Youth vaping during the early stages of the COVID-19 pandemic period: adjusted annual changes in vaping between the pre-COVID and initial COVID-lockdown waves of the COMPASS study.

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Abstract

Background: Adolescence is a critical period for vaping onset. The purpose of this paper was to examine the effect of the early stages of the COVID-19 pandemic period on youth vaping.

Methods: We used 3-year linked data from the COMPASS study, including 7585 Canadian (Quebec, Ontario) adolescents from which 1,949 completed all 3 survey waves (pre-COVID-19 [2018, 2019] and online [2020] during the early pandemic period [May-July 2020]) and provided vaping data. Structural equation modeling (SEM) and **difference-in-**difference (DD) models were used to estimate pre-COVID-19 to initial COVID-19 pandemic period change (2019-2020) in vaping (monthly, weekly, daily) compared to 2018 to 2019 change to adjust for age-related effects. Models were adjusted for age of entry into the cohort and sociodemographic characteristics.

Results: In the SEM and DD models, **the proportion of youth who were** monthly and weekly vaping increased from 2018 to 2019 but decreased from 2019 to 2020; daily vaping increased across all waves. However, for all vaping outcomes modelled, the expected increases from the pre-COVID-19 wave (2019) to the initial COVID-19 period wave (2020) were lesser relative to the changes seen across the 2018 to 2019 waves.

Conclusion: The early stages of the COVID-19 pandemic period **appears to be associated with a reduction in the proportion of youth who were monthly and weekly vapers in our adjusted longitudinal models. While daily vaping increased over this same period of time, the magnitude of the increase in our adjusted longitudinal models appears attenuated by the early stages of the pandemic.**

Keywords: COVID-19; pandemic; youth; vaping; e-cigarette; adolescents; prospective; cohort

Implications

This large prospective study of youth that included pre-pandemic data is unique in that we were able to identify that the early stages of the COVID-19 pandemic period **was associated with a reduction in the proportion of youth who were monthly and weekly vapers in our adjusted longitudinal models. Conversely, the proportion of youth who were daily vaping increased over this same period of time, but the magnitude of the increase appears smaller than expected during the early stages of the pandemic in our adjusted longitudinal models.** This study provides novel robust evidence that the patterns of vaping most aligned with onset and progression (i.e., monthly and weekly use), appear attenuated during the initial pandemic period.

Background

Electronic cigarettes (e-cigarettes) are battery-operated devices that heat a liquid typically comprised of flavoring agents, additives, and other derivatives such as nicotine.[1] Vaping is the act of inhaling and exhaling aerosol produced by an e-cigarette or similar device (e.g., vape mod, vaporizer or vape pen). Cross-sectional surveillance data suggest that vaping has escalated rapidly in Canada among youth populations in recent years.[2-5] For instance, according to national estimates, past 30-day vaping has doubled from 14.6% in 2017 to 29.4% in 2019 among Canadian students in grades 10 to 12.[6] Similar increases in the prevalence of vaping among youth between 2017 and 2019 have also been reported in the United States (US).[7-8] Data from the 2020 Canadian Tobacco and Nicotine Survey suggest that 14.4% of youth aged 15 to 19 report past 30 day vaping and 5% report daily vaping.[9] Since vaping is more commonly initiated in adolescent populations than adult populations,[2,9] improving our understanding of vaping and factors associated with changes in vaping behaviour over time is critical for informing future prevention efforts.

On March 11, 2020, the World Health Organization announced that COVID-19 was a global pandemic (WHO, 2020). In Canada, this immediately resulted in new emergency lockdowns and restrictions that initially lasted for the first few months of the pandemic (March to July 2020). This included social restrictions that limited the ability of youth to socialize with friends/peers, stay at home orders that increased home-based confinement with parents/guardians and closures to in-person learning in schools, which forced students to transition to online learning platforms. This created a novel situation that inevitably directly affected youth, at least in the short-term, given the immediate and unprecedented disruption to their lives.[10] Early cross-sectional evidence from a small sample of Canadian youth suggests that students reduced their vaping in the weeks immediately following the implementation of these restrictions (early April, 2020).[11] More recent evidence from another small cross-sectional sample of Canadian youth and young adults (ages 16 to 24) found similar results, where vaping frequency (days per week) decreased from the onset of pandemic

