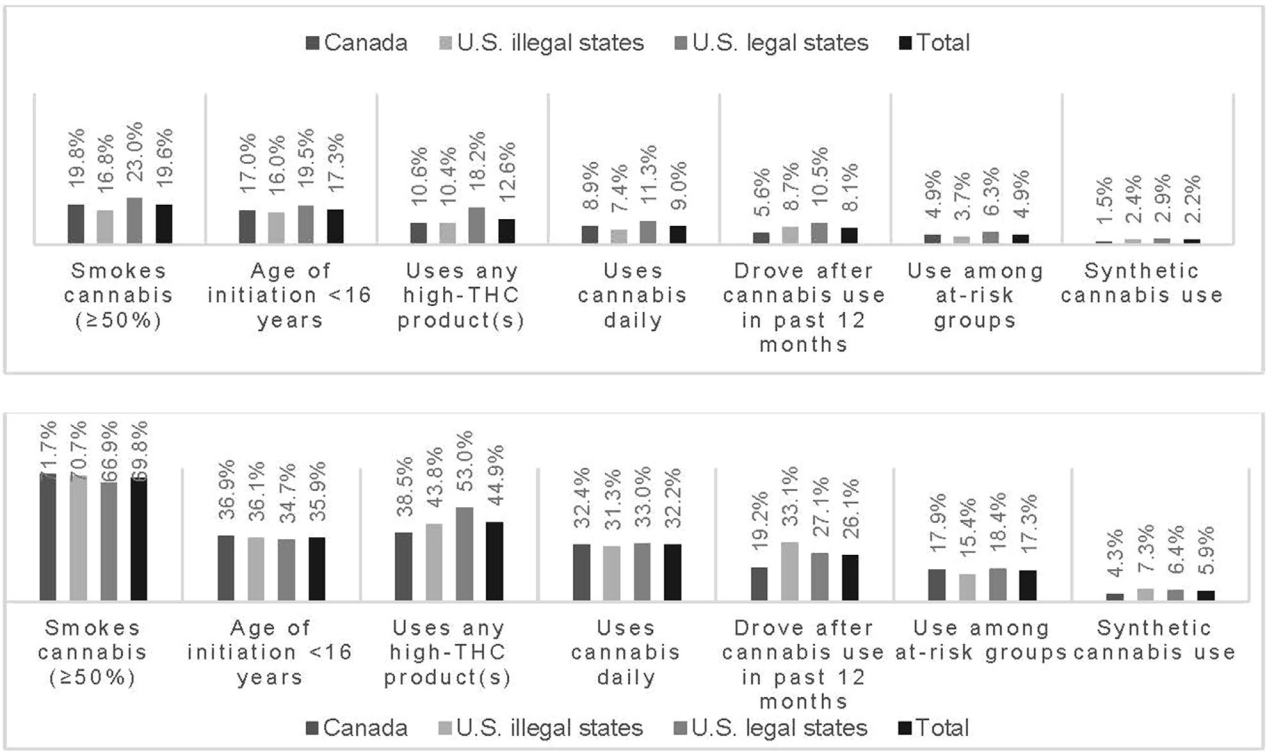

Figure 1. Prevalence of nonadherence to LRCUG recommendations by jurisdiction among (A) all respondents (N=27,024) and (B) past 12−month cannabis consumers (n=7,584) in the 2018 ICPS.[a]

[a]ICPS conducted among respondents in Canada and U.S. states that had and had not legalized nonmedical cannabis as of August 2018. Note that 0.6% (69) of the respondents who reported never trying cannabis reported that they had used synthetic cannabis in the past 12 months.

ICPS, International Cannabis Policy Study; LRCUG, Lower-Risk Cannabis Use Guideline; THC, tetrahydrocannabinol.

exception of consuming cannabis through smoking, age was significantly associated with engaging in all risk behaviors. In general, older adults aged 56−65 years were less likely to engage in LRCUG risk behaviors than younger age groups; however, respondents aged 16−25 years were less likely than those aged 56−65 years to be daily cannabis consumers. Compared with those with less than high school education, those with higher education levels were less likely to begin using cannabis before age 16 years, and those with a bachelor's degree or higher were also less likely to report daily cannabis use. Conversely, the use of high-potency products and synthetic cannabis and driving after cannabis use were generally more common among those with higher education levels. Ethnicity was not associated with LRCUG-identified risk behaviors, with the exception that White consumers were more likely to smoke their cannabis. Those with authorization to use medical cannabis were significantly less likely to begin using cannabis before age 16 years and to smoke their cannabis but were more likely to engage in the remaining risk behaviors than were those without medical authorization.

