Nicotine and Tobacco Research, 2025, **00**, 1–10
https://doi.org/10.1093/ntr/ntaf152
Advance access publication date 25 July 2025
Original Investigation

Trends in the Use of Vaping Products and Other Smoking Cessation Methods Among Adults Who Attempt to Stop Smoking: Findings From the International Tobacco Control Four-Country Smoking and Vaping Surveys (2016–2020)

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Abstract

Introduction: E-cigarettes are an increasingly popular method of smoking cessation assistance; however, there is little research on whether this has affected the number of smokers who quit using "any" evidence-based cessation aid. This study examined trends in the use of cessation aids, including e-cigarettes and other evidence-based methods.

Aims and Methods: Data were cross-sectional surveys in 2016, 2018, and 2020 from the International Tobacco Control Four Country Smoking and Vaping Survey conducted in Canada, United States (US), England, and Australia. Respondents were adults (≥18) recruited by commercial panel firms who currently smoked, and/or quit smoking in the past 12 months. Respondents were asked about use of e-cigarettes, nicotine replacement therapies, prescription medications, quitlines, and counseling services during their last quit attempt (LQA). Generalized estimating equation regression models that were analyzed separately by country examined use of cessation assistance among 14 536 observations (Canada = 4880; US = 2917; England = 4846; and Australia = 1898).

Results: E-cigarettes (29.9%) and nicotine replacement therapy (29.8%) were popular methods of cessation assistance at LQA. Using e-cigarettes at LQA increased in Australia (2016 = 11.1%; 2020 = 25.1%; p=.002) and England (2016 = 37.1%; 2018 = 46.7%; p=.002), with no significant change in Canada or the US. Across all countries, there was little change over time in the overall use of evidence-based cessation assistance. Nearly half of respondents used some form of cessation assistance excluding e-cigarettes. Approximately two-thirds used "any" form of evidence-based cessation including e-cigarettes at LQA, which decreased in Canada (2016 = 64.0%, 2020 = 58.9%; p=.010).

Conclusions: While e-cigarettes are a popular cessation aid, use of other evidence-based cessation assistance has remained comparatively stable among adults that tried to quit smoking.

Implications: The findings indicated that e-cigarettes are a popular cessation method among adults trying to quit smoking. Despite differences in e-cigarette use and regulatory environments in the four countries, rates of evidence-based cessation assistance were similar across countries and over time. E-cigarettes can be an effective method for stopping smoking; however, the current study suggests few, if any, changes in the proportion of adults who smoke using any evidence-based form of cessation assistance, despite changes in the use of e-cigarettes as a quit aid.

Introduction

Despite notable reductions in the prevalence of tobacco use worldwide, smoking remains a leading preventable cause of death.[1] Quitting smoking can be a challenge for many individuals; however, cessation aids and behavioral interventions can increase the likelihood of cessation success when used individually or combined.[2,3] Approved methods for smoking cessation in several countries, including the United States (US), Canada (CA), the United Kingdom (UK), and Australia (AU), typically include: nicotine replacement therapies (NRTs; gum, transdermal patch, etc.); prescription medications (varenicline, bupropion, and cytisine); and behavioral interventions (eg, counseling services, clinical interventions, telephone or quitlines, tailored self-help materials, etc.).[2,4-6]

Recent evidence including data from randomized controlled trials, has shown that electronic cigarettes (e-cigarettes) containing nicotine are more likely to help people successfully stop smoking at comparable or potentially higher rates than NRT.[7] Evidence from observational studies highlights that patterns of use and reasons for using e-cigarettes can influence

Received: October 21, 2024. **Revised:** July 14, 2025. **Accepted:** July 24, 2025

cessation efficacy[3]: daily or frequent vaping is associated with increased smoking cessation, whereas less frequent vaping has been shown to have little impact on smoking cessation.[8-10] There are also concerns about the uptake of e-cigarettes among young people and vaping among long-term former smokers who are at little risk of relapsing to smoking.[11,12]

While no e-cigarette product has received approval as a smoking cessation aid across countries to date,[2] vaping is currently acknowledged as a less harmful alternative to smoking, and is recognized to help adults quit smoking by national health authorities in CA, the US, and England (EN).[13-15] Population level data have shown that vaping is an increasingly common method of quitting smoking in many high-income countries.[16-19] E-cigarettes are a particularly popular method of quitting among younger people who smoke; for example, 44% of young adults aged 20–24 in CA used vaping as a method to quit smoking in 2022, compared to 15% of those aged 45 and over.[20] Overall, e-cigarettes have become well-established as a form of cessation assistance among people trying to quit smoking.

The extent to which the popularity of e-cigarettes has influenced smoking cessation rates represents a critically important policy question. The trajectory of population-level smoking cessation rates—the percentage of all people who smoke and who stop smoking in a given period—has differed across countries over the period in which e-cigarettes have emerged as a popular method of cessation assistance. In CA, the percentage of people who smoke, who make a cessation attempt and the prevalence of cessation success has remained relatively unchanged for the past two decades.[21,22] In the US, overall cessation rates have been steadily increasing for the past three decades, with accelerated increases in the past decade, which could reflect the increasing availability of e-cigarette products on the market.[23,24] In EN, the smoking cessation rate increased between 2013 and 2016 (ie, after e-cigarettes became widely available), before declining from 2017 to 2019 to similar levels in the 2012 pre-e-cigarette period.[19,25,26] To our knowledge, there are no data available on population-level cessation rates in AU.

