

Original quantitative research

Investigating individual-level correlates of e-cigarette initiation among a large sample of Canadian high school students

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Abstract

Introduction: Having a better understanding of individual factors associated with e-cigarette initiation can help improve prevention efforts. Therefore, this study aimed to (1) identify baseline characteristics associated with e-cigarette initiation, and (2) determine whether changes in these baseline characteristics were associated with e-cigarette initiation.

Methods: This study used data from Year 6 (2017/18, baseline) and Year 7 (2018/19, follow-up) of the COMPASS study. The final sample included 12 315 students in Grades 9 to 11 who reported never having tried e-cigarettes at baseline. Students reported demographic information, other substance use, school behaviours, physical activity, sedentary behaviour, sleep, symptoms of anxiety and depression, and emotional regulation and flourishing scores. Hierarchical GEE models, stratified by gender, examined the association between (1) baseline characteristics and e-cigarette initiation at follow-up and (2) changes in baseline characteristics and e-cigarette initiation at follow-up.

Results: In total, 29% of students who had not yet initiated e-cigarette use reported initiating e-cigarette use at follow-up. Students in Grades 10 and 11 were less likely to initiate e-cigarette use. Other substance use, skipping school and meeting the physical activity guidelines at baseline and one-year changes to these behaviours were associated with e-cigarette initiation among both male and female students. Additionally, some differences were noted between females and males.

Conclusion: Given that other health behaviours were associated with e-cigarette initiation, prevention approaches should target multiple health-risk behaviours to help prevent youth e-cigarette use. Additionally, school-based approaches may benefit by being implemented at the beginning of high school or in junior high school.

Keywords: *vaping, adolescent, alcohol drinking, cannabis smoking, cigarette smoking, mental health, exercise, sedentary behaviour*

Introduction

E-cigarettes are rapidly evolving devices that deliver an aerosol (or another substance), often containing nicotine, to the user in the absence of tobacco and combustion.¹ The prevalence of e-cigarette use, also known as vaping, has increased

dramatically among youth in recent years.²⁻⁵ Both Canada and the United States have seen notable increases in e-cigarette use among adolescents.⁴ The US saw an increase in prevalence among high school students from 1.5% to 20.8% from 2011 to 2018, with the largest jump between 2017 and 2018 (from 12% to

Highlights

- Twenty-nine percent of students who had not yet initiated e-cigarette use reported initiating e-cigarette use at follow-up. Other substance use (i.e. alcohol, cannabis and cigarettes) was strongly associated with e-cigarette initiation.
- Students who met the Canadian physical activity guidelines were more likely to initiate e-cigarette use, and female students who met the screen time guidelines were less likely.
- Anxiety and depression were not significantly associated with e-cigarette initiation, but there was an association with higher emotional dysregulation for females and higher flourishing for males.
- The majority of students maintained their behaviours over time; results for changes from baseline were largely consistent with findings at baseline.

21%).⁵ Similarly, e-cigarette use among adolescents aged 15 to 19 in Canada doubled from 10% in 2016 to 20% in 2018.² Among Canadian adolescents who report e-cigarette use, 40% report daily or almost daily use and 90% report using products with nicotine.² E-cigarette use among youth is concerning due to the unknown effects of exposure to aerosolized chemicals and the known negative impacts of nicotine on the developing brain.^{6,7}

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While many studies have linked e-cigarette use and cigarette initiation,⁸ few have focussed on the individual factors associated with e-cigarette use initiation. Evidence suggests that tobacco use (e.g. cigars, cigarillos) and substance use,⁹⁻¹² high levels of sensation seeking,^{13,14} poor mental health,^{15,16} exposure to e-cigarette marketing,^{9,17,18} and positive attitudes towards e-cigarettes among individuals, friends and family^{9,19-21} are factors associated with initiating e-cigarette use. While many studies have identified a significant association between e-cigarette initiation and gender, they have not explored further gender differences in predictive factors.^{9,10,13-15,18,19} A better understanding of individual factors associated with e-cigarette initiation can improve prevention efforts by identifying the characteristics (both modifiable and nonmodifiable) of at-risk groups. However, there has been little investigation into the influence of other risk behaviours (e.g. truancy, poor grades), movement behaviours²² and mental well-being on e-cigarette initiation, and how these change over time.

There is a well-established literature demonstrating that less healthy behaviour patterns among adolescents increase over time. For example, substance use and screen time tend to increase over time, while physical activity and sleep tend to decrease with age.^{2,23-25} Although many of these changes have been well documented, there is a lack of evidence concerning how changes over time are associated with more novel experiences, including e-cigarette initiation. To date, studies examining e-cigarette initiation have examined baseline behaviours only, and it is unknown how changes in behaviour may be associated with e-cigarette initiation.

Given the novelty of e-cigarettes, there is a need to further explore the individual-level factors that are associated with e-cigarette initiation among adolescents. The objectives of this study were to identify (1) the baseline characteristics associated with e-cigarette initiation, and (2) whether changes in these baseline characteristics were associated with e-cigarette initiation among Canadian adolescents.

Methods

Host study

COMPASS is a prospective cohort study that collects data from students in Grades

9 to 12 (aged 13–18 years) in British Columbia, Alberta and Ontario, and in Secondary I–V (aged 12–17 years) in Quebec, Canada.²⁶ All procedures were approved by the University of Waterloo Office of Research Ethics (reference number 30118) and appropriate school board committees. A full description of the COMPASS study methods can be found in print²⁶ or online (www.compass.uwaterloo.ca).

