

Effect of vaping on past-year smoking cessation success of Australians in 2019—evidence from a national survey

Mark S. Chambers 

National Drug and Alcohol Research Centre,
University of New South Wales, Sydney,
NSW, Australia

Correspondence

Mark S. Chambers, National Drug and Alcohol
Research Centre, University of New South
Wales, Sydney, NSW, Australia.
Email: mark.stanley.chambers@gmail.com.

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Abstract

Background and aims: Previous analyses of the effect of e-cigarettes on real world smoking cessation success have mainly been based on surveys undertaken in the United States and United Kingdom, where nicotine e-cigarettes can be readily obtained. In Australia, regulations have made obtaining e-cigarettes containing nicotine difficult. The effectiveness of e-cigarette use as a smoking cessation aid in Australia might therefore be lower than survey-based estimates published to date. This study aimed to estimate the effect of using e-cigarettes for a smoking cessation attempt on past-year smoking cessation success in Australia.

Design: Multivariable logistic regression models for past-year smoking cessation success.

Setting and participants: Respondents to the 2019 wave of Australia's National Drug Strategy Household Survey who made a smoking cessation attempt in the 12 months leading up to the survey.

Measurements: Past-year smoking cessation success was assumed if a smoking cessation attempt resulted in abstinence of more than a month at the time of the survey.

Findings: In 2019, Australians who attempted to quit smoking using e-cigarettes achieved greater success than smokers attempting to quit without e-cigarettes [adjusted odds ratio (aOR) = 1.68; 95% confidence interval (CI) = 1.09–2.60]. If people who only tried e-cigarettes once or twice are considered not to have used e-cigarettes, the estimated effect was slightly stronger (aOR = 1.98; 95% CI = 1.27–3.10). Also, the estimated odds ratio was higher among vapers who acquired their e-cigarettes from overseas websites (aOR = 2.24; 95% CI = 1.02–4.93).

Conclusions: Use of e-cigarettes for a smoking cessation attempt appears to be associated with greater success among Australians who attempted to quit tobacco in 2019 compared with Australians attempting to quit without e-cigarettes, after adjusting for confounding effects.

KEYWORDS

E-cigarettes, nicotine, population surveys, regulatory environment, smoking cessation, tobacco

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INTRODUCTION

Despite marked declines in the prevalence of smoking in Australia, disease associated with the smoking of tobacco contributed to 13% of deaths in Australia in 2015 and its burden on public health, in quality-of-life years lost, continues to exceed that of any other lifestyle risk factor [1].

The latest Cochrane Review of the efficacy of e-cigarettes as a smoking cessation aid suggests that there is, at present, moderate evidence that use of nicotine e-cigarettes increases quit rates compared with the use of nicotine replacement therapy (NRT) and nicotine-free e-cigarettes with estimated risk ratios of 1.53 and 1.94, respectively [2]. Evidence of greater real-world smoking cessation success among people using e-cigarettes compared to those who used NRT or attempted to quit unaided has been presented in analyses of population survey data [3,4], although some have found daily use of e-cigarettes was associated with increased smoking cessation success, while less frequent use was not [5–7]. Other researchers have reported significant associations between cross-sectional estimates of smoking cessation success from repeated surveys and concomitant rates of daily e-cigarette use [8,9]. However, most studies of real-world effectiveness of e-cigarettes have been based on analyses of population surveys from the United States and United Kingdom, countries with liberal regulations regarding the sale and use of nicotine e-cigarettes.

