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# Cannabis labelling and consumer understanding of THC levels and serving sizes

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ABSTRACT

*Objective:* As part of cannabis legalization in Canada and several US states, regulations specify how THC levels should be labelled on products; however, there is little evidence on the extent to which consumers understand and use THC labelling to inform consumption amounts. The current study was designed to assess comprehension of cannabis-related information including communication of dose and strength of product on different labelling designs among young Canadians.

*Methods:* Two experiments were conducted in October 2017 among Canadian youth and young adults aged 16–30 years as part of an online cross-sectional survey (N = 870). Experiment 1 randomized respondents to one of three labelling conditions (1 = No Label, 2 = mgTHC, 3 = Doses). Respondents interpreted a recommended serving and number of servings contained in the package. Experiment 2 randomized respondents to one of four labelling conditions communicating THC level (1 = No Label, 2 = %THC, 3 = mgTHC, 4 = Traffic Light System). Respondents determined level of THC in the product.

*Results:* Labelling the number of doses per package was associated with the greatest proportion of correct responses (54.1 %) when respondents had to determine a recommended serving compared with the no-label control condition (7.4 %) and THC mg condition (13.4 %). When cannabis products were labelled using a traffic light system, participants were more likely to identify THC level: low THC (85.1 %) or high THC (86.4 %) than the control condition (2.0 % and 5.2 % respectively).

*Conclusion:* Few consumers can understand and apply quantitative THC labelling; in contrast, THC labels that provide 'interpretive' information, such as descriptors, symbols, or references to servings have greater efficacy.

## 1. Introduction

Cannabis comes in a wide array of product types (e.g., dried herb, edibles, hashish or kief, cannabis oils, concentrates), which lead to a diversity of modes of administration. The various product types and preparations deliver different levels of the primary psychoactive component Tetrahydrocannabinol, $\Delta^9$-THC (THC) – a proxy for potency. Cannabidiol (CBD) is secondary to THC and the major non-psychoactive compound found in cannabis in terms of its concentration; it is often cited and investigated for its therapeutic qualities (NASEM, 2017). THC concentrations of dried herb have increased considerably over the past 30 years in North American markets (ElSohly et al., 2016; Chandra et al., 2019). Currently, dried herb on both the licit and illicit market typically includes 15 %–17 % THC, whereas high extract products such as oils or solid concentrates like waxes may contain up to 80–90 % THC (Mehmedic et al., 2010; Caulkins et al., 2018). These increases are of public health concern because higher potency products have been associated with increased risk of health effects including psychoses, dependence, marked effects on memory and cognition, and increased use of emergency hospital services (Volkow et al., 2014; Hall and Degenhardt, 2015). After alcohol, cannabis is the most widely used substance in Canada among youth and young adults (Health Canada, 2018). According to the 2017 Canadian Cannabis Survey, 41 % of youth aged 16–19 years and 45 % of those aged 20–24 years reported using cannabis in the past year (Health Canada, 2017).

The most common forms of cannabis consumed among Canadians are dried herb (86 %), followed by edibles (32 %) (Statistics Canada, 2018). Hashish (20 %), cannabis oils (19 %) and liquid concentrates (20 %), which represent relatively higher potency products, were used by 1 in 5 past 3-month cannabis consumers in the second quarter of 2018

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(Statistics Canada, 2018). Gender differences in cannabis product use have been detected where males used dried herb more than females (90 % vs 81 %) and females consumed more edibles than males (41 % vs 26 %) (Statistics Canada, 2018).

The diversity of cannabis products represents challenges to effective regulation such as creating clear, effective labelling standards to guide consumer decisions with respect to potency and consumption amounts (Hammond, 2019). The strength or 'potency' of dried herb is typically conveyed in terms of the THC percentage. Indeed, all jurisdictions that have legalized cannabis require dried herb products to list the THC % on products. To date, we are not aware of any formal limits in terms of what constituents a 'high' level of THC; however, cannabis retailers often provide additional non-numeric indicators of product potency. For example, the Canadian province of Québec, which operates cannabis retail stores, refers to dried herb products greater than 20 % THC as high or 'strong', similar to other jurisdictions (Hammond, 2019). THC labelling for edibles typically focuses on THC content in terms of the mg of THC contained in an edible. Currently, Alaska, Massachusetts and Oregon use 5 mg THC as the standard serving, while California, Colorado, Nevada, Washington and Canada use 10 mg of THC as the standard serving.

