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Trends in youth cannabis use across cannabis legalization: Data from the COMPASS prospective cohort study

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ABSTRACT

Canada legalized recreational cannabis use for adults on October 17, 2018 with decision-makers emphasising the need to reduce cannabis use among youth. We sought to characterise trends of youth cannabis use before and after cannabis legalization by relying on a quasi-experimental design evaluating cannabis use among high school students in Alberta, British Columbia, Ontario, and Québec who participated in the COMPASS prospective cohort study. Overall trends in use were examined using a large repeat cross-sectional sample (n = 102,685) at two time points before legalization (16/17 and 17/18 school years) and one after (18/19 school year). Further differential changes in use among students affected by legalization were examined using three sequential four-year longitudinal cohorts (n = 5,400) of students as they progressed through high school. Youth cannabis use remains common with ever-use increasing from 30.5% in 2016/17 to 32.4% in 2018/19. In the repeat cross-sectional sample, the odds of ever use in the year following legalization were 1.05 times those of the preceding year (p = 0.0090). In the longitudinal sample, no significant differences in trends of cannabis use over time were found between cohorts for any of the three use frequency metrics. Therefore, it appears that cannabis legalization has not yet been followed by pronounced changes on youth cannabis use. High prevalence of youth cannabis use in this sample remains a concern. These data suggest that the Cannabis Act has not yet led to the reduction in youth cannabis use envisioned in its public health approach.

1. Introduction

Canada federally legalized recreational cannabis use for adults aged 18 or over (Bill C-45, An Act respecting cannabis and to amend the Controlled Drugs and Substances Act, the Criminal Code and other Acts, "Cannabis Act") on October 17, 2018 (Parliament of Canada, 2018). In laying the groundwork for this change, researchers and federal policy makers emphasised public health considerations, including the need to prevent harmful effects on cannabis use among youth (Spithoff et al., 2015). The importance of youth protection was subsequently highlighted in both the Cannabis Act via the first two stated purposes of the Act ["(a) to protect the health of young persons by restricting their access to cannabis; (b) to protect young persons and others from inducements to use cannabis" (1, pg. 6)], and by the Task Force on Cannabis Legalization, which noted that Canadian youth are more likely to use cannabis than their international peers as well as Canadian adults (Task Force on Cannabis Legalization and Regulation, 2016; UNICEF Office of Research, 2013; Grant and Bélanger, 2017). The adverse effects of cannabis use on developing brains and the fact that adult substance use trajectories are most often rooted in adolescence were likewise identified as factors to consider during the legalization process (Task Force on Cannabis Legalization and Regulation, 2016; Patte et al., 2017; Coffey and Patton, 2016; Melchior et al., 2017; Maggs et al., 2015; Volkow et al., 2014; Degenhardt et al., 2010; Macleod et al., 2004; Kalant, 2016; Ammerman and Tau, 2016).

Evidence on the effect of cannabis law liberalization on youth cannabis use has so far been mixed, and though many investigations have detected few harmful consequences others found that youth were

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adversely affected (Wen et al., 2015; Stolzenberg et al., 2016; Stevens, 2019; Goodman et al., 2020; Melchior et al., 2019; Castillo-Carniglia et al., 2020; Philbin et al., 2019; Ammerman et al., 2015; Shi et al., 2015; Williams and Bretteville-Jensen, 2014; Hasin et al., 2015; Cerdá et al., 2018, 2017; Choo et al., 2014; Schinke et al., 2017). Analysis of Canadian policy effects is further complicated by the lack of a comparison group. Uruguay is the only other country to have federally legalised recreational cannabis use, and though Portugal has broadly decriminalised drug use and only a minority of US states have not somewhat liberalised access to medical or recreational cannabis (Arie, 2013; van het Loo et al., 2002; National, 2020; State medical, 2020), policy approaches in most of these contexts have tended to be market-driven rather than informed by principles of public health (Watson and Erickson, 2019). Interpretation of the evidence has also been hampered by the recency of policy change and scientific evaluations as well as differences in methodological approaches (Midgette and Reuter, 2020; Johnson and Guttmannova, 2019).

In Canada, the 2018 National Cannabis Survey (NCS) found that a substantial proportion of youth and young adults (aged 15–24) intended to try cannabis or increase their use following legalization (Sandhu et al., 2019 Jun 14). There is also evidence that occasional cannabis use by youth rose after restrictions around medical cannabis access were loosened (Parker, 2000; Canada, 2016; Smith, 2015; Cox, 2018), prior to legalization (Zuckermann et al., 2019). Considering this extended timeline of possible cannabis policy changes, results from Canadian studies with insufficient pre-legalization time points may be biased. For instance, the NCS only commenced data collections in the first quarter of 2018, several years after medical cannabis access restrictions were first loosened (Statistics Canada, 2018 Apr). And though the NCS and the annual Canadian Cannabis Survey contain the most comprehensive measures on cannabis use in Canada, both are limited in terms of relevance to understanding youth cannabis use by the cross-sectional nature of the data collected and the exclusion of Canadians under 15 years of age (Canada and Survey, 2019; Statistics Canada, 2019). More longitudinal and youth-focused data will be essential in evaluating the short- and long-term effects of cannabis legalization.