Smoking cessation guidance and policies have generally sought to increase the use of "any" effective smoking cessation assistance—rather than promoting certain forms of assistance over others—to enable individuals to have a choice and maximize their chances of success. In terms of assessing the public health benefit from e-cigarettes as a cessation aid, the greatest public health benefit would be to see an increase in the "net" proportion of those quitting who use any form of effective assistance. Alternatively, it is possible that e-cigarettes serve as a substitute for other effective forms of cessation assistance; in other words, people who smoke and are currently quitting with e-cigarettes may have otherwise quit with NRT or another effective cessation aid, such that the net contribution to cessation rates may be neutral.[3]

There is little research to date on the extent to which "substitution" between e-cigarettes and other cessation assistance has occurred. One study of population-level cessation rates between 2007 and 2022 in EN found that e-cigarettes were positively associated with the success of a quit attempt; however, there was no evidence to suggest changes in the number of quit attempts or overall "population-level" smoking cessation rate.[19] National monitoring surveys in CA indicate that some forms of cessation assistance (ie, NRT) have decreased as the use of e-cigarettes for quitting has increased.[27] In addition, a study of US sales data found that greater e-cigarette advertising and sales were associated with lower use of nicotine gum and patches.[28] Overall, these studies suggest there is preliminary evidence that e-cigarettes may be at least partially acting as a "substitute" for other effective cessation aids.[28]

The current study examined trends in the use of e-cigarettes for attempting to quit smoking in comparison to trends in the use of other forms of evidence-based cessation assistance such as NRT, prescription medication, counseling services, telephone or quitlines, and self-help assistance methods in CA the US, EN, and AU. Our analysis examined population-level trends in use of these methods for attempting to quit smoking in 2016, 2018, and 2020 within each country, including differences by sociodemographic factors.

Materials and Methods

Study Design and Sample

Data were from wave 1 (2016), wave 2 (2018), and wave 3 (2020) of the International Tobacco Control (ITC) Four-Country Smoking and Vaping (4CV) Survey. The ITC-4CV Survey is a cohort study of parallel online surveys conducted in CA, the US, EN, and AU. These countries were selected because of similar historical trends in smoking and tobacco markets, with different tobacco and vaping policies. Adults (≥18 years) representative of people who smoke were recruited by commercial panel firms in each country. Participants were re-contacted at each follow-up wave and those lost to attrition were replenished with newly recruited respondents. Complete methodological details are available in the technical reports.[29] The analytical sample included adults with an attempt to quit smoking in the past 12 months. There were 14 536 observations across 12 155 individuals included in the analysis (CA = 4880; US = 2912; EN = 4846; and AU = 1896).

Measures

A copy of the complete ITC-4CV surveys, including all measures described below, is available at: https://www.itcproject.org/surveys/.

Sociodemographic Variables

Respondents provided demographic information, including country of residence, sex-at-birth, age group (18–24; 25–39; 40–54; 55; and up), ethnicity or race, highest education level, and annual household income. Ethnicity or race was assessed with country-specific measures that were analyzed as a binary variable based on majority vs. minority, drawn from census or benchmark health surveys.

Perceived Addiction to Cigarettes

Respondents were asked if they "consider [themselves] addicted to cigarettes?" (Not at all, Yes—somewhat addicted, Yes—very addicted, Refused, and Don't know).

Attempts to Quit Smoking

Respondents were asked about the timing of their attempt(s) to quit smoking. Different wording was used depending on participant groups characterized as people who had quit smoking (former smoking) and those who currently smoke (current smoking) in the sections below. Respondents who

formerly smoked were asked, "How long ago did you quit smoking" (wave 1), or "How long ago did your current quit attempt start?" (waves 2 and 3). Respondents who currently smoke were asked, "How many times, if any, have you tried to quit in the past 12 months?" (wave 1), or "How many times, if any have you tried to quit since last survey date?" (waves 2 and 3). If respondents had made at least one quit attempt, they were asked, "How long ago did your most recent quit attempt start?" Respondents were asked to provide timing of their last or current quit attempt (less than 1 week ago; 1–2 weeks ago; 3–4 weeks ago; 1–3 months ago; 4–6 months ago; 7–12 months ago; 13–18 months ago; 19–24 months ago; Refused; Don't know; and additional selections were available for adults who formerly smoked only: 2–3 years ago; 3–5 years ago; more than 5 years ago). A measure of all respondents who had attempted to quit smoking in the 12 months prior to the survey date was derived from these measures.

Use of Self-Reported Cessation Assistance During Last Quit Attempt

Respondents were asked about their use of cessation assistance during an attempt to quit smoking. Use of e-cigarettes for quitting smoking was asked separately from use of other quit methods. Respondents who had ever tried vaping and made at least one quit attempt were asked, "Did you use an e-cigarette or vaping device on your last or current quit attempt?" (Yes, No, Refused, and Do not know). For the use of other cessation assistance, respondents who made at least one quit attempt were asked: "Which of the following forms of help did you receive or use as part of your last or current quit attempt?". Respondents could select from the following aids (multiple options were allowed to be selected): (1) NRT; (2) varenicline (Chantix or Champix); (3) bupropion (Zyban or Wellbutrin); (4) cytisine (Cravv) (waves 2 and 3); (5) telephone or quitline; (6) counseling or clinic or program; (7) smoking cessation session(s) offered by your doctor; (8) mobile apps; (9) cessation website; (10) pamphlets or brochures; (11) smokeless tobacco—ie, snus, chew, or dip (US and CA only); (12) heated tobacco product (eg, IQOS) (waves 2 and 3); (13) other type of aid not mentioned above (open-ended); and (14) none of the above.