Accurate labelling is important in order to avoid or minimize adverse consequences that tend to occur when information is incomplete, unreliable, does not promote engagement or lacks practical knowledge such as information for first time users including excessive consumption, failure to dose properly, and increases in acute adverse events (Vandrey et al., 2015; Hammond, 2019). Given the increasing number of jurisdictions that have legalized medical and non-medical cannabis in North America, there is surprisingly little literature on consumer understanding of numerical THC information or other aspects of product labelling (Orenstein and Glantz, 2018). Evaluations of the effectiveness of warnings, such as whether they increase consumer knowledge about product potency, are limited to a few studies examining edibles (Kosa et al., 2017; Vandrey et al., 2015). Findings from focus groups suggest that many consumers are unsure about how to interpret THC information (Kosa et al., 2017). Colorado consumers also reported feeling overwhelmed by the amount of information on the product label, the small font size, and being confused about some kinds of information, such as information on the variability of testing standards (Kosa et al., 2017). Despite Colorado's requirement for a Universal Symbol indicating that a product contains cannabis, it was not clear to nonusers that certain Colorado cannabis products, such as edibles, contained cannabis (Kosa et al., 2017). Cannabis labelling may not be satisfying a principal objective of labelling— providing clear and easy-to-understand messages about cannabis products that consumers can use to understand key characteristics of these products— both within product class (e.g., distinguishing potency within edibles) and between product classes (e.g., distinguishing potency between edibles and combustibles).

The extent to which consumers can interpret THC numbers is unclear, particularly given that some consumers are unfamiliar with terminology used for cannabis products, let alone what 'THC', 'CBD' numbers may communicate (McKiernan and Fleming, 2017; Spackman et al., 2017; Porath et al., 2013). Evidence in the areas of nutrition and tobacco labelling consistently demonstrate that consumers struggle to understand and apply quantitative constituent information. For example, although many consumers report using the calorie and nutrient numbers that appear in the 'nutrition facts tables' displayed on prepackaged foods, most consumers struggle to correctly apply serving size information (Campos et al., 2011; Cowburn and Stockley, 2005; Vanderlee et al., 2012). Comprehension of food labels has been highly associated with literacy and numeracy skill, however, even individuals with strong literacy skills appear to have trouble reading food labels (Cowburn and Stockley, 2005). There are substantial and persistent disparities in consumer understanding and use of quantitative health information: consumers with lower education, income, and literacy skills are less likely to use and apply the nutrient amounts displayed on product labels (Cowburn and Stockley, 2005). Similarly, findings in cigarette labels indicate widespread misperceptions of the tar and nicotine numbers that were routinely displayed on packaging and marketing, to the extent that these numbers have been removed or prohibited in many jurisdictions (National Cancer Institute, 2001; WHO, 2008).

Canada became the second country in the world, after Uruguay, to legalize nonmedical cannabis in October 2018. The *Cannabis Act* created a legal framework for the control of production, distribution, sale, and possession of cannabis in Canada (Department of Justice, 2018). The *Cannabis Act* restricts access to nonmedical cannabis to individuals over the age of 18 across Canada with the exception of Alberta and Quebec, where those aged 18 years and older are legally permitted to purchase nonmedical cannabis (Government of Canada, 2018a, 2018b). As part of labelling regulations in the *Cannabis Act*, Health Canada requires cannabis packages to display its constituents, product type, potency and other essential information, including THC and CBD content information depending on the product type (e.g., dried herb: net weight in grams, %THC, %CBD) (Canada Gazette, 2018). The maximum personal possession limit of cannabis in public is 30 g in its dried form or its equivalent for other product types such as oils, consistent with the amount of cannabis a legal consumer would be able to possess in public.

