Differences between adults who smoke cigarettes daily and do and do not co-use cannabis: Findings from the 2020 ITC four country smoking and vaping survey

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ABSTRACT

Background: Little is known about population-level differences between adults who exclusively smoke cigarettes and those who smoke cigarettes and also use cannabis (co-consumers). Thus, this study describes differences on sociodemographic, cigarette-dependence, health and behavioral variables, and risk perceptions associated with smoking cannabis.

Methods: This cross-sectional study included 6941 respondents from the 2020 ITC Four Country Smoking and Vaping Survey (US, Canada, Australia, England). Adult daily cigarette smokers were included and categorized as: *cigarette-only smokers* (never used cannabis/previously used cannabis, but not in the past 12 months, n = 4857); *occasional co-consumers* (cannabis use in the past 12 months, but < weekly use, n = 739); or *regular co-consumers* (use cannabis ≥ weekly, n = 1345). All outcomes were self-reported. Regression models were conducted on weighted data.

Results: Overall, 19.9 % of respondents reported regular cannabis co-use and 10.1 % reported occasional co-use. Regular co-use was highest in Canada (27.2 %), followed by the US (24.4 %), England (12.7 %) and Australia (12.3 %). Compared to cigarette-only smokers, regular co-consumers were more likely to be male and report chest/breathing problems (p < 0.001). All co-consumers were more likely to be younger, have lower income, be experiencing financial stress, reside in Canada, have depressive symptoms, use alcohol more frequently and binge drink, use other tobacco/nicotine products, and perceive smoking cannabis as low health risk and less harmful than smoking cigarettes (all p < 0.001). Cigarette dependence measures were similar between co-consumers and cigarette-only smokers (all p ≥ 0.05).

Conclusions: Although there were no differences on cigarette dependence measures between daily cigarette smokers who do and do not use cannabis, there are several other risk factors that may affect tobacco use and abstinence among co-consumers (e.g., greater depression, high-risk alcohol consumption). Thus, tobacco cessation treatment may require multi-pronged strategies to address other health behaviors. Continued surveillance is needed to determine the nature and health implications of co-use considering changing policies, markets, and products.

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1. Introduction

Cannabis and nicotine (most commonly consumed through tobacco cigarettes) are two of the world's most used drugs. Globally, there are an estimated 1.3 billion people who smoke, and 200 million people reported past-year cannabis use (UN, 2021; WHO, 2021a). While cigarette smoking has been declining over the last several decades (WHO, 2021b), the overall global number of people who used cannabis in the past year is estimated to have increased by nearly 18 % between 2010 and 2019 (UN, 2021).

The co-occurrence of the use of nicotine and cannabis (co-use) is well established, including dual use of both products by the same individual, on different occasions, in sequenced use episodes, or mixed together in the same delivery mechanism (Agrawal et al., 2012; Alberta Health Services, 2021; Goodwin et al., 2018; Hindocha et al., 2015; 2021; Rabin et al., 2015; Schauer et al., 2015). Evidence has found that the combined effects of smoking tobacco and cannabis pose significant risks. For example, relative to the exclusive use of tobacco or cannabis, people who co-use both (consume both tobacco and cannabis in any pattern or method [co-use]) are exposed to greater toxicant levels (Meier et al., 2020; Smith et al., 2020a). Additionally, regular (frequent) co-use of cannabis and tobacco has been found to be associated with poorer physical and mental functioning, more intensive tobacco and cannabis use, higher rates of cannabis use disorder (CUD), greater nicotine dependence, lower rates of attempts to quit cigarette smoking and cessation, and higher rates of relapse back to cigarette smoking among former smokers (Agrawal et al., 2012; Driezen et al., 2022; Filbey et al., 2015; Goodwin, 2020; Hindocha et al., 2015; 2021; Jayakumar et al., 2021; Peters et al., 2014; Rabin et al., 2015; Strong et al., 2018; Weinberger et al., 2020). Evidence also supports a higher risk of significant respiratory problems among people who smoke both tobacco and cannabis compared to exclusively smoking either product (Agrawal et al., 2012; Strong et al., 2018).

While co-use of cannabis and tobacco is common, it has received less attention compared to research on the exclusive use of either substance. Notably, the existing research on co-use has primarily consisted of clinical or repeated cross-sectional epidemiologic studies outlining patterns and trends of co-use, modes of cannabis use, and/or implications for smoking cessation and tobacco treatment (Agrawal et al., 2012; Akbar et al., 2019; Carliner et al., 2017; Goodwin et al., 2018; Gunn et al., 2020; Hindocha et al., 2021; Jayakumar et al., 2021; Leung et al., 2022; Lowry & Corsi, 2020; Masters et al., 2018; McClure et al. 2020; Patrick et al., 2020; Pacek et al., 2018; Schauer et al., 2015; 2020; Shiplo et al., 2016; Smith et al., 2021; 2022a, b, Statistics Canada, 2019; Ramo et al., 2013; Reboussin et al., 2021; Tucker et al., 2019). Clinical treatment research has explored co-use, typically via secondary analyses of clinical trials and convenience samples, rather than among national and/or representative samples; thus, several questions still remain regarding how key characteristics and behavioral outcomes vary between single and co-consumers at a population level. Moreover, because studies have reported high rates of cannabis use among cigarettes smokers relative to former and never smokers, lower odds of quitting cigarette smoking, and higher nicotine dependence among cigarette smokers who also use cannabis (Agrawal et al., 2012; Driezen et al., 2022; Fix et al., 2019; Goodwin et al., 2018; Hindocha et al., 2015; 2021; Statistics Canada, 2017; Strong et al., 2018; Weinberger et al., 2020), describing such differences is important because certain characteristics may have implications and challenges for both direct cigarette cessation assistance and broader tobacco control efforts.

