The prevalence of cigarette smoking has declined in Canada, from about 50% in the 1960s to 13% in 2015.1 As in most other countries, the majority of Canadian smokers begin smoking during adolescence, and reductions in the prevalence of cigarette smoking in Canada have been achieved primarily through declining rates of smoking initiation among youth.1

The emergence of vapourized nicotine products — widely referred to as electronic cigarettes or e-cigarettes — has provided consumers with an alternative means of nicotine intake. The use of e-cigarettes is largely concentrated among adult smokers, most of whom report using e-cigarettes to quit smoking or for the purpose of smoking reduction.2,3 However, substantial proportions of youth also report using e-cigarettes. In Canada, about 20% of youth aged 15–19 years report “ever” using e-cigarettes, including 14% of youth nonsmokers, similar to estimates from the United Kingdom and the United States.4–7 Although many Canadian youth try e-cigarettes, fewer report regular use.8 For example, in a recent study of Canadian youth, only 0.2% of all youth — and 2% of those who had tried e-cigarettes — reported daily use.9

Studies have consistently shown a strong association between e-cigarette use and smoking initiation.10–12 In addition, US studies have suggested that the availability of e-cigarettes has expanded the nicotine market: rather than simply substituting e-cigarettes for cigarette smoking, the total number of youth using any type of nicotine product has increased for the first time in decades.12

The extent to which e-cigarette use is causally related to smoking initiation remains a source of considerable debate. To date, 4 studies have examined the temporal order between e-cigarette use and smoking initiation. Three studies involving US secondary students found that “ever” users of e-cigarettes at baseline were more likely to report smoking cigarettes 12 months later.13–15 In addition, a smaller study of secondary students in California found that students who reported “ever” using e-cigarettes were more likely to report using cigarettes, cigars, pipes and shisha at follow-up, compared with a matched sample of “never” e-cigarette users.16

Although longitudinal studies have been conducted in the US, the Canadian market is distinct in several important ways. In Canada, federal regulations require premarket approval for nicotine-containing e-cigarettes, and no products have received approval in Canada to date. Although e-cigarettes with nicotine are widely available through vape shops and online, supermarkets and other
Conventional retail outlets typically sell non-nicotine-containing e-cigarettes. At the time of the study, non-nicotine e-cigarettes could be legally purchased by minors, and accounted for a greater proportion of the e-cigarette market than in many other countries. In addition, there is little advertising or marketing for e-cigarettes in traditional media outlets in Canada, in contrast to the situation in the US and the UK. Canada’s distinct regulatory environment may have important implications for e-cigarette use among youth and its association with smoking behaviour. For example, the greater prevalence of non-nicotine-containing e-cigarettes may be less likely to promote smoking behaviour, given the lack of nicotine exposure.

We sought to examine e-cigarette use in a large longitudinal sample of Canadian youth, including the extent to which e-cigarette use was associated with cigarette-smoking initiation at 1-year follow-up.

Methods

The COMPASS study is an ongoing cohort study that collects longitudinal data from a convenience sample of secondary school students (grades 9–12) in Ontario and Alberta, Canada. A full description of the design and methods of the study is available. For the current study, we assessed e-cigarette use at baseline (year 2 of the COMPASS study, in 2013/14), as well as at 1-year follow-up (year 3 of the study, in 2014/15).

Schools were recruited for the survey through purposefully selected school boards that met the following eligibility criteria: English-speaking, with at least 100 students in each of grades 9 through 12, and permitted the use of active-information, passive-consent parental permission protocols (whereby information letters are mailed to the parents or guardians, who are asked to contact the researcher to decline their child’s participation). Within each school, all students were invited to participate. A more detailed description of study enrolment is provided in Appendix 1 (available at www.cmaj.ca/lookup/suppl/doi:10.1503/cmaj.161002/-/DC1).