COMPASS, a large prospective cohort study of secondary school students in Canada, has been collecting unique data on youth cannabis use since 2012 (Leatherdale et al., 2014). The study is therefore ideally placed to examine trends in cannabis use before and after legalization occurred. The objectives of the present work were to make use of the nationally unique data available in COMPASS to investigate the effects of cannabis legalization in Canada on cannabis use metrics among youth (ever use, current use, and frequency of use) using both repeat cross-sectional and longitudinal data in the context of a natural experiment evaluation.

2. Methods

2.1. Design

The COMPASS Study (COMPASS) is a prospective cohort study (2012–2021) designed to collect hierarchical and longitudinal data from a convenience sample of secondary school students in a sample of provinces in Canada (Leatherdale et al., 2014 Dec 8). Using active-information, passive-consent parental permission protocols, eligible consenting students completed the COMPASS questionnaire (Cq) during class time. The Cq is an anonymous, self-administered questionnaire with items based on national guidelines or surveillance tools as previously described (Cerdá et al., 2017; Schinke et al., 2017). All COMPASS procedures received ethics approval from the University of Waterloo Research Ethics Board (ORE 30118), as well as all participating school board review panels. A full description of the COMPASS study is available online (www.compass.uwaterloo.ca) and in print (Leatherdale et al., 2014).

The current study used a quasi-experimental design, relying on both repeat cross-sectional data to examine overall trends in use, and sequential cohort longitudinal data to examine the differential changes in use among students affected by legalization. The null hypothesis for natural experiment evaluation of an intervention is that the intervention had no effect. The repeat cross-sectional analysis relied on data from Time 1 in 2016–17 (T1; Year 5, baseline 2 years pre-legalization), Time 2 in 2017–18 (T2; Year 6, baseline immediately pre-legalization), and Time 3 in 2018–19 (T3; Year 7, post-legalization). All Year 7 data collections took place after October 17, 2018, post-implementation of Bill C-45. The longitudinal analysis relied on data from three cohorts staring in 2013–14 with Cohort 1 (C1; grade 9 in 2013–14, not impacted by legalization), followed by Cohort 2 (C2; grade 9 in 2014–15, graduating just before legalization) and Cohort 3 (C3; grade 9 in 2015–2016, impacted by legalization during grade 12 in 2018–19). Evaluating the impact of the Cannabis Act implementation is challenging due to the lack of a non-exposed control group (Leatherdale, 2019). Given available data, our quasi-experimental evaluation using a longitudinal cohort-control pre-post approach (Shadish et al., 2002) was the strongest design and included repeat cross-sectional data pre-post legalization to help triangulate the longitudinal results.

2.2. Sample

The repeat cross-sectional sample consisted of 76 schools in Alberta (n = 7), British Columbia (n = 3), Ontario (n = 55) and Québec (n = 11) that consistently participated in three years of COMPASS study pre-post legalization. Data from students in grades 9–12 in Alberta, British Columbia, and Ontario and students in Secondary 3–5 in Québec (equivalent to grades 9–11) at three time points (T1 n = 36,045; T2 n = 35,825; T3 n = 35,250) were used. Participation rate among eligible students was 77.5% in 2016–17, 81.8% in 2017–18, and 84.2% in 2018–19. Longitudinal cohort student data from students in grade 9 in their baseline year (C1 n = 1,916; C2 n = 1,875; C3 n = 1,868) were collected in COMPASS years 2–7 (school years 2013/14 to 2018/19) at schools in Alberta (n = 3) and Ontario (n = 46). Longitudinal student data are obtained through an anonymous linking process using a self-generated identification code which allows matching of student responses over time described in detail in COMPASS technical reports (Battista et al., 2019; Qian et al., 2015). The cohorts included the subsets of students in grade 9 in their baseline year who were successfully linked across four consecutive years.

2.3. Measures

Students provided demographic information on grade (ON/AB/BC: 9, 10, 11, 12; QC: Secondary 3, 4, 5), gender (female, male), ethnicity (Asian, Black, Hispanic, White, Other/Mixed) and weekly spending money (none, $1-$20, $21-$40, $41-$100, more than $100, don't know), which is a proxy for socioeconomic status. Participants were asked "In the last 12 months, how often did you use marijuana or cannabis? (a joint, pot, weed, hash)". Response options included "I have never used marijuana", "I have used marijuana but not in the last 12 months", and frequency options ranging from "Less than once a month" to "Every day". Cannabis *ever-use* was defined as any previous cannabis use and *current use* as use of at least "once a month" or more frequent. Among cases classified as *ever-use*, *regular use* was defined as use that occurred at least "once a week" or more frequently and *occasional use* was defined as use occurring "1 to 3 times a month" or less often.