This international study conducted exploratory analyses to examine whether adults who smoke cigarettes daily (and are likely highly dependent on nicotine) and co-use cannabis were characteristically different from adults who exclusively smoke cigarettes (referred to herein as 'cigarette-only smokers') on sociodemographic measures, recent financial stress, health problems (depression and chest/breathing problems), cigarette (nicotine) dependence, use of other tobacco/

nicotine products, cigarette quit attempts and quit interest, alcohol use (frequency and binge drinking), and perceptions of health risks associated with smoking cannabis. Additionally, because co-consumers appear to differ by age (and thus may have different cigarette smoking histories) (Akbar et al., 2020; Government of Canada, 2017; Jeffers et al., 2021; Lim et al., 2022; Ramo et al 2013) and by country (Gravely et al., 2020), we conducted supplemental analyses to assess whether cigarette-dependence measures and use of other tobacco/nicotine products differed between cigarette-only smokers vs occasional and regular co-consumers, first among younger respondents (ages 18–39), second among older respondents (ages 40 +), and third, within each country.

2. Methods

The International Tobacco Control Project Four Country Smoking and Vaping (ITC 4CV) Survey is a longitudinal cohort study that consists of parallel online surveys conducted in Canada, US, England, and Australia. Respondents (adults aged ≥ 18 years) were recruited by commercial panel firms in each country at Wave 1 (W1: July-November 2016) as a person who: (1) has smoked at least 100 cigarettes in lifetime and were currently smoking at least monthly or less than monthly but occasionally; (2) has smoked at least 100 cigarettes in their life-time and had quit smoking within the previous 2 years; or (3) were currently vaping nicotine (using e-cigarettes) at least weekly. All Wave 1 respondents were invited back to complete the Wave 2 survey (February-July 2018), and Wave 2 respondents were invited to complete Wave 3 (February-June 2020). At each wave, new respondents were recruited (using the same eligibility criteria as mentioned above) to compensate for those lost to follow-up and thus maintain the overall sample sizes for each country/user group combination. The sample in each country was designed to be as representative as possible of cigarette smokers and vapers (e.g., by age, sex, and region). The overall sample retention rate was 45.2 % at Wave 2 and 42.2 % at Wave 3. Full details of the ITC 4CV Surveys can be found elsewhere (ITC Project, 2021; Thompson et al., 2019).

Respondents for the study came from the Wave 3 (2020) ITC 4CV Survey (ITC Project, 2021) which included 11,607 respondents, of whom 7298 were daily cigarette smokers at the time of the survey. Respondents were eligible for inclusion in the current study if they were currently smoking daily and completed the survey questions about their cannabis use in the last 12 months. Those who: (1) declined to answer the question on current cannabis use or reported that they did not know (n = 224); and (2) used cannabis in the last 12 months but did not report their frequency in the last 12 months (n = 13) were excluded. We additionally excluded 120 respondents who reported having used cannabis in the last 12 months, but then reported that they had quit using it because we could not determine their frequency of use at the time that they were using cannabis. The resulting sample included in this study were 6941 daily cigarette smokers (cigarette-only smokers: n = 4857; co-consumers: n = 2084). Supplemental Fig. 1 presents a study flow diagram showing the study selection process.

2.1. Measures

Table 1 describes the measures in the survey that were used in this study.

2.1.1. Classification of co-use of cigarettes and cannabis (primary independent variable)

All respondents were asked whether they had used cannabis in the last year, and the frequency at which they usually use it. Based on these two questions, respondents were categorized as: (1) *cigarette-only smokers* (never used cannabis or previously used cannabis, but not in the last 12-months); (2) *occasional co-consumers* (used cannabis in the last 12 months, and use it less than weekly); or (3) *regular co-consumers* (use cannabis at least weekly).

Table 1
Measures used in the current study (Wave 3, ITC 4CV 2020).

Measures	Survey Question	Response options	Variable description used in the study
Cannabis use	When was the last time you used marijuana/ cannabis?	Never used; In the last 30 days; In the last 1–12 months; More than 1 year ago.	Those who reported use in the last 12 months were defined as 'co-consumers', and those who did not were classified as 'cigarette-only smokers'.
Frequency of cannabis use	If used cannabis in the last 12 months: On average, how often do you CURRENTLY use any form of marijuana/ cannabis?	Daily; Not daily, but at least weekly; Not weekly, but at least monthly; Not monthly, but occasionally; I have quit using it.	Combined with the definition above, respondents were further categorized as: 'Cigarette-only smokers': never use cannabis or no cannabis use in the last year; 'Occasional co-consumers': use cannabis less than weekly 'Regular co-consumers': use cannabis at least weekly
Age **Sex** **Income**	Collected by commercial panels firms and verified by respondents at the time of survey completion Report sex Collected by commercial panels firms and verified by respondents at the time of survey completion	18–24; 25–39; 40–54; 55 +), Report sex Under $10,000; $10,000–29,999; $30,000–44,999; $45,000–59,999; $60,000–74,999; $75,000–99,999; $100,000–149,999; $150,000 and over.	18–39; 40+ Male; female $\leq$ $30,000 (low) $30,000 to < $60,000 (moderate), $\geq$ $60,000 (high); not reported. Categorized as "low income" vs other (moderate, high, not reported).
Education	Collected by commercial panels firms and verified by respondents at the time of survey completion	Grade school/ some high school; Completed high school; Technical/ trade school or community college; Some university, no degree; Completed university degree; Post-graduate degree.	$\leq$ High school (low); college/associate degree (moderate); $\geq$ bachelor's degree (high) Categorized as "low education" vs other (moderate, high, not reported) .
Smoking status	Daily cigarette smoking was determined by asking current smokers: How often, if at all, do you CURRENTLY smoke ordinary cigarettes?	Daily; Less than daily, but at least once a week; Less than weekly, but at least once a month; Less than monthly, but occasionally; I have quit smoking; I have never been a smoker.	Daily smokers were included in this study.
Length of time being a daily smoker	How long have you been smoking daily?	<1 year; 13–18 months; 19–24 months; 2–3 years; 3–5 years; 6–10 years; More than 10 years.	Categorized as: '0–9 years' vs '10 + years' (median response). Not used in analytical models
Financial stress	In the last 30 days, because of a shortage of money, were you unable to pay any important bills on time, such as electricity, telephone or rent bills?	Yes; No; Don't know.	'Yes' vs 'no/don't know'
Nicotine dependence variables			(1)
Cigarettes smoked/day	On a typical day, how many cigarettes do you usually smoke each day, Response options were $\leq$ 10, 11–20, 21–30 or 31 +.	1–10 cigarettes; 11–20 cigarettes; 21–30 cigarettes; More than 31 cigarettes.	'1-10' vs '11+' (2) '1-19' vs '20+'
Time to first cigarette (TTFC)	Time to first cigarette (TTFC): How soon after waking do you usually smoke your first cigarette?	Enter minutes or hours	'Within 30 min' vs 'after 30 min'
Urges/cravings to smoke cigarettes	In general, how strong have urges to smoke been in the last 24 h?	I have not felt the urge to smoke in the last 24 h; Slight Moderate; Strong; Very strong; Extremely strong; Don't know.	'Extremely strong/very strong/strong' vs 'other' (moderate/slight/none/don't know).
Perceived level of addiction to cigarettes	Do you consider yourself addicted to cigarettes?	Not at all; Yes, somewhat addicted; Yes, very addicted; Don't know.	'Very addicted' vs 'other' (somewhat/not at all/ don't know)
Plans to quit cigarette smoking	Are you planning to quit smoking?	Within the next month; Between 1 and 6 months from now; Sometime in the future, beyond	'Yes, within the next 6 months' vs 'other' (sometime in the future, beyond 6 months/not planning to quit/don't know).