Measures

Data for all measures were collected using paper-based surveys administered by teachers, under the supervision of study research assistants. Sociodemographic measures included age, sex, race/ethnicity (“How would you describe yourself?” with the following “Mark all that apply” options: white, black, Asian, Aboriginal [First Nations, Metis, Inuit], Latin American/Hispanic and other; those selecting more than 1 option were categorized as “other/mixed”) and spending money (“About how much money do you usually get each week to spend on yourself or to save? [Remember to include all money from allowances and jobs like babysitting, delivering papers, etc.]” with options of zero, $1 to $5, $6 to $10, $11 to $20, $21 to $40, $41 to $100, more than $100 and “I do not know how much money I get each week”).

We defined past 30-day cigarette use as 1 or more days in response to the question, “On how many of the last 30 days did you smoke one or more cigarettes?” We first classified smoking status into 6 categories: current daily smokers, who had smoked at least 100 cigarettes (lifetime) and had smoked on at least 1 day, but fewer than 30 days, of the past 30 days; former smokers, who had smoked at least 100 cigarettes (lifetime), but had not smoked in the last 30 days; experimental smokers, who had smoked a whole cigarette, but less than 100 cigarettes (lifetime); puffers, who had tried smoking but had not smoked a whole cigarette; and those who reported never having tried smoking. We then further classified the “never tried” group as susceptible or not susceptible to smoking, where susceptibility was defined as the absence of a firm commitment not to smoke (i.e., any response other than “definitely not”) on all 3 of the following susceptibility questions: “Do you think in the future you might try smoking cigarettes?” “If one of your best friends was to offer you a cigarette, would you smoke it?” and “At any time during the next year do you think you will smoke a cigarette?”

We created a variable for smoking initiation using the measure of ever having smoked a whole cigarette (“Have you ever smoked a whole cigarette?”) at baseline and follow-up: “never smokers” were those who responded “No” at both waves, and “initiators” were those who responded “No” at baseline but “Yes” at follow-up; those who had already smoked at baseline were excluded. We also created a variable for daily smoking initiation, using the measure of ever having smoked daily for 7 consecutive days (“Have you ever smoked every day for at least 7 days in a row?”) at baseline and follow-up: “never daily smokers” were those who responded “No” at both waves, and “daily initiators” were those who responded “No” at baseline but “Yes” at follow-up; those who had already smoked every day for 7 days at baseline were excluded.

We assessed past 30-day use of e-cigarettes by asking, “In the last 30 days, did you use any of the following? (Mark all that apply),” with a list of products, including “e-cigarettes (electronic cigarettes that look like cigarettes/cigars, but produce vapour instead of smoke).”

Statistical analysis

All of the analyses were conducted using SAS version 9.4 (SAS Institute).

For cross-sectional analyses, we used $\chi^2$ tests to examine differences between survey years in past-month e-cigarette and cigarette use, as well as differences in characteristics between the single-wave and longitudinal samples. To examine variables associated with past 30-day use of e-cigarettes in the baseline sample, we estimated a generalized linear mixed-effects (GLM) model, including covariates for age, sex, race/ethnicity, spending money, smoking status (as fixed effects) and a random effect of school (to account for student clustering within schools). We also estimated separate GLM models for each covariable to generate unadjusted estimates.

For the longitudinal analyses, to examine cigarette-smoking initiation between baseline and follow-up, we estimated a GLM for the linked sample at follow-up (among those who had never smoked a whole cigarette at baseline), accounting for student clustering within schools by entering school as a random effect, and including the past-wave covariables (i.e., baseline values) of age, sex, race/ethnicity, spending money and past 30-day e-cigarette use as fixed effects. We estimated a similar GLM model.
using daily cigarette-smoking initiation between baseline and follow-up (among those who had never smoked daily for 7 days at baseline). We excluded participants with missing data from the models on a case-wise basis.

Ethics approval
The COMPASS study was reviewed by and received ethics clearance from the University of Waterloo Office of Research Ethics and appropriate school board review panels.

Results

Samples
The COMPASS study was conducted in 89 secondary schools at baseline (79 in Ontario and 10 in Alberta) and 87 secondary schools at follow-up (78 in Ontario and 9 in Alberta); 86 schools (77 in Ontario and 9 in Alberta) participated at both baseline and follow-up. Figure 1 shows sample participation in each wave; 19,310 students who provided data for both waves were included in the longitudinal analysis.