Among those who selected NRT as part of their most recent quit attempt, the specific form of NRT was assessed. Respondents were asked: "Which of the following nicotine replacement product or products did you use for this last/current quit attempt?". Respondents could select from the following aids (multiple options were allowed to be selected): (1) nicotine patch; (2) nicotine gum; (3) nicotine lozenges; (4) nicotine mouth spray; (5) nicotine inhaler or inhalator (eg, Voke); (6) nicotine sublingual tablets; (7) nicotine dissolvable oral strips; (8) nicotine nasal spray; and (9) other type of aid not mentioned above (open-ended).

Derived Outcome Variables

ITC measures yielded 23 individual methods of cessation assistance, categorized as described below. Table S1 shows a full list of methods and categories.

Categories of Cessation Assistance

Individual types of cessation assistance were grouped into six categories: (1) e-cigarette or vape; (2) nicotine replacement products (NRT); (3) prescription medication; (4) telephone/quitline services; (5) counseling services; and (6) self-help materials (see Table S1). These categories are not mutually exclusive as respondents could report use of more than one form of cessation assistance.

Use of Evidence-Based Cessation Assistance (Excluding E-Cigarettes)

A dichotomous variable was created to characterize the use of any evidence-based cessation assistance at the last quit attempt, excluding e-cigarettes. Evidence-based forms of cessation assistance were based on clinical practice guidelines and evidence reviews.[3,30] This variable captures observations of responding "yes" to any use of: NRT, prescription medication, telephone or quitline services, and counseling services. Responses to other methods including mobile apps, cessation websites, pamphlets or brochures were not included in this group.

Use of "Any" Evidence-Based Cessation Assistance (Including E-Cigarettes)

Another dichotomous variable was created to include the use of "any" evidence-based assistance including e-cigarettes. This variable captured observations of responding "yes" to any use of e-cigarettes or vapes, NRT, prescription medication, telephone or quitline services, and counseling services. Responses to other methods including mobile apps, cessation websites, pamphlets, or brochures were not included in this group.

Analysis

Analyses were pre-registered (https://osf.io/jpnqc). Four main changes were made to the planned analysis to best fit the data in the project: exclusion of 2022 data (because of changes in question wording and routing), predicted marginal standardization method (PREDMARG) was not utilized for generalized estimating equation (GEE) models as this could not be handled through the GENMOD procedure in SAS, findings were independently analyzed by country, and three-way interactions were excluded. Further details are available in the supplemental files.

Repeat cross-sectional analyses were conducted using GEEs to model outcomes separately by country. GEE models were used to account for the correlated nature of responses for participants who contributed data to multiple survey waves. A binary GEE model was fit to examine changes over time in each of the six cessation assistance categories. For example, a GEE model was fit to examine the prevalence of using e-cigarettes as cessation assistance in the last quit attempt (0 = no vs. 1 = yes), while a separate GEE model examined the prevalence of using NRT in the last quit attempt (0 = no NRT use vs. 1 = NRT use), etc. Two additional binary GEE models were estimated to examine use of evidence-based cessation assistance (excluding e-cigarettes) and use of "any" evidence-based cessation assistance (including e-cigarettes). In all cases, models included the variable for survey year and were adjusted for age, sex-at-birth, education, income, ethnicity, perceived addiction to cigarettes, and time-in-sample. Sensitivity analyses included linear regression models which examined changes in the mean number of multiple evidence-based cessation aids and forms of NRT during an attempt to quit smoking, within countries, over time. All analyses were conducted with SAS statistical software, version 9.4 and weighted using cross-sectional sampling weights rescaled to the unweighted sample size of respondents in each country.

Additional detail on the construction of the survey weights is available in the technical report.[29]

Results

Sample Characteristics

Table 1 presents the weighted profile of adults that made an attempt to quit smoking in the past 12 months prior to the survey date ($n = 12\,155$). Across all countries, the population of people who currently or formerly smoked were majority male (53.9%), currently smoke daily (66.6%), and reported feeling "somewhat addicted" (41.0%) or "very addicted" (44.9%) to cigarettes.

Use of Multiple Evidence-Based Smoking Cessation Assistance Products

Tables S8 and S9 show the mean number of quit aids used among adults who used at least one cessation aid. The mean number of quit aids used during an attempt to quit smoking was 1.62 (SD = 0.83) among respondents who used at least one type of cessation aid during an attempt to quit smoking. Linear regression models tested changes in the mean number of quit aids used over time, with no changes in CA and EN. In the US, the mean number of quit aids decreased over time (2018: mean = 1.59 [SD = 0.86], p=.034; 2020: mean = 1.53 [SD = 0.71], p=.014) compared to 2016 (mean = 1.65 [SD = 0.86]). In AU, there was an increase in the mean number of quit aids from 2016 (mean = 1.47 [SD = 0.73]) to 2020 (mean = 1.57 [SD = 0.78]; p=.016). Among those who used at least one form of NRT, respondents reported using a mean = 1.50 (SD = 0.83) forms of NRT at their last quit attempt. In CA, the mean number of NRT products increased over time from 2016 (mean = 1.49 [SD = 0.83]) to 2020 (mean = 1.63 [SD = 0.92], p=.029). No differences in the mean number of NRT products used were observed over time in the US, EN, or AU.

Categories of Cessation Assistance

Figure 1 shows "any" use of cessation assistance categories at last quit attempt, within each country and among adults who tried to quit smoking in the past 12 months. Across all countries, e-cigarettes (29.9%) and NRT (29.8%) were the most reported methods of cessation assistance used at last quit attempt (see Table S2).