restrictions, with males reporting larger declines in vaping frequency than females.[12] This is consistent with cross-sectional evidence from a national survey of youth and young adults in the US, where two-thirds of vapers reported reduced vaping or quitting vaping since the start of the pandemic.[13] Additional cross-sectional evidence from the US suggests a similar decline in current e-cigarette use among youth during the early stages of the pandemic.[14] Conversely, prospective evidence from the US spanning the pre-pandemic to early-pandemic period suggests that there was a decline in vaping observed prior to the COVID-19 pandemic restrictions being implemented, and that vaping did not change during the early pandemic period.[15] **While not reported, the differences in the findings between these cross-sectional studies and the available longitudinal evidence is likely due to selection bias across the different study designs.** Additional prospective evidence evaluating the impact of these early pandemic restrictions on youth vaping behaviour spanning from the pre-pandemic to early pandemic period, **that adjusts for potential selection bias**, is required. Determining the directionality of the impact (positive or negative), or more aptly, examining how youth adapted their behaviour in response to this situation, is a unique opportunity for evaluating this real-world natural experiment.[16]

There are a variety of reasons why the restrictions associated with the COVID-19 pandemic may impact youth vaping. For instance, despite that most youth report obtaining vaping products from friends and brick-and-mortar stores prior to the pandemic,[17] recent evidence suggests that youth have now had to switch to online sources.[13] It has also been suggested that since many youth hide vaping from their parents,[18] youth may vape less during the pandemic while restrictions require them to spend more time at home with parents and vaping is harder to do without raising suspicion.[12] In addition, given that youth vaping is often done in the context of peers,[19] and considering that most youth consume substances for social reasons, they may be less likely to do so alone.[20] It is also possible that when social interaction was limited during the early pandemic period, vaping frequency may have actually declined. Given the lack of prospective evidence, the purpose of

this study is to leverage pre- and early-pandemic data from an ongoing Canadian cohort study of Canadian youth to evaluate the effect of COVID-19 during the early stages of the pandemic period on **changes in the proportion of youth who are monthly, weekly or daily vapers** as a natural experiment. We test the hypothesis that the expected escalation trajectory for these vaping patterns among youth in our sample would decrease between the pre-COVID-19 period and the early pandemic period (May-July 2020) to a greater extent than **what would have otherwise been** expected in this age group. In addition, using cross-sectional data collected during the early pandemic period, we also examine **respondents self-**reported changes in vaping as a result of COVID-19 and reports of vaping to cope with changes related to COVID-19 among current vapers.

Methods

The COMPASS Study (COMPASS) is a prospective study designed to collect hierarchical (student- and school-level) health data annually from a rolling cohort of students in grades 9 through 12 (Secondary I-V in Quebec) and the secondary schools they attend in a convenience sample of Canadian secondary schools.[21] The student-level data are collected annually during the school year (e.g., Sept. 2017 to May 2018, referred to as the 2018 year) via a self-reported questionnaire across multiple content domains (including vaping), using an active information passive-consent protocol (as described in more detail elsewhere[22]). All procedures were approved by the University of Waterloo Office of Research Ethics (ORE# 30118), CIUSSS de la Capitale-Nationale–Université Laval (#MP-13-2017-1264), and appropriate school board committees. A full description of the COMPASS study methods are available online (https://uwaterloo.ca/compass-system/).

Design

Consistent with previous research,[23] in order to evaluate the effect of COVID-19 as a natural experiment, we used linked longitudinal COMPASS data collected from students that attended 43 schools in Ontario (N=20) and Quebec (N=23). The schools selected participated in Wave 6 (2018

school year; 81.8% response rate) and Wave 7 (2019 school year; 84.2% response rate) which was administered as an in-person paper-based survey, and Wave 8 (2020 school year; 29.2% response rate) which was an online survey. All student-level data in these 43 schools collected during Wave 6 and Wave 7 used a paper-based survey in class time (described elsewhere[24]). In Wave 8, these 43 schools were closed for in-person learning due to COVID-19 social distancing restrictions, so all of the student-level data in these schools were collected using an online Qualtrics® survey completed at home between May 01 and July 06, 2020 (described elsewhere[25]). Across these three waves of data, the questionnaire includes five initial questions designed exclusively for linkage purposes and that allow us to match student responses over time using a self-generated identification code creating our longitudinal data file.[26] To examine how students reported that COVID-19 effected their vaping behaviour, we used cross-sectional data from all students who participated in the Wave 8 (2020) online data collection from the 43 schools.

Participants

As described elsewhere,[23] linked-longitudinal survey data were available from 7,653 eligible students who participated in Wave 6 (grades 9 and 10 in Ontario or Secondary II-III in Quebec in Wave 6); 5,554 were followed from Wave 6 to Wave 7 and 2,099 were followed from Wave 6 to Wave 8. **Within these linked samples, vaping behaviour data required for the fixed effects models were provided by 7,572 respondents in Wave 6, 7,585 respondents in Wave 7, and 1,949 respondents in Wave 8.** Cross-sectional student-level data were available from 7,496 students (grades 9 to 12 in Ontario and Secondary I-V in Quebec) who participated in the 2020 online data collection in the 43 schools.

