



# E-cigarette use by Ontario public elementary school and secondary school students: Has the use among sociodemographic groups changed from 2017 to 2019?

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## ABSTRACT

This project examined e-cigarette use among Elementary School (ES) (grades 7 and 8) and Secondary School (SS) (grades 9–12) students in Ontario, Canada, for 2017 and 2019 and relationships with sociodemographic variables and traditional cigarette use. The data came from the Ontario Student Drug Use and Health Survey OSDUHS (2017, 2019). Socio-demographics included grade, school performance, sex, race, years in Canada, living arrangements and language spoken at home. E-cigarette use and cigarette smoking were any past year use. For 2017, there are a greater percentage of ES males than females who used e-cigarettes, older students, those living in more than one home and those smoking cigarettes. For SS students a greater percentage for those of older age, higher grades, living in Canada all their lives, using only English language at home, self-identified as white, with lower school performance, those with multiple household living arrangements and who reported smoking traditional cigarettes reported using e-cigarettes. Use was lower among females in 2017 (OR = 0.63, 95% CI = 0.46, 0.86,  $p = 0.002$ ), but by 2019 use was higher among females, which resulted in a non-significant difference between males and females (OR = 0.91, 95% CI = 0.77, 1.09). Greater use of e-cigarettes was found among students who smoked traditional cigarettes compared to those who did not smoke in both years. Monitoring the trends, patterns and trajectories of use and variables related to use needs to be continued which may help inform the development of further legislative and educational measures.

## 1. Introduction

Currently, there are many different forms of electronic cigarettes (e-cigarettes); most have a battery, a heating element and a place to hold liquid (Center for Disease Control and Prevention (CDC), 2021). E-cigarettes are known by different names including e-cigs, e-hookahs, mods, vape pens, vapers, tank systems. The overall category is electronic nicotine delivery systems (CDC, 2016). These delivery systems can contain nicotine, marijuana, a range of potentially dangerous chemicals and can come in a wide variety of flavors that make them attractive to users.

E-cigarettes have been in use for a century. In 2003 the first commercially successful e-cigarette was developed by Hon Lik in China (U.S. Department of Health and Human Services, 2016). More recent

versions of e-cigarettes look like USBs and pods (CDC, 2021; Marynak et al., 2019).

Most youth e-cigarette use research is from the U.S. (Cole et al., 2021). Studies have shown that the prevalence of e-cigarette use among students increased from 2014 onward with a substantive increase between 2017 and 2019 (e.g., Miech et al., 2019; Mirolouk et al. 2022). For example, Mirolouk et al. (2022), using the Youth Risk Behavior Surveillance System data for 2015–2019, found past 30-day-use of 13.2% in 2017 and over a two-fold increase (32.7%) in 2019. However, some differences in e-cigarette policies between the U.S. and Canada could affect e-cigarette use rates among students between the countries (Cole et al., 2021).

Two large-scale student surveys examining e-cigarette use have been conducted in Canada. The Canadian Student Tobacco, Alcohol and

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Drugs survey conducted from 2014 to 2019, found that in 2016–2017, 22.8% of students (males = 26.0%; females = 19.6%) in grades 7–12 had ever tried an e-cigarette (Government of Canada, 2018). In 2018–2019, 33.9% in grades 7–12 (males = 34.2; females = 33.5) had ever tried an e-cigarette (Government of Canada, 2019). Similarly, a multi-province repeated cross-sectional survey found that in Ontario in 2015–2016, 28.9% of students in grades 7–12 had ever tried an e-cigarette (Cole et al., 2021). In 2017–2018, 34.9% had ever tried one, with the largest increase occurring among females from 2017–2018 to 2018–2019 (Cole et al., 2021). However, very limited information is available on Canadian student correlates of vaping.

**PURPOSE.** The purpose of this project was to examine e-cigarette use among Elementary School (ES) and Secondary School (SS) students in Ontario, Canada, in the years 2017 and 2019 and to investigate the relationship of use with socio-demographic and school performance variables. In addition, the extent of traditional cigarette use among e-cigarette users was examined. Cross-sectional surveys were used to determine prevalence of past year use as well as 30 day use among representative samples of ES and SS students (Boak et al., 2020). Of interest was whether the relationships in the two levels of schools and the two time periods were similar or whether some specific changes were found. Identification of socio-demographic variables associated with use and increases in use can provide the basis for monitoring and targeted interventions.

## 2. Method

Data for this study came from two cycles of the Ontario Student Drug Use and Health Survey (OSDUHS) (2017, 2019), conducted by the Centre for Addiction and Mental Health (CAMH) (Boak et al., 2017, 2020). This survey has been conducted biennially since 1977. Ontario's four publicly funded school systems were included (English language public, English language Catholic, French language public, and French language Catholic). Approximately 8% of students were excluded from the sample: those enrolled in private schools, home-schooled, lived on military bases, lived in First Nations communities, were institutionalized for correctional or health reasons, or lived in remote northern regions of Ontario (Boak et al., 2020). This approach to sampling and stratification has been used in the OSDUHS from 2017 (Boak et al., 2020).

Both ES and SS were stratified by region and school level and were selected by probability proportionate to school size. In the second stage, classes within selected schools were selected with equal probability. For ES, the grades included 7 and 8; for SS, grades included 9–12. Both stages employed sampling without replacement (Boak et al., 2020).