Trends in Use of e-Cigarettes During an Attempt to Quit Smoking

As seen in Figure 1, the blue line illustrates the prevalence of reported e-cigarette use during an attempt to quit smoking in the past 12 months within each country, over time. In EN, 37.1% of respondents reported using e-cigarettes during a quit attempt in 2016, which increased to 46.7% in 2018 (OR = 1.40, 95% CI = 1.13% to 1.73%, p = .002), and decreased to 39.9% in 2020 vs. 2018 (OR = 0.76, 95% CI = 0.58% to 0.98%, p = .032; see Figure 1a and Table S10). In CA, 28.4% of respondents reported using e-cigarettes during a quit attempt in 2016, which did not significantly change in 2018 (29.2%, OR = 0.96, 95% CI = 0.78% to 1.17%, p = .662) or 2020 (27.7%; 2020 vs. 2018 OR = 0.90, 95% CI = 0.73% to 1.11%, p = .319; see Figure 1a and Table S11). In the US, 24.8% of respondents reported using e-cigarettes during a quit attempt in 2016, which did not significantly change in 2018 (26.1%; OR = 0.95, 95% CI = 0.72% to 1.25%, p = .703) or 2020 (22.0%, 2020 vs. 2018 OR = 0.84, 95% CI = 0.61% to 1.16%, p = .294; see Figure 1c and Table S12). In AU, 11.1% of respondents reported using e-cigarettes during a quit attempt in 2016, which increased to 21.3% in 2018 (OR = 2.19, 95% CI = 1.35% to 3.56%, p=.002); however, it did not significantly change in 2020 (25.1%; 2020 vs. 2018 OR = 1.05, 95% CI = 0.65% to 1.68%, p=.855; see Figure 1d and Table S13).

Exclusive Use of E-Cigarettes During an Attempt to Quit Smoking

Overall, 29.9% of adults reported using an e-cigarette at their last quit attempt across countries, including 13.2% who reported using only e-cigarettes and no other cessation aid (CA: 9.5%, US: 11.0%, EN: 19.5%, and AU: 7.7%), and 17.1% who reported using e-cigarettes with at least one other method (CA: 18.0%, US: 13.4%, EN: 20.6%, and AU: 8.7%). Models testing for changes over time for exclusive use of e-cigarettes during an attempt to quit smoking are shown in Tables S14–S17. In EN, there was a decrease in the proportion of adults who reported exclusive use of e-cigarettes as a cessation aid from 2018 (24.1%) to 2020 (19.2%, p=.042). There were no changes over time in the exclusive use of e-cigarettes during an attempt to quit smoking in other countries.

Trends in the Use of Other Categories of Cessation Methods

The models that tested for changes over time for other categories of cessation methods used during an attempt to quit smoking are shown in Tables S12–S39. In CA, adults reported an increase in the use of telephone/quitline services (2016 = 2.1%; 2020 = 3.1%, p = .025; see Table S21) while reported use of counseling services decreased over time (2016 = 13.4%; 2020 = 5.9%, p < .001; see Table S25). In EN, there was an increase over time in reported use of prescription medication (2016 = 8.7%; 2020 = 10.3%, p = .012; see Table S22), telephone/quitline services (2016 = 2.6%; 2020 = 4.1%, p = .035; see Table S26), and self-help services (2016 = 17.5%; 2020 = 23.7%, p = .001; see Table S34). In the US, reported use of counseling services decreased from 2016 (11.1%) to 2020 (4.5%; p < .01; see Table S32). In AU, reported use of self-help services increased from 2016 (14.2%) to 2020 (18.4%; p = .008; see Table S37).

Trends in the Use of Evidence-Based Cessation Assistance (Excluding E-Cigarettes)

Figure 2 shows the reported use of evidence-based cessation assistance (excl. e-cigarettes) during last quit attempt among adults who made an attempt to quit smoking in the past 12 months, by country (ie, used at least one of NRT, prescription medication, telephone or quitline services, or counseling services). Across all countries, nearly half of the population of adults who smoke or formerly smoked reported using some form of cessation assistance excluding e-cigarettes (2016 = 45.9%, 2018 = 42.7%, and 2020 = 43.4%—see Table S7). No significant changes over time were observed in the reported use of evidence-based cessation assistance excluding e-cigarettes within each of the four countries (see Tables S38–S41).

Table 1. Population of Adults Who Currently or Formerly Smoked With an Attempt to Quit Smoking in the Past 12 Months in Canada, the United States, England, and Australia From 2016 to 2020[a]