Table 1 shows the baseline characteristics of the overall and longitudinal samples. Students in the longitudinal sample, who provided data at both waves, were significantly more likely to be female, to report their race/ethnicity as white and to report lower levels of smoking and e-cigarette use, and were significantly different on age (younger at baseline) and spending money (less at baseline) compared with students who provided data at only 1 wave (p < 0.001 for all comparisons).

Cross-sectional results: e-cigarette prevalence and predictors
Among all students surveyed (n = 44,163 at baseline; n = 41,262 at follow-up), prevalence of past 30-day e-cigarette use increased significantly from baseline to follow-up (7.2% v. 9.7%, p < 0.001). Past 30-day cigarette smoking decreased slightly between baseline and follow-up (11.4% v. 10.8%, p = 0.02).

Use of e-cigarettes was strongly associated with cigarette smoking: at baseline, 31.5% of students who had smoked a cigarette in the past 30 days also reported using an e-cigarette over the same period, compared with 5.0% of students who had not smoked in the past 30 days. After multivariable adjustment (and controlling for the effect of school), age, sex, race/ethnicity, spending money and smoking status were significantly associated with past 30-day e-cigarette use in the baseline sample (Table 2).

Longitudinal results: initiation of cigarette smoking by follow-up
Respondents who had already smoked a whole cigarette at baseline (n = 1,992) were excluded from the analysis of initiation of cigarette smoking. Overall, 8.4% of the longitudinal sample who had “never smoked” at baseline had smoked a whole cigarette by 1-year follow-up. Students who reported past 30-day e-cigarette use at baseline were significantly more likely to initiate smoking at follow-up (adjusted odds ratio [OR] 2.12, 95% confidence interval [CI] 1.68–2.66) (Table 3). Smoking initiation was more likely among males (adjusted OR 1.44, 95% CI 1.28–1.62)
and those with more spending money ($21–$100 v. $0 per week, adjusted OR 1.25, 95% CI 1.04–1.50; > $100 v. $0 per week, adjusted OR 1.53, 95% CI 1.22–1.91). Compared with nonsusceptible never-smokers, smoking initiation was more likely among those who were susceptible to smoking (adjusted OR 3.86, 95% CI 3.36–4.43) and those who had already tried smoking less than a whole cigarette (adjusted OR 13.56, 95% CI 11.60–15.85).

The analysis of daily smoking initiation excluded respondents who had already smoked every day for 7 days at baseline (n = 619). Overall, 3.7% of the longitudinal sample who had never “smoked every day for 7 days in a row” at baseline had done so by 1-year follow-up. Correlates of daily smoking initiation at follow-up (Table 4) were similar to those for ever-smoking initiation, including e-cigarette use at baseline (adjusted OR 1.79, 95% CI 1.41–2.28).

### Table 1: Baseline characteristics of the overall COMPASS sample (2013/14) and respondents followed longitudinally to 2014/15, Ontario and Alberta, Canada