2.4. Statistical analysis

For the repeat cross-sectional analysis, 4.1% of students with missing values for any measures were excluded from the analysis, resulting in a final sample of 34,416 students at T1, 34,470 students at T2, and 33,799 students at T3. A summary of missing responses is provided in Supplementary Table 2. Higher rates of missing cannabis use frequency data

were observed for males and minority ethnicities; however, given the low overall rate of missingness (<5%), any potential bias due to missing data is expected to be limited and imputation methods may only have negligible impacts on bias reduction (Schafer, 1999; Dong and Peng, 2013; Jakobsen et al., 2017). Using the complete case sample, cannabis use frequency trends over time were examined by grade, gender, and province. Logistic regression was performed using generalized estimating equations (GEE) with binomial distribution and logit link function to examine differences in population-average odds of cannabis use while accounting for school-level clustering. A working exchangeable log odds ratio correlation structure was used; however, GEE methods are robust to the misspecification of the covariance structure (Fitzmaurice et al., 2008). The odds of *ever use* (Model 1) and *current use* of cannabis among all students (Model 2), and the odds of *regular use* among those who indicated *ever use* of cannabis (Model 3) were examined by year, controlling for grade, gender, province, ethnicity, and spending money. T2 (2017–18) was chosen as the reference year as it served as a separation between students unaffected by the (run-up to) legalization and students affected by it, allowing a direct comparison of pre- and post-legalization years. Additional models with year interactions for grade, gender, and province were tested to examine potential differential trends. No meaningful interactions were found (results not presented) and these were therefore excluded from the final models.

In the longitudinal analysis, 4.6% of students with missing values for any measures were excluded from the analysis, resulting in a final sample of 1,825 students in Cohort 1 (C1), 1,786 students in Cohort 2 (C2), and 1,789 students in Cohort 3 (C3). A summary of missing responses is provided in Supplementary Table 1. Consistent with previous findings (Qian et al., 2015), baseline cannabis use was less prevalent among students who were successfully linked than among those who were not. Using the complete case sample, chi-square tests were used to examine differences in baseline characteristics by cohort. Logistic regression was performed using GEE with binomial distribution and logit link function to examine differences in population-average odds of cannabis use while accounting for within-student correlation of responses. GEE (i.e. marginal) models were chosen over random- and fixed-effects approaches in alignment with the objective of examining overall population-averaged effects (Fitzmaurice et al., 2011; Gunasekara et al. Feb, 2014). The resulting coefficients of GEE models provide a population-level interpretation appropriate when examining between-student variables such as cohort differences (Fitzmaurice et al., 2011). A working exchangeable correlation structure was used (Fitzmaurice et al., 2011). The odds of *ever use* (Model 4) and *current use* of cannabis among all students (Model 5), as well as the odds of regular use among those who indicated *ever use* of cannabis (Model 6) were examined by cohort and grade, controlling for gender, province, ethnicity, and spending money. Analogously to the cross-sectional analyses, C2 (baseline 2014–15) was chosen as the reference cohort to facilitate comparison of pre- and post-legalization grade 12 time points. Grade interactions with cohort were included to examine the differential increase in odds of use by cohort. Further cohort and grade interactions with gender were tested but found to have no meaningful interactions (results not presented) and were therefore excluded from the final models. Statistical analyses were conducted in SAS 9.4.

3. Results

3.1. Sample characteristics

The repeat cross-sectional sample of high school students examined

Table 1
Demographic and cannabis use characteristics of two samples of youth taking part in COMPASS who attended high school (grades 9–12) between 2013 and 14 and 2018–19 (Canada).

n (%)	Repeat cross-sectional sample				Longitudinal sample[†]			
	Time 1 2016–17 n = 34 416	Time 2 2017–18 n = 34 470	Time 3 2018–19 n = 33 799	Chi-square test p-value	Cohort 1 2013–14 n = 1 825	Cohort 2 2014–15 n = 1 786	Cohort 3 2015–16 n = 1 789	Chi-square test p-value
Gender								
Female	17 212 (50.0)	17 374 (50.4)	16 963 (50.2)	0.5886	989 (54.2)	973 (54.5)	943 (52.7)	0.5226
Male	17 204 (50.0)	17 096 (49.6)	16 836 (49.8)		836 (45.8)	813 (45.5)	846 (47.3)	
Grade								
9	9 487 (27.6)	9 664 (28.0)	9 613 (28.4)	0.0450	1 825	1 786	1 789	–
10	9 697 (28.2)	9 492 (27.5)	9 323 (27.6)		"	"	"	
11	8 726 (25.4)	8 943 (25.9)	8 552 (25.3)		"	"	"	
12	6 506 (18.9)	6 371 (18.5)	6 311 (18.7)		"	"	"	
Province								
Alberta	2 378 (6.9)	2 322 (6.7)	2 380 (7.0)		64 (3.5)	62 (3.5)	66 (3.7)	
British Columbia	1 795 (5.2)	2 187 (6.3)	2 145 (6.3)	< 0.0001	–	–	–	0.9311
Ontario	26 747 (77.7)	26 616 (77.2)	25 756 (76.2)		1761 (96.5)	1724 (96.5)	1723 (96.3)	
Québec	3 496 (10.2)	3 345 (9.7)	3 518 (10.4)		–	–	–	
Cannabis use[§]								
Never	23 929 (69.5)	23 575 (68.4)	22 841 (67.6)	< 0.0001	1 700 (93.2)	1 668 (93.4)	1 687 (94.3)	0.9261
Not in past 12 months	1 677 (4.9)	1 584 (4.6)	1 464 (4.3)		35 (1.9)	29 (1.6)	30 (1.7)	
Less than once a month	3 355 (9.7)	3 661 (10.6)	3 791 (11.2)		42 (2.3)	44 (2.5)	39 (2.2)	
1–3 times a month	2 235 (6.5)	2 378 (6.9)	2 410 (7.1)		24 (1.3)	22 (1.2)	16 (0.9)	
1–6 times a week	1 890 (5.5)	1 940 (5.6)	2 045 (6.1)		17 (0.9)	17 (1.0)	14 (0.8)	
Every day	1 330 (3.9)	1 332 (3.9)	1 248 (3.7)		7 (0.4)	6 (0.3)	3 (0.2)	
Derived categories of use								
Ever use	10 487 (30.5)	10 895 (31.6)	10 958 (32.4)	-[¶]	125 (6.8)	118 (6.6)	102 (5.7)	-[¶]
Current use	5 455 (15.9)	5 650 (16.4)	5 703 (16.9)		48 (2.6)	45 (2.5)	33 (1.8)	
Occasional use[‡]	7,267 (21.1)	7 623 (22.1)	7 665 (16.9)		101 (5.5)	95 (5.3)	85 (4.8)	
Regular use[‡]	3 220 (9.4)	3 272 (9.5)	3 293 (9.7)		24 (1.3)	23 (1.3)	17 (1.0)	