	2016 (*n* = 5 870)	2018 (*n* = 4 739)	2020 (*n* = 3 927)	Total (*n* = 12 155)
Country	% (*n*)	% (*n*)	% (*n*)	% (*n*)
Canada	30.6 (1 800)	31.9 (1 572)	33.6 (1 320)	30.7 (3 731)
United States	20.2 (1 184)	20.8 (987)	18.6 (731)	19.8 (2 399)
England	34.3 (2 013)	33.3 (1 581)	32.0 (1 257)	35.6 (4 333)
Australia	14.9 (873)	13.9 (659)	15.8 (619)	14.0 (1 693)
Age group				
18–24	15.8 (931)	15.3 (726)	14.0 (668)	17.4 (2 119)
25–39	34.1 (2 020)	36.1 (1 711)	34.0 (1 336)	35.2 (4 277)
40–54	26.9 (1 576)	26.4 (1 250)	27.1 (1 063)	26.1 (3 171)
55 and above	22.9 (1 343)	22.2 (1 052)	21.9 (861)	21.3 (2 588)
Sex				
Female	46.0 (2 698)	47.8 (2 265)	45.2 (1 774)	46.1 (5 608)
Male	54.0 (3 172)	52.2 (2 474)	54.8 (2 153)	53.9 (6 547)
Time in sample				
in 1 wave	100.0 (5 870)	53.4 (2 530)	53.8 (2 112)	88.2 (10 719)
in 2 waves	–	46.6 (2 209)	19.9 (781)	9.7 (1 177)
in 3 waves	–	–	26.4 (1 035)	2.1 (259)
Ethnicity				
White (CA, US & EN) or English (AU)	85.6 (5 027)	83.0 (3 932)	80.9 (3 178)	83.2 (10 112)
Non-white (CA, US & EN) or non-English (AU)	13.2 (777)	15.7 (744)	18.2 (717)	15.6 (1 900)
Not stated	1.2 (67)	1.4 (64)	0.8 (33)	1.2 (143)
Education[b]				
Low	30.4 (1 783)	29.4 (1 392)	24.2 (951)	28.5 (3 458)
Moderate	48.6 (2 850)	47.9 (2 269)	52.6 (2 065)	50.2 (6 097)
High	19.9 (1 167)	21.9 (1 038)	22.4 (878)	20.3 (2 466)
Not stated	1.2 (70)	0.8 (40)	0.9 (34)	1.1 (133)
Income[c]				
Low	23.5 (1 382)	23.7 (1 121)	25.2 (990)	23.9 (2 905)
Moderate	28.5 (1 672)	29.3 (1 388)	28.6 (1 124)	28.7 (3 487)
High	41.9 (2 459)	42.1 (1 997)	40.8 (1 602)	41.7 (5 068)
Not stated	6.1 (358)	4.9 (233)	5.4 (213)	5.7 (696)
Perceived addiction to cigarettes				
Not at all	10.7 (630)	13.1 (619)	14.6 (573)	12.5 (1v523)
Yes—somewhat addicted	41.4 (2 432)	39.9 (1 893)	40.6 (1 595)	41.0 (4 981)
Yes—very addicted	46.3 (2 718)	45.4 (2 150)	43.5 (1 708)	44.9 (5 454)
Not stated	1.6 (92)	1.6 (78)	1.3 (52)	1.6 (198)
Frequency of cigarette smoking				
Current daily smoker	69.2 (4 062)	62.6 (2 964)	62.9 (2 471)	66.6 (8 101)
Current weekly smoker	9.8 (576)	9.7 (462)	12.8 (505)	10.9 (1 326)
Current monthly smoker	3.2 (189)	3.7 (174)	4.7 (186)	3.5 (430)
Current less-than-monthly smoker	6.9 (406)	1.9 (91)	2.2 (89)	4.5 (548)
Recent quitter	10.9 (638)	22.2 (1 050)	17.3 (678)	14.4 (1 750)

[a]This table shows sociodemographic characteristics by the number of observations in each wave (*n* = 14 536) and total observations for unique respondents (*n* = 12 155). [b]EN: Low = secondary or vocational 3 or less, Moderate = college or university (no degree), High = completed university or post-graduate; CA or US: Low = completed high school or less, Moderate = community college or trade or technical school or some university (no degree), High = completed university or post-graduate; AU: Low = completed high school or less, Moderate = technical or trade or some university (no degree), High = Completed university or post-graduate [c]EN: Low = less than £15 000, Moderate = £15 001–30 000, High = £30 001 or greater; CA or US or AU: Low = less than $30 000, Moderate = $30 000–59 999, High = $60 000.

Trends in the Use of "Any" Evidence-Based Cessation Assistance (Including E-Cigarettes)

Figure 2 shows the reported use of "any" evidence-based cessation assistance including e-cigarettes, among adults who made an attempt to quit smoking in the past 12 months by country (ie, used at least one of e-cigarettes, NRT, prescription medication, telephone or quitline services, or counseling services). Across all countries, more than half of respondents reported using "any" form of cessation assistance, including e-cigarettes (2016 = 60.0%, 2018 = 60.1%, and 2020 = 59.4%; see Table S7). Despite modest differences in prevalence estimates for the overall use of "any" evidence-based cessation assistance over time, no significant changes were observed within each of the four countries—with the exception of CA, where use of "any" evidence-based cessation assistance decreased from 2016 (64.0%) to 2020 (58.9%; p=.010; see Tables S42–S45).

Factors Associated With Use of Cessation Assistance

Figure 3 illustrates results from GEE models examining factors associated with the use of cessation assistance categories used during an attempt to quit smoking; additional model results for cessation methods by category are available in Figure S1 and Tables S10–S37. Age group was negatively associated with reporting the use of e-cigarettes during an attempt to quit smoking in all countries except EN. In AU, the use of e-cigarettes during an attempt to quit smoking was