In a 2019 study, Gravelly et al. [10] classified the regulations of 14 countries into four categories; most restrictive, restrictive, less restrictive and no restrictions. Australia's regulations were categorized as most restrictive, characterized by 'strongly enforced' regulations prohibiting the sale and marketing of nicotine e-cigarettes, with nicotine e-cigarettes 'not widely available for sale'. By contrast, the same study categorized the United States and United Kingdom as less restrictive, characterized by an environment where the sale and marketing of nicotine e-cigarettes are legal with some regulations and are widely available. Until recently, Australians wishing to obtain nicotine e-cigarettes have mainly been required to purchase them from overseas websites and import them by mail through the Personal Importation Scheme, although there was technical provision for compounding pharmacies to prepare refill solutions containing nicotine for some patients with prescriptions [11]. Since the introduction of new regulations on 1 October 2021 nicotine e-cigarettes can only be acquired with a prescription from a medical practitioner, but Australians with a prescription can now obtain nicotine e-cigarettes from pharmacies. Australia's Therapeutic Goods Administration is scheduled to review the current regulations in the second half of 2022 [12].

Previous researchers have suggested that estimates of the effect of e-cigarettes on smoking cessation from countries such as the United States and the United Kingdom, where nicotine e-cigarettes can be easily obtained, may not be generalizable to Australia because of differences in regulations [13,14]. Yong and colleagues [13] found that in Australia and Canada, countries that had restrictive e-cigarette policies at the time, people using e-cigarettes had 64% lower odds of 30-day abstinence than people from the same countries who

attempted to quit without a cessation aid. However, only 41% of Australian e-cigarette users surveyed in that study were confident their vaping products contained nicotine. By contrast, 91% of Australian current vapers surveyed for the International Tobacco Control Four-Country Smoking and Vaping Survey in 2016 used vaping products containing nicotine [15].

Chan et al. [14] estimated that among past-year smokers in 2016, Australians who used e-cigarettes daily were more than six times as likely to have recently quit smoking as those who had never used e-cigarettes, after adjusting for demographic factors. Chan et al. describe their findings, based on logistic regression analyses of the 2016 wave of the National Drug Strategy Household Survey (NDSHS), as correlates of e-cigarette use, not implying that the effect was causal. The results reported by Chan et al., while noteworthy, cannot be interpreted as evidence of effectiveness of e-cigarettes as a smoking cessation aid for at least two reasons. First, the past-year smokers fitted to their logistic regression models included those who did not attempt to quit. Therefore, the association between e-cigarette use and quit success may reflect a higher quit attempt rate among e-cigarette users compared with non-users, rather than the effectiveness of the devices for smoking cessation. Secondly, the daily e-cigarette use variable included in the models fitted by Chan et al. [14] measured e-cigarette use at the time of the survey and therefore would include people who commenced daily vaping after quitting tobacco and exclude those who used e-cigarettes for a smoking cessation attempt but quit before the survey.

The aim of the present study is to estimate the real-world effect on past-year smoking cessation success of using e-cigarettes for a cessation attempt. Changes made to the NDSHS questionnaire for its 2019 wave have improved the basis to estimate this effect compared with previous analyses. Existing limitations in the questionnaire mean that the effects of e-cigarette use estimated in the current study reflect the overall success of e-cigarette users in Australia in 2019, including those who used nicotine and those who did not. The effect of sourcing e-cigarettes from overseas websites, estimated using a separate model, probably compares the success of people who overwhelmingly used e-cigarettes containing nicotine for a smoking cessation attempt with those who did not use e-cigarettes.

METHODS

The NDSHS [16] is a representative cross-sectional survey of Australian households that has been repeated every 3 years since 1985. The NDSHS collects information about the attitudes towards and use of a range of drugs and includes a section dedicated to smoking and tobacco. Surveys for the 2019 wave were completed between 8 April and 22 September 2019. The Confidential Unit Record File (CURF) for the 2019 NDSHS was sourced from the Australian Institute of Health and Welfare (AIHW). Details of the survey, including the most recent questionnaire are available on-line [16].

