



# Frequency of E-cigarette use and cigarette smoking among Canadian students

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## ARTICLE INFO

### Keywords:

Tobacco  
Electronic cigarettes  
Combustible cigarettes  
Adolescents  
Canada  
Frequency of electronic cigarettes use

## ABSTRACT

The emergence of electronic nicotine delivery systems (commonly referred to as e-cigarettes) has created an ongoing public health debate and concerns, especially in regards to adolescents. The present study examined associations between the frequency of e-cigarette use and cigarette smoking among school students. Data on students (grades 7–12) was obtained from the 2016–2017 Canadian Student Tobacco, Alcohol and Drugs Survey (n = 51,661). Multivariable logistic regression analyses were conducted to examine associations between the frequency of e-cigarette use and smoking. Subgroup analyses were performed for male and female students. Among those who reported any cigarette smoking in the past 30 days, 55% reported e-cigarette use at least once in the last 30 days. Additionally, 17% reported e-cigarette use for 21–30 days among those who smoked cigarettes for at least 21 days. Multivariable logistic regression analysis showed e-cigarette use was associated with higher odds of cigarette smoking, especially among more frequent e-cigarette users. Those who used an e-cigarette 21–30 days had higher odds of cigarette smoking (smoked cigarette at least once AOR = 4.83, CI = 3.33–7.01; at least 11 days AOR = 3.73, CI = 2.40–5.80; at least 21 days AOR = 3.39, CI = 2.16–5.34). Findings suggest that those who smoked cigarettes at least once in the past 30 days had a higher frequency of e-cigarette use.

## 1. Introduction

Electronic vapor products, commonly referred to as e-cigarettes, are devices that deliver nicotine, flavorings, and other additives to users through an inhaled aerosol. Though there has been considerable progress in the reduction of smoking prevalence in the past two decades, the emergence of e-cigarettes has created an ongoing public health debate and concerns about negative health outcomes (National Academies of Sciences, Engineering, and Medicine, 2018; U.S. Department of Health and Human Services, 2016). The popularity of e-cigarettes has grown substantially, with e-cigarette use now surpassing cigarette smoking among adolescents in some countries (Canadian Student Tobacco, Alcohol and Drugs Survey, n.d.). For example, since entering the U.S. market around 2007, e-cigarettes have become the most commonly used tobacco product among youth (National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health, 2014). Faced with skyrocketing e-cigarette use in adolescent populations (an increase of 78% between 2017 and 2018) the Food and Drug Administration has threatened to stop e-cigarette sales in the U.S. if this alarming trend among youth continues (Fox,

2019). In 2017, 4.6 million Canadians aged 15 years and older reported ever trying an e-cigarette, with 863,000 reporting past-30-day use (Health Canada, 2018).

There is limited knowledge about the long-term health effects of e-cigarette use, the products used in e-cigarettes may contain fewer chemicals than traditional cigarettes (Goniewicz et al., 2014; Farsalinos and Polosa, 2014; Hajek et al., 2014), although these products are not risk free (England et al., 2015). Thus, some studies have reasoned that e-cigarettes may present a potentially less toxic alternative to traditional cigarette use (Goniewicz et al., 2014; Polosa et al., 2018). From a harm reduction perspective, e-cigarette use could improve population health by aiding in cigarette reduction or cessation (Bullen et al., 2013; Buu et al., 2018; Cahn and Siegel, 2011; Flahault and Etter, 2014). Further, some have argued that if e-cigarettes continue to rise in popularity, there will be little incentive for continued use of cigarettes (Etter, 2013), saving lives that would otherwise be lost to smoking-related illness and disease (Middlekauff, 2015). However, the relationship between e-cigarette use and tobacco remains an ongoing debate with the extant studies reporting mixed findings (National Academies of Sciences, Engineering, and Medicine, 2018; U.S.

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<https://doi.org/10.1016/j.ypmed.2019.105769>

Received 22 February 2019; Received in revised form 24 June 2019; Accepted 12 July 2019

Available online 13 July 2019

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Department of Health and Human Services, 2016; Bullen et al., 2010; Dawkins et al., 2012; Vansickel et al., 2010).