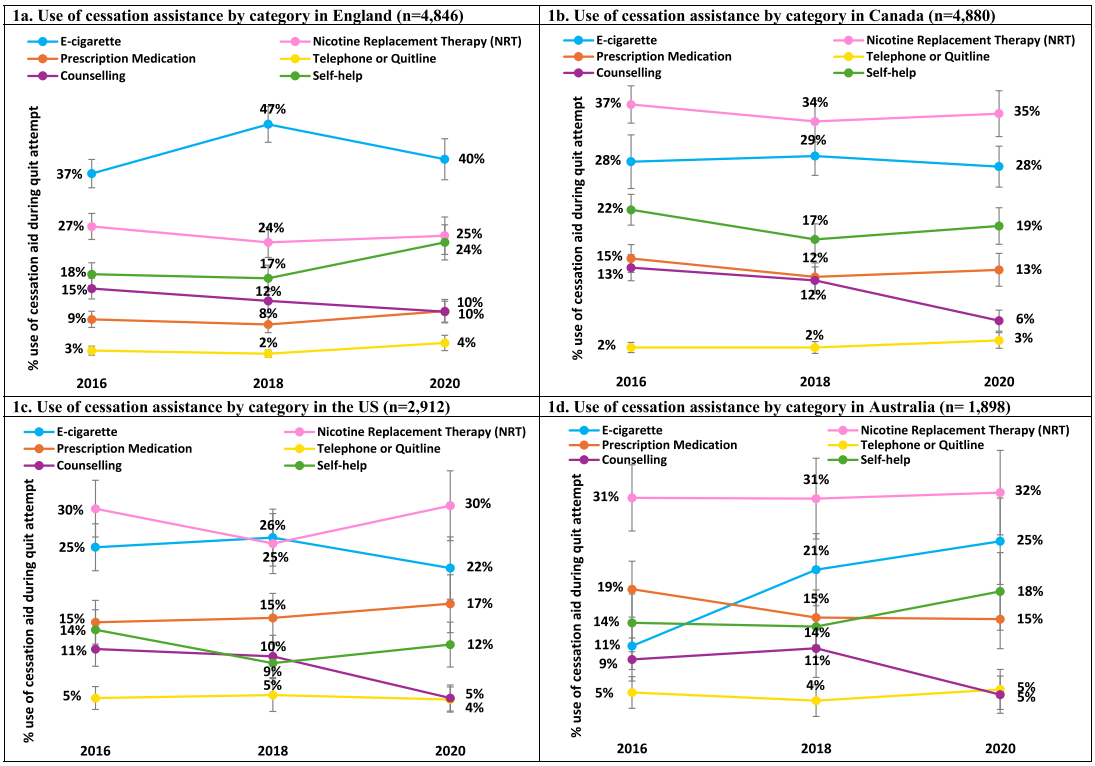

Figure 1. Use of cessation assistance by category, among adults with an attempt to quit smoking in the past 12 months within each country, 2016–2020∗. ∗Categories are not mutually exclusive. A: England, B: Canada, C: the United States, D: Australia.

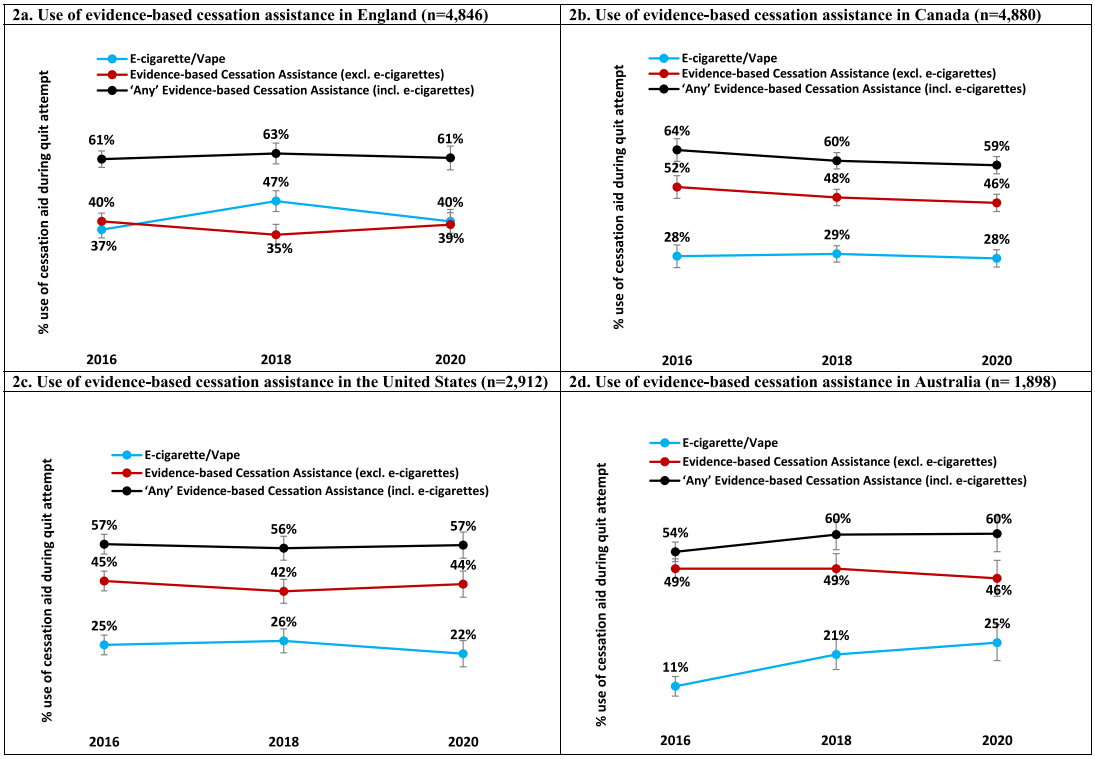

Figure 2. Any use of evidence-based cessation assistance among adults with an attempt to quit smoking in the past 12 months within each country, 2016–2020∗. ∗Categories are not mutually exclusive. A: England, B: Canada, C: the United States, D: Australia.

more likely among the youngest age group 18–24 (22%) compared to the oldest group 55 and up (12%; p=.02; see Table S13). In CA and the US, use of e-cigarettes was more likely among younger age groups during an attempt to quit smoking ($p \leq .005$ for all contrasts; see Tables S11–S12). Conversely, age group was positively associated with

Covariates	E-CIGARETTES				EVIDENCE-BASED CESSATION (EXCL. ECIG)				'ANY' EVIDENCE-BASED CESSATION (INCL. ECIG)			
	EN	CA	US	AU	EN	CA	US	AU	EN	CA	US	AU
Wave	+			+						-		
Age group		-	-	-	+	+	+	+	+			
Sex												
Ethnicity			+			-						
Education	+		+						-		+	
Income			-									
Perceived addiction	+			-	+	+	+	+	+	+	+	+
Time-in-sample	+	+		+	-			-				