The process used to select usable cases from the complete CURF sourced from the AIHW is shown in Figure 1. Respondents were

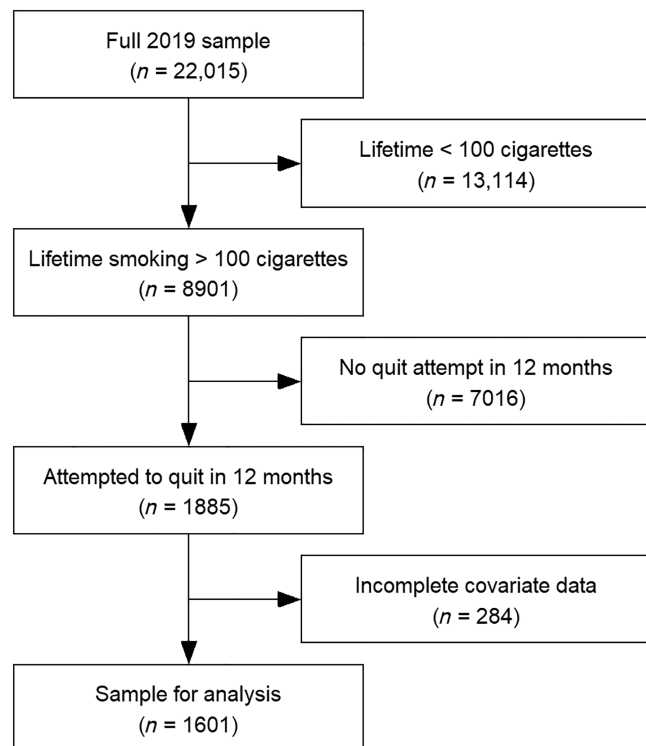


FIGURE 1 Flow diagram for filtering of the 2019 National Drug Strategy Household Survey respondents used for logistic regression models of past-year success of smoking cessation attempts

assumed to have made a quit attempt if they checked boxes indicating either of the following statements applied to them: ‘In the last 12 months have you successfully given up smoking (for more than a month)?’ or ‘In the last 12 months have you tried to give up unsuccessfully?’. We include only people who attempted to quit smoking in the year before the survey to allow estimation of the effect of e-cigarettes on the success of people attempting to quit, unaffected by differences in the proportions of e-cigarette users and non-users who made quit attempts.

Survey respondents making a quit attempt may have been abstinent from smoking for less than a month at the time of the survey. If these respondents had not made an earlier unsuccessful attempt in the preceding 12 months, they would be expected to check neither the successful attempt nor the unsuccessful attempt boxes on account of these abbreviated cessation attempts. This is appropriate because ongoing attempts to quit of duration less than a month do not satisfy our success criteria, but it would be clearly inappropriate to classify these attempts as unsuccessful when the unbroken abstinence might be permanent [13].

Outcome variable

We defined a binary indicator variable for past-year smoking cessation success. The value of the variable for each subject was determined from responses to two survey questions. Respondents were

deemed to have been successful in past-year smoking cessation if they both responded positively to the question: ‘In the last 12 months have you successfully given up smoking (for more than a month)?’; and to the question: ‘How often do you now smoke cigarettes, pipes or other tobacco products?’, checked the response: ‘Not at all, but I have smoked in the last 12 months’. Conversely, if responses to the same two questions implied that the respondent had not abstained from smoking for a month or they were a current smoker at the time of the survey, they were assumed to have made an attempt or attempts without success. Respondents classified as successful may have made unsuccessful attempts before their successful attempt. Respondents who were abstinent for less than a month at the time of the survey but had made earlier attempts in the 12 months leading up to the survey would be expected to have checked the unsuccessful attempt box only and therefore be included in the analytical sample as unsuccessful.

Study variable

For the primary analysis, the study variable was use of e-cigarettes for a smoking cessation attempt in the previous 12 months. The value of this variable was deduced from the question: ‘During the last 12 months have you used e-cigarettes to help quit smoking regular tobacco cigarettes?’. The use of responses to this question, rather than e-cigarette use at the time of the survey, ensures that the e-cigarette variable measures e-cigarette use at the time of a quit attempt for the purpose of smoking cessation.

To investigate two additional questions, we fitted another two models that each used slightly modified study variables. For the second model, model 2, the study variable was modified to exclude those who only managed to use e-cigarettes once or twice from the definition of e-cigarette use.