Table 1 (*continued*)

Measures	Survey Question	Response options	Variable description used in the study
Recent attempt to quit cigarette smoking	In the last 24 months, have you tried to stop smoking?	6 months; Not planning to quit; Don't know. Yes; No; Don't know.	'Yes' vs 'no/don't know'
Polyuse of other tobacco/nicotine products	How often, if at all, do you CURRENTLY use vaping products (i.e. vape)? At the time when you were using a heated tobacco product most often, how often did you use it? In the last 30 days, have you used any of these other smoked tobacco products? Cigars, cigarillos, Waterpipe or hookah or shisha, smokeless tobacco	Daily; Less than daily, but at least once a week; Less than weekly, but at least once a month; Less than once a month, but occasionally; Yes No	Current use of vaping and heated tobacco products was defined as using them at least monthly.
Alcohol use (frequency)	How often do you have a drink containing alcohol?	Never; Once a month or less; 2–4 times a month; 2–3 times a week; 4 or more times a week.	A three-level variable was created: (1) never; (2) occasionally (once a month or less/2–4 times a month/2–3 times a week); (3) often (4 or more times a week).
Binge drinking	How often do you have 6 or more drinks on one occasion?	Never; Less than monthly; Monthly; Weekly; Daily or almost daily.	A three-level variable was created for the analysis: (1) never; (2) occasionally (less than monthly, monthly); (3) often (weekly, daily/almost daily).
Depressive symptoms	During the last 30 days, have you often been bothered by feeling down, depressed, or hopeless?	Yes; No; Don't know.	Yes' vs 'no/don't know'
Beathing problems	Have you had wheezing or whistling in the chest in the past 12 months?	Yes; No; Don't know.	Yes' vs 'no/don't know'
Absolute risk of using cannabis	In your opinion, what is the level of health risk of using marijuana/ cannabis ON ITS OWN in each of the following ways: (1) SMOKING marijuana/ cannabis DAILY?; (2) SMOKING marijuana/ cannabis OCCASIONALLY?	Very low risk; Low risk; Moderate risk; High risk; Very high risk.	'Low/very low risk; 'moderate risk'; 'high/very high risk', or 'don't know'. 'Low/very low risk vs other ('moderate risk'; 'high/very high risk', or 'don't know')
Relative risk of smoking cannabis compared to cigarettes	Compared to smoking cigarettes, how harmful do you think it is to smoke marijuana/ cannabis without tobacco? We mean only SMOKING marijuana/ cannabis, not other methods of consumption.	Much less harmful than smoking cigarettes; Somewhat less harmful; Equally harmful to smoking cigarettes; Somewhat more harmful; Much more harmful than smoking cigarettes; Don't know.	Less/much less harmful vs other ('equally' or 'more harmful', 'don't know')..
Use roll-you-own cigarettes	Do you smoke [factory-made/ packet] cigarettes, roll-your-own cigarettes, or both?	Only [factory-made/ packet] cigarettes; Mainly [factory-made/ packet] cigarettes; About the same amount of each; Mainly roll-your-own cigarettes; Only roll-your-own cigarettes.	Not used in analytical models
Mode of cannabis delivery	If used cannabis in the last 12 months: How have you used marijuana/ cannabis in the last 12 months?	Smoked it without tobacco; Smoked it with tobacco; Vaped it in liquid formVaped (used a vapourizer); the dried leaves or herb; Vaped it some other way; Dabbed concentrates such as shatter, budder, or wax; Used it orally; (e.g. oil, capsules, dissolvable strips, or spray); Used it topically; (e.g. lotions, bath salts); Consumed it in food or drinks (edibles such as 'pot brownies', cannabis-infused beverage).	Not used in analytical models

Outcome variables assessed in this study were: age, sex, education, income, country of residence, recent financial stress, cigarettes smoked per day (CPD), time to first cigarette (TTFC), urges/cravings to smoke cigarettes, perceived level of addition to cigarettes, plans to quit smoking cigarettes, made an attempt quit smoking cigarettes in the last 2 years, polyuse of other tobacco/nicotine products in addition to cigarettes, alcohol use (frequency and binge drinking), depression, perceived level of risk of smoking cannabis, and perceived relative risk of cannabis smoking compared to cigarettes (see Table 1 for variable descriptions and response options).

2.2. Analyses

Unweighted descriptive statistics were used to describe the overall sample, and by group: (1) cigarette-only smokers; (2) occasional cannabis co-consumers; and (3) regular co-consumers. Chi-square tests were used to test differences in sample characteristics. All other analyses were conducted on weighted data using cross-sectional weights. A *raking algorithm* (Kolenikov, 2014) was used to calibrate the weights on smoking status, geographic region, and demographic measures (e.g., sex, age, ethnicity, and education). All confidence intervals were computed at the 95 % confidence level. Analyses were conducted using SAS Version 9.4.