Among all respondents, mean scores on the LRCUG index (mean=0.74, SE=0.01) and ASSIST tool (mean=6.75, SE=0.06) were positively correlated (r =0.81, p<0.001). LRCUG index was also positively associated with the ASSIST risk categorization of low, moderate, and high risk (F[1, 27,069]=44,106.6, p<0.001).

DISCUSSION

The LRCUGs help to identify specific cannabis use behaviors that increase the risk of problematic use. In this study, more than half of the respondents in Canada and the U.S. had consumed cannabis in their lifetime, and more than a quarter had used cannabis in the past year. The majority of the consumers had engaged in at least 1 other risky behavior discouraged in the LRCUGs, the most common of which were smoking cannabis and early initiation of cannabis use. These findings are consistent with previous literature on the epidemiology of cannabis use: recent Canadian data indicate a median age of initiation of cannabis of 17.0 years,[19] and the

Table 3. Odds of Past 12—Month Cannabis Consumers Reporting Nonadherence to Each LRCUGs Recommendation

Characteristic	Age of initiation <16 years, AOR (95%CI) (*n*=7,584)	Used any high-THC product(s), AOR (95%CI) (*n*=7,584)	Past 12—month synthetic cannabis use, AOR (95%CI) (*n*=7,584)	>50% dried herb or concentrate smoked, AOR (95%CI) (*n*=7,584)	Uses cannabis daily, AOR (95%CI) (*n*=7,584)	Drove after cannabis use in the past 12 months, AOR (95%CI) (*n*=7,584)	Past 30-day cannabis use and belongs to a high-risk group, AOR (95%CI) (*n*=7,584)
Jurisdiction	F(2, 6,734)=0.10	**F(2, 6,734)=19.85**	**F(2, 6,734)=3.53**	F(2, 6,734)=2.36	F(2, 6,734)=0.16	**F(2, 6,734)=32.17**	F(2, 6,734)=1.63
U.S. illegal versus U.S. legal states	0.97 (0.81, 1.17)	**0.56 (0.47, 0.67)**	1.22 (0.82, 1.81)	**1.18 (0.97, 1.42)**	0.97 (0.81, 1.18)	**1.40 (1.15, 1.69)**	0.81 (0.64, 1.02)
Canada versus U. S. legal states	0.96 (0.80, 1.16)	**0.71 (0.59, 0.85)**	0.73 (0.48, 1.11)	1.22 (1.01, 1.47)	0.95 (0.79, 1.14)	**0.64 (0.52, 0.79)**	0.92 (0.74, 1.15)
U.S. illegal states versus Canada	1.01 (0.86, 1.91)	**1.26 (1.08, 1.49)**	**1.68 (1.15, 2.45)**	0.96 (0.81, 1.15)	1.03 (0.86, 1.22)	**2.17 (1.79, 2.62)**	0.88 (0.72, 1.09)
Age group, years	**F(4, 6,732)=2.68**	**F(4, 6,732)=7.53**	**F(4, 6,732)=12.69**	**F(4, 6,732)=3.33**	**F(4, 6,732)=13.30**	**F(4, 6,732)=4.18**	**F(4, 6,732)=4.21**
56—65 (ref)	ref	ref	ref[a]	ref	ref	ref	ref
46—55	**1.30 (1.03, 1.64)**	**1.28 (1.01, 1.61)**	ref[a]	1.07 (0.84, 1.35)	1.11 (0.88, 1.39)	1.20 (0.93, 1.55)	1.25 (0.95, 1.66)
36—45	0.91 (0.72, 1.16)	**1.70 (1.34, 2.14)**	**3.62 (2.05, 6.39)**	**1.34 (1.05, 1.71)**	0.87 (0.68, 1.11)	**1.45 (1.12, 1.87)**	**1.43 (1.06, 1.94)**
26—35	0.94 (0.75, 1.18)	**1.74 (1.40, 2.18)**	**5.18 (3.06, 8.74)**	0.87 (0.70, 1.08)	1.04 (0.83, 1.30)	**1.43 (1.12, 1.82)**	**1.44 (1.09, 1.91)**
16—25	1.01 (1.43, 2.04)	**1.41 (1.10, 1.80)**	**3.53 (1.87, 6.67)**	1.21 (0.87, 1.44)	**0.44 (0.33, 0.57)**	0.92 (0.69, 1.23)	0.82 (0.59, 1.14)
Sex	F(1, 6,732)=1.17	**F(1, 6,735)=65.83**	**F(1, 6,735)=23.65**	**F(1, 6,735)=7.40**	F(1, 6,735)=0.56	**F(1, 6,735)=38.59**	**F(1, 6,735)=4.16**
Female (ref)	ref	ref	ref	ref	ref	ref	ref
Male	1.08 (0.94, 1.26)	**1.82 (1.57, 2.10)**	**2.29 (1.64, 3.20)**	**1.23 (1.06, 1.43)**	0.94 (0.81, 1.10)	**1.67 (1.42, 1.96)**	**1.21 (1.01, 1.45)**
Race/ethnicity	F(1, 6,735)=0.17	F(1, 6,735)=0.19	F(1, 6,735)=0.38	**F(1, 6,735)=17.84**	F(1, 6,735)=0.19	F(1, 6,735)=0.96	F(1, 6,735)=2.43
White (ref)	ref	ref	ref	ref	ref	ref	ref
Other/mixed/ unstated	0.96 (0.79, 1.17)	1.04 (0.86, 1.26)	1.14 (0.75, 1.74)	**0.66 (0.54, 0.80)**	1.05 (0.85, 1.28)	0.90 (0.72, 1.11)	0.81 (0.63, 1.06)
Education	**F(3, 6,733)=50.04**	**F(3, 6,733)=2.97**	F(3, 6,733)=2.25	F(3, 6,733)=1.00	**F(3, 6,733)=35.13**	**F(3, 6,733)=5.76**	**F(3, 6,733)=6.36**
Less than high school (ref)	ref	ref	ref	ref	ref	ref	ref
High school diploma	**0.44 (0.34, 0.58)**	**1.37 (1.02, 1.83)**	1.18 (0.61, 2.28)	1.07 (0.79, 1.43)	1.30 (0.97, 1.76)	**2.03 (1.42, 2.90)**	1.32 (0.91, 1.90)
College/vocational training	**0.37 (0.29, 0.48)**	**1.44 (1.09, 1.90)**	1.62 (0.89, 2.93)	1.11 (0.84, 1.46)	1.07 (0.81, 1.42)	**1.81 (1.28, 2.57)**	1.08 (0.76, 1.53)
Bachelor's degree or higher	**0.18 (0.14, 0.24)**	1.21 (0.91, 1.61)	**2.02 (1.11, 3.67)**	0.95 (0.71, 1.27)	**0.44 (0.32, 0.60)**	**1.56 (1.09, 2.23)**	0.70 (0.48, 1.04)
Medical cannabis authorization	**F(1, 6,735)=12.68**	**F(1, 6,735)=71.11**	**F(1, 6,735)=28.39**	**F(1, 6,735)=12.37**	**F(1, 6,735)=41.41**	**F(1, 6,735)=14.37**	**F(1, 6,735)=1.26**
No/unstated (ref)	ref	ref	ref	ref	ref	ref	ref
Yes	**0.64 (0.50, 0.82)**	**2.87 (2.25, 3.66)**	**2.85 (1.94, 4.20)**	**0.66 (0.52, 0.83)**	**2.09 (1.67, 2.61)**	**1.59 (1.25, 2.03)**	**1.18 (0.88, 1.57)**