Participants

This study used data from Year 6 (2017/18, baseline) and Year 7 (2018/19, follow-up) of the COMPASS study. A total of 40 388 students in Grades 9 to 11 (and Secondary III–V in Quebec) from 111 schools participated at baseline (81.5% participation rate), and 23 168 of these (57%) were linked across both baseline and follow-up. Linked students were younger, comprised more females and had lower frequencies of substance use, including e-cigarette use, at baseline (data available upon request). Students for whom information on covariates was missing at baseline or at both baseline and follow-up ($n = 5338$, 23%) were removed. Students who were missing data and those who were not did not differ by frequency of e-cigarette use (data available upon request). Finally, those who had ever tried e-cigarettes at baseline were also removed from the sample ($n = 5515$, 31%). Thirty-three percent of students removed based on this criterion were in Grade 9 ($n = 1805$), 42% were in Grade 10 ($n = 2304$), and 25% were in Grade 11 ($n = 1406$). The final sample included 12 315 students in Grades 9 to 11 who reported never having tried e-cigarettes at baseline. We additionally examined a subsample of students ($n = 10 727$) who had complete data both at baseline and follow-up to explore whether changes in these baseline characteristics were associated with e-cigarette initiation.

Measures

Student responses were captured using the COMPASS questionnaire, which was administered during class time. Consistent with other youth health research,²⁷ students reported their grade, gender, ethnicity and weekly spending money.

To identify e-cigarette initiation, students were asked, “Have you ever tried an electronic cigarette, also known as an

e-cigarette?” Students who indicated “yes” at baseline were removed from the sample. Students who indicated “no” at baseline and “yes” at follow-up were considered to have initiated e-cigarette use.

The questionnaire also collected information on the use of other substances, including alcohol, cannabis and cigarettes. For alcohol and cannabis use, students were categorized as “monthly” users if they indicated use once per month or more, and “infrequent” users if they indicated use less than once per month. For cigarette use and e-cigarette use, students were categorized as “ever” users or “past month” users.

The questionnaire also collected data about behaviours at school, including skipping school in the past four weeks, and English grades (French grades in Quebec).

Additionally, students were asked to report the amount of time per day spent doing moderate-to-vigorous physical activity (MVPA), engaging in sedentary screen time activities (watching or streaming TV or movies, playing video or computer games, surfing the internet and texting, messaging or emailing), and sleeping. Students were categorized as meeting or not meeting the targets for each of these movement behaviours as set by the Canadian 24-Hour Movement Guidelines for Children and Youth.²² It is recommended that each day children and youth should accumulate at least 60 minutes of MVPA, less than 2 hours of screen time, and 8 to 10 hours of uninterrupted sleep.²²

Finally, mental health and wellbeing were assessed using the Centre for Epidemiological Studies Depression Scale (CES-D-10),²⁸ the Generalized Anxiety Disorder 7 (GAD-7) scale,²⁹ the Difficulties in Emotional Regulation Scale (DERS),³⁰ and the Flourishing Scale.³¹ The CES-D-10 and the GAD-7 are continuous scales ranging from 0 to 30 and 0 to 21 respectively, where a score of 10 or higher is indicative of clinically relevant symptomatology; scales were dichotomized to reflect this.^{28,29} The DERS is a continuous scale with a range of 6 to 30, where a higher score indicates poorer emotional regulation. The Flourishing Scale is a continuous scale with a range of 8 to 40, where a higher score indicates better flourishing. Flourishing is a state of overall wellbeing

used to describe the presence of mental health;³² the scale included level of agreement with questionnaire items such as “I lead a purposeful and meaningful life,” “I am engaged and interested in my daily activities” and “I am optimistic about my future.” We modelled a 3-unit change in both DERS and flourishing scores to capture a relevant change in score ($> 1/2$ a standard deviation) that was not due to chance alone. These scales have been previously validated among adolescents.^{28,30,33-37}

Analyses

The analyses were conducted in two parts. First (Part 1), we examined the association between baseline individual-level characteristics and follow-up e-cigarette initiation. Chi-squared tests compared categorical variables and *t*-tests compared continuous variables across e-cigarette use initiation at follow-up. Generalized estimating equations (GEE) via PROC GENMOD in SAS with an exchangeable correlation structure were used to identify baseline variables associated with e-cigarette initiation at follow-up while accounting for the nesting of students within schools. We first ran partially adjusted models examining the association between each variable and e-cigarette initiation, adjusting only for province, grade and gender. We then ran fully adjusted models adjusting for all other variables. All models were stratified by gender due to known differences in behaviour and differences identified using chi square and bivariate analyses.

Second (Part 2), we explored how changes in individual-level characteristics between baseline and follow-up were associated with e-cigarette initiation at follow-up. Students were categorized into different groups based on the change in their behaviours between baseline and follow-up. For substance use, “abstainers” did not engage in a specific behaviour at baseline or follow-up; “maintainers” continued the same level of frequency of the behaviour at baseline and follow-up; “escalators” increased the frequency of the behaviour from baseline to follow-up; and “reducers” decreased the frequency of the behaviour from baseline to follow-up. For binary variables such as skipping school, meeting movement behaviour guidelines, and depression and anxiety, students were categorized based on having “yes” responses for “both years,” “neither year,” “follow-up only” or “baseline only.” For continuous variables, including

DERS and flourishing, students were categorized as “no change,” “increase” or “decrease” based on the difference between their responses at baseline and at follow-up. We used the same analytic approach as in Part 1. All analyses were performed using SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Descriptive characteristics

Just over half of the sample was female (56%); 41% of students were in Grade 9, 36% in Grade 10 and 23% in Grade 11; 65% were White. Between baseline (2017/18) and follow-up one year later (2018/19), 29% of students who had not yet initiated e-cigarette use reported initiating e-cigarette use (Table 1).

Part 1: Association between baseline characteristics and e-cigarette initiation

After adjusting for all other factors, being in Grade 10 or 11 was associated with lower odds of e-cigarette initiation among both female and male students compared to being in Grade 9 (Table 2). More spending money was associated with increased odds of e-cigarette initiation.

After adjusting for all other factors, infrequent and monthly alcohol use and ever and past month cigarette smoking were associated with e-cigarette initiation among both female and male students. Infrequent and monthly cannabis use was associated with e-cigarette initiation among female students, while only infrequent use was associated with e-cigarette initiation among male students. Skipping school and getting lower grades were associated with increased likelihood of e-cigarette initiation.