The first analysis used a multinomial regression on weighted data to estimate the proportion of respondents (overall and in each of the four countries) who self-reported having co-used cannabis either regularly (>weekly) or occasionally (<weekly) in the last 12 months.

The second set of analyses used separate adjusted binary logistic regression models to describe sociodemographic differences between co-consumers and cigarette-only smokers. Each of the five variables (age, sex, income, education and financial stress) were treated as outcome measures and adjusted for the other sociodemographic variables and country of residence.

The third set of analyses used separate adjusted binary or multinomial logistic regression models (where appropriate) to describe differences between co-consumers and cigarette-only smokers on the following outcome variables: six cigarette (nicotine) dependence variables, polyuse of other tobacco/nicotine products, breathing problems, depressive symptoms, alcohol use, and perceptions of health risks associated with smoking cannabis (both absolute and relative to cigarettes). All outcomes were dichotomized with the exception of alcohol use which included a 3-level outcome (see Table 1). Each model controlled for age, sex, income, education, and country of residence.

Finally, we conducted supplemental analyses using binary regression models based on age and country of residence to assess whether cigarette smoking-related measures and use of other tobacco/nicotine products differed: (1) between cigarette-only smokers vs occasional and regular co-consumers: (a) among those ages 18–39; and (b) among those ages 40+; and (2) between cigarette-only smokers vs occasional and regular co-consumers within each of the four countries.

3. Results

Respondents' characteristics are presented in Table 2. There were several differences between sample respondents. Relative to cigarette-only smokers, co-consumers were younger, smoked <10 cigarettes a day, and were more likely to use roll-your-own cigarettes and other tobacco/nicotine products. Regular co-consumers were more likely to be male, have lower income and education relative to all other respondents. Among co-consumers, the most common way of using cannabis was by smoking it. Regular co-consumers had higher rates of using cannabis in multiple other ways compared to occasional co-consumers.

3.1. Proportion of co-consumers among daily smokers in each country

Fig. 1 presents the proportion of daily cigarette smokers who smoke cigarettes only, occasionally co-use cannabis or regularly co-use cannabis. Overall, 19.9 % of respondents reported regular co-use of cigarettes and cannabis, and 10.1 % reported occasional co-use (70.0 % were cigarette-only smokers). The highest rate of regular co-use was found in Canada (27.2 %), followed by US (24.4 %), England (12.7 %) and Australia (12.3 %). Canada also had the highest rate of occasional co-use (14.5 %), followed by the US (9.0 %), Australia (8.9 %) and England (7.1 %).

Table 3 presents sociodemographic differences between co-consumers and cigarette-only smokers. Compared to cigarette-only smokers, regular co-consumers were more likely to be male, younger and have lower income (all p < 0.001), and occasional co-consumers were more likely to be male, younger, have lower income (all p < 0.001) and higher education (p = 0.02). Both regular and occasional co-consumers were significantly more likely to report that they had experienced financial stress in the last 30 days than cigarette-only smokers (p < 0.001).

3.2. Differences between co-consumers and cigarette-only smokers on behavioural and health factors and perceptions of harm

Table 4 shows the comparisons between cigarette-only smokers and co-consumers on cigarette smoking-related outcomes (cigarette dependence, plans to quit cigarette smoking, having made a quit attempt to quit smoking cigarettes in the last 24 months), use of other nicotine products (in addition to cigarettes), health problems (chest/breathing problems and depression), alcohol use, and perceptions of cannabis risk (both absolute and relative to cigarettes).

There were no significant differences for any of the cigarette-smoking measures by co-use status (all p ≥ 0.05). Compared to cigarette-only smokers, regular and occasional co-consumers were significantly more likely to: currently use at least one other tobacco/nicotine product (in addition to cigarettes) (p < 0.001), drink occasionally or often (p < 0.001), binge drink (p < 0.001), report that they had depressive symptoms (p < 0.001), believe that there is a low health risk of smoking cannabis on a daily or occasional basis (vs moderate/high risk/don't know), and to perceive that smoked cannabis is less harmful than cigarettes (p < 0.001). Regular co-consumers were more likely to report past-year chest/breathing problems than cigarette-only smokers, but there was no significant difference between occasional co-consumers and cigarette-only smokers.

Supplemental analyses (cigarette smoking-related differences by age groups) found that there were no differences on any of the cigarette-dependence measures between cigarette-only smokers and co-consumers among those who were ages 18–39 (all p ≥ 0.05) and 40+ (all p ≥ 0.05). However, relative to cigarette-only smokers, both occasional and regular co-consumers were more likely to have reported using at least one other tobacco/nicotine product in addition to cigarettes among those who were ages 18–39 (19.6 % vs 25.8 % and 28.7 % respectively, p < 0.01) and among those aged 40+ (12.9 % vs 18.5 % and 18.3 % respectively, p < 0.01) (see Supplemental Table 1).

When data were stratified by country, there were few differences on cigarette-related measures, with the exception that regular co-consumers in Canada were more likely than cigarette-only smokers to have their first cigarette within 30 min of waking. Both regular and occasional co-consumers in England were less likely to smoke more than 10 cigarettes per day (vs 1–10 cigarettes) compared to cigarette-only smokers. Relative to cigarette only smokers, regular co-consumers in all countries, and occasional co-consumers in England and the US, were more likely to be using at least one other tobacco-nicotine product (see Supplemental Table 2).

Table 2
Respondent sample characteristics.