To date there exists no empirical evidence examining cannabis literacy in terms of specific constituents such as THC and/or CBD, perceptions of potency, or practical aspects related to consumption of cannabis products such as dosing or serving size. Given this considerable gap in the literature concerning cannabis consumer behavior and Canada's legislative changes around practical aspects of cannabis regulation, the current study was designed to assess comprehension of cannabis-related information including communication of dose and strength of product on different labelling designs among youth and young adults by cannabis use status and sociodemographic factors.

## 2. Methods

### 2.1. Design

Two experiments, each composed of two tasks, were conducted as part of an online cross-sectional survey conducted among youth and young adults in Canada to assess respondents' comprehension and practical application of information presented on cannabis product labels. The survey took place in October 2017. Recruitment occurred by e-mail through Léger's consumer panel for web surveys consisting of approximately 400,000 active members, half of them sampled using probability-based methods using the Canadian Census, along with other non-probability-based methods, including commercial surveys (Leger Web, 2017). Inclusion criteria included individuals aged 16–30 years of age with a Canadian IP address, cannabis users and non-users. Respondents aged 16–30 were recruited across Canada directly with the exception of youth aged 16–18 which were recruited through their parents; parental consent was obtained prior to this younger demographic accessing the survey. Respondents received remuneration from Léger in accordance with their usual incentive structure which included both points-based and monetary rewards which may be cashed out or donated, as well as opportunities to win monthly prizes; the monetary incentive for this study was Can$2.00. All of the data provided by respondents were anonymous and information was kept strictly confidential. In all cases, respondents were provided with information about the study and asked to provide consent before participating. They were reassured of their anonymity again after providing consent and proceeded to the survey. The study was reviewed by and received ethics clearance from the Office of Research Ethics at the University of Waterloo (ORE# 22392).

### 2.2. Measures

Respondents were asked to complete a set of tasks that required them to use different labelling executions such as presentations of THC in milligrams, percentages, or more intuitive presentations of THC level (e.g., as a 'dose', a pictorial 'traffic light' system) to determine serving sizes, and strength of cannabis products.

#### 2.2.1. Experiment 1 – Comprehension of cannabis serving size information

Experiment 1 was designed to examine how three different ways of conveying information about serving size affected consumer understanding. As shown in the figures presented in Table 2, participants were randomized to view cannabis edibles with one of three THC labels: 1) no THC label (control), 2) THC in milligrams, and 3) number of 'doses'. While viewing the labels, participants were asked two questions: 1) "Based on the information provided, how much of the cookie should someone eat on one occasion if they wanted a recommended serving?" with the following answer options: "¼ of a cookie", "½ of a cookie", "¾ of a cookie", "1 cookie", "2 cookies", "3 cookies", "More than 3 cookies", and "Don't know"; and 2) "How many servings are in this package?" with response options, "1", "2", "3", "4", "5", "More than 5", and "Don't know". The responses for each question were recoded into a binary variable where 1 = correct answer, and 0 = incorrect answer: for the first question, "1/4 of a cookie" was the correct answer; for the second question, "4 servings" was the correct answer.

#### 2.2.2. Experiment 2 – Comprehension of THC potency information

Experiment 2 was designed to examine how four different ways of presenting information about potency affected potency perceptions. Participants were randomized to view containers of dried marijuana leaf where information about potency was expressed in one of four ways, displayed in Table 3: 1) No THC Label (control), 2) THC as a percent, 3) THC in milligrams, and 4) traffic-light graphic (green for 'low' potency, and red for 'high' potency). Participants first viewed the 'low' potency container, and then the 'high' potency container. While viewing each image, participants were asked the following question: "Based on the available information, what is the level of THC in this product?" with responses, "Low", "Moderate", "High", "Don't know". As illustrated in Table 3, the 5 % THC and 5 mg of THC were classified as 'low' amounts, whereas 25 % THC and 25 mg of THC were classified as 'high' amounts. Binary variables were created where 1 = Correctly identified THC potency of displayed product, and 0 = Did not correctly identify THC potency of displayed product.