Frequency of e-cigarette use at the time of the survey was measured with the question: ‘How often, if at all, do you currently use electronic cigarettes?’. The available responses for this question were (i) daily, (ii) at least weekly (but not daily), (iii) at least monthly (but not weekly), (iv) less than monthly, (v) I used to use them, but no longer use, (vi) I only tried them once or twice and (vii) never used. For model 2 only, respondents who indicated that they had only tried e-cigarettes ‘once or twice’ were deemed to not have used e-cigarettes. While the question on frequency of e-cigarette use relates to current frequency, we assumed that people who claimed to have used e-cigarettes once or twice were never regular users and so did not sustain e-cigarette use at the time of their quit attempt. People who used e-cigarettes more than once or twice for a smoking cessation attempt but later ceased vaping would be expected to have reported their status as: ‘I used to use them, but no longer use’.

The NDSHS does not collect information on whether e-cigarettes used by vapers contain nicotine. However, the regulatory conditions governing nicotine e-cigarette sales and use in Australia at the time might suggest that vapers purchasing e-cigarettes on overseas websites would be more likely to use nicotine than other Australian

vapers. Therefore, a third model was fitted to estimate the effects of using e-cigarettes sourced from overseas websites separately from e-cigarettes obtained from other sources. For this model, the definition of e-cigarette use was as for model 1, but respondents who sourced their e-cigarettes from overseas websites were distinguished from other e-cigarette users. This classification was based on responses to the question: 'Where do you usually obtain your electronic cigarettes?'. Respondents who selected 'From the internet—overseas retailers' were deemed to have sourced their e-cigarettes from overseas websites. Respondents who reported using e-cigarettes for a quit attempt and selected any of the other options were classified as 'other supplier'. As in model 1, the reference category for this variable was 'did not use e-cigarettes for a cessation attempt'. More information on other e-cigarette supplier types is provided in the Results section.

Covariates

The NDSHS collects a range of demographic and smoking variables potentially related to smoking cessation success. We added a number of these variables to regression models as covariates to adjust for their confounding effects, consistent with standard practice for the analysis of observational studies. In the absence of purposive measures of cigarette dependence, we used past-year daily smoking and an indicator variable for initiation to cigarette smoking before 16 years of age. Demographic variables included were gender, marital status, age, education level, employment status and remoteness. Also included were level of psychological distress, an indicator variable for alcohol use three or more times per week and use of other smoking cessation aids or strategies.

The 2019 CURF included a composite education variable, education, derived from years of secondary education completed and highest technical or university qualification achieved. The original variable included five levels, ranging from level 1, for year 11 high school and below, including certificates I and II technical qualifications; to level 5, for a bachelor's degree or higher. We pooled level 3, certificates III or IV technical qualification and level 4, diploma, resulting in a variable with four levels, which we label from lowest (I) to highest (IV). For simpler interpretation, the education variable is modelled as nominal rather than ordinal.

The classification of respondents, as either daily or non-daily smokers, at the time of the cessation attempt was based on responses from a combination of questions. Ever smokers were asked: 'Have you ever smoked on a daily basis?'. Respondents who indicated that they were daily smokers at the time of the survey were assumed to have been daily smokers at the time of their quit attempt. Values of the daily smoking variable for Australians who indicated that they had previously been daily smokers were based on their responses to the question: 'About what age were you when you stopped smoking daily?' in combination with their age, in years, at the time of the survey. If the difference between the current age of the respondent and the reported age they stopped smoking daily

was greater than 1 year, they were assumed not to have been a daily smoker at the time of the quit attempt. If this difference was one or zero, the respondent was assumed to have been a daily smoker at the time of the quit attempt. The selection of surveyed individuals within selected households was determined by the most recent birthday among residents aged 14 years and older [16]. Therefore, the average time since respondents' most recent birthdays would have been somewhat less than 6 months.