		Cigarette-only smokers n = 4857 (70.0 %)		Occasional co-consumers n = 739 (10.7 %)		Regular co-consumers n = 1345 (19.4 %)		p	Overall sample N = 6941	
		Unweighted %	Weighted %	Unweighted %	Weighted %	Unweighted %	Weighted %		Unweighted %	Weighted %
Respondent Type	Cohort (n = 3183)	50.1	53.0	36.0	42.6	35.8	42.0	<0.001	45.9	49.8
	New respondent (n = 3758)	49.9	47.0	64.0	57.4	64.2	58.0		54.1	50.2
Country	Australia (n = 1067)	18.3	15.2	10.0	11.9	7.7	8.3	<0.001	15.4	13.5
	Canada (n = 2057)	22.6	26.3	44.0	45.4	47.1	43.4		29.6	31.7
	England (n = 2452)	40.4	37.0	25.6	22.6	22.2	20.6		35.3	32.3
	US (n = 1365)	18.6	21.5	20.4	20.1	23.0	27.7		19.7	22.6
Sex	Male (n = 3427)	48.0	50.8	48.9	51.0	54.5	58.7	<0.001	49.4	52.4
	Female (n = 3514)	52.0	49.2	51.2	49.0	45.5	41.3		50.6	47.6
Age	18–39 (n = 2590)	29.1	33.1	53.6	50.5	58.1	54.6	<0.001	37.3	39.1
	40+ (n = 4351)	70.9	66.9	46.4	49.5	41.9	45.4		62.7	60.9
Income	Low (n = 1954)	25.9	26.8	29.8	31.2	35.4	37.3	<0.001	28.2	29.3
	Moderate (n = 2019)	30.0	30.8	27.7	27.6	26.5	29.2		29.1	30.2
	High (n = 2604)	38.9	36.9	36.3	34.9	33.2	28.0		37.5	34.9
	Not stated (n = 364)	5.2	5.5	6.2	6.4	4.8	5.5		5.2	5.6
Education	Low (n = 1840)	25.8	28.7	23.6	26.2	30.6	36.3	<0.001	26.5	30.0
	Moderate (n = 3204)	46.2	53.7	45.5	52.4	46.4	48.5		46.2	52.5
	High (n = 1840)	27.1	16.4	30.2	20.5	22.2	14.5		26.5	16.5
	Not stated (n = 57)	0.8	1.2	0.8	0.8	0.7	0.7		0.8	1.1
Daily cigarette smoking (yrs)	10 years+ (n = 4657)	74.1	78.6	51.6	62.0	51.5	65.4	<0.001	67.3	74.3
CPD	≤ 10 (n = 3093)	42.0	40.8	50.6	49.1	50.3	46.0	<0.001	44.6	42.7
	11–20 (n = 2816)	43.3	44.7	33.4	36.1	34.7	39.6		40.6	42.8
	21–30 (n = 682)	10.2	10.6	8.5	9.9	9.2	10.1		9.8	10.4
	31+ (n = 156)	2.3	2.4	2.6	2.4	2.0	2.1		2.3	2.3
	Don't know (n = 172)	1.9	1.2	4.5	2.3	3.4	2.0		2.5	1.5
	Not stated (n = 22)	0.3	0.2	0.4	0.3	0.5	0.1		0.3	0.2
Current use of other tobacco/ nicotine products, yes										
	E-cigarettes (n = 2005)	10.8	9.6	36.8	12.2	34.3	10.0	<0.001	28.9	9.9
	Heated tobacco products (n = 920)	3.5	4.1	20.3	8.4	18.1	5.5	<0.001	13.3	4.8
	Smokeless tobacco (n = 375)	8.3	1.7	8.7	3.7	10.6	3.8	<0.001	5.4	2.3
	Cigars/cigarillos (n = 827)	1.6	6.0	20.4	12.8	20.3	12.8	<0.001	11.9	8.0
	Hookah (n = 286)	1.3	0.7	6.5	2.8	11.9	7.5	<0.001	4.1	2.3
	Nicotine pouches (n = 177)	10.8	0.4	4.1	2.0	6.3	1.6	<0.001	2.6	0.8
Use RYO cigarettes, yes	Yes (n = 1658)	22.2	22.2	28.5	26.6	28.1	27.1	<0.001	24.0	23.6
Mode of cannabis delivery	Smoked it[†]	—	—	88.1	85.5	78.0	78.1	<0.001	—	—
	Smoked with tobacco (n = 995)	—	—	43.4	44.5	50.1	48.1	0.005	—	—
	Smoked without tobacco (n = 1226)	—	—	50.2	54.5	63.6	68.0	<0.001	—	—
	Vaporized it (n = 187)	—	—	8.0	4.8	9.5	6.7	0.09	—	—
	Vaped it (n = 270)	—	—	9.7	7.2	14.7	12.8	0.002	—	—
	Edibles (n = 567)	—	—	21.8	23.1	30.2	29.3	<0.001	—	—
	Used it orally (n = 276)	—	—	10.3	9.5	14.9	13.0	0.003	—	—
	Used it topically (n = 132)			5.1	3.6	7.0	6.4	0.05	—	—
	Dabbed concentrates (n = 236)	—	—	3.8	2.7	15.5	14.3	<0.001	—	—

Data are unadjusted. Unweighted estimates describe the study sample and weighted estimates describe the population of daily cigarette smokers who do vs do not use cannabis. p-value tested sample group differences (Chi-square). Yrs: Years; RYO: Roll-your-own.

Cigarette-only smokers (reference group): do not use cannabis/have not used cannabis in the last 12 months; Occasional co-consumers: use cannabis less than weekly; regular co-consumers: use cannabis at least weekly. CPD: Cigarettes smoked per day. Current use of other tobacco/nicotine products: E-cigarettes and heated tobacco products: use at least monthly; all other products: used in the last 30 days.

*Modes of cannabis delivery are not mutually exclusive (respondents selected all modes in which they have used cannabis in the last 12 months). Assessed among respondents who reported using cannabis in the last 12 months.

[†] Smoked it with or without tobacco.