The rationale for including 5 % and 5 mg as the experimental labelling conditions was based on current regulatory practices and market conditions. As previously noted, in jurisdictions that have developed categories for what is considered lower, moderate and high level of THC. In all cases, 5 % would be considered a low amount and 25 % would be considered a 'high' amount, which is also consistent with THC levels in cannabis markets, the average THC percentage of dried herb in both the legal and illegal markets in Canada is 15–20 % and the reference used as 'high' in our study—25 % THC—is at or very near the maximum THC % of commercially available products.

#### 2.2.3. Data integrity

Data quality was controlled for using two questions to ensure participants were sufficiently engaged with the survey. Near the end of the survey, they were asked, "What is the current month?" and, "One last question, did you feel you were able to provide honest answers about your marijuana use during the survey?". If respondents selected the wrong month or respondent that they felt unable to provide honest answers for 'all questions', they were not included in the analytic sample.

### 2.3. Analysis

All analyses were conducted using SPSS Statistical Software (Version 25.0, Armonk, NY: IBM Corp.). Bivariate tests were conducted to detect differences between sex, age, race and cannabis use status across experimental conditions with no differences detected. Logistic regression models were fitted to examine correct responses to interpreting a single serving size, identifying number of servings contained in a cannabis package, identifying the 'low' THC product, and identifying the 'high' THC product. Relative risk estimates are presented as odds ratios would have overstated the effect size of experimental conditions (Davies et al., 1998). For the first experiment, an indicator variable representing experimental condition was entered into the model (1 = "No THC Label", 2 = "mg THC Label", 3 = "THC as 'dose' label") along with sex, age, race, and cannabis use status. For the second experiment an indicator variable was also constructed representing experimental condition (1 = "No THC Label", 2 = "% THC", 3 = "mg THC", 4 = "green/red traffic-light") along with sex, age, race and cannabis use status. A two-way interaction term was tested between cannabis use status and experimental condition for each of the tasks. There were no significant interactions between the effects of cannabis use status and experimental condition on providing correct answers when respondents were shown low or high THC level products ($F(1862) = 0.432$, $p = 0.080$; $F(1861) = 0.979$, $p = 0.323$ respectively).

## 3. Results

Table 1 displays the current study's sample characteristics. A total of 1045 respondents completed the survey, however, the final analytic sample was 870 as the rest were excluded from analysis due to completing survey from a mobile device instead of a desktop computer (28), missing data on key measures including cannabis use status (8) and/or failed data integrity questions; 62 records deleted due to incorrectly identifying the current month and 77 respondents reported being unable to provide honest answers to all of the survey questions.

### 3.1. Experiment 1 – Comprehension of serving size information

*Recommended serving size*—As Table 2 indicates, 7.4 % respondents in the control condition were able to correctly interpret a recommended serving size as ¼ of the cookie, or 10 mg of THC. When products included constituent information such as "mg THC", only 13.4 % of respondents correctly identified the recommended survey amount; although this represented a significant increase from the no label control condition (RR = 1.80 95 %CI 1.09–2.97) as detailed in Table 3. More than one-quarter (27.8 %) of respondents who viewed the THC mg label incorrectly reported the recommended serving was the entire cookie, while 44.0 % selected 'don't know'. Labelling the number of doses per

**Table 1**
Sample characteristics (N = 870).

| | | % (N) |
|---|---|---|
| Sex | Female | 52.1 (453) |
| | Male | 47.9 (417) |
| Age (years) | 16–18 | 25.2 (219) |
| | 19–24 | 30.7 (267) |
| | 25–30 | 44.1 (384) |
| Race | White | 64.5 (561) |
| | Non-white | 35.5 (309) |
| Cannabis use status | Never use | 41.5 (361) |
| | Ever use, not in past 30 days | 36.0 (313) |
| | Current use, within past 30 days | 22.5 (196) |