While there is no universal definition of the term, many prior studies have defined e-cigarette use as any use in the last 30 days (Azagba et al., 2017; Dutra and Glantz, 2014; Barrington-Trimis et al., 2016; King et al., 2015). Recent studies questioned the utility of using any last-30-day-use classification given that it does not differentiate between experimental and regular users (Farsalinos et al., 2018; Warner, 2016). Additionally, one study found that most participants who identified as past 30-day users were experimenters and were unlikely to persist in use (Amato et al., 2016). In the current study, we examined the frequency of e-cigarette use among cigarette smokers and non-cigarette smokers. In addition, we examined the association between frequency of e-cigarette use and cigarette smoking.

## 2. Methods

### 2.1. Data

Data were utilized from the 2016–2017 Canadian Student Tobacco, Alcohol and Drugs Survey (CSTADS; formerly the Youth Smoking Survey), a biennial, cross-sectional, school-based survey of a generalizable sample of students intended to track adolescent and youth substance use behavior. The target population consists of Canadians attending private, public, and Catholic schools enrolled in grades 7 to 12 (secondary I through V in Quebec). The survey excluded those living on First Nations reserves, Canada's three northern Territories (i.e., Yukon, Nunavut, and Northwest Territories), and those attending special schools or schools on military bases. CSTADS uses a stratified single-stage cluster design (with the exception of the province of Quebec), with strata based on health-region smoking rate and type of school. For each province, two or three health-region smoking rate strata and two school-level strata are defined. Random selection of schools within each stratum allowed for a generalizable sample for each province. All eligible students within selected schools were administered the survey. Research ethics boards at multiple levels approved the study (e.g., Health Canada, the University of Waterloo, institutions and school boards in each participating province). Consistent with school board requirements, parents provided permission for their child to participate in the study via active parent permission or active information-passive permission protocols. Only students with parental permission were invited to participate on the day the survey was administered. All schools that participated in the 2016–2017 survey, except for schools in Quebec, received a \$100 honorarium. Students were not remunerated and could stop answering the survey at any time. The 2016–2017 CSTADS was implemented in schools between October 2016 and June 2017. The province of New Brunswick declined participation in the 2016–2017 cycle. A total of 52,103 students in grades 7–12 completed the survey, corresponding to 76% of the eligible student population in participating schools.

### 2.2. Measures

#### 2.2.1. Outcome variables

Three dichotomous variables were created to represent levels of cigarette smoking in the 30 days prior to the survey: (i) Any cigarette use in the past 30 days prior to the survey (smoked at least once), (ii) Smoked at least 11 days out of the past 30 days (smoked at least 11 days), (iii) Smoked at least 21 days out of the past 30 days (smoked at least 21 days). We used the last two measures in order to capture more frequent cigarette smoking beyond the commonly used any past 30-day use. These variables were derived from the question on how many of the last 30 days did students smoke one or more cigarettes, with categorical response options: “none”, “1 day”, “2 to 3 days”, “4 to 5 days”, “6 to 10 days”, “11 to 20 days”, “21 to 29 days”, or “30 days (every day)”.

#### 2.2.2. Independent variables

The primary independent variable of interest, e-cigarette use status, was derived from the survey question regarding use in the 30 days prior to the survey. Categorical e-cigarette use variables were derived to represent frequency of use from the question, “On how many of the last 30 days did you use an e-cigarette (vaporizer with e-juice, vape pen, tank, mod)” with possible response options including “none”, “1 day”, “2 to 3 days”, “4 to 5 days”, “6 to 10 days”, “11 to 20 days”, “21 to 29 days”, or “30 days (every day)”. Frequency of e-cigarette use responses were collapsed to “none (no e-cigarette use)”, “2 - 3 days”, “4 - 5 days”, “6 - 10 days”, “11 to 20 days”, and “21 to 30 days”. Included in the multivariable analysis were gender, grade level (7–12), level of urbanization (urban, rural), school-level median household income (measured continuously—the first three digits of the postal code of the respondent's school was used to extract school-level median household income from the 2011 Canadian Census data), exposure to cigarette smoking (using the question, “During the last 30 days, did you ride in a car with someone who was smoking cigarettes?”), and region of residence: East (Newfoundland and Labrador, Prince Edward Island, and Nova Scotia), West (Saskatchewan, Alberta, Manitoba, and British Columbia), Quebec, and Ontario.