Various movement behaviours were also associated with e-cigarette initiation. After adjusting for all other factors, meeting the physical activity guidelines was associated with e-cigarette initiation for both female (adjusted odds ratio [aOR] = 1.14; 95% CI = 1.02–1.27) and male (1.35; 1.16–1.57) students. Meeting the screen time guidelines was associated with decreased odds of e-cigarette initiation only among female students (0.69; 0.58–0.84). Meeting the sleep guidelines was not significantly associated with e-cigarette initiation.

After adjusting for all other factors, reporting clinically relevant symptoms of anxiety

or depression was not associated with e-cigarette initiation among either female or male students. However, among females, each 3-point increase in the DERS, representing poorer emotional regulation, was associated with slightly increased odds of e-cigarette initiation (1.07; 1.02–1.12), whereas among males, each 3-point increase in the Flourishing Scale, representing stronger flourishing, was associated with a slightly increased odds of e-cigarette initiation (1.09; 1.04–1.15).

Part 2: Association between changes in covariates and e-cigarette initiation

Across both genders, most students maintained their behaviours over time between baseline and follow-up, although, notably, 29% of students reported increasing their alcohol use (Table 3).

Similar to the results from Part 1, female and male students who abstained from other substance use, specifically alcohol use, cannabis use and cigarette smoking, at both baseline and follow-up had lower odds of initiating e-cigarette use compared to those who maintained their frequency of substance use in the fully adjusted models (Table 4).

Significant results were found for students who did not skip classes either year and for female students who skipped class in the baseline year only.

Male students who met the physical activity guidelines both years, who started meeting the guidelines and who stopped meeting the guidelines were at increased risk of e-cigarette initiation compared to those who did not meet the guidelines either year. Female students who met the screen time and sleep guidelines both years were less likely to start using e-cigarettes than those who met the guidelines neither year.

Changes in mental health and well-being indicators were not significantly associated with e-cigarette initiation.

Discussion

Over the course of one year, almost one-third (29%) of the Canadian secondary school students who had not yet initiated e-cigarette use reported initiation. This is consistent with research showing a rapid increase in the popularity of e-cigarette use among students,³ and highlights the

TABLE 1
Characteristics of students in Grades 9 to 11 who had not tried e-cigarettes at baseline,
by gender and e-cigarette initiation status at follow-up, 2017/18 to 2018/19 COMPASS study

Variable	Total (n = 12 315)		Female (n = 6891)			Male (n = 5424)		
	n	%	E-cigarette initiation status			E-cigarette initiation status		
			No (%) (n = 4791)	Yes (%) (n = 2100)	p-value	No (%) (n = 3907)	Yes (%) (n = 1517)	p-value
Grade								
9	5 049	41.0	40.3	41.1	0.83	41.5	42.0	0.16
10	4 478	36.4	36.9	36.6		35.3	37.1	
11	2 788	22.6	22.8	22.4		23.2	20.9	
Ethnicity								
White	8 041	65.3	61.3	73.5	< 0.01	63.1	72.4	< 0.01
Non-White	4 274	34.7	38.7	26.5		36.9	27.6	
Weekly spending money								
Zero	2 627	21.3	21.6	13.8	< 0.01	26.3	17.9	< 0.01
\$1–\$20	3 622	29.4	29.9	28.1		29.7	28.9	
\$21–\$100	2 612	21.2	20.3	26.5		18.8	23.1	
\$100+	1 361	11.1	8.9	15.4		9.8	15.1	
Don't know/missing	2 093	17.0	19.3	16.2		15.4	15.0	
Alcohol use								
None	8 325	67.6	74.4	41.2	< 0.01	79.9	51.0	< 0.01
Infrequent	2 315	18.8	17.3	30.9		11.8	25.1	
Monthly	1 675	13.6	8.4	28.0		8.3	23.9	
Cannabis use								
None	11 597	94.2	96.6	85.1	< 0.01	97.5	90.4	< 0.01
Infrequent	410	3.3	2.1	8.5		1.3	5.3	
Monthly	308	2.5	1.3	6.4		1.2	4.4	
Cigarette use								
None	11 673	94.8	97.1	87.7	< 0.01	97.5	90.2	< 0.01
Ever use	480	3.9	2.3	8.7		2.1	7.1	
Past month use	162	1.3	0.6	3.7		0.4	2.7	
Skipping school								
No	10 182	82.7	84.6	71.4	< 0.01	88.1	78.4	< 0.01
Yes	2 133	17.3	15.5	28.6		11.9	21.6	
English grade^a								
80%–100%	7 489	60.8	71.8	63.1	< 0.01	53.1	43.0	< 0.01
70%–79%	3 115	25.3	19.9	24.6		29.2	33.4	
60%–69%	1 166	9.5	6.0	7.9		11.8	16.6	
< 60%	545	4.4	2.4	4.4		5.9	7.1	
Meeting PA guidelines								
No	7 355	59.7	66.5	61.6	< 0.01	55.8	45.8	< 0.01
Yes	4 960	40.3	33.5	38.4		44.2	54.3	
Meeting screen time guidelines								
No	11 250	91.4	88.3	93.2	< 0.01	93.0	94.1	0.15
Yes	1 065	8.7	11.7	6.8		7.0	5.9	

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TABLE 1 (continued)
Characteristics of students in Grades 9 to 11 who had not tried e-cigarettes at baseline,
by gender and e-cigarette initiation status at follow-up, 2017/18 to 2018/19 COMPASS study