[†] Characteristics at grade 9 reported with the listed school year indicating baseline. Complete case sample. Cohort 1/2/3 represent students who participated in COMPASS in grade 9 in 2013–14/2014–15/2015–16 respectively and continued to participate all three subsequent grades (10to12). [§] Counts reflect a pooled sample in the cross-sectional analysis and grade 9 baseline in the longitudinal analysis. [‡] Percentages indicate proportion of ever use. [¶] As derived categories of use are not mutually exclusive or exhaustive, no chi-square p-value is given.

was equally split in terms of gender with more than three quarters attending school in Ontario (Table 1). Most students did not report using cannabis, though the proportion of ever-use increased slightly over time from 30.5% at T1 (2016–17) to 32.4% at T3 (2018–19). Current use also increased between T1 and T3 (from 15.9% to 16.9%) among student who has ever used cannabis, the proportion using regularly remained flat (30.7% to 30.1%). Among the three cohorts in the longitudinally linked sample, female students were slightly overrepresented at baseline with between 52.7% and 54.5%. This sample was drawn only from Alberta and Ontario with more than 95% of students attending school in the latter province. Never-use of cannabis in grade 9 increased from 93.6% in C1 to 94.3% in C3, though chi-square tests revealed no significant differences in baseline sample characteristics between cohorts.

3.2. Cross-sectional analyses

Trends in cannabis use by gender, grade and province are presented in Fig. 1. Exploration of time trends in the repeat cross-sectional sample showed that cannabis ever use increased slightly over time. GEE modelling revealed that, after controlling for sociodemographic factors, the adjusted odds of cannabis ever use in the year following legalization of recreational cannabis use (T3: 2018–19) were 1.05 higher than those of the preceding year (T2: 2017–18; $p = 0.0090$) (Table 2; Model 1). There was no statistically significant difference in the odds of current use before and after legalization (AOR 1.04, $p = 0.0703$; Model 2) or the odds of regular use among those who had ever used (AOR 1.00, $p = 0.9857$; Model 3). Consistent with the trends seen in Fig. 1, male students and students in higher grades had significantly higher odds of reporting cannabis ever and current use. Among students reporting ever use, male participants had higher odds of regular use, while no statistically significant differences in odds of use were seen by grade. Compared to participants in Alberta, who reported the highest proportion of all types of use investigated, students in Québec and British Columbia were significantly less likely to report regular cannabis use. However, there were no statistical differences between these provinces in the odds of ever or current use. Students in Ontario were no more likely than those in Alberta to report ever, current, or regular cannabis use.

3.3. Longitudinal analyses

Trends in overall cannabis use and cannabis use by gender are presented in Fig. 2. Grade 12 in cohort three represents the only post-legalization time point. Overall, differences in trends between cohorts appeared minor. Among male students in cohort 3, ever and current use appeared to increase more steeply between grades 11 and 12 than in the earlier two cohorts. In addition, among those who had indicated ever use of cannabis, regular use among male students in cohort 3 rose consistently between grades 9 and 12. GEE modelling showed no significant differences over time/grade between cohorts in the odds of ever or current cannabis use, or of regular use among cases of ever use (Table 3). Here, male students had higher odds of current and regular use than female students but did not differ in terms of ever-use. A pronounced increase in the odds of ever and current use was seen as students progressed from grade 9 to grade 12 (Models 4 and 5), with a more modest but nonetheless significant increase in odds of regular use among cases of ever use in grades 11 and 12 (Model 6). AORs for the grade 12 interaction terms for cohort 3 (representing the multiplicative increase in odds of use in the post-legalization period) were 1.20 (95% CI 0.91, 1.58) for ever use, 1.44 (95%CI 0.91, 2.28) for current use, and 1.60 (95% CI 0.29, 3.26) for regular use. All were non-significant at the $\alpha = 0.05$ level.

4. Discussion

Considering a core objective of the Act is to prevent cannabis use and access among youth (Parliament of Canada, 2018), our longitudinal and cross-sectional results suggest that the Cannabis Act has not yet led to significant declines in youth cannabis use. The repeat cross-sectional analysis showed that cannabis ever use was significantly lower in the year before and significantly higher in the year after legalization compared to the year in which it took place, though this does not appear to have translated to a change in regular use. This result is in line with pre-legalization cannabis use trends observed by the authors in a similar sample, which showed an increase in occasional but not regular use starting several years prior to legalization (Zuckermann et al., 2019). As only a minority of adolescents who try cannabis proceed to use regularly (Schaub et al., 2010; Pérez et al., 2010; Legleye et al., 2016; Perkonigg et al., 1999), these results may similarly indicate increased experimentation without progression into regular use. Further, the longitudinal analysis found no difference between the oldest and youngest cohorts, the latter of which included data from the only post-legalization time point. This suggests that levels of ever use post-legalization are in line with cohort-specific trends. However, the high prevalence of cannabis use in this sample remains a cause for concern and suggests that, to date, the Cannabis Act has not slowed or reversed concerning trends in youth cannabis use.

