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ORIGINAL ARTICLE

Use of flavored cannabis vaping products in the US, Canada, Australia, and New Zealand: findings from the international cannabis policy study wave 4 (2021)

Kimberly D'Mello[a], Gary C.K. Chan[b], Wayne Hall[b], Marta Rychert[c], Chris Wilkins[c], and David Hammond[a]

[a]School of Public Health Sciences, Faculty of Health, University of Waterloo, Waterloo, Ontario, Canada; [b]National Centre for Youth Substance Use Research, The University of Queensland, Brisbane, Australia; [c]SHORE & Whariki Research Centre, College of Health, Massey University, Auckland, New Zealand

ABSTRACT

Background: Vaping is an increasingly popular mode of cannabis use. Few studies have characterized the role of flavors in cannabis e-liquids.
Objectives: To explore the prevalence of flavored vaping liquids, including differences between countries and correlates of use.
Methods: Data were from Wave 4 (2021) of the International Cannabis Policy Study with national samples aged 16–65 in Canada, the United States (US), Australia, and New Zealand. The sample comprised 52,938 respondents, including 6,265 who vaped cannabis e-liquids in the past 12-months (2,858 females, 3,407 males). Logistic regression models examined differences in the use of flavored e-liquids between countries and sociodemographic characteristics.
Results: The prevalence of vaping cannabis e-liquids was highest in the US (15.3%) and Canada (10.7%) compared to Australia (4.0%) and New Zealand (3.7%). Among past 12-month cannabis consumers, 57.5% reported using flavored vaping liquids, 34.2% used unflavored vaping products and 8.3% did not know. People who vape in Australia were most likely to report using flavored liquids compared to New Zealand (OR = 2.29), Canada (OR = 3.14), and the US (OR = 3.14) ($p < .05$ for all). Fruit was the most reported vaping flavor (40.8%), followed by candy/dessert (20.4%) and vanilla (15.2%). Use of flavored vapes was greater among younger, ethnic minorities, female, higher education and income adequacy, and more frequent consumers ($p < .05$).
Conclusion: Many cannabis consumers reported using flavored e-liquids, with highest levels among young people aged 16–35. Given the high prevalence of vaping in legal markets, regulators should consider the role of flavored vaping products in promoting cannabis use among this group.

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Introduction

The cannabis market is rapidly evolving, with an increasing array of product forms, especially in countries with legal cannabis markets. Cannabis can be vaped in several ways, including dried flower, solid extracts, as well as liquids or "oils" that contain cannabis extracts (1–5). Of these different vaping modes, recent national surveys in the US and Canada have shown that vaping oil/liquids are the most common of the three forms used among consumers (6,7) and are often sold as disposable vape pens or in cartridges or pods that are used with reusable devices (1,6–9). For the purpose of this paper, we refer to these products as "vaping liquids," as opposed to nicotine-containing vaping products which we will refer to as "e-cigarettes." Cannabis vaping liquids come in a wide range of delta-9-tetrahydrocannabinol (THC) levels, the cannabinoid primarily responsible for the intoxicating effects (10). Some cannabis vaping liquids are marketed as "CBD" products with negligible levels of THC and promoted as non-intoxicating natural health or therapeutic products (11,12). In contrast, cannabis vaping liquids most commonly used in North American markets and among youth under 18 and young adults under 30 years of age contain high levels of THC; whereas dried flower has a maximum THC concentration close to 30%, vape oils typically contain 60–90% THC (4,9,13).

Vaping is among the fastest-growing modes of cannabis administration, particularly among young people (13–18). In Canada and the United States (US), the prevalence of vaping THC liquids among 16–19-year-olds doubled from 2017 to 2019, to approximately 5% in the past 12-months among the entire population and 19% among past 30-day cannabis users (8). National monitoring surveys in the US and Canada suggest similar increases among adults (19–21). After briefly declining in late 2019 and early 2020 following the outbreak of e-cigarette, or vaping, product use associated lung injury (EVALI) (22) – which was primarily caused by

CONTACT David Hammond david.hammond@uwaterloo.ca School of Public Health Sciences, Faculty of Health, University of Waterloo, Waterloo, ON BMH 1616

contamination of illicit THC liquids with vitamin E acetate (22) – the prevalence of vaping in North America has rebounded to pre-EVALI levels (7).

