



# Trends in exposure to and perceptions of e-cigarette marketing among youth in England, Canada and the United States between 2017 and 2019

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Received on 13 January 2021; editorial decision on 1 November 2021; accepted on 11 November 2021

## Abstract

E-Cigarette marketing may influence e-cigarette use among youth. This study examined reported exposure to and perceptions of e-cigarette marketing among youth between 2017 and 2019 across countries with varying e-cigarette marketing restrictions. Cross-sectional online surveys were conducted with 35 490 youth aged 16–19 from England, Canada and the United States in 2017, 2018 and 2019. Weighted logistic regression models examined trends in the adjusted prevalence of self-reported exposure to e-cigarette marketing and the perceived appeal of e-cigarette ads between 2017 and 2019, by country and by smoking/vaping status. Reports of frequent exposure to e-cigarette marketing increased between 2017 and 2019 in all countries, but less so in England, where e-cigarette marketing is more restricted. Perceiving e-cigarette marketing as appealing increased from 2017 to 2019 in Canada and the United States, but not in England. In England, exposure to e-cigarette marketing did not increase in prohibited channels between 2017 and 2019. Between 2017 and 2019, never-users' reports increased for exposure to and appeal of e-cigarette marketing. The results suggest some

effectiveness of e-cigarette marketing bans in England and receptivity to e-cigarette marketing among youth never users.

## Introduction

E-Cigarettes are increasingly popular among young people [1]. For example, e-cigarettes have been the most used tobacco product among US youth since 2014 [2]. Past 30-day (hereafter 'current') e-cigarette use among US high school students increased from 1.5% in 2011 to 27.5% in 2019 [3, 4] but decreased to 19.6% in 2020 [5]. Similarly, current e-cigarette use among high school students in Canada markedly increased from 14.6% in 2016–17 to 29.4% in 2018–19 [6]. In England, current e-cigarette use increased from 8.7% in 2017 to 12.6% in 2019, showing a lesser increase than in the United States and Canada [1].

Increases in e-cigarette use have been associated with e-cigarette marketing. In the United States, e-cigarette advertising expenditures increased from \$12 million in 2011 to \$110 million in 2018 [7, 8]. In observational studies of youth, most of which were conducted in the United States, frequent exposure to e-cigarette marketing has been associated with an increased likelihood of e-cigarette use [9–13] and subsequent e-cigarette experimentation

among non-users [14, 15]. Experimental studies in the United States suggest that e-cigarette marketing increases intentions to use e-cigarettes among youth who do not smoke or vape [16–18], consistent with the well-established link between exposure to cigarette marketing and smoking initiation [19]. The association between vaping and smoking among youth is widely debated. There is a robust association between vaping and smoking at the individual level, in which youth who vape have an increased risk of subsequent smoking in prospective cohort studies [20, 21]. The observed association, however, could be attributable to shared risk factors [22–24]. Smoking prevalence has continued to decline, while e-cigarette prevalence has increased in countries such as the United States [25] and Canada from 2017 to 2019 [1]. The overall use of any tobacco or nicotine product increased in Canada and the United States during this time [1, 26].

Restrictions on e-cigarette marketing vary across countries. England is among the few countries that established a range of provisions regarding marketing restrictions, absent in Canada and the United States, to allow e-cigarette marketing only to help smokers quit [27, 28]. For instance, since 2017, under a code by the Committee of Advertising Practice, England has banned e-cigarette marketing targeting young people such as placing poster near a school and ads that feature young people or include anything that appeals to young people [28]. Furthermore, England restricts e-cigarette marketing on media having cross-border effects, such as TV and radio, print and online, as imposed by the 2014 Tobacco Products Directive [29]. e-Cigarette marketing remains allowed inside and outside shops, on billboards, posters, public transport, flyers and direct communication to existing consumers via mail, email or SMS [28, 30]. In Canada, e-cigarette marketing was subject to comprehensive restrictions prior to May 2018. New federal regulations in May 2018 permitted e-cigarette marketing through traditional media such as TV, radio and print, and at the point of sale, provided that the products being advertised do not appeal to youth or make health claims [31]. Certain

Canadian provinces implemented more comprehensive restrictions, similar to tobacco products [32]. In the United States, e-cigarette advertising is largely unregulated and can be placed on TV, radio and print media and online, although ads must include a warning about nicotine addiction and should not contain unauthorized claims about reduced risk compared to smoking or appeal to youth [33, 34].

Few studies have evaluated the impact of e-cigarette marketing restrictions on youth exposure to e-cigarette marketing or e-cigarette use. Data from the 2017 International Tobacco Control (ITC) Youth Tobacco and Vaping Survey indicated that reported exposure to e-cigarette marketing among youth was more prevalent in England and the United States than in Canada, where there were more restrictions on e-cigarette marketing at the time of the survey [12]. The same data also showed that, after e-cigarette marketing was permitted in 2018 in Canada, the overall frequent exposure to e-cigarette marketing among youth increased and was more prevalent in provinces with fewer restrictions on marketing in 2019 [32]. In addition, the overall prevalence of current e-cigarette use was higher in provinces with less comprehensive marketing restrictions [24]. As countries seek to regulate e-cigarettes in a way that maximizes public health benefits, it is important to evaluate England's policy that allows marketing of e-cigarettes only to encourage addicted smokers to quit. This study evaluated the impact of federal e-cigarette marketing policies by comparing trends in reported exposure to e-cigarette marketing among youth in England, Canada and the United States between 2017 and 2019, including channels of exposure and perceptions of ad appeal.

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## Methods

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### Data sources

Data came from the ITC Youth Tobacco and Vaping Survey, repeat cross-sectional surveys conducted online in 2017 (July/August), 2018 (August/

September) and 2019 (August/September). Samples were recruited through the Nielsen Consumer Insights Global Panel, using non-probability sampling. The analytic sample included 35 490 youth aged 16–19 from England ( $n = 11\,362$ ), Canada ( $n = 12\,018$ ) and the United States ( $n = 12\,110$ ). The analysis excluded respondents who later rescinded their consent to participate, provided incomplete data on key measures used to construct sampling weights, or provided an incorrect response to a data quality check question [35–37]. The survey methods are described in detail elsewhere [35–37]. The study protocol received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#21847) and the King's College London Psychiatry, Nursing & Midwifery Research Ethics Subcommittee.

## Measures

### *Self-reported frequent exposure to e-cigarette marketing in the last 30 days*

The overall exposure to e-cigarette marketing was assessed via self-report by asking: 'In the last 30 days, how often have you noticed things that promote e-cigarettes/vaping?' ('never', 'rarely', 'sometimes', 'often', 'very often', 'don't know' and 'refused'). Those who responded 'often' or 'very often' were classified as being frequently exposed to e-cigarette marketing. All other respondents, including 'don't know', were classified as not being frequently exposed. Those who refused to respond were excluded from all analyses using this measure. This approach was used for all subsequent measures.

### *Channels of e-cigarette ad exposure in the last 30 days*

Respondents who reported noticing e-cigarette marketing at least 'rarely' (i.e. excluding those who responded 'never', 'don't know' or 'refused') were asked whether they noticed e-cigarettes/vaping devices or e-liquid being advertised in the last 30 days through 15 different channels, including regular postal mail, websites/social media (e.g. Facebook, Twitter, YouTube, Instagram and

Snapchat), and email or text messages (see the full list in Table II). Those who responded 'yes' were classified as noticing e-cigarette ads through that channel, while those who responded 'no' or 'don't know' were classified as not noticing e-cigarette ads in that location.

### *Appeal of e-cigarette ads*

The overall appeal of e-cigarette ads was assessed by asking respondents who reported noticing e-cigarette ads at least 'rarely' to finish the statement: 'Thinking about the ads you've seen for e-cigarettes, do you think they make e-cigarettes/vaping seem...': 'very unappealing', 'unappealing', 'neither appealing nor unappealing', 'appealing' or 'very appealing'. Those who responded 'appealing' or 'very appealing' were classified as perceiving e-cigarette ads as appealing and all other responses, including 'don't know', were classified as not finding ads appealing.

### *Smoking or vaping status*

Questions on ever and current smoking and vaping behaviors were used to determine use status: exclusive vapers (vaped but did not smoke in the past 30 days); exclusive smokers (smoked but did not vape in the past 30 days); dual users (smoked and vaped in the past 30 days); former users (ever smoked or vaped, but not in the past 30 days) and never users (never smoked nor vaped).

### *Socio-demographic measures*

Socio-demographic measures were sex (male or female), age group (16–17 and 18–19), race/ethnicity (white only, other/mixed and not stated) and perceived family socio-economic status (not meeting basic expenses, just meeting basic expenses, meeting needs with a little left over, living comfortably and not stated) adapted from a validated measure [38].

## Statistical analysis

In each country, post-stratification sampling weights were constructed to match the demographic profile of youth aged 16–19 in each country

**Table I.** Sample characteristics of the ITC Youth Tobacco and Vaping Survey, 2017–2019, unweighted %

	Wave 1 (2017)			Wave 2 (2018)			Wave 3 (2019)		
	England <i>n</i> = 3995	Canada <i>n</i> = 4038	US <i>n</i> = 4095	England <i>n</i> = 3874	Canada <i>n</i> = 3845	US <i>n</i> = 4034	England <i>n</i> = 3493	Canada <i>n</i> = 4135	US <i>n</i> = 3981
Sex									
Male	42.6	35.0	39.5	36.1	46.5	35.7	35.4	37.4	30.8
Female	57.4	65.0	60.5	63.9	53.5	64.3	64.6	62.6	69.2
Age group									
16–17	40.1	63.3	52.9	30.2	59.8	61.0	43.3	61.7	70.4
18–19	59.9	36.7	47.1	69.8	40.2	39.0	56.7	38.3	29.6
Ethnicity									
White only	78.4	53.8	65.5	74.7	45.0	61.7	75.0	54.3	54.5
Other/mixed	20.6	44.3	33.9	24.1	47.2	38.3	23.5	42.7	45.5
Not stated	1.0	1.9	0.6	1.2	7.9	–	1.5	3.0	–
Perceived family socioeconomic status (SES)									
Not stated				3.9	5.3	4.0	4.6	5.8	4.5
Not meeting basic expenses				2.7	4.1	4.2	4.8	5.6	8.0
Just meeting basic expenses				20.0	22.2	26.6	23.3	25.4	31.6
Meeting needs with a little leftover				35.3	33.7	33.8	34.8	32.4	29.0
Living comfortably				38.2	34.8	31.5	32.6	30.8	26.9
Smoking/vaping status									
Exclusive vapers	3.5	3.9	5.5	3.0	7.3	8.9	6.4	13.5	13.3
Exclusive smokers	11.0	6.0	5.2	11.3	8.0	4.6	9.7	5.6	5.1
Dual users	5.0	3.6	5.7	5.2	7.4	6.5	7.2	8.0	8.6
Former smokers or vapers	28.7	25.7	26.1	28.8	26.8	22.8	26.8	26.7	28.4
Never users	51.7	60.8	57.6	51.7	50.5	57.2	49.9	46.2	44.6

**Table II.** Channels of noticing e-cigarette/vaping devices or e-liquid being advertised in the past 30 days, by country, ITC Youth Tobacco and Vaping Survey, 2017–2019, weighted %

	England			Canada			United States		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
	n = 3736	n = 3728	n = 3313	n = 3737	n = 3549	n = 3887	n = 3821	n = 3817	n = 3764
On websites or social media, like Facebook, Twitter, YouTube, Instagram or Snapchat <sup>b,c</sup>	<b>42.3<sup>a</sup></b>	<b>41.1<sup>a</sup></b>	<b>43.8<sup>a</sup></b>	<b>39.9<sup>a</sup></b>	42.6 <sup>a</sup>	50.0 <sup>a</sup>	40.8 <sup>a</sup>	42.9 <sup>a</sup>	52.3 <sup>a</sup>
On television or radio <sup>b,c,d</sup>	<b>21.1<sup>a</sup></b>	<b>21.4<sup>a</sup></b>	<b>21.4<sup>a</sup></b>	<b>17.3<sup>a</sup></b>	18.0 <sup>a</sup>	27.9 <sup>a</sup>	26.9 <sup>a</sup>	27.3 <sup>a</sup>	43.6 <sup>a</sup>
In print newspapers or magazines <sup>d</sup>	<b>20.0<sup>a</sup></b>	<b>21.3<sup>a</sup></b>	<b>22.1<sup>a</sup></b>	<b>14.6<sup>a</sup></b>	15.9 <sup>a</sup>	19.0 <sup>a</sup>	20.4 <sup>a</sup>	21.2 <sup>a</sup>	23.9 <sup>a</sup>
In e-mail or text messages <sup>b,c</sup>	5.6 <sup>a</sup>	5.5 <sup>a</sup>	5.8 <sup>a</sup>	<b>8.6<sup>a</sup></b>	10.7 <sup>a</sup>	12.5 <sup>a</sup>	8.9 <sup>a</sup>	12.5 <sup>a</sup>	14.1 <sup>a</sup>
In shops/stores that sell cigarettes <sup>b,d</sup>	50.6 <sup>a</sup>	50.7 <sup>a</sup>	53.7 <sup>a</sup>	<b>40.3<sup>a</sup></b>	37.6 <sup>a</sup>	48.2 <sup>a</sup>	49.4 <sup>a</sup>	46.8 <sup>a</sup>	56.6 <sup>a</sup>
Outside shops/stores that sell cigarettes <sup>b,c,d</sup>	47.5 <sup>a</sup>	47.6 <sup>a</sup>	51.0 <sup>a</sup>	<b>35.7<sup>a</sup></b>	35.8 <sup>a</sup>	43.8 <sup>a</sup>	48.1 <sup>a</sup>	46.1 <sup>a</sup>	54.9 <sup>a</sup>
At kiosks or temporary sales locations <sup>b,c</sup>	42.8 <sup>a</sup>	40.1 <sup>a</sup>	42.0 <sup>a</sup>	<b>26.5<sup>a</sup></b>	23.7 <sup>a</sup>	26.8 <sup>a</sup>	26.8 <sup>a</sup>	24.3 <sup>a</sup>	26.2 <sup>a</sup>
On billboards or posters <sup>b,c</sup>	31.1 <sup>a</sup>	31.4 <sup>a</sup>	37.9 <sup>a</sup>	<b>18.4<sup>a</sup></b>	22.5 <sup>a</sup>	31.0 <sup>a</sup>	25.5 <sup>a</sup>	25.3 <sup>a</sup>	33.1 <sup>a</sup>
At events like fairs, markets, festivals, sporting events or music concerts	19.4 <sup>a</sup>	19.9 <sup>a</sup>	21.2 <sup>a</sup>	<b>19.5<sup>a</sup></b>	18.9 <sup>a</sup>	23.2 <sup>a</sup>	20.5 <sup>a</sup>	21.5 <sup>a</sup>	22.2 <sup>a</sup>
Taxis or buses/public transit <sup>b,c,d</sup>	17.6 <sup>a</sup>	18.2 <sup>a</sup>	23.3 <sup>a</sup>	<b>10.1<sup>a</sup></b>	12.9 <sup>a</sup>	18.6 <sup>a</sup>	11.1 <sup>a</sup>	12.5 <sup>a</sup>	13.9 <sup>a</sup>
In bars or pubs <sup>b,c</sup>	14.4 <sup>a</sup>	15.9 <sup>a</sup>	17.6 <sup>a</sup>	<b>11.4<sup>a</sup></b>	13.1 <sup>a</sup>	14.8 <sup>a</sup>	13.0 <sup>a</sup>	13.5 <sup>a</sup>	14.8 <sup>a</sup>
In flyers (CA, US)/leaflets (EN)	13.8 <sup>a</sup>	16.5 <sup>a</sup>	15.8 <sup>a</sup>	<b>10.6<sup>a</sup></b>	13.1 <sup>a</sup>	16.4 <sup>a</sup>	12.2 <sup>a</sup>	14.1 <sup>a</sup>	17.0 <sup>a</sup>
At a pharmacy (CA, US)/chemist (EN) <sup>b</sup>	13.8 <sup>a</sup>	14.2 <sup>a</sup>	14.6 <sup>a</sup>	<b>9.4<sup>a</sup></b>	9.4 <sup>a</sup>	11.9 <sup>a</sup>	12.4 <sup>a</sup>	11.7 <sup>a</sup>	14.1 <sup>a</sup>
In regular postal mail <sup>b,c,d</sup>	3.1 <sup>a</sup>	3.7 <sup>a</sup>	4.3 <sup>a</sup>	<b>3.8<sup>a</sup></b>	4.6 <sup>a</sup>	6.0 <sup>a</sup>	6.5 <sup>a</sup>	7.4 <sup>a</sup>	8.9 <sup>a</sup>
At the movies (CA, US)/cinema (EN) <sup>b,c</sup>	4.9 <sup>a</sup>	4.3 <sup>a</sup>	5.8 <sup>a</sup>	<b>6.7<sup>a</sup></b>	7.7 <sup>a</sup>	10.3 <sup>a</sup>	7.0 <sup>a</sup>	9.2 <sup>a</sup>	10.5 <sup>a</sup>

Bolded estimates denote channels in which e-cigarette marketing was banned within each country at the time of the survey.

<sup>a</sup>Estimates with different superscript letters denote significant ( $P < 0.05$ ) differences in prevalence between years, within country and measure. Estimates with the same letter indicate no significant difference within each country and measure.

<sup>b</sup>Significant difference in prevalence between England and Canada within measure in 2019.

<sup>c</sup>Significant difference in prevalence between England and United States within measure in 2019.

<sup>d</sup>Significant difference in prevalence between Canada and United States within measure in 2019.

CA = Canada, EN = England, US = United States of America.

in each survey year. Weights were calibrated to national estimates of the number of youth ages 16–19 by geographic region, sex, age group (16–17 and 18–19) and race/ethnicity (only in the United States). To facilitate comparison across survey years, weights for survey years 2018 and 2019 were calibrated to 2017 estimates for student status (student versus non-student), academic grades (not stated or <70%, 70–79%, 80–89% or 90–100%), as well as to national estimates of the trend in past 30-day smoking where available (National Youth Tobacco Surveys in the US and Canadian Student Tobacco, Alcohol and Drugs Survey in Canada).

Weighted multivariable logistic regression was used to estimate the average marginal probabilities of youth reporting frequent exposure to e-cigarette marketing, channels of ad exposure and perceived appeal of e-cigarette ads by survey year, first by country and then by smoking or vaping status. For models on channels of exposure and perceptions of appeal, analyses were restricted to those who reported noticing e-cigarette ads at least ‘rarely’. Models adjusted for sex, age group (16–17 and 18–19), country (in models pooled across countries), and smoking or vaping status (in models pooled across smoking or vaping status groups).

For each outcome, we tested differences in the adjusted prevalence between years (2017 versus 2018, 2017 versus 2019 and 2018 versus 2019) within each country and in the adjusted prevalence between countries in 2019 (England versus Canada, England versus the United States and Canada versus the United States). For the outcomes of frequently noticing marketing and perceived appeal, we tested differences in the trends between countries in 2017 versus 2019 (England versus Canada, England versus the United States and Canada versus the United States). We also examined differences in the trends by smoking or vaping status (2017 versus 2019) after testing the overall three-way interaction between country, smoking or vaping status, and survey year, as well as differences in the adjusted prevalence between smoking or vaping groups in 2019 after testing the two-way interactions between country and smoking or vaping status. To account for multiple

comparisons, all *P*-values were corrected for multiple testing using the Benjamini–Hochberg false discovery rate adjustment [39]. Statistical analyses were conducted using SAS-callable SUDAAN (Version 11.0.3) for regression models and SAS (Version 9.4) to account for multiple testing.

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## Results

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### Sample characteristics

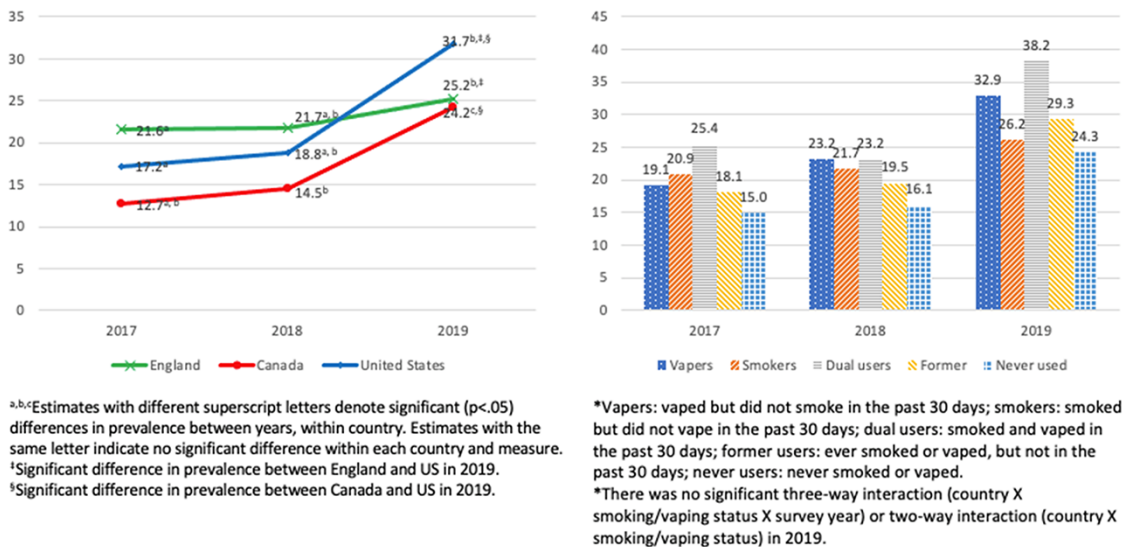
Table 1 shows sample characteristics. Approximately half of youth in England were never users in each survey year. As previously reported, 61% of Canadian and 58% of US respondents were never users in 2017, which decreased to 46% and 45%, respectively, by 2019 [1].

### Prevalence of self-reported frequent exposure to e-cigarette marketing

Figure 1 shows that prevalence of youth reporting frequent exposure to e-cigarette marketing increased significantly between 2017 and 2019 within each country, with a smaller increase observed in England than in Canada [−7.9%, 95% confidence interval (CI) = −10.7–−5.2, *P* < 0.001] and in the United States (−10.9%; 95% CI = −14.0–−7.9, *P* < 0.001). In 2019, 31.7% of youth in the United States reported frequent exposure to e-cigarette marketing. Compared to the United States, self-reported frequent exposure to e-cigarette marketing was less prevalent among youth in England (25.2%; Adjusted Odds Ratio (AOR) = 0.72, 95% CI = 0.64–0.82, *P* < 0.001) and Canada (24.2%; AOR = 0.69, 95% CI = 0.61–0.77, *P* < 0.001).

Reported frequent exposure to e-cigarette marketing increased significantly between 2017 and 2019 among exclusive vapers (13.6% increase, 95% CI = 8.9–18.3, *P* < 0.001), dual users (13.3% increase, 95% CI = 8.0–18.6, *P* < 0.001) and never users (8.2% increase, 95% CI = 6.6–9.9, *P* < 0.001), with no significant three-way interaction between country, smoking or vaping status, and wave ( $\chi^2 = 15.46$ , *df* = 16, *P* = 0.491). In 2019, frequent exposure to e-cigarette marketing





**Fig. 1.** Noticed e-cigarette marketing ('often/very often') in the past 30 days, by country and smoking or vaping status, %.

was more prevalent among dual users and exclusive vapers than never users (AOR = 1.99, 95% CI = 1.67–2.36; AOR = 1.48, 95% CI = 1.26–1.73), with no significant interaction effect between vaping status and country ( $\chi^2 = 7.90$ ,  $df = 8$ ,  $P = 0.443$ ).

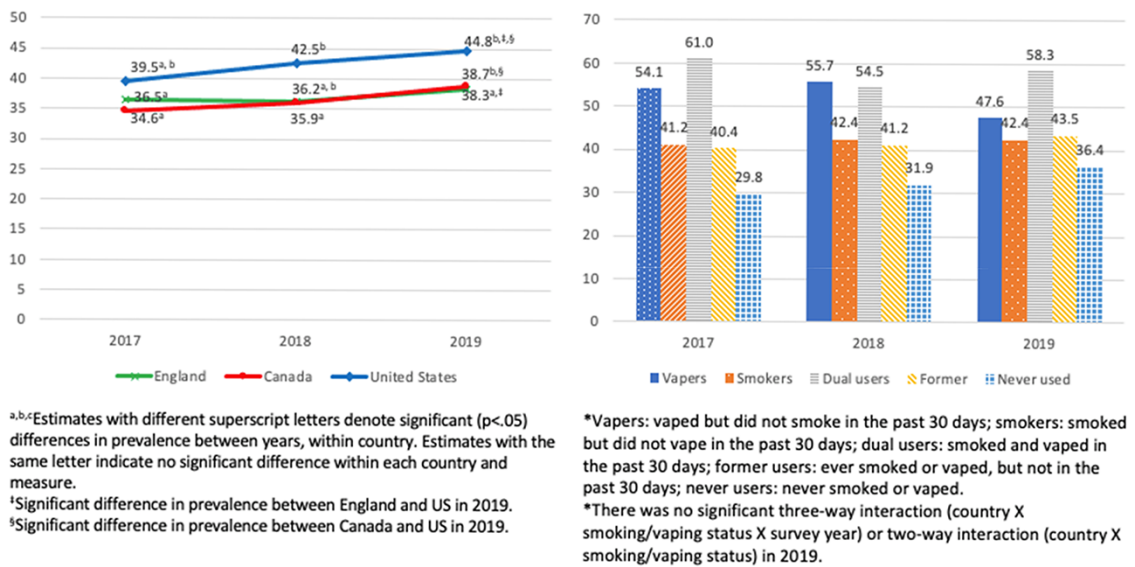
### Exposure to e-cigarette marketing by channels

Table II shows the prevalence of youth noticing e-cigarette marketing in each channel within each country by survey year, including prohibited channels for e-cigarette marketing in England between 2017 and 2019 (websites or social media, TV or radio, and newspapers or magazines). In the three specific channels that were prohibited in England, self-reported exposure did not increase between 2017 and 2019. In contrast, self-reported marketing exposure increased in 7 of 12 channels that were not prohibited in England, where reported exposure to marketing on billboards increased the most between 2017 and 2019 (6.8% increase, 95% CI = 4.4–9.2,  $P < 0.001$ ), followed by taxis and public transportation (5.6% increase, 95% CI = 3.7–7.8,  $P < 0.001$ ). In Canada, the prevalence of noticing marketing increased

significantly between 2017 and 2019 in 14 of 15 channels. The increase was greatest for billboards (12.7% increase, 95% CI = 10.6–14.8,  $P < 0.001$ ), followed by TV or radio (10.5% increase, 95% CI = 8.5–12.6,  $P < 0.001$ ) and websites or social media (10.1% increase, 95% CI = 7.64–12.6,  $P < 0.001$ ). The prevalence of noticing marketing increased in 11 of 15 channels in the United States, with the greatest increase reported for TV or radio (16.7% increase, 95% CI = 14.0–19.3,  $P < 0.001$ ), followed by websites or social media (11.4% increase, 95% CI = 8.7–14.1,  $P < 0.001$ ) and billboards (7.6% increase, 95% CI = 5.1–10.1,  $P < 0.001$ ). For cross-country comparisons limited to 2019, reported exposures to e-cigarette marketing on websites or social media and on TV or radio were more prevalent in Canada and the United States than in England, but there was no significant difference in reported exposure to e-cigarette marketing in newspapers or magazines.

### Perceived appeal of e-cigarette marketing

The prevalence of youth reporting that e-cigarette ads made e-cigarettes or vaping seem 'appealing' or 'very appealing' increased significantly between 2017 and 2019 within Canada and the



**Fig. 2.** E-Cigarette ads make vaping seem ‘appealing/very appealing,’ by country and smoking or vaping status, %.

United States, but not England (Fig. 2). In 2019, compared to the United States, the prevalence of reporting perceived appeal of e-cigarette marketing was lower in England (AOR = 0.76, 95% CI = 0.67–0.86) and Canada (AOR = 0.78, 95% CI = 0.69–0.88).

Between 2017 and 2019, the prevalence of reporting perceived appeal increased only among never users (6.5% increase, 95% CI = 4.3–8.6,  $P < 0.001$ ), and there was no significant three-way interaction among country, smoking or vaping status, and wave ( $\chi^2 = 23.84$ ,  $df = 16$ ,  $P = 0.093$ ). In 2019, compared to never users, dual users and exclusive vapers were more likely to report that e-cigarette marketing made e-cigarettes or vaping seem appealing (AOR = 2.47, 95% CI = 2.06–2.97; AOR = 1.58, 95% CI = 1.36–1.85, respectively), with no significant interaction effect between country and smoking or vaping status ( $\chi^2 = 4.05$ ,  $df = 8$ ,  $P = 0.853$ ).

## Discussion

The prevalence of reporting frequent exposure to e-cigarette marketing increased significantly from

2017 to 2019 among 16- to 19-year-old youth in England, Canada and the United States. The increase in self-reported frequent ad exposure in Canada and the United States was particularly apparent and coincided with increases in youth vaping over this time [1]. The less dramatic increase in reported exposure to e-cigarette marketing in England suggests that restrictions on e-cigarette marketing may have limited reported exposure to e-cigarette marketing among youth. In 2017, Canada had the lowest level of frequent exposure among youth, but Canada and England had similar levels of the overall reported exposure by 2019. The overall increase in Canada obscures different trends across Canadian provinces, several of whom had more restrictions than England in 2019. As previously reported, the strength of restrictions across Canadian provinces was significantly associated with changes in reported exposure over this period, adding further support to the impact of regulatory restrictions on reported exposure among youth [32].

Marketing bans on traditional media and online channels appear to have prevented increases in youth exposure to e-cigarette marketing in the



banned channels in England. In England, the prevalence of reported exposure to e-cigarette ads did not increase from 2017 to 2019 in any banned channel: websites/social media, TV/radio or newspapers/magazines. By contrast, the prevalence of reported ad exposure increased significantly in 11 of 15 channels in the United States and 14 of 15 channels in Canada, where federal restrictions on e-cigarette marketing were relaxed in 2018 with no channel-specific bans on e-cigarette advertising [32].

Some evidence was found for a market adjustment around marketing bans in England, which may explain the increase in reported frequent exposure to marketing in England despite channel-specific bans. Self-reported exposure to marketing increased in 7 of 12 unrestricted channels in England, including in shops that sell tobacco. Given that the tobacco industry has historically shifted its marketing efforts to permitted channels, such as at point-of-sale [40], e-cigarette marketing expenditures may have been increased across these channels. Indeed, stores that sell cigarettes and online were the two most common sources of self-reported exposure to marketing among young people across countries and survey years, as reported previously [11, 13]. Moreover, reported exposure to e-cigarette advertising in retail stores continued to increase from 2017 to 2019, adding to prior research finding on increased reported exposure to e-cigarette advertising in retail stores from 2014 to 2016 among youth in the United States [13].

In Canada and the United States, the prevalence of youth who perceived that e-cigarette ads made vaping seem appealing increased between 2017 and 2019 (34.6% to 38.3% and 39.5% to 44.8%, respectively). There was no corresponding increase observed in England, indicating some effectiveness of the advertising content regulations that ban featuring young people or anything that appeals to young people [28]. It is possible that these regulations have prevented youth in England from noticing some marketing, resulting in a smaller increase in the overall marketing exposure among youth in England, compared to the United States

or Canada. However, while perceived appeal of e-cigarettes was greater among youth who vaped and smoked than never users, as would be expected, e-cigarette marketing also had broad appeal among never users. By 2019, for example, more than one-third of never users reported e-cigarette marketing as appealing. This suggests that the content of e-cigarette advertising and promotions reaches and appeals to non-users. Indeed, never smokers or vapers were the only group in which the appeal of e-cigarette ads increased over time. Further research on the content and design features of e-cigarette marketing that appeal to youth could inform guidelines on e-cigarette ads and pre-market authorization of e-cigarette ads to minimize their appeal among youth and to ensure these messages are adequately targeted to adult smokers [41].

This study has some limitations. First, a post-only evaluation design was used to assess the impact of marketing restrictions in England. Future studies could compare data collected before and after the implementation of policies to better understand the impact of marketing restrictions. Second, the use of a non-probability sample limits the generalizability of the study results. However, post-stratification sampling weights were used to make the samples more representative of youth in each country, and estimates of the prevalence of e-cigarette use are consistent with other national representative data [4, 42]. Moreover, the consistency of the methodology over the three waves ensures that the trends captured in this study should be accurate and enabled us to assess the impact of marketing bans in England by comparing trends between countries. Third, recall bias may have influenced reports of marketing exposure. For example, reported exposure to e-cigarette marketing may be underestimated because youth may not consciously recognize strategies of e-cigarette marketing, including engagement with online e-cigarette marketing [43]. Yet, previous studies have supported the concurrent validity of self-reported measures of marketing exposure with direct measures of marketing presence in stores [44] and gross rating points, which are often used to measure marketing reach and frequency

of exposure [45]. Last, our repeat cross-sectional study design limits our ability to make any causal inference, including the influence of marketing exposure on e-cigarette use. For instance, youth interested in vaping or smoking could be more likely to engage with and recall e-cigarette ads. The design also does not allow us to evaluate recursive relationships between the study variables, such as that which may occur between advertising exposure and appeal. Furthermore, this study cannot address the net public health impact of marketing or marketing bans. Future studies should consider changes in the overall patterns of nicotine use, including interactions between smoking and vaping behavior among both adults and youth [22, 25].

In conclusion, self-reported frequent exposure to e-cigarette marketing increased among youth in England, Canada and the United States between 2017 and 2019, with a relatively small increase observed in England compared to other countries. Differences in trends for exposure through specific channels and within regulatory environments suggest that e-cigarette marketing restrictions in England limited youth exposure to marketing, but marketing exposure still increased through permitted channels. Moreover, more than one-third of youth in England, Canada and the United States reported perceiving e-cigarettes as appealing in marketing, which increased among never users of cigarettes and e-cigarettes between 2017 and 2019. Future studies should consider the relative impact of e-cigarette marketing among youth compared to young adults and adult smokers.

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### Funding

U.S. National Institutes of Health (P01 CA 200512); Cancer Research UK (C51836 and A30541); Canadian Institutes of Health Research-Public Health Agency of Canada Applied Public Health Research Chair; Canadian Institutes of Health Research (FDN 148-477 to P.D.).

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### Conflict of interest statement

D.H. and J.F.T. have served as a paid expert witness in tobacco and vaping-related litigation on behalf of governments and public health authorities. All other authors have no conflicts of interest to declare.

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