For the 2017 questionnaire, 285 schools were invited to participate. Of these, 214 schools from 52 school boards participated, resulting in a school participation rate of 61%, 94% of selected classes, and 61% of eligible students in those classes completed the survey (Boak et al., 2017). Of this sample, 12% of students were lost due to absenteeism, and 27% were lost due to either unreturned consent forms and/or parental refusal. Grade differences were found in nonresponse: in the lower grades unreturned consent or parental refusal was the major source of nonresponse (30% in grade 7 versus 21% in grade 12), whereas in the upper grades, absenteeism was higher than in the lower grades (18% in grade 12 versus 10% in grade 7). In 2019, 264 schools from 47 school boards participated in the survey, resulting in a school participation rate of 50%, with one school eliminated because of an editing problem. 92% of selected classes participated; student participation from selected classes was 59% (Boak et al., 2020). Of this sample, 12% of students were lost due to absenteeism, and 29% were lost due to either unreturned consent forms or parental refusal. The sources of nonresponse varied by grade whereby the major source of nonresponse in the younger grades was unreturned consent and/or parental refusal (33% in grade 7 versus 25% in grade 12), while in the older grades, absenteeism was higher than in the lower grades (19% in grade 12 versus 8% in grade 7). Nonresponse bias is difficult to assess. Some research has found that

among student surveys, non-participating students who do not return parental or their own consent forms are more likely to use drugs, engage in risky behaviors, or have mental health problems compared with participating students (Courser et al., 2009; Shaw et al., 2015). Other research has found no differences (de Winter et al., 2005; Eaton et al., 2010; Jelsma et al., 2012). Previous studies have examined OSDUHS prevalence rates for classes with high and low response rates. For example, Vingilis et al. (2011) found no significant differences for demographics, drug use, or delinquent behavior between higher and lower response rate classes suggesting no evidence of response bias in their study. However, as no information is available on non-respondents or non-participating schools it is not possible to assess nonresponse bias, which is a limitation to be noted.

Information was collected using anonymous self-administered questionnaires in classrooms. Consent to participate was provided by both parents and students. There were four split ballot versions of the questionnaire (Form A-ES, Form B-ES, Form A-SS, Form B-SS); each version averaged 30 min to complete. Form A and Form B were alternately distributed to students such that one-half of students in each class room completed Form A and the other half completed Form B to achieve two near-equal random samples completing each form. The use of two different forms was done so that along with a large number of core questions, a range of additional emerging topics could be included in the questionnaires without adding a high response burden because of undue numbers of questions in one form. This project was classified as exempt from REB approval by the University of Western Ontario because the research relied exclusively on secondary use of anonymous information.

## 3. Measures

Questions included health and behavioral topics, school and family life, drug use, and health behaviors (Boak et al., 2020). For the current analyses, only Form B versions were used because the questions on e-cigarette use were not included in the Form A versions. In 2017, 5,071 participants completed Form B; in 2019, 6,525 participants completed Form B. Demographic information included grade, school performance, sex, race, years in Canada, living arrangements and language spoken at home. E-cigarette use was defined as any use in the past year, as well as past 30-day use. Cigarette smoking was also categorized as any use in the past year. Appendix Table 1 provides the detailed response categories used in the analyses. Given the low frequency of responses to some categories, the response categories were combined for some variables and the details of the responses used are presented in the Appendix Table 2.

**ANALYSIS:** The data used in the analyses were obtained from CAMH. Because the SAS software was not able to calculate the contribution to the variance of the estimates for strata containing a single cluster, these strata were removed from the data. From the 2017 dataset a single cluster of size 13 was removed for ESs and a single cluster of size 41 was removed for SSs. The percentages reported are calculated using weights as provided by CAMH and are considered representative for the population surveyed.

Computations of estimates and their standard errors included the effect of strata, clusters and appropriate weights. Univariable analysis of e-cigarette vaping (Yes/No) over levels of each of the socio-demographic variables, grade, sex, age, living in Canada all my life, English language only, race, school performance, living arrangements and smoker, was done with SAS Proc SURVEYFREQ. Then a multivariable logistic regression of e-cigarette vaping on all the socio-demographic variables except for age was fitted using SAS proc SURVEYLOGISTIC. Age was excluded because it was highly correlated with grade, with values 0.77 and 0.93 for ESs and SSs, respectively, in 2017, and 0.78 and 0.92 in 2019. Including age would possibly reduce the estimated effect of grade because of the near-collinearity of age and grade.

Results were calculated separately for ES and SS students, and for years 2017 and 2019. Comparisons were made between the years by

calculating the statistic  $(\text{estimate}_{2017} - \text{estimate}_{2019}) / \sqrt{(\text{standard error}_{2017}^2 + \text{standard error}_{2019}^2)}$  and comparing it to the critical values of the Normal distribution. This follows the advice of Thomas and Wannell (2009) for combining the results of surveys taken at different times. In addition, it was possible to compare the odds ratios from the two years by using the MOVER (method of variance estimate recovery) methodology recommended by Zou and Donner (2008).

The analysis for this paper was generated using SAS/STAT software, Version 14.2 for Windows (SAS/STAT 14.2 User's Guide). SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA. Statistical

significance for all analyses was determined using  $p \leq 0.05$ .

#### 4. Results

Table 1 presents the proportion of past year e-cigarette use by demographic variables (see Appendix tables for a list of variables), separately for 2017 and 2019.

In 2017, 4.60% (95% CI = 2.95%, 6.27%) of the ES respondents reported any use of e-cigarettes in the past year, compared to 6.39% (95% CI = 4.97, 7.80) in 2019. This difference was not statistically significant. For those in SS, the percent of use in 2017 was 23.14% (95%

**Table 1**

Per cent of students who reported using e-cigarettes at least once in the past year. Univariable relationships for 2017 and 2019, and differences between the two time periods.

Elementary School		2017 N = 1767			2019 N = 1869			change from 2017 to 2019		
Variables		%	95% CI	p-value	%	95% CI	p-value	change	95% CI	p-value
overall		4.61	(2.95,6.27))		6.39	(4.97,7.80)		1.78	(-0.37,3.93)	0.104
Grade	Grade 7	2.74	(0.89,4.59)		3.81	(2.06,5.57)		1.08	(-1.43,3.58)	0.401
	Grade 8	6.33	(3.58,9.09)		8.89	(6.46,11.31)		2.55	(-1.06,6.16)	0.166
	odds ratio	2.40	(1.01,5.69)	<b>0.036</b>	2.46	(1.36,4.45)	<b>0.001</b>	0.06	(-3.41,2.48)	0.527
Sex	male	6.29	(3.71,8.86)		7.04	(4.95,9.13)		0.75	(-2.51,4.02)	0.652
	female	2.88	(0.97,4.79)		5.70	(4.10,7.29)		2.82	(0.37,5.26)	<b>0.024</b>
	odds ratio	0.44	(0.20,0.96)	<b>0.028</b>	0.80	(0.53,1.19)	0.275	0.36	(-0.23,0.82)	0.295
Age	12 or younger	2.48	(0.57,4.39)		3.03	(1.66,4.40)		0.56	(-1.76,2.87)	0.638
	13 or older	5.98	(3.52,8.44)		8.57	(6.49,10.66)		2.59	(-0.58,5.76)	0.109
	odds ratio	2.50	(1.03,6.33)	<b>0.028</b>	3.00	(1.77,5.07)	<b>&lt;0.001</b>	0.49	(-3.52,3.03)	0.313
Canada all my life	yes	4.92	(2.98,6.86)		6.18	(4.64,7.71)		1.26	(-1.18,3.69)	0.312
	no	2.94	(0.64,5.23)		6.61	(3.96,9.26)		3.67	(0.23,7.12)	<b>0.037</b>
	odds ratio	0.58	(0.23,1.47)	0.196	1.07	(0.66,1.76)	0.777	0.49	(-0.49,1.26)	0.261
English language only	yes	4.77	(2.68,6.85)		5.95	(4.38,7.52)		1.18	(-1.38,3.75)	0.366
	no	4.23	(1.84,6.62)		7.11	(4.39,9.82)		2.88	(-0.68,6.43)	0.113
	odds ratio	0.88	(0.43,1.83)	0.732	1.21	(0.74,1.97)	0.458	0.33	(-0.73,1.22)	0.440
Race	white	5.48	(2.72,8.24)		6.97	(5.01,8.93)		1.49	(-1.84,4.82)	0.380
	other	3.28	(1.59,4.98)		5.86	(4.00,7.72)		2.58	(0.10,5.06)	<b>0.042</b>
	odds ratio	0.59	(0.27,1.26)	0.187	0.83	(0.53,1.30)	0.412	0.25	(-0.49,0.81)	0.608
School performance	90 or more	3.16	(0.57,5.75)		3.56	(0.78,6.33)		0.40	(-3.39,4.19)	0.837
	80-89	4.66	(2.48,6.84)		6.43	(4.38,8.49)		1.77	(-1.23,4.76)	0.247
	odds ratio	1.49	(0.54,4.122)	0.439	1.86	(0.78,4.46)	0.159	0.37	(-2.47,3.14)	0.739
	70-79	4.80	(2.06,7.54)		6.59	(4.50,8.68)		1.79	(-1.66,5.23)	0.309
	odds ratio	1.04	(0.54,2.00)	0.910	1.03	(0.66,1.58)	0.908	-0.01	(-1.03,0.74)	0.976
	69 or less	6.25	(0.65,11.86)		10.74	(2.93,18.55)		0.209	(-5.13,14.10)	0.360
	odds ratio	1.32	(0.45,3.86)	0.604	1.71	(0.63,4.60)	0.282	0.38	(-2.37,3.40)	0.728
Living arrangements	one	3.00	(1.61,4.39)		5.78	(4.20,7.36)		2.78	(0.71,4.85)	<b>0.008</b>
	more	14.24	(8.07,20.41)		10.12	(5.64,14.61)		-4.12	(-11.62,3.39)	0.282
	odds ratio	5.39	(2.94,9.90)	<b>0.001</b>	1.84	(0.99,3.42)	0.096	-3.56	(-8.14,0.24)	0.080
Smoker	no	3.60	(2.32,4.89)		5.73	(4.34,7.1)3		2.13	(0.27,4.00)	<b>0.025</b>
	yes	61.26	(36.41,86.11)		77.49	(58.48,96.49)		16.23	(-14.56,47.01)	0.302
	odds ratio	42.31	(14.90,120.11)	<b>0.015</b>	56.58	(18.63,171.82)	<b>&lt;0.001</b>	14.27	(-72.29,132.72)	0.367
Secondary School		2017 N = 1767			2019 N = 1869			change from 2017 to 2019		
Variables		%	95% CI	p-value	%	95% CI	p-value	change	95% CI	p-value
overall		23.14	(19.39,26.90)		35.70	(32.95,38.44)		12.55	(7.96,17.15)	<b>&lt;0.001</b>
Grade	9	15.20	(10.39,20.00)		25.27	(21.40,29.14)		10.08	(3.97,16.18)	<b>0.001</b>
	10	19.59	(14.55,24.63)		29.97	(25.91,34.03)		10.38	(3.98,16.77)	<b>0.001</b>
	odds ratio	1.36	(0.88,1.41)	0.163	1.30	(0.98,1.73)	0.068	-0.06	(-0.86,0.58)	0.863
	11	26.91	(20.90,32.91)		39.05	(33.69,44.41)		12.14	(4.18,20.10)	<b>0.003</b>
	odds ratio	1.51	(1.01,2.26)	<b>0.045</b>	1.44	(1.08,1.90)	0.011	-0.08	(-0.91,0.61)	0.835
	12	28.34	(23.31,33.37)	<b>&lt;0.001</b>	44.27	(40.24,48.30)	<b>&lt;0.001</b>	15.93	(9.55,22.30)	<b>&lt;0.001</b>
	odds ratio	1.07	(0.79,1.47)	0.647	1.25	(0.95,1.64)	0.109	0.17	(-0.32,0.66)	0.470
Sex	male	26.99	(23.38,30.59)		36.71	(33.21,40.21)		9.72	(4.75,14.70)	<b>&lt;0.001</b>
	female	18.90	(13.84,23.96)		34.60	(31.35,37.86)		15.70	(9.76,21.64)	<b>&lt;0.001</b>
	odds ratio	0.63	(0.46,0.86)	<b>0.002</b>	0.91	(0.77,1.09)	0.300	0.28	(-0.01,0.52)	0.062
Age	14 or younger	15.61	(10.34,20.87)		25.47	(21.46,29.47)		9.86	(3.32,16.40)	<b>0.003</b>
	15	17.72	(11.29,24.15)		28.23	(24.16,32.31)		10.51	(2.98,18.04)	<b>0.006</b>
	odds ratio	1.16	(0.62,2.20)	0.637	1.15	(0.86,1.53)	0.335	-0.01	(-1.09,0.65)	0.971
	16	25.13	(19.54,30.72)		36.57	(31.74,41.40)		11.44	(4.13,18.75)	<b>0.002</b>
	odds ratio	1.56	(0.99,2.46)	0.057	1.42	(1.09,1.85)	<b>0.008</b>	-0.13	(-1.10,0.58)	0.736
	17 or older	28.02	(23.31,32.72)		44.32	(39.36,49.28)		16.30	(9.54,23.07)	<b>0.002</b>
	odds ratio	1.16	(0.82,1.64)	0.398	1.43	(1.10,1.86)	<b>0.007</b>	0.27	(-0.31,0.82)	0.338
Canada all my life	yes	24.70	(20.54,28.86)		38.48	(35.55,41.41)		13.78	(8.75,18.82)	<b>&lt;0.001</b>
	no	15.19	(10.85,19.53)		24.52	(20.47,28.57)		9.33	(3.46,15.20)	<b>0.002</b>
	odds ratio	1.83	(1.28,2.63)	<b>&lt;0.001</b>	1.93	(1.53,2.43)	<b>&lt;0.001</b>	0.09	(-0.79,0.84)	0.206

(continued on next page)

Table 1 (continued)

Elementary School		2017 N = 1767		2019 N = 1869		change from 2017 to 2019				
English language only	yes	25.31	(20.85,29.77)	40.35	(37.24,43.46)	15.04	(9.67,20.41)	<0.001		
	no	16.60	(12.90,20.31)	26.67	(22.94,30.40)	10.07	(4.87,15.27)	<0.001		
	odds ratio	1.70	(1.38,2.53)	<0.001	1.86	(1.49,2.32)	<0.001	0.16	(-0.74,0.72)	0.155
Race	white	27.22	(21.81,32.63)	47.26	(43.88,50.64)	20.04	(13.73,26.34)	<0.001		
	other	16.70	(14.07,19.33)	24.37	(21.46,27.27)	7.67	(3.79,11.55)	<0.001		
	odds ratio	0.54	(0.40,0.73)	<0.001	0.36	(0.29,0.44)	<0.001	-0.18	(-0.38,-0.01)	0.001
School performance	90 or more	12.03	(8.20,15.86)	22.99	(19.34,26.64)	10.96	(5.73,16.19)	<0.001		
	80-89	17.83	(13.74,21.93)	33.96	(29.75,38.18)	16.13	(10.32,21.94)	<0.001		
	odds ratio	1.59	(1.01,2.49)	0.045	1.97	(1.49,2.61)	<0.001	0.38	(-0.64,1.25)	0.418
	70-79	28.86	(23.32,34.40)	42.13	(38.79,45.87)	13.27	(6.87,19.67)	<0.001		
	odds ratio	1.87	(1.44,2.43)	<0.001	1.32	(1.08,1.63)	0.008	-0.55	(-1.16,-0.12)	0.042
Living arrangements	69 or less	43.81	(35.47,52.15)	47.94	(41.03,54.86)	4.13	(-6.59,14.85)	0.450		
	odds ratio	1.92	(1.30,2.84)	0.001	1.51	(1.08,2.10)	0.016	-0.42	(-0.14,0.45)	0.348
	one	21.43	(17.91,24.96)	34.50	(31.71,37.29)	13.06	(8.62,17.51)	<0.001		
Smoker	more	34.53	(26.50,42.56)	45.57	(40.23,50.91)	11.04	(1.51,20.57)	0.023		
	odds ratio	1.93	(1.38,2.70)	<0.001	1.59	(1.29,1.96)	<0.001	-0.34	(-1.17,0.28)	0.657
	no	14.44	(11.43,17.46)	29.05	(26.44,31.67)	14.61	(10.66,18.55)	<0.001		
odds ratio	yes	63.44	(56.60,70.27)	88.29	(84.63,91.96)	24.86	(17.19,32.53)	<0.001		
	no	10.28	(7.02,15.04)	<0.001	18.42	(12.87,26.36)	<0.001	8.14	(0.83,16.73)	0.030

CI = Confidence Interval

CI = 19.39%, 26.90%) in 2017 and 35.70% (95% CI = 32.95%, 38.44%) in 2019, with the increase being statistically significant (difference = 12.55%, 95% CI = 7.96%, 17.15).

As the above analyses examined any e-cigarette use in the past year, past 30-day use has been included to document the difference between what could be habitual use in the two time periods and two school levels. In 2017, 0.48% (95% CI = 0.06%, 0.89%) of ES students reported using e-cigarettes within the past 30 days compared to 6.54% (95% CI = 4.37%, 8.71%) in 2019. For those in SS, the percent of past 30-day use was 1.90% (95% CI = 1.18%, 2.62%) in 2017, and 19.90% (95% CI = 17.80, 22.00) in 2019. In both school levels, the increase in 30-day use between the two time periods was substantial.

The patterns for the ES students for reported any use of cigarettes were similar for both time periods. Any use in past year was higher in Grade 8 than in Grade 7 (for 2017, OR = 2.4, 95% CI = 1.01, 5.69, p = 0.036 and for 2019, OR = 2.46, 95% CI = 1.36, 4.45, p = 0.001). For 2017, a lower percentage of females than males used e-cigarettes (OR = 0.44, 95% CI = 0.20, 0.96, p = 0.028), as well as those who lived in more than one household (OR = 5.39, 95% CI = 2.94, 9.90, p = 0.001). For both 2017 and 2019, older students (for 2017, OR = 2.50, 95% CI = 1.03, 6.33, p = 0.028; for 2019, OR = 3.00, 95% CI = 1.77, 5.07, p = 0.001) and those reporting cigarette use in past year (see below) tended to use e-cigarettes. For SS students, there were significant differences across almost all variables in 2017 and 2019 (p < 0.001). A greater percentage of those in higher grades who used e-cigarettes, were of older ages, lived in Canada all their life, used English language only, identified as white, had multiple household living arrangements, lower school performance and reported cigarette use in past year. Of interest is the fact that use was statistically lower among females than males in 2017 (OR = 0.63, 95% CI = 0.46, 0.86, p = 0.002, but by 2019 usage had increased among females, which resulted in a not statistically significant difference between males and females (OR = 0.91, 95% CI = 0.77, 1.09). E-cigarette use among different racial groups was consistent; it was lower for other (non-whites) both in 2017 (OR = 0.54, 95% CI = 0.40, 0.73, p < 0.001) and in 2019 (OR = 0.36, 95% CI = 0.29, 0.44, p < 0.001). Also, use increased significantly for both groups from 2017 to 2019: for whites (difference = 20.04, 95% CI = 13.73, 36.34, p < 0.001) and for other (difference = 7.67, 95% CI = 3.79, 11.55, p < 0.001). Of note is the substantial difference in e-cigarette use among those reporting past year smoking, compared to those who did not smoke in both years: for ES, for 2017, OR = 42.31, 95% CI = 14.90, 120.11, p = 0.015, while for 2019, OR = 56.58, 95% CI = 18.63, 171.82, p < 0.001; for SS, for 2017, OR = 10.28, 95% CI = 7.02, 15.04, p < 0.001, and for 2019, OR = 18.42, 95% CI = 12.87, 26.36, p < 0.001,

with a significant increase in SS (change in OR = 8.14, 95% CI = 0.83, 16.73, p = 0.030).

Table 2 presents the results for the multivariable models for 2017 and 2019. For the ES students, several variables remained significant in 2017 compared to the univariable analysis: sex (OR = 0.27, 95% CI = 0.11, 0.65, p = 0.004), living arrangements (OR = 5.58, 95% CI = 2.50, 12.48, p < 0.001) and smoking (OR = 58.98, 95% CI = 16.55, 210.19, p < 0.001). In 2019, grade (OR = 2.33, 95% CI = 1.19, 4.56, p = 0.014) and smoking (OR = 54.14, 95% CI = 14.97, 195.78, p < 0.001) remained significant. English as the primary language at home (OR = 2.00, 95% CI = 0.99, 4.02, p = 0.052) and living arrangements (OR = 1.90, 95% CI = 0.93, 3.86, p = 0.077) were close to significance. For the SS students, several of the same variables were significant in 2017: grade (p = 0.041), school performance (p < 0.001), living arrangements (OR = 1.50, 95% CI = 1.01, 2.24, p = 0.046) and smoking (OR = 8.17, 95% CI = 5.31, 12.55, p < 0.001), whereas sex was marginally significant (OR = 0.71, 95% CI = 0.50, 1.01, p = 0.55). In 2019, grade (p < 0.001), race (OR = 0.54, 95% CI = 0.40, 0.71, p < 0.001), school performance (p < 0.001) and smoking (OR = 17.53, 95% CI = 11.09, 27.71, p < 0.001) remained significant. When the differences in the effects of the variables for each year were examined, for ES students, the only statistically significant difference was found for living arrangements, with a decrease for those who lived in more than one residence (change in OR = -3.69, 95% CI = -10.65, -0.03, p = 0.45). The difference for sex (change in OR = 0.41, 95% CI = -0.05, 0.86, p = 0.65) and “Canada all my life” (change in OR = 0.77, 95% CI = -0.14, 1.80, p = 0.074) approached significance. In SS students, e-cigarette use increased significantly with sex (change in OR = 0.40, 95% CI = 0.02, 0.77, p = 0.013) and cigarette smoking (change in OR = 9.36, 95% CI = 1.57, 19.94, p = 0.016).

### 5. Discussion

There are several important findings evident from these analyses. First, e-cigarette use appears to have increased dramatically over this 2017 and 2019 time period using OSDUHS, as well as in other Canadian surveys (Canadian Broadcasting Corporation, 2021; Cole et al., 2021; Government of Canada, 2018, 2019; Statistics Canada, 2020) and in the U.S. (Cooper et al., 2022; CDC, 2016, 2019, 2021; Singh et al., 2020; Wang et al., 2020). Since 2019, e-cigarette use among youth appears to have decreased in the U.S. (e.g., Gaiha et al., 2020; Wang et al., 2021) or plateaued (e.g., Miech et al., 2021) and stabilized in Canada (e.g., Statistics Canada, 2022b). For example, the Canadian Tobacco and Nicotine Survey found past-30-day vaping prevalence among youth aged 15 to 19

**Table 2**  
Adjusted odds ratio for students who reported using e-cigarettes at least once in the past year compared to those who did not: Multivariable models for 2017 and 2019.

Elementary School		2017			2019			Change from 2017 to 2019		
		N = 1767			N = 1869					
Variables		Odds Ratio	95% CI	p-value	Odds ratio	95% CI	p-value	Change	95% CI	p-value
Grade	Grade 7									
	Grade 8	2.20	(0.93,5.19)	<b>0.071</b>	2.33	(1.19,4.56)	<b>0.014</b>	0.13	(-3.07,2.69)	0.917
Sex	Male									
	Female	0.27	(0.11,0.65)	<b>0.004</b>	0.68	(0.42,1.10)	0.114	0.41	(-0.05,0.86)	0.065
Canada all my life	Yes									
	No	0.30	(0.08,1.05)	0.058	1.07	(0.55,2.08)	0.849	0.77	(-0.14,1.80)	0.074
English language only	Yes									
	No	2.00	(0.87,4.62)	0.101	2.00	(0.99,4.02)	0.052	0.00	(-2.80,2.32)	0.996
Race	White									
	Other	0.77	(0.36,1.66)	0.506	0.70	(0.40,1.23)	0.208	-0.08	(-1.01,0.60)	0.826
School performance	90 or more									
	88-89	1.99	(0.56,7.04)	0.281	1.70	(0.73,3.97)	0.219	-0.29	(-5.44,2.39)	0.835
	70-79	0.83	(0.38,1.80)	0.627	1.05	(0.63,1.75)	0.850	0.22	(-0.84,1.06)	0.608
	69 or less	0.71	(0.16,3.08)	0.639	1.42	(0.49,4.13)	0.510	0.72	(-1.83,3.48)	0.442
	overall			<b>0.689</b>			<b>0.422</b>			
Living arrangements	One household									
	More than one	5.58	(2.50,12.48)	<b>&lt;0.001</b>	1.90	(0.93,3.86)	0.077	-3.69	(-10.65,-0.03)	<b>0.045</b>
Smoker	No									
	Yes	58.98	(16.55,210.19)	<b>&lt;0.001</b>	54.14	(14.97,195.78)	<b>&lt;0.001</b>	-4.84	(-161.04,143.02)	0.925
Secondary School		2017			2019			Change		
		N = 3247			N = 4025					
Variables		Odds Ratio	95% CI	p-value	Odds Ratio	95% CI	p-value	Change	95% CI	p-value
Grade	9									
	10	1.43	(0.95,2.14)	0.083	1.28	(0.94,1.74)	0.116	-0.15	(-0.94,0.51)	0.665
	11	1.18	(0.78,1.78)	0.437	1.25	(0.90,1.73)	0.173	0.06	(-0.46,0.59)	0.818
	12	0.87	(0.52,1.47)	0.610	1.26	(0.82,1.93)	0.284	0.39	(-0.35,1.14)	0.280
	overall			<b>0.041</b>			<b>&lt;0.001</b>			
Sex	Male									
	Female	0.71	(0.50,1.01)	0.055	1.11	(0.88,1.41)	0.366	0.40	(0.02,0.77)	<b>0.013</b>
Canada all my life	Yes									
	No	0.76	(0.48,1.18)	0.212	0.72	(0.50,1.04)	0.083	-0.03	(-0.51,0.39)	0.886
English language only	Yes									
	No	1.11	(0.83,1.50)	0.482	0.89	(0.66,1.18)	0.413	-0.22	(-0.67,0.19)	0.281
Race	White									
	Other	0.73	(0.52,1.04)	0.078	0.54	(0.40,0.71)	<b>&lt;0.001</b>	-0.20	(-0.53,0.08)	0.170
School performance	90 or more									
	80-89	1.34	(0.71,2.52)	0.366	2.04	(1.48,2.81)	<b>&lt;0.001</b>	0.70	(-0.61,1.69)	0.239
	70-79	1.44	(1.07,1.94)	<b>0.017</b>	1.13	(0.86,1.48)	0.389	-0.31	(-0.88,0.20)	0.228
	69 or less	1.48	(0.88,2.47)	0.137	1.35	(0.90,2.03)	0.148	-0.13	(-1.22,0.77)	0.786
	overall			<b>&lt;0.001</b>			<b>&lt;0.001</b>			
Living arrangements	One household									
	More than one	1.50	(1.01,2.24)	<b>0.046</b>	1.28	(0.95,1.73)	0.108	-0.22	(-1.03,0.44)	0.520
Smoker	No									
	Yes	8.17	(5.31,12.55)	<b>&lt;0.001</b>	17.53	(11.09,27.71)	<b>&lt;0.001</b>	9.36	(1.57,19.94)	<b>0.016</b>

CI = Confidence Interval

to be 15% in 2019, 14% in 2020 and 13% in 2021 (Statistics Canada 2020, 2022a,b). Hence, there may be less reason for concern about the dramatic 2017-2019 increase found in both countries. That said, a recent international systematic review of prevalence of e-cigarette use among youth identified Canada as the country with the highest current e-cigarette use (Kim et al., 2022). This is of concern as the long-term effects of e-cigarette use on health are unknown (Marques et al., 2021).

Second, for SS students, the sex difference evident in 2017 disappeared by 2019. Kim et al. (2022) in their review identified that of the 36 studies that examined sex differences, 61.1% found significantly higher prevalence of e-cigarette use for males compared to females and 11.1% presented prevalence of e-cigarette use by gender but without

including statistical analysis of gender differences; however, 27.7% found no significant differences in use between genders. Explanations for increased e-cigarette use by females are not clear. There is evidence of increased marketing to females. Websites with titles such as, "How women are redefining the vape culture," present health information, role models, glamour, entrepreneurial opportunities, etc., in support of female vaping (e.g., e-puffer 2020; Women Triangle 2019). Research has shown a relationship between exposure to e-cigarette marketing and lower perceptions of harm of e-cigarettes, increased intention to use e-cigarettes, and e-cigarette experimentation, reflecting on the need for advertising regulations for e-cigarettes (Collins et al., 2019; Vogel et al., 2021).

Third, the association with at least some use of traditional cigarettes has changed over time and over school status, and appears to be an important variable related to e-cigarette use. In fact, the strongest association for e-cigarette use was any cigarette smoking in past year. For ES students the odds ratios were 58.98 and 54.14 for 2017 and 2019, respectively, while for SS students the odds ratios were 8.17 and 17.53 for 2017 and 2019, respectively. These findings parallel U.S. studies; Anic et al. (2018) found that 77% of middle and high school students who reported using e-cigarettes also reported using other tobacco products. Yet, given the nature of the cross-sectional information available, it is not possible to determine if there was any predictable order in the use of the products.

It is important to continue tracking these relationships, particularly the ones related to the similarity of use for males and females. Whether educational messages should be comprised of different content depending on sex is another area that needs to be considered (e.g., Yimsaard et al., 2021). Tracking use is also important to determine whether some reported vaping may only be transient or whether individuals become addicted to nicotine and continue vaping and/or whether use of traditional cigarettes follows. Evidence is conflicting on whether e-cigarettes are a gateway drug for smoking (e.g., Chapman et al., 2019) or a substitution (e.g., Cotti et al., 2022). The finding that in 2017 1.90% of SS students reported e-cigarette use in last 30 days while in 2019, 19.90% reported doing so is of concern as this represents a 10-fold increase.

These findings have policy implications. In 2020, the government of Canada banned advertising of e-cigarettes where they can be viewed by youth (Health Canada, 2020). In Canada, legislative measures have been enacted federally and provincially to control use by young people; some measures include restrictions on flavors, on sales and increases in taxation (Chadi and Bélanger, 2020; Heart and Stroke Foundation, 2021). The Heart and Stroke Foundation of Canada (2021) has reported vaping among youth from all provinces and has found declines in a range of measures of use. Hammond et al. (2021a, 2021b) have noted that the recent declines in number of e-cigarette users may be due to stricter regulations, awareness of risks from vaping and lifestyle changes resulting from the COVID-19 pandemic.

There are limitations that need to be considered in examining these findings. First, sample sizes that include 61% and 59% of individuals may introduce non-respondent bias. As previously mentioned, no information was available on non-respondents by which to assess potential bias. Since agreement was necessary for participation in the surveys, differences may exist in reports of e-cigarette use and traditional cigarette use between participants and non-participants. There is no way to estimate the differences since reasons for non-participation were not collected. Moreover, some CIs were large suggesting caution in interpretation. Second, questions about use vary, particularly with regard to any use in a specific time period and/or amount of use during specific times. In this analysis, we focused primarily on any use during the past year. The use of this definition mixed infrequent or sporadic use together with habitual use. For example, in this study in 2017 0.48% of ES students reported e-cigarette use in last 30 days. However, it is important to point out that the measure of past year use may capture use that is experimental, does not result in continued use and could potentially be a positive development in terms of reducing long term cigarette use. Third, the current surveys were anonymous classroom self-administered questionnaires which can introduce certain biases. Other surveys have collected information online or on the phone; for example, the 2021

OSDUHS was collected online during the COVID-19 school lockdown, and subsequent surveys will be collected using electronic methods (computers and personal devices) in schools (CAMH, 2022). The variations in data collection methods in 2021 and beyond may not result in useful longer-term trend information, and hence 2021 data were not used in this study. It is unclear what impact the different data collection methods on responses might be (e.g., Hemsworth et al., 2021; Kann et al., 2002; Weigold et al., 2013). Finally, there is no information available about when first use of vaping and how access to products occurred.

In summary, this study found significant increases in e-cigarette use from 2017 to 2019. Two other key findings were that for SS students, the sex difference evident in 2017 disappeared by 2019 and e-cigarette use was strongly associated with cigarette use. Hence, it is important that relevant and appropriate messages about e-cigarettes are available for youth. Chadi and Bélanger (2020) present links to information and resources to assist with the design of effective programs. Legislative measures that restrict access and ingredients may be necessary to reduce use (e.g., Pesko et al., 2016). However, it is important to consider all potential outcomes from such legislation (Warner et al., 2022). For example, some measures such as increased taxation to reduce use of e-cigarettes by youth may result in increased use of cigarettes (Cotti et al., 2022). Some evidence also finds that restricting e-cigarette availability may increase youth smoking (Friedman, 2021). Finally, to ensure that the information is relevant to youth, the development and design of interventions need to be conducted with input from these groups.