Figure 3. Factors associated with use of cessation assistance categories among adults with an attempt to quit smoking in the past 12 months in Canada, the United States, England, and Australia*. *Refer to Supplementary Fig. S1 for additional model results for all categories of cessation methods. Note: (+) indicates positive association between covariate and GEE model outcome ($p < .05$). (−) indicates negative association between covariate and GEE model outcome ($p < .05$).

reporting use of NRT and prescription medication (Figure S1; $p \leq .049$; see Tables S18–S25) such that there was a positive association between age-group and use of cessation assistance (excluding e-cigarettes) across all countries. In EN, age-group was positively associated with the reported use of "any" evidence-based cessation assistance (including e-cigarettes; see Table S42), while no significant age-group associations were observed in other countries. Individuals who reported greater perceived addiction to cigarettes were more likely to report using e-cigarettes during an attempt to quit smoking in EN ($p \leq .01$; see Table S10). Across countries, respondents with greater perceived addiction to cigarettes were also more likely ($p \leq .008$) to report using "any" evidence-based cessation assistance (including e-cigarettes). Respondents present in more than one survey wave were more likely to report using an e-cigarette during an attempt to quit smoking in all countries except the US ($p \leq .03$ for all contrasts; see Tables S10, S11, and S13). No consistent effects were observed for sex-at-birth, education, ethnicity, income, or time in sample across models.

Discussion

The current study is among the first to examine population-level time trends in the use of e-cigarettes and other forms of assistance during attempts to quit smoking across countries. Overall, there were strikingly similar rates of cessation assistance used across all four countries, despite differences in tobacco control policies and rates of e-cigarette use. In 2020, between 57% and 61% of respondents used some form of evidence-based cessation assistance (including e-cigarettes) during an attempt to quit smoking. Comparisons with previous literature are complicated by differences in the way that "effective" or "evidence-based" aids are defined and asked in population-level surveys. For example, a 2014–2016 brief report of US adults who smoke cigarettes, found that 75% of people used multiple cessation methods during a recent quit attempt; however, the methods that are included in these estimates are unclear.[16]

Our study found that e-cigarettes are a popular method of cessation assistance among adults trying to quit smoking in CA, the US, EN, and AU, consistent with prior research.[16-18,31] However, the prevalence of using e-cigarettes for attempting to quit smoking varied between countries: prevalence was higher in countries with more permissive e-cigarette policies (eg, EN) compared to countries with more restrictive policies (eg, AU). Likewise, this study reported prevalence of exclusively using e-cigarettes as a quit aid reflected these patterns as well.

While e-cigarettes are a popular cessation aid overall, use of other evidence-based cessation assistance has remained comparatively stable among adults who attempted to quit smoking. In AU, modest increases were observed in the use of any evidence-based cessation assistance, which paralleled an increase in the use of e-cigarettes as a quit aid; however, in EN, there was an inverse relationship between use of e-cigarettes and evidence-based cessation assistance, while there were little to no changes in the US and CA. A time-series analysis of data from the Smoking Toolkit Study in EN, between 2007 and 2022 found that, while prevalence of using NRT and prescription medication during a quit attempt declined over time, there was only modest evidence that decline in the use of NRT was associated with the increase in use of e-cigarettes as a quit method, which would suggest a "substitution" effect of e-cigarettes for NRT in terms of quit attempts.[19] It is unclear whether these associations in the Toolkit analysis would reach conventional levels of statistical significance if NRT and prescription medications were aggregated, rather than analyzed separately.

Overall, the current study provides somewhat "mixed signals" on the population-level use of e-cigarettes as a cessation aid, some of which are consistent with substitution and some of which are suggestive of complementarity. The pattern of results reflects both the advantages and challenges of examining this issue across multiple countries and time periods. It is possible that the complementarity versus substitution effects of e-cigarettes vary over different contexts and time periods. To the extent that complimentary or substitution has occurred, it does not appear to be sufficiently strong to be consistently detected across the four countries examined in the current study. This is best illustrated in the absence of changes in the use of "any" evidence-based cessation assistance between countries or over time. Future studies and potentially different data sources are needed to address this issue. For example, trends in the retail sales of NRT over the past decade would be informative: a lack of association would suggest complementarity whereas as an inverse association would suggest substitution at the population level. Data over a longer timeframe than the current study would be particularly informative given the rapid rise in e-cigarette prevalence prior to 2016 in countries such as the US, CA, and the UK.

The scope of the current study examined quit methods used at last quit attempt among those who attempted to stop smoking. Though not assessed in this article, it is also possible that e-cigarettes may have increased the number of

quit attempts, which could have led to an increase in overall smoking cessation rates. To our knowledge, the Smoking Toolkit data is one of few studies to have directly examined this question.[19,32] A time-series analysis found there was no clear evidence that the use of e-cigarettes was associated with the percentage of smokers that tried to quit, or the overall quit rate at the population level.[19] National monitoring surveys suggest different trends in overall cessation rates between countries over the period in which e-cigarettes have emerged as a popular quit method, with increases in the overall cessation rate in the US and little or no change in CA.[22,23] Another study explored the association between e-cigarette use and changes in quit rates using 2014–2015 data from the Current Population Survey-Tobacco Use Supplement (CPS-TUS) in the US. This analysis found that increases in cessation rates were associated with higher rates of quit attempts and success among adult smokers who used e-cigarettes.[33] We are unaware of additional studies in CA, the US, or AU that have examined potential substitution of quit methods or associations between e-cigarette use and population-level cessation rates.