Measures

Each year students were asked, “On how many of the last 30 days did you use an e-cigarette?”, which has response options ranging from “None” to “30 days (every day)”. **Responses were recoded**

into the proportion of youth who reported any *monthly use* [1 day, 2 to 3 days, 4 to 5 days, 21 to 29 days, or 30 days (everyday)], *weekly use* [4 to 5 days, 21 to 29 days, or 30 days (everyday)], and *daily use* [30 days (everyday)]. In the 2020 online survey, students were also asked to report if their vaping has changed because of COVID (increased, stayed the same/not applicable, decreased), and if they have been vaping to cope with the changes related to COVID-19 (yes, no). Covariates included sex (female, male), age in 2018 (12 years to 16 years), weekly spending money (≤$5, $6-$10, $11-$20, ≥$20), and province (Ontario, Quebec).

Analyses

The modelling approach used here is consistent with previous research using the COMPASS data from this sample.[23] Longitudinal-linked student-level data from the 43 schools were used to examine the adjusted annual changes in the proportion of youth who were in each vaping category (monthly, weekly, and daily) among students in the pre-COVID waves (2018 and 2019) and during the waves straddling the early pandemic period (2019 and 2020). It is not possible to have control group data (i.e., a group of students not exposed to COVID-19 restrictions but still provided 2020 data) given the nature of the COVID-19 pandemic. Our hypothesis is that there will be a different progression in the annual **proportion of these vaping categories** as a function of COVID-19. We tested this assumption in each of the two intervals using **difference-in-**difference (DD) models. The DD provides an estimation of the average effect of the early stages of the COVID-19 pandemic response on student vaping, where the first difference consists of subtracting the mean potential outcomes for students in 2018 and 2019 and the second difference compares the same student responses in 2019 and 2020.[15,27]

Stata 15 Generalized Structural Equation Modeling (GSEM) procedures (Stata Corp, College Station, TX) were used to determine the mean potential outcomes and average treatment effects. To control for unobserved heterogeneity, as recommended,[28-29] we used a fixed effect method using GSEM given the advantages of simultaneously controlling for time-invariant unmeasured confounders and

producing final estimates for time-invariant predictors (sex and age at entry into the cohort). A structural model was developed for each outcome (monthly vaping, weekly vaping, daily vaping) and each model included three equations (one for each year). Following Allison's approach,[28] each set of equations included a vector of invariant predictors (sex and age at entry into the cohort) as well as a latent term (Alpha) representing all other unobserved stable differences between individuals. Full Information Maximum Likelihood method was used to account for missing data. Robust estimators accounted for school clustering. An additional complication that needed to be addressed in these models pertains to the self-selection process encountered in the Wave 8 (2020), as the transition from a paper-based survey to an online survey resulted in a lower response rate in 2020 and hence the data are subject to subsequent bias. To account for potential self-selection in 2020, the initial models (Type 1 Model) were supplemented by Heckman-type sample selection models (Models 2 and 3).[30] A selection equation was first estimated (probit equation) using a set of predictors of self-selection (age **at entry into the cohort**, sex, weekly spending money, province). Then, the inverse Mills Ratio was generated and introduced as an additional explanatory variable into the 2020 equation of each SEM model to correct for the selection bias.

For each outcome, the DD calculations were performed following the same stepped modelling approach designed to obtain the mean predicted values under the counterfactual scenarios, computing simple differences, and estimating the causal effect through DD. Available evidence suggests that few youth in previous waves of COMPASS who vape regularly spontaneously reduce their use,[31] suggesting that any changes observed in this DD approach are likely a result of the early stages of the COVID-19 pandemic period having an effect **on vaping behaviour**. We assume that without such impact, the annual change (*expected increase*) in the proportion of vaping students would be the same between the pre-COVID-19 period (2018 to 2019) and the initial COVID-19 period (2019 to 2020).

Using the cross-sectional student-level data collected from 7,496 students attending these 43 schools in 2020, we examined changes in vaping as a result of COVID-19 and vaping to cope with COVID-19 related negative affect among students who reported any vaping in the past month (current vapers).

Results

The mean age in 2018 was 14.1 (±1.0) years, with just over half (53.1%) identifying themselves as females, and 53.5% attended a school in Quebec. At baseline in 2018 (Table 1), 16.4% (±0.4) of students reported vaping monthly 7.1% (±0.3) reported vaping weekly, and 1.3% (±0.1) reported vaping daily.