Note: Boldface indicates statistical significance ($p<0.05$).
[a]Reference group for the risk behavior used synthetic cannabis was aged 46—65 years owing to small cell sizes in the group aged 56—65 years.
F, Type-III test of fixed effects; LRCUG, Lower-Risk Cannabis Use Guideline; ref, reference group; THC, tetrahydrocannabinol.

majority of Americans who initiated cannabis in 2018 were youth/young adults aged 12−25 years.[20] Among those who use cannabis, smoking is the most common method of consumption in both Canada and the U.S. states with and without cannabis legalization.[19,21,22] In this study, the use of products high in tetrahydrocannabinol (THC) was the third most common behavior among cannabis consumers. These findings suggest that more specific recommendations regarding routes of administration are needed. The LRCUGs discourage smoking owing to its negative effects on respiratory health,[8] yet many of the remaining routes involve higher THC products and may present other health risks. For example, edibles are associated with a risk of overconsumption owing to consumer difficulties in dosing,[23,24] and vape oils have been associated with cases of serious lung disease, mainly in the U.S., largely attributable to contaminants.[25] More specific guidelines regarding the safe use of these alternate product forms are warranted. Moreover, the term "high potency" may require greater specification. The recommendation to "start low, go slow" is a common refrain in public education campaigns; however, for this to be possible, consumers require guidance regarding what represents a high level of THC as well as clear and consistent product information.[24,26]

The prevalence of engaging in higher-risk cannabis use behaviors was not equally distributed across the sample. Compared with jurisdictions where recreational cannabis remained illegal, the prevalence of all risk behaviors was higher in the U.S. states that had legalized nonmedical cannabis use. This difference may be due to pre-existing trends; in most cases, legal states had higher rates of cannabis use before legalization.[22] However, when only past 12−month cannabis consumers were examined, the differences between jurisdictions persisted only for selected risk behaviors, especially the use of high-potency products. This suggests that the higher prevalence of most but not all risk behaviors may be attributed to a greater number of cannabis consumers in legal jurisdictions.

