

# Self-reported THC content and associations with perceptions of feeling high among cannabis consumers

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## Abstract

**Introduction:** Few studies have examined consumer knowledge and communication of tetrahydrocannabinol (THC) content among cannabis consumers, including potential differences by cannabis legislation. The study sought to: (i) examine self-reported knowledge of THC content across 10 cannabis products; (ii) examine self-reported intoxication levels; and (iii) examine association between self-reported THC levels and intoxication levels.

**Methods:** Repeat cross-sectional surveys were conducted in Canada and the United States in September–November 2020 as part of the International Cannabis Policy Study. Respondents were past 12-month cannabis consumers, aged 16–65 ( $n = 13,689$ ). A weighted logistic regression model examined the association between expected intoxication of dried flower, jurisdiction and frequency of cannabis use.

**Results:** Across all 10 cannabis products, approximately two-thirds of consumers did not know the quantitative THC level of the cannabis product they last used. Qualitative levels of THC (e.g., ‘low’ or ‘high’ THC) showed moderate correspondence with quantitative self-reported THC levels for most products. Approximately half of consumers across all products reported achieving their desired intoxication level at last use, with higher levels among more frequent consumers and Canadian consumers of dried flower ( $F = 2.54$ ,  $p = 0.019$ ).

**Discussion and Conclusions:** Overall, comprehension of THC levels in cannabis products is low among consumers in both illegal and legal markets.

## KEYWORDS

Canada, cannabis, labelling, marijuana, United States

## 1 | INTRODUCTION

Cannabis is among the most widely used drug in the world [1]. Cannabis is used for its psychoactive effects, including the euphoric experience of feeling ‘high’, as well perceived therapeutic effects, such as sleep outcomes and pain management [2]. Cannabis can also have adverse outcomes, ranging from acute effects associated with over-consumption, impaired driving and longer-term adverse effects associated with early onset and heavy cannabis use, including addiction [3].

Adverse outcomes from cannabis use are influenced by the type of cannabis product. The short- and long-term effects of cannabis vary depending on the mode of administration (e.g., smoking, vaping, eating) and product forms (e.g., dried flower, oral oils, edibles). Product forms can have markedly different potency, which is typically assessed by tetrahydrocannabinol (THC) levels [4]. Cannabis concentrates contain substantially higher levels than dried flower and can exceed 90% in solid concentrates and vaping liquids [5, 6]. THC levels can also vary

within product categories; for example, edibles can range from several milligrams (mg) of THC to several hundred mgs of THC [4].

The diversity of THC levels across cannabis products presents challenges for communicating THC levels to consumers and consumer understanding and resulting consumption [7]. Overconsumption is particularly common with cannabis edibles due to the wide range of potency levels, combined with the delayed onset of effects from oral consumption [8, 9]. Although overconsuming cannabis products is not fatal, these adverse events can be highly unpleasant and result in increased use of health-care resources [5, 10].

Several studies indicate that many cannabis consumers are aware of THC; however, understanding of THC levels is very low [11]. Low consumer knowledge of THC levels likely reflects unreliable labelling practices and communication in illegal markets. Products sourced in illegal markets are often sold without any formal packaging and the potency of cannabis products is often inferred from the strain and various descriptors, which are unreliable indicators of potency or THC levels [12, 13]. When illegal products are sold in 'manufactured' packaging and display THC content, the accuracy of THC numbers is questionable [13].

Legalisation and regulation of cannabis markets provides an opportunity to educate consumers about product characteristics, including THC levels. As of 2022, 18 US states and the District of Columbia have legalised non-medical cannabis, while Canada has also legalised cannabis at the national level. Each of these jurisdictions have regulations that require product testing and display of THC numbers on product packaging, either in THC percentage or mg [13]. A 2016 study examined consumer use and understanding of edible products in Colorado and Washington State and called for improvements in labelling, noting that respondents found labels unclear and lacking information [14]. To date, only one study has directly compared THC knowledge between US jurisdictions that have and have not legalised non-medical cannabis [11]. The effectiveness of mandated THC labels in enhancing consumer knowledge and understanding depends on whether consumers are actually exposed to the information displayed on the label; in the first 24 months following legalisation in Canada, approximately half of consumers continued to source their products from illegal sources [15, 16].

Better communication and understanding of THC levels has the potential to promote lower-risk cannabis use. The shifting legal status of cannabis presents an opportunity to address this lack of knowledge through accurate product labelling and targeted consumer education. The current study had three primary objectives:

(i) to examine self-reported knowledge of THC content across 10 cannabis products using both quantitative and qualitative descriptors; (ii) to examine self-reported intoxication levels associated with 10 types of cannabis products; and (iii) to examine association between self-reported THC levels and intoxication levels of dried flower.