Use of smoking cessation aids and strategies other than e-cigarettes were each included as separate binary predictor variables. This allowed the effects of combinations of multiple aids and strategies to be considered with each having a multiplicative effect on the odds of success. Aside from e-cigarettes, the strategies included were NRT, smoking cessation medication, use of a smartphone app, calling Quitline and asking a doctor for help.

The NDSHS includes the 10 questions of the Kessler K10 psychological distress measure [17]. We used the derived variable, K10rc, included in the CURF to define a covariate based on the responses to the 10 questions. Combined K10 scores up to 15 are rated as 'low' psychological distress, scores between 16 and 21 are rated 'moderate' and scores of 22 and above are rated 'high or very high'.

The supplied CURF classifies the remoteness of households using either a three-level variable, ASGS3, or a four-level variable, ASGS4, depending on the Australian state that the household is in. We converted ASGS4 classifications unambiguously to the three ASGS3 categories: (i) major cities; (ii) inner regional; and (iii) outer regional, remote or very remote.

Statistical analysis

With the full survey sample used to specify a survey design representing the Australian population 14 years of age and older, as described in the NDSHS methodology document, we used the survey package [18] in R version 4.1.1 [19] to specify a corresponding survey design representing the subpopulation of adult Australians who made a quit attempt in 2019.

Summary statistics of Australians who attempted to quit smoking in 2019 with and without e-cigarettes were estimated from responses to the NDSHS questionnaire using standard functions included in the survey package [18]. Null hypotheses of no difference between the two population means of continuous variables were tested using *t*-tests. Null hypotheses of identical distributions of categorical variables were tested using χ^2 tests. Multivariable logistic regression models for past-year smoking cessation success were fitted to NDSHS survey respondents who attempted to quit smoking in 2019. Adjusted odds ratios were calculated from the fitted models. All analyses incorporated NDSHS survey weights and stratification. Hosmer–Lemeshow tests and randomized quantile residuals were used to test goodness of fit. Additional logistic regression analyses based on the same three models described above were carried out on the full set of 1885 respondents who made a smoking cessation attempt, with missing

covariate values handled using multiple imputation using chained equations [20] as sensitivity analyses.

Ethical approval was granted for analysis of NDSHS data for research into e-cigarette use in Australia by Research Ethics and Compliance Support at University of New South Wales (no. HC210162). The analysis described in this study was not pre-registered and the findings should be considered exploratory.

RESULTS

General characteristics of Australians who attempted to quit smoking in 2019

The final analytical sample size was comprised of 1601 quit attempters (Figure 1), of whom 189 used e-cigarettes for a quit attempt. Among Australians aged 14 years and above who were smokers during 2019, 49% made a quit attempt during that 12-month period [incidence = 0.492, 95% confidence interval (CI) = 0.471–0.512]. Approximately 12% of Australians who made quit attempts in 2019 used e-cigarettes for the purpose (incidence = 0.119; 95% CI = 0.103–0.137) and of these, approximately 28% predominantly sourced their vaping supplies from overseas websites (incidence = 0.277, 95% CI = 0.203–0.361; Figure 2).

Slightly fewer than a quarter of Australians who attempted to quit smoking in 2019 satisfied our abstinence criteria for success (point success rate = 0.239, 95% CI = 0.216–0.263). Among Australians who used e-cigarettes predominantly sourced from overseas websites, an estimated 34% (95% CI = 0.196–0.518) satisfied the criteria for cessation success, while 28% (95% CI = 0.202–0.381) of those who sourced e-cigarettes from other sources satisfied the criteria.