<insert Table 1 about here >

Table 2 provides the proportion of users for the three vaping behaviour outcomes based on the adjusted models across the three waves. Accordingly, between 2018 and 2019 there was an increase in the proportion of youth who were monthly users, weekly users, and daily users in the sample, and then a decrease in monthly and weekly use across between 2019 and 2020, with a slight increase in daily use between 2019 and 2020. Table 3 presents the examination of the possible differential impact of the early stages of the COVID-19 pandemic period on vaping stratified by sex.

<insert Table 3 about here >

Figure 1 presents the examination of the possible differential impact of the early COVID-19 pandemic period on vaping stratified by sex and age at entry into the cohort (2018).

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Monthly Vaping

As shown in Table 2, there was an increase i**n the proportion of youth who** were monthly vaping between 2018 and 2019, and then a decline between 2019 and 2020. The average discrete change between years decreased 9.2% between the pre-COVID-19 and early COVID-19 pandemic period. Even after **adjusting** for predictors of self-selection in the 2020 sample, the negative estimated causal effect shown for the DD results for monthly vaping was -24.6%, which supports the hypothesis that there was a reduction in the expected escalation of monthly vaping within the sample during the early stages of the COVID-19 pandemic period. As shown in Table 3, there was significant reduction in the expected escalation of monthly vaping among males (-28.2%) that was larger relative to females (-21.5%) during the initial COVID-19 period. As shown in Figure 1, it appears that among female students there was a greater reduction in the expected escalation of monthly vaping among students **who were older at baseline** (≥15 years) relative to younger students **at baseline** during the initial COVID-19 period.

Weekly Vaping

As shown in Table 2, there was an increase **in the proportion of youth who were** weekly vaping between 2018 and 2019, and then a decline between 2019 and 2020. The average discrete change between years decreased 4.5% between the pre-COVID-19 and early stages of the COVID-19 pandemic period. Even after adjusting for predictors of self-selection in the 2020 sample, the negative estimated causal effect shown for the DD results for weekly vaping was -16.3%, which supports the hypothesis that there was a reduction in the expected escalation of weekly vaping within the sample during the early stages of the COVID-19 pandemic period. As shown in Table 3, it appears that there was a significant reduction in the expected escalation of weekly vaping among males (-20.0%) that was larger relative to females (-13.0%) during the initial COVID-19 period. As

shown in Figure 1, it appears that among female students there was a smaller reduction in the expected escalation of weekly vaping among **students who were older at baseline** (≥15 years) and the youngest **at baseline** (≤13 years) relative to students aged 14 during the initial COVID-19 period.

Daily Vaping

As shown in Table 2, there was an increase **in the proportion of youth who were** daily vaping between 2018 and 2019, which increased again between 2019 and 2020. However, the average discrete change between years only increased 0.3% between the pre-COVID-19 and early stages of the COVID-19 pandemic period. Even after adjusting for predictors of self-selection in the 2020 sample, the negative estimated causal effect shown for the DD results for weekly vaping was -5.2%, which supports the hypothesis that there was a reduction in the expected escalation of daily vaping within the sample during the early stages of the COVID-19 pandemic period. As shown in Table 3, it appears that there was a significant reduction in the expected escalation of daily vaping among males (-8.4%), but a smaller non-significant reduction among females (-2.4%) within the sample during the initial COVID-19 period. As shown in Figure 1, while there was a greater reduction in the expected escalation of daily vaping among 14 year old students **at baseline** relative to younger (≤13 years) and older (≥15 years) male students **at baseline;** there does not appear to be a reduction in the escalation of daily vaping among females of any age group.

Current Vapers and Changes due to COVID-19

In the cross-sectional sample in 2020, 11.8% (n=881) were current (past 30-day) vapers. Among current vapers, 30.6% (n=270) reported that their vaping has increased because of COVID-19, whereas 19.3% (n=170) reported their vaping had decreased because of COVID-19. Similarly, 41.5% (n=366) of current vapers reported that they were vaping to cope with changes related to COVID-19.

Discussion

We believe this is the first Canadian study to provide robust evidence that the early stages of the COVID-19 pandemic period does not appear to have resulted in an overall increase in **the proportion of youth who were monthly or weekly** vaping (**based on adjusted estimates**) in our prospective sample of youth in Ontario and Quebec (Canada) spanning the pre-pandemic to early pandemic period. In fact, despite evidence of a steady increase in the prevalence of vaping among youth in the years preceding the pandemic,[2-3] it appears that based on our adjusted estimates, the vaping patterns that may be most aligned with onset and progression (i.e., monthly and weekly use), appears attenuated during the initial pandemic period (May to July 2020). Considering the observed frequencies are consistent with recent nationally representative data on youth vaping from 2020,[9] data using the larger cross-sectional COMPASS samples,[2] and align with prospective evidence examining changes in youth cannabis use during the early pandemic period[23] [i.e., significant increase or reduction in use], lends further support to the merit of these findings.