#### 2.3. Statistical analysis

A multivariable logistic regression analysis was performed to examine the association between frequency of e-cigarette use and cigarette smoking among adolescents. Adjusted odds ratios (AOR) with the 95% confidence interval (CI) from the multivariable logistic regression are reported. In addition, a separate analysis was performed for males and females, as previous research has found rates of smoking differ significantly between genders. The descriptive and the multivariable logistic regression used the Fay-modified balanced repeated replication approach (Judkins, 1990) in order to account for the complex survey design and producing of population estimates, as well as adjusting for unequal probabilities of selection. All analyses were conducted using Stata 15.0 (Stata Corp, College Station, Texas).

## 3. Results

### 3.1. Cigarette smoking and e-cigarette use patterns

Table 1 reports the cigarette smoking status and e-cigarette use patterns in the 30 days prior to the survey. The analysis included 51,661 students in grades 7 to 12. A majority of the students, 94% (95% CI = 93.1%, 94.5%), reported no cigarette smoking in the past 30 days. Approximately 6.2% (95% CI = 5.5%, 6.9%) of students reported

**Table 1**

Cigarette smoking and e-cigarette use among Canadian Students in grades 7–12 (n = 51,661), 2016/2017.

	% (95% CI)
Cigarette smoking status in the past 30 days	
No smoking	93.8 (93.1, 94.5)
Smoke at least once in the past 30 days	6.2 (5.5, 6.9)
Smoke at least 11 days out of the past 30 days <sup>a</sup>	2.6 (2.2, 3.0)
Smoke at least 21 days out of the past 30 days <sup>b</sup>	2.0 (1.7, 2.4)
Frequency of e-cigarette use in the past 30 days	
No e-cigarette use	89.1 (88.1, 90.0)
1 day	3.6 (3.3, 3.9)
2–3 days	2.7 (2.4, 3.0)
4–5 days	1.2 (1.0, 1.4)
6–10 days	1.0 (0.8, 1.2)
11–20 days	0.8 (0.7, 0.9)
21–30 days	1.6 (1.4, 1.9)

The analysis was population-weighted, and accounted the survey design.

<sup>a</sup> & <sup>b</sup>Both groups are not mutually exclusive.

**Table 2**  
Cigarette smoking by frequency of e-cigarette use.

Cigarette smoking in the past 30 days	E-cigarette use status in the past 30 days, % (95% CI)						
	No use	1 day	2–3 days	4–5 days	6–10 days	11–20 days	21–30 days
Non-smoker	92 (91.1, 92.8)	3.2 (2.9, 3.4)	2.1 (1.8, 2.3)	0.9 (0.7, 1.0)	0.6 (0.5, 0.8)	0.5 (0.4, 0.7)	0.8 (0.6, 1.0)
Smoke at least once	44.7 (39.8, 49.6)	10.8 (9.1, 12.4)	11.9 (9.6, 14.2)	6.9 (5.6, 8.2)	7 (4.5, 9.5) <sup>m</sup>	4.5 (3.6, 5.5)	14.2 (11.6, 16.8)
Smoke at least 11 days	46.9 (41.4, 52.4)	9.7 (7.4, 12)	10.5 (8.2, 12.7)	5.9 (4.5, 7.2)	5.7 (4, 7.4)	4.7 (3.2, 6.2)	16.7 (13, 20.4)
Smoke at least 21 days	48 (41.1, 54.9)	10.2 (7.7, 12.7)	10.5 (7.7, 13.3)	4.9 (3.7, 6.2)	5.4 (3.7, 7)	3.9 (2.3, 5.5) <sup>m</sup>	17.1 (13, 21.3)

<sup>m</sup> Moderate sampling variation.

having smoked a cigarette at least once in the 30 days prior to the survey. For frequency of cigarette use (represented as the number of days in the past month that students smoked cigarettes), 2.6% (95% CI = 2.2%, 3.0%) smoked at least 11 days out of the past 30 days, and 2% (95% CI = 1.7%, 2.4%) smoked at least 21 days out of the past 30 days. For e-cigarette use, 11% reported past 30-day e-cigarette use with most students reporting between 1 and 3 days use out of the past 30 days. Use for 2–3 days in the past 30 days was 2.7%, 4–5 days was 1.2%, and 21–30 days was 1.6%. Overall, 89% (95% CI = 88.1%, 90%) of the students reported no e-cigarette use in the past 30 days.

**3.2. Frequency of e-cigarette use by cigarette smoking status**

The frequency of e-cigarette use by cigarette smoking status is shown in Table 2. Among students who did not smoke cigarettes in the past 30 days, 92% (95% CI = 91.1%, 92.8%) reported no past 30-day e-cigarette use. Also, non-smokers reported using e-cigarettes for 1-day (3.2%), 2–3 days (2.1%), and 4–5 days (0.9%) out of the past 30 days. About 0.8% (95% CI = 0.6%, 1%) of adolescent non-smokers used e-cigarettes for at least 21 days. Out of those who smoked cigarettes at least once in the past 30 days, 44.7% (95% CI = 88.1%, 90%) had no e-cigarette use in the last 30 days prior, 11.9% (95% CI = 9.6%, 14.2%) used e-cigarettes for 2–3 days, and 14.2% (95% CI = 11.6%, 16.8%) used e-cigarettes for 21–30 days. Out of adolescent cigarette smokers who smoked cigarettes at least 11 days of the last 30 days, 10.5% (95% CI = 8.2%, 12.7%) used e-cigarettes for 2–3 days, and 16.7% (95% CI = 13%, 20.4%) used e-cigarettes for 21–30 days. Likewise, out of smokers who smoked cigarettes for at least 21 days, 10.5% (95% CI = 7.7%, 13.3%) used e-cigarettes for 2–3 days, and 17.1% (95% CI = 13%, 21.3%) used e-cigarettes for 21–30 days.

**3.3. Multivariable regression analysis of cigarette smoking and e-cigarette use patterns**

Results from the multivariable logistic regression are reported in Table 3. E-cigarette use was significantly associated with cigarette smoking in the past month. Those who used e-cigarettes more frequently in the past month were more likely to have smoked cigarettes at least once in the past month when compared to those who used e-cigarettes for 1 day (2–3 days AOR = 1.58, CI = 1.16–2.16; 4–5 days AOR = 2.28, CI = 1.55–3.37; 6–10 days AOR = 2.71, CI = 1.81–4.04; 11–20 days AOR = 2.28, CI = 1.58–3.28; 21–30 days AOR = 4.83, CI = 3.33–7.01). Students who did not use e-cigarettes were less likely to have smoked cigarettes at least once when compared to those that used e-cigarettes for 1 day (AOR = 0.24, CI = 0.20–0.29). Similarly, more frequent use of e-cigarettes was positively associated with higher odds of cigarette smoking when higher thresholds for cigarette smoker were used (smoked at least 11 days or 21 days out of the last 30 days prior to the survey). However, some of the results were not statistically significant.

**3.4. Multivariable regression analysis by gender**

Further analysis was conducted separately for males (n = 25,685)

**Table 3**  
Adjusted logistic regression of cigarette use on the frequency of e-cigarette use—odds ratios and confidence intervals in parentheses (n = 51,661).

Frequency of e-cigarette use in the past 30 days	Cigarette smoking in the past 30 days		
	At least once	At least 11 days	At least 21 days
1 day	Ref	Ref	Ref
Non-use	0.24 (0.20, 0.29)	0.37 (0.28, 0.48)	0.37 (0.27, 0.49)
2–3 days	1.58 (1.16, 2.16)	1.31 (0.95, 1.82)	1.22 (0.85, 1.76)
4–5 days	2.28 (1.55, 3.37)	1.62 (1.08, 2.42)	1.22 (0.83, 1.80)
6–10 days	2.71 (1.81, 4.04)	1.58 (0.93, 2.68)	1.34 (0.78, 2.29)
11–20 days	2.28 (1.58, 3.28)	1.99 (1.20, 3.29)	1.49 (0.85, 2.59)
21–30 days	4.83 (3.33, 7.01)	3.73 (2.40, 5.80)	3.39 (2.16, 5.34)

Ref = reference category. Analyses adjusted for gender, grade level, smoking exposure in car, socioeconomic status, living area, and region of residence.

and females (n = 25,976) while controlling for grade level, smoking exposure in vehicle, socioeconomic status, living area, and region of residence; this analysis revealed significant results, especially for females (results are shown in Table 4). Females who used e-cigarettes more frequently in the past month were more likely to have smoked cigarettes at least once in the past month when compared to those who used e-cigarettes for 1 day (2–3 days AOR = 1.66, CI = 1.19, 2.32; 4–5 days AOR = 2.50, CI = 1.65, 3.79; 6–10 days AOR = 2.68, CI = 1.69, 4.22; 11–20 days AOR = 2.31, CI = 1.42, 3.74; 21–30 days AOR = 4.07, CI = 2.52, 6.56). Females who used e-cigarettes more frequently in the past month were more likely to have smoked cigarettes at least 11 days in the past month when compared to those who used e-cigarettes for 1 day (2–3 days AOR = 1.51, CI = 0.88, 2.59; 4–5 days AOR = 2.53, CI = 1.54, 4.15; 6–10 days AOR = 1.80, CI = 1.03, 3.14; 21–30 days AOR = 5.00, CI = 2.94, 8.53). Females who used e-cigarettes more frequently in the past month were more likely to have smoked cigarettes at least 21 days in the past month when compared to those who used e-cigarettes for 1 day (4–5 days AOR = 2.23, CI = 1.36, 3.67; 6–10 days AOR = 1.96, CI = 1.06, 3.62; 21–30 days AOR = 4.68, CI = 2.71, 8.08). Males who used e-cigarettes more frequently in the past month were more likely to have smoked cigarettes at least once in the past month when compared to those who used e-cigarettes for 1 day (4–5 days AOR = 2.08, CI = 1.19, 3.62; 6–10 days AOR = 2.66, CI = 1.55, 4.56; 11–20 days AOR = 2.24, CI = 1.40, 3.58; 21–30 days AOR = 4.98, CI = 3.15, 7.88). Males who used e-cigarettes for 11–20 days had higher odds of smoking cigarettes for at least 11 days (AOR = 1.97, CI = 1.11, 3.50). Males who used e-cigarettes for 21–30 days had higher odds of smoking cigarettes at least 11 days (AOR = 3.39, CI = 2.00, 5.76) and at least 21 days (AOR = 3.13, CI = 1.81, 5.43).

**Table 4**  
Adjusted logistic regression of cigarette use on the frequency of e-cigarette use by gender — odds ratios and confidence intervals in parentheses.

	Cigarette smoking in the past 30 days					
	Male (n = 25, 685)			Female (n = 25, 976)		
	At least once	At least 11 days	At least 21 days	At least once	At least 11 days	At least 21 days
Frequency of e-cigarette use in the past 30 days						
1 day	Ref	Ref	Ref	Ref	Ref	Ref
Non-use	0.23 (0.18, 0.30)	0.33 (0.24, 0.46)	0.34 (0.24, 0.50)	0.25 (0.20, 0.32)	0.43 (0.29, 0.64)	0.41 (0.26, 0.66)
2–3 days	1.50 (0.99, 2.28)	1.15 (0.75, 1.76)	1.11 (0.66, 1.87)	1.66 (1.19, 2.32)	1.51 (0.88, 2.59)	1.37 (0.73, 2.56)
4–5 days	2.08 (1.19, 3.62)	1.14 (0.66, 1.96)	0.75 (0.42, 1.34)	2.50 (1.65, 3.79)	2.53 (1.54, 4.15)	2.23 (1.36, 3.67)
6–10 days	2.66 (1.55, 4.56)	1.41 (0.65, 3.03)	1.06 (0.50, 2.27)	2.68 (1.69, 4.22)	1.80 (1.03, 3.14)	1.96 (1.06, 3.62)
11–20 days	2.24 (1.40, 3.58)	1.97 (1.11, 3.50)	1.40 (0.73, 2.70)	2.31 (1.42, 3.74)	1.74 (0.75, 4.02)	1.66 (0.64, 4.28)
21–30 days	4.98 (3.15, 7.88)	3.39 (2.00, 5.76)	3.13 (1.81, 5.43)	4.07 (2.52, 6.56)	5.00 (2.94, 8.53)	4.68 (2.71, 8.08)

Ref = reference category. Analyses adjusted for grade level, smoking exposure in car, socioeconomic status, living area, and region of residence.

#### 4. Discussion

Although the long-term impact of e-cigarettes remains unknown, the recent increase in popularity of e-cigarettes, especially among teens, raises public health concerns. National data on adolescent use of e-cigarettes was only available in Canada with the publication of the 2014/2015 CSTADS, and the most recent version of this survey showed that 10% of students had used an e-cigarette in the past-30-days in 2016–2017 (Canadian Student Tobacco, Alcohol and Drugs Survey, n.d.). Prior studies have mainly defined e-cigarette use as any use in the last 30 days, which limits the ability to determine the frequency of e-cigarette use more accurately. The present study fills the gap in the extant literature by examining the frequency of e-cigarette use and its association with cigarette smoking among adolescents.

We found that the frequency of e-cigarette use varies by cigarette smoking status. A higher percentage of students who did not smoke cigarettes in the past 30 days reported no past 30-day e-cigarette use compared to those who smoked cigarettes at least once in the past 30 days. Those who reported smoking cigarettes at least once, smoking cigarettes at least 11 days, and smoking cigarettes at least 21 days had a higher frequency of e-cigarette use compared to those who reported no cigarette use. These findings are consistent with prior studies showing that adolescent e-cigarette use is more prevalent among ever and past-30 day smokers compared to never adolescent smokers in the U.S. (Farsalinos et al., 2018; Warner, 2016).

Multivariable analysis was used to examine the association between the frequency of e-cigarette use and cigarette smoking among cigarette smokers and non-smokers while controlling for gender, grade level, smoking exposure in cars, socioeconomic status, living area, and region of residence. We found that e-cigarette use was significantly associated with cigarette smoking in the past month prior to the survey, especially among those who used e-cigarettes more frequently. Non-e-cigarette users were less likely to smoke cigarettes as compared to e-cigarette users. Further analysis was conducted separately for males and females and produced significant results. We found that e-cigarette use was significantly associated with cigarette smoking in the past month in most levels of e-cigarette use for females. E-cigarette use for 21–30 days was consistently associated with all cigarette use measures for both males and females. It is important to note that some have suggested that vaping is not a precursor for cigarette smoking (Bauld et al., 2017), at least at the population level, based on incompatible population-level trends between e-cigarette use and cigarette smoking (Levy et al., 2018). This argument, however, is countered by pointing to data showing that traditional smoking was on the decline long before the

popularity of e-cigarette use among adolescents was identified (Johnston et al., 2018).

Some limitations of the study are worth noting. First, given the data and the analytical approach, the study does not identify causation. We make no claim about the temporal relationship between e-cigarette use and cigarette smoking. Second, there is the possibility of self-report biases, as the survey relied on self-report of students' e-cigarette use and cigarette smoking. Finally, CSTADS is generalizable to adolescents in grades 7 through 12 attending private, public, and Catholic schools. The survey excluded those living on First Nations reserves, Canada's three northern Territories, and those attending special schools or schools on military bases. Despite the aforementioned limitations, the findings of this study add to the limited literature on the association between frequency of e-cigarette use and cigarette smoking using a large nationally representative dataset.

#### 5. Conclusions

This study, using a large nationally representative dataset from Canada, documents the frequency of e-cigarette use among adolescent cigarette smokers and non-cigarette smokers. Findings suggest that a higher percentage of students who did not smoke cigarettes in the past 30 days reported no past 30-day e-cigarette use compared to those who smoked cigarettes at least once in the past 30 days. Adolescent cigarette smokers had a higher frequency of e-cigarette use.

#### Funding source

There were no sources of funding for this research.

#### Declaration of Competing Interest

The authors have no conflicts of interest to disclose.

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