Age-related trends in use of cessation methods varied by country. In general, younger participants in CA, the US, and AU—but not the UK—were more likely to use e-cigarettes during an attempt to quit smoking compared to older respondents. These findings are consistent with other studies which show a higher prevalence of e-cigarette use during a quit attempt among younger age groups.[34,35] In addition, qualitative interviews with US young adults aged 18–25 report that young people found e-cigarettes to be a safer alternative to smoking because of positive vaping experiences.[36] Reasons for the lack of an age effect in the UK are somewhat unclear but may reflect a broader integration of e-cigarettes into the smoking cessation advice provided by the National Health Service.[15]

In this study, perceived addiction acts as a proxy measure for dependence among participants trying to quit. Individuals who reported greater addiction to cigarettes were more likely to report using "any" evidence-based cessation assistance (including e-cigarettes) in all countries. Previous literature has found associations between tobacco and/or nicotine dependence and use of cessation aids during an attempt to quit smoking.[37-40] Therefore, it is plausible that individuals with higher levels of dependence are likely to use these methods during an attempt to quit smoking.

Limitations

This study is subject to limitations common to survey research, including self-report and social desirability bias, although the effect of this bias should be relatively consistent over time and are unlikely to influence time trends. The ITC sample was recruited and weighted to be broadly representative of smokers in each country. However, estimates are subject to time-in-sample effects and the use of non-probability sampling in some cases which may account for the lower magnitude of study estimates compared to nationally representative surveys. More information on sample representativeness and recruitment is provided in the ITC technical reports.[29]

Directly testing substitution between quit methods presents challenges given that many adults use more than one method during an attempt to quit smoking.[16,18,41] In the present study, use of multiple cessation aids during an attempt to quit smoking had little evidence of change over time within each country, suggesting that there was not consistent change in the number of aids used during the period when e-cigarettes use changed. Accordingly, the analysis focused on population-level changes in the use of different cessation methods, with descriptive comparisons in changes over time. In addition, there are a range of factors that could affect the use of different cessation methods, such that it is not possible to infer causality between the changes in the use of e-cigarettes versus other methods of quitting. For example, the onset of the COVID-19 pandemic in 2020 may have affected the use of some cessation methods more than others, such as the use of in-person counseling.[42] Policy-related changes could also have affected the use of cessation methods, including changes in funding or delivery of smoking cessation services in each country.

Other limitations include varying intervals between survey waves that are subject to differences in seasonal quitting behaviours;[43,44] smaller sample size in AU which may limit power to detect overall changes in cessation aid use. Future studies should consider using established measures of dependence, where possible. Additional research may also wish to explore quitting history when examining the use of quit methods, given that previous experience with specific cessation aids is likely to influence future quitting decisions.[45,46]

Conclusions

Overall, the emergence of e-cigarettes represents a notable addition to the list of smoking cessation methods available to people who smoke; however, the current study suggests few, if any, changes in the proportion of adults using any evidence-based form of cessation assistance in attempts to quit smoking, despite changes in the use of e-cigarettes as a quit aid at the population level. Understanding the impacts of e-cigarettes on cessation rates will require future studies to examine effectiveness of these products in relation to increased quit attempts and success in different countries, as seen in England's Smoking Toolkit Study. The results in this study are similar to recent data from EN which found no clear evidence that e-cigarettes were associated with the overall quit rate.[19] Further research is needed to examine changes in the use of population smoking cessation methods and to more closely examine possible substitution effects with other quit aids.

Author Contributions

Kimberly D'Mello (Conceptualization [equal], Formal analysis [lead], Methodology [equal], Visualization, Writing—original draft [lead], Writing—review & editing [equal]), Pete Driezen (Methodology, Writing—review & editing [equal]), Katherine East (Methodology [equal], Supervision [supporting], Writing—review & editing [equal]), Geoffrey T. Fong (Data curation [equal], Funding acquisition [lead], Investigation, Methodology [equal], Supervision [supporting], Writing—review & editing [equal]), and David Hammond (Conceptualization, Data curation [equal], Funding acquisition [lead], Methodology [equal], Supervision [lead], Writing—review & editing [equal])

Supplementary Material

Supplementary material is available at *Nicotine and Tobacco Research* online.

Funding

The 2016–2020 ITC Four Country Smoking and Vaping Surveys were supported by grants from the US National Cancer Institute (P01 CA200512), the Canadian Institutes of Health Research (FDN-148477), and the National Health and Medical Research Council of Australia (APP1106451). KD was supported by the Canadian Institutes of Health Research (CIHR) 2022 Canada Graduate Scholarships—Master's program. KE is the recipient of Fellowship funding from the UK Society for the Study of Addiction (SSA), and also received salary support from Research England and the US National Cancer Institute (P01 CA200512). GTF receives additional support from a Senior Investigator Grant from the Ontario Institute for Cancer Research.

Declaration of Interests

DH has served as a paid expert witness on behalf of governments and public health authorities in response to legal challenges from tobacco, vaping, and cannabis companies. GTF has served as an expert witness or as a consultant on behalf of governments defending their country's policies or regulations in litigation. All other authors have no conflicts of interest to declare.

Acknowledgments

The authors would like to acknowledge and thank all those who contributed to the International Tobacco Control Four-Country Smoking and Vaping Survey (ITC 4CV) Survey: all study investigators and collaborators, and the project staff at their respective institutions.

Data Availability

In each country, participating in the International Tobacco Control Policy Evaluation (ITC) Project, the data are jointly owned by the lead researcher(s) in that country and the ITC Project at the University of Waterloo. Data from the ITC Project are available to approved researchers 2 years after the date of issuance of cleaned data sets by the ITC Data Management Centre. Researchers interested in using ITC data are required to apply for approval by submitting an International Tobacco Control Data Repository (ITCDR) request application and subsequently to sign an ITCDR Data Usage Agreement. The criteria for data usage approval and the contents of the Data Usage Agreement are described online (http://www.itcproject.org).

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https://doi.org/10.1093/ntr/ntaf152
Original Investigation