## 2 | METHODS

Data are from Wave 3 of the International Cannabis Policy Study, a cross-sectional survey conducted in Canada and the United States [17]. Data were collected via self-completed web-based surveys conducted in September–November 2020 from respondents aged 16–65 years and recruited through the Nielsen Consumer Insights Global Panel and their partners' panels. The Nielsen panels are recruited using a variety of probability and non-probability sampling methods. Nielsen draws stratified random samples from the online panels, with quotas based on age and state/province of residence. Nielsen emailed panellists an invitation to access the survey via a hyperlink; respondents were unaware of the survey topic prior to accessing the link. Respondents confirmed their eligibility and provided consent before completing the survey. Upon completion, respondents were transferred back to the Nielsen platform and receive remuneration. The American Association on Public Opinion Research Cooperation rate was 62.0% in 2020 [18].

Surveys were conducted in English in the United States and English or French in Canada. Median survey time was 21 min. 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 Technical Report and methodology paper [17, 19].

### 2.1 | Measures

#### 2.1.1 | Socio-demographics

Respondents provided demographic information, including sex at birth, age, race, highest education level, perceived income adequacy and device used to complete survey. See Table S1, Supporting Information, for measures.

#### 2.1.2 | Cannabis use frequency

Frequency of cannabis use was categorised as: 'Less than monthly, but in the past year', 'Monthly', 'Weekly', 'Daily/almost daily'.

### 2.1.3 | US cannabis laws

US states were categorised according to their cannabis laws at the time of survey. 'Illegal' states were defined as states without medical or non-medical cannabis laws. 'Medical' states were defined as those with medical cannabis laws. 'Non-medical' states were defined as those with non-medical cannabis laws.

### 2.1.4 | Cannabis product use

Respondents were asked about their use of nine cannabis products in the past 12 months (no; yes, but not in past 12 months; yes, in past 12 months): dried flower (smoked or vaped), cannabis oils/liquids taken orally (drops or capsules), cannabis oil/liquid for vaping, edibles/foods, drinks, solid concentrates (e.g., wax, shatter), hash or kief, tinctures and topicals. Respondents who reported past 12-month consumption were asked to provide their frequency of each product use: 'Less than monthly, but in the past year', 'Monthly', 'Weekly', 'Daily/almost daily'. Cannabis drops and capsules were separated to total 10 cannabis products.

### 2.1.5 | Qualitative THC ratio

Past 12-month consumers of each product type were asked, 'Think of the last time you used ... [product type]. Which of the following best describes the THC level?' See Table 1 for response options.

### 2.1.6 | Quantitative THC levels

Past 12-month consumers of each product type were asked, 'Do you know the amount of THC or CBD of the [product type] you used last?' with response options 'Yes', 'No', and 'Do not know'. Respondents who answered 'Yes' were asked to enter the THC level (either as a percentage or in mg, depending on the cannabis product).

### 2.1.7 | Self-reported intoxication

Past 12-month consumers of each product type were asked, 'The last time you used [product type], how high did you feel?'. See Table 1 for response options.

### 2.1.8 | Desired intoxication

Past 12-month consumers of each product type were asked, 'Which best describes your experience after using

[product type]?'. See Table 1 for full response options. For regression analyses, responses were categorised as: 'More high than I wanted', 'About right' and 'Less high than I wanted'.

All questions included 'Do not know' and 'Refuse to answer' options. All 'Refuse to answer' options were set to missing. Except in measures described above, all 'Do not know' options were set to missing.

## 2.2 | Data analysis

The full sample comprised 43,871 survey respondents, of which a final sample of 13,689 past 12-month cannabis consumers was used for analyses. A sub-sample of 13,275 were included in the current analysis after excluding those with missing data on education and income adequacy ( $n = 414$ ).

Post-stratification sample weights were constructed based on known population targets. Respondents from Canada were classified into age-by-sex-by-province, education and age-by-smoking status groups. Respondents from US legal states were classified into age-by-sex-by-legal state, region-by-race and education-by-legal state. Respondents from US illegal and medical only states were classified into age-by-sex, region-by-race and education. Separately for jurisdiction, a raking algorithm was applied to the analytic sample to compute weights that were calibrated to these groupings. Weights were rescaled to the sample size for each jurisdiction. Estimates are weighted unless otherwise specified.

First, descriptive statistics were used to describe THC knowledge, self-reported and desired intoxication across 10 cannabis products. Second, the mean and median THC levels were estimated among respondents who reported knowing the THC level of their products. Third, the mean and median percentage of THC was examined across desired intoxication of all 10 cannabis products. Finally, a multinomial logistic regression model was fitted to examine the association between desired intoxication of dried flower, jurisdiction and frequency of cannabis use. Regression models were adjusted for age, sex, education level, race, income adequacy and survey device type. Adjusted odds ratios were reported with 95% confidence intervals. Analyses were conducted using survey procedures in SAS (SAS version 9.4, SAS Institute Inc., Cary, NC, USA).

## 3 | RESULTS

### 3.1 | Sample characteristics

Table S1 displays the sample characteristics of past 12-month cannabis consumers in Canada and the

**TABLE 1** Potency knowledge and experience across 10 cannabis product types among past 12-month cannabis consumers.

	Liquid					Solid				
	Dried flower, n = 10,503	Oral oils, n = 2669	Capsules, n = 1443	Vape oils, n = 5076	Edibles, n = 8100	Drinks, n = 2456	Concentrates, n = 3280	Hash, n = 3459	Tinctures, n = 2287	Topicals, n = 3157
What was the THC level the last time you used ...	n = 10,475	n = 2666	n = 1442	n = 5039	n = 8060	n = 2423	n = 3236	n = 3399	n = 2231	n = 3100
No THC	0.7% (76)	13.9% (371)	8.3% (120)	1.6% (82)	2.0% (164)	4.8% (117)	0.9% (28)	0.5% (16)	11.8% (263)	18.5% (573)
Low THC	6.7% (706)	24.6% (656)	19.2% (277)	9.4% (476)	15.2% (1228)	19.6% (476)	6.3% (204)	6.5% (220)	18.6% (415)	18.3% (568)
Medium THC	28.5% (2991)	24.0% (639)	27.8% (401)	23.2 (1167)	27.2% (2192)	30.3% (734)	14.6% (471)	18.3% (623)	18.8% (420)	17.9% (556)
High THC	32.0% (3353)	16.8% (447)	22.9% (330)	31.1% (1565)	22.3% (1801)	18.3% (443)	29.4% (952)	29.5% (1002)	18.5% (413)	11.5% (355)
Very high THC	12.4% (1299)	11.3% (300)	13.0% (188)	19.1% (962)	10.3% (832)	10.8% (262)	32.6% (1056)	19.5% (664)	12.8% (286)	5.9% (182)
Do not know	19.6% (2051)	9.5% (253)	8.7% (126)	15.6% (788)	22.9% (1843)	16.1% (391)	16.2% (525)	25.7% (873)	19.4% (434)	27.9% (866)
Do you know the % of THC of the product you used last?	n = 10,474	n = 2664	n = 1439	n = 5036	-	n = 2426	n = 3233	n = 3396	n = 2234	n = 3104
Yes	27.6% (2890)	37.8 (1006)	40.5% (582)	25.8% (1297)	-	34.4% (835)	24.9% (804)	18.2% (616)	28.9% (646)	21.7% (674)
No	54.4% (5699)	44.9% (1195)	42.3% (609)	53.3% (2684)	-	46.5% (1129)	53.2% (1719)	56.6% (1921)	48.0% (1071)	55.4% (1718)
Do not know	18.0% (1886)	17.4% (463)	17.3% (248)	20.9% (1055)	-	19.1% (463)	22.0% (710)	25.3% (858)	23.2% (517)	22.9% (711)
How high did you feel?	n = 10,365	n = 2635	n = 1409	n = 4871	n = 7962	n = 2266	n = 3066	n = 3106	n = 2035	n = 2843
Not at all high	4.1% (425)	32.7% (862)	20.4% (287)	6.3% (306)	12.0% (951)	15.6% (353)	3.6% (109)	2.4% (75)	26.8% (545)	63.3% (1800)
A little high	30.2% (3130)	30.4% (801)	29.7% (418)	24.9% (1212)	31.0% (2456)	35.1% (795)	13.3% (406)	16.5% (514)	27.0% (550)	14.3% (403)
High	40.3% (4179)	18.5% (488)	23.4% (329)	34.5% (1679)	28.0% (2217)	25.8% (586)	27.9% (854)	39.7% (1232)	23.4% (477)	11.8% (336)
Very high	17.7% (1837)	9.6% (252)	19.2% (271)	22.8% (1111)	16.9% (1343)	12.8% (290)	31.1% (953)	27.3% (848)	13.2% (269)	5.9% (167)
Extremely high	7.7% (794)	8.8% (233)	7.3% (104)	11.6% (564)	12.1% (959)	10.7% (242)	24.2% (743)	14.1% (437)	9.6% (195)	4.6% (132)
Which best describes your experience?	n = 10,329	n = 2629	n = 1414	n = 4855	n = 7897	n = 2270	n = 3069	n = 3095	n = 2046	n = 2844
I did not feel high at all	2.7% (277)	25.3% (664)	15.2% (215)	4.4% (212)	9.1% (715)	11.4% (259)	2.5% (77)	1.3% (40)	21.6% (443)	54.3% (1543)
Much less high than wanted	3.8% (390)	6.4% (168)	5.0% (71)	4.2% (204)	6.2% (490)	8.0% (181)	2.8% (86)	3.2% (100)	6.9% (141)	3.6% (102)
A little less high than I wanted	9.7% (1005)	10.9% (286)	15.5% (219)	12.7% (615)	12.3% (969)	16.7% (380)	8.5% (262)	12.9% (400)	12.0% (246)	8.3% (235)
About right	68.2% (7043)	42.7% (1122)	43.1% (609)	57.4% (2785)	49.2% (3888)	44.9% (1019)	52.8% (1621)	58.2% (1802)	41.6% (852)	23.9% (681)
A little more high than I wanted	11.0% (1133)	8.4% (220)	14.1% (199)	13.8% (670)	14.7% (1161)	11.2% (254)	19.9% (611)	16.5% (511)	9.5% (195)	5.5% (156)
Much more high than I wanted	4.7% (481)	6.4% (169)	7.1% (100)	7.6% (369)	8.5% (674)	7.8% (174)	13.4% (411)	7.8% (243)	8.3% (170)	4.5% (127)

Abbreviation: THC, tetrahydrocannabinol.

United States in 2020. In all jurisdictions, half of respondents were male, three-quarters were 'White', over a third were daily/almost daily cannabis consumers and a third resided in Canada.

### 3.2 | Qualitative THC levels

Table 1 displays qualitative descriptors of the THC levels of the products 'last used' across 10 cannabis product types among past 12-month cannabis consumers. The percentage of respondents who reported not knowing the THC level was lowest for liquid capsules (8.7%) and highest for topicals (27.9%). Qualitative THC levels differed among products. Most solid concentrate consumers reported that their product contained high or very high THC (62.0%). In contrast, 17.1% of topical consumers reported that their product contained high or very high THC.

### 3.3 | Knowledge of quantitative THC levels

A minority of consumers in each product category reported knowing the quantitative THC level (Table 1). For example, only 27.6% of dried flower consumers reported knowing the THC percentage of the dried flower they used last, with a low of 18.2% among hash consumers and a high of 40.5% among consumers of liquid capsules.

Table S2 displays the average THC level of cannabis products used last among consumers who reported knowing the quantitative THC level. The lowest median THC level was for oral oils (23.3%) and the highest median THC level was for solid concentrates (74.9%). For edibles, the median THC content reported was 10.0 mg. The median value for dried flower was below the biological limit of 30% THC (23.9%), but the mean THC level was above (31.9%).

### 3.4 | Self-reported and desired intoxication

Most consumers for dried flower (70.5%), drinks (60.9%), edibles (59.0%), vape oils (57.3%) and capsules (53.1%) reported feeling 'a little high' or 'high' after consuming their respective product (Table 1). Most consumers of topicals (77.6%), oral oils (63.1%) and tinctures (53.8%) reported feeling 'not at all high' or 'a little' high. Most hash/kief (67.3%) or solid concentrate (59.0%) consumers reported feeling 'high' or 'very high'.

In terms of the desired versus experienced level of intoxication, close to half of consumers reported that the

high that they experienced was 'about right' in all product categories except for topicals, where over half of consumers reported feeling 'not high at all' (Table 1). Nearly 70% of consumers of dried flower indicated feeling 'about right' and only 5% of consumers were 'much more high' than they wanted. Although half of solid concentrate consumers indicated feeling 'about right', over one-third of consumers indicated being 'more high' or 'much more high' than they wanted.

### 3.5 | Association between self-reported THC level and intoxication levels

Tables 2 and 3 compare self-reported qualitative and quantitative THC levels among consumers who reported the quantitative THC level of their product. In general, qualitative levels of THC aligned with the median order of quantitative THC percentages. For example, the median percentage of THC in dried flower among consumers who reported using a product with 'no THC' was 0.0% increasing to and 28.0% among those reporting 'very high THC' in their dried flower. The alignment between qualitative and quantitative THC levels was less consistent for other products, including oral oils, liquid capsules and tinctures, particularly with respect to THC levels described as 'medium'.

Consumers of dried flower, oral oils, liquid capsules, edibles, drinks, tinctures and topicals who reported that their experience was 'about right' reported lower THC levels than consumers who reported feeling higher than was desired. For example, capsule consumers who reported feeling 'about right' reported a median THC level of 35.0%, compared to consumers who felt higher than they desired (45.0%). Among vape oil, solid concentrate, and hash/kief consumers, those reporting feeling 'about right' also reported the highest median THC level, 79.0%, 82.0% and 49.0%, respectively.

### 3.6 | Correlates of self-intoxication level among dried flower consumers

A multinomial logistic regression model was fitted to examine correlates of the desired intoxication of dried flower at last use (Table 4). Respondents in Canada had higher odds of reporting their experience was 'about right' versus 'higher than I wanted' compared to respondents in all US jurisdictions. Respondents in Canada had higher odds of reporting their experience was 'less than I wanted' relative to 'higher than I wanted' compared to respondents in US medical states.

Monthly or more frequent dried flower consumption was associated with higher odds of reporting an



**TABLE 2** The average self-reported THC level by qualitative THC levels and self-reported intoxication across dried flower, oral oils, liquid capsules, vape oils and edibles among consumers who reported knowing the quantitative THC level of their respective product.

	Dried flower, <i>n</i> = 2123			Oral oils, <i>n</i> = 237			Liquid capsules, <i>n</i> = 249			Vape oils, <i>n</i> = 532			Edibles, <i>n</i> = 2069		
	Mean THC % (SEM)	Median THC % (SE)	Mean THC % (SEM)	Median THC % (SE)	Mean THC (mg) (SEM)	Median THC (mg) (SE)	Mean THC % (SEM)	Median THC % (SE)	Mean THC (mg) (SEM)	Median THC % (SE)	Mean THC (mg) (SEM)	Median THC % (SE)	Mean THC (mg) (SEM)	Median THC (mg) (SE)	
What was the THC level the last time you used...															
No THC	0.8% (0.4)	0.0% (1.1)	5.1% (2.5)	0.0% (1.6)	0.5 (0.3)	0.0 (0.5)	<sup>a</sup>	<sup>a</sup>	7.8 (7.3)	0.0 (11.8)					
Low THC	25.6% (3.6)	14.6% (3.6)	15.4% (3.5)	5.9% (2.2)	8.8 (2.9)	4.0 (0.6)	32.2% (4.3)	28.5% (8.4)	17.9 (5.7)	5.7 (1.2)					
Medium THC	28.2% (1.1)	20.7% (0.5)	34.6% (4.7)	37.2% (8.4)	18.6 (6.5)	7.7 (1.6)	40.3% (3.1)	45.0% (6.0)	47.1 (8.3)	9.7 (0.9)					
High THC	32.7% (1.0)	23.9% (0.4)	42.8% (5.7)	29.5% (8.8)	17.7 (3.7)	5.7 (1.8)	65.6% (2.5)	74.5% (4.8)	68.5 (8.2)	23.0 (1.5)					
Very high THC	37.9% (1.4)	27.9% (0.6)	57.0% (5.2)	48.4% (6.2)	44.8 (9.6)	20.7 (10.3)	74.6% (2.4)	83.1% (1.8)	157.9 (25.1)	47.7 (8.0)					
The last time you used ..., how high did you feel?															
Not at all high	19.3% (2.6)	17.2% (3.7)	13.2% (4.5)	0.7% (0.2)	10.0 (3.7)	1.4 (0.8)	<sup>a</sup>	<sup>a</sup>	40.1 (11.3)	8.1 (1.2)					
A little high	26.8% (1.4)	21.3% (0.6)	28.9% (3.3)	24.2% (4.8)	17.6 (5.7)	5.8 (1.3)	47.8% (3.4)	43.6% (5.1)	28.3 (3.2)	9.5 (7.3)					
High	31.4% (0.9)	23.6% (0.5)	39.8% (5.6)	43.1% (8.6)	19.3 (6.7)	3.7 (0.7)	59.7% (2.6)	69.0% (5.2)	68.6 (10.4)	14.2 (2.4)					
Very high/extremely high	38.4% (1.3)	28.4% (0.8)	47.3% (5.4)	47.4% (7.6)	27.2 (4.6)	11.3 (5.1)	70.5% (2.3)	79.5% (3.3)	96.0 (13.4)	24.4 (2.7)					
Which best describes your experience after using the product?															
I did not feel high at all	17.5% (3.2)	17.6% (5.1)	15.2% (5.8)	0.6% (0.2)	9.9 (4.2)	1.5 (0.7)	<sup>a</sup>	<sup>a</sup>	46.7 (15.3)	5.7 (0.9)					
Less high than expected	31.8% (1.8)	22.9% (0.5)	35.3% (5.1)	27.2% (8.7)	24.2 (9.3)	4.8 (1.3)	59.3% (4.0)	50.1% (10.3)	52.7 (12.0)	14.0 (2.3)					
About right	30.4% (0.8)	23.5% (0.4)	34.9% (4.2)	24.7% (7.8)	18.3 (4.1)	4.8 (0.8)	67.0% (1.9)	78.2% (2.4)	70.4 (8.0)	11.5 (2.1)					
Higher than expected	38.8% (1.8)	33.4% (3.6)	36.2% (4.4)	45.3% (8.9)	25.0 (5.1)	9.1 (2.4)	52.6% (3.3)	48.4% (5.9)	58.6 (11.8)	11.5 (2.5)					

Abbreviation: THC, tetrahydrocannabinol.

<sup>a</sup>Mean and median values suppressed for *n* < 30.

**TABLE 3** The average self-reported THC levels by qualitative THC levels and self-reported intoxication across cannabis drinks, solid concentrates, hash, tinctures and topicals among consumers who reported knowing the quantitative THC level of their respective product.

	Drinks, n = 459		Solid concentrates, n = 240		Hash, n = 289		Tinctures, n = 257		Topicals, n = 124	
	Mean THC (SEM)	Median THC (mg) (SE)	Mean THC % (SEM)	Median THC % (SE)	Mean THC % (SEM)	Median THC % (SE)	Mean THC (mg) (SEM)	Median THC (mg) (SE)	Mean THC % (SEM)	Median THC % (SE)
What was the THC level the last time you used ...										
No THC	a	a	a	a	a	a	0.3 (0.2)	0.0 (1.2)	a	a
Low THC	11.4 (2.4)	4.2 (0.7)	a	a	25.6% (4.4)	22.8% (6.8)	11.9 (4.3)	4.1 (1.1)	24.6% (6.3)	15.3% (10.2)
Medium THC	35.4 (6.7)	9.8 (1.5)	a	a	36.5% (3.8)	36.5% (7.8)	39.2 (21.3)	9.3 (1.7)	30.0% (4.0)	19.8% (3.3)
High THC	36.9 (5.7)	10.7 (4.6)	68.1% (4.1)	71.6% (6.3)	43.7% (3.5)	43.9% (4.6)	20.9 (4.5)	6.7 (4.3)	a	a
Very high THC	71.8 (16.4)	34.1 (10.6)	72.5% (3.3)	79.7% (2.7)	49.2% (3.5)	49.4% (3.8)	87.5 (27.8)	26.3 (9.7)	a	a
The last time you used ... how high did you feel?										
Not at all high	12.6 (4.6)	1.5 (0.4)	a	a	a	a	9.9 (6.2)	0.0 (0.4)	19.5% (5.6)	4.4% (3.0)
A little high	24.2 (4.6)	5.5 (1.7)	a	a	29.6% (4.9)	21.0% (8.0)	37.5 (22.2)	5.1 (2.3)	a	a
High	38.6 (9.7)	9.5 (1.4)	63.0% (4.9)	69.3% (7.8)	40.6% (3.0)	39.4% (5.9)	28.3 (8.4)	5.7 (1.6)	a	a
Very high/extremely high	54.7 (9.6)	20.6 (6.4)	70.0% (3.3)	79.4% (3.7)	45.2% (3.0)	49.1% (2.6)	48.8 (16.3)	9.6 (5.6)	a	a
Which best describes your experience after using the product?										
I did not feel high at all	16.0 (6.6)	1.4 (0.5)	a	a	a	a	10.1 (7.2)	0.0 (0.5)	16.0% (5.0)	5.2% (3.9)
Less high than expected	21.5 (4.9)	4.3 (1.8)	54.1% (6.8)	66.4% (14.3)	30.6% (4.8)	26.7% (10.2)	12.4 (3.1)	4.5 (1.4)	a	a
About right	47.9 (8.9)	10.5 (3.1)	73.1% (2.7)	81.5% (2.4)	45.9% (2.8)	45.7% (3.7)	53.0 (18.5)	9.6 (4.2)	34.2% (4.8)	23.0% (5.7)
Higher than expected	45.0 (8.9)	14.3 (4.4)	55.5% (4.9)	49.9% (8.7)	41.2% (3.3)	44.5% (4.5)	42.1 (16.8)	5.7 (2.4)	a	a

Abbreviation: THC, tetrahydrocannabinol.

<sup>a</sup>Mean and median values suppressed are n < 30.

**TABLE 4** Weighted multinomial logistic analysis for correlates of expected intoxication from dried flower among dried flower consumers in 2020 ( $n = 8899$ ).