While additional ongoing prospective evidence is required, our results are suggestive that the highly disruptive nature of the COVID-19 early pandemic period may have inadvertently contributed to preventing or limiting vaping onset and progression among some youth. For instance, in **our cross-sectional sample, although just less than a third of current vapers reported that their vaping increased because of COVID-19, more than two-thirds of current vapers reported that that their vaping either did not change or it decreased due to COVID-19. In our longitudinal models,** the largest reduction identified **was in the proportion of youth who reported** monthly vaping during the early pandemic period which may suggest that COVID-19 may have initially had the most impact on delayed experimentation, whereas the smallest reduction identified was for daily use suggesting less of an impact on most established vapers. These findings are consistent with evidence from the US[13-14] (Kerslake et al., 2021; Galha et al., 2020) and Iceland.[32] **Statistics Canada recently reported that only 23% of youth vapers reported vaping to reduce stress in 2020,[9] and similarly, our cross-**

sectional data identified that the majority of current vapers reported that they were not vaping to cope with COVID-19. In alignment with a recent position paper by the Canadian Public Health Association on youth vaping,[33] this highlights the importance of ongoing prospective surveillance of youth vaping behaviour data through established data infrastructure systems like COMPASS. If our evidence of pertaining to understanding the impact of the pandemic on vaping behaviour is limited to weaker longitudinal post-test or repeat cross-sectional designs,[16] these subtle but important differences may be overlooked. As such, there is an important need for continued prospective surveillance to robustly understand the ongoing impact of the pandemic on youth vaping behaviour.

Recent research suggests that although the prevalence of vaping is typically higher among males relative to females during high school,[2,34] in recent years the relative increase in vaping prevalence has actually been considerable larger among females compared to males.[34] This may help to explain our finding where although the frequency of vaping was lower for females relative to males, we identified that during the early stages of the COVID-19 pandemic period, females appeared more apt to maintain (or even escalate for daily vaping as shown in Figure 1) use relative to males across all vaping outcomes modelled. Interesting, recent evidence suggest that there was a larger relative decrease in the prevalence of vaping among female youth compared to male youth in the 3 weeks after COVID-19 social distancing measures came into effect in March 2020, but a larger relative decrease in the number of days vaping among male youth compared to female youth in the same period of time.[11] This is supported by other research suggesting that among a cross-sectional sample of Canadian youth who vape, where data were collected online in the early pandemic period, male vapers reporting fewer vaping episodes per day relative to female vapers, and while males vapers also reported significantly less puffs per vaping episode, females did not reduce the number of puffs per vaping episode during the early pandemic period.[12] While it cannot be determined with these data, it is possible that females may be more responsive to the non-nicotine elements of vaping (e.g., perceived stress reduction when stress may have been increased during the pandemic) and

males may be more responsive to the socially driven aspects of vaping (e.g., vaping with friends). Moving forward, there is a need to both explore the potential mechanisms underlying the sex differences identified here, especially with respect to the differences observed in vaping attenuation between males and females for daily vaping.

It appears that the early pandemic period may impact youth vaping differently than adult vaping. For instance, evidence from a cross-sectional online survey in the United Kingdom (UK) suggests that among adult vapers, 42% reported vaping more during the early pandemic period and 48% reported no change in vaping frequency (May to June 2020).[35] However, our longitudinal results showed rather large reductions in the expected vaping frequency in the DD results, especially for youth reporting less frequent vaping during pre-COVID cycles. The reductions identified here (-24.6 for monthly vaping use and -16.3 weekly vaping use) were substantially larger that the reductions for cannabis use previously reported (-5.7 monthly cannabis use and -3.0 weekly cannabis use) using the same analytical approach.[23] Evidence from a small cross-sectional online sample of youth aged 16 to 18 years in Ontario (Canada) also suggests that the prevalence of vaping decreased 3 weeks after social distancing measures came into effect,[11] with similar reductions in vaping behaviour since the start of the pandemic reported from Canadian youth and young adults (aged 16 to 24 years) in another small cross-sectional online survey.[12] Evidence from the US suggests a drop in the average number of days youth vaped during the early pandemic period relative to before the pandemic.[14,36] The consistency in the evidence of a reduction in youth vaping during the early pandemic period is encouraging but not surprizing. Considering that data from the US suggests that most youth vape to either experiment or for social reasons and entertainment,[19] it makes sense that vaping among youth (especially less frequent users), would decline when social distancing restrictions associated with the COVID-19 pandemic are in place and vaping with peers is more challenging and accessing vape products becomes more challenging.[13] Research has identified that youth vapers with reduced access to retail environments during the early pandemic period reported less vaping.[14]