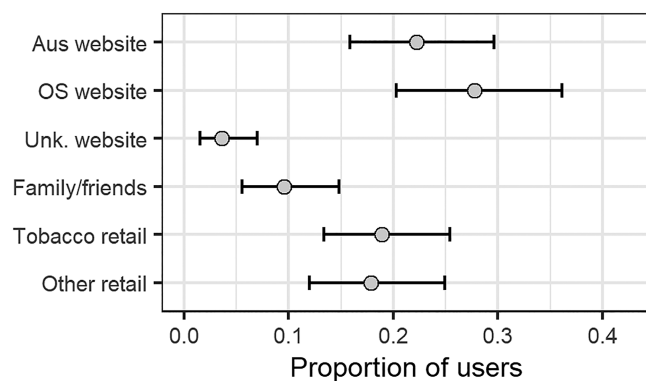


FIGURE 2 Sources used to obtain e-cigarettes by Australians aged 14 and above who used e-cigarettes for an attempt to quit smoking in 2019. Error bars are 95% confidence intervals. The estimated proportion of Australians who sourced their e-cigarettes from pharmacies in 2019 was too small to estimate. OS = overseas (i.e. outside Australia); Unk. website = Website of unknown origin

Comparisons of Australians who attempted to quit with and without e-cigarettes

The gender make-up of the two groups was similar. Australians who used e-cigarettes were slightly younger, on average, than those who made quit attempts without e-cigarettes but had similar education and employment status. The mean age of initiation to smoking for both groups was 16 years, and there was not significant evidence of a relationship between psychological distress and use of e-cigarettes. A higher proportion of Australians who used e-cigarettes for a quit attempt than those who did not were daily smokers during the 12 months before the survey (Table 1).

Of the broad class of Australians who used e-cigarettes for a smoking cessation attempt, more than 10% only tried them once or twice (incidence = 0.153, 95% CI = 0.108–0.198). The proportions who were daily users, non-daily users and ex-users at the time of the survey were all between 25 and 35% (Figure 3).

Effects of e-cigarette use and other explanatory variables on smoking cessation success

After adjusting for covariates, Australians aged 14 years and above who attempted to quit smoking using e-cigarettes in 2019 are estimated to have had 68% higher odds of being abstinent for more than a month at the time of the survey [adjusted odds ratio (aOR) = 1.68, 95% CI = 1.09–2.60] than other Australians who had made a quit attempt (Table 2). If people who only managed to use e-cigarettes once or twice are considered not to have used e-cigarettes, the odds of success of e-cigarette users are estimated to have been approximately double those of others who made a quit attempt (aOR = 1.98, 95% CI = 1.27–3.10).

Australians who were non-daily smokers at the commencement of their attempt were significantly more likely than daily smokers to achieve past-year smoking cessation success (aOR = 2.71, 95% CI = 1.95–3.77). Use of a quit smoking app (aOR = 1.74, 95% CI = 1.01–3.01) and sometimes avoiding places where likely to encounter cigarette smoke (aOR = 1.57, 95% CI = 1.15–2.13) were both associated with higher odds of cessation success (Table 2).

According to model 3, the odds of success of Australians who sourced e-cigarettes from overseas websites were 124% higher (aOR = 2.24, 95% CI = 1.02–4.93) than those who did not use e-cigarettes for a smoking cessation attempt after adjusting for the other variables in the model. The relationship between past-year success of smoking cessation attempts and using e-cigarettes not sourced from overseas websites versus not using e-cigarettes for a smoking cessation attempt was inconclusive (aOR = 1.59, 95% CI = 0.96–2.64) (Table 2).

Hosmer–Lemeshow tests gave no evidence of lack of fit for any of model 1 ($\chi^2_{18} = 10.5$, P -value = 0.914), model 2 ($\chi^2_{18} = 19.8$, P -value = 0.342) or model 3 ($\chi^2_{18} = 0.972$). Similarly, diagnostic tests based on randomized quantile residuals gave no evidence of a failure

TABLE 1 Population summary statistics of Australians aged 14 and above who attempted to quit smoking in 2019 by use of e-cigarettes

	Used e-cigarettes Est. (RSE)	No e-cigarettes Est. (RSE)	P-value
Age (mean)	37 (0.03)	41 (0.01)	< 0.001
Female (%)	45 (0.09)	44 (0.03)	0.824
Currently married/ <i>de-facto</i> (%)	46 (0.09)	51 (0.03)	0.310
Age first smoked (mean)	16 (0.02)	16 (0.01)	0.673
Cigarettes per week (mean)	64 (0.15)	57 (0.06)	0.538
Daily smoking during 12 months (%)	81 (0.05)	69 (0.02)	0.012
Used NRT (e.g. gum, patch, spray, lozenge) (%)	29 (0.13)	21 (0.06)	0.044
Used smoking cessation medication (e.g. Champix, Zyban) (%)	9 (0.28)*	10 (0.08)	0.600
Asked doctor for help to quit (%)	16 (0.18)	14 (0.07)	0.412
Used quit smoking smart phone app (%)	10 (0.24)	8 (0.10)	0.378
Called Quitline (%)	5 (0.37)*	2 (0.16)	0.055
Consumed alcohol 3 or more times per week (%)	22 (0.15)	31 (0.05)	0.032
Psychological distress category (%)			0.102
Low	42 (0.10)	51 (0.03)	
Medium	31 (0.13)	25 (0.05)	
High/very high	27 (0.14)	24 (0.05)	
Remoteness (%)			0.273
City	71 (0.05)	66 (0.04)	
Inner regional	18 (0.18)	22 (0.10)	
Outer regional/remote	11 (0.24)	12 (0.15)	
Avoid others' cigarette smoke (%)			0.149
Never	57 (0.07)	58 (0.03)	
Sometimes	37 (0.11)	32 (0.05)	
Always	6 (0.31)*	10 (0.09)	
Employment category (%)			0.512
Paid employment	67 (0.06)	61 (0.03)	
Unemployed	7 (0.26)*	8 (0.11)	
Retired	8 (0.26)*	11 (0.08)	
Other incl. home duties, students and charity	17 (0.19)	19 (0.06)	
Education level (%)			0.346
I (year 11 or lower including certificates I and II)	20 (0.16)	22 (0.06)	
II (completed year 12)	25 (0.16)	19 (0.07)	
III (certificates III or IV or diploma)	37 (0.11)	39 (0.04)	
IV (Bachelor's degree or higher)	18 (0.18)	20 (0.06)	
Self-reported smoking status when surveyed (%)			0.047
Non-smoker	1 (0.71)**	5 (0.15)	
Ex-smoker	30 (0.13)	24 (0.05)	
Less than daily	20 (0.18)	19 (0.06)	
Daily	49 (0.09)	52 (0.03)	

*Estimates with relative standard errors exceeding 0.25 should be interpreted with caution.

**Estimates with relative standard errors exceeding 0.5 are unsuitable for most purposes. NRT = nicotine replacement therapy. Values in parentheses are relative standard errors (RSE) = estimated standard error divided by point estimate.

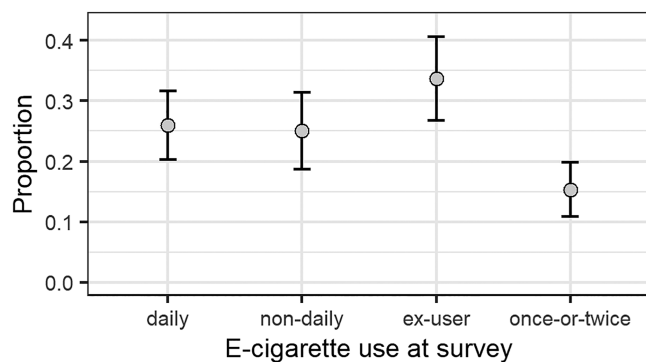


FIGURE 3 Frequency of e-cigarette use at the time of the 2019 survey among Australian adults who used e-cigarettes during an attempt to quit smoking in the previous 12 months, including those who used them once or twice. Error bars are 95% confidence intervals

of model assumptions (Supporting information, Section S1). The same three logistic regression models fitted to multiply imputed data sets considering all 1885 NDSHS respondents who made a smoking cessation attempt suggested that all variants of e-cigarette use for a smoking cessation attempt were associated with increased smoking cessation success relative to Australians who did not use e-cigarettes for a smoking cessation attempt in 2019 (Supporting information, Table S2).

DISCUSSION

This analysis of data from the 2019 NDSHS suggests that use of e-cigarettes for a smoking cessation attempt in 2019 was associated with increased odds of past-year smoking cessation success after adjusting for a range of potential confounders. To our knowledge, this represents the first population estimate for the effect of e-cigarettes on smoking cessation success of Australians. The previous analysis by Yong et al. [13] included Canadians as well as Australians, while Chan et al. [14] estimated the association between different frequencies of e-cigarette use at the time of the survey and having recently quit tobacco among past-year smokers.

The position statement of Australia's Department of Health at the time of writing claims 'No studies have yet demonstrated the safety of e-cigarettes or the efficacy of e-cigarettes as a smoking cessation tool at a population level' in explaining current restrictions on the sale of nicotine e-cigarettes in Australia [21]. Key reviews published in the last few years have suggested that the case for e-cigarettes as an effective smoking cessation aid has strengthened [2,4]. The present study provides evidence that Australians who used e-cigarettes for smoking cessation attempts in 2019 were more successful than those who did not. Therefore, improving access to nicotine e-cigarettes in Australia could be expected to assist some Australian smokers to quit. These benefits should be considered when reviewing Australia's current policy settings regarding e-cigarettes.

The proportion of vapers sourcing their e-cigarettes from overseas websites, while substantial, was well below proportions of Australian vapers using nicotine in recent studies [15,22]. Reliable information on the proportion of Australian vapers using nicotine e-cigarettes and differences in efficacy of e-cigarettes with and without nicotine is needed to understand the impact of Australia's current e-cigarette regulations.

It is perhaps surprising that Australians who used e-cigarettes also used other cessation aids about as frequently as Australians who made quit attempts without e-cigarettes (Table 1). Summaries of data collected during the International Tobacco Control Four-Country Smoking and Vaping Survey [23] suggest that frequent use of multiple aids for quit attempts may be the norm throughout the United States, Canada, Australia and the United Kingdom.

Approximately 15% of Australians who intended to use e-cigarettes for a quit attempt ultimately used them only once or twice (Figure 3). Given that smokers can experiment with alternative aids before settling on one or a combination that suits them, it could be argued that comparisons of cessation rates between people who persevere with e-cigarettes and those who do not use them are most relevant.

Limitations of the study

Questions in the 2019 NDSHS relating to e-cigarette use were not sufficient to determine the frequency of e-cigarette use at the time of the quit attempt. Ideally, the effects of daily and non-daily vaping would have been estimated separately. Other recommended information pertaining to e-cigarette use [24] not collected by the 2019 NDSHS include the type of e-cigarette device used and whether e-cigarettes used contained nicotine. Past-year daily smoking and an indicator variable for initiation to smoking before 16 years of age were used to control for cigarette dependence. Past-year daily smoking was positively related to past-year smoking cessation success (Supporting information, Table S1) and was also associated with e-cigarette use (Table 1). Therefore, it was important to adjust for daily smoking. Nevertheless, purposive measures of nicotine dependence at the time of the cessation attempt may have been more sensitive. Previous studies have found people who use cessation aids tend to be more dependent, on average, than people who try to quit unaided [6,25]. Some respondents assumed to have been daily smokers at the time of their quit attempt would have become non-daily smokers before commencing their attempt. This may have reduced the estimated effect of non-daily smoking but is likely to have had minimal impact on estimates of the effect of e-cigarettes.

It is possible that people responding to the NDSHS could use e-cigarettes on an unsuccessful smoking cessation attempt and then successfully quit without using e-cigarettes in the 12 months leading up to the survey. There were 19 respondents who satisfied the smoking cessation success criteria who also reported a failed smoking cessation attempt in the 12 months before the survey. None of these reported using e-cigarettes for a smoking cessation attempt.

TABLE 2 Adjusted odds ratios (aOR) and *P*-values of explanatory variables included in survey logistic regression models for smoