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# Exploring Differences in Daily Vaping of Nicotine and Cannabis among People Who Use Drugs in New Zealand

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## ABSTRACT

**Background:** Little is known about daily vaping of different substances, particularly cannabis. **Aim:** To explore daily vaping of cannabis and nicotine products in a sample of people who use drugs in New Zealand. **Method:** The online New Zealand Drug Trends convenience survey ( $N=23,500$ ) was promoted to those aged 16+ via a targeted Facebook™ campaign, with 9,042 reporting vaping in the past six months. Multivariate logistic regression models were fitted to identify predictors of daily vaping of: (i) nicotine e-liquids, (ii) no-nicotine e-liquids, (iii) cannabis e-liquids/oils, (iv) cannabis herb. **Results:** Forty-two percent of past 6-month vapers used a vaporizing device “daily or near daily” ( $n=3,508$ ). Nicotine was most common substance used by daily vapers (96%), followed by dry herb cannabis (12%), no-nicotine e-liquids (10%) and cannabis e-liquid (6%). Daily vaping of no-nicotine e-liquids was associated with abstinence from tobacco use. Frequency of cannabis use was negatively correlated with daily vaping of nicotine liquids and positively correlated with daily vaping of no-nicotine and herbal cannabis. Younger age strongly predicted daily vaping of nicotine and no-nicotine liquids, but the reverse association was observed for daily vaping of herbal cannabis. Māori were less likely to daily vape cannabis herb than NZ Europeans. Daily vaping of both cannabis e-liquid and cannabis herb was associated with medicinal cannabis use. **Conclusion:** Daily vapers of nicotine and cannabis differed by several characteristics. Younger age group is at risk of daily vaping nicotine and non-nicotine, while herbal cannabis vaping is associated with older and medicinal use, suggesting a need for a nuanced vape policy response.

## KEYWORDS

Vape; marijuana; e-cigarette; ENDS; flavor vape; medicinal cannabis; vaporizing

## Introduction

There has been a rapid increase in the popularity of vaping in many countries, including New Zealand. Notable increases in vaping have been identified in New Zealand among youth and Māori (the indigenous people) (Ball et al., 2021; Wamamili et al., 2020). While vaping technology that involves the use of nicotine (flavored) liquids was originally developed to assist with tobacco smoking cessation, vaping is also used to administer tetrahydrocannabinol (THC) and cannabidiol (CBD)—active ingredients in cannabis—via heating cannabis e-liquids/oils or cannabis dried flower (Blundell et al., 2018; Bonner et al., 2021; Budney et al., 2015).

While nicotine e-cigarettes contain lower levels of harmful toxins compared to tobacco smoke, they are not harmless and their long-term health effects remain unknown (Grana et al., 2014; Helen et al., 2020). A number of governments have embraced the harm reduction potential of nicotine vaping technology by regulating e-cigarettes as part of a wider strategy to reduce tobacco smoking prevalence, including in New Zealand as part of the 2025 smokefree action plan (MOH, 2019).

Cannabis vaping is also likely to reduce pulmonary harm (compared to smoking) but the extent of the benefit to

respiratory health remains uncertain (Gieringer et al., 2004; Tashkin, 2015). The mode of cannabis vaping is likely to play a role in the harm reduction mechanism: cannabis e-liquid cartridges have been found to pose a greater risk of contamination with harmful ingredients than dry herb vaporizer (Lanzarotta et al., 2020; Poklis et al., 2019), and they can deliver much higher doses of concentrated THC than vaporized cannabis flower (which has a natural biological ceiling of 30–35% THC (Stith et al., 2019)), raising concerns about adverse mental health and other harms (e.g. vehicle, workplace and other accidents) particularly when used by youth or inexperienced users. Similar to nicotine e-cigarettes, cannabis vaping products are increasingly commercially marketed in jurisdictions that have recently legalized recreational cannabis markets (e.g. in Canada, Colorado) and in some countries that have legalized medicinal cannabis use and supply (e.g. Australia, New Zealand).

The recent policy reforms regulating access to nicotine and cannabis vaping products have occurred in the context of scientific uncertainty about long-term effects of vaping, and concerns have been raised about the uptake of vaping by never-smokers, youth and dual use (i.e. concurrent vaping and smoking), the risk of dependence (particularly from

high-potency nicotine and THC products), adverse effects from adulterants, and commercialization (Borodovsky et al., 2017; Dewhirst, 2023; Fadus et al., 2019; Walker et al., 2020). The New Zealand government regulations aim to encourage vaping by current tobacco smokers (to quit smoking) and in some cases legal medicinal cannabis users, while at the same time discouraging recreational vaping of nicotine and cannabis by youth and nonsmokers and the vaping of illegal products (see: Britton & McNeill, 2013; Gartner, 2015; Hall et al., 2021 for discussions of vape policies and harm reduction).

While cannabis for non-medical use is illegal in New Zealand, the prevalence of use is high by international standards, with 14.7% of adults (15+) reporting use in the past year, and Māori twice as likely to report cannabis use than other ethnicities (MOH, 2022b; UNODC, 2022). There is currently little research on modes of cannabis administration in New Zealand to inform understanding of levels of cannabis vaping or modes of vaping (e.g. dry herb vs. cannabis e-liquid/oils). According to the 2019/2020 New Zealand Health Survey, 27% of adults (aged 15+ years) had ever used an electronic cigarette and 8.3% used e-cigarettes daily (up from 3.5% two years prior) (MOH, 2022a). The majority of daily e-cigarettes users (76%) vaped nicotine-containing e-cigarettes, but there was no similar representative population data on levels of cannabis vaping (MOH, 2020b). Māori (the indigenous people of New Zealand) were twice as likely to have tried vaping (49.7% vs. 26%) and vape e-cigarettes daily (17.6% vs. 7.7%) than New Zealand Europeans (MOH, 2022a).

Most vaping research to date has focused on electronic cigarettes containing nicotine and no-nicotine flavored e-liquids. The emerging research on *cannabis* vaping comes primarily from legal cannabis jurisdictions in the US and Canada, although the phenomenon has also been explored in countries where cannabis remains illegal for recreational use (e.g. Fataar & Hammond, 2019; Hindocha et al., 2016). Researchers have found similarities in vaping behavior across cannabis and nicotine, for example, with regard to users' perception of reduced harm (Etter, 2015; Lee et al., 2016; Wackowski et al., 2016), and an association between vaping nicotine and concurrent vaping of cannabis (Boakye et al., 2021; Smith et al., 2021). There are mixed results in terms of the variables that predict vaping of nicotine and cannabis, including the role of socio-economic status, ethnicity, age and gender. For example, some studies in the US found that having ever used e-cigarettes was higher among males than females (Schoenborn & Gindi, 2015), whereas others reported the opposite (Zhu et al., 2013). Additionally, high frequency vaping remains less researched despite it raising important dilemmas for regulators: e.g. adults who use e-cigarettes on a daily basis report higher levels of tobacco smoking cessation (Biener & Hargraves, 2015), but young adults who vape e-cigarettes daily are more likely to report higher levels of nicotine dependency (Camara-Medeiros et al., 2021).

Vaping surveys to date have not always specifically asked about the content of e-cigarettes or other vaping devices, including whether they contain nicotine (see e.g. Laverty et al. (2018)) or cannabis (Ball et al., 2021; Pearson & Villanti, 2020). Additionally, research on *cannabis* vaping has

not always clearly differentiated between the different products vaped (e.g. oil/liquid vs “dry herb”) (Lim et al., 2022), nor has it explored the patterns of vaping in people who use drugs frequently and therefore have high prevalence and patterns of cannabis use.

This study aimed to contribute to the understanding of the frequent vaping phenomenon across a range of nicotine, no-nicotine and cannabis products. As others have previously suggested, researching and developing policy responses to the vaping phenomenon *across* nicotine and cannabis in tandem “may save time and energy and result in a more comprehensive and effective public health policy on vaping” (Budney et al., 2015). With this comparative lens in mind, this study explored the demographic and substance use characteristics associated with daily vaping of four distinct classes of vaping products, i.e.: (i) nicotine e-liquids, (ii) no-nicotine e-liquids, (iii) cannabis e-liquids/oil, and (iv) dried cannabis herb, among a large sample of people who use drugs with the aim of informing future research and policy and the regulatory response. The study provides a rare examination of *daily* cannabis vaping in the context of an illegal recreational cannabis market in New Zealand.

## Methods

The study analyzed data from the 2020 wave of the New Zealand Drug Trends Survey (NZDTS) conducted from January to May 2020. The NZDTS is an anonymous online convenience survey designed to provide an annual snapshot of frequent drug use and drug markets in New Zealand. The NZDTS questionnaire is reviewed annually, with core questions derived from established drug use and drug market studies previously conducted annually in New Zealand over the past decade (e.g. NZ Arrestee Drug Use Monitoring—NZADUM; Illicit Drugs Monitoring System - IDMS), in Australia (Drug Use Monitoring in Australia—DUMA), and other surveys conducted internationally. Recruitment for the NZDTS is *via* a Facebook™ promotion campaign targeting people aged 16 years or older and living in New Zealand who had expressed interest in a range of entertainment options and activities associated with alcohol, tobacco and other substance use, such as alcoholic beverages, music genres and the nighttime economy (Van Havere et al., 2011). No incentive payment for participating was offered.

A total of 26,121 people clicked on the link and began the survey. Surveys were audited for quality and extent of completion. Those with less than 15% completion (i.e. only the demographic section answered) and responses in which age was unspecified or outside the age range 16–90 years were removed. To avoid compromising anonymity, respondent IP addresses were not stored; rather a custom software solution was utilized to convert IP addresses into nonreversible numbers. Survey responses with the same numbers were flagged as potential duplicates and then checked for demographic similarities and extent of completion to determine if they had been submitted by the same person. In cases where demographics matched, the most complete survey response was kept. If demographics differed, both responses were kept

(i.e. two separate people had completed the survey on the same device). Following this quality control process, a total of 2,621 responses were removed, 110 of which were duplicates, 826 insufficiently completed, and 1,685 for being outside the age range (i.e. younger than 16 and older than 90), leaving a total of 23,500 completed surveys. The median time taken to complete the survey was 17 min. The NZDTS was approved by the Massey University Human Ethics Committee (Application code: SOA 17/43).

## Measures

### Demographics

Participants were asked about their age, gender (“male”, “female”, “gender diverse”), ethnicity (“Māori”, “NZ European/Pākehā”, “Pacific Islander”, “Asian”, “Indian”, “other” (including open text field)), highest level of education (“none”, “primary/intermediate”, “high school”, “polytech/trade”, “university”), employment status (“employed”, “student”, “unemployed”, “retired/parenting”, “sickness”), whether they lived in a “city”, “small town” or “rural area”, and the region of residence.

### Tobacco, cannabis, and other drug use

Participants were asked to select all substances they had used in the previous six months, including tobacco, cannabis, alcohol, MDMA, methamphetamine, LSD, and non-prescription opioids. Those who reported using a drug in the past six months were then asked to indicate how frequently they had used it in the past six months (i.e. “daily or near daily”, “once or twice a week”, “monthly”, “once or twice in the last 6 months”). Those who used cannabis were asked to choose all modes of cannabis administration they used in the past 6 months (“What ways have you taken cannabis in the past six months?” (“Smoked: a joint or dry pipe”; “Inhaled: through a water bong”; “Inhaled: heated spots of oil”; “Inhaled: through a vaporizer or vape pen”; “Eaten: as a cookie/gummy bear/tablet/other edible”, “Taken by mouth: in a spray form or liquid”, “Applied to skin (e.g. cream)”, “Other”—open answer option).

### Vaping patterns

Participants were asked whether they had used an e-cigarette or another vaporizing device in the previous six months (“Have you used an e-cigarette or other vaporizing device in the past six months?”), how frequently they had done so (“How often have you vaped in the past 6 months?”; i.e. “daily or near daily”, “once or twice a week”, “monthly”, “once or twice in the last 6 months”), and what substances and products they had vaped (i.e. “nicotine e-liquid”, “no-nicotine e-liquid”, “cannabis e-liquid/oil—CBD only”, “cannabis e-liquid/oil—THC/CBD mix”, “dried cannabis herb”, “other” (open-text field)). Those who vaped nicotine e-liquids were also asked about the perceived impact of vaping on their level of smoking tobacco cigarettes (“What impact, if any, did vaping nicotine e-liquids have on your level of tobacco

smoking?”; i.e. “never smoked tobacco”, “no impact on level of tobacco smoking”, “stopped smoking tobacco”, “smokeless tobacco”, “smoke more tobacco”, “started smoking tobacco”).

### Medicinal cannabis use

Those who used cannabis in the past six months were asked how much of their cannabis use was for medicinal reasons (i.e. “none”, “hardly any”, “some”, “most”, “all”).

### Health risk perceptions

Participants were asked to rate the perceived health risk of regularly (i.e. at least monthly) using nine drug types, including cannabis and smoking tobacco, on a 1 to 7 scale (1 = no risk, 7 = extreme risk).

### Analysis

Four separate logistic regression models were fitted to characterize the daily use of four vaping products [(i) nicotine e-liquids, (ii) no-nicotine e-liquids, (iii) cannabis e-liquids (i.e. respondents who used THC and CBD-only e-liquids combined), and (iv) dried herb cannabis] using demographic variables, frequency of tobacco and cannabis use, and perceptions of health risks of cannabis and tobacco as described above.

The demographic variables included age categorized using dummy variables for the groups 16–17, 18–20, 21–25, 26–35, and 36+ (reference), gender (1 = “male”, 0 = “female”; “gender diverse” was removed due to small respondent numbers), and ethnicity. Age was categorized, rather than included as a continuous variable to avoid the inclusion of polynomial terms or smoothing functions (e.g. splines) and so better facilitate the interpretation of results across drug types. Ethnicity was categorized using dummy variables for the groups “Māori”, “NZ European” (reference) and “other ethnicity”. Highest level of education was grouped by tertiary education (high) versus other levels of education such as high school (low). The dummy variable was then fitted as 0 = “trade/technical” or “university” versus 1 = “none”, “primary/intermediate”, “high school”. Employment status was also fitted as dummy variables for the groups (“student”, “employed” (reference) versus “unemployed/others”). The “geographical” variables included were New Zealand regions and town type (0 = “rural area” or “small town” versus 1 = “city”). Frequency of cannabis and tobacco use was included as continuous variables assuming the value 0 to 4 (i.e. none (0), once or twice (1), monthly (2), weekly (3), and daily (4), respectively). Due to the unbalanced spread of the frequency of use data, a continuous variable was used to enable the most consistent fit across the models. Perceptions of health risks of cannabis and tobacco were included in the analysis as continuous variables (i.e. 0 = no risk, 7 = extreme risk).

The “COVID-19 period” variable was considered in the analysis (i.e. responses recorded “during first nation-wide lockdown” versus “pre-lockdown”) to control for any effect of the COVID related public health restrictions on retail and

**Table 1.** Total NZDTS sample demographics and drug use patterns.

Demographics (total sample) ( <i>n</i> = 23,500)		
Gender	Male	61.0%
	Female	37.7%
	Gender diverse	1.2%
Age	Mean: 29, median: 23, std dev: 13, range: 16–88	
Ethnicity	NZ European	73.9%
	Māori	15.9%
	Other	10.0%
Education	High (includes polytechnic and university)	60.2%
Residence	Low (high school and lower)	39.6%
	City	65.0%
	Small town	23.1%
Main occupation	Rural	11.8%
	Employed	62.5%
Drug use in the past 6 months	Student	25.8%
	Unemployed/parenting/sickness benefit	11.5%
	Alcohol	91.3%
Frequency of cannabis use in past 6 months ( <i>n</i> = 16,004)	Cannabis	74.8%
	Tobacco	60.9%
	Ecstasy/MDMA	51.0%
	LSD	30.5%
	Cocaine	14.7%
	Methamphetamine	8.9%
	Opioids/Morphine	3.1%
	Daily	39.0%
Frequency of tobacco use in the past 6 months ( <i>n</i> = 13,289)	Once or twice per week	18.8%
	Monthly	16.1%
	Once or twice (in past 6 months)	26.1%
	Daily	47.1%
Medicinal cannabis use ( <i>n</i> = 15,404)	Once or twice per week	14.1%
	Monthly	13.5%
	Once or twice (in past 6 months)	25.4%
	“All”/“most” cannabis used for medicinal reasons	19.4%
Route of cannabis administration ( <i>n</i> = 17,567)	“Some” cannabis used for medicinal reasons	20.6%
	“Hardly any” of cannabis used for medicinal reasons	9.3%
	“None” of cannabis used for medicinal reasons (=all recreational)	50.6%
	Smoked: a joint or dry pipe	75.1%
Route of cannabis administration ( <i>n</i> = 17,567)	Inhaled: through a water bong	57.3%
	Eaten: as a cookie/gummy bear/other edible	33.7%
	Inhaled: through a vaporizer or vape pen	18.2%
	Inhaled: heated spots of oil	13.2%
	Applied to skin (e.g. cream)	5.6%
	Taken by mouth: in a spray form or liquid	3.7%

movement on daily vaping habits. New Zealand went into a nation-wide COVID lockdown half-way through the survey data collection on 26 March 2020, with the subsequent re-opening of retail and relaxation of movement restrictions on 27 May 2020. Lockdown measures included the closure of brick-and-mortar vaping retailers and restricting people's movement to their neighborhood suburbs.

Covariates were kept in the logistic regression models if they were statistically significant ( $p < 0.05$ ). The goodness of fit for all the logistic regression models was assessed

using the Hosmer and Lemeshow test (Hosmer & Lemeshow, 2000).

## Results

### Sample demographics

The demographics of the entire NZDTS sample ( $n = 23,500$ ) are presented in Table 1. The sample was majority male (61% vs 38% female) with a median age of 23 years (mean: 28.5, IQR = 14). Seventy-four percent were New Zealand European and 16% were Māori (compared to 17% in the latest available national census data for 2018). Sixty-two percent of respondents worked full- or part-time, 26% were students, and 11% were unemployed, retired, in unpaid work, or on a sickness benefit.

The sample reported high levels of drug use in the previous six months, with 75% having used cannabis, 61% tobacco, 51% ecstasy/MDMA and 31% LSD/psychedelics. The majority of cannabis users reported frequent consumption (i.e. 39% daily and 19% weekly). Smoking cannabis was by far the most common route of administration (75%), followed by inhaling *via* a water bong (57%). However, 18% reported administering cannabis *via* vaping at least once in the past six months.

### Demographics and vaping patterns of those who vaped

Over half of the sample (55%) had used a vaporizing device in the past six months, with the majority vaping nicotine (85%), followed by no-nicotine e-liquids (19%), “dry herb” cannabis (14%), and cannabis e-liquids (7%) (Table 2). Fifty-eight percent had vaped at least once a week, and 42% had vaped “daily or near daily”. Just over half of the past 6-month nicotine vapers reported that vaping resulted in them either stopping smoking cigarettes (22%) or smoking less (31%). However, 30% reported vaping had no impact on their smoking and 14% had never smoked.

Among those who vaped daily in the past six months, the majority were male (67% male, 32% female), the median age was 22 years, 76% were NZ European and 15% Māori. Sixty-one percent worked full or part-time, 30% were students and 9% unemployed, retired, in unpaid work or on a sickness benefit. Fifty-eight percent had a high level of education and 70% lived in a city (Table 2). Among daily vapers, 86% consumed cannabis in the past six months, of which the majority reported frequent cannabis consumption (i.e. 44% used cannabis daily and 19% weekly).

### Preference for using one vs multiple vaping products among those who vaped daily

Eighty percent of the daily vapers used only one type of the four vaping products. Daily nicotine e-liquid users preferred to use only one vaping product category, while daily cannabis e-liquid users often used multiple vaping product categories (Table 3). Among daily nicotine e-liquid vapers who used two or more products, 48.8% also used cannabis dry herb, 44.7% also used no-nicotine e-liquids and 27.7% also used cannabis e-liquids.

**Table 2.** Demographics and vaping patterns among those who vaped in the past 6 months.

Demographic characteristics		Vaped in the past 6 months (n=9,042)	Daily vaped in the past 6 months (n=3,501)
Gender	Male	62.0%	66.7%
	Female	36.7%	31.8%
	Gender diverse	1.2%	1.5%
Age	Mean:	26	26
	Median: (std dev)	22 (10)	22(11)
	range:	16–83	16–83
Ethnicity	NZ European	74.6%	75.6%
	Māori	16.2%	15.3%
	Other	9.2%	9.1%
Education	High (includes polytechnic and university)	59%	58%
	Low (high school and lower)	41%	42%
Residence	City	69%	70%
	Small town/rural	31%	30%
Main occupation	Employed	60.2%	60.5%
	Student	30.9%	30.1%
	Unemployed/parenting/sickness benefit	8.9%	9.4%
	Alcohol	95.4%	94.3%
Drug use in the past 6 months	Cannabis	84.3%	86.0%
	Tobacco	75.7%	79.4%
	Ecstasy/MDMA	59.4%	61.2%
	LSD	35.4%	38.9%
	Cocaine	14.5%	14.8%
	Methamphetamine	7.5%	7.4%
	Opioids/Morphine	2.6%	3.3%
Substances vaped in past 6 months	Nicotine e-liquid	85.3%	95.9%
	No nicotine e-liquid	19.2%	10.1%
	Cannabis “dry herb”	13.5%	12.1%
	THC/CBD cannabis e-liquid	7.1%	6.0%
Frequency of vaping in the past 6 months	Daily or near daily	41.8%	100%
	Once or twice per week	16.8%	N/A
	Monthly	12.6%	N/A
	Once or twice (in past 6 months)	28.8%	N/A
Perceived impact of vaping nicotine e-liquids on the level of tobacco smoking*	Never smoked tobacco	13.8%	8.2%
	No impact on level of tobacco smoking	29.7%	9.1%
	Smokeless tobacco	30.9%	39.6%
	Stopped smoking tobacco	21.6%	40.0%
	Smoke more tobacco	3.0%	2.3%
	Started smoking tobacco	1.0%	0.9%

\*Only respondents who vaped nicotine e-liquids.

### Predictors of daily vaping of (i) nicotine, (ii) no-nicotine, (iii) cannabis e-liquids, and (iv) “dry herb” cannabis

Results of multivariate logistic regression models for the four vaping product categories are included in Table 4. Those aged 18–20 were ten times more likely to be daily vapers of nicotine liquids than those aged 36+ (OR = 10.1). Furthermore, the youngest age group (i.e. 16–17 year olds) was six times more likely (OR = 5.8) to be daily nicotine vapers than those aged 36+. Younger age was also positively associated with daily use of no-nicotine vapes, particularly for underage users aged 16–17 years (OR = 3.6). In contrast, the association was reversed for “dry herb” cannabis. Those 36 years and older were nearly twice as likely to vape “dry herb” cannabis than those aged 16–17 and 18–20 years.

New Zealand Europeans were more likely than Māori to vape “dry herb” cannabis (OR = 1.53) and nearly twice as likely than other ethnicities (i.e. Pacific Islander, Asian, Indian, other) to daily vape nicotine e-liquids (OR = 1.92). Māori were more likely to vape no-nicotine e-liquids than New Zealand Europeans (OR = 1.41).

Medicinal cannabis users were more likely than non-medicinal cannabis users to daily vape cannabis, both in the e-liquid and “dry herb” models. Males were more likely to daily vape cannabis e-liquids than females (OR = 1.52). Non-medicinal cannabis users were more likely than medicinal users to daily vape nicotine e-liquids.

Frequency of tobacco use was positively associated with daily vaping of nicotine liquids (OR = 1.65) but negatively associated with daily vaping of “dry herb” cannabis (OR = 0.64). Daily no-nicotine liquid vape use was associated with no tobacco use in the past six months (OR = 1.4) and marginally increased with frequency of cannabis use (OR = 1.1). Frequency of cannabis use was negatively correlated with vaping nicotine liquids and positively correlated with daily vaping of herbal cannabis.

Respondents who participated in the survey during the lockdown restrictions had lower odds of reporting daily vaping of “dry herb” cannabis (OR = 1.3) and cannabis e-liquid (OR = 1.8) than those who participated pre-lockdown.

## Discussion

The overwhelming majority of daily vapers in our sample vaped nicotine only, with cannabis more often vaped in “dry

**Table 3.** Preference for number of vaping products by those who vaped daily in the past 6 months.

Number of vaping products used in the past 6 months by daily vapers	All daily vapers (n=3,501)	Daily nicotine e-liquid vapers (n=3,358)	Daily no-nicotine vapers (n=352)	Daily cannabis e-liquid vapers (n=211)	Daily “dry herb” cannabis vapers (n=425)
1	80.1%	79.6%	10.5%	6.2%	18.8%
2	16.5%	16.8%	70.5%	47.4%	56.2%
3	2.8%	2.8%	11.9%	34.6%	19.1%
4	0.7%	0.7%	7.1%	11.9%	5.9%
Multiple products (2+) concurrency:		Dry herb 48.8%	Nicotine 97.1%	Nicotine 96.0%	Nicotine 96.8%
		No nicotine 44.7% Cannabis e-liquid 27.7%	Dry herb 17.8% Cannabis e-liquid 14.3%	Dry herb 43.4% No nicotine 22.7%	Cannabis e-liquid 24.9% No nicotine 16.2%

**Table 4.** Sociodemographic and substance use predictors of daily vaping 4 categories of vaping products (multivariate logistic regression models).

Effect	Nicotine e-liquid			No-nicotine e-liquid			Cannabis e-liquid/oil (CBD and THC/CBD)			Cannabis dry herb						
	Estimate	p-value	OR	95% CI	Estimate	p-value	OR	95% CI	Estimate	p-value	OR	95% CI	Estimate	p-value	OR	95% CI
Sample size for the model			3493				3488									2999
Proportion of "xxx daily vapers"			0.959				0.101									0.142
Intercept	3.27	<.0001			-2.99	<.0001			-3.19	<.0001			-3.14	<.0001		
Age: 16–17 vs 36+	1.75	0.0011*	5.77	2.01 16.53	1.28	<.0001*	3.58	2.12 6.06					-0.66	0.0107*	0.52	0.31 0.86
Age: 18–20 vs 36+	2.31	<.0001*	10.12	5.03 20.34	0.84	<.0001*	2.33	1.53 3.54					-0.68	<.0001*	0.51	0.36 0.71
Age: 21–25 vs 36+	1.31	<.0001*	3.72	2.24 6.16	0.62	0.0043*	1.85	1.21 2.82					-0.51	0.0031*	0.60	0.43 0.84
Age: 26–35 vs 36+	0.70	0.0025*	2.01	1.28 3.15	0.42	0.0604	1.52	0.98 2.36					-0.53	0.0041*	0.59	0.41 0.85
Period: Lockdown vs Pre-lockdown									-0.58	0.0023*	0.56	0.39 0.81	-0.26	0.0452*	0.77	0.60 1.00
Gender: Male vs Female									0.42	0.0159*	1.52	1.08 2.13				
Education: Low vs High																
Occupation: Student vs Employed					-0.22	0.1311	0.81	0.61 1.07								
Occupation: Unemployed/others vs Employed					0.42	0.0211*	1.52	1.07 2.17								
Ethnicity: Māori vs NZ Euro	0.16	0.5515	1.17	0.69 1.99	0.34	0.0215*	1.41	1.05 1.89					-0.44	0.0119*	0.65	0.46 0.91
Ethnicity: Other vs NZ Euro	-0.65	0.0236*	0.52	0.30 0.92	0.37	0.0468*	1.45	1.01 2.10					0.33	0.0664	1.39	0.98 1.98
City town: City vs Rural/small town																
Cannabis frequency of use (continuous)*	-0.68	<.0001*	0.51	0.40 0.64	0.08	0.0436*	1.08	1.00 1.17					0.78	<.0001*	2.18	1.90 2.50
Tobacco frequency of use (continuous)*	0.48	<.0001*	1.62	1.42 1.84									-0.18	<.0001*	0.84	0.78 0.90
Tobacco use last 6 m: Yes vs No					-0.32	0.0280*	0.73	0.54 0.97								
Medicinal cannabis: Any/some vs Most/all	0.16	0.4564	1.18	0.77 1.81					0.02	0.9234	1.02	0.71 1.46	0.24	0.0767	1.28	0.97 1.67
Medicinal cannabis: None vs Most/all	0.50	0.0471*	1.65	1.01 2.69					-0.51	0.0114*	0.60	0.41 0.89	-0.45	0.0041*	0.64	0.47 0.87
Medicinal cannabis: Non-user vs Most/all**	-0.03	0.9595	0.97	0.29 3.29												
Perception health risk cannabis (continuous)																
Perception health risk tobacco (continuous)																
P-value Hosmer and Lemeshow Goodness-of-fit	0.262				0.930				0.641				0.789			

\* – Statistically significant results at  $p < 0.05$ . \*\* – Category excluded for outcomes relating to cannabis vaping products. Statistically non-significant predictors were removed from the final model (empty cells).

herb” form than as an e-liquid or oil. Smoking remained the dominant route of cannabis administration among cannabis users, yet just under one-in-five had vaped cannabis in the previous six months. The dominance of nicotine vaping even among frequent drug users likely reflects the legal status and wide availability of nicotine and no-nicotine vaping products in New Zealand. Conversely, the lower prevalence of cannabis vaping in the sample likely reflects the ongoing illegality of recreational cannabis products and absence of a legal recreational cannabis vaping sector. Evidence from countries with legal adult-recreational cannabis markets suggests that, following cannabis legalization, there has been a steady shift from cannabis smoking toward alternative modes of cannabis administration such as vaping and edibles (Fischer et al., 2021; Hammond et al., 2022).

This study explored predictors of daily vaping of four different vape products: nicotine, no-nicotine, cannabis e-liquids, and “dry herb” cannabis. We found that daily vapers of nicotine and cannabis differed on several key demographic characteristics. Younger age was a predictor of daily vaping of legally available products: nicotine and no-nicotine liquids. We found that those under the legal age for tobacco and nicotine vape purchase in New Zealand (16–17 years) were more likely to daily vape nicotine and no-nicotine e-liquids than older people. Similarly, those aged 18–20 had much higher odds of daily vaping of *nicotine* e-liquids than older people. The association between the youngest age bracket and daily vaping of no-nicotine e-liquids may reflect the appeal of *no-nicotine* vapes to younger consumers, and the more liberal laws around access to no-nicotine vaping products (v. nicotine e-cigarettes) for youth at the time of data collection. The sale of *no-nicotine* vape liquids and toy vaping products to people under the age of 18 was prohibited for the first time in New Zealand after the survey data collection (from 11 November 2020 (MOH, 2017, 2021)) due to concerns around normalization and the potential exposure to toxic ingredients from no-nicotine vaping products. By contrast, the sale of *nicotine* vaping products manufactured from tobacco to minors was deemed prohibited already from 2018 (by a way of a judicial decision which ruled that the sale of oral products derived from tobacco is legal and falls under the general tobacco control laws), although legal uncertainties remained until a comprehensive framework for e-cigarettes control was introduced in 2020 (MOH, 2020a).

In contrast, older age predicted daily vaporizing of “dry herb” cannabis. This finding may seem surprising, given prior research has identified an association between cannabis vaping and younger age (Lee et al., 2016; M. E. Morean et al., 2015). However, our analysis focused on *daily* vapers rather than the experimentation with cannabis vaping explored in prior studies. Our finding may reflect older cannabis users being more aware and concerned about smoking-related health risks and wanting to mitigate these risks. Older users may also experience higher prevalence of health problems and vape cannabis (daily) for therapeutic reasons whereas younger age groups are more likely to use cannabis recreationally (with less frequent patterns of use). Additionally, the price of dry herb vaporizers may be a

financial barrier to this mode of cannabis vaping by young people. One survey of adult users of e-cigarettes also found that *older* vapers were more likely to report *past-month* cannabis vaping (specifically hash oil, THC-infused wax, and dried cannabis buds vaping) (M.E. Morean et al., 2017), with the authors calling for more research to further test and explain this finding. Of note, we found that the association between older age and cannabis vaping was statistically significant in the “dry herb” vaping model, but not in the cannabis e-liquid model. This underlines the need for further research on cannabis vaping and the rise of a range of cannabis vape products (i.e. oil/e-liquid vs “dry herb” vaping modalities).

Being male predicted daily use of cannabis e-liquids. This extends prior research on youth and adult populations that found males have higher odds of cannabis vaping than females in their lifetime (Cuttler et al., 2016; Lee et al., 2016; Meghan E. Morean et al., 2021; M. E. Morean et al., 2015; M.E. Morean et al., 2017). However, one study of *past-month* cannabis vaping among adults did not find an association between past-month cannabis vaping and male gender (M.E. Morean et al., 2017), with the authors hypothesizing that this could mean males are simply more likely to *experiment* with cannabis vaping. More research is needed to investigate this hypothesis. Of note, we did not find an association between male gender and daily cannabis vaping in the “dry herb” vaping model.

New Zealand Europeans were nearly twice as likely as other ethnicities to daily vape nicotine e-liquids and more likely than Māori to daily vape “dry herb” cannabis. This is consistent with international evidence finding lower levels of vaping among disadvantaged ethnic minorities (Hartwell et al., 2017). For example, US studies report similar ethnic patterns in adult use of (nicotine) electronic cigarettes (Webb Hooper & Kolar, 2016) and cannabis vaping (Lee et al., 2016), with African-Americans less likely to vape than white Americans. However, the association between ethnicity and daily e-cigarettes vaping in our study was inconsistent with findings from the New Zealand representative population survey, the NZ Health Survey, which consistently finds that Māori are more likely to vape daily than New Zealand Europeans (MOH, 2022a). In New Zealand youth surveys, Māori students were also more likely to be daily e-cigarette users than non-Māori students (Walker et al., 2020). On the other hand, we found that Māori and other non-European ethnicities were more likely to vape *no-nicotine* e-liquids than Europeans. This may indicate their greater engagement with vaping as a smoking *and* nicotine cessation tool. There is some limited evidence suggesting that Māori and Pacific peoples are more likely to find vaping satisfying (Glover et al., 2012; Tucker et al., 2017). However, more research is needed to evaluate the effectiveness of vaping as a smoking cessation tool, including the viability of sustained use of no-nicotine e-cigarettes in different ethnicities, and eventually their willingness to quit vaping.

Our analysis supports evidence from prior research on the relationship between medicinal cannabis status and cannabis vaping (Lankenau et al., 2017; Pacula et al., 2016). We found that medicinal cannabis users were more likely to be

daily cannabis vapers than recreational users in separate models examining cannabis oil/e-liquid and “dry herb” vaping. This suggests that medicinal cannabis users are keen to utilize vaping in any modality (oil/liquid and herbal cannabis vaping) and they may perceive it as a “reduced harm” route of cannabis administration, in a similar way as tobacco smokers perceive both nicotine e-cigarettes and heat-not-burn tobacco products (Fung et al., 2020). Given medicinal cannabis users tend to use cannabis more frequently (often daily) than recreational cannabis users (Sznitman, 2017; Turna et al., 2020), reductions in exposure to respiratory toxins may be particularly salient for this group. Findings are consistent with another recent New Zealand survey that found high levels of preference for vaping as a mode of cannabis administration in a sample of medicinal cannabis users (Rychert et al., 2020).

It remains to be seen whether frequent cannabis smokers will utilize cannabis vaping products as a “cannabis smoking cessation tool” under the new medicinal cannabis scheme recently introduced in New Zealand. Current barriers include a limited availability of cannabis vaping products, their cost, access to prescriptions and the cost of vaping devices (Rychert et al., 2021; Withanarachchie et al., 2023). As of May 2023, there were eight dried herb cannabis products approved for vaping (THC potency ranges from 9% to 25%) and no cannabis e-liquids available under the New Zealand Medicinal Cannabis Scheme. Additionally, regulations require medical cannabis vaporizing devices to be registered by an overseas regulator and the consequent cost of those devices may be prohibitive for patients (with prices ranging from \$500 to \$1000 NZD). A survey of female medicinal cannabis users ( $N=213$ ) found that 93% of respondents would use a cannabis vaporizer if it was provided by a general practitioner or a pharmacy, with device cost being the main barrier to this form of cannabis administration in New Zealand (Armour et al., 2021).

Daily vaping of *no-nicotine* e-liquids was associated with abstinence from tobacco use in the previous six months, likely because daily users of no-nicotine vaping products are never smokers or have quit smoking. Somewhat surprisingly, the odds of daily vaping nicotine e-liquids increased with the reported frequency of tobacco use in the past six months. Due to methodological limitations (the frequency of substance use questions in the NZDTS referred to the past 6 months), we are unable to establish if this finding represents concurrent heavy use of smoked tobacco and daily nicotine vaping, or reflects participants’ trajectory of transitioning from frequent tobacco smoking to daily vaping within the past six months. Recent research found an association between the number of cigarettes smoked daily and subsequent vaping uptake and higher frequency of vaping (Chan et al., 2019).

Findings in this study highlight the differences between daily vapers of nicotine and cannabis in a sample of frequent drug users in New Zealand, providing a comparative lens to the study of frequent vaping phenomenon. Daily cannabis vaping remained limited compared to daily nicotine vaping and was associated with older age and medicinal cannabis use status. While this may suggest that the current

policy in New Zealand (i.e. prescription-based access to cannabis vaping under medicinal cannabis scheme) adequately responds to the needs of most consumers, cannabis vaping reported at the time of data collection was mostly illegal and unregulated due to no legal cannabis vaping products for pharmacy sales at the time. The wider legal access to a range of vaping devices following government regulation of e-cigarette market, including portable vaporizers and commercial e-liquids which can be used to produce DIY (do-it-yourself) cannabis e-liquids, indicates the need for ongoing monitoring of cannabis vaping trends.

Research into the health effects of switching from smoking to vaping continues (including considerations of pulmonary harm reduction from nicotine relative to cannabis vaping (Tashkin, 2015)), and—as noted in the introduction, there are unique features of cannabis vaping that can increase harms other than respiratory, particularly for young and inexperienced cannabis users at greater risk of mental health harm and vehicle, workplace, and other accidents from high-potency THC vapes. A nuanced vaping policy must recognize the overlaps and interactions between nicotine and cannabis vaping, including cross-over between vaping devices, and shared aims to discourage access to youth, particularly those who have never smoked tobacco or used cannabis, but facilitate access to vaping for older frequent cannabis users wishing to reduce the pulmonary health risks of smoking cannabis.

## Limitations

NZDTS is an anonymous online convenience survey that targets people who frequently use drugs to provide a snapshot of drug use and drug market trends. It is not intended to be representative of the New Zealand population and reports much higher levels of drug use than the general New Zealand population (e.g. 75% reported use of cannabis in the past 6 months compared to 15% past year prevalence in the general population). Despite the targeted recruitment approach, the NZDTS sample broadly resembles the demographic profile of the New Zealand population with respect to a number of characteristics, for example in regard to Māori (e.g. 16% Māori in NZDTS vs 16.5% in the NZ census (Stats, 2019) and European representation (74% respondents in NZDTS vs 70% in the national census (Stats, 2019)), and employment statistics (5% unemployed in NZDTS closely matches the 4% figure in national statistics (Stats, 2022b)). However, there were also some important differences. For example, our online sample was younger with a median age of 23 compared to the median New Zealand population age of 37 years and included more males (61% in NZDTS vs 50% in census data) (Stats, 2022a).

The NZDTS does recruit a very large sample of cannabis users and daily vapers, which allowed detailed sub-population analysis. Targeted recruitment of e-cigarette users *via* social media has been found more efficient than panel recruitment, providing access to heavier users (Guillory et al., 2016). Additionally, it is possible that the anonymous online survey may have encouraged greater sharing of sensitive information on illegal and stigmatized behavior such as cannabis use

than face-to-face surveying. The NZDTS is a cross sectional survey, so it was not possible to track respondents' progression to vaping over time. Finally, all drug use and vaping behavior in the survey is self-reported.

## Conclusions

To our knowledge, this is the first study to explore daily vaping of cannabis and nicotine products among people who frequently use drugs in New Zealand. Suffice to say, this is a significantly under researched topic that is of emerging importance. We found that daily vapers of nicotine and cannabis differed by several key demographic characteristics. Younger age predicted daily use of legally available products, including nicotine and no-nicotine e-liquids, while older age was associated with vaporizing illegal "dry herb" cannabis. Medicinal cannabis users were more likely to be daily cannabis vapers. This supports the concern that younger age groups may be at risk from daily vaping of nicotine and related dependency but also suggests that older daily cannabis users and medicinal cannabis users are interested in adopting vaping to minimize the health risks from exposure to respiratory toxins from cannabis smoking. This indicates the need for a nuanced vaping policy that discourages access to youth, particularly those who have never smoked tobacco or used cannabis, but facilitates access to vaping for older frequent cannabis users wishing to reduce the pulmonary health risks of smoking cannabis.

## Disclosure statement

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