Strengths and Limitations

Key strengths of this study include the prospective cohort design with a relatively large sample size from two Canadian provinces. COMPASS data are also unique in that there is the availability of early pandemic period data linked to two years of pre-COVID-19 data from youth, allowing examination of within-individual effects and adjustment for age-related changes. While the COMPASS study is based on self-reported data, which can be prone to recall and social desirability bias, it uses passive consent protocols which is essential in self-report research for producing robust results that limit self-selection and response bias, particularly for measures of substance use behaviours;[37-38] student names are not required for longitudinal data linkage, helping to preserve perceptions of anonymity for honest reporting. Due to the nature of the COVID-19 pandemic, we did not have a possible comparison group. As such, we built counterfactuals into our DD models, although the models remain limited by assuming parallel trends; therefore, there is no control for within-individual variations over time related to time-varying unobserved characteristics (e.g. changes in socioeconomic status). Possible limitations include the transitioning from school-based paper-and-pencil questionnaires (2018, 2019) to online assessment (2020), which may have influenced reports but was unavoidable given the constraints imposed by COVID-19 restrictions on data collection protocols. The lower online response rates may bias the results; students not participating in the online survey may be at higher risk of vaping. Based on the previous in-school data collections within COMPASS, we utilized correction methods here to mitigate the impact of self-selection into the 2020 wave. However, the consistency of estimates may be affected if there are departures from the statistical assumptions of sample selection models (e.g. assuming error terms that are jointly normally distributed and a fairly acceptable model of the selection process). Lastly, COMPASS is based on a convenience sample of participating schools, so results may not be generalizable to all Canadian youth.

Conclusion

This large prospective study of youth that included pre-pandemic data is unique in that we were able to identify that the early stages of the COVID-19 pandemic period was associated with a reduction in the proportion of youth who were monthly and weekly vapers in our adjusted longitudinal models. Conversely, the proportion of youth who were daily vaping increased over this same period of time, but the magnitude of the increase appears smaller than expected during the early stages of the pandemic in our adjusted longitudinal models. Further prospective research is needed to explore the impact of the ongoing pandemic context on youth vaping onset and progression.

List of Abbreviations

COMPASS - the Cannabis use, Obesity, Mental health, Physical activity, Alcohol use, Smoking, and Sedentary behaviour Study

GSEM - Generalized Structural Equation Modeling

SEM - Structural Equation Model

Declarations

Ethics approval and consent to participate: The host study used an active information passive-consent protocol for parents/guardians, and active assent for participants. All procedures were approved by the University of Waterloo Office of Research Ethics (reference number 30118), CIUSSS de la Capitale-Nationale–Université Laval (#MP-13-2017-1264), and appropriate school board committees.

Consent for publication: Not applicable

Availability of data and materials: The datasets used and/or analysed during the current study available from the corresponding author on reasonable request submitted via the following online

application form (https://uwaterloo.ca/compass-system/sites/ca.compass-system/files/uploads/files/compass_data_use_application_2020.pdf).

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Authors' contributions: STL is the principal investigator of the host study and drafted this manuscript; REB assisted in the interpretation of the results and edited the manuscript for content; RJB performed statistical analyses and edited the manuscript for content; AGC edited the manuscript for content; SH conceptualized the analytical strategy, performed statistical analyses, assisted in the interpretation of the results, and edited the manuscript for content. All authors have reviewed and approved the manuscript.

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Table 1

Frequency of vaping behaviour among eligible students who provided vaping behaviour data attending the 43 linked-longitudinal COMPASS schools across three study waves (2018, 2019, 2020).

	Wave of COMPASS Data (School year)					
	Wave 6 (2018)		***Wave 7 (2019)***		***Wave 8 (2020)***	
Linked longitudinal sample	N (7,653)	%	N (7,653)	%	N (2,099)	%
Province						
Ontario	3,560	46.5				
Quebec	4,093	53.5				
Sex						
Male	3,589	46.9				
Female	4,064	53.1				
Age (in years)						
12	646	8.4				
13	1,240	16.2				
14	2,791	36.5				
15	2,418	31.6				
16	555	7.3				
Weekly Spending Money						
≤$5	2,159	28.2	1,571	20.5	394	18.7
$6 to $10	676	8.8	481	6.3	71	3.4
$11 to $20	1,109	14.5	938	12.3	157	7.5
≥$20	3,709	48.5	4,663	60.9	1,477	70.4
Linked longitudinal sample with vaping data provided	N (7,572)	%	N (7,585)	%	N (1,949)	%
Frequency of Vaping (past 30 days)						
None	6,333	83.6	5,164	68.1	1,598	82.0
'1 day' or '2 to 3 days'	702	9.3	981	12.9	138	7.1
'4 to 5 days' or '21 to 29 days'	436	5.8	927	12.2	123	6.3
'30 days (everyday)'	101	1.3	513	6.8	90	4.6
Vaping Behaviour[a]						
Monthly Use		16.4		31.9		18.0
Weekly Use		7.1		19.0		10.9
Daily Use		1.3		6.8		4.6