| Characteristic (at baseline) | Sample; no. (%) of participants | p value† |
|-----------------------------|---------------------------------|---------|
|                             | Overall sample n = 44 163 | Longitudinal sample* n = 19 310 |
| **Age, yr**                 |                                |         |
| ≤ 14                        | 9743 (22.1)                   | 6255 (32.4) |
| 15                          | 11 283 (25.6)                 | 6517 (33.7) |
| 16                          | 11 175 (25.3)                 | 5238 (27.1) |
| 17                          | 9122 (20.7)                   | 1198 (6.2)  |
| ≥ 18                        | 2840 (6.4)                    | 102 (0.5)   |
| **Sex**                     |                                |         |
| Female                      | 21 901 (49.6)                 | 10 303 (53.4) |
| Male                        | 22 262 (50.4)                 | 9007 (46.6) |
| **Race/ethnicity‡**         |                                |         |
| White                       | 32 886 (74.8)                 | 14 940 (77.7) |
| Black                       | 1689 (3.8)                    | 603 (3.1)   |
| Asian                       | 2241 (5.1)                    | 979 (5.1)   |
| Aboriginal                  | 1546 (3.5)                    | 478 (2.5)   |
| Latin American/Hispanic     | 830 (1.9)                     | 305 (1.6)   |
| Other/mixed                 | 4759 (10.8)                   | 1929 (10.0) |
| **Spending money, $**       |                                |         |
| 0                           | 7046 (16.0)                   | 3605 (18.7) |
| 1–20                        | 12 680 (28.7)                 | 6594 (34.1) |
| 21–100                      | 11 749 (26.6)                 | 4650 (24.1) |
| > 100                       | 6994 (15.8)                   | 1850 (9.6)  |
| Don’t know/not stated       | 5694 (12.9)                   | 2611 (13.5) |
| **Smoking status**          |                                |         |
| Never tried, not susceptible| 22 187 (50.2)                 | 11 075 (57.4) |
| Never tried, susceptible    | 9537 (21.6)                   | 4719 (24.4) |
| Puffer                      | 4465 (10.1)                   | 1524 (7.9)  |
| Experimental smoker         | 4819 (10.9)                   | 1447 (7.5)  |
| Former smoker               | 372 (0.8)                     | 90 (0.5)    |
| Current occasional smoker   | 1409 (3.2)                    | 263 (1.4)   |
| Current daily smoker        | 1374 (3.1)                    | 192 (1.0)   |

* A total of 19 310 student surveys from the baseline wave (2013/14) were linked to surveys in the follow-up wave (2014/15).
† From χ² test of difference in baseline characteristics between overall sample and those retained at follow-up.
‡ Totals of 212 and 76 in the baseline and longitudinal samples, respectively, were missing information on race/ethnicity.
Longitudinal results: change in smoking status at follow-up
Transitions between all smoking status groups from baseline (2013/14) to follow-up (2014/15) are shown in Appendix 2 (available at www.cmaj.ca/lookup/suppl/doi:10.1503/cmaj.161002/-/DC1). Among the 455 respondents who were current smokers at baseline (192 daily, 263 occasional), 39 (8.6%) were former smokers at follow-up and 349 (76.7%) were current smokers; the remaining 67 (14.7%) were classified as having a nonsmoking status that was inconsistent with having been a current smoker (and were excluded from further analysis). Of the 39 respondents