Sociodemographic differences in adherence to the LRCUGs were also observed. For certain subgroups, including male individuals and in some cases younger individuals, a higher prevalence of risk behaviors was consistent with previous literature indicating greater cannabis use in these populations.[17] By contrast, the differences in risk behaviors by education level were mixed. For example, respondents with higher education levels were less likely to begin using cannabis at an early age but were generally more likely to report using high-potency products and synthetic cannabis and to drive after cannabis use. In addition, consumers with the authorization to use medical cannabis were more likely to report every risk behavior, with the exception of early initiation age and consumption of cannabis through smoking. More frequent cannabis use is expected among medical cannabis consumers, and consumption of cannabis through methods other than inhalation is consistent with higher use of therapeutic products, which are often taken orally or topically.

Although the LRCUGs were not designed to provide an overall measure or index of problematic use, nonadherence to LRCUG recommendations was highly associated with the WHO ASSIST measure. The ASSIST measure was developed to assess problematic cannabis use in primary care settings and characterizes both one's level of dependence and risk of downstream outcomes such as health, social, legal, or financial problems associated with substance use.[6] Conceptually, the LRCUGs have a greater focus on the upstream behavioral indicators that may increase the risk of the downstream outcomes measured in the ASSIST tool. The strong associations between the LRCUG indicators and ASSIST scores warrant further consideration in terms of how current or future lower-risk guidelines relate to the different measures of problematic cannabis use.

Limitations

This initial attempt at operationalizing the LRCUG indicators highlighted several challenges. For example, regarding the LRCUG recommendation not to drive or operate machinery after cannabis use, operating machinery was not considered owing to the level of subjectivity involved in determining hazardous work environments. Individual LRCUG indicators also utilize different timeframes: current, past 30−day, or past 12−month cannabis use, whereas some indicators do not refer to a specific timeline at all. The timeframe used will affect the prevalence of these indicators in the population and warrants further consideration. It is also likely that the majority of consumers were unaware of the LRCUGs and certain risk behaviors (e.g., don't drive high) may have been more clearly communicated to the public than others (e.g., avoid synthetic cannabis use), suggesting that more widespread public health messaging is needed. In addition, if the LRCUG indicators are to serve any surveillance function, it is important to recognize that indicators such as the age of initiation must account for historical cohort effects; the age of initiation for middle-aged and older adults provides little insight into today's cannabis context. This study also highlights several limitations in the way that several cannabis use behaviors are assessed. References to THC and synthetic cannabis may be prone to misunderstanding; although the ICPS survey measure of synthetic cannabis use refers to *spice, K2, K3, scene, herbal mixtures, herbal incense,*

etc., respondents could be misinterpreting the question as referring to synthetic prescription medications such as dronabinol and nabilone. Finally, one recommendation from the LRCUGs (avoid deep inhalation) was not examined in this study given the difficulties of assessing inhalation patterns through self-reported measures.

This study is also subject to limitations common to survey research. Respondents were recruited using nonprobability-based sampling; therefore, the findings do not provide nationally representative estimates. The data were weighted by age group, sex, and region in both countries and region × race in the U.S. However, the study sample was somewhat more highly educated than the national population in the U.S. In both countries, the ICPS sample had poorer self-reported general health compared with the national population, which is a feature of many nonprobability samples[27] and partly may be due to the use of web surveys, which provide greater perceived anonymity than in-person or telephone-assisted interviews often used in national surveys.[28] The rates of cannabis use were also somewhat higher than in national samples; however, this is likely because the ICPS sampled individuals aged 16–65 years, whereas the national surveys included older adults who may have lower rates of cannabis use.

CONCLUSIONS

The LRCUGs provide a set of indicators that can be used to assess problematic cannabis use, including for the purpose of monitoring the impact of cannabis policies and patterns of cannabis use relevant to public health in population-based surveys. Evidence from this study suggests varying levels of adherence across the guidelines' different recommendations, with inhalation of cannabis smoke, use of high-potency products, daily cannabis use, and impaired driving emerging as common risk behaviors. Future research should examine the impact of different cannabis control policies as well as related intervention measures in both legal and illegal jurisdictions. In addition, ongoing efforts to revise the LRCUGs should consider adding more prescriptive recommendations to facilitate the identification of risky cannabis use behaviors. In particular, the development of a standardized THC unit might provide clearer guidance to consumers in regard to high-potency products and dosing.[26,29,30]

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