As the prevalence of vaping cannabis products has increased particularly among young people (8,23), the role of flavors in the appeal of vaping among youth and young adults remains largely unexplored. Indeed, there are few estimates of the prevalence of vaping products, including potential differences across countries with different cannabis laws. Most of the literature on cannabis vaping has been conducted in North America, with little evidence from other countries where cannabis use is prevalent (8,13,19,24–26). Non-medical ("recreational") cannabis use was legalized in Canada in October 2018, and at the time of data collection, 18 states and Washington D.C. legalized recreational cannabis use, while 17 states had approved cannabis for medical use only in the US (27–30). There is very little evidence on the different modes of use in other countries that have not legalized recreational cannabis, including Australia where some states have decriminalized and others have depenalised cannabis use, and New Zealand where cannabis remains prohibited but police are directed to avoid arrest unless in the public interest, where laws for cannabis use are restricted to medicinal use (31–33). Previous research suggests that medical cannabis consumers in Australia and New Zealand may have a higher likelihood of vaping cannabis (34–36) compared those who report non-medical cannabis use while a school-based study conducted in New Zealand indicated only modest increases in cannabis vaping between 2016 and 2018 (37)

Flavors can enhance the appeal of substances, including vaping products. Children and youth have an innate preference for sweet flavors, including fruit flavors commonly used in candy and confectionary treats (38). It is well-established that flavors serve as a strong inducement for substance use among youth, including for alcohol (39,40), e-cigarettes (41–43), and tobacco products (43,44). The role of flavors in the rise of nicotine e-cigarettes has received considerable attention (41,45,46). E-cigarettes are marketed with a wide range of different flavors, including fruit and mint/menthol, the two most popular flavors (47–52). The use of fruit and other non-tobacco flavors have been associated with greater appeal and longer-term use of e-cigarettes among middle and high school students, as well as greater satisfaction among adult smokers who vape (30,51,53).

To date, there is little research on the role of flavors in cannabis products. Flavored cannabis products include flavored blunt wraps, edibles, cannabis-infused drinks, and vaping liquids. Flavored rolling papers and blunts contained by flavored tobacco cigars are common ways for cannabis users to add flavor to smoked products, with a preference for fruit-flavored cigarillos (54,55). Flavors are also a fundamental attribute of cannabis edibles. In 2021, the most popular cannabis edibles in Canada were candy/chews, followed by chocolates, and baked goods such as brownies and cookies (56). These products are inherently appealing to children and youth, as reflected in the popularity of cannabis edibles among youth, as well as rates of hospital attendances for accidental ingestion among children (8,57–59). There are also concerns that some flavors used in THC-containing vape oils and liquids may increase the toxicity of the aerosol inhaled by consumers (60). Currently, a wide range of flavor agents are used, many of which have been subjected to little testing. For example, terpenes such as phytol have been found to be highly toxic when added to vaping liquids in high concentrations in animal studies (61).

To date, few studies have examined the use of flavored cannabis vaping products. A cross-sectional survey conducted among Californian students in grades 9 and 10 reported high rates of flavored cannabis products in 2021 (62). Among past 30-day cannabis consumers, 48% of people who smoked cannabis reported using a flavored cannabis product, and 58% of people who vaped cannabis reported using flavored products (62). The most popular flavor for both smoked and vaped products was fruit, followed by candy or dessert flavors (62). A 2020 national survey conducted on behalf of Health Canada found that among youth (aged 15 to 24) who vaped, 90% of respondents had tried a flavored cannabis vape product at least once, and 51% of respondents used these products regularly (63). Within this group of regular users, 58% of youth reported using flavored cannabis vaping products compared to 44% of adults. Fruit, candy, and mint/menthol were the most commonly reported flavors by both youth and adults (63). Further, 42% of respondents cited the availability of flavored products as a key reason for choosing to vape cannabis versus using it in other ways. Another 33% mentioned a preference for flavored products that do not taste like cannabis (63).

The current study assessed the use of vaping flavored cannabis products across four countries: Canada, the US, Australia, and New Zealand. The study examined four specific objectives: 1) the prevalence of vaping liquid cannabis products with flavors, including differences between countries; 2) the range of flavor types used by people who vape cannabis; 3) the association between the use of nicotine e-cigarettes and cannabis vaping; and 4) sociodemographic correlates of flavored cannabis vaping, including differences by age.

Methods

Data collection

Data are cross-sectional findings from wave four of the International Cannabis Policy Study (ICPS), conducted in Canada, the US, Australia, and New Zealand. Data were collected via self-completed web-based surveys conducted in September-November 2021 from respondents aged 16–65. A non-probability sample of respondents was 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. For the ICPS surveys, Nielsen draws stratified random samples from the online panels, with quotas based on age and state/province of residence. Upon completion, respondents receive remuneration in accordance with their panel's usual incentive structure. Monetary incentives have been shown to increase response rates and decrease response bias in subgroups under-represented in surveys, including disadvantaged subgroups (64). The cooperation rate was 61%, which was calculated based on AAPOR Cooperation Rate #2 as the percentage of respondents who completed the survey of eligible respondents those who accessed the survey link (65). Surveys were conducted in English in the US, Australia, New Zealand, and English or French in Canada. Median survey time was 22.0 minutes, including 34.3 minutes among past 12-month cannabis users and 18.1 minutes among those who had never used cannabis or not used it in the past 12 months (66). 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 Reports (66) and methodology paper (67).

Measures

A copy of the 2021 ICPS survey, including all measures described below, is available at www.cannabisproject.ca/methods.

Socio-demographic correlates

Respondents provided demographic information, including country of residence, sex at birth, age group, ethnicity/race, highest education level, and perceived income adequacy. Based on numerical response to "how old are you today?," a derived variable of age group was created for the analysis (16–25; 26–35;36–45; 46–55; 56–65). Age group categories were derived based on 10-year age groupings of eligible respondents (aged 16–65) in the survey and allowed us to test non-linear trends across the age range. Briefly, perceived income adequacy was assessed as a family having enough money to pay for the things they need, while ethnicity/race was assessed with country-specific measures that were analyzed as a binary variable of majority vs. minority, drawn from the census or benchmark health surveys.

Vaping correlates

Respondents were asked about their use of cannabis liquids for vaping and past 12-month use of e-cigarettes. Respondents reported whether they have used different forms of cannabis. They were asked "Have you used marijuana in any of the following ways?" including a choice of "cannabis oils or liquids for vaping" (No; Yes, but not in past 12 months; Yes, in past 12 months; Don't know). Frequency of use for cannabis oils or liquids for vaping was assessed (Less than once a month; Monthly; Weekly; Daily; Don't know; Refuse to answer). Based on their frequency of use, respondents were asked to enter the average number of days over the past 12 months, days per month, days per week, or times per day, respectively. Additionally, respondents reported if they had ever used an e-cigarette or vaped nicotine. They were asked "Have you ever used any of the following drugs?" including a choice of "e-cigarettes/vaped nicotine" (Select if applicable; Don't know; Refuse to answer). If respondents selected use of e-cigarettes, recency of use was assessed (More than 12 months ago; Between 3 to 12 months ago, 1 to 3 months ago; Within the last month; Within the last week; Don't know; Refuse to answer). Based on participant response selection, a derived variable was created for the analysis of e-cigarette use in the past 12 months (Not in past 12 months, yes, in past 12 months; Don't know; Refuse to answer).

Outcome of interest: use of flavored cannabis liquid for vaping

Respondents were also asked if "in the past 12 months, have you used cannabis vape oil with any of the following flavors?" (I have not used any flavored vape oils; Fruit (peach, berry, lemon, apple, etc.); Spice (e.g., clove); Vanilla; Menthol or mint; Cake, candy, desserts, or sweets; Other flavor (specify: open-ended); Don't know; Refuse to answer). As noted above, we refer to these products as vaping liquids in the current paper. Based on their reported use of flavored products, respondents who selected more than one flavor category (excluding "I have not used any"), were asked which one flavor was used most often (Fruit (peach, berry, lemon, apple, etc.); Spice (e.g., clove); Vanilla; Menthol or mint; Cake, candy, desserts, or sweets; Other flavor (specify:

open-ended); Don't know; Refuse to answer). The response options for flavor categories used in the current study were developed based on categories used in studies of nicotine e-cigarettes studies and informed by retail scans of the legal and illegal cannabis markets in Canada (68,69).

Analysis

A total of 52,938 respondents completed the 2021 survey, included from Canada ($n = 16,952$), US ($n = 30,081$), Australia ($n = 2,925$), and New Zealand ($n = 2,980$). The current analyses focus on the subsample of 6,305 respondents who reported vaping liquid cannabis in the past 12 months. (Participants who vaped "solid" extracts and dried flower were not asked about flavored products and were therefore excluded from the current analysis.) Respondents who refused to answer if they had vaped a *flavored* liquid ($n = 40$), were excluded, resulting in a final sample of 6,265 respondents (Canada = 1,713; US = 4,337; Australia = 111, and New Zealand = 104). All analyses were weighted using post-stratification sample weights which were constructed based on known population targets. This aligns the sample to the target population. Briefly, respondents from Canada were classified into age-by-sex-by-province, education, and age-by-smoking status groups. Respondents from the US states with legal recreational cannabis markets were classified into age-by-sex-by-legal state, education-by-legal state, region-by-race, and age-by-smoking status groups, while those from the illegal states were classified into age-by-sex, education, region-by-race, and age-by-smoking status groups, where for both the legal and illegal states the region refers to the US Census Division, which groups the states into nine groups (New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain or Pacific). Respondents from Australia were classified into age-by-sex-by-state/territory, education, and ethnicity-by-state/territory groups. There were seven state/territory groups, including six individual states/territories (New South Wales, Victoria, Queensland, South Australia, Western Australia, and Australian Capital Territory), and Tasmania and Northern Territory were merged. Respondents from New Zealand were classified into age-by-sex-by-region, education, and ethnicity-by-region groups, where region was defined as the following six grouped regions (Northland/Auckland, Waikato/Bay of Plenty, Gisborne/Hawke's Bay/Taranaki/Manawatu-Wanganui, Wellington, Tasman/Nelson/Marlborough/West Coast/Southland/Otago, and Canterbury). Correspondingly grouped population count and proportion estimates were obtained from Statistics Canada, the U.S. Census Bureau, Australian Bureau of Statistics, and Statistics New Zealand (66). A raking algorithm was applied to the cross-sectional analytic sample in each country to compute weights that were calibrated to these groupings. Weights were rescaled to the sample size in each country.

Descriptive statistics were used to characterize the use of flavored vaping liquids overall and by type of flavor, stratified by country. Sociodemographic differences in the prevalence of vaping THC liquids by country were examined via chi-square tests. A binary logistic regression model was fitted to examine the association between the outcome, use of flavored vaping liquids among people who vaped cannabis in the past 12 months, and sociodemographic correlates of flavored cannabis vaping. This model adjusted for country, age, sex, ethnicity, education, perceived income adequacy, frequency of cannabis vaping, and past 12-month use of e-cigarettes. Analyses were conducted using SPSS 28 and SAS 9.4.

Results

Sample characteristics

The prevalence of vaping cannabis liquid in the past 12-months was 15.5% in the US ($n = 4,667$), 10.8% in Canada ($n = 1,832$), 4.1% in Australia ($n = 118$), and 3.9% in New Zealand ($n = 117$). Table 1 shows the sample profile of the people who vaped cannabis in the past 12-months who were included in the analyses. Chi-square tests showed significant differences of all sociodemographic variables examined by country (excluding sex at birth) in the sample profile of people who vaped cannabis in the past 12-months (Table 1); age group ($x^2 = 44.84$, $p < .001$); ethnicity ($x^2 = 108.62$, $p < .001$); education ($x^2 = 160.64$, $p < .001$); income adequacy ($x^2 = 75.63$, $p < .001$); frequency of vaping cannabis ($x^2 = 58.94$, $p < .001$); and, past 12 month use of e-cigarettes ($x^2 = 15.76$, $p = .02$).

Prevalence of flavored cannabis liquid for vaping

Among all respondents (including those who did not use cannabis in the past year), the use of any flavored vaping liquids was highest in the US (8.3%) and Canada (5.6%) compared to Australia (3.1%) and New Zealand (2.2%).

Flavour types used by people who vape cannabis

Table 2 shows the range of flavor categories used among people who vaped cannabis liquids in the

Table 1. Sample characteristics of people who vape liquid cannabis in the past 12-months in Canada, United States, Australia, and New Zealand.

	CAN ($n = 1713$)	US ($n = 4337$)	AUS ($n = 111$)	NZ ($n = 104$)	Total ($n = 6265$)
Age Group	% (n)	% (n)	% (n)	% (n)	% (n)
Mean (SD)	35.4 (11.6)	36.6 (12.3)	36.2 (10)	32.4 (10.8)	36.2 (12.1)
16–25	20.9 (357)	19.0 (824)	19.3 (21)	27.9 (29)	19.7 (1232)
26–35	36.0 (616)	33.0 (1430)	26.3 (29)	38.4 (40)	33.8 (2115)
36–45	23.2 (397)	24.1 (1045)	38.8 (43)	22.4 (23)	24.1 (1507)
46–55	12.6 (215)	14.0 (607)	13.2 (15)	8.4 (9)	13.5 (845)
56–65	7.4 (127)	10.0 (432)	2.4 (3)	2.9 (3)	9.0 (565)
Sex					
Female	46.4 (794)	45.7 (1983)	36.0 (40)	39.3 (41)	45.6 (2858)
Male	53.6 (919)	54.3 (2354)	64.0 (71)	60.7 (63)	54.4 (3407)
Ethnicity					
Majority	70.2 (1202)	77.9 (3378)	64.4 (71)	41.6 (43)	74.9 (4694)
Minority	29.8 (511)	22.1 (960)	35.6 (39)	58.4 (61)	25.1 (1571)
Education					
Less than High school	16.3 (280)	8.8 (383)	10.0 (11)	16.0 (17)	11.0 (690)
High school diploma	30.6 (524)	23.7 (1027)	24.9 (28)	37.9 (39)	25.8 (1618)
Some college or technical vocation	32.7 (560)	41.0 (1779)	35.4 (39)	18.1 (19)	38.3 (2398)
Bachelor's degree or higher	19.6 (336)	25.9 (1125)	29.8 (33)	24.9 (26)	24.3 (1520)
Not stated	0.8 (13)	0.5 (22)	0.0 (0)	3.0 (3)	0.6 (38)
Income adequacy					
Very difficult	12.4 (213)	12.3 (534)	4.0 (4)	15.9 (17)	12.3 (768)
Difficult	22.3 (382)	19.8 (857)	8.7 (10)	21.2 (22)	20.3 (1271)
Neither easy nor difficult	33.9 (581)	31.8 (1379)	28.8 (32)	30.0 (31)	32.3 (2023)
Easy	18.9 (324)	18.1 (787)	33.8 (37)	18.1 (19)	18.6 (1167)
Very Easy	9.0 (153)	14.8 (641)	22.7 (25)	12.8 (13)	13.3 (833)
Not stated	3.4 (59)	3.2 (140)	2.0 (2)	1.9 (2)	3.2 (203)
Liquid cannabis vaping frequency					
Less than monthly use	39.1 (669)	32.0 (1387)	22.0 (24)	34.4 (36)	33.8 (2116)
Monthly use	19.3 (331)	21.0 (911)	24.1 (27)	21.3 (22)	20.6 (1291)
Weekly use	21.2 (362)	23.3 (1012)	33.0 (37)	14.4 (15)	22.8 (1426)
Daily /almost daily use	15.0 (256)	18.9 (821)	14.6 (16)	17.9 (19)	17.8 (1112)
Not stated	5.5 (94)	4.8 (206)	6.3 (7)	12.0 (12)	5.1 (319)
Past 12-month use of E-cigarettes					
Never used	56.8 (973)	55.6 (2410)	62.1 (69)	63.1 (66)	56.1 (3518)
Yes, but not used in past 12 months	13.4 (230)	12.5 (542)	4.8 (5)	4.5 (5)	12.5 (782)
Yes, used in past 12 months	29.8 (510)	31.9 (1385)	33.1 (37)	32.4 (34)	31.4 (1965)

past 12-months. Among all people who vaped cannabis liquids in the past 12-months, 34.2% reported using no flavored products, 30.8% reported using a single flavor, 26.7% reported using more than one flavor, and 8.3% did not know if they used a flavored product. Overall, fruit (40.8%), Cake/candy/dessert (20.4%), and vanilla (15.2%) were the most often used flavors by people who vaped cannabis liquids in the past 12-months across all countries ($n = 6,265$), while fruit was the leading flavor in each of the four countries. Similarly, among those who used more than one flavored product ($n = 1,673$) the patterns of most often used flavors followed the trend of any flavor use across countries.

Sociodemographic correlates of vaping flavored cannabis liquids

Table 3 shows the results of the logistic regression model examining the prevalence of using a flavored vaping liquid among people who vaped cannabis liquids in the past 12-months. Australian cannabis consumers had the highest odds of using a flavored vaping liquid compared to people who vape in New Zealand (OR = 2.29; 1.17, 4.47), Canada (OR = 3.14; 1.89, 5.23), and the US (OR = 3.14; 1.89, 5.21). In terms of sociodemographic correlates, the odds of using flavored vapes were greater among younger respondents: respondents aged 16–45 had higher odds of using flavored vapes compared to 46–55- and 56–65-year-olds. Minority ethnic groups had higher odds of using flavored vapes (OR = 1.22; 1.00, 1.48) compared to the majority ethnic group. Females were more likely to use flavored vaping liquids than males (OR = 1.30; 1.10, 1.53). Those with higher education and higher perceived income adequacy had increased odds of using flavored vapes when compared to respondents with less than high school education or low-income adequacy, respectively. Compared to those who vaped less than monthly, those who vaped more frequently had higher odds of using a flavored vaping liquid, with daily/almost daily use being the most likely to use a flavored product (OR = 2.79; 2.20, 3.53). The likelihood of vaping flavored cannabis liquids was similar between respondents who used nicotine e-cigarettes and those who did not.

Table 2. Use of flavors among people who vape liquid cannabis in the past 12-months in Canada (CAN), United States (US), Australia (AUS), and New Zealand (NZ).

	CAN ($n = 1713$) % (n)	US ($n = 4337$) % (n)	AUS ($n = 111$) % (n)	NZ ($n = 104$) % (n)	Total ($n = 6265$) % (n)
No flavor	36.7 (628)	33.8 (1465)	14.0 (16)	30.8 (32)	34.2 (2140)
Don't know	7.9 (135)	8.7 (376)	3.9 (4)	5.4 (6)	8.3 (521)
At least one flavor	55.5 (950)	57.6 (2497)	82.0 (91)	63.8 (66)	57.5 (3604)
Only one flavor	33.4 (571)	29.6 (1285)	31.5 (35)	37.2 (39)	30.8 (1929)
More than one flavor	22.1 (379)	27.9 (1212)	50.5 (56)	26.6 (28)	26.7 (1675)
Specific flavors[a]					
Fruit (peach, berry, lemon, apple, etc.)					
Any use	39.7 (679)	40.6 (1762)	58.6 (65)	46.1 (48)	40.8 (2554)
Most often used	11.4 (195)	13.2 (571)	17.5 (19)	10.4 (11)	12.7 (796)
Cake, candy, desserts, or sweets					
Any use	14.2 (243)	23.0 (999)	20.4 (23)	12.2 (13)	20.4 (1277)
Most often used	3.9 (66)	6.2 (268)	2.9 (3)	5.4 (6)	5.5 (343)
Vanilla					
Any use	14.3 (244)	14.9 (646)	36.5 (40)	19.3 (20)	15.2 (951)
Most often used	2.1 (37)	3.8 (163)	9.5 (10)	4.5 (5)	3.4 (215)
Menthol or mint					
Any use	13 (222)	10.9 (472)	32.5 (36)	18.6 (19)	12.0 (749)
Most often used	2.9 (49)	2.6 (112)	8.8 (10)	4.0 (4)	2.8 (175)
Spice (e.g., clove)					
Any use	6.9 (118)	7.4 (323)	29.4 (33)	13.3 (14)	7.8 (488)
Most often used	0.9 (15)	1.3 (55)	10.7 (12)	1.7 (2)	1.3 (83)
Other flavor					
Any use	1.7 (29)	1.4 (63)	0 (0)	0 (0)	1.5 (91)
Most often used	0.2 (3)	0.3 (11)	0 (0)	0 (0)	0.2 (14)

[a]For most often used flavors, $n = 1673$ respondents who used more than one flavor; 2 respondents refused to answer (1 from Canada, 1 from USA).

Discussion

The current study is among the first to examine the use of flavored vaping liquid in a population-based sample of people who vape cannabis across different countries.

Overall, the prevalence of vaping cannabis liquids was substantially higher in the US (15.5%) and Canada (10.8%) compared to Australia (4.1%) and New Zealand (3.9%). The higher rate of vaping is consistent with historical trends, in which cannabis use generally is more prevalent in North America, and more recent findings that suggest the use of inhaled cannabis "extracts" for vaping are higher in jurisdictions that have legalized cannabis (8,9,19,70). Australia and New Zealand permit medical cannabis use, although under stricter conditions in New Zealand than Australia (71,72). For example, there are no cannabis liquid vaping products approved for legal sale under the country's Medicinal Cannabis Scheme yet. Consequently, New Zealand respondents in the present survey must have used cannabis liquid vaping products that were procured illegally, perhaps from overseas websites, or were home-made. In contrast, "recreational" cannabis use was legal in Canada and among 18 US states at the time of data collection, and there was a substantially higher prevalence of cannabis use and cannabis vaping. Thus, while people who vape cannabis in Canada and the US were less likely to report the use of flavored THC vapes, the overall proportions who use flavors were higher in the populations of Canada and US legal states because cannabis vaping rates that are more than twice the rates in Australia and New Zealand (15,59).