Variable	Total (n = 12 315)		Female (n = 6891)			Male (n = 5424)		
	n	%	E-cigarette initiation status			E-cigarette initiation status		
			No (%) (n = 4791)	Yes (%) (n = 2100)	p-value	No (%) (n = 3907)	Yes (%) (n = 1517)	p-value
Meeting sleep guidelines								
No	6 872	55.8	57.8	60.1	0.07	51.9	53.7	0.22
Yes	5 443	44.2	42.2	39.9		48.1	46.3	
Depression symptoms								
No	8 366	67.9	62.9	54.4	< 0.01	77.6	77.5	0.93
Yes	3 949	32.1	37.1	45.6		22.4	22.5	
Anxiety symptoms								
No	9 484	77.0	70.6	65.7	< 0.01	87.3	86.6	0.46
Yes	2 831	23.0	29.4	34.3		12.7	13.5	
DERS (mean, SD)	13.8, 4.6		14.3, 4.8	15.2, 4.9	< 0.01	12.8, 4.1	13.0, 4.1	0.15
Flourishing Scale (mean, SD)	32.2, 5.4		32.1, 5.5	31.8, 5.5	0.03	32.2, 5.3	32.9, 4.8	< 0.01

Abbreviations: DERS, Difficulties in Emotional Regulation Scale; PA, physical activity; SD, standard deviation.

^a English grade in all provinces except Quebec, where the French grade was considered instead.

importance of investigating e-cigarette initiation. We identified multiple demographic and behavioural factors that were associated with e-cigarette initiation. Furthermore, we explored how changes to baseline behavioural factors among both female and male students were associated with e-cigarette initiation. The stratified findings illustrate some differences in factors associated with e-cigarette initiation between the genders that could inform tailored e-cigarette use prevention programs.

This study adds to the current literature by exploring an expanded range of factors associated with e-cigarette initiation. Younger students were more likely to initiate e-cigarette use, possibly because they are less resistant to peer influence.³⁸ This suggests that e-cigarette prevention efforts are needed prior to starting Grade 9 and may need to be reinforced in secondary school. Consistent with previous evidence for cigarette smoking³⁹ and e-cigarette initiation,¹⁶ female and male students with more spending money were more likely to initiate e-cigarette use. The cost of devices can be a deterrent for price-sensitive youth; therefore, taxation policies that increase the cost of e-cigarette devices and accessories (e.g. e-liquid, pods) may help to reduce e-cigarette initiation among youth.

As expected, participation in other substance use (i.e. alcohol, cannabis and

cigarettes) was strongly associated with e-cigarette initiation. At baseline, monthly alcohol use posed the greatest risk for females and past month cigarette use posed the greatest risk for males, followed by monthly alcohol use. Due to the relatively high number of students who reported alcohol use (33% for alcohol use vs. 6% for cannabis use and 5% for cigarette use) and the high odds of initiation, prevention efforts in this domain may also help prevent e-cigarette use, although additional evaluation evidence is required.

Results for changes in substance-use behaviours over time were similar. Many earlier studies have noted the clustering of health-risk and substance-use behaviours among adolescents, and it is likely that impulsivity and high levels of sensation seeking are underlying risk factors for these behaviours.^{9,10,12-15,21} Prevention programs should therefore address multiple substances and the underlying reasons that students use these substances, although additional evaluation of such programs on multiple health-risk behaviours is necessary.

Other health related behaviours were also associated with e-cigarette initiation, though results were sometimes complex and some differences between male and female students were observed. For example, students who met the Canadian

physical activity guidelines were more likely to initiate e-cigarette use. An earlier Canadian study also identified a link between physical activity and e-cigarette use;⁴⁰ however, other US-based studies have identified no link.⁴¹⁻⁴³ There is also evidence that youth view e-cigarettes as a less harmful alternative to cigarettes.⁴⁴ While students are increasingly aware of the harms of regular nicotine vaping, fewer students perceive harms with non-nicotine vaping or occasional nicotine vaping.^{2,45} This may explain their appeal to youth participating in sport who have been found to avoid other inhaled substances such as cannabis and cigarettes.⁴⁶

Meeting screen time guidelines, however, was negatively associated with e-cigarette initiation among female students who met screen time guidelines at baseline and follow up (i.e. maintainers). Previous research has identified a link between exposure to e-cigarette advertising and e-cigarette initiation,^{9,17,18} and students who meet Canadian screen time recommendations could have lower levels of exposure to advertising, particularly online. E-cigarette promotion is prevalent online, and youth who report exposure are more likely to initiate use.^{47,48} This result may have only been found among female students due to gender differences in how students engage in screen time: male students are more likely to spend time playing video games while

TABLE 2
GEE logistic regression models examining the association between individual-level characteristics at baseline and adjusted odds of e-cigarette initiation at follow-up among students in the 2-year linked sample, by gender, 2017/18 to 2018/19 COMPASS study (n = 12 315)

