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RESEARCH REPORT

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Adolescent cannabis use and psychological distress from 2013 to 2023: A population-based study in Ontario, Canada

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Abstract

Background and aims: Epidemiologic research suggests that adolescent cannabis use is associated with psychological distress (i.e. depression and anxiety symptoms); however, most studies have relied on 20th-century data, when cannabis was significantly less potent than today. This study aimed to estimate the association between adolescent cannabis use and psychological distress using contemporary population-based data and examine the roles of time [as a proxy for increasing Δ9-tetrahydrocannabinol (THC) potency], sex and age of initiation.

Design: Representative cross-sectional survey conducted biennially from 2013 to 2023.

Setting: Ontario, Canada.

Participants: 35 007 adolescents in grades 7 to 12.

Measurements: Past-year cannabis use was categorized as Never, 1–2 times, 3–9 times, 10–39 times or 40+ times. Psychological distress was measured with the Kessler-6 scale using a cut-off score of 13+ indicating anxiety/depression symptoms. Multivariable modified Poisson and least-squares models were used to estimate the association between past-year cannabis use and psychological distress. Survey year and sex were tested as effect modifiers on the multiplicative and additive scales. The association between school grade of cannabis use initiation and psychological distress was also estimated.

Findings: From 2013 to 2023, the prevalence of psychological distress increased from 10.7% to 27.4%, whereas cannabis use decreased from 23.1% to 17.6%. Survey year and sex were statistically significant effect modifiers for the association between cannabis use and psychological distress with associations consistent with a super-additive effect but not multiplicative synergy (additive interactions: $P < 0.05$; multiplicative interactions: $P > 0.05$). The association between cannabis use and psychological distress strengthened over time, particularly for those using 40+ times compared with abstinence (from 0% [95% confidence interval (CI) = −6% to 6%] adjusted prevalence difference in 2013 to

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18% (95% CI = 11%–25%] adjusted prevalence difference in 2023). Independent of time, there was evidence of dose–response among females, but not males. A 5% (95% CI = 1%–10%) lower prevalence of psychological distress was observed per later school grade of cannabis use initiation.

Conclusions: Psychological distress increased markedly among adolescents in Ontario, Canada, from 2013 to 2023. In that setting, adolescent cannabis use was statistically significantly associated with psychological distress, especially among females, and this association increased in magnitude over time, especially for those using most frequently. It is possible that adolescents are increasingly self-medicating psychological distress with cannabis and/or that rising cannabis potency is increasingly contributing to psychological distress. While causality cannot be established, based on the precautionary principle, policymakers should prioritize cannabis prevention strategies that aim to reduce frequency of use, limit potency and delay age of initiation, particularly among females.

KEYWORDS
adolescence, anxiety, cannabis, cannabis legalisation, depression, mental health, sex, youth

INTRODUCTION

Psychological distress (i.e. depression and anxiety symptoms) represents the leading cause of disability globally and continues to increase rapidly among adolescents [1–4]. Cannabis use during adolescence may be a risk factor for psychological distress [5]. However, the current evidence base makes causal inference challenging [6]. For example, a meta-analysis found that cannabis use during adolescence was only modestly associated with depression in young adulthood (OR = 1.37; 95% CI = 1.16–1.62) and not significantly associated with anxiety (OR = 1.18; 95% CI = 0.84–1.67) [7]. Moreover, the directionality of the association is unclear, with some studies suggesting psychological distress leads to cannabis use, and others suggesting a bidirectional relationship [7–9].

Previous research on the association between adolescent cannabis use and psychological distress has important methodological limitations [6]. To date, relatively few general population studies have been conducted specifically among adolescents [7, 10–16], whose neurodevelopment may be particularly vulnerable to cannabis exposure [17]. Moreover, recent studies have highlighted the importance of cannabis potency in evaluating this relationship [16, 18–20], yet the current literature still relies largely on 20th century data when cannabis was significantly less potent than today in terms of Δ9-tetrahydrocannabinol (THC) [21]. The average THC potency of dried flower cannabis in Canada increased from 6% in the late 1990s to approximately 20% in 2018 [21, 22]. New high-potency cannabis products (e.g. cannabis extracts) have also become more popular, reaching upward of 95% THC [23–26]. It is, therefore, possible that the magnitude of association between cannabis use and distress has grown in recent years because of increasing THC exposure [21].

Some adult studies suggest that the strength of association between cannabis use and psychological distress has increased over time, hypothesising increased potency as a reason [27–32]. Adolescent studies have produced mixed findings as some report no temporal change [10, 33], while others suggest increasing [13, 14] or decreasing effect sizes [15]. However, these adolescent studies assessed time as an effect modifier only on the multiplicative scale. Reporting guidelines recommend assessing effect modification on both the multiplicative and additive scales [34, 35]. Assessing effect modification on the additive scale can be more consequential to public health because it quantifies absolute risk differences, which corresponds to the number of cases that could be prevented if an exposure were minimised, and helps identify subgroups or trends that would yield the greatest population benefit from intervention. Notably, interaction can be present on one scale but not the other, and focusing solely on multiplicative interaction may misidentify priority subgroups when resources are limited [36].

Sex and age differences in the association between cannabis and psychological distress are also under examined in the literature and could similarly have important health policy implications [12, 37]. Males use cannabis more than females [38], while females are more susceptible to distress [39, 40]. Early evidence suggests that the association between cannabis use and psychological distress is stronger in females compared to males [12]. Age may also play an important interrelated role, as the transition from adolescence to early adulthood is when cannabis use is most commonly initiated and when psychological distress typically begins to develop [38, 39, 41].

Understanding recent trends in the association between adolescent cannabis use and psychological distress is a critical public health issue, especially as more jurisdictions legalise cannabis use and perception of harm declines among adolescents [32]. The objective of this study was to examine whether the association between adolescent cannabis use and psychological distress changed over time using recent population-based data. We assessed effect modification on the multiplicative and additive scales for survey year to proxy rising cannabis potency and sex to obtain sex-specific estimates. This study also sought to estimate the association between age of cannabis use initiation and distress. We hypothesised that cannabis use would be

positively associated with distress (particularly among females), that this association would strengthen over time and that earlier age of cannabis use initiation would be positively associated with distress.

METHODS

Study sample

We used data from the 2013, 2015, 2017, 2019 and 2023 cycles of the Ontario Student Drug Use and Health Survey (OSDUHS). The OSDUHS is a population survey of Ontario secondary school students that is self-administered anonymously [42]. The target population was Ontario students from 7th to 12th grade enrolled in Ontario's four publicly funded school sectors [42], which captures 95% of all Ontario adolescents aged 12 to 18 years based on Statistics Canada population estimates [42]. Surveys were facilitated by research staff during regular class times and took 30 minutes on average to complete. We excluded the 2021 cycle because of non-comparability (low participation rates early in coronavirus disease 2019 (COVID-19) pandemic [42]). OSDUHS did not measure psychological distress before 2013. From 2013 to 2019, only one random half of the sample was asked the psychological distress measure, which reduced the sample size. The completion rate for the included survey cycles was 63%, 59%, 61%, 59% and 49%. After list-wise deletion of respondents with missing data (n = 2897), the final analytic sample size was n = 32 110. The Center for Addiction and Mental Health's Research Ethics Board approved survey data collection.

Measures

Exposure

For the main exposure of self-reported past-year cannabis use, participants were asked: 'In the LAST 12 MONTHS, how often did you use CANNABIS (also known as marijuana, "weed", "'pot", "grass", "hashish", "hash", "hash oil", etc.)? 1 or 2 times; 3 to 5 times; 6 to 9 times; 10 to 19 times; 20 to 39 times; 40 or more times; Used, but not in the last 12 months; Never used in lifetime; Don't know what cannabis is.' To ensure sufficient cell sizes for interaction analyses, we recategorised past-year cannabis use frequency to never (including those who used, but not in past 12 months), 1 or 2 times, 3 to 9 times, 10 to 39 times and 40 or more times. Past-month cannabis use (never, <weekly, weekly, daily+) was also used in a sensitivity analysis.

Outcome

Self-reported psychological distress was measured using the Kessler 6-item psychological distress scale (K6) with the established cut-off score of 13 or higher indicating anxiety/depression symptoms [43]. The K6 has been validated among Canadian youth showing strong psychometric properties for mood and anxiety disorders [44]. The K6 asks: 'During the past 30 days, about how often did you feel…Nervous? Hopeless? Restless or fidgety? So depressed that nothing could cheer you up? That everything was an effort? Worthless?' Each item is scored 0 (none of the time) to 4 (all of the time), producing an overall score ranging from 0 to 24 when summed.

Confounders

Socio-demographic confounders included age and socio-economic status (SES), which was measured using a validated item that asked students to place themselves on a 10-rung ladder representing Canada's socio-economic structure [45]. Past-year cigarette use was categorised as never, <daily or daily+. Past-year alcohol use was categorised as never, <weekly or weekly+. Confounders were selected based on previous literature and the creation of a directed acyclic graph [46]. Unmeasured confounders included family history of substance use/mental health problems, genetic predisposition and trauma.

Effect modifiers

We explored survey year and sex assigned at birth (male/female) as effect modifiers. Because the survey did not include questions about cannabis potency, survey year served as a proxy for increasing THC potency of cannabis.

School grade of cannabis use initiation

School grade of cannabis use initiation (treated as continuous), was measured with the question: 'When (if ever) did you first try cannabis (also known as marijuana, "weed", "pot", "grass", "hashish", "hash", "hash oil")? Never tried cannabis in lifetime; Grade 4 or before; Grade 5; Grade 6; Grade 7; Grade 8; Grade 9; Grade 10; Grade 11; Grade 12'. (See Table S1 for comprehensive list of survey questions).