Among the results presented are indications that the situation may continue to develop and therefore require future monitoring. Indeed, a previous investigation of cross-national trends found that the association between cannabis liberalisation and regular cannabis use among youth was only significant once five years had passed since the policy change (Shi et al., 2015). Here, use measures reported by male youth rose more steeply between grades 11 and 12 in cohort 3 than in the other cohorts. Male youth engage in more substance use than their female peers (Toci et al., 2014; Horwood et al., 2010; ter Bogt et al., 2014; Sussman and Dent, 2004; Zuckermann et al., 2020, 2019), so it is possible that this rise may be more pronounced, or appear earlier, in forthcoming cohorts, or that population subgroups at varying levels of existing risk are differentially affected. Alternatively, female students may simply lag male students in this trend. A potential explanation may be found in evidence that female youth appear more affected by stigma associated with drug use (Haines-Saah et al., 2014) and by drug law liberalization (Shi et al., 2015) and may therefore eventually either increase their cannabis use or decrease associated underreporting following the social normalization of cannabis use (Duff and Erickson, 2014; Brochu et al., 2011; Kolar et al., 2018; Duff et al., 2012; Parker et al., 2002; Parker, 2005). Female youth are also more likely to use alternative cannabis products, such as edibles, which are more prevalent in areas with liberal cannabis laws and whose production and sale has only recently been permitted in Canada (Goodman et al., 2020; Canada, 2016; Cuttler et al., 2016; Friese et al., 2016; Borodovsky et al., 2016, 2017; Knapp et al., 2019; Government of Canada, 2018). In this subpopulation, an increase in use of alternative forms of cannabis may bring with it more frequent use overall.

Several provincial differences were also found. In the repeat cross-sectional model, students in Québec and British Columbia were significantly less likely to report regular use than students in Alberta. In the longitudinal model, Alberta students also had significantly higher odds than Ontario students of reporting regular use. Some of these differences may have partially been due to sample composition, though others, such as the low rate of regular use in Québec, are supported by evidence gathered at the federal level (Rotermann, 2020; Statistics Canada, 2020). All COMPASS Alberta schools are situated outside of large urban centres and there is some evidence that rural youth are at higher risk of substance use though this effect is not universal (Rose et al., 2018; Smith et al., 2008; Nargiso et al., 2015; Lambert et al., 2008). Alberta also has a very high density of cannabis retailers (2.0 per 100,000 population compared to 0.5 or lower for British Columbia, Ontario, and Québec) which may reflect higher levels of and/or contribute to normalisation (Myran et al., 2019; Statistics Canada, 2019; Pennay and Measham, 2016; Sznitman and Taubman, 2016). Taken in combination with