Variable	Female		Male	
	Partially adjusted aOR (95% CI)	Fully adjusted aOR (95% CI)	Partially adjusted aOR (95% CI)	Fully adjusted aOR (95% CI)
Grade				
9	1.00	1.00	1.00	1.00
10	0.99 (0.87–1.13)	0.65 (0.57–0.75)*	1.06 (0.92–1.21)	0.81 (0.70–0.94)*
11	1.10 (0.96–1.25)	0.54 (0.46–0.63)*	1.02 (0.87–1.21)	0.62 (0.51–0.75)*
Ethnicity				
White	1.00	1.00	1.00	1.00
Non-White	0.70 (0.61–0.80)*	0.76 (0.66–0.87)*	0.83 (0.70–0.98)*	0.86 (0.72–1.03)
Weekly spending money				
Zero	1.00	1.00	1.00	1.00
\$1–\$20	1.50 (1.29–1.75)*	1.34 (1.14–1.58)*	1.45 (1.20–1.75)*	1.29 (1.06–1.58)*
\$21–\$100	2.01 (1.70–2.39)*	1.65 (1.37–1.99)*	1.82 (1.50–2.19)*	1.42 (1.16–1.74)*
\$100+	2.63 (2.14–3.24)*	1.89 (1.50–2.38)*	2.27 (1.86–2.77)*	1.65 (1.32–2.06)*
Don't know/missing	1.26 (1.08–1.47)*	1.19 (1.00–1.41)*	1.43 (1.17–1.75)*	1.29 (1.05–1.58)*
Alcohol use				
None	1.00	1.00	1.00	1.00
Infrequent	3.37 (2.92–3.88)*	2.81 (2.42–3.25)*	3.42 (2.88–4.04)*	2.99 (2.50–3.57)*
Monthly	6.48 (5.50–7.63)*	4.12 (3.45–4.91)*	4.51 (3.71–5.48)*	3.16 (2.55–3.93)*
Cannabis use				
None	1.00	1.00	1.00	1.00
Infrequent	4.68 (3.71–5.90)*	1.87 (1.42–2.46)*	4.45 (3.33–5.96)*	2.00 (1.36–2.95)*
Monthly	5.85 (4.29–7.97)*	1.69 (1.17–2.45)*	4.05 (2.56–6.42)*	1.26 (0.75–2.14)
Cigarette use				
None	1.00	1.00	1.00	1.00
Ever use	4.38 (3.36–5.70)*	2.13 (1.54–2.96)*	3.89 (2.96–5.11)*	2.52 (1.87–3.39)*
Past month use	6.38 (4.16–9.79)*	1.72 (1.00–2.94)*	8.35 (4.23–16.69)*	4.28 (2.02–9.06)*
Skipping school				
No	1.00	1.00	1.00	1.00
Yes	2.28 (1.97–2.63)*	1.54 (1.32–1.79)*	2.01 (1.72–2.35)*	1.42 (1.20–1.67)*
English grade^a				
80%–100%	1.00	1.00	1.00	1.00
70%–79%	1.37 (1.21–1.55)*	1.23 (1.07–1.41)*	1.32 (1.16–1.51)*	1.33 (1.15–1.54)*
60%–69%	1.48 (1.20–1.83)*	1.26 (0.97–1.63)	1.57 (1.27–1.94)*	1.55 (1.24–1.92)*
< 60%	2.23 (1.77–2.82)*	1.68 (1.28–2.21)*	1.44 (1.13–1.84)*	1.43 (1.09–1.88)*
Meeting PA guidelines				
No	1.00	1.00	1.00	1.00
Yes	1.27 (1.15–1.41)*	1.14 (1.02–1.27)*	1.54 (1.34–1.77)*	1.35 (1.16–1.57)*
Meeting screen time guidelines				
No	1.00	1.00	1.00	1.00
Yes	0.53 (0.44–0.63)*	0.69 (0.58–0.84)*	0.87 (0.68–1.11)	0.97 (0.75–1.27)
Meeting sleep guidelines				
No	1.00	1.00	1.00	1.00
Yes	0.82 (0.73–0.92)*	0.90 (0.80–1.02)	0.88 (0.76–1.02)	0.93 (0.80–1.06)

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TABLE 2 (continued)

GEE logistic regression models examining the association between individual-level characteristics at baseline and adjusted odds of e-cigarette initiation at follow-up among students in the 2-year linked sample, by gender, 2017/18 to 2018/19 COMPASS study (n = 12 315)

Variable	Female		Male	
	Partially adjusted aOR (95% CI)	Fully adjusted aOR (95% CI)	Partially adjusted aOR (95% CI)	Fully adjusted aOR (95% CI)
Depression symptoms				
No	1.00	1.00	1.00	1.00
Yes	1.51 (1.34–1.70) ^a	1.13 (0.98–1.31)	1.05 (0.88–1.25)	1.00 (0.80–1.24)
Anxiety symptoms				
No	1.00	1.00	1.00	1.00
Yes	1.29 (1.15–1.44) ^a	0.89 (0.75–1.05)	1.10 (0.91–1.33)	1.02 (0.80–1.30)
DERS (3-unit increase)	1.14 (1.10–1.18) ^a	1.07 (1.02–1.12) ^a	1.04 (0.99–1.09)	1.05 (0.99–1.11)
Flourishing Scale (3-unit increase)	0.94 (0.92–0.97) ^a	1.03 (1.00–1.07)	1.06 (1.02–1.10) ^a	1.09 (1.04–1.15) ^a

Abbreviations: aOR, adjusted odds ratio; CI, confidence intervals; DERS, Difficulties in Emotional Regulation Scale; GEE, generalized estimating equations; PA, physical activity.

Notes: Partially adjusted models controlled for grade, ethnicity, province and school-level clustering. Fully adjusted models controlled for all variables in table, province and school-level clustering. Physical activity guidelines: at least 60 minutes of moderate-to-vigorous physical activity per day. Screen time guidelines: less than 2 hours of screen time per day. Sleep guidelines: 8 to 10 hours of uninterrupted sleep. Depression and anxiety symptoms were measured using the CES-D-10 and the GAD-7, respectively. These are continuous scales where a score of 10 or higher was used to indicate clinically relevant symptomatology.

^a English grade in all provinces except Quebec, where the French grade was considered instead.