A majority of people who vape cannabis liquids reported using flavored liquids across all four countries, with the highest prevalence of use among people who vape cannabis in Australia and the lowest prevalence of flavored use among people who vape cannabis from Canada and the US. The estimates from Australia and New Zealand warrant more caution given the relatively low numbers, which reflects the lower prevalence of cannabis vaping in these countries. Across the four countries, fruit was the most popular flavor of THC vapes, followed by confectionary/dessert flavors. The popularity of fruit flavors is consistent with previous surveys and qualitative research conducted in Canada and the US (62,63). To our knowledge, there have been no studies that have explored the prevalence of flavored cannabis vaping liquids in Australia and New Zealand. These findings also align with the more extensive research on e-cigarette products which has shown significant preferences for fruit flavored e-cigarette liquids across age groups (48,49,73,74).

The use of flavored vapes was more common among younger people who vape cannabis. Notably, the current analysis was restricted to respondents who reported vaping cannabis liquids; because vaping is a more

Table 3. Logistic regression examining sociodemographic correlates of flavored liquid use among people who vape liquid cannabis in the past 12-months ($n = 6265$).

	Beta (β)	OR (95% CI)	p-level
Country[1]			
US vs. Canada	0.01	1.00 (0.85, 1.18)	.983
Australia vs. Canada	1.15	3.14 (1.89, 5.23)	<.001
New Zealand vs. Canada	0.32	1.37 (0.86, 2.20)	.186
Australia vs. US	1.14	3.14 (1.89, 5.21)	<.001
New Zealand vs. US	0.32	1.37 (0.86, 2.19)	.188
Australia vs. New Zealand	0.83	2.29 (1.17, 4.47)	.015
Age[2]			
26–35 vs. 16–25	0.01	1.01 (0.80, 1.28)	.913
16–25 vs. 36–45	0.07	1.07 (0.85, 1.36)	.571
26–35 vs. 36–45	0.08	1.08 (0.88, 1.34)	.453
16–25 vs. 46–55	0.48	1.61 (1.21, 2.14)	.001
26–35 vs. 46–55	0.49	1.63 (1.25, 2.12)	<.001
36–45 vs. 46–55	0.41	1.50 (1.15, 1.96)	.003
16–25 vs. 56–65	0.62	1.85 (1.33, 2.57)	<.001
26–35 vs. 56–65	0.63	1.88 (1.38, 2.56)	<.001
36–45 vs. 56–65	0.55	1.73 (1.27, 2.36)	.001
46–55 vs. 56–65	0.14	1.15 (0.82, 1.62)	.417
Sex			
Female	−0.26	1.30 (1.10, 1.53)	.002
Male	Reference		
Ethnicity			
White	Reference		
Other/mixed/unstated	0.20	1.22 (1.00, 1.48)	.046
Education			
Less than High school	Reference		
High school diploma	−0.03	0.97 (0.71, 1.34)	.869
Some college or technical vocation	−0.03	0.97 (0.71, 1.32)	.866
Bachelor's degree or higher	0.34	1.41 (1.01, 1.95)	.043
Not stated	−0.91	0.40 (0.16, 1.01)	.052
Income adequacy			
Very difficult	Reference		
Difficult	−0.33	0.72 (0.54, 0.96)	.026
Neither easy nor difficult	−0.29	0.75 (0.56, 0.99)	.044
Easy	−0.15	0.86 (0.63, 1.17)	.342
Very Easy	0.09	1.09 (0.76, 1.56)	.640
Not stated	−0.82	0.44 (0.23, 0.83)	.012
Liquid cannabis vaping frequency			
Less than monthly use	Reference		
Monthly use	0.83	2.28 (1.83, 2.84)	<.001
Weekly use	0.97	2.65 (2.13, 3.29)	<.001
Daily /almost daily use	1.03	2.79 (2.20, 3.53)	<.001
Not stated	−0.57	0.57 (0.36, 0.89)	.015
Past use of E-cigarettes			
Never used	Reference		
Yes, but not used in past 12 months	−0.11	0.90 (0.70, 1.14)	.373
Yes, used in past 12 months	0.15	1.16 (0.97, 1.39)	.104

[1]Model includes multiple comparisons by country where the second country listed is the reference category.
[2]Model includes multiple comparisons by age group where the second age group listed is the reference category.

popular mode of administration among young people, differences in the age profile of people who vape flavored cannabis liquids in the broader population would be even more pronounced (7). These findings are consistent with previous studies indicating that flavored vapes are particularly popular among the youngest cannabis consumers. For example, a US study showed that 58% of high school students who vape cannabis reported the use of flavored products (62), while surveys from Canada indicate that people who vape cannabis aged 15 to 24 have at least tried or used flavored products on a regular basis (63). The extent to which flavored cannabis extracts serve as an inducement for youth represents an important question, particularly in legal cannabis markets with a mandate to regulate cannabis products and to minimize the appeal of vaping products among youth. Indeed, in 2021 the Government of Canada's proposed regulations that would restrict flavors for inhaled cannabis extracts (75).

The study also found that the use of flavored THC vaping liquids was greater among people who vape cannabis that self-identified as ethnic minorities and those with higher socioeconomic status, as measured through education and perceived income adequacy.

Although no other studies have examined correlates of flavored THC liquids, the prevalence of vaping cannabis extracts may skew to higher income respondents given the higher "up front" costs of purchasing these products related to dried flower. Interestingly, females reported greater use of flavored THC vape liquids. Although the overall prevalence of vaping cannabis is moderately lower among females; the use of flavored cannabis products may be particularly appealing to females, as is the case for flavored tobacco products, such as menthol (76). Future research should examine sex and gender-related differences in the use of flavored cannabis products more thoroughly.

People who vape cannabis more frequently were substantially more likely to report the use of flavored vaping liquids. The cross-sectional nature of the study is unable to establish the directionality of this finding; a bi-directional association is possible, in which more frequent consumers opt for flavored vapes and flavored vapes may promote more frequent consumption. Finally, although the use of nicotine e-cigarettes is strongly associated with the prevalence of cannabis vaping (77), it was not associated with the use of flavored cannabis vaping liquids in the current study (42,76,77).

Limitations

This study has a number of limitations. Respondents were recruited using non-probability-based sampling; therefore, the findings do not necessarily provide nationally representative estimates. However, the data were weighted by age group, sex, region, and education in all four countries and smoking status in Canada and the US, and region-by-ethnicity in the US, Australia, and New Zealand. The use of flavored cannabis vaping products may be underestimated in the current study given the analysis focused on cannabis e-liquid products and that consumers who only vaped dried flower or solid extracts ("other" people who vape) were not asked about the use of flavors. In the current study, there were an additional 1.9% ($n = 1{,}008$) of consumers who fall into the latter category. These "other" people who vape account for 5.7% of all past 12-month cannabis consumers ($n = 17{,}651$). However, flavor additives are very rare in dried flower and relatively uncommon in solid extracts. In addition, the ICPS surveys record prevalence of use of typical THC-containing cannabis products separately from non-THC-containing CBD products. The current paper only reports on the former, however, consumer confusion between THC and non-THC-containing products is widespread and the current findings may reflect some level of misreporting (12). In addition, more restrictive cannabis laws in Australia, New Zealand and some US states may have led to greater under-reporting of cannabis use (including vaping) compared to Canada and US states in which non-medical cannabis has been legalized. Due to the low prevalence of vaping in New Zealand and Australia, we were unable to test for possible interaction effects between country and sociodemographics, or to stratify our models for robust comparisons in the different markets. Finally, the pre-coded checklist of flavor categories presented to respondents in the question assessing vaping flavors was based on flavors commonly included in nicotine containing e-cigarettes. Although the categories are consistent with the flavor descriptors used for cannabis products in a retail scan (69), further validation could be undertaken to tailer the list of flavors for cannabis and THC containing products.

Conclusion

Flavored vaping liquids are commonly used by people who vape cannabis in Canada, the US, Australia, and New Zealand. The safety and role that flavors play in promoting cannabis use are an understudied and important topic for future research. As the cannabis landscape continues to evolve, a main area of focus should examine trends in use and behaviors of these products in both, restricted and legal jurisdictions in which government authorities have a mandate for the regulation of vaping products.

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ORCID

Kimberly D'Mello http://orcid.org/0000-0003-3498-0038

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