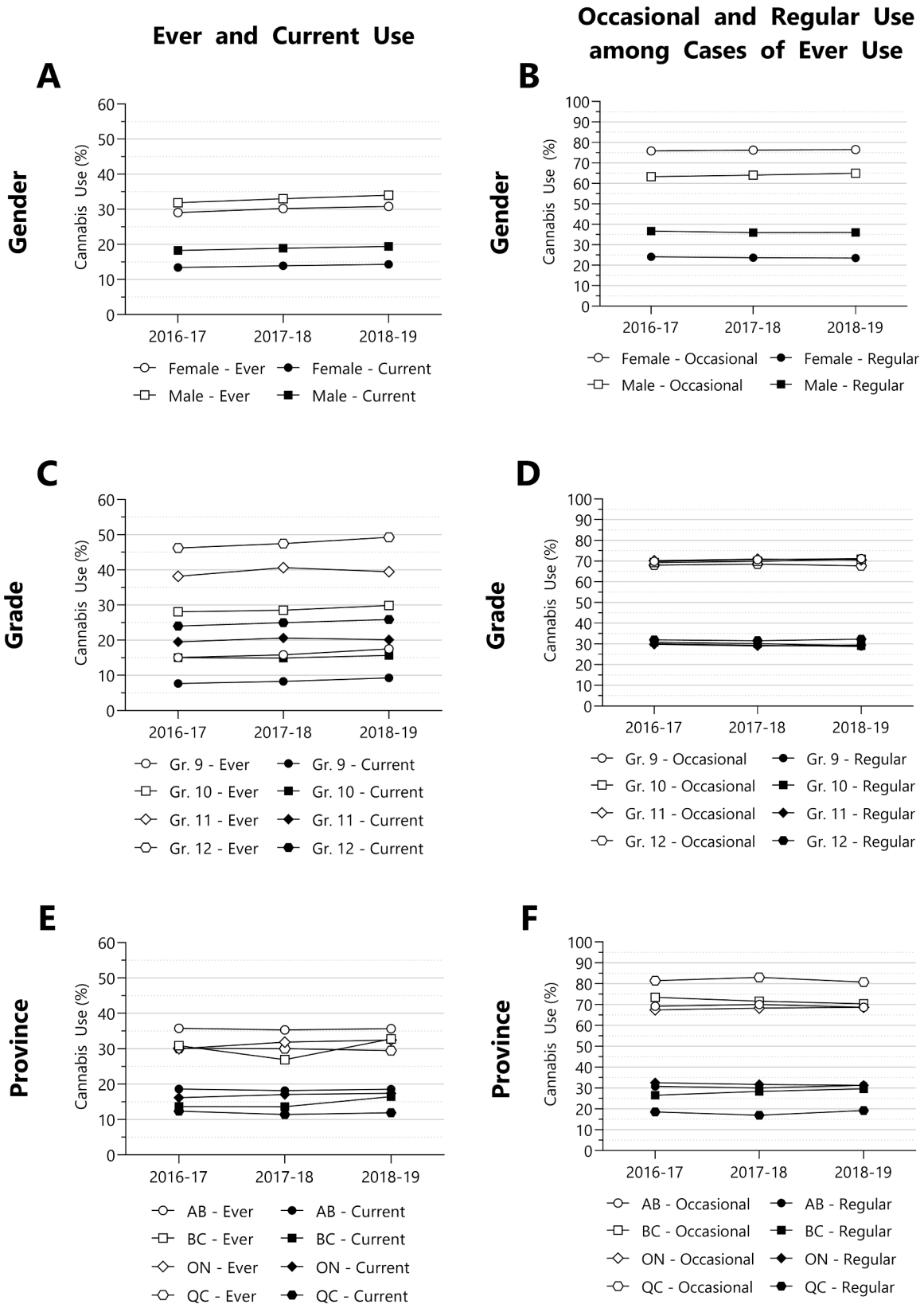

Fig. 1. Cannabis use among three longitudinal cohorts of high school students who were attending grades 9–12 in Alberta (AB) and Ontario (ON) and taking part in COMPASS (Canada) starting at grade 9 in the 2013-14 (Cohort 1; C1), 2014-15 (Cohort 2; C2), and 2015/16 (Cohort 3; C3) school years. Students reported cannabis ever use (any previous use), current use (once a month or more often). Among students indicating ever use, frequency of use is differentiated by occasional use (up to three times a month) and regular use (once a week or more often).

Table 2
GEE model results for repeat cross-sectional analysis of cannabis ever-use, current use, and regular use among cases of ever use among high school students taking part in COMPASS (Canada) at two time points (T1, T2) prior to and one (T3) following recreational cannabis legalization.

Repeat cross-sectional analysis	Model 1 Ever use *vs* never-use *(ref)* n = 102 685		Model 2 Current use *vs* ever- and never-use *(ref)* n = 102 685		Model 3 Regular use *vs* occasional use *(ref)* n = 32 340	
	AOR (95% CI)	p	AOR (95% CI)	p	AOR (95% CI)	p
Time						
T1 (2016–17)[†]	0.94 (0.89, 0.99)	0.0107	0.96 (0.91, 1.01)	0.1163	1.04 (0.97, 1.12)	0.2759
T2 (2017–18) *(ref)*[‡]						
T3 (2018–19)	1.05 (1.01, 1.08)	0.0090	1.04 (1.00, 1.09)	0.0703	1.00 (0.93, 1.07)	0.9857
Gender						
Female *(ref)*						
Male	1.13 (1.08, 1.19)	<0.0001	1.41 (1.33, 1.49)	<0.0001	1.77 (1.66, 1.90)	<0.0001
Province						
Alberta *(ref)*						
British Columbia	0.95 (0.68, 1.33)	0.7539	0.87 (0.62, 1.20)	0.3895	0.93 (0.79, 1.11)	0.4331
Ontario	0.90 (0.72, 1.13)	0.3758	0.95 (0.76, 1.18)	0.6341	1.07 (0.93, 1.23)	0.3518
Québec	0.98 (0.73, 1.32)	0.9016	0.72 (0.55, 0.94)	0.0175	0.56 (0.46, 0.69)	<0.0001
Grade						
9 *(ref)*						
10	1.96 (1.86, 2.08)	<0.0001	1.81 (1.69, 1.95)	<0.0001	1.04 (0.94, 1.14)	0.4557
11	2.89 (2.71, 3.09)	<0.0001	2.30 (2.13, 2.50)	<0.0001	1.00 (0.90, 1.10)	0.9208
12	3.98 (3.69, 4.30)	<0.0001	2.84 (2.60, 3.10)	<0.0001	1.01 (0.92, 1.12)	0.7864

[†] indicates school year of data collection. Samples comprise all students without missing variables participating in COMPASS in a given school year. [‡] T2 was chosen as the reference year to facilitate comparison between students unexposed to the cannabis legalization process and those who were directly exposed. All models controlled for ethnicity, spending money and school-level clustering.

differing approaches to cannabis distribution and age restrictions (Government of Canada, 2020), as well as less tangible factors such as public health efforts, it is likely that provincial differences in youth cannabis use with persist and potentially become more pronounced over time.

Continuing investigations will be required to track changes in youth cannabis use over time. In addition to the initial step of legalization, which itself followed liberalization of access to medical cannabis (Parker, 2000; Canada, 2016; Smith, 2015; Cox, 2018), further changes to regulations concerning topics such as alternative forms of cannabis or retail approaches are likely. The complexity of a developing regulatory landscape will be compounded by provincial differences in cannabis control, population demographics, and public health support. Future work must therefore not only characterise youth cannabis use overall, but also investigate how it is affected by individual, community, and provincial factors, including prevention and harm reduction programs, as recreational cannabis use becomes embedded in Canadian society.

4.1. Strengths and limitations

COMPASS benefits from several strengths, including prospective design, validated measures, large sample size, and extensive longitudinal data from the pre-legalization period (Leatherdale et al., 2014). However, self-reports of cannabis use may be affected by recall and social desirability biases, leading to potential underreporting of cannabis use (Haines-Saah et al., 2014). In addition, youth who use cannabis regularly are more likely to skip class or drop out (Stiby et al., 2015; Roebuck et al., 2004) and therefore miss data collection dates. This could result in further underestimations of cannabis use, particularly in the longitudinal sample. To reduce these biases, COMPASS relies on an active-information, passive-consent approach which produces more representative samples and leads to robust estimations of risk behaviours among youth (Thompson-Haile et al., 2013; Hollmann and McNamara, 1999; Rojas et al., 2008; White et al., 2004). As COMPASS schools form a convenience sample, generalizability of results is limited. However, high rates of participation (between 77.5% and 84.2% in the cross-sectional sample) and the large sample size suggest results will nevertheless be applicable to a substantial proportion of Canadian youth.

5. Conclusion

Recreational cannabis legalization has not been followed by the slowing or reversing of concerning trends in youth cannabis use, suggesting that, so far, the Cannabis Act has not yet led to the benefits for youth envisioned in adopting a public health approach to legalisation. Further monitoring will be essential in characterising its longer-term effects as well as to track impacts of additional regulatory changes.

6. Data sharing

COMPASS data are available to researchers upon successful completion of a data usage application. More information is available online at https://uwaterloo.ca/compass-system/information-researchers.

Ethical approval

All COMPASS procedures received ethics approval from the University of Waterloo Research Ethics Board (ORE 30118), as well as all participating school board review panels.

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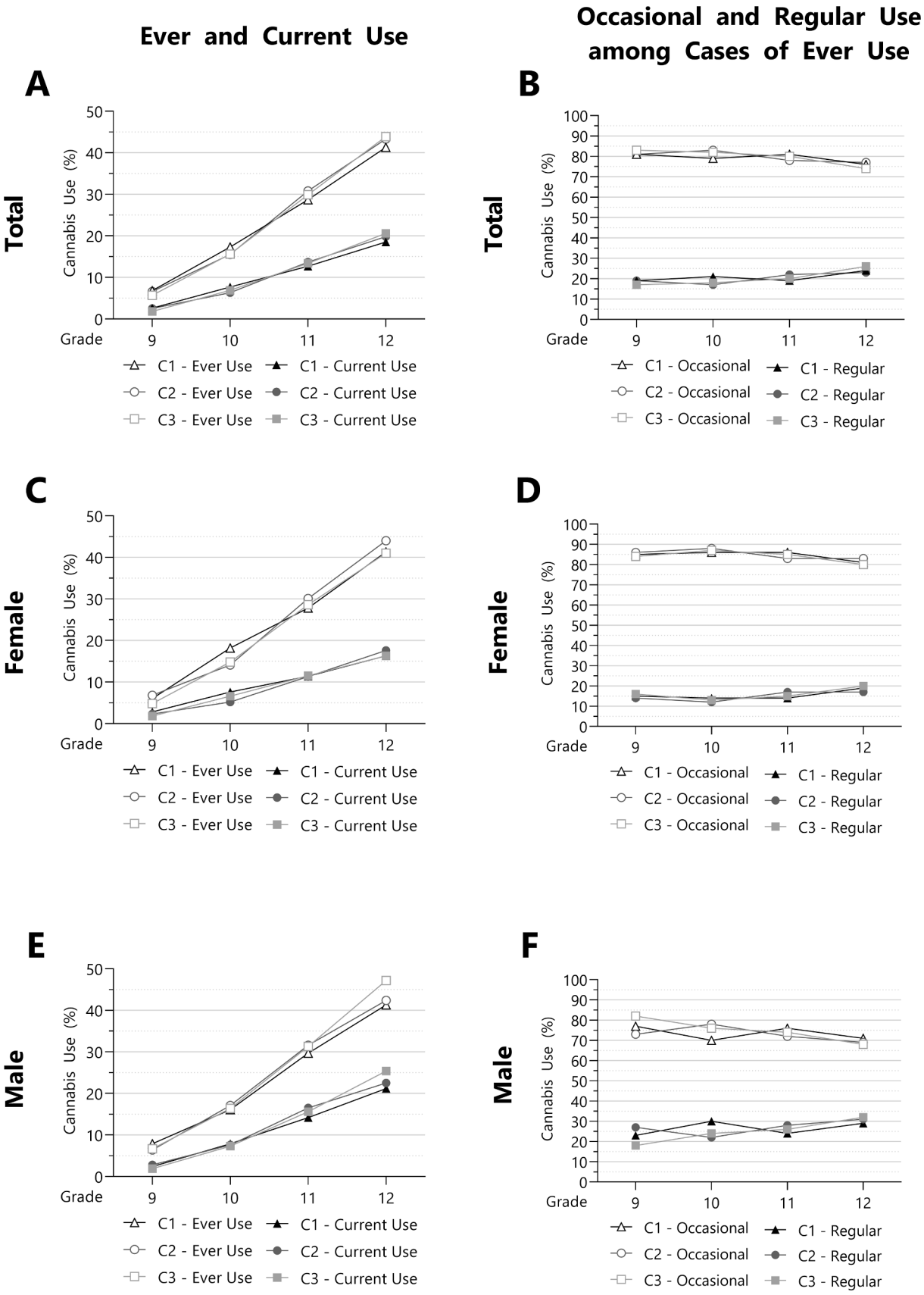