^{*}p < 0.05

TABLE 3
Change in individual-level behaviours between baseline and follow-up among students in the 2-year linked sample, by gender, 2017/18 to 2018/19 COMPASS study

Variable	Total (n = 10 727)		Female (n = 6032)			Male (n = 4695)		
	n	%	E-cigarette initiation status			E-cigarette initiation status		
			No (%) (n = 4191)	Yes (%) (n = 1841)	p-value	No (%) (n = 3399)	Yes (%) (n = 1296)	p-value
Alcohol use								
Maintainers	2045	19.1	14.9	35.7	< 0.01	11.7	28.1	< 0.01
Abstainers	4977	46.4	55.6	13.1		62.9	20.5	
Escalators	3053	28.5	24.1	43.4		20.0	43.4	
Reducers	652	6.1	5.4	7.8		5.3	7.9	
Cannabis use								
Maintainers	340	3.2	1.5	9.1	< 0.01	1.0	6.0	< 0.01
Abstainers	8950	83.4	91.8	60.3		93.2	63.6	
Escalators	1259	11.7	5.3	27.3		4.9	28.3	
Reducers	178	1.7	1.4	3.3		1.0	2.1	
Cigarette use								
Maintainers	338	3.2	1.6	8.1	< 0.01	1.1	6.5	< 0.01
Abstainers	9511	88.7	95.1	71.4		95.7	74.0	
Escalators	721	6.7	2.4	17.8		2.1	17.3	
Reducers	157	1.5	1.0	2.7		1.1	2.2	
Skipping school								
Skipped both years	1169	10.9	9.1	20.9	< 0.01	6.7	13.4	< 0.01
Skipped neither year	7009	65.3	68.4	46.2		75.2	56.7	
Skipped follow-up only	1882	17.5	16.3	25.4		13.2	21.8	
Skipped baseline only	667	6.2	6.2	7.6		4.9	8.0	

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TABLE 3 (continued)
Change in individual-level behaviours between baseline and follow-up among students
in the 2-year linked sample, by gender, 2017/18 to 2018/19 COMPASS study

Variable	Total (n = 10 727)		Female (n = 6032)			Male (n = 4695)		
	n	%	E-cigarette initiation status			E-cigarette initiation status		
			No (%) (n = 4191)	Yes (%) (n = 1841)	p-value	No (%) (n = 3399)	Yes (%) (n = 1296)	p-value
English grade^a								
No change	7050	65.7	73.3	67.1	< 0.01	60.8	52.2	< 0.01
Increase in grade	1779	16.6	13.0	16.1		19.2	22.0	
Decrease in grade	1898	17.7	13.8	16.8		19.9	25.8	
Meeting PA guidelines								
Met neither year	4884	45.5	52.7	46.8	< 0.01	42.0	29.9	< 0.01
Met both years	2551	23.8	17.9	21.1		27.8	36.0	
Met follow-up only	1519	14.2	13.6	14.8		14.0	15.6	
Met baseline only	1773	16.5	15.8	17.3		16.2	18.5	
Meeting screen time guidelines								
Met neither year	9408	87.7	83.3	90.3	< 0.01	90.2	91.7	0.11
Met both years	333	3.1	4.8	1.8		2.3	1.5	
Met follow-up only	400	3.7	5.1	3.0		3.0	2.2	
Met baseline only	586	5.5	6.8	4.9		4.4	4.7	
Meeting sleep guidelines								
Met neither year	4887	45.6	48.7	50.1	0.09	40.9	41.1	0.22
Met both years	2784	26.0	25.1	22.1		28.7	27.0	
Met follow-up only	1096	10.2	9.0	9.9		10.8	12.8	
Met baseline only	1960	18.3	17.2	17.9		19.6	19.1	
Depression symptoms								
Neither year	5617	52.4	46.6	37.3	< 0.01	64.3	61.1	0.04
Both years	2536	23.6	29.1	34.7		14.4	14.6	
Follow-up only	1647	15.4	16.0	17.8		12.9	16.1	
Baseline only	927	8.6	8.3	10.3		8.3	8.2	
Anxiety symptoms								
Neither year	6948	64.8	57.3	48.9	< 0.01	78.6	75.2	0.04
Both years	1604	15.0	20.1	23.2		7.0	7.4	
Follow-up only	1286	12.0	13.2	16.7		8.4	10.7	
Baseline only	889	8.3	9.4	11.1		5.9	6.7	
DERS								
No change	5399	50.3	48.9	45.4	0.05	54.1	52.1	0.44
Increase	2884	26.9	28.6	30.3		23.7	25.0	
Decrease	2444	22.8	22.5	24.3		22.2	22.9	
Flourishing Scale								
No change	5567	51.9	52.3	50.3	0.26	52.5	51.3	0.77
Increase	2276	21.2	19.9	21.6		22.1	22.6	
Decrease	2884	26.9	27.7	28.1		25.4	26.1	

Abbreviations: DERS, Difficulties in Emotional Regulation Scale; PA, physical activity.

Notes: Changes in DERS and Flourishing Scale reflect a 3-unit change.

For substance use, “abstainers” did not engage in a specific behaviour at baseline or follow-up; “maintainers” continued the same level of frequency of the behaviour at baseline and follow-up; “escalators” increased the frequency of the behaviour from baseline to follow-up; and “reducers” decreased the frequency of the behaviour from baseline to follow-up.

^a English grade in all provinces except Quebec, where the French grade was considered instead.

TABLE 4
GEE logistic regression models examining the association between change in individual-level behaviours between baseline and follow-up and e-cigarette initiation at follow-up among students in the 2-year linked sample, by gender, 2017/18 to 2018/19 COMPASS study (n = 10 727)

Variable	Female		Male	
	Partially adjusted aOR (95% CI)	Fully adjusted aOR (95% CI)	Partially adjusted aOR (95% CI)	Fully adjusted aOR (95% CI)
Alcohol use				
Maintainers	1.00	1.00	1.00	1.00
Abstainers	0.09 (0.07–0.11)*	0.19 (0.15–0.23)*	0.13 (0.11–0.16)*	0.26 (0.21–0.33)*
Escalators	0.69 (0.58–0.82)*	0.87 (0.72–1.05)	0.87 (0.71–1.06)	1.13 (0.91–1.40)
Reducers	0.60 (0.47–0.77)*	0.70 (0.54–0.90)*	0.63 (0.48–0.83)*	0.80 (0.58–1.09)
Cannabis use				
Maintainers	1.00	1.00	1.00	1.00
Abstainers	0.10 (0.07–0.14)*	0.31 (0.21–0.45)*	0.10 (0.07–0.15)*	0.30 (0.19–0.49)*
Escalators	0.81 (0.57–1.16)	1.01 (0.68–1.49)	0.87 (0.56–1.34)	1.12 (0.68–1.83)
Reducers	0.40 (0.24–0.66)*	0.60 (0.33–1.07)	0.35 (0.19–0.63)*	0.52 (0.25–1.08)
Cigarette use				
Maintainers	1.00	1.00	1.00	1.00
Abstainers	0.14 (0.11–0.20)*	0.37 (0.25–0.53)*	0.12 (0.08–0.19)*	0.27 (0.17–0.43)*
Escalators	1.45 (1.01–2.08)*	1.55 (0.98–2.45)	1.35 (0.84–2.17)	1.26 (0.73–2.17)
Reducers	0.56 (0.33–0.97)*	0.58 (0.31–1.07)	0.38 (0.20–0.73)*	0.39 (0.19–0.80)*
Skipping school				
Skipped both years	1.00	1.00	1.00	1.00
Skipped neither year	0.26 (0.22–0.31)*	0.58 (0.49–0.69)*	0.35 (0.28–0.43)*	0.72 (0.58–0.90)*
Skipped follow-up only	0.64 (0.53–0.78)*	0.84 (0.68–1.05)	0.82 (0.66–1.01)	1.05 (0.82–1.35)
Skipped baseline only	0.51 (0.39–0.66)*	0.65 (0.50–0.85)*	0.80 (0.60–1.06)	1.14 (0.82–1.59)
English grade^a				
No change	1.00	1.00	1.00	1.00
Increase	1.37 (1.18–1.59)*	0.98 (0.81–1.19)	1.31 (1.11–1.54)*	1.17 (0.96–1.42)
Decrease	1.39 (1.19–1.62)*	1.06 (0.87–1.29)	1.46 (1.22–1.74)*	1.21 (0.99–1.49)
Meeting PA guidelines				
Met neither year	1.00	1.00	1.00	1.00
Met both years	1.39 (1.20–1.61)*	1.15 (0.97–1.36)	1.91 (1.58–2.30)*	1.48 (1.18–1.84)*
Met follow-up only	1.30 (1.10–1.54)*	1.09 (0.92–1.30)	1.64 (1.34–2.01)*	1.28 (0.98–1.68)
Met baseline only	1.30 (1.12–1.50)*	1.13 (0.95–1.34)	1.69 (1.39–2.06)*	1.36 (1.08–1.71)*
Meeting screen time guidelines				
Met neither year	1.00	1.00	1.00	1.00
Met both years	0.32 (0.22–0.47)*	0.58 (0.39–0.84)*	0.60 (0.38–0.96)*	0.94 (0.57–1.54)
Met follow-up only	0.54 (0.39–0.74)*	0.82 (0.59–1.14)	0.69 (0.43–1.11)	0.79 (0.48–1.32)
Met baseline only	0.64 (0.49–0.83)*	0.88 (0.66–1.16)	1.13 (0.82–1.55)	1.39 (0.92–2.09)
Meeting sleep guidelines				
Met neither year	1.00	1.00	1.00	1.00
Met both years	0.74 (0.63–0.86)*	0.84 (0.71–0.98)*	0.87 (0.72–1.04)	1.01 (0.83–1.23)
Met follow-up only	0.98 (0.78–1.23)	0.96 (0.75–1.22)	1.14 (0.90–1.43)	1.26 (0.99–1.62)
Met baseline only	0.96 (0.82–1.12)	1.02 (0.87–1.20)	0.92 (0.75–1.14)	1.02 (0.81–1.29)

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TABLE 4 (continued)
GEE logistic regression models examining the association between change in individual-level behaviours between baseline and follow-up and e-cigarette initiation at follow-up among students in the 2-year linked sample, by gender, 2017/18 to 2018/19 COMPASS study (n = 10 727)

Variable	Female		Male	
	Partially adjusted aOR (95% CI)	Fully adjusted aOR (95% CI)	Partially adjusted aOR (95% CI)	Fully adjusted aOR (95% CI)
Depression symptoms				
Both years	1.00	1.00	1.00	1.00
Neither year	0.62 (0.54–0.72)*	1.04 (0.85–1.27)	0.88 (0.71–1.09)	1.13 (0.82–1.57)
Follow-up only	0.91 (0.75–1.10)	1.19 (0.94–1.51)	1.21 (0.94–1.55)	1.31 (0.90–1.89)
Baseline only	1.02 (0.83–1.26)	1.11 (0.86–1.45)	0.94 (0.72–1.24)	1.02 (0.70–1.49)
Anxiety symptoms				
Both years	1.00	1.00	1.00	1.00
Neither year	0.72 (0.62–0.84)*	0.91 (0.72–1.14)	0.88 (0.69–1.12)	0.99 (0.69–1.44)
Follow-up only	1.09 (0.89–1.33)	1.13 (0.88–1.46)	1.20 (0.89–1.63)	1.26 (0.82–1.93)
Baseline only	1.03 (0.81–1.30)	0.96 (0.72–1.28)	1.09 (0.82–1.45)	1.11 (0.77–1.61)
DERS (3-unit change)				
No change	1.00	1.00	1.00	1.00
Increase	1.16 (1.03–1.30)*	1.05 (0.89–1.23)	1.09 (0.93–1.26)	0.98 (0.81–1.18)
Decrease	1.19 (1.03–1.38)*	1.12 (0.94–1.33)	1.08 (0.92–1.27)	1.03 (0.86–1.24)
Flourishing Scale (3-unit change)				
No change	1.00	1.00	1.00	1.00
Increase	1.13 (1.00–1.28)*	1.04 (0.88–1.23)	1.07 (0.90–1.27)	1.00 (0.82–1.23)
Decrease	1.06 (0.95–1.18)	0.92 (0.80–1.33)	1.04 (0.90–1.20)	0.97 (0.81–1.16)

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; DERS, Difficulties in Emotional Regulation Scale; GEE, generalized estimating equations; PA, physical activity.

Notes: Partially adjusted models controlled for grade, ethnicity, province and school-level clustering. Fully adjusted models controlled for grade, ethnicity, spending money, all variables in table, province and school-level clustering.

For substance use, “abstainers” did not engage in a specific behaviour at baseline or follow-up; “maintainers” continued the same level of frequency of the behaviour at baseline and follow-up; “escalators” increased the frequency of the behaviour from baseline to follow-up; and “reducers” decreased the frequency of the behaviour from baseline to follow-up.

^a English grade in all provinces except Quebec, where the French grade was considered instead.

* $p < 0.05$

female students are more likely to spend time on their mobile phone.⁴⁹ However, these results should be interpreted with caution, given that the vast majority of both female and male students did not meet screen time guidelines.

Finally, meeting the sleep guidelines both years among females was negatively associated with e-cigarette initiation. These results are intuitive and add to the literature. While cannabis use and initiating binge drinking have been associated with not meeting the sleep guidelines,^{50,51} other research has found no association.⁵² This finding may be due to a shift in lifestyle less conducive to sleep, although more research is warranted.

In contrast to previous studies,^{15,16,53} mental health indicators were not significantly associated with e-cigarette initiation. Two previous studies identified internalizing problems (e.g. anxiety, depression) were

associated with initiation of e-cigarettes only but not dual use of e-cigarettes and conventional cigarettes,^{15,16} while another identified depressive symptoms as associated with initiation of e-cigarette use, cigarette use and dual use.⁵³ However, these studies used different measures, accounted for dual use of cigarettes and e-cigarettes, and two did not control for cannabis use,^{16,53} which has also been associated with depression⁵⁴ and could confound results. Additional studies are necessary to further explore the association between mental health indicators and e-cigarette initiation.

Results for the Difficulties in Emotional Regulation Scale (DERS) were significant for female students. This is consistent with previous research that has found emotional dysregulation to be associated with cigarette initiation.⁵⁵ Higher DERS indicates lower levels of emotional regulation, suggesting that female students are

potentially using e-cigarettes as a coping strategy. Therefore, teaching alternative positive coping strategies could be an important component of e-cigarette prevention programs for female students.

In contrast, higher flourishing was associated with increased odds of e-cigarette initiation among males. This is opposite to results that have linked higher flourishing with less substance use or no effect,^{56–58} suggesting that e-cigarettes are not being used as a coping mechanism among males. Curiosity about a novel product is a leading reason adolescents try e-cigarettes and could be motivating this group, along with marketing that broadly appeals to youth.^{59,60} Previous research has been cross-sectional,^{56–58} and it is possible that the direction of association changed after students transitioned to more regular use. Based on these results and the positive associations seen between physical activity and e-cigarette use, e-cigarette use may

be more of a social activity, but more research is needed to explore this hypothesis.

Strengths and limitations

The main strength of this study is the use of a large, school-based longitudinal dataset to examine factors associated with e-cigarette use. In particular, the use of passive consent procedures maximizes the student participation rate and limits selection bias that is common in youth substance-use studies that use active consent procedures.^{26,61-64} This study is the first of its kind to examine e-cigarette initiation in the Canadian context and how changes in behaviour may impact e-cigarette initiation among Canadian students. The COMPASS study includes questions that assess a range of health behaviours, allowing a comprehensive examination of the influence of demographic characteristics, behavioural factors and mental health indicators on e-cigarette initiation.

Although the COMPASS study has a large sample size, it was designed to evaluate changes in school programs and policies using natural experiment methodology. Therefore, it is not representative of all Canadian secondary school students. Also, because the questionnaire neither defines “e-cigarette” nor lists brands, and because of the changing language used by youth to refer to e-cigarette devices (e.g. “vaping,” “Juuling”), this study may under-report e-cigarette use. It is also likely that the relationship between risk factors and e-cigarette initiation is influenced by other factors not measured in the COMPASS survey, such as exposure to e-cigarette marketing^{9,17,18} or e-cigarette susceptibility.¹²

Additionally, as is the case with most self-report surveys, there could be reporting bias with respect to substance use; however, students are assured of the anonymity of their responses. Furthermore, participant drop-out and limitations with linking students across both waves may have resulted in an underestimation of e-cigarette initiation rates and their associations with demographic and behavioural variables, because students who are linked over time are more likely to be younger, female and less likely to use substances.^{65,66} There were also some differences between the complete case sample and those removed, as well as differences between the samples in Part 1 and Part 2 that may have resulted in bias. Finally, the

use of two time points prevented us from assessing the temporal order between changes in covariates at follow-up and e-cigarette initiation (i.e. e-cigarette initiation could have occurred before or after covariate status at follow-up). Our analysis of changes in characteristics on e-cigarette use should therefore be considered exploratory.

Conclusion

This prospective study examining factors associated with e-cigarette initiation provides novel evidence to support the need for stronger e-cigarette prevention efforts aimed at youth populations. Over the span of just one year, almost one-third of the sample of previous nonusers initiated e-cigarette use. Prevention approaches should target multiple health-risk behaviours to help prevent youth e-cigarette initiation. Additionally, given that Grade 9 students were at higher risk of initiation, school-based approaches may benefit from being implemented before high school.

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Conflicts of interest

Scott Leatherdale is an Associate Scientific Editor with the HPCDP Journal but has

recused himself from the review process for this paper. The authors have no other conflicts of interest to declare.

Authors’ contributions and statement

GCW collaborated on the study methodology, conducted statistical analysis, interpreted the results and drafted the original manuscript. AGC conceived of the study research questions, collaborated on the study methodology, interpreted study results, contributed to the original manuscript draft and reviewed the manuscript for important intellectual content. MdG, YJ and STL collaborated on the study methodology, interpreted study results and revised the manuscript for important intellectual content. STL is the principal investigator of the COMPASS study, wrote the funding proposal, developed the tools and led study implementation and coordination. All authors read and approved the final manuscript.

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

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