| Characteristic | No. (%) within category with past 30-day e-cigarette use at baseline | OR (95% CI) Unadjusted* | Adjusted† |
|---------------|---------------------------------------------------------------------|-------------------------|-----------|
| **Age, yr**   |                                                                     |                         |           |
| ≤ 14          | 458/9743 (4.7)                                                      | 1.0 (ref)               | 1.0 (ref) |
| 15            | 765/11 283 (6.8)                                                   | 1.46 (1.29–1.64)        | 1.07 (0.94–1.22) |
| 16            | 962/11 175 (8.6)                                                   | 1.88 (1.67–2.11)        | 1.01 (0.89–1.15) |
| 17            | 738/9122 (8.1)                                                     | 1.75 (1.55–1.98)        | 0.73 (0.63–0.84) |
| ≥ 18          | 243/2840 (8.6)                                                     | 1.87 (1.59–2.21)        | 0.62 (0.51–0.74) |
| **Sex**       |                                                                     |                         |           |
| Female        | 1117/21 901 (5.1)                                                  | 1.0 (ref)               | 1.0 (ref) |
| Male          | 2049/22 262 (9.2)                                                  | 1.91 (1.77–2.06)        | 1.70 (1.57–1.85) |
| **Race/ethnicity‡** |                                                               |                         |           |
| White         | 2236/32 886 (6.8)                                                  | 1.0 (ref)               | 1.0 (ref) |
| Black         | 152/1689 (9.0)                                                     | 1.48 (1.24–1.76)        | 1.10 (0.91–1.34) |
| Asian         | 96/2241 (4.3)                                                      | 0.60 (0.48–0.74)        | 0.68 (0.54–0.86) |
| Aboriginal    | 139/1546 (9.0)                                                     | 1.34 (1.11–1.63)        | 0.68 (0.55–0.84) |
| Latin American/Hispanic |                                              | 1.14 (0.87–1.48)        | 0.89 (0.66–1.18) |
| Other/mixed   | 467/4759 (9.8)                                                     | 1.52 (1.37–1.69)        | 1.21 (1.08–1.36) |
| **Spending money, $** |                                                               |                         |           |
| 0             | 312/7046 (4.4)                                                     | 1.0 (ref)               | 1.0 (ref) |
| 1–20          | 748/12 680 (5.9)                                                   | 1.37 (1.19–1.57)        | 1.33 (1.15–1.54) |
| 21–100        | 968/11 749 (8.2)                                                   | 1.94 (1.70–2.22)        | 1.63 (1.42–1.89) |
| > 100         | 813/6994 (11.6)                                                    | 2.86 (2.49–3.28)        | 1.80 (1.54–2.09) |
| Don’t know/not stated |                                              | 1.29 (1.10–1.51)        | 1.21 (1.02–1.44) |
| **Smoking status** |                                                               |                         |           |
| Never tried, not susceptible | 343/22 187 (1.5)                  | 1.0 (ref)               | 1.0 (ref) |
| Never tried, susceptible | 412/9537 (4.3)                | 2.83 (2.45–3.28)        | 2.76 (2.38–3.20) |
| Puffer        | 468/4465 (10.5)                                                    | 7.85 (6.79–9.07)        | 7.79 (6.73–9.01) |
| Experimental smoker | 924/4819 (19.2)          | 16.03 (14.07–18.26)     | 15.64 (13.69–17.87) |
| Former smoker | 49/372 (13.2)                                                      | 10.84 (7.85–14.96)      | 10.48 (7.55–14.54) |
| Current occasional smoker | 409/1409 (29.0)      | 29.52 (25.15–34.66)     | 28.79 (24.41–33.96) |
| Current daily smoker | 561/1374 (40.8)             | 50.03 (42.82–58.45)     | 48.85 (41.56–57.43) |

Note: CI = confidence interval, OR = odds ratio.
*From separate generalized linear mixed models for using an e-cigarette in the past 30 days, including only the listed covariable, with school as a random effect (n = 44 163 for all models except race/ethnicity; n = 43 951 for race/ethnicity model).
†From a generalized linear mixed model for using an e-cigarette in the past 30 days, including all covariables in the table and school (n = 89) as a random effect (n = 43 951).
‡Information on race/ethnicity was missing for 212 participants; these were excluded from the model.
who became former smokers, 10 (25.6%) reported past 30-day e-cigarette use at baseline and 6 (15.4%) reported past 30-day e-cigarette use at follow-up. Of the 349 respondents who remained current smokers, 116 (33.2%) reported past 30-day e-cigarette use at baseline and 130 (37.2%) reported past 30-day e-cigarette use at follow-up.

**Interpretation**

The current study is among the largest longitudinal studies of e-cigarette use and cigarette-smoking initiation to date. The findings are consistent with those of other surveys conducted in Canada, which have shown increasing rates of e-cigarette use among youth:

| Characteristic (at baseline) | No. (%) within category who initiated smoking by follow-up | OR (95% CI) |
|-----------------------------|----------------------------------------------------------|-------------|
|                            | Unadjusted† | Adjusted‡ |
| **Age, yr**                 |             |           |
| ≤14                         | 436/5936 (7.3) | 1.0 (ref) | 1.0 (ref) |
| 15                          | 511/5845 (8.7) | 1.23 (1.07–1.41) | 1.08 (0.94–1.25) |
| 16                          | 397/4464 (8.9) | 1.27 (1.10–1.47) | 1.04 (0.89–1.21) |
| ≥ 17§                       | 105/1073 (9.8) | 1.43 (1.13–1.79) | 1.02 (0.80–1.32) |
| **Sex**                     |             |           |
| Female                      | 683/9289 (7.4) | 1.0 (ref) | 1.0 (ref) |
| Male                        | 766/8029 (9.5) | 1.37 (1.22–1.52) | 1.44 (1.28–1.62) |
| **Race/ethnicity¶**         |             |           |
| White                       | 1143/13 423 (8.5) | 1.0 (ref) | 1.0 (ref) |
| Black                       | 42/562 (7.5) | 1.00 (0.72–1.40) | 1.03 (0.72–1.45) |
| Asian                       | 44/925 (4.8) | 0.62 (0.45–0.85) | 0.67 (0.47–0.93) |
| Aboriginal                  | 58/328 (17.7) | 2.04 (1.50–2.77) | 1.29 (0.93–1.80) |
| Latin American/Hispanic     | 21/274 (7.7) | 0.98 (0.62–1.54) | 0.71 (0.44–1.15) |
| Other/mixed                 | 140/1735 (8.1) | 1.00 (0.83–1.20) | 0.95 (0.78–1.16) |
| **Spending money, $**       |             |           |
| 0                           | 224/3342 (6.7) | 1.0 (ref) | 1.0 (ref) |
| 1–20                        | 454/6048 (7.5) | 1.14 (0.96–1.34) | 1.00 (0.84–1.20) |
| 21–100                      | 416/4077 (10.2) | 1.57 (1.32–1.86) | 1.25 (1.04–1.50) |
| >100                        | 193/1473 (13.1) | 2.05 (1.67–2.52) | 1.53 (1.22–1.91) |
| Don’t know/not stated       | 162/2378 (6.8) | 1.01 (0.82–1.25) | 1.02 (0.82–1.28) |
| **Smoking status**          |             |           |
| Never tried, not susceptible| 364/11 075 (3.3) | 1.0 (ref) | 1.0 (ref) |
| Never tried, susceptible    | 562/4719 (11.9) | 3.95 (3.44–4.53) | 3.86 (3.36–4.43) |
| Puffer                      | 523/1624 (34.3) | 15.08 (12.97–17.53) | 13.56 (11.60–15.85) |
| **Past 30-day e-cigarette use** |             |           |
| No                          | 1313/16 831 (7.8) | 1.0 (ref) | 1.0 (ref) |
| Yes                         | 136/487 (27.9) | 4.81 (3.90–5.94) | 2.12 (1.68–2.66) |

Note: CI = confidence interval, OR = odds ratio.
*Among those who had never smoked a whole cigarette at baseline, but had smoked a whole cigarette at follow-up; n = 1992 had already initiated smoking at baseline and were excluded from this measure.
†From separate generalized linear mixed models for initiating smoking between waves, including only the listed covariable, with school as a random effect (n = 17 318 for all models except race/ethnicity; n = 17 247 for race/ethnicity model).
‡From a generalized linear mixed model for initiating smoking between waves, including the covariables in the table, with school (n = 86) as a random effect (n = 17 247).
§Categories for age 17 and age ≥ 18 were combined because of low numbers for the latter category (n = 8).
¶Information on race/ethnicity was missing for 71 participants; these were excluded from the multivariable model.
in our study, about 10% of youth reported using an e-cigarette in the past 30 days, compared with national estimates of 3% in 2013.3,7

In the cross-sectional analysis, e-cigarette use was associated with cigarette-smoking behaviour in a dose–response fashion. Differences in past 30-day e-cigarette use were observed even among lower thresholds of smoking behaviour, including between “puffers” and never smokers, and by smoking susceptibility. We did not assess reasons for e-cigarette use among youth smokers; however, research with adults has indicated that smokers use e-cigarettes for a variety of reasons other than quitting,

