Bidirectional associations between cannabis, e-cigarette, and cigarette use among Canadian youth: findings from the COMPASS Study

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ABSTRACT

Substance use behaviours have been found to cluster in youth, and cannabis use has been previously linked to tobacco and e-cigarette use. The objective of the current study was to examine the bidirectional associations between cannabis, e-cigarette, and cigarette use among a large sample of Canadian secondary school students. A sample of students in grades 9–11 (n = 14,652) from Ontario and Alberta, Canada who participated in two waves of the COMPASS Study (Time 1 (T1): 2015–2016; Time 2 (T2): 2016–2017) was identified. Autoregressive cross-lagged models investigated the stability of product use between T1 and T2, as well as the bidirectional associations between current cannabis, e-cigarette, and cigarette use while controlling for demographic covariates. Significant autoregressive and bidirectional associations between all three substances were observed. Students who reported using cigarettes and e-cigarettes at T1 were more likely to report using cannabis at T2. Similarly, students who reported using cannabis at T1 were more likely to report using cigarettes and e-cigarettes at T2. Given the bidirectional associations identified between cannabis, e-cigarette, and cigarette use in this research, continued monitoring of evolving policies related to cannabis and e-cigarette use in Canada is needed. Additionally, school and community-based prevention efforts targeting youth should consider addressing poly-substance use.

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1. Introduction

Youth in Canada is consistently ranked among the world’s most prevalent and youngest consumers of cannabis (Currie et al., 2012). Approximately one-third of Canadian youth report having tried cannabis at least once by the age of 15 years (Health Canada, 2018). High prevalence rates of cannabis use among Canadian youth may be attributable to cultural and social normalization, beliefs about cannabis not being harmful where youth perceive use as low-risk, perceived medical benefits, and acceptability and availability of cannabis (McKiernan & Fleming, 2017; Zuckermann, Battista, et al., 2019). Existing literature suggests that early cannabis exposure during adolescence poses risk for adverse psychological effects that are largely attributable to heightened susceptibility of the developing brain (Chadwick et al., 2013; Giedd et al., 1999; Lenroot & Giedd, 2006). Amidst increasing social acceptability and normalization of the use of cannabis for non-medicinal purposes (Carliner et al., 2017; Duff & Erickson, 2014), the Canadian federal government legalized the controlled sale of cannabis for recreational use by adults (e.g. 18 years or older) in October 2018 (Government of Canada, 2018). Beyond increases in cannabis use itself, there is also concern that changes in the perceptions, prevalence, patterns, and alternative modes of cannabis use post-legalization may affect youths’ propensity to use other substances (Doggett et al., 2021; Kelsall, 2017).

Over the past two decades, cigarette smoking rates among youth have decreased substantially (Levy et al., 2019; Reid et al., 2019). While social acceptability of tobacco use has declined in Canada (Asbridge et al., 2016), the use of electronic vaping devices (commonly referred to as e-cigarettes), initially intended as a nicotine delivery system for adults seeking to quit smoking, has increased rapidly among youth (Hammond et al., 2019; Reid et al., 2019). While the recent outbreak of fatal lung disease due to contaminants found in THC vaping oils and reports of acute toxicity to nicotine associated with vaping (Grégoire, 2019; Hammond, 2019), researchers argue that the development of nicotine dependence through vaping among youth may increase susceptibility to use cigarettes (Aleyan et al., 2018; Levy et al., 2019) and cannabis (Chadi et al., 2019; Dai et al., 2018). Considering the evolving nicotine market in Canada and the increase in the use of e-cigarette and vaping products by youth, further examination of changes in other substance use behaviours, such as cannabis, is needed.
Concurrent use is defined as using multiple substances separately within a given time period (Hernández-Serrano et al., 2018). Concurrent use of cannabis and tobacco products is common among youth (Amos et al., 2004; Audrain-McGovern et al., 2018). Both nicotine and cannabis have been found to enhance the rewarding effects that each substance produces, ultimately increasing the risk of addiction (Balero et al., 2004; Rabin & George, 2015; Tucker et al., 2019) as well as difficulties in cessation attempts (Moore & Budney, 2001). Existing research suggests that concurrent use of cannabis and nicotine-containing tobacco products may further promote dependence (Rabin & George, 2015; Ream et al., 2008), as withdrawal symptoms may be more severe (Vandrey et al., 2008). Most of the existing research has been focused on cannabis use and combustible tobacco products; in recent years, e-cigarette use among youth has increased (Cullen et al., 2018) and is correlated with higher rates of cannabis use (Chadi et al., 2019); as such, there is a need to explore the directionality of associations between e-cigarettes and cannabis use.

Changing perceptions and increasing acceptability of cannabis use (Carliner et al., 2017; Duff & Erickson, 2014) (e.g. as a result of federal legalization of cannabis in Canada) has raised concerns regarding the implications the policy change may have on population health and wellbeing. Therefore, developing a deeper understanding of Canadian youth cannabis use is relevant and timely. While recent research has demonstrated bidirectional associations between tobacco and e-cigarette use (Aleyan et al., 2019; Bold et al., 2018; East et al., 2018), to our knowledge, there are no data examining the directionality of cannabis use and e-cigarettes. Given the legalization of cannabis across Canada in 2018, as well as the changing contexts of cannabis and tobacco product use, research is needed to examine the interrelationships among cannabis, e-cigarette, and cigarette use among youth to inform ongoing changes to substance use policy in Canada. Investigating any existing associations between cannabis use and other substance use behaviours before the legalization of cannabis is needed in order to evaluate whether relationships evolve in response to this policy change. As such, the objective of this study was to examine the bidirectional associations between (1) current cannabis and cigarette use and (2) current cannabis and e-cigarette use among a large sample of Canadian secondary school students in the COMPASS Study before recreational cannabis was legalized in Canada. Considering that Canadian youth are among the most prevalent cannabis users globally (Currie et al., 2012), and that youth substance use behaviours tend to be highly correlated (Bailey, 1992; Jackson et al., 2012; Mills & Noyes, 1984), we hypothesize that all substance use pathways will be reciprocal and that cannabis use will be more predictive of both cigarette and e-cigarette use than the contrariwise relationships examined in this study (Rabin & George, 2015; Ream et al., 2008).

2. Materials and methods

2.1. Sample selection

The COMPASS Study (2012–2021) was designed to evaluate the impact of changes in programs, policies, and the built environment on youth health behaviors over time (Leatherdale et al., 2014). The current study used linked, longitudinal data from secondary school students participating in two waves of the COMPASS Study (Time 1 (T1): 2015–2016; Time 2 (T2): 2016–2017). Schools were purposefully recruited using an active-information passive-consent permission protocol where all eligible students whose parent(s) or guardian(s) did not withdraw their child were eligible to participate (Thompson-Haile et al., 2013). Students could decline or withdraw themselves from the study at any time during the consent process or during the data collection (Leatherdale et al., 2014). Researchers may access COMPASS data by completing an online application form (https://uwaterloo.ca/compass-system/information-researchers). All COMPASS procedures received ethics approval from the University of Waterloo Research Ethics Board (ORE: 30118) and all participating school boards. A full description of the COMPASS Study and its methods can be found elsewhere in print (Leatherdale et al., 2014) and online (www.COMPASS.uwaterloo.ca).

2.2. Participants

Using a unique, self-generated code (Qian et al., 2015), students were linked over 2 years (T1–T2) from a rolling sample (e.g. a student in grade 11 at T1 would be in grade 12 at T2). Data from the sample of grades 9–11 students (aged: 14–17) at T1 (n = 32,213) were linked at T2 (n = 31,376) from 68 Ontario and 9 Alberta secondary schools that participated over both waves of data collection. This process resulted in successfully linked data from 14,652 students across the two waves (linkage rate: 46.7%). Primary reasons for unlinked data were absenteeism and students who did not complete the survey due to scheduled free periods where they are not expected to be in a class (comparison of T1 characteristics of linked to unlinked students presented in Supplementary File A [Appendix]). In Ontario, the legal purchase age of e-cigarettes and cigarettes is 19 years and there were no students within the sample who were of legal age to purchase e-cigarettes and cigarettes in Ontario. At the time of the study (2015–2017), the legal age to purchase cigarettes was 18 years in Alberta, and there were no provincial laws prohibiting the sale of e-cigarettes to youth. At T2, 80 students in Alberta (7.5% of the Alberta sample and 0.5% of the total sample) were 18 years old and could legally purchase cigarettes.