**Table 2**
Interpreting recommended serving size contained in a cannabis package without THC indicators, "mg THC" label, or "Doses" label (N = 870).

| | Experimental conditions | | |
|---|---|---|---|
| |  |  |  |
| | No THC Label Control<br>n = 296 | "mg THC" Label<br>n = 284 | "Doses" Label<br>n = 290 |
| How much should someone eat on one occasion if they wanted a recommended serving? %(n) | | | |
| ¼ of a cookie[a] | 7.4 (22) | 13.4 (38) | 54.1 (157) |
| ½ of a cookie | 8.1 (24) | 11.3 (32) | 5.9 (17) |
| ¾ of a cookie | 1.7 (5) | 1.1 (3) | 1.0 (3) |
| 1 cookie | 37.8 (112) | 27.8 (79) | 16.9 (49) |
| 2 cookies | 3.4 (10) | 2.1 (6) | 1.0 (3) |
| 3 cookies | 0.3 (1) | 0.0 (0) | 0.3 (1) |
| More than 3 cookies | 0.3 (1) | 0.4 (1) | 2.8 (8) |
| I don't know | 49.9 (121) | 44.0 (125) | 17.9 (52) |
| How many servings are in this package? %(n) | | | |
| 1 serving | 33.8 (100) | 29.9 (85) | 9.7 (28) |
| 2 servings | 7.1 (21) | 7.4 (21) | 1.0 (3) |
| 3 servings | 3.4 (10) | 2.8 (8) | 0.7 (2) |
| 4 servings[a] | 5.1 (15) | 6.0 (17) | 77.9 (226) |
| 5 servings | 1.0 (3) | 2.5 (7) | 0.0 (0) |
| More than 5 servings | 2.0 (6) | 1.8 (5) | 0.7 (2) |
| I don't know | 47.6 (141) | 49.6 (141) | 10.0 (29) |

[a] 'Correct' answer.

packages was associated with the greatest proportion of correct responses (54.1 %) compared with the no-label control condition (RR = 7.28 95 %CI 4.81–11.039) and THC mg condition (RR = 4.05 95 %CI 2.96–5.54). Respondents who reported using within the past 30 days (current users) were 1.5 times as likely to correctly identify the recommended serving size than never users (RR = 1.47 95 %CI 1.12–1.92).

*Number of servings per package*—No differences were observed between the 'no label control condition' and the THC mg condition in the proportion of participants who correctly identified the number of servings in the package (5.1 % vs. 6.0 %). In contrast, 77.9 % of participants were able to correctly identify the number of servings as four when the THC information was displayed as 'doses', a significant increase from the no label control and the THC mg conditions (RR = 15.38 95 %CI 9.36–25.28; RR = 13.02 95 %CI 8.18–20.73, respectively). Current users were more likely to correctly identify the number of servings contained in the package than never users (RR = 1.32 95 %CI 1.03–1.70).

### 3.2. Experiment 2 – Comprehension of THC potency information

Table 4 displays the results of the second experiment examining 'low' and 'high' level THC products. In the control condition of the set communicating 'low' THC levels, where there was no THC information, virtually no respondents (2.0 %) identified the displayed product as having a 'low' THC level. In contrast, 35.3 % of respondents correctly identified THC level as 'low' in the condition that displayed THC as a percentage, a significantly higher proportion compared to the control condition (RR = 18.10 95 %CI 6.76–48.52). Table 5 shows relative risk estimate analyses for Experiment 2. Respondents who viewed the

**Table 3**
Relative risk estimates examining correct responses to questions regarding recommended serving size and number of servings in cannabis product packages.