Statistical analyses

We used multi-variable modified Poisson modelling to estimate adjusted prevalence ratios (aPR) for the association between past-year cannabis use frequency and psychological distress [47], and assessed survey year as an effect modifier on the multiplicative scale by including a cross-product interaction term (cannabis × year). We also wanted to show sex-specific estimates, which necessitated including sex × cannabis and sex × year in two-way interactions, and a three-way interaction (cannabis × year × sex). The initial model included main effects, all two- and three-way interaction terms between cannabis use, sex and survey year, as well as age, SES, cigarette use and alcohol use. Higher order interaction terms that were not statistically

significant based on likelihood ratio tests ($P \geq 0.05$) were removed. However, regardless of *P*-value, effect modification was explored with fitted, stratum-specific estimates and graphically with fitted probability plots to illustrate on a natural scale, the joint effects of cannabis exposure, modified by year and specific to sex. We used multivariable logistic regression with marginal means for graphs to ensure predicted probabilities were bounded between 0% and 100% [48]. Because of the difficulty in estimating unbiased interaction effects

TABLE 1 Study sample characteristics (weighted) stratified by survey cycle, Ontario Student Drug Use and Health Survey from 2013 to 2023 (pooled unweighted *n* = 35 007).

		Survey cycle					
	Overall	2013 *n* = 5478	2015 *n* = 5403	2017 *n* = 6364	2019 *n* = 7617	2023 *n* = 10 145	χ^2/*t* test *P*-value
Psychological distress (K6 13+), %							<0.001
Yes	18.2	10.4	13.7	16.5	19.6	25.3	
No	77.0	86.7	83.1	80.0	75.8	67.0	
Missing	4.8	2.9	3.2	3.5	4.5	7.7	
Cannabis use frequency past 12 months, %							0.021
Never	78.8	76.6	79.1	80.1	76.6	80.4	
1 or 2 times	5.9	6.1	5.2	5.7	6.8	5.7	
3 to 9 times	5.4	6.4	6.1	5.5	6.1	4.1	
10 to 39 times	4.2	5.1	4.4	3.9	4.5	3.8	
40+ times	4.4	5.5	5.0	3.7	4.8	3.6	
Missing	1.2	0.3	0.2	1.1	1.2	2.4	
Sex, %							0.989
Male	51.7	52.2	51.7	51.8	51.2	51.6	
Female	48.3	47.8	48.3	48.2	48.8	48.3	
Missing	0.0	0.0	0.0	0.0	0.0	0.1	
Age in years							0.947
Mean	15.1	15.2	15.1	15.1	15.1	15.1	
IQR	13.1–16.1	13.2–16.2	13.0–16.2	13.2–16.2	13.2–16.1	13.1–16.1	
Missing	0.1%	0.0%	0.0%	0.0%	0.1%	0.3%	
Socio-economic status (1–10 scale)							0.005
Mean	6.9	7.0	7.0	6.9	6.9	6.8	
IQR	5.4–7.6	5.7–7.6	5.5–7.6	5.3–7.6	5.3–7.6	5.3, 7.5	
Missing	2.6%	1.7%	1.5%	4.3%	2.1%	3.1%	
Cigarette use frequency past 12 months, %							<0.001
Never	88.8	85.7	86.2	89.0	89.9	91.4	
Less than daily	8.2	10.6	10.4	8.5	7.7	5.7	
Daily or more	2.1	3.5	3.2	2.3	1.7	0.8	
Missing	0.9	0.2	0.2	0.2	0.6	2.2	
Alcohol use frequency past 12 months, %							<0.001
Never	41.0	32.0	34.1	36.9	38.1	53.9	
Less than weekly	52.9	61.2	59.5	57.1	56.4	40.3	
Weekly or more	5.3	6.3	6.3	5.7	4.6	4.3	
Missing	0.8	0.5	0.1	0.3	0.9	1.6	
Gender identity, %							<0.001
Boy	22.0	Unmeasured	Unmeasured	37.6	38.6	34.5	
Girl	20.8	Unmeasured	Unmeasured	35.6	36.2	32.7	
Transgender/gender diverse	1.0	Unmeasured	Unmeasured	0.7	0.6	4.0	
Missing	56.2	Unmeasured	Unmeasured	28.4	24.6	28.7	

Abbreviations: IQR, interquartile range; K6, Kessler 6-item psychological distress scale with the established cut-off score of 13.

involving continuous variables when using multiple imputations [49], particularly in the context of a complex survey design, complete case analysis was used.

We used modified least-squares modelling [50] to estimate adjusted prevalence differences (aPD), again including cross-product interaction terms, which assessed additive interaction. Additive interaction means that the combined effect of two exposures is larger (or smaller) than the sum of the individual effects of the two exposures, whereas multiplicative interaction means that the combined effect is larger (or smaller) than the product of the individual effects [51]. The null hypothesis for additive interaction is, therefore, a joint additive effect ($PD_{11} - PD_{10} + PD_{01} = 0$), whereas the null hypothesis for multiplicative interaction is a joint multiplicative effect $\left(\frac{PR_{11}}{PR_{10}PR_{01}} = 1\right)$. Supplementary Methods provides a detailed explanation of three-way interaction.

We also examined the association between school grade of cannabis use initiation and psychological distress among grade 11 and 12 students who reported lifetime cannabis use in a separate multivariable modified Poisson model, adjusting for cannabis use, sex, survey year, age, SES, cigarette use and alcohol use.

For sensitivity analyses, we tested gender identity instead of sex as an effect modifier. We replicated our primary analysis, but treated psychological distress as continuous (i.e. linear regression). We also replicated the primary analysis but with past-month cannabis use (never, <weekly, weekly, daily+) as the exposure instead of past-year. We tabulated the proportion of past-year cannabis users in 2023 who reported using cannabis to cope with psychological distress, as well as the proportion of respondents with unmet mental healthcare, stratified by sex and cannabis use frequency.

We calculated descriptive statistics for our sample and used Rao-Scott χ^2 tests and design-based t tests to assess whether measures changed across the five survey cycles and to compare those with missing data to those without. Multicollinearity was assessed using

TABLE 2 Modified Poisson models estimating prevalence ratios for the association between cannabis use frequency and psychological distress with no adjustment, adjustment for socio-demographics only and adjustment for all covariates.

	Psychological distress (K6 13+)								
	Unadjusted, *n* = 33 160			Socio-demographics only, *n* = 32 205			Fully adjusted, *n* = 32 110		
Variables	aPR	95% CI	Joint test *P*-value	aPR	95% CI	Joint test *P*-value	aPR	95% CI	Joint test *P*-value
Cannabis use frequency past 12 months			<0.001			<0.001			<0.001
Never	Ref	–		Ref	–		Ref	–	
1–2 times	1.66	1.44–1.90		1.41	1.22–1.62		1.22	1.06–1.40	
3–9 times	1.57	1.37–1.79		1.44	1.28–1.63		1.18	1.04–1.34	
10–39 times	1.58	1.38–1.81		1.43	1.25–1.63		1.09	0.95–1.26	
40 or more times	2.01	1.77–2.28		1.85	1.65–2.08		1.31	1.14–1.51	
Sex						<0.001			<0.001
Male	–	–		Ref	–		Ref	–	
Female	–	–		2.66	2.45–2.88		2.65	2.45–2.87	
Survey year (yearly change)	–	–		1.09	1.08–1.10	<0.001	1.10	1.09–1.11	<0.001
Age	–	–		1.05	1.03–1.08	<0.001	1.04	1.01–1.07	<0.001
Socio-economic status (1–10 scale)	–	–		0.83	0.81–0.84	<0.001	0.83	0.81–0.84	<0.001
Cigarette use frequency past 12 months									<0.001
Never	–	–		–	–		Ref	–	
Less than daily	–	–		–	–		1.39	1.25–1.54	
Daily or more	–	–		–	–		1.92	1.62–2.28	
Alcohol use frequency past 12 months									<0.001
Never	–	–		–	–		Ref	–	
Less than weekly	–	–		–	–		1.27	1.13–1.42	
Weekly or more	–	–		–	–		1.20	0.99–1.45	

Note: Cannabis × sex and cannabis × year interactions not included in the final modified Poisson models because they were not statistically significant ($P > 0.05$).

Abbreviations: aPR, adjusted prevalence ratio; K6, Kessler 6-item psychological distress scale with the established cut-off score of 13; Ref, reference category.

variance inflation factors. All statistical analyses were conducted using R version 4.5.0 and the survey package [52], accounting for survey weights and sampling design for point and variance estimation [42]. Analyses were not pre-registered, therefore, results should be considered exploratory. Findings are reported in accordance with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

RESULTS

Descriptive statistics

Table 1 presents the descriptive characteristics of the study sample (weighted), stratified by survey cycle. Overall, when not including the missing category, 19.1% of respondents reported psychological distress (10.7% in 2013 and 27.4% in 2023) and 20.2% of respondents reported past-year cannabis use (23.1% in 2013 and 17.6% in 2023). All substance use variables and SES were associated with survey cycle. We note that from 2013 to 2023, the prevalence of alcohol use decreased markedly (67.9% in 2013 and 45.2% in 2023).

Primary analyses

We first conducted a multi-variable modified Poisson model, initially including a three-way interaction between cannabis use, survey year and sex, which was not statistically significant ($P = 0.29$). We, then, tested two-way interactions between cannabis use and sex ($P = 0.24$) and between cannabis use and survey year ($P = 0.57$), which were non-significant suggesting the absence of multiplicative interaction. Table 2 presents the final multi-variable modified Poisson model,

TABLE 3 Adjusted prevalence differences for the association between past-year cannabis use frequency and psychological distress (K6 13+) conditional on survey year, estimated from a multi-variable modified least-squares model.

		Psychological distress (K6 13+)		
Year	Cannabis use frequency past 12 months	aPD	95% CI	*P*-value
2013	Never	Ref	–	
	1–2 times	0.01	−0.04 to 0.06	0.68
	3–9 times	0.02	−0.02 to 0.07	0.35
	10–39 times	−0.00	−0.05 to 0.05	0.97
	40 or more times	−0.00	−0.06 to 0.06	0.98
2015	Never	Ref	–	
	1–2 times	0.03	−0.01 to 0.06	0.17
	3–9 times	0.03	−0.01 to 0.07	0.11
	10–39 times	0.01	−0.03 to 0.05	0.61
	40 or more times	0.03	−0.01 to 0.08	0.15
2017	Never	Ref	–	
	1–2 times	0.04	0.01–0.08	0.01
	3–9 times	0.04	0.01–0.07	0.02
	10–39 times	0.02	−0.01 to 0.05	0.20
	40 or more times	0.07	0.03–0.11	<0.01
2019	Never	Ref	–	
	1–2 times	0.06	0.02–0.10	<0.01
	3–9 times	0.05	0.01–0.08	0.01
	10–39 times	0.03	−0.00 to 0.07	0.08
	40 or more times	0.11	0.06–0.15	<0.01
2023	Never	Ref	–	
	1–2 times	0.09	0.02–0.16	0.01
	3–9 times	0.06	0.01–0.12	0.03
	10–39 times	0.05	−0.01 to 0.12	0.08
	40 or more times	0.18	0.11–0.25	<0.01

Note: Model adjusted for sex, age, socio-economic status, past 12 months cigarette use frequency and past 12 months alcohol use frequency. The model used to estimate adjusted prevalence differences can be found in Table S1.

Abbreviations: aPD, adjusted prevalence difference; K6, Kessler 6-item psychological distress scale with the established cut-off score of 13; Ref, reference category.

which includes main effects and different sets of covariates. All cannabis use frequencies were significantly associated with distress compared to no cannabis use. There was little evidence of a linear dose–response relationship, although the largest measure of association was for adolescents reporting using cannabis 40 or more times in the past year (aPR = 1.31; 95% CI = 1.14–1.51). We note that cigarette use was the substance most strongly associated with distress (daily+ aPR = 1.92; 95% CI = 1.62–2.28).

We subsequently tested for additive interaction using modified least-squares regression, initially including a three-way interaction that was not significant ($P = 0.13$). We, then, tested two-way interactions between cannabis use and sex ($P < 0.01$) and between cannabis use and survey year ($P < 0.01$), which were both statistically significant (see Table S2 for final models). aPDs for the association between cannabis use and psychological distress conditional on survey year and sex are presented in Tables 3 and 4. The most pronounced increase over time compared to no past-year use was among those who used cannabis 40+ times [from aPD = 0.00 (95% CI = −0.06 to 0.06) in 2013 to aPD = 0.18 (95% CI = 0.11–0.25) in 2023]. All levels of cannabis use frequency were significantly associated with distress compared to non-use among females [e.g. using 40+ times had 19% (95% CI = 13%–26%) higher prevalence of distress compared to non-users], while no levels were among males.

Figure 1 illustrates the association between past-year cannabis use and distress modified by survey wave (see Figure S1 for time trends in psychological distress by cannabis use frequency). Distress increased for all levels of cannabis use frequency over time, but particularly in the 40+ times group.

Figure 2 illustrates the association between past-year cannabis use and psychological distress modified by sex, showing dose–response among females, but not among males. We also graphed the non-significant three-way interaction in Figure S2.

Among grade 11 and 12 students reporting lifetime use, we observed a significant association between school grade of cannabis use initiation and psychological distress (aPR = 0.95; 95% CI = 0.90–0.99; $P = 0.03$), suggesting a 5% lower prevalence of distress per later grade of cannabis use initiation.

Sensitivity analyses

We explored gender identity (boy, girl or transgender/gender diverse) instead of sex as an effect modifier (see Table S3 and Figure S3). We also replicated the primary analysis, but treated psychological distress as a continuous outcome (i.e. K6 score) instead of dichotomous and used past-month cannabis use (instead of past-year) as the focal exposure and found similar results (see Tables S4–S6).

Compared to complete cases, respondents with missing data were more likely to be younger, abstinent from alcohol, male and in later cycles. Missing data was not associated with psychological distress, cannabis use, cigarette use or SES (see Table S7).

Coping and unmet need (2023)

Using cannabis to cope with psychological distress was reported by 48.4% of cannabis users in 2023 (see Table S8). Females were more likely to report using cannabis to cope with distress, especially those who used 40+ times in the past year (96.0%). Unmet need for professional mental healthcare was reported by 50.5% of cannabis users (see Table S9), with a higher proportion observed among females, especially those who used 40+ times in the past year (78.3%).

TABLE 4 Adjusted prevalence differences for the association between past-year cannabis use frequency and psychological distress (K6 13+) conditional on sex, estimated from a multi-variable modified least-squares model.

		Psychological distress (K6 13+)		
Sex	**Cannabis use frequency past 12 months**	**aPD**	**95% CI**	***P*-value**
Male	Never	Ref	–	
	1–2 times	0.04	−0.01 to 0.09	0.10
	3–9 times	−0.00	−0.05 to 0.04	0.85
	10–39 times	−0.02	−0.05 to 0.01	0.23
	40 or more times	0.02	−0.03 to 0.07	0.39
Female	Never	Ref	–	
	1–2 times	0.07	0.02–0.11	0.01
	3–9 times	0.08	0.04–0.13	<0.01
	10–39 times	0.08	0.03–0.14	<0.01
	40 or more times	0.19	0.13–0.26	<0.01

Note: Model adjusted for survey year, age, socio-economic status, past 12 months cigarette use frequency and past 12 months alcohol use frequency. The model used to estimate adjusted prevalence differences can be found in Table S1.
Abbreviations: aPD, adjusted prevalence difference; K6, Kessler 6-item psychological distress scale with the established cut-off score of 13; Ref, reference category.

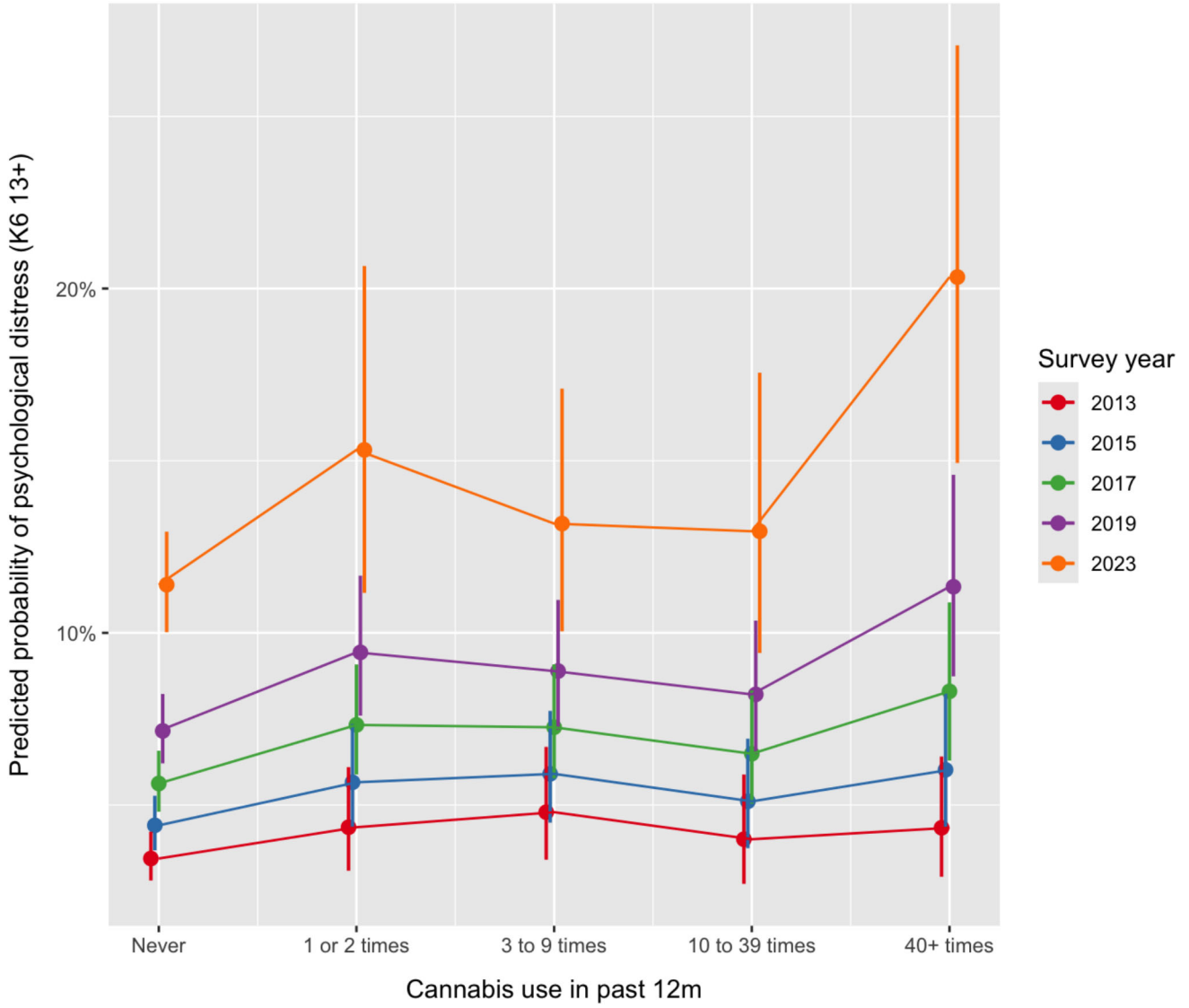

FIGURE 1 Illustration of the relationship between cannabis use frequency and estimated adjusted probability of psychological distress (Kessler 6-item psychological distress scale 13+ (K6)] modified by survey year, with 95% CI. Adjusted probabilities of psychological distress were estimated from a multi-variable logistic regression model to ensure that probabilities were bounded between 0% and 100% (model adjusted for sex, cigarette use, alcohol use, age and socio-economic status).

DISCUSSION

This study found that, alongside a marked increase in the prevalence of psychological distress from 2013 to 2023 (10.7%–27.4%), the magnitude of association between adolescent cannabis use and psychological distress increased significantly (particularly frequent use). Previous studies examining whether the association between adolescent cannabis use and distress has changed over time have found mixed results [10, 13–15, 33], but have only assessed time as an effect modifier on the multiplicative scale. The current study assesses interaction on the additive scale as well, finding that in absolute terms, psychological distress increased for all levels of cannabis use frequency over time, but particularly among those using most frequently. We also observed sex differences in the association between cannabis use and distress, finding dose–response among females and no evidence of association among males. Finally, initiating cannabis use in an earlier school grade was associated with higher prevalence of distress.

The increasing magnitude of association between cannabis use and psychological distress may reflect that adolescents are turning to cannabis to self-medicate distress, particularly post-legalisation [53]. In 2023, nearly half of cannabis users reported using cannabis to cope with psychological distress, and many reported unmet need for professional mental healthcare. Among females who used cannabis 40+ times in the past year, almost all reported using cannabis to cope with distress and approximately four in five had an unmet need for professional mental healthcare. This suggests that adolescents using cannabis frequently, particularly females, are self-medicating with cannabis instead of seeking professional help, which is concerning given

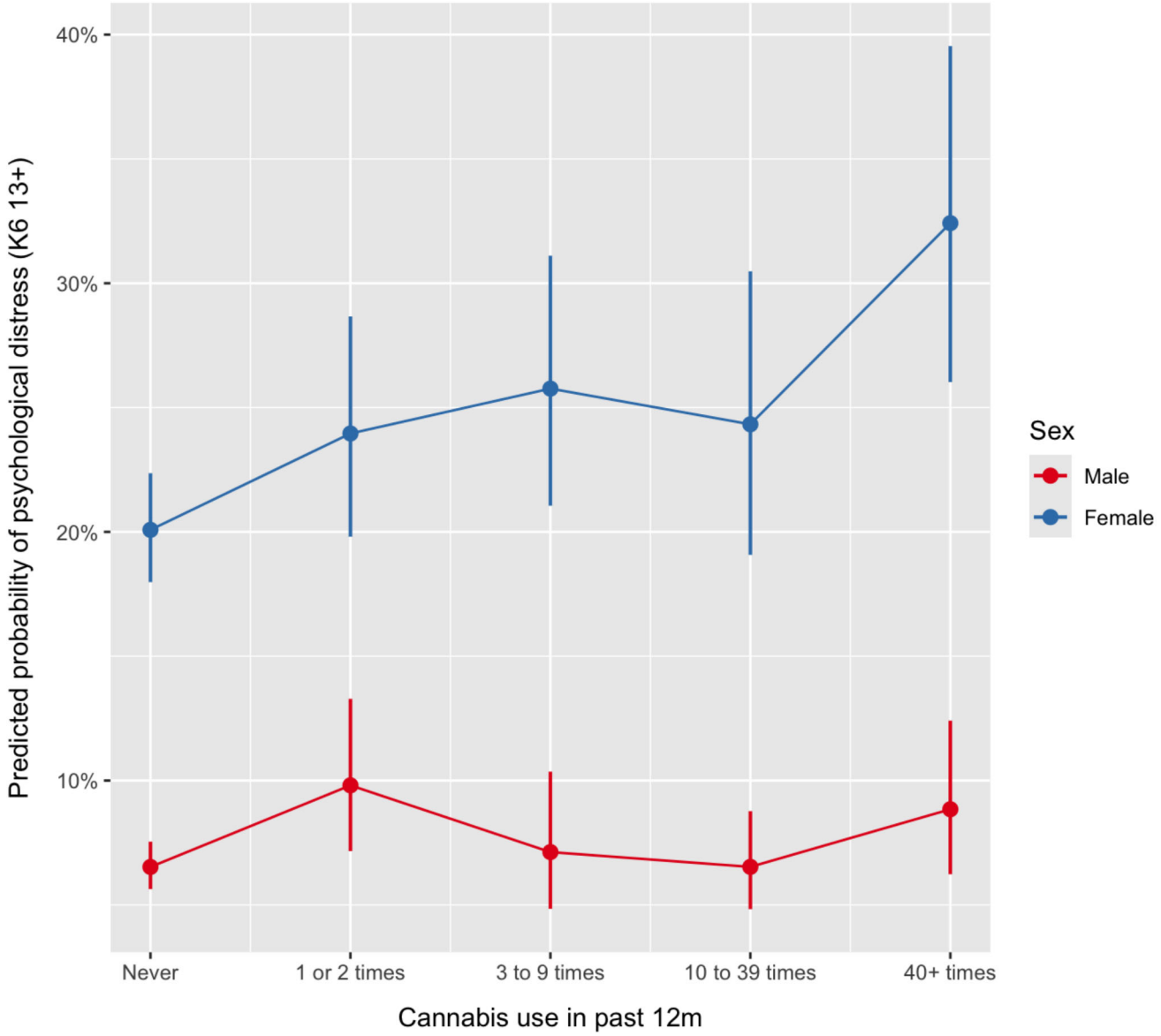

FIGURE 2 Illustration of the relationship between cannabis use frequency and estimated adjusted probability of psychological distress [Kessler 6-item psychological distress scale 13+ (K6)] modified by sex, with 95% CI. Adjusted probabilities of psychological distress were estimated from a multi-variable logistic regression model to ensure that probabilities were bounded between 0% and 100% (model adjusted for sex, cigarette use, alcohol use, age and socio-economic status).

the lack of evidence for cannabis as a mental health treatment [54]. Because the coping and unmet need questions were not measured in earlier survey waves, it is impossible to determine whether this is a new phenomenon or longstanding trend. However, adolescents with concurrent cannabis use and psychological distress may be less likely to use health services for many reasons including having negative attitudes toward providers, being less motivated to seek help, feeling stigmatised or facing systemic barriers to access [6, 55–58]. Therefore, adolescents who use cannabis frequently may be less likely to seek and access mental healthcare despite having a greater need [6].

Another explanation is the recent proliferation of high-potency cannabis products, which may be exposing adolescents today to more THC than ever before, potentially contributing to greater neurodevelopmental harm [21]. It is plausible that earlier exposure to THC disrupts the endocannabinoid system, synaptic pruning, white matter development and CB1 receptor binding, which could have lasting effects on cognition and emotional regulation [6, 17]. The current study found that initiating cannabis use in an earlier school grade was associated with higher prevalence of psychological distress, which is consistent with the neurodevelopmental theory and previous research suggesting early use of cannabis is associated with other adverse mental health outcomes [37, 59, 60].