	What best describes your experience the last time you used dried flower? $n = 8899$	
	Less high than I wanted (vs. higher than I wanted)	About right (vs. higher than I wanted)
	AOR (95% CI), $p$ -value	AOR (95% CI), $p$ -value
<b>Jurisdiction</b>		
Canada (vs. US illegal states)	1.34 (0.95, 1.88), $p = 0.093$	<b>1.40 (1.07, 1.84), <math>p = 0.013</math></b>
US medical (vs. US illegal)	0.98 (0.67, 1.42), $p = 0.904$	0.94 (0.70, 1.26), $p = 0.677$
US non-medical (vs. US illegal)	1.08 (0.77, 1.52), $p = 0.663$	1.06 (0.81, 1.39), $p = 0.673$
Canada (vs. US medical)	<b>1.37 (1.01, 1.85), <math>p = 0.041</math></b>	<b>1.49 (1.19, 1.88), <math>p = 0.001</math></b>
US non-medical (vs. US medical)	1.11 (0.81, 1.50), $p = 0.523$	1.13 (0.90, 1.42), $p = 0.304$
Canada (vs. US non-medical)	1.24 (0.95, 1.61), $p = 0.108$	<b>1.33 (1.09, 1.62), <math>p = 0.005</math></b>
<b>Frequency of dried flower use</b>		
Less than monthly, but in past 12 months	REF	REF
Monthly/weekly	<b>1.39 (1.07, 1.82), <math>p = 0.015</math></b>	<b>1.85 (1.52, 2.24), <math>p &lt; 0.001</math></b>
Daily/almost daily	<b>2.70 (2.02, 3.62), <math>p &lt; 0.001</math></b>	<b>3.04 (2.42, 3.83), <math>p &lt; 0.001</math></b>
<b>Age, years</b>		
16–25	REF	REF
26–35	<b>0.71 (0.51, 0.98), <math>p = 0.036</math></b>	0.97 (0.75, 1.26), $p = 0.817$
36–45	0.77 (0.55, 1.08), $p = 0.125$	1.22 (0.92, 1.60), $p = 0.164$
46–55	<b>0.64 (0.45, 0.93), <math>p = 0.019</math></b>	1.32 (0.98, 1.76), $p = 0.066$
56–65	0.99 (0.69, 1.46), $p = 0.993$	<b>1.96 (1.45, 2.65), <math>p &lt; 0.001</math></b>
<b>Sex</b>		
Male	REF	REF
Female	1.11 (0.89, 1.38), $p = 0.375$	1.01 (0.85, 1.19), $p = 0.953$
<b>Ethnicity/race</b>		
White	REF	REF
Other/mixed	0.86 (0.66, 1.12), $p = 0.257$	0.85 (0.69, 1.03), $p = 0.099$
<b>Education</b>		
Less than high school	REF	REF
High school diploma	1.12 (0.76, 1.67), $p = 0.566$	1.15 (0.83, 1.60), $p = 0.388$
Some college or technical vocation	1.13 (0.77, 1.65), $p = 0.537$	1.19 (0.87, 1.63), $p = 0.272$
Bachelor's degree or higher	0.96 (0.63, 1.44), $p = 0.825$	0.91 (0.65, 1.26), $p = 0.562$
<b>Income adequacy</b>		
Very difficult	REF	REF
Difficult	1.13 (0.78, 1.62), $p = 0.525$	<b>1.38 (1.02, 1.87), <math>p = 0.037</math></b>
Neither easy nor difficult	0.72 (0.50, 1.03), $p = 0.074$	<b>1.73 (1.29, 2.31), <math>p = 0.001</math></b>
Easy	<b>0.60 (0.40, 0.89), <math>p = 0.011</math></b>	<b>1.38 (1.01, 1.89), <math>p = 0.042</math></b>
Very easy	<b>0.54 (0.34, 0.86), <math>p = 0.010</math></b>	0.93 (0.65, 1.33), $p = 0.685$
<b>Device used</b>		
Smartphone	REF	REF
Computer	1.03 (0.80, 1.32), $p = 0.831$	1.04 (0.86, 1.25), $p = 0.702$
Tablet	1.07 (0.60, 1.91), $p = 0.829$	1.15 (0.75, 1.75), $p = 0.520$

Note: Bold font indicates statistical significance.

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.



experience of being 'less high than I wanted' as well as being 'about right' compared to 'higher than I wanted'. Compared to respondents aged 16–25, respondents aged 26–35 and 46–55 had higher odds of reporting 'less high than I wanted'. Respondents aged 56–65 had higher odds of reporting an experience which was 'about right' compared to respondents aged 16–25. Respondents who reported finding it easy or very easy to make ends meet had lower odds of reporting 'less high than I wanted' relative to those who reported finding it very difficult. With the exception of respondents who reported finding it very easy to make ends meet, all respondents had higher odds of reporting an experience which was 'about right' compared to respondents who reported finding it very difficult.

Sex at birth, ethnicity/race, highest level of education and survey device used were not significantly associated with expectation of dried flower experience.

## 4 | DISCUSSION

The current study is among the few to analyse consumer knowledge of THC levels and its association with self-reported intoxication. Across all 10 product categories, approximately two-thirds of consumers did not know the THC level of the cannabis product they last used. Some differences were observed across products: a greater percentage of consumers of products associated with 'medical cannabis' use, such as oral oils and capsules, reported knowing THC levels. These products used for medical purposes may be more likely to be sold in manufactured packaging with THC labelling [11, 20]. Knowledge of THC levels was low even for dried flower, the most common cannabis product, where only one-quarter of dried flower consumers reported knowing the THC levels of the last product they used. However, estimates have increased from the same study in 2018, where only 1 in 10 dried flower consumers reported knowing the THC levels [11]. Legal jurisdictions should improve public education to more effectively communicate THC levels to consumers and future research should examine whether consumer awareness and understanding of THC levels are increasing over time in the broader population.

