

Prevalence and correlates of electronic cigarette use among Canadian students: cross-sectional findings from the 2014/15 Canadian Student Tobacco, Alcohol and Drugs Survey

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Abstract

Background: Over the past decade, youth tobacco use has declined, and electronic cigarettes (e-cigarettes) have entered the market. The aims of this study were to describe the prevalence of e-cigarette use among youth in Canada, by province, across sociodemographic variables and smoking-related correlates; and to examine associations among e-cigarette use, sociodemographic variables and smoking-related correlates, with adjustment for other factors.

Methods: The 2014/15 Canadian Student Tobacco, Alcohol and Drugs Survey, a biennial, school-based survey, was administered to students in grades 6–12 in all Canadian provinces. Logistic regression models were fitted to estimate odds of ever and past 30-day e-cigarette use by sociodemographic variables and smoking-related correlates.

Results: A total of 336 schools from 128 school boards (47% of eligible schools approached) and 42 094 students (66% of eligible students approached) participated in the survey. In Canada, 17.7% (95% confidence interval [CI] 16.4%–18.9%) of students in grades 6–12 reported ever using e-cigarettes, and 5.7% (95% CI 5.2%–6.3%) reported past 30-day use. Substantial variation was observed across provinces. Female students had decreased odds of past 30-day use relative to male students (odds ratio [OR] 0.71, 95% CI 0.59–0.86), whereas current smokers (OR 10.0, 95% CI 6.66–15.02) and experimental smokers (OR 3.61, 95% CI 2.40–5.42) had increased odds relative to never smokers. Students who perceived that access was easy also had increased odds of using e-cigarettes relative to students who perceived that access was difficult (OR 3.86, 95% CI 2.96–5.03). Students who believed that regular use entailed slight risk (OR 0.68, 95% CI 0.52–0.88) and those who did not know risk levels (OR 0.31, 95% CI 0.21–0.46) had decreased odds compared with those perceiving no risk.

Interpretation: Our data confirm that many youth used e-cigarettes in the 30 days preceding the survey, although rates were substantially higher among current and experimental smokers than among students who had never tried smoking.

The past decade has seen a decline in tobacco smoking among youth in many countries.^{1–3} Over the same period, electronic cigarettes (e-cigarettes or vapour devices) were introduced into the market.⁴ E-cigarettes are devices in which a liquid solution, which may contain flavours or nicotine (or both), is heated to create an aerosol that is inhaled,⁵ mimicking the experience of conventional cigarette smoking to a greater extent than other noncombustible delivery methods, such as patches, inhalers and gum.⁶ Lifetime use of e-cigarettes is common among teenagers in many countries, including the United States, the United Kingdom, France and Poland; in the US, use of e-cigarettes has surpassed cigarette smoking.^{1,7–9} Concerns about e-cigarette use have led to fierce debate in the public health community, with advocates arguing that e-cigarettes have substantial potential for harm reduction,^{6,10} and others arguing that e-cigarettes could be a gateway to conventional tobacco use among youth and that they may renormalize smoking.^{11,12} Most studies indicate that e-cigarette use primarily occurs among conventional

cigarette smokers, with few nonsmokers engaging in regular e-cigarette use.^{7,13–15} Some evidence suggests that a substantial number of young nonsmokers try e-cigarettes¹⁶ and that e-cigarette use among never-smoking youth could be related to initiation of use of combustible tobacco products.^{17,18} The evidence of a causal relationship, however, is limited.^{17,19}

Long-term trend data on e-cigarette use are limited and not yet available in Canada. In Quebec, ever and past 30-day use of e-cigarettes among students in grades 7–11 were 34% and 6%, respectively, in 2012/13.¹⁶ Lifetime e-cigarette use was 15% among students in grades 7–12 in Ontario in 2013¹⁴

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and 10% among grade 9 students in the Niagara region in 2015.²⁰ By comparison, in 2015, 16% of US students in grades 9–12 and 5% of those in grades 6–8 reported using e-cigarettes in the past 30 days, a significant increase from 1.5% and 0.6%, respectively, in 2011.¹ In the UK, lifetime rates of e-cigarette use ranged from 8% to 12% in 2013/14,^{15,21,22} whereas more-than-monthly use ranged from 0.4% to 2%.²³ Literature on e-cigarette use across Canada is lacking, because of the absence of representative data for high school and middle school students. Long-term monitoring of e-cigarette and other tobacco product use is important for surveillance and public health. To this end, Health Canada's Canadian Student Tobacco, Alcohol and Drugs Survey²⁴ included questions on e-cigarette use beginning in the 2014/15 cycle. Our aims are to describe the prevalence of e-cigarette use among youth in Canada, by province, across sociodemographic variables and smoking-related correlates; and to examine associations among e-cigarette use, sociodemographic variables and smoking-related correlates, with adjustment for other factors.

Methods

Source of data

We obtained data from a cross-sectional, biennial paper-and-pencil school-based survey administered to elementary and secondary school students across Canada between October 2014 and May 2015. The target population was students in grades 6–12 (grade 6 to secondary 5 in Quebec) attending private, public and Catholic schools in all 10 Canadian provinces, excluding schools in the 3 territories and special schools (e.g., schools for students with visual impairment and schools on First Nations reserves). A generalizable sample was achieved at the national and provincial levels, with the exception of New Brunswick (because of low response rate). However, national estimates do include data from participating New Brunswick schools.

Study design

The survey employed a stratified, single-stage cluster design, with strata based on health-region smoking rate and type of school. In each province, 2 or 3 health-region smoking rate strata and 2 school-level strata were defined. Random selection of schools within each stratum ensured a generalizable sample within each province. Classroom teachers administered the survey. Questionnaires were available in English and French. The survey's website offers details (www.cstads.ca).

Measures

The primary outcome measures of interest were self-reported ever and past 30-day e-cigarette use (yes/no). Smoking-related correlates included ever use of other tobacco products (little cigars or cigarillos, cigars, roll-your-own cigarettes, bidis, smokeless tobacco, water pipe, blunt wraps), smoking status (current smoker, former smoker, experimental smoker or never tried smoking), perceived risk of harm from using e-cigarettes on a regular basis (no risk, slight, moderate, great risk, don't know) and perceived ease of access of e-cigarettes (very difficult,

fairly difficult, fairly easy, very easy, don't know). We also analyzed sociodemographic variables of sex (male, female), grade (6–12; grade 6 to secondary 5 in Quebec), province of residence, ethnicity (white, black, West Asian/Arab, South Asian, East/Southeast Asian, Latin American/Hispanic, Aboriginal, other), socioeconomic level of school neighbourhood (obtained from school postal code) and school location (urban, rural). All measures are defined in Appendix 1 (available at www.cmajopen.ca/content/5/2/E460/suppl/DC1).

Statistical analysis

We used descriptive statistics to estimate the weighted prevalence of ever and past 30-day e-cigarette use across socio-demographic variables, use of other tobacco products, smoking status, perceived ease of access to e-cigarettes and perceived risk of harm from regularly using e-cigarettes. We fitted unadjusted and adjusted logistic regression models to estimate odds of ever and past 30-day e-cigarette use by the listed socio-demographic and smoking-related variables. We selected these covariates because other studies have shown that they are significant predictors of e-cigarette use and smoking onset in adolescents.^{25,26} The calculation of tolerances and variance inflation factors indicated no problems of multicollinearity among explanatory variables. We report our results as unadjusted and adjusted odds ratios (ORs) with 95% confidence intervals (CIs). Participants with missing data pertaining to the variables of interest were excluded from all analyses.

We used survey weights to adjust for sample selection (school and class levels), nonresponse (school, class and student levels) and poststratification of the sample population relative to grade and sex distribution in the total population. Bootstrap weights, which we used to calculate CIs of the prevalence estimates and regression analyses, account for the effects of survey design on variance estimates. We performed all analyses using SAS version 9.4 (SAS Institute Inc.).

All references to "students" refer specifically to students in grades 6–12, unless specified otherwise.

Ethics approval

Multiple bodies provided ethics review and approval: Health Canada Research Ethics Board, University of Waterloo Office of Research Ethics and ethics review boards at participating institutions and school boards. Depending on school board requirements, parents or guardians provided active or passive permission (with active information) for their child to participate. Individual student consent to participate was also obtained.

Results

A total of 336 schools from 128 school boards (47% of eligible schools approached) and 42 094 students (66% of eligible students approached) were recruited for the survey.

In Canada, 17.7% (95% CI 16.4%–18.9%) of students in grades 6–12 reported ever using e-cigarettes, which represents about 441 900 students, and 5.7% (95% CI 5.2%–6.3%) reported past 30-day use (representing about 142 900) (Table 1). Past 30-day use was reported by 46.6% (95% CI

Table 1 (part 1 of 2): Prevalence of e-cigarette use by sociodemographic and smoking-related correlates among Canadian students in grades 6–12, based on the 2014/15 Canadian Student Tobacco, Alcohol and Drugs Survey*

Characteristic	Ever use of e-cigarettes		Past 30-day use of e-cigarettes	
	n	% (95% CI)	n	% (95% CI)
Canada	441 900	17.7 (16.4–18.9)	142 900	5.7 (5.2–6.3)
Sex				
Female	180 000	14.7 (13.5–15.9)	53 900	4.4 (3.8–5.1)
Male	261 900	20.4 (18.8–22.0)	88 900	7.0 (6.1–7.8)
Grade				
6	8000	2.5 (1.8–3.3)	¶	¶
7	22 000	6.3 (5.1–7.6)	6000	1.7 (1.1–2.3)**
8	44 300	12.6 (10.6–14.6)	14 600	4.2 (3.0–5.3)
9	65 800	17.6 (15.1–20.0)	21 300	5.7 (4.4–7.0)
10	85 800	22.8 (19.4–26.3)	30 500	8.1 (6.5–9.8)
11	109 800	28.8 (26.2–31.4)	37 700	9.9 (8.2–11.7)
12	106 200	29.7 (26.4–33.1)	30 700	8.7 (7.0–10.3)
6–9	140 100	10.1 (8.9–11.2)	44 000	3.2 (2.5–3.8)
10–12	301 800	27.1 (24.8–29.3)	98 900	8.9 (7.9–9.9)
Ethnicity				
White	293 700	19.6 (17.8–21.4)	92 800	6.2 (5.5–7.0)
Black	21 200	18.2 (14.8–21.5)	7700	6.6 (4.5–8.7)
Asian†	56 300	10.2 (8.3–12.1)	18 100	3.3 (2.5–4.1)
Aboriginal	31 700	30.4 (27.4–33.4)	12 100	11.7 (9.4–14.1)
Latin American	13 000	22.2 (16.9–27.5)	4800	8.1 (5.8–10.5)
Other	23 700	15.9 (13.6–18.2)	6800	4.6 (3.4–5.9)
Urban location of school				
Yes	328 600	16.4 (14.7–18.2)	107 800	5.4 (4.7–6.2)
No	113 400	22.4 (18.8–26.1)	35 000	7.0 (5.5–8.4)
Socioeconomic level of school neighbourhood				
Low	151 200	20.2 (17.0–23.3)	49 700	6.7 (5.0–8.3)
Middle	131 100	15.2 (12.4–18.0)	38 400	4.5 (3.4–5.5)
High	159 500	18.0 (15.0–20.9)	54 700	6.2 (5.2–7.1)
Province‡				
Newfoundland and Labrador	8900	26.3 (23.6–29.1)	4500	13.3 (9.9–16.7)
Prince Edward Island	2400	21.7 (19.5–23.9)	1100	9.8 (8.3–11.3)
Nova Scotia	13 000	20.0 (18.3–21.7)	5300	8.2 (6.7–9.7)
Quebec	112 800	24.1 (20.8–27.4)	31 800	6.8 (4.8–8.9)
Ontario	155 800	14.1 (11.9–16.3)	46 800	4.3 (3.4–5.1)
Manitoba	17 700	18.5 (16.2–20.8)	8800	9.2 (6.8–11.7)
Saskatchewan	15 800	20.3 (16.0–24.5)	6300	8.2 (6.2–10.1)
Alberta	42 300	15.1 (12.6–17.5)	13 300	4.8 (3.4–6.1)
British Columbia	59 900	19.2 (16.2–22.2)	22 000	7.1 (5.8–8.4)
Smoking status				
Current smoker	64 400	75.7 (70.7–80.8)	38 900	46.6 (39.3–53.9)
Former smoker	8800	77.6 (68.7–86.5)	2400	20.4 (11.8–28.9)**
Experimental smoker	194 900	57.3 (55.1–59.6)	65 500	19.4 (17.7–21.2)
Never tried smoking	173 800	8.4 (7.7–9.2)	36 100	1.8 (1.5–2.0)

Table 1 (part 2 of 2): Prevalence of e-cigarette use by sociodemographic and smoking-related correlates among Canadian students in grades 6–12, based on the 2014/15 Canadian Student Tobacco, Alcohol and Drugs Survey*

Characteristic	Ever use of e-cigarettes		Past 30-day use of e-cigarettes	
	n	% (95% CI)	n	% (95% CI)
Tried other tobacco products				
Little cigars or cigarillos	219 300	69.0 (66.4–71.6)	90 500	28.9 (26.2–31.7)
Water pipe	170 200	67.5 (63.7–71.4)	73 300	29.6 (26.6–32.7)
Smokeless	90 500	73.8 (70.5–77.2)	43 500	36.4 (32.8–40.1)
Any tobacco product other than cigarettes§	290 000	61.7 (59.3–64.1)	110 700	23.8 (21.7–25.9)
Perceived ease of access to e-cigarettes				
Very or fairly easy	374 500	32.9 (30.9–34.9)	122 600	10.8 (9.8–11.9)
Very or fairly difficult	41 900	5.2 (4.6–5.9)	9700	1.2 (1.0–1.5)
Don't know	16 000	3.3 (2.5–4.0)	5800	1.2 (0.8–1.6)
Perceived risk of harm from using e-cigarettes on a regular basis				
No risk	115 200	40.5 (37.4–43.5)	45 200	15.9 (14.1–17.7)
Slight risk	142 800	31.3 (29.0–33.5)	43 300	9.6 (8.3–10.8)
Moderate risk	104 400	15.4 (13.8–17.0)	28 000	4.1 (3.5–4.8)
Great risk	41 500	6.7 (5.9–7.6)	11 900	1.9 (1.5–2.4)
Don't know	24 200	6.3 (5.1–7.5)	8600	2.2 (1.6–2.9)

Note: CI = confidence interval.
*Data are presented as weighted number (n) and weighted percentage (%), with 95% CI). The weighted n values are rounded to the nearest 100.
†"Asian" combines students who identified as West Asian/Arab, South Asian or East/Southeast Asian.
‡The 2014/15 Canadian Student Tobacco, Alcohol and Drugs Survey does not include a generalizable sample of students from the province of New Brunswick. As a result, data for New Brunswick students cannot be used to produce provincial estimates.
§Students who reported using little cigars or cigarillos, cigars, roll-your-own cigarettes, bidis, smokeless tobacco, water pipe or blunt wraps.
¶Data suppressed because of unacceptable data quality (due to high variability or low numbers).
**Because of moderate sampling variability, these data should be interpreted with caution.

39.3%–53.9%) of current smokers, 20.4% (95% CI 11.8%–28.9%) of former smokers, 19.4% (95% CI 17.7%–21.2%) of experimental smokers and 1.8% (95% CI 1.5%–2.0%) of students who had never tried smoking. The prevalence of ever and past 30-day use was higher among male students (compared with female students) and students in grades 10–12 (compared with those in grades 6–9). Rates were highest among students identifying as Aboriginal and lowest among students identifying as Asian. E-cigarette use varied across provinces, with the lowest rates found in Ontario and Alberta and the highest in Newfoundland and Labrador.

Ever and past 30-day e-cigarette use was more prevalent among students who had tried other tobacco products, those who perceived getting e-cigarettes was easy and those who thought regular use entailed no risk. Prevalence of e-cigarette use did not vary by socioeconomic level of school neighbourhood, but rate of ever use was higher among students attending a school located in a rural area. Missing data for self-reported ever and past 30-day e-cigarette use was 1.8% and 2.1%, respectively, and ranged from 0% for smoking status, sex, grade, location, socioeconomic level of school neighbourhood and province to 3.9% for perceived risk of harm.

Results presented in Table 2 describe factors associated with ever and past 30-day use of e-cigarettes (with only past 30-day use being discussed below). In terms of sociodemographic indicators, adjusted logistic regression models showed that female students had decreased odds of using e-cigarettes compared with male students (OR 0.71, 95% CI 0.59–0.86), while students in grades 10–12 had decreased odds of e-cigarette use compared with students in grades 6–9 (OR 0.78, 95% CI 0.63–0.98). In terms of provincial variations, students in British Columbia, Manitoba, Newfoundland and Labrador, Nova Scotia, Prince Edward Island and Saskatchewan all had higher odds of e-cigarette use compared with Ontario. Students attending a school located in a high socioeconomic level neighbourhood had increased odds of e-cigarette use (OR 1.55, 95% CI 1.26–1.92) compared with students whose school was located in a middle-income neighbourhood. No difference in e-cigarette use was observed across ethnic groups or by location of school.

In terms of cigarette and other tobacco use, current smokers (OR 10.0, 95% CI 6.66–15.02), experimental smokers (OR 3.61, 95% CI 2.40–5.42) and former smokers (OR 2.75, 95% CI 1.31–5.80) all had elevated odds of e-cigarette use compared with students who had never tried smoking, as did

Table 2 (part 1 of 2): Logistic regression of ever use and past 30-day use of e-cigarettes on sociodemographic and smoking-related correlates among students in grades 6–12, based on the 2014/15 Canadian Student Tobacco, Alcohol and Drugs Survey

Correlate	Ever use of e-cigarettes		Past 30-day use of e-cigarettes	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Sex				
Male	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Female	0.68 (0.60–0.77)	0.76 (0.65–0.90)	0.60 (0.49–0.75)	0.71 (0.59–0.86)
Grade				
6–9	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
10–12	3.30 (2.78–3.91)	1.06 (0.92–1.23)	2.99 (2.21–4.05)	0.78 (0.63–0.98)
Ethnicity				
White	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Black	0.94 (0.72–1.22)	1.06 (0.78–1.44)	1.05 (0.71–1.55)	1.16 (0.79–1.71)
Asian*	0.45 (0.35–0.59)	0.69 (0.58–0.83)	0.47 (0.35–0.64)	0.83 (0.61–1.12)
Aboriginal	1.75 (1.42–2.15)	0.91 (0.71–1.18)	1.99 (1.54–2.58)	0.81 (0.60–1.10)
Latin American	1.16 (0.80–1.69)	0.80 (0.46–1.40)	1.30 (0.93–1.81)	0.97 (0.58–1.63)
Other	0.76 (0.60–0.96)	1.07 (0.81–1.41)	0.71 (0.46–1.09)	0.98 (0.57–1.69)
Urban location of school				
Yes	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
No	1.46 (1.07–1.98)	0.86 (0.69–1.08)	1.34 (0.96–1.88)	0.84 (0.55–1.29)
Socioeconomic level of school neighbourhood				
Middle	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Low	1.42 (1.02–1.98)	1.13 (0.91–1.39)	1.49 (1.06–2.11)	1.13 (0.86–1.49)
High	1.15 (0.74–1.78)	1.17 (1.01–1.36)	1.40 (0.95–2.07)	1.55 (1.26–1.92)
Province†				
Ontario	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Alberta	1.07 (0.80–1.42)	1.32 (1.02–1.71)	1.03 (0.68–1.56)	1.25 (0.83–1.89)
British Columbia	1.37 (1.01–1.88)	1.59 (1.26–2.01)	1.62 (1.20–2.20)	1.86 (1.30–2.66)
Manitoba	1.39 (1.03–1.87)	1.24 (0.89–1.72)	2.22 (1.49–3.30)	2.20 (1.42–3.42)
Newfoundland and Labrador	2.13 (1.67–2.70)	1.87 (1.41–2.50)	3.36 (2.33–4.84)	2.85 (1.70–4.79)
Nova Scotia	1.49 (1.18–1.89)	1.26 (1.01–1.56)	1.93 (1.45–2.56)	1.56 (1.14–2.15)
Prince Edward Island	1.61 (1.25–2.06)	1.18 (0.90–1.54)	2.23 (1.67–2.98)	1.57 (1.09–2.25)
Quebec	1.89 (1.40–2.57)	2.33 (1.88–2.89)	1.58 (0.99–2.52)	1.50 (0.98–2.30)
Saskatchewan	1.51 (1.03–2.22)	1.29 (0.99–1.68)	1.97 (1.34–2.89)	1.69 (1.09–2.62)
Smoking status				
Never tried smoking	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Experimental smoker	14.92 (13.23–16.82)	3.88 (3.03–4.97)	14.16 (11.35–17.66)	3.61 (2.40–5.42)
Former smoker	43.28 (22.87–81.91)	10.5 (4.20–26.0)	14.13 (7.71–25.92)	2.75 (1.31–5.80)
Current smoker	34.21 (25.13–46.58)	5.88 (3.91–8.85)	48.07 (34.49–67.00)	10.0 (6.66–15.02)
Tried other tobacco products				
No	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Yes‡	20.76 (17.81–24.21)	5.42 (4.18–7.02)	20.39 (17.01–24.45)	4.33 (3.20–5.87)
Perceived ease of access to e-cigarettes				
Very or fairly difficult	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Very or fairly easy	9.03 (7.77–10.50)	4.86 (4.21–5.61)	10.22 (7.95–13.13)	3.86 (2.96–5.03)
Don't know	0.62 (0.47–0.80)	0.83 (0.63–1.11)	0.89 (0.59–1.35)	1.13 (0.70–1.84)

Table 2 (part 2 of 2): Logistic regression of ever use and past 30-day use of e-cigarettes on sociodemographic and smoking-related correlates among students in grades 6–12, based on the 2014/15 Canadian Student Tobacco, Alcohol and Drugs Survey

Correlate	Ever use of e-cigarettes		Past 30-day use of e-cigarettes	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Perceived risk of harm from using e-cigarettes on regular basis				
No risk	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Slight risk	0.66 (0.58–0.75)	0.71 (0.58–0.87)	0.54 (0.44–0.66)	0.68 (0.52–0.88)
Moderate risk	0.26 (0.22–0.31)	0.34 (0.27–0.42)	0.23 (0.18–0.28)	0.40 (0.31–0.51)
Great risk	0.10 (0.08–0.11)	0.16 (0.12–0.21)	0.10 (0.07–0.13)	0.25 (0.17–0.34)
Don't know	0.09 (0.07–0.12)	0.20 (0.16–0.26)	0.10 (0.07–0.14)	0.31 (0.21–0.46)

Note: CI = confidence interval, OR = odds ratio, ref = reference category.

*Asian" combines students who identified as West Asian/Arab, South Asian or East/Southeast Asian.

†The 2014/15 Canadian Student Tobacco, Alcohol and Drugs Survey does not include a generalizable sample of students from the province of New Brunswick. As a result, data for New Brunswick students cannot be used to produce provincial estimates.

‡Students who reported using little cigars or cigarillos, cigars, roll-your-own cigarettes, bidis, smokeless tobacco, water pipe or blunt wraps.

students who had tried any other tobacco product (OR 4.33, 95% CI 3.20–5.87). Perceptions and access also matter; students who perceived that access to e-cigarettes was easy (OR 3.86, 95% CI 2.96–5.03) had increased odds of use compared with those who perceived that access was difficult. Meanwhile, students who perceived that regular use of e-cigarettes was at all risky had lower odds of using e-cigarettes.

Interpretation

This study provides national estimates of the prevalence of e-cigarette use among students in grades 6–12 in Canada. Almost 18% of students reported ever having tried an e-cigarette, and almost 6% indicated use in the past 30 days; these rates correspond to about 441 900 and 142 900 student users, respectively. Patterns in e-cigarette use observed across sociodemographic indicators suggest that male students, those attending schools located in high socioeconomic neighbourhoods and those in younger grades had higher odds of use. Reported rates of e-cigarette use among current, experimental and former cigarette smokers were all higher than rates among students who never tried smoking, as were rates among those who used other tobacco products. Perceived ease of access to e-cigarettes and perceived harm also affected use, with higher odds of use among those students who perceived that e-cigarettes were fairly easy or very easy to access, and lower consumption among those who perceived that e-cigarettes pose a health harm.

Overall, lifetime and past 30-day rates of e-cigarette use among students were similar to those observed for smoking cigarettes (17.6% [447 100] and 6.2% [158 900], respectively).²⁴ The Canadian Tobacco, Alcohol and Drugs Survey, based on telephone interviews of participants 15 years and older, is the only other national-level data against which to compare these results.²⁷ According to that survey, e-cigarette prevalence among participants 15–19 years of age in 2015 was

26% for ever use and 6% for past 30-day use, an increase from 2013 (20% and 3%, respectively).²⁷ The rate observed in our study among students of the same age (those in grades 10–12) were similar for ever use (27.1%) but slightly higher for past 30-day use (8.9%). Rates of past 30-day use are higher in the US (16% of high school students and 5% of middle school students in 2015)¹ and lower in the UK (2% of those 11–18 years old in Great Britain in 2014¹⁵ and 3% of those 15 years old in Scotland²¹). International comparisons should be interpreted with caution because of differences in the timing of surveys, age ranges and designs.

In the current study, we observed substantial variations across provinces, with the lowest rate found in Ontario and the highest rate in Newfoundland and Labrador. Reasons for these provincial differences are unknown and should be investigated. Consistent with the literature, use of e-cigarettes was much higher among current and former smokers than among never smokers.²⁸ A recent study in Ontario's Niagara region found that only 6% of adolescents reported using e-cigarettes for reduction or cessation of smoking,²⁰ with several studies finding that young smokers are less likely than older smokers to report using e-cigarettes to quit smoking.^{13,29,30} Consistent with other studies, use is more prevalent among males,^{1,13,14,20} users of other tobacco products such as little cigars, water pipes and smokeless tobacco;^{16,31} users of alcohol and marijuana;¹⁰ and students who perceive that access is easy.¹³ Use is less prevalent among students who perceive they risk harming themselves by using e-cigarettes.¹³

Limitations

This study had several limitations. First, the results do not indicate the proportions of students who used e-cigarettes with and without nicotine. This information was not assessed in the questionnaire because, at the time of data collection, e-cigarettes with nicotine, although widely available, had not

been authorized to be legally sold on the Canadian market, and because the labelling of nicotine content on e-cigarettes has been shown to be inaccurate.^{32,33} Second, the response rate of eligible schools approached was just under 50%. Schools have competing priorities, including other provincial, regional and local surveys. In 2014/15, recruitment in New Brunswick was limited by concurrent administration of its census Student Wellness Survey. Third, our results are not representative of young people who do not attend school, who live in institutions, who attend school on First Nations reserves, or who attend special schools or schools located on military bases. Finally, cross-sectional results do not allow the inference of causal relationships between e-cigarette use and factors associated with such use.

Conclusion

Our results suggest that a substantial number of Canadian students use e-cigarettes. There is considerable debate and uncertainty surrounding the role of e-cigarettes as a gateway to smoking; our cross-sectional study cannot be used to inform this debate. Although e-cigarette use is substantially less likely among never smokers and experimental smokers than among current smokers, in absolute numbers never smokers and experimental smokers make up the majority of grade 6–12 students in Canada who reported using e-cigarettes in the past 30 days. More research is needed to document the frequency of and reasons for use of e-cigarettes among youth, which are likely to differ among current, experimental and never smokers.

Since these data were collected in 2014/15, many provinces have banned sales of e-cigarettes to minors, promotion and advertising of e-cigarettes, and use of these devices where smoking is prohibited, all of which are likely to further decrease perceptions that e-cigarettes are easily accessible to minors. Studies will be needed to monitor use of, access to and perceptions of e-cigarettes in the coming years, given that Canada has introduced major changes in the regulation of e-cigarettes, plain packaging for tobacco products and legalization of marijuana.

References

- Singh T, Arrazola RA, Corey CG, et al. Tobacco use among middle and high school students — United States, 2011–2015. *MMWR Morb Mortal Wkly Rep* 2016;65:361–7.
- Smoking, drinking and drug use among young people in England in 2014*. London (UK): Health and Social Care Information Centre; 2015.
- Reid JL, Hammond D, Rynard VL, et al. *Tobacco use in Canada: patterns and trends, 2015 edition*. Waterloo (ON): University of Waterloo, Propel Centre for Population Health Impact; 2015.
- Alderson SE, O'Connor RJ, Bansal-Travers M, et al. Electronic nicotine delivery systems: international tobacco control four-country survey. *Am J Prev Med* 2013;44:207–15.
- Electronic nicotine delivery systems and electronic non-nicotine delivery systems (ENDS/ENNDs). Conference of the Parties to the WHO Framework Convention on Tobacco Control; 2016 Nov. 7–12; Delhi (India). FCTC/COP/7/11. Geneva: World Health Organization; 2016. Available: www.who.int/fctc/cop_cop7/FCTC_COP_7_11_EN.pdf?ua=1&ua=1 (accessed 2016 Sept. 15).
- Nicotine without smoke: tobacco harm reduction*. London (UK): Royal College of Physicians; 2016.
- Bauld L, MacKintosh AM, Ford A, et al. E-cigarette uptake amongst UK youth: experimentation, but little or no regular use in nonsmokers. *Nicotine Tob Res* 2016;18:102–3.
- Goniewicz ML, Gawron M, Nadolska J, et al. Rise in electronic cigarette use among adolescents in Poland. *J Adolesc Health* 2014;55:713–5.
- Spilka S, Le Nézet O, Ngantcha M, et al. Consommation de tabac et usage de cigarette électronique à 17 ans en France, 2014. *Bull Epidemiol Hebdo (Paris)* 2015;17–18:289–96.
- Flahault A, Etter JF. Electronic cigarettes: it is urgent to promote them to save lives. *Int J Public Health* 2014;59:681–2.
- Stanbrook MB. Electronic cigarettes and youth: a gateway that must be shut. *CMAJ* 2016;188:785.
- McKee M. Electronic cigarettes: proceed with great caution. *Int J Public Health* 2014;59:683–5.
- Czoli CD, Reid JL, Rynard VL, et al. Special supplement: E-cigarettes in Canada. In: *Tobacco use in Canada: patterns and trends, 2015 edition*. Waterloo (ON): University of Waterloo, Propel Centre for Population Health Impact; 2015.
- Hamilton HA, Ferrence R, Boak A, et al. Ever use of nicotine and non-nicotine electronic cigarettes among high school students in Ontario, Canada. *Nicotine Tob Res* 2015;17:1212–8.
- Eastwood B, Dockrell M, Arnott D, et al. Electronic cigarette use in young people in Great Britain 2013–2014. *Public Health* 2015;129:1150–6.
- Lasnier B, Montreuil A. *Electronic cigarette use among secondary school students in Québec: 2012–2013*. Montréal: Institut national de santé publique du Québec; 2015. Available: https://www.inspq.qc.ca/sites/default/files/publications/2019_electronic_cigarette_secondary_students.pdf (accessed 2017 Apr. 4).
- Leventhal AM, Strong DR, Kirkpatrick MG, et al. Association of electronic cigarettes with the initiation of combustible tobacco product smoking in early adolescence. *JAMA* 2015;314:700–7.
- Barrington-Trimis JL, Urman R, Berhane K, et al. E-cigarettes and future cigarette use. *Pediatrics* 2016;138:e20160379.
- Cardenas VM, Evans VL, Balamurugan A, et al. Use of electronic delivery systems and recent initiation of smoking among US youth. *Int J Public Health* 2016;61:237–41.
- Khoury M, Manlhot C, Fan CPS, et al. Reported electronic cigarette use among adolescents in the Niagara region of Ontario. *CMAJ* 2016;188:794–800.
- Scottish schools adolescent lifestyle and substance use survey (SALSUS): smoking among 13 and 15 year olds in Scotland 2013*. Edinburgh (Scotland): National Services Scotland; 2014. Available: www.isdscotland.org/Health-Topics/Public-Health/Publications/2014-11-25/SALSUS_2013_Smoking_Report.pdf (accessed 2016 Sept. 8).
- Moore G, Hewitt G, Evans J, et al. Electronic cigarette use among young people in Wales: evidence from two cross sectional surveys. *BMJ Open* 2015;5:e007072.
- Bauld L, MacKintosh AM, Ford A. E-cigarette uptake amongst UK youth: experimentation, but little or no regular use in nonsmokers. *Nicotine Tob Res* 2016;18:102–3.
- CSTADS: Canadian Student Tobacco, Alcohol and Drugs Survey [website]. Waterloo (ON): University of Waterloo, Propel Centre for Population Health Impact; 2016. Available: <https://uwaterloo.ca/canadian-student-tobacco-alcohol-drugs-survey> (accessed 2016 Sept. 8).
- Glasser AM, Collins L, Pearson JL, et al. Overview of electronic nicotine delivery systems: a systematic review. *Am J Prev Med* 2017;52:e33–66.
- Wellman RJ, Dugas EN, Dutczak H, et al. Predictors of the onset of cigarette smoking: a systematic review of longitudinal population-based studies in youth. *Am J Prev Med* 2016;51:767–78.
- Canadian Tobacco, Alcohol and Drugs Survey (CTADS): 2015 summary. Ottawa: Health Canada; 2016. Available: www.canada.ca/en/health-canada/services/canadian-tobacco-alcohol-drugs-survey/2015-summary.html (accessed 2017 Apr. 4).
- Wang M, Wang JW, Cao SS, et al. Cigarette smoking and electronic cigarettes use: a meta-analysis. *Int J Environ Res Public Health* 2016;13:E120.
- Kong G, Morean ME, Cavallo DA, et al. Reasons for electronic cigarette experimentation and discontinuation among adolescents and young adults. *Nicotine Tob Res* 2015;17:847–54.
- Bold KW, Kong G, Cavallo DA, et al. Reasons for trying e-cigarettes and risk of continued use. *Pediatrics* 2016;138:e20160895.
- Bunnell RE, Agaku IT, Arrazola RA, et al. Intentions to smoke cigarettes among never smoking US middle and high school electronic cigarette users: National Youth Tobacco Survey, 2011–2013. *Nicotine Tob Res* 2015;17:228–35.
- Davis B, Dang M, Kim J, et al. Nicotine concentrations in electronic cigarette refill and do-it-yourself fluids. *Nicotine Tob Res* 2015;17:134–41.
- Farsalinos KE, Romagna G, Tsapras D, et al. Evaluation of electronic cigarette use (vaping) topography and estimation of liquid consumption: implications for research protocol standards definition and for public health authorities' regulation. *Int J Environ Res Public Health* 2013;10:2500–14.

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