The finding of dose–response among females and no significant association among males may have a biological basis, as animal and human models suggest that there are sex differences in

sensitivity to cannabis, cannabis metabolisation and the acute effects of cannabis, all of which could contribute to differing impacts of cannabis use on mental health [61, 62]. Puberty is also a unique developmental period when hormonal differences by sex could alter the pharmacodynamic effects of cannabis. At the same time, there are numerous behavioural and socio-cultural factors contributing to gender-based differences in cannabis use and mental health that may map onto sex differences [63]. For example, boys are more likely to use cannabis, while girls are more susceptible to psychological distress [6, 64]. Further epidemiological research is needed to deepen our understanding of these sex differences.

In the overall sample, we observed a significant, but modest association between cannabis use and psychological distress among adolescents but little evidence of dose–response [7]. Most previous studies have found a dose–response relationship between cannabis use and psychological distress regardless of sex [65], although some recent studies have not [6, 18]. The lack of dose–response may have been because of measurement error, because frequency of use is a crude proxy for THC exposure given different patterns of use and variation in cannabis potency, particularly post-legalisation when product preferences changed [24, 26, 66]. Alternatively, it might indicate a non-causal relationship that is driven by residual and/or unmeasured confounding. We note that cigarette use was the substance most strongly associated with distress.

Strengths and limitations

The OSDUHS is a high-quality population-based survey that is representative of adolescents in Ontario, Canada. This study is one of the first to explore increasing cannabis potency and sex as effect modifiers for the association between adolescent cannabis use and psychological distress on both the multiplicative and additive scales. Contemporary data were used (as recently as 2023), which enhances the study's generalisability to adolescent cannabis use today. We also used a validated mental health outcome with robust psychometric properties [44].

This study also had limitations. It used a cross-sectional design that does not allow for temporality to be established and causality inferred between cannabis and psychological distress. Recent Mendelian randomisation studies and meta-analyses raise uncertainty regarding the direction or presence of causality, therefore, caution should be used in interpreting results [7, 65, 67–69]. Unmeasured and/or residual confounding may have biased estimates. Recall bias may have been present considering cannabis use was measured as the number of times used over the past year. Under-reporting of cannabis use was likely given that cannabis use was illegal for adolescents across the study period (although decriminalised after 2018). Although the average THC potency of cannabis products has consistently increased over time in Canada, the use of survey year remains a crude proxy. Additional factors may have confounded this relationship such as the COVID-19 pandemic and associated virtual schooling, the cost-of-living crisis and shifting public perception of cannabis [70], among others. Moreover, cannabis product preferences and modes of use changed over the study period, particularly following recreational cannabis legalisation for adults [24, 26, 66], making it even more difficult to approximate THC exposure levels for adolescents. As THC is the true exposure of interest, future studies are needed that better quantify THC levels (e.g. with standard THC units) and account for mode of consumption [71].

CONCLUSION

Psychological distress increased markedly among adolescents from 2013 to 2023. Adolescent cannabis use is significantly associated with psychological distress, especially among females, and this association increased in magnitude over the study period, especially for those using most frequently. It is possible that adolescents are increasingly self-medicating psychological distress with cannabis and/or that rising cannabis potency is increasingly contributing to psychological distress. Although causality cannot be established, based on the precautionary principle, policymakers should prioritise cannabis prevention strategies that aim to reduce frequency of use, limit potency and delay age of initiation, particularly among females.

AUTHOR CONTRIBUTIONS

André J. McDonald: Conceptualization (lead); data curation (lead); formal analysis (lead); funding acquisition (lead); investigation (lead); methodology (lead); visualization (lead); writing—original draft (lead); writing—review and editing (lead). **Amanda Doggett:** Investigation (supporting); methodology (supporting); writing—review and editing (supporting). **Susan J. Bondy:** Investigation (supporting); methodology (supporting); writing—review and editing (supporting). **Ian Colman:** Investigation (supporting); writing—review and editing (supporting). **Steven Cook:** Investigation (supporting); writing—review and editing (supporting). **Hayley A. Hamilton:** Investigation (supporting), funding acquisition (lead); writing—review and editing (supporting). **Paul Kurdyak:** Investigation (supporting); writing—review and editing (supporting). **Scott T. Leatherdale:** Investigation (supporting); writing—review and editing (supporting). **Daniel T. Myran:** Investigation (supporting); writing—review and editing (supporting). **Jürgen Rehm:** Investigation (supporting); writing—review and editing (supporting). **Christine M. Wickens:** Investigation (supporting); writing—review and editing (supporting). **James MacKillop:** Funding acquisition (supporting); investigation (supporting); writing—review and editing (supporting). **Jillian Halladay:** Investigation (supporting); writing—review and editing (supporting).

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DECLARATION OF INTERESTS

J.M. is a principal in Beam Diagnostics. All other authors report no conflicts of interest.

DATA AVAILABILITY STATEMENT

The datasets analyzed for the current study are available under a data sharing agreement by contacting osduhs@camh.

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SUPPORTING INFORMATION

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

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