Compared to THC levels, consumers were much more capable of reporting 'descriptive' levels of THC for their last product consumed. Descriptive terms are commonly used anecdotally by consumers and, in some cases, in retail settings as context [5]. In the current study, the descriptive THC levels across product types was generally consistent with typical THC concentrations: THC levels for solid concentrates, hash and vape oils were rated as higher THC compared to other product categories such as tinctures and topicals, consistent with data on actual THC

content of cannabis products [11]. Descriptive THC levels showed moderate correspondence with self-reported quantitative THC levels among the minority of respondents who reported quantitative amounts. Although the relative order of THC levels corresponded to the order of the qualitative descriptors, the mean numbers across all categories were more variable and unrealistically high in some cases. For example, dried flower consumers reported a mean THC level of 32%, which exceeds the biological limit for dried flower of approximately 30% to 35%, unless infused with oil or other high THC extracts [3, 21]. Even participants who reported the qualitative THC level as 'low' reported a mean of 26% THC. Compared to mean THC levels, median numbers were more reasonable and more consistent with the range of products on the commercial market. A study which examined the validity of self-reported THC levels also found a moderate association between qualitative descriptors of product strength and objectively verified THC levels after product use, although less so for dried flower than cannabis resin [22]. Overall, the findings raise doubts about the validity of self-reported THC levels—either qualitative or quantitative—at the individual level. Low awareness of THC levels is a particular concern for high-potency products and oral products, such as edibles, where there may be a delay in the onset of effects and accidental overconsumption could result in adverse events [23].

Consumers self-reported a range of intoxication levels during their last use of cannabis products. The findings were consistent with the hypothesised pattern across products: greater levels of self-reported intoxication were reported for product types with typically higher THC concentration, including solid concentrates, whereas lower, if any, intoxication levels were reported for products such as topicals. The correspondence between desired and self-reported level of intoxication varied across products. Approximately two-thirds of dried flower consumers reported intoxication levels that were 'about right'—the highest of any product category—compared with approximately half of consumers for other products. These data suggest that many consumers have difficulty accurately 'dosing' non-flower products to their desired levels, particularly when using higher THC products. Consumer difficulty in identifying and consuming desired amounts of cannabis likely contributes to adverse events from cannabis use [5, 24, 25].

More frequent consumers were substantially more likely to report achieving their desired levels when using dried flower, which may be attributable to greater familiarity with cannabis products, as well as higher tolerance levels [3]. Canadian consumers were also more likely to report achieving their desired intoxication level compared to US consumers. This could reflect more comprehensive cannabis labelling regulations in Canada mandated as part of the federal legalisation of cannabis in October 2018.

However, few differences were observed between US states when comparing states that have legalised non-medical adult use, medical use, or states in where all cannabis use remains illegal. Currently, states that have legalised medical cannabis or non-medical cannabis have adopted different labelling practices for THC on cannabis products [26]. Harmonising THC labelling practices across states, combined with public education campaigns, has the potential to increase understanding of THC concentrations. Further research should examine the role of cannabis labelling in legal markets and the extent to which they can increase consumer understanding of THC content and reduce over-consumption and the associated adverse outcomes.

#### 4.1 | Limitations

This study is subject to limitations common to survey research. Respondents were recruited using non-probability-based sampling; therefore, the findings do not necessarily provide nationally representative estimates. The data were weighted by age, sex, region, education and cigarette 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 generally lower than national estimates for young adults and higher than national surveys in both countries. In both countries, the International Cannabis Policy Study sample also had poorer self-reported general health compared to the national population, which is a feature of many non-probability samples 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 [27, 28].

Self-reported data are subject to social desirability biases. At the time of study, cannabis was illegal at the federal level in the United States; therefore, patterns of cannabis use or experience may be underreported or misrepresented. However, the survey included a data integrity question wherein those who reported not answering questions honestly were excluded. In addition, this survey was self-administered online, which compared to interviewer assisted surveys, can reduce social desirability biases by providing anonymity.

Non-medical and medical cannabis laws vary across the United States, and therefore combining states by their cannabis laws may lose the nuance of individual state laws, especially with regards to product content and labelling. In addition, future studies should examine potential differences in knowledge between consumers authorised for medical cannabis use versus those who use cannabis for 'recreational' purposes.

Finally, only dried flower was analysed in the models examining self-reported and desired intoxication, whereas accuracy in dosing may vary according to product. However, dried flower contributes the majority of the cannabis market in both illegal and legal settings and would provide a decent representation of THC knowledge and experience.

## 5 | CONCLUSIONS

In legal, regulated cannabis markets, consumers should be able to easily identify, understand and apply information on the THC content of cannabis products. Broad knowledge of THC and the strength of products is also important for adherence to lower risk cannabis use guidelines in Canada and the elsewhere, which advise consumers to avoid 'high potency' and 'high THC' products [29, 30]. To date, however, knowledge of THC levels in cannabis products is low among cannabis consumers, particularly among less frequent consumers who are at greater risk of over-consumption and adverse events. Thus, guidance to consumers to 'start low and go slow' has little meaning if consumers are unable to identify 'low' THC levels in products. Overall, there is a need for clear THC labelling on cannabis products, as well as targeted public education campaigns. Future research should examine more effective approaches to label THC content of products, including the use of symbols, descriptors or standardised units to enhance consumer comprehension and use [5].

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### CONFLICT OF INTEREST STATEMENT

The authors report there are no competing interests to declare. David Hammond has served as a paid Expert Witness on behalf of public health authorities in response to industry legal challenges to cannabis regulations in Canada.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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