2.3. Measures

The COMPASS questionnaire includes measures of cannabis, e-cigarette, and cigarette use that are consistent with national surveillance measures of youth substance use in Canada (Leatherdale et al., 2008; Elton-Marshall et al., 2011). Current use of cannabis was assessed using responses to the question, ‘In the last 12 months, how often did you use marijuana or cannabis?’ Individuals who reported never using cannabis, ever using but not in the last 12 months, or using less than once a month during the last 12 months were
considered non-current users. Individuals who reported using cannabis at least monthly in the last 12 months were considered current users. Current use of cigarettes was assessed with a single question: ‘On how many of the last 30 days did you smoke one or more cigarettes?’ Individuals who reported smoking cigarettes on any days within the last 30 were considered current users while all others were considered non-current users. Similarly, the current use of e-cigarettes was assessed with a single question: ‘On how many of the last 30 days did you use an e-cigarette?’ Students that reported using e-cigarettes on any days within the last 30 were considered current users while all others were considered non-current users. Concurrent use has been used to describe a student that reported using more than one product within the 30-day period. Definitions of current substance use are consistent with previous literature (Cullen et al., 2019; Hernández-Serrano et al., 2018; Shiplo et al., 2015; Wang et al., 2016).

The COMPASS questionnaire collects basic demographic information including school grade (grade 9, 10, 11, 12), gender (female, male), students’ self-identified ethnicity (non-minority [White] and minority [Black, Asian, Off-reserve Aboriginal, Latin American or Hispanic, Mixed/Other]), and weekly spending money of students ($0, $1 to $20, $21 to $100, $>100). Data from students reporting ‘I don’t know’ for how much spending money they received each week were treated as missing for this variable.

2.4. Analysis

We fit an autoregressive cross-lagged model (ARCL) to examine bidirectional associations between the use of cannabis, e-cigarettes, and cigarettes between T1 and T2 while accounting for the nested hierarchy of students within schools. As shown in Supplementary File A and reported elsewhere (Qian et al., 2015), students who could not be linked were more commonly male, in older grades, and had higher rates of substance use compared to the students in the linked sample. The ARCL model allowed for the simultaneous assessment of whether substance use at T1 (e.g. cannabis use) predicted later use of the same substance, as well as other substances (e.g. cigarettes and e-cigarettes) by combining two modeling strategies (Kearney, 2017). The ‘autoregressive’ model first estimated whether subsequent use of each substance was predicted by earlier use of the same substance. Second, the ‘cross-lagged’ model estimated whether subsequent use of a substance (e.g. cigarettes) was predicted by earlier use of a different substance (e.g. cannabis) and vice versa. Model fit was assessed using root mean square error (RMSE), the comparative fit index (CFI), and Tucker–Lewis index (TLI). Smaller values of RMSE, CFI and TLI values that are closer to 1, indicate better model fit (Hooper et al., 2008). Models were tested with and without grade as an included control. Likely due to large variations in substance use behaviours across time, removing grade as the control from our model improved fit indices slightly the model fit indices improved slightly. As such, the final model presented in Figure 1 does not control for the grade; only gender, ethnicity, and province (Ontario, Alberta) at T1 were included as controls in the model. As noted in previous literature (Leatherdale et al., 2008), self-reported weekly spending money (at T1 and T2) was also included as a control given its association with substance use behaviours. School-level clustering was also accounted for in the model.

Figure 1. Autoregressive cross-lagged model demonstrating the association between current cannabis, e-cigarette, and cigarette use among the sample of secondary school students participating in Time 1 (2015–2016) and Time 2 (2016–2017) of the COMPASS Study (n = 14,652), Ontario, Alberta, Canada. An autoregressive cross-lagged model results in demonstrating the relationship between current e-cigarette, cigarette and cannabis use between Time 1 (2015–2016) and Time 2 (2016–2017) of the COMPASS Study. All relationships are significant at p<0.05 (RMSE= 0.044; CFI= 0.86; TLI=0.70). Estimates represent odds ratios (ORs), adjusted for gender, ethnicity, province, and weekly spending. For all pathways, OR (95% CI) are as follows: Cigarette use at Time 1 (T1): cigarette use [T2]: OR: 4.95 (4.08–6.00), cannabis use [T2]: OR: 1.91 (1.60–2.30), e-cigarette use [T2]: OR: 2.03 (1.65–2.51) Cannabis use at Time 1 (T1): cannabis use [T2]: OR: 4.01 (3.63–4.44), cigarette use [T2]: OR: 1.68 (1.49–1.90), e-cigarette use [T2]: OR: 1.35 (1.18–1.55) E-cigarette use at Time 1 (T1): e-cigarette use [T2]: OR: 6.05 (4.87–7.52), cannabis use [T2]: OR: 3.09 (2.45–3.91), cigarette use [T2]: OR: 3.74 (2.93–4.78).
We used Mplus 8.0 (Muthén & Muthén, 2009) software to fit the ARCL model. Mplus uses full information maximum likelihood to address and retain cases with missing outcome data (cannabis, cigarette, and e-cigarette use) (Muthén & Muthén, 2009). Rate of missingness for each outcome are as follows: cigarette smoking: \((n = 113 \; [0.4\%])\), cannabis use: \((n = 428 \; [1.5\%])\), and e-cigarette use: \((n = 656 \; [2.5\%])\). Beta estimates generated in Mplus were exponentiated to produce adjusted odds ratios. Based on the fit indices collectively, we believe the overall model fit is adequate; although the TLI and CFI model fit indices demonstrated a sub-optimal fit to the data (CFI = 0.86, TLI = 0.70), the RMSEA suggests a good fit with a narrow interval (RMSEA: 0.044 [0.041, 0.048]) (Hooper et al., 2008).

3. Results

Table 1 provides the frequency of substance use types by time and gender. Use of any three substances, as well as overall cannabis, e-cigarette, and cigarette use, was more commonly reported by male students in both T1 and T2. Non-current use of any substance declined from 84.8% in T1 to 75.8% in T2. The frequency of all types of substance use increased at T2; over the 1-year period analysed, the prevalence of overall cannabis use increased from 8.8% at T1 to 15.4% at T2 (a relative increase of 75.0%). E-cigarette-only use increased from 7.9% at T1 to 12.2% at T2 (a relative increase of 54.4%) and cigarette-only use increased from 6.1% at T1 to 10.2% at T2 (a relative increase of 67.2%). Concurrent use of cannabis and e-cigarettes increased from 1.5% at T1 to 2.5% at T2 (a relative increase of 66.7%) and concurrent use of cannabis and cigarettes increased from 1.6% at T1 to 2.8% at T2 (a relative increase of 75.0%). Moreover, cannabis, e-cigarette, and cigarette users increased from 1.8% to 3.5% over the 1-year period (a relative increase of 94.4%). In both T1 and T2, cannabis use only was the most frequent type of substance use pattern reported, followed by e-cigarettes use only. At T1, concurrent use of cannabis and cigarettes (2.8%), as well as cannabis and e-cigarettes (2.5%), was higher than concurrent use of cigarettes and e-cigarettes (1.5%). Notably, students reporting use of all 3 substances nearly doubled between T1 (1.8%) and T2 (3.5%). Among all students, 13.4% reported using only one type of substance, and 10.3% reported using multiple products.

Figure 1 presents the autoregressive and bidirectional associations between cannabis, e-cigarette, and cigarette use at T1 and T2. Autoregressive relationships were more strongly associated than cross-lagged relationships across all three substances examined. Students who used cannabis at T1 had higher odds of using cannabis at T2 (OR = 4.01, 95% CI: 3.63–4.44). Similarly, significant autoregressive associations were observed among those that used e-cigarettes and cigarettes (OR = 6.05, 95% CI: 4.87–7.52; and OR = 4.95, 95% CI: 4.08–6.00, respectively). After adjusting for relevant covariates, all bidirectional associations examined were also significant. Significant associations were identified between cigarette use at T1 and subsequent cannabis use (OR = 1.91, 95% CI: 1.60–2.30), as well as e-cigarette use at T1 and subsequent cannabis use (OR = 3.09, 95% CI: 2.45–3.91). Reciprocally, students who reported cannabis use at T1 were more likely to report cigarette use (OR = 1.68, 95% CI: 1.49–1.90) and e-cigarette use (OR = 1.35, 95% CI: 1.18–1.55) at T2.

4. Discussion

To our knowledge, this study represents the first autoregressive cross-lagged model analysis of current cannabis, e-cigarette, and cigarette use. This research examining youth substance use in the 2 years prior to the legalization of cannabis in Canada provides valuable evidence to inform prevention strategies targeted at youth. Our findings contribute unique results to the existing literature by filling an important knowledge gap, particularly with respect to youth use of e-cigarette and cannabis, and provide a more complete picture of youth substance use behaviours overall by including three types of substances. While it is unclear whether and

**Table 1. Frequency of current substance use among the sample of secondary school students, by gender, participating in Time 1 (2015–2016) and Time 2 (2016–2017) of the COMPASS Study (n = 14,652), Ontario, Alberta, Canada.**

| Time 1 (T1) | Time 2 (T2) |
|------------|-------------|
|            | Total (n)   | Females (n) | Males (n) | Total (n)   | Females (n) | Males (n) |
| Any use of substances* | 2163 (15.2) | 915 (12.3) | 1229 (18.2) | 3467 (24.2) | 1543 (20.7) | 1890 (27.9) |
| Non-current use of substance | 12,093 (84.8) | 6512 (87.7) | 5523 (81.8) | 10,859 (75.8) | 5905 (79.3) | 4882 (72.1) |
| Overall cannabis use | 1265 (8.8) | 576 | 677 | 2227 (15.4) | 1006 | 1200 |
| Cannabis use only | 564 (4.0) | 279 (3.8) | 279 (4.1) | 965 (6.7) | 490 (6.6) | 470 (6.9) |
| Cannabis and cigarette use | 235 (1.6) | 124 (1.7) | 110 (1.6) | 409 (2.8) | 218 (2.9) | 187 (2.8) |
| Cannabis and e-cigarette use | 207 (1.5) | 75 (1.0) | 132 (1.95) | 362 (2.5) | 127 (1.7) | 229 (3.4) |
| Cannabis, e-cigarette, and cigarette use | 259 (1.8) | 98 (1.3) | 156 (2.3) | 491 (3.5) | 171 (2.3) | 314 (4.6) |
| Overall cigarette use | 893 (6.1) | 411 | 472 | 1478 (10.2) | 662 | 797 |
| Cigarette use only | 230 (1.6) | 128 (1.7) | 98 (1.4) | 353 (2.2) | 193 (2.6) | 152 (2.2) |
| Cigarette and e-cigarette use | 169 (1.2) | 61 (0.8) | 108 (1.6) | 225 (1.6) | 80 (1.1) | 144 (2.1) |
| Overall e-cigarette use | 1134 (7.9) | 384 | 652 | 1740 (12.2) | 642 | 1081 |
| E-cigarette use only | 499 (3.3) | 150 (2.0) | 346 (5.1) | 662 (4.6) | 264 (3.5) | 394 (5.8) |

*Any combination of substance use that is inclusive of the substances of interest.
how the federal legalization of cannabis in Canada will impact youth use and uptake of tobacco and vaping products, findings from this study demonstrate the complex and intertwined nature of youth substance use behaviours via the significant autoregressive and bidirectional associations between cannabis, e-cigarette, and cigarette use that were observed. This novel insight has the potential to advance youth-focused substance use research moving forward and prevention practice to support drug policy reform in Canada as these results suggest substance-specific efforts may not be sufficient.

Results from our autoregressive models are largely supported by existing evidence. These autoregressive effects demonstrate the stability of all three substances being used over time (Kearney, 2017), and students who used cannabis, e-cigarettes, and cigarettes were all likely to continue their use of each respective substance at follow-up (T2). Zuckermann, Gohari, et al. (2019) found, over a 2-year period of time, 36.5% of Canadian youth maintain use of cannabis and 29.5% escalated their use, whereby only 19.4% ceased and 14.6% reduced use. Similar trends for cigarette and e-cigarette use have been demonstrated by other research as well (Boak et al., 2018; Everett et al., 1999; Pechacek et al., 2016; Ream et al., 2008; Vandrey et al., 2008). This is cause for concern given that sustained use of these substances may increase the risk of experiencing a myriad of negative health outcomes, particularly among youth (Agrawal et al., 2012).

Overall, strong autoregressive and bidirectional associations identified within this study suggest it is likely that many students maintain use of the initial product and some students use additional substances over time. Novel electronic vaping devices (including e-cigarettes) may further complicate these traditional theories of progression; evidence indicates that the prevalence of vaping has increased among adolescents who are non-smokers and experimental smokers (Hammond et al., 2019), and robust correlations have been observed between e-cigarette use and subsequent cigarette use (Aleyan et al., 2018; Miech et al., 2017) and cannabis use (Dai et al., 2018) among youth. It is possible that this generalized progression is changing among youth due to increased social acceptability and availability of cannabis (i.e. by way of cannabis legalization in Canada) alongside decreasing social acceptability of cigarette use (i.e. by way of successful population-level tobacco interventions) (McNeill et al., 2017). In general, age is an evident risk factor in substance use uptake; as such, it is also possible that maturation may explain a large portion of the autoregressive and bidirectional associations identified, as research consistently demonstrates that substance use tends to increase with age (Boak et al., 2020; Leatherdale, 2015; Leatherdale & Rynard, 2013).

We further contribute to the existing literature by examining multiple product use and provide evidence of bidirectional associations between e-cigarette and tobacco use (Aleyan et al., 2019), as well as cannabis and cigarette use (Kristman-Valente et al., 2017). Importantly, our results should be interpreted in light of the context of how youth may use substances. For example, as smoking remains the most common mode of cannabis use (Health Canada, 2018), the strong associations we observed between cannabis and cigarette use may be attributable to a similar mode of use (i.e. smoking) (Tucker et al., 2019). Similarly, vaping represents a mode of use by which youth may ingest nicotine or cannabis concentrates using similar (or the same) devices (i.e. e-cigarettes and other electronic vaping devices). In fact, recent meta-analytic findings show that e-cigarette use is significantly associated with subsequent cannabis use (Chadi et al., 2019). We further identify bidirectional associations between e-cigarette and cannabis use whereby e-cigarette use was more predictive of cannabis use than the reciprocal relationship, which has been demonstrated elsewhere (Chadi et al., 2019). It is plausible that the relationship between cannabis and e-cigarette use may partially be explained by vaping cannabis (Rabin & George, 2015). Cannabis is also often mixed with tobacco (Tucker et al., 2019; Vandrey et al., 2008), and existing literature has demonstrated that nicotine-containing products may reinforce the effects of other substances, priming the brain to be more susceptible to dependence and addiction (Kandel & Kandel, 2014; Rabin & George, 2015; Ream et al., 2008; Vandrey et al., 2008).

In addition to product characteristics that encourage and promote the transition between different substances, it is important to consider the personal factors that may drive substance use across products (i.e. cigarettes, e-cigarettes, and cannabis). Significant associations were observed for all substance use pathways analyzed, suggesting that youth are predisposed to the use of various and multiple substances. As described by the common liability to addiction (CLA) theory (Vanyukov et al., 2012) it is possible that there are common underlying personal factors that influence the use of all three products. It is also worth noting that the strength in the association between cigarette/e-cigarette use and cannabis use was stronger than the association between cannabis use and cigarette/e-cigarette use. As described by the gateway hypothesis, inter-drug use progression among youth typically begins with legally available substances (e.g. tobacco) followed by illicit substances (e.g. cannabis) (Kandel, 2002; Werch & Anzalone, 1995). Theories of substance use progression remain contentious and neither theory can be fully validated within this study. Due to limitations with the data collected, we are unable to confirm whether underlying predispositions (e.g. genetics, psychology, problem behaviour) are responsible for the bidirectional associations demonstrated in this study, or explore differences in substance use progression following initiation of a particular product. Affirmation of substance use progression theories was beyond the objective of this research, however, our results further the context of research within this field and suggest that substances should not be considered in isolation of each other. Future research should aim to further test the theories of substance use progression within youth using data from linked longitudinal studies that survey multiple types of substances, such as alcohol.

The underlying biological and/or environmental risk of engaging in the use of cannabis, e-cigarettes, and cigarettes may be both ubiquitous and reciprocal. While existing research has continually demonstrated significant relationships between cigarettes and cannabis use (Ramo et al., 2012), and e-cigarettes and cannabis use (Chadi et al., 2019),...
this study contributes evidence for both autoregressive and bidirectional associations among all three substances and provides further support for universal, multi-substance use programming (Leatherdale & Ahmed, 2010; MacArthur et al., 2018). The interconnectedness of substance use demonstrated in this study suggests prevention programs should consider universal and/or comprehensive approaches that address substance use behaviours collectively, rather than in isolation. Universal school-based drug prevention efforts have been found to have the potential to mitigate adolescent drug use (Hodder et al., 2014; National Crime Prevention Centre, 2009; Tobler et al., 2000) and such program settings should be considered given the potential to reach much youth. As risk behaviours have been shown to cluster in adolescence (Burke et al., 1997; de Looze et al., 2015; van Nieuwenhuijzen et al., 2009), and almost half of students that indicate using substances in this study report using more than one product, programs that address multiple risk behaviours simultaneously may be most effective at addressing and reducing substance use overall (MacArthur et al., 2018).

While it remains unknown how changes to drug policy reform in Canada will impact youth substance use overall, a recent study (Zuckermann, Battista, et al., 2019) has observed a gradual increase in cannabis use among Canadian youth following initial discourse around cannabis legalisation. Given that students who used cannabis were more likely to report subsequent cigarette and e-cigarette use at follow-up, it is possible that changes in cannabis use patterns following post-legalization may affect the uptake of other substances, as suggested by existing research (Kelsall, 2017). Where data are available, future exploration may consider examining concurrent (using cannabis and tobacco separately within a given time period [i.e. smoke cigarettes and cannabis but not necessary at the same time]) and simultaneous [using more than one product at the same time or on a single occasion (e.g. blunts, ‘poppers’)] (Hernández-Serrano et al., 2018) substance use to improve our understanding of substance use patterns (Morean et al., 2015). Additional research is needed to examine the relationship between different modes of cannabis use and tobacco product use, and how these behaviours change over time. Lastly, future research may want to examine the theories of substance use progression within youth populations using longitudinal linked samples where data on multiple types of substances (cigarette, e-cigarette, cannabis, alcohol, opioids) are available (e.g. the COMPASS Study).

4.1. Strengths and limitations

The primary strengths of the present study include its longitudinal design and large school and student sample size. Moreover, we used a novel methodological approach to simultaneously examine autoregressive and bidirectional associations of cannabis, e-cigarette, and cigarette use to provide a deeper understanding of current use before the legalization of cannabis in Canada. This approach was used to assess the directionality and stability of multiple types of substances used by youth over a 2-year period. By using this analytic method, this study was able to demonstrate reciprocal relationships across all three types of substances examined and measure the strength of these associations over time.

However, this research is not without limitations. We were not able to assess whether students were using e-cigarettes that contained nicotine or not. Future research should explore whether the use of nicotine versus non-nicotine e-cigarettes has an impact on the bidirectional associations observed between cannabis and e-cigarette use. Previous research using linked data from the COMPASS study is available from Qian et al. (2015) and highlights potential differences between the linked and non-linked longitudinal samples. However, given that linkage rates were disproportionately lower for students who use substances, the current results may underestimate the associations identified (Qian et al., 2015).

Although our measure of substance use is consistent with previous research (Cullen et al., 2019; Shiplo et al., 2015; Wang et al., 2016), past 30-day use may overestimate substance use rates among participating students. This study relied on self-reported substance use behaviors, and therefore, responses are subject to social desirability and recall biases. However, self-reported cigarette smoking measures have previously been demonstrated to be reliable and valid (Wong et al., 2012). Moreover, the use of active-information passive-consent protocols reduces the effects of systematic sample bias and missing data (Hollmann & McNamara, 1999). This protocol has also been identified as an important recruitment strategy for collecting robust data on youth substance use behaviours (Rojas et al., 2008). Lastly, the COMPASS Study used a convenience sample of students and as such, the results may not be generalizable to all youth in Ontario, Alberta, or Canada. Lastly, it is likely that there are numerous transitions in substance use behaviour occurring between T1 and T2, (e.g. single product users becoming dual product users) and more frequent longitudinal data collection (multiple times in a year) is needed to identify these trends and the characteristics of youth who consume substances. Observed associations between cannabis and e-cigarette use within this study demonstrate the need for continued monitoring and research to identify potential mediators of these associations in order to improve our understanding of mechanisms driving these relationships.

5. Conclusion

Findings from this study demonstrate both autoregressive and bidirectional associations between cannabis use and e-cigarette use, and cannabis use and cigarette use among youth. This research illustrates the need for continued multi-substance use programming targeting youth populations. It is unclear whether and how the federal legalization of cannabis in Canada will impact youth use and uptake of tobacco and vaping products, and continued research should continue to monitor the use of each substance and concurrent use of multiple substances following cannabis legalization in Canada.
Disclosure statement

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