[a] refers to the proportion of users for the corresponding vaping behaviour, defined as monthly use [1 day, 2 to 3 days, 4 to 5 days, 21 to 29 days, and 30 days (everyday)], weekly use [4 to 5 days, 21 to 29 days, and 30 days (everyday)], and daily use [30 days (everyday)].

Table 2

Adjusted proportions of vaping behaviour over survey waves, discrete change of vaping behaviour over time, and estimated causal effect of the early COVID-19 period on vaping by difference-in-difference among eligible students attending the 43 linked-longitudinal COMPASS schools across three study waves (2018, 2019, 2020).

		Vaping Behaviour		
		Monthly Use	***Weekly Use***	***Daily Use***
	Wave	**Mean[b] (95% CI)**	**Mean[b] (95% CI)**	**Mean[b] (95% CI)**
Adjusted Estimates[a]	2018	16.3 (13.4, 19.2)	7.0 (5.6, 8.5)	1.3 (0.9, 1.8)
	2019	31.7 (30.0, 33.9)	18.8 (16.5, 21.1)	6.8 (5.4, 8.1)
	2020	22.5 (12.2, 32.9)	14.3 (11.8, 16.9)	7.1 (4.3, 9.7)
		Mean[b] (95% CI)	**Mean[b] (95% CI)**	**Mean[b] (95% CI)**
Average Discrete Change	2019-2018 (pre-COVID-19 period)	15.4 (13.1, 17.7)	11.8 (9.8, 13.6)	5.5 (0.4, 6.6)
	2020-2019 (early COVID-19 period)	-9.2 (-19.3, 0.9)	-4.5 (-7.1, -1.8)	0.3 (-2.7, 3.2)
		Difference-in-Difference (95% CI)	**Difference-in-Difference (95% CI)**	**Difference-in-Difference (95% CI)**
Estimated Causal Effect	(2020-2019) – (2019-2018)	-24.6 (-35.4, -13.8)	-16.3 (-20.1, -12.2)	-5.2 (-8.8, -1.6)

Notes:
95% CI (confidence interval)
[a] Fixed effect model with a lagged variable as the outcome, controlling for time-invariant confounders but constraining sex and age effects on the outcome to be fixed across time, and sample selection correction with the predictors of age, sex, weekly spending money, and province.
[b] Refers to the proportion of users for the corresponding vaping outcome based on the adjusted models.

Table 3

Average discrete change of adjusted proportions of vaping behaviour over time and estimated causal effect of the early COVID-19 period on vaping by difference-in-difference, stratified by sex, among eligible students attending the 43 linked-longitudinal COMPASS schools across the three study waves (2018, 2019, 2020).

		Vaping					
		Monthly Use[a]		***Weekly Use***[a]		***Daily Use***[a]	
		Mean[b] (95% CI)		**Mean[b] (95% CI)**		**Mean[b] (95% CI)**	
		Female	Male	Female	Male	Female	Male
Average Discrete Change	2019-2018 (pre-COVID-19 period)	15.3 (12.5,18.2)	15.5 (12.3,18.8)	10.6 (8.7,12.5)	13.1 (10.6,15.6)	4.5 (3.4, 5.6)	6.5 (4.8, 8.1)
	2020-2019 (early COVID-19 period)	-6.2 (-15.8,3.4)	-12.7 (-23.9,-1.5)	-2.4 (-4.8,0.1)	-6.9 (-10.9,-2.9)	2.1 (-0.1, 4.1)	-1.9 (-6.3, 2.6)
		Difference-in-Difference (95% CI)		**Difference-in-Difference (95% CI)**		**Difference-in-Difference (95% CI)**	
		Female	Male	Female	Male	Female	Male
Estimated Causal Effect[b]	(2020-2019) – (2019-2018)	-21.5 (-32.3,-10.8) *P<0.001*	-28.2 (-40.5,-15.9) *p<0.001*	-13.0 (-16.7,-9.3) *P<0.001*	-20.0 (-25.6,-14.3) *P<0.001*	-2.4 (-5.1, 0.2) *p=0.068*	-8.4 (-13.9,-2.8) *p=0.003*

Notes:
95% CI (confidence interval)
[a] Fixed effect model with a lagged variable as the outcome, controlling for time-invariant confounders but constraining age effects on the outcome to be fixed across time, and sample selection correction with the predictors of age, weekly spending money, and province.
[b] Refers to the proportion of users for the corresponding vaping outcome based on the adjusted models.