Fig. 2. Cannabis use among three longitudinal cohorts of high school students who were attending grades 9-12 in Alberta (AB) and Ontario (ON) and taking part in COMPASS (Canada) starting at grade 9 in the 2013-14 (Cohort 1; C1), 2014-15 (Cohort 2; C2), and 2015/16 (Cohort 3; C3) school years. Students reported cannabis ever use (any previous use), current use (once a month or more often). Among students indicating ever use, frequency of use is differentiated by occasional use (up to three times a month) and regular use (once a week or more often).

Table 3
GEE model results for longitudinal analysis of cannabis ever-use, current use, and regular use among cases of ever use for three cohorts of high school students taking part in COMPASS (Canada) at four consecutive time points starting in a given baseline year. Students in two cohorts (C1, C2) graduated prior to legalization, students in the third (C3) attended grade 12 in the year following legalization.

Longitudinal analysis	Model 4 Ever use *vs* never-use (*ref*) n = 5 400		Model 5 Current use *vs* ever- and never-use (*ref*) n = 5 400		Model 6 Regular use *vs* occasional use (*ref*) n = 2 446	
	AOR (95% CI)	p	AOR (95% CI)	p	AOR (95% CI)	p
Cohort						
C1 (2013–14)†	1.02 (0.79, 1.32)	0.8855	1.03 (0.68, 1.55)	0.8919	0.93 (0.52, 1.65)	0.8048
C2 (2014–15) *(ref)*						
C3 (2015–16)	0.85 (0.64, 1.12)	0.2426	0.72 (0.46, 1.14)	0.1632	0.64 (0.32, 1.28)	0.2058
Gender						
Female *(ref)*						
Male	1.07 (0.97, 1.19)	0.1849	1.46 (1.29, 1.66)	<0.0001	1.50 (1.30, 1.71)	<0.0001
Grade						
9 *(ref)*						
10	2.60 (2.21, 3.07)	<0.0001	2.63 (1.97, 3.51)	<0.0001	1.19 (0.76, 1.85)	0.4430
11	6.44 (5.39, 7.70)	<0.0001	6.22 (4.65, 8.31)	<0.0001	1.70 (1.13, 2.55)	0.0108
12	11.19 (9.29, 13.48)	<0.0001	9.78 (7.27, 13.17)	<0.0001	1.96 (1.30, 2.96)	0.0014
Cohort 1 * Grade						
9 *(ref)*						
10	1.10 (0.87, 1.39)	0.4321	1.18 (0.80, 1.76)	0.4018	1.38 (0.75, 2.55)	0.2998
11	0.86 (0.67, 1.11)	0.2499	0.87 (0.58, 1.31)	0.5199	1.03 (0.57, 1.88)	0.9127
12	0.88 (0.68, 1.14)	0.3317	0.87 (0.58, 1.32)	0.5196	1.02 (0.56, 1.86)	0.9401
Cohort 3 * Grade						
9 *(ref)*						
10	1.18 (0.93, 1.51)	0.1699	1.51 (0.97, 2.37)	0.0682	1.68 (0.81, 3.50)	0.1655
11	1.12 (0.86, 1.46)	0.3926	1.34 (0.85, 2.11)	0.2039	1.51 (0.74, 3.09)	0.2541
12	1.20 (0.91, 1.58)	0.1874	1.44 (0.91, 2.28)	0.1188	1.60 (0.79, 3.26)	0.1946

† indicates school year at baseline when participating students were attending grade 9. Samples comprise only students participating in COMPASS in all four grades from grade 9 to 12. ‡ C2 was chosen as the reference cohort to facilitate comparison between students unexposed to the cannabis legalization process and those who were directly exposed. All models controlled for province, ethnicity, spending money and student-level clustering. AORs for main effects can be interpreted as the increased risk when all other variables held at their reference levels. AORs for interaction terms represent the multiplicative increase in risk among the corresponding non-reference categories.

CRediT authorship contribution statement

Alexandra M.E. Zuckermann: Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Visualization. **Katelyn V. Battista:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Visualization, Project administration. **Richard E. Bélanger:** Conceptualization, Methodology, Writing - review & editing, Supervision, Project administration, Funding acquisition. **Slim Haddad:** Conceptualization, Methodology, Writing - review & editing, Supervision, Project administration, Funding acquisition. **Alexandra Butler:** Conceptualization, Writing - original draft, Writing - review & editing, Project administration. **Mary Jean Costello:** Conceptualization, Methodology, Writing - review & editing, Funding acquisition. **Scott T. Leatherdale:** Conceptualization, Methodology, Resources, Writing - review & editing, Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

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

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2021.101351.

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