4. Discussion

Prior to this study, little was known about population-level differences between adults who smoke cigarettes daily and who do versus do not use cannabis. This study examined whether cigarette-only smokers were characteristically different from cigarette and cannabis consumers on several measures. We found that nearly-one-third of daily cigarette smokers were also consuming cannabis, with about one-fifth reporting regular co-use. We found little difference in self-reported cigarette (nicotine) dependence measures; however, co-use was associated with greater use of other tobacco/nicotine products in addition to cigarettes, thus co-consumers appear to be using nicotine in multiple ways. Our findings also showed that other factors were strongly associated with co-use, including being male, engaging in risky alcohol consumption, and
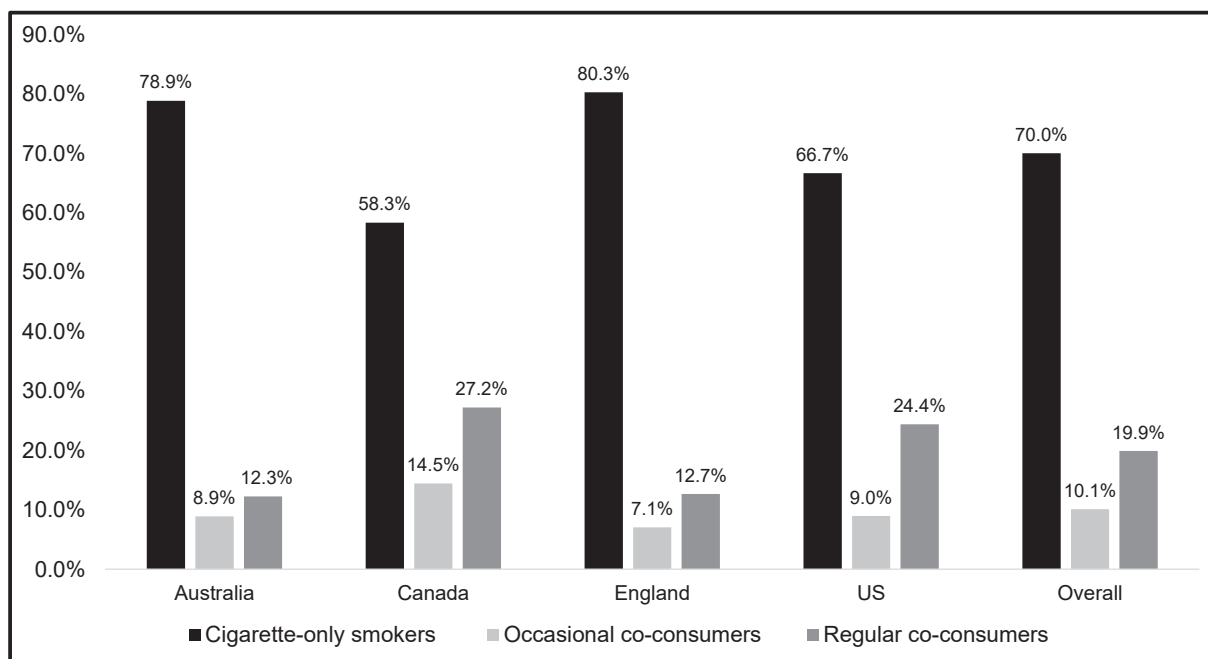
Data are weighted. Cigarette-only smokers (never used/no use in the last year, n=4857); occasional co-consumers (cannabis use in the last year, but <weekly use, n=739); or regular co-consumers (use cannabis ≥weekly, n=1345).

Fig. 1. Proportion of adults who smoke daily and do or do not co-use cannabis Data are weighted. Cigarette-only smokers (never used/no use in the last year, n = 4857); occasional co-consumers (cannabis use in the last year, but < weekly use, n = 739); or regular co-consumers (use cannabis ≥ weekly, n = 1345).

having lower income, financial problems, and depression. These latter findings are consistent with other published studies (Government of Canada, 2017; Hindocha et al., 2021; Jayakumar et al., 2021; Lim et al.,

Table 3
Sociodemographic differences between co-consumers and cigarette-only smokers.

	Cigarette-only smokers	Occasional co-consumers	Regular co-consumers	p-value*
	n = 4857	n = 739	n = 1345	
Sex				
Male (vs female)	50.3 %	52.9 %	60.9 %	<0.001
aOR (95 % CI)	reference	**1.11 (0.89–1.38)**	**1.54 (1.29–1.85)**	
Age				
18–39 (vs 40 +)	31.1 %	54.3 %	58.9 %	<0.001
aOR (95 % CI)	reference	**2.63 (2.13–3.25)**	**3.17 (2.65–3.80)**	
Income				
Low (vs moderate/ high)	27.0 %	32.9 %	36.3 %	<0.001
aOR (95 % CI)	reference	**1.34 (1.05–1.71)**	**1.56 (1.29–1.89)**	
Education				
Low (vs moderate/ high)	24.4 %	19.1 %	27.0 %	0.02
aOR (95 % CI)	reference	**0.73 (0.57–0.94)**	1.14 (0.94–1.39)	
Financial stress (vs no)	15.8 %	22.5 %	27.8 %	<0.001
aOR (95 % CI)	reference	**1.54 (1.17–2.03)**	**2.05 (1.67–2.53)**	

Data are weighted and adjusted (age, sex, country, income, education, and country of residence). Cigarette-only smokers: do not use cannabis/have not used cannabis in the last 12 months; Occasional co-consumers: use cannabis less than weekly; Regular co-consumers: use cannabis at least weekly.
*p-value is for user-type (regular and occasional co-consumers vs cigarette-only smokers); aOR: adjusted odds ratio; CI: confidence interval.

2022; Schauer et al., 2015; Statistics Canada, 2021a; Reboussin et al., 2021).

Co-use of cigarettes and cannabis was markedly different between countries. Regular co-use was substantially higher in Canada and the US relative to England and Australia. There could be several explanations for this finding in Canada. First, more liberalized cannabis policies allow for greater access to cannabis. At this time, little is known about how policies may impact cannabis use; however, Canadian data suggest that the prevalence of cannabis use increased the year before and following legalization of non-medical cannabis in 2018 (Government of Canada, 2017; Statistics Canada, 2019; 2021a), but appears to have stabilized between 2019 and 2021 (Statistics Canada, 2021a). Less is known about changes in co-use trends in Canada; however, a recent study found that co-use of cigarettes and cannabis among adult past-year cannabis consumers in one Canadian province (Ontario), declined from 59.8 % in 1996 to 41.7 % in 2017 (Jayakumar et al., 2021). The study did not report on trends of cannabis use among cigarette smokers/nicotine users, nor on co-use trends post-legalization of non-medical cannabis.