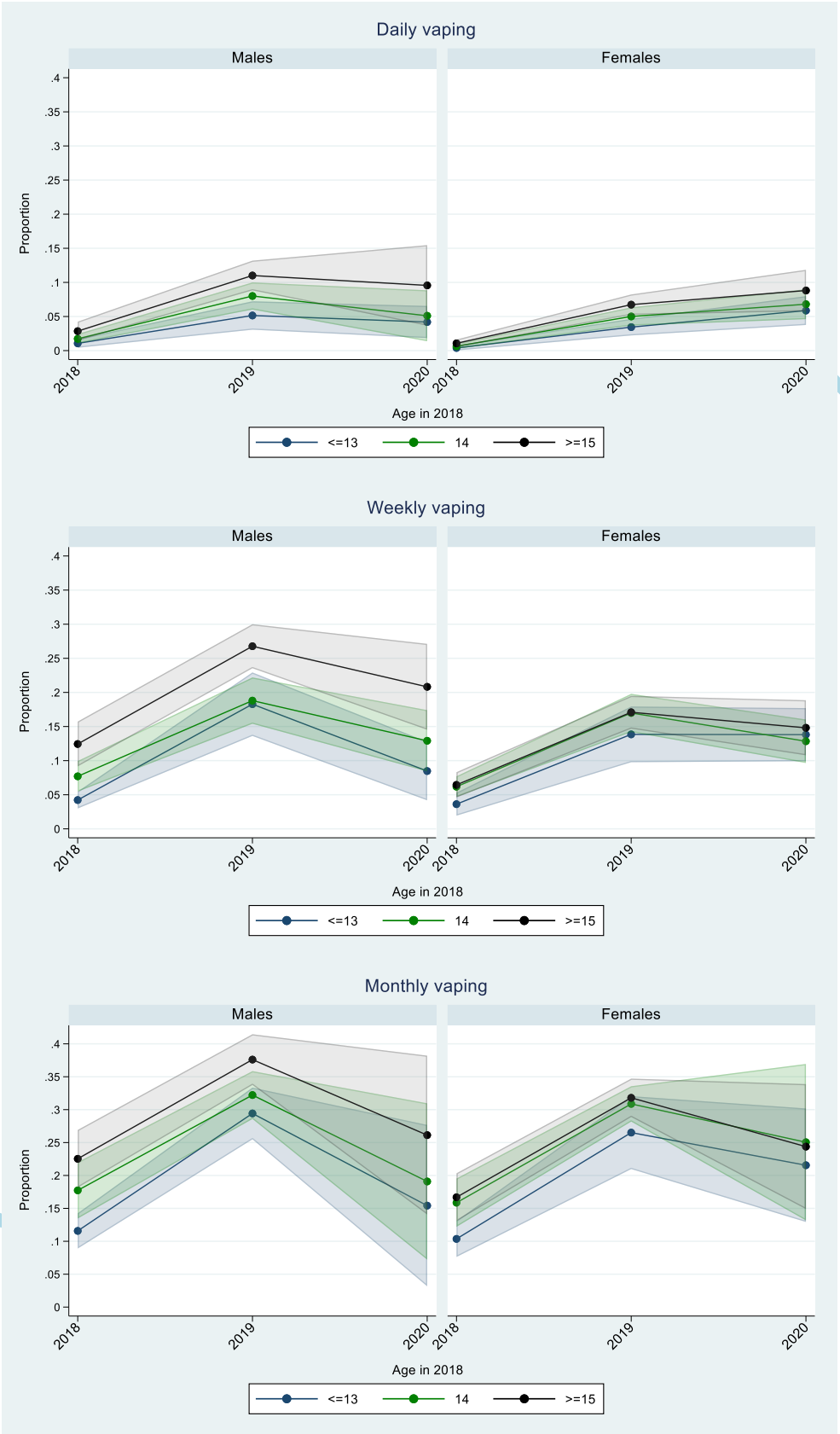

Figure 1. Average adjusted predictions of the proportion of youth who were vaping over survey waves, stratified by sex and age (at entry into cohort in 2018), among eligible students attending the 43 linked-longitudinal COMPASS schools across the three study waves (2018, 2019, 2020).