| Characteristic (at baseline) | No. (%) within category who initiated daily smoking by follow-up | OR (95% CI) Unadjusted† | Adjusted‡ |
|-----------------------------|---------------------------------------------------------------|-------------------------|-----------|
| **Age, yr**                  |                                                               |                         |           |
| ≤ 14                        | 204/6179 (3.3)                                                | 1.0 (ref)               | 1.0 (ref) |
| 15                          | 219/6298 (3.5)                                                | 1.04 (0.86–1.27)        | 0.74 (0.60–0.92) |
| 16                          | 206/4997 (4.1)                                                | 1.27 (1.04–1.55)        | 0.70 (0.55–0.88) |
| ≥ 17§                       | 58/1217 (4.8)                                                 | 1.46 (1.07–1.98)        | 0.73 (0.51–1.03) |
| **Sex**                     |                                                               |                         |           |
| Female                      | 320/9996 (3.2)                                                | 1.0 (ref)               | 1.0 (ref) |
| Male                        | 367/8695 (4.2)                                                | 1.36 (1.17–1.59)        | 1.36 (1.15–1.62) |
| **Race/ethnicity¶**         |                                                               |                         |           |
| White                       | 525/14 488 (3.6)                                              | 1.0 (ref)               | 1.0 (ref) |
| Black                       | 21/585 (3.6)                                                  | 1.23 (0.78–1.94)        | 1.30 (0.78–2.15) |
| Asian                       | 11/965 (1.1)                                                  | 0.38 (0.21–0.70)        | 0.45 (0.24–0.85) |
| Aboriginal                  | 43/406 (10.6)                                                 | 2.49 (1.75–3.54)        | 1.42 (0.96–2.09) |
| Latin American/Hispanic     | 11/296 (3.7)                                                  | 1.21 (0.65–2.23)        | 1.03 (0.54–1.98) |
| Other/mixed                 | 75/1876 (4.0)                                                 | 1.21 (0.94–1.56)        | 1.09 (0.82–1.43) |
| **Spending money, $**       |                                                               |                         |           |
| 0                           | 95/3513 (2.7)                                                 | 1.0 (ref)               | 1.0 (ref) |
| 1–20                        | 219/6436 (3.4)                                                | 1.26 (0.99–1.62)        | 1.07 (0.81–1.39) |
| 21–100                      | 182/4480 (4.1)                                                | 1.49 (1.15–1.92)        | 1.03 (0.78–1.36) |
| > 100                       | 109/1731 (6.3)                                                | 2.24 (1.69–2.99)        | 1.16 (0.84–1.60) |
| Don’t know/not stated       | 82/2531 (3.2)                                                 | 1.20 (0.89–1.62)        | 1.15 (0.83–1.60) |
| **Smoking status**          |                                                               |                         |           |
| Never tried, not susceptible| 83/11 075 (0.7)                                               | 1.0 (ref)               | 1.0 (ref) |
| Never tried, susceptible    | 129/4719 (2.7)                                                | 3.69 (2.79–4.87)        | 3.58 (2.70–4.73) |
| Puffer                      | 106/1514 (7.0)                                                | 9.81 (7.31–13.16)       | 9.33 (6.91–12.59) |
| Experimental smoker         | 308/1274 (24.2)                                               | 40.80 (31.65–52.60)     | 37.73 (28.91–49.25) |
| Former smoker               | 13/29 (44.8)                                                  | 96.81 (44.52–210.49)    | 94.99 (43.19–208.92) |
| Current occasional smoker   | 48/80 (60.0)                                                  | 193.01 (116.72–319.16)  | 157.54 (93.59–265.19) |
| **Past 30-day e-cigarette use** |                                             |                         |           |
| No                          | 551/17 911 (3.1)                                              | 1.0 (ref)               | 1.0 (ref) |
| Yes                         | 136/780 (17.4)                                                | 6.97 (5.65–8.60)        | 1.79 (1.41–2.28) |

Note: CI = confidence interval, OR = odds ratio.

*Among those who had never smoked every day for 7 days at baseline, but had smoked every day for 7 days at follow-up; n = 619 had already initiated daily smoking at baseline and were excluded from this measure.
†From separate generalized linear mixed models for initiating daily smoking between waves, including only the listed covariate, with school as a random effect (n = 18 691 for all models except race/ethnicity; n = 18 616 for race/ethnicity model).
‡From a generalized linear mixed model for initiating daily smoking between waves, including the covariates in the table, with school (n = 86) as a random effect (n = 18 616).
§Categories for age 17 and age ≥ 18 were combined because of low numbers for the latter category (n = 5).
¶Information on race/ethnicity was missing for 75 participants; these were excluded from the multivariable model.
including for use in places where smoking is not allowed and to
cut back on, but not quit, smoking.21 There is a need for similar
data on reasons for use from population-based studies of youth.