| Characteristics | | *Comparison* | Correctly identified recommended serving size | | Correctly identified servings in package | |
|---|---|---|---|---|---|---|
| | | | RR | 95 %CI | RR | 95 %CI |
| Age (years) | 19-24 | 16-18 | 1.25 | 0.89-1.75 | 0.98 | 0.76-1.31 |
| | 25-30 | 16-18 | 1.37 | 1.01-1.87 | 1.00 | 0.78-1.29 |
| | 19-24 | 25-30 | 0.91 | 0.70-1.18 | 1.00 | 0.78-1.27 |
| Sex | Female | Male | 1.00 | 0.79-1.26 | 0.89 | 0.73-1.10 |
| Race | Non-White | White | 0.87 | 0.67-1.11 | 0.86 | 0.69-1.07 |
| Cannabis use status | Ever use, not in past 30 days | Never Use | 1.05 | 0.80-1.39 | 1.03 | 0.80-1.31 |
| | Current use, within past 30 days | Never Use | 1.47 | 1.12-1.95 | 1.32 | 1.03-1.70 |
| | Ever use, not in past 30 days | Current Use, within past 30 days | 0.71 | 0.54-0.95 | 0.78 | 0.60-1.00 |
| Labelling Condition | "mg THC" Label | No THC Label Control | 1.80 | 1.09-2.97 | 1.18 | 0.60-2.32 |
| | "Doses" Label | No THC Label Control | 7.28 | 4.81-11.04 | 15.38 | 9.36-25.28 |
| | "Doses" Label | "mg THC" Label | 4.05 | 2.96-5.54 | 13.02 | 8.18-20.73 |

**Table 4**
Determining cannabis product potency through four labelling strategies, no THC label control, THC presented as a percentage, in milligrams, and a traffic light system (N = 870).

| | "What is the level of THC in this marijuana product?" | | | |
|---|---|---|---|---|
| |  |  |  |  |
| LOW POTENCY | No THC Label Control %(n) | "5 % THC" Label %(n) | "5 mg THC" Label %(n) | Traffic Lights "Green" %(n) |
| n = | 204 | 232 | 232 | 202 |
| Low[a] | 2.0 (4) | 35.3 (82) | 27.6 (64) | 85.1 (172) |
| Moderate | 9.3 (19) | 13.8 (32) | 15.5 (36) | 4.5 (9) |
| High | 6.4 (13) | 4.3 (10) | 3.9 (9) | 1.5 (3) |
| I don't know | 82.4 (168) | 45.7 (106) | 53.0 (123) | 8.9 (18) |
| |  |  |  |  |
| HIGH POTENCY | No THC Label control %(n) | "25 % THC" Label %(n) | "100 mg THC" Label %(n) | Traffic Lights "Red" %(n) |
| n = | 231 | 220 | 221 | 198 |
| Low | 3.5 (8) | 15.9 (35) | 7.2 (16) | 2.5 (5) |
| Moderate | 8.7 (20) | 30.9 (68) | 18.1 (40) | 1.5 (3) |
| High[a] | 5.2 (12) | 22.7 (50) | 29.0 (64) | 86.4 (171) |
| I don't know | 82.7 (191) | 30.0 (66) | 45.7 (101) | 9.1 (18) |

[a] 'Correct' answer.

cannabis product displaying a green traffic light which read "Low THC" had a much greater likelihood in correctly identifying it as a low THC product than when no THC information was present (85.1 % vs. 2.0; RR = 43.43 95 %CI 16.43–114.79). Current users had greater odds of correctly identifying the 'low' THC level products they were displayed than never users using the product labels (RR = 1.41 95 %CI 1.14–1.75). Similar patterns emerged in the conditions where high THC level products were displayed to respondents.

## 4. Discussion

The current study found that intuitive cannabis constituent labelling strategies that include symbols or simple, common units of measurement such as "dose" were better understood by Canadian youth and young adults compared to numerical THC information. These findings are consistent with existing literature regarding the ways in which consumers interact with product information including pre-packaged food and beverage or tobacco products (Cowburn and Stockley, 2005; WHO, 2008). Canadians have difficulty understanding and applying quantitative nutrient amounts displayed in food labels of pre-packaged foods (Cowburn and Stockley, 2005). Consumers also struggle to interpret numerical information on tobacco labels to the extent that certain tar and nicotine figures have been prohibited in many jurisdictions (National Cancer Institute, 2001; WHO, 2008).

The inclusion of easily understandable THC and serving size considerations on product packaging is an important approach to educate

**Table 5**
Relative risk estimates examining correct responses to questions regarding cannabis product potency.

| Characteristics | | *Comparison* | Correctly identified cannabis with low potency | | Correctly identified cannabis with high potency | |
|---|---|---|---|---|---|---|
| | | | RR | 95 %CI | RR | 95 %CI |
| Age (years) | 19-24 | 16-18 | 1.11 | 0.87-1.40 | 0.94 | 0.73-1.22 |
| | 25-30 | 16-18 | 1.08 | 0.87-1.35 | 1.10 | 0.88-1.39 |
| | 19-24 | 25-30 | 1.02 | 0.84-1.25 | 0.85 | 0.68-1.06 |
| Sex | Female | Male | 1.12 | 0.94-1.34 | 0.93 | 0.77-1.11 |
| Race | Non-White | White | 0.90 | 0.75-1.09 | 0.96 | 0.79-1.17 |
| Cannabis use status | Ever use, not in past 30 days | Never Use | 1.17 | 0.95-1.44 | 1.07 | 0.86-1.33 |
| | Current use, within past 30 days | Never Use | 1.41 | 1.14-1.75 | 1.24 | 0.99-1.56 |
| | Ever use, not in past 30 days | Current Use, within past 30 days | 0.83 | 0.67-1.01 | 0.87 | 0.69-1.09 |
| Labelling Condition | % THC | Trade name | 18.10 | 6.76-48.52 | 4.40 | 2.41-8.03 |
| | mg THC | Trade name | 14.07 | 5.22-37.96 | 5.57 | 3.09-10.04 |
| | Traffic Light System | Trade name | 43.43 | 16.43-114.79 | 16.71 | 9.61-29.07 |
| | %THC | Traffic Light System | 0.42 | 0.35-0.50 | 0.26 | 0.21-0.34 |
| | mg THC | Traffic Light System | 0.32 | 0.26-0.40 | 0.33 | 0.27-0.41 |
| | mg THC | %THC | 0.97 | 0.76-1.23 | 1.27 | 0.92-1.75 |

the public on the consumption of cannabis products, particularly among first time and low-literacy populations. These findings are consistent with consumer studies of nutrition labelling, in which the use of simple, interpretive information increases consumer understanding (Jones et al., 2016). Although there may be a tendency for regulators to present information in precise and accurate technical terms (e.g., mg, mL), doing so is likely to be less effective in conveying the necessary understanding for consumers to make accurate choices about dosing and potency of cannabis products. The current study demonstrated that only a third of consumers accurately identified a high potency product (e.g., 25 %THC, 100 mg THC, red traffic light) when technical information was presented compared to the traffic light system. The concept of 'servings' is an interesting one, in that it can be used to refer to a consumers' typically or desired consumption amount, or it can refer to a 'standard unit' as determined by a regulatory authority. In the context of the current study, respondents who viewed packaged with no THC information would presumably be more likely to report the former—typical or expected consumption amounts. However, that is indeed reflective of how labelling 'works': effective labelling educates consumers about 'standard serving' amounts and provides an objective reference for reporting consumption amounts. Therefore, the differences between the control condition and the condition which communicated the number of 'doses' reflects the movement towards consumer understanding for more standardized consumption units. In addition, the condition with only THC numbers demonstrates that the numbers alone are not sufficient to communicate standardized serving amounts. It should also be noted that even for the most effective labelling condition, in which the number of doses was displayed on packages, almost half of participants continued to select an incorrect consumption amount or indicated that they didn't know how much of the cannabis edible to consume. This highlights the importance of other packaging standards, such as unit-dose packaging, in which each THC serving or dose is packaged separately, rather than multi-serving units, such as the cannabis cookie tested in the current study which are common to both the legal and illegal cannabis markets. For example, Canada has recently proposed new regulations for edibles, in which each 10 mg unit of THC must be packaged separately (Government of Canada, 2018a, 2018b). This represents a more prescriptive approach than US states such as Colorado, which require 10 mg servings to carry individual cannabis symbols, but not to be packaged separately.

The findings also suggest that interpretative symbols may be effective in providing context for THC levels with respect to whether they are 'high' or 'low'. This is particularly important given the diversification of the cannabis market and the wide range of THC levels in products, ranging from very low THC products, to concentrates that can exceed 90 % THC levels. The findings are consistent with the use of traffic light symbols to communicate nutrient amounts and research on the efficacy of graphic formats in enhancing consumer comprehension (Mansoor and Dowse, 2003; Emerich et al., 2017). However, one potential limitation of traffic light symbols is that a 'green' or 'low' symbol can be misinterpreted by consumers as an indicator of permissiveness or decreased risk. In the case of cannabis products, consumption amounts are ultimately determined by consumers, and 'lower' or 'moderate' THC products can still be consumed in excessive amounts. For example, in the current study, a green traffic light was equated to 5 % THC or 5 mg THC, which to a regular cannabis consumer may be 'low' potency; however, a first-time or novice user may not consider it 'low'. Perhaps for this reason, the Quebec government has avoided any symbol or descriptor associated with 'low' when labelling cannabis products on its government-run online cannabis store; instead, products are labelled 'moderate', 'medium', or 'high' depending on the THC level (SQC, 2018).

Existing online retail practices from the Ontario Cannabis Store use percentages, allow ambiguous language such as "mid-range THC Content" to describe product potency, product experience as having a "woody and earthy aroma", with expected effects to include "relaxation, happiness and/or euphoria" (Ontario Cannabis Store, 2018). The limited objective information to make decisions about product use may be outweighed by a wide range of pleasant product descriptors that may promote initiation and continued consumption of cannabis among the Canadian population. Additional research should examine the efficacy of symbols and other graphical formats for communicating THC levels and potency through product labelling.

### 4.1. Strengths and limitations

The commercial sample in the current study used probability and non-probability-based recruitment methods. As a result, the finding may not be representative of Canadian youth and young adults. However, a broad and diverse sample was surveyed with similar sociodemographic characteristics and patterns of cannabis use as the 2017 Canadian Cannabis Survey (Health Canada, 2017). The sample consisted of young people aged 16–30 exclusively. This subgroup has the highest rates of cannabis use in Canada and a key population of interest in legalization efforts. Another limitation may be in the alignment of the mocked-up product potencies; for example, in the second experimental task, the quantity of dried herb was not labelled on the container; therefore, 100 mg THC may not neatly align with a 25 % THC product, further the quantities of each product were not displayed which would help inform consumers gauge level of THC. Whereas the current study listed the number of 'doses' on the edible product, most jurisdictions in which cannabis is legal refer to the number of 'serving's rather than 'doses'. Future research should explore any potential differences in how consumers perceive these terms. Study strengths include the use of between-group experimental design as well as the use of existing products within our experimental conditions and demonstration of parallel findings between tobacco control and nutrition literature. With respect to generalizability, the experimental study conditions do not reflect the conditions and wide range of other factors that determine whether consumers engage with cannabis labelling and the settings in which they determine their consumption amounts. Therefore, the effectiveness of labelling interventions may different than their efficacy in experimental settings reported.

## 5. Conclusion

THC numbers used to express potency have little or no meaning to most youth and young adults in Canada. Expressing THC in terms of the number of 'doses' or servings may provide consumers with better guidance on consumption amounts for cannabis edibles; however, additional measures, such as unit-dose packaging, may be required to provide consumers with clear, unequivocal guidance on THC levels. Future research should consider whether other labelling, such as symbols or descriptors provide additional benefit.

## Contributions

C.L.T. and D.H. contributed to the design and conceptualization of the current study. C.L.T. and D.H. conducted data collection. Under the supervision of D.H., C.L.T. analyzed and interpreted the data, drafted the manuscript, and collaborated on intellectual content. G.F. and S.M. were involved in revision of manuscript's intellectual content and provided additional insight and interpretation. All authors reviewed the manuscript and have approved the final version.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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