#### CRediT authorship contribution statement

**Linda L. Pederson:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Supervision. **John J. Koval:** Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Evelyn Vingilis:** Writing – original draft, Writing – review & editing.

#### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### Data availability

The authors do not have permission to share data.

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#### Appendix

[Appendix Table 1](#)

[Appendix Table 2](#)

Appendix Table 1

Questions and response categories.

Variable name	Grade 7/8	Grades 9–12
Grade		
Age	12 years or younger 13 years 14 years or older	14 years or younger 15 years 16 years 17 years 18 years or older
Sex	Male Female	Male Female
Lived in Canada	All of my life 2 years or less 3 to 5 years 6 to 10 years 11 years or longer	All my life 2 years or less 3 to 5 years 6 to 10 years 11 years or longer
Language spoken at home	English only French English and French English, French, and another language English and another language French and another language Other language(s)	English only French English and French English, French, and another language English and another language French and another language Other language(s)
Background/Race (Can answer more than one)	White (for example, British, French, Italian, Portuguese, German, Ukrainian, Russian) Chinese South Asian (for example, East Indian, Pakistani, Bangladeshi, Sri Lankan) Black (African, Caribbean, North American) Indigenous (First Nations, Inuit, Métis) Filipino Latin American, Central American, South American (for example, Mexican, Brazilian, Chilean, Guatemalan, Venezuelan, Colombian, Argentinian, Salvadoran, Costa Rican) Southeast Asian (for example, Vietnamese, Cambodian, Indonesian, Malaysian, Laotian) West Asian or Arab (for example, Egyptian, Saudi Arabian, Syrian, Iranian, Iraqi, Afghan, Lebanese, Palestinian) Korean Japanese Not sure	White (for example, British, French, Italian, Portuguese, German, Ukrainian, Russian) Chinese South Asian (for example, East Indian, Pakistani, Bangladeshi, Sri Lankan) Black (African, Caribbean, North American) Indigenous (First Nations, Inuit, Métis) Filipino Latin American, Central American, South American (for example, Mexican, Brazilian, Chilean, Guatemalan, Venezuelan, Colombian, Argentinian, Salvadoran, Costa Rican) Southeast Asian (for example, Vietnamese, Cambodian, Indonesian, Malaysian, Laotian) West Asian or Arab (for example, Egyptian, Saudi Arabian, Syrian, Iranian, Iraqi, Afghan, Lebanese, Palestinian) Korean Japanese Not sure
Living arrangements	I live in one home only I split my time between 2 or more homes	I live in one home only I split my time between 2 or more homes
School Performance	90% – 100% (Mostly A + ) 80% – 89% (Mostly As or A-) 70% – 79% (Mostly Bs) 60% – 69% (Mostly Cs) 50% – 59% (Mostly Ds) below 50% (Mostly Fs)	90% – 100% (Mostly A + ) 80% – 89% (Mostly As or A-) 70% – 79% (Mostly Bs) 60% – 69% (Mostly Cs) 50% – 59% (Mostly Ds) below 50% (Mostly Fs)
e-cigarette use Electronic cigarettes (E-CIGARETTES) are battery-operated devices that look like cigarettes and create a mist which the user inhales. Some e-cigarettes contain nicotine and some do not. Other names for e-cigarettes include "vape pipes", "hookah pens", and "ehookahs". In the LAST 12 MONTHS, how often did you smoke E-CIGARETTES?	Smoked only once in the last 12 months (a few puffs to a whole e-cigarette) A few times in the last 12 months At least once a month 04c At least once a week 05 A few times a week, but not every day 1 or 2 times a day 3 to 5 times a day 6 to 10 times a day 11 or more times a day Smoked an e-cigarette, but not in the last 12 months Never smoked an e-cigarette in lifetime Don't know what an e-cigarette is	Smoked only once in the last 12 months (a few puffs to a whole e-cigarette) A few times in the last 12 months At least once a month 04c At least once a week 05 A few times a week, but not every day 1 or 2 times a day 3 to 5 times a day 6 to 10 times a day 11 or more times a day Smoked an e-cigarette, but not in the last 12 months Never smoked an e-cigarette in lifetime Don't know what an e-cigarette is
Cigarette smoking status	Smoked a few puffs to a whole cigarette in the last 12 month Smoked more than one cigarette, but not every day 1 or 2 cigarettes a day 3 to 5 cigarettes a day 6 to 10 cigarettes a day 11 to 15 cigarettes a day 16 to 20 cigarettes a day 21 to 29 cigarettes a day 30 or more cigarettes a day Smoked, but not in the last 12 months Never smoked cigarettes in lifetime	Smoked a few puffs to a whole cigarette in the last 12 month Smoked more than one cigarette, but not every day 1 or 2 cigarettes a day 3 to 5 cigarettes a day 6 to 10 cigarettes a day 11 to 15 cigarettes a day 16 to 20 cigarettes a day 21 to 29 cigarettes a day 30 or more cigarettes a day Smoked, but not in the last 12 months Never smoked cigarettes in lifetime

**Appendix Table 2**

Variables and categories used in the univariable and multi-variable analyses.

Elementary School	
Grade	Grade 7 Grade 8
Sex	male female
Age	12 or younger 13 or older
Canada only	Yes No
English only	Yes No
Race	White Other
School performance	90 or more 80–89 70–79 69 or less
Living arrangements	One household More than one
Smoker	no yes
Secondary school	
Grade	9 10 11 12
Sex	Male Female
Age	14 or younger 15 16 17 or older
Canada only	Yes No
English only	Yes No
Race	White Other
School performance	90 or more 80–89 70–79 69 or less
Home	One More than one
Smoker	No Yes

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