The US has historically had much higher rates of cannabis use than most other countries (UN, 2021; Yu et al., 2020), with national data showing that cannabis use has increased among adults over the past decade since several jurisdictions have legalized cannabis (CDC, 2021; Hasin et al. 2018; Weinberger et al., 2022; Yu et al., 2020). With regard to co-use, some research has also shown that the prevalence of co-use has been increasing in the US (Schauer et al., 2015; Smith et al., 2022a), with higher co-use rates in US states where medical cannabis has been legalized (Wang et al., 2016; Smith et al. 2020b). It is not clear if the rise in co-use is related to more cigarette smokers initiating cannabis use or more cannabis consumers initiating cigarette smoking, or both. Data from the Population Assessment of Tobacco and Health (PATH) Study found nicotine product use (e.g., cigarettes, e-cigarettes, cigars, smokeless tobacco) declined between 2013 and 2019 among adults in the US, but co-use of cannabis and nicotine increased. Use patters differed based on the denominator, with cannabis use increasing among adults who reported current use of various nicotine products, whereas nicotine use decreased among those who reported current

Table 4
Differences between co-consumers and cigarette-only smokers: nicotine dependence, plans to quit smoking, health problems, use of other nicotine products, alcohol use, and perceptions of cannabis risk.

Outcome variables n = sample size included in each model	Comparisons	Cigarette-only smokers	Occasional co-consumers	Regular co-consumers	p-value*
Cigarettes smoked per day n = 6747	11+ (vs 1–10) aOR (95 % CI)	58.0 % reference	51.9 % **0.78** **(0.63–0.97)**	54.9 % 0.88 (0.73–1.06)	0.06
	20+ (vs 1–19) aOR (95 % CI)	11.6 % reference	12.0 % 1.03 (0.78–1.28)	11.6 % 1.00 (0.78–1.28)	0.98
Time to first cigarette n = 6537	≤30 min (vs 31 + minutes) aOR (95 % CI)	62.8 % reference	61.7 % 0.95 (0.76–1.19)	65.3 % 1.12 (0.92–1.35)	0.41
Urges to smoke cigarettes n = 6878	Extremely strong/very strong/strong (vs other) aOR (95 % CI)	48.9 % reference	45.5 % 0.87 (0.70–1.08)	48.9 % 0.96 (0.80–1.14)	0.45
Perceived level of addiction to cigarettes n = 6864	Very addicted (vs other) aOR (95 % CI)	58.5 % reference	57.5 % 0.96 (0.77–1.20)	58.4 % 1.00 (0.83–1.20)	0.94
Plans to quit smoking cigarettes n = 6928	Within 6 months (vs greater than 6 months/not at all/don't know) aOR (95 % CI)	32.1 % reference	33.2 % 1.05 (0.84–1.41)	30.7 % 0.94 (0.78–1.13)	0.65
Recent attempt to stop smoking cigarettes n = 6936	At least one attempt in the last 24 months (vs no) aOR (95 % CI)	34.1 % reference	36.2 % 1.10 (0.88–1.37)	34.3 % 1.01 (0.84–1.21)	0.71
Polyuse of other tobacco/nicotine products n = 6941	Use of at least one other product (vs no other products) aOR (95 % CI)	15.0 % reference	22.4 % **1.63** **(1.31–2.04)**	24.7 % **1.86** **(1.54–2.25)**	<0.001
Depressive symptoms n = 6896	Yes (vs no) aOR (95 % CI)	34.5 % reference	47.1 % **1.69** **(1.36–2.11)**	45.4 % **1.58** **(1.32–1.89)**	<0.001
Breathing problems in the past 12 months n = 6941	Yes (vs no) aOR (95 % CI)	36.2 % reference	39.1 % 1.13 (0.91–1.40)	48.4 % **1.65** **(1.38–1.98)**	<0.001
Alcohol use n = 6872	Occasionally (vs never) aOR (95 % CI)	62.2 % reference	71.7 % **2.96** **(2.09–4.19)**	64.3 % **1.33** **(1.06–1.68)**	<0.001
	Often (vs never) aOR (95 % CI)	15.2 % reference	19.4 % **3.28** **(2.18–4.94)**	18.1 % **1.54** **(1.15–2.06)**	
Binge drinking: 6 + drinks on one occasion	Occasionally (vs never) aOR (95 % CI)	33.1 % reference	**52.8 %** **2.97** **(2.33–3.80)**	43.4 % **1.80** **(1.47–2.21)**	<0.001
	Often (vs never) aOR (95 % CI)	11.4 % reference	17.4 % **2.86** **(2.04–3.99)**	16.3 % **1.97** **(1.50–2.58)**	
Absolute risk of smoking cannabis n = 6916					
Daily cannabis smoking	Low risk Moderate risk High risk Don't know Low risk vs other, aOR (95 % CI)	18.1 % 24.7 % 35.9 % 21.3 % reference	36.7 % 34.6 % 20.1 % 8.6 % **2.61** **(2.05–3.33)**	59.3 % 25.9 % 7.6 % 7.2 % **6.47** **(5.33–7.86)**	<0.001
Occasional cannabis smoking	Low risk Moderate risk High risk Don't know Low risk vs other, aOR (95 % CI)	**35.8 %** 25.1 % 20.5 % 18.7 % reference	64.0 % 22.1 % 8.0 % 5.9 % **3.17** **(2.54–3.96)**	76.6 % 14.5 % 3.6 % 5.4 % **5.71** **(4.71–6.93)**	<0.001
Relative risk of smoking cannabis vs cigarettes n = 6941	Smoking cannabis is less harmful than cigarettes Less harmful vs not less harmful, aOR (95 % CI)	12.9 % reference	33.3 % **3.36** **(2.61–4.33)**	48.0 % **6.21** **(5.06–7.62)**	<0.001

Data are weighted and adjusted (age, sex, country, income, education, and country of residence). *p-value represents differences by user-type (regular and occasional co-consumers vs cigarette-only smokers).

Frequency of alcohol use: occasionally (once a month or less/2–4 times a month/2–3 times a week); often (4 or more times a week) vs never.