Youth who reported e-cigarette use in the past 30 days at base-
line were more likely to initiate cigarette smoking and more likely
to report having smoked daily at follow-up, even after adjustment
for a range of other factors at baseline. These findings are consis-
tent with prior longitudinal studies.13,14,16 It is unclear the extent to
which this association is causal. At the individual level, e-cigarettes
may be causally related to cigarette smoking because they provide
early exposure to nicotine or greater exposure to environmental
risk factors, including greater exposure to smokers or certain
social settings. E-cigarette use may also help to “re-normalize”
smoking by promoting more positive normative beliefs about nic-
one use and smoking, which are important predictors of
uptake.22 Alternatively, both e-cigarettes and cigarette smoking
could be the result of unmeasured “common factors.”23 Several
studies to date have adjusted for factors such as sensation-
seeking, parental support and rebelliousness, and have found that
the association with e-cigarette use persists; however, it is doubt-
ful that any analysis can adequately control for the range of “com-
mon factors” that may account for the use of multiple nicotine
products.14,15 Put more simply, youth who try e-cigarettes may be
different from those who do not.24 The temporal order, whereby
e-cigarette use precedes cigarette-smoking initiation, may be
explained by the fact that e-cigarettes are more accessible than
cigarettes to Canadian youth, and are therefore likely to be
encountered and used first.

Despite a substantial increase in the prevalence of past
30-day e-cigarette use between baseline and follow-up, the prev-
ance of cigarette smoking decreased slightly in the overall sam-
ple. This pattern of data has previously been cited by proponents
as evidence that e-cigarette use does not increase cigarette-
smoking initiation and, subsequently, smoking rates; however, it
is also possible that smoking rates might have decreased further
in the absence of e-cigarette use. Regardless, the current pattern
of data suggests that — if e-cigarettes do in fact increase smoking
initiation — the impact to date has been insufficient to com-
pletely stall or reverse the decline in youth smoking in Canada.

Limitations and strengths
The current study is among the largest to examine e-cigarette
use among youth. The study was conducted in only 2 Canadian
provinces, and schools were not recruited using probability-
based sampling methods; therefore, comparisons with national
estimates should be made with caution. The study had several
limitations common to longitudinal research, including nonran-
don attrition at follow-up. All measures relied on self-report;
however, the confidentiality of responses was emphasized, and
self-reported measures of tobacco use have been previously val-
dated using biochemical measures.25 The regulatory context of e-
cigarettes in Canada should also be noted when interpreting
these findings. In particular, non–nicotine-containing e-
cigarettes account for a greater proportion of the e-cigarette
market in Canada than in many other countries.3,26 Future re-
search should examine the likelihood of smoking initiation with
nicotine-containing versus non–nicotine-containing e-cigarettes.
Finally, the current study examined only 1 dimension of e-
cigarettes and cigarette smoking (i.e., initiation): it did not have
adequate statistical power to assess the impact of e-cigarette
use on smoking cessation among youth smokers, which is a criti-
cally important determinant of the net public health impact of e-
cigarettes. However, we have reported raw data on e-cigarette
use and subsequent smoking cessation.

Conclusion
The current study provides strong evidence that e-cigarettes are
associated with initiation of cigarette smoking among youth; how-
ever, the controversy as to whether e-cigarette use “causes”
cigarette-smoking initiation will undoubtedly persist. In fact, the
findings from our study provide support for both sides of the de-
bate. It is highly plausible that “common factors” account for a
substantial proportion of increased cigarette-smoking initiation
among e-cigarette users. At the same time, it would be foolhardy
to dismiss the likelihood that early exposure to nicotine via e-
cigarettes increases smoking uptake. Attributing the relative im-
portance of these 2 factors will not be straightforward, and rep-
resents a critical challenge to the research community. In the
meantime, regulatory frameworks that succeed in shifting e-
cigarette use away from youth and concentrating their use
among cigarette smokers for the purposes of smoking cessation
are likely to have the greatest public health impact.

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