Polyuse of other tobacco/nicotine products include: e-cigarettes, heated tobacco products (HTPs), cigars/cigarillos, hookah, smokeless tobacco, or nicotine pouches.

cannabis use (Smith et al., 2022a), corroborating a similar decrease between 2003 and 2012 (Schauer et al., 2015). Thus, in the US, increasing co-use appears to be driven by nicotine users adopting cannabis, rather than cannabis consumers adopting nicotine.

Expanding access to cannabis through legalization for medical and non-medical use, coupled with the high rate of cannabis use among cigarette smokers, has led to some public health concerns that legalizing cannabis may undermine efforts to reduce cigarette smoking or influence problematic tobacco-cannabis smoking co-use behaviours. Because cannabis use is one of the strongest predictors for the onset of daily cigarette smoking (Agrawal et al., 2008a, Becker et al., 2015), the increasing use of cannabis could pose a significant public health risk. Further, non-daily cigarette smoking increased in the US among daily cannabis consumers between 2002 and 2015 (Pacek et al., 2018). Accordingly, it is particularly important to determine if cannabis-tobacco interrelatedness is associated with more frequent cigarette smoking, lower rates of cigarette cessation, and greater nicotine dependence, of which has been found in some studies (Agrawal et al., 2008a,b, Akbar et al., 2019; Driezen et al., 2022; Rubinstein et al., 2014; Weinberger et al. 2020). In contrast to these studies, our findings did not demonstrate any associations of greater cigarette dependence, quit intentions, or recent quit smoking attempts among this sample of daily cigarette smokers based on cannabis co-use or not. Future investigations should attempt to address inherent causal differences, including if co-consumers are at a disadvantage for cigarette cessation across time, or develop greater cigarette (nicotine) dependence as they age.

Perceptions of cannabis use as being low risk, or even harmless, may increase with growing public support and social acceptibility in countries with more liberalized cannabis policies (Government of Canada, 2017; Hasin et al. 2018; Weatherburn et al., 2021). For example, some studies have found that perceptions of cannabis harm are lower and/or have decreased in jurisdictions that have legalized it (Carliner et al., 2017; Cerda et al., 2017; Gravely et al. 2020; Schuermeyer et al., 2014; Wadsworth et al., 2019). Moreover, the belief that cannabis poses low health risks has been found to be associated with cannabis use (Hellemans et al., 2019; Johnston et al., 2018; Salloum, et al., 2018). Our study found that regular co-consumers had 6.5 times greater odds of believing that daily cannabis smoking poses low risk to health and 6.2 times greater odds of perceiving that smoked cannabis is less harmful than cigarette smoking relative to cigarette-only smokers. A similar pattern was found between occasional co-consumers and cigarette-only smokers. Educational campaigns, especially for youth, describing balanced information about the possible health harms of cannabis use are urgently needed, particularly in jurisdictions where non-medical cannabis has been decriminalized or legalized, and is more easily accessible. Similarly, educating people about the additive toxic effects of co-use should be an important public health priority.

Although this is a large study with representative daily cigarette smokers from four countries, there are some limitations to consider. First, this is a cross-sectional study; therefore, it cannot be determined whether cannabis and tobacco smoking preceded the predictors examined in this study. Second, the sample was limited to adult daily cigarette smokers, so observations may not apply to other populations of interest, including youth or less frequent smokers who co-use cannabis. The current study did not evaluate inherent differences among non-daily smokers, who are a growing group of co-consumers in the US (Pacek et al. 2018). Third, this study was conducted during the early phase of the COVID-19 pandemic, and as a result, these findings may have differed prior to the pandemic. For example, some studies have reported increased use of cannabis among adults the during the early phase of the COVID-19 pandemic (Brenneke et al., 2022; Lake et al., 2022; Schauer et al., 2021; Statistics Canada, 2021b, Sznitman et al., 2022). Therefore, rates of co-use may be inflated and should be interpreted with caution. Fourth, it was not possible to separate US data by state. As cannabis policies differ widely between and even within states (NCSL, 2022), a stratified analysis based on medical and non-medical legalization status

may have yielded different results. Finally, we recognize that there are differing patterns of co-use, including use on different occasions (concurrent use), the use of one product after the other (sequential use, such as 'chasing'), or mixed in the same delivery mechanism (coadministration/simultaneous use); however, examining differing patterns of modes and patterns of cannabis use were beyond the scope of this paper. This should be further examined as co-use practices, particularly co-administration, may be associated with problematic cannabis and cigarette dependence, adverse health outcomes (e.g., higher risk of respiratory distress), lower motivation to reduce tobacco consumption, and lower rates of smoking cessation (Agrawal et al, 2012).

5. Conclusion

These descriptive results suggest that the profile of adult daily cigarette smokers who also use cannabis are likely to be younger, use other nicotine products in addition to cigarettes, report depressive symptoms, and engage in higher risk alcohol consumption. Additionally, a sizable minority of co-consumers of cigarettes and cannabis reported financial stress. Overall, we found little difference in cigarette smoking measures (e.g., cigarette/nicotine dependence) between co-consumers and cigarette-only smokers; however, there are several other risk factors that may affect tobacco use and abstinence among co-consumers. Tobacco cessation treatment may require multi-pronged strategies to address other health behaviors. Continued surveillance is needed to determine the nature and health implications of co-consumption of cigarettes and cannabis considering changing policies, markets, and products.

6. Ethics approval

The survey protocols and all materials, including the survey questionnaires, were approved by the Research Ethics committee at the University of Waterloo, Canada (ORE#20803/30570, ORE#21609/30878), King's College London, UK (RESCM-17/18–2240), Cancer Council Victoria, Australia (HREC1603), University of Queensland, Australia (20160000330/HREC1603), Deakin University, Australia (DUHREC2018-346) and Medical University of South Carolina, US (waived due to minimal risk).

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: 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. KMC has served as paid expert witness in litigation filed against cigarette manufacturers. GTF and DH have served as expert witnesses on behalf of governments in litigation involving the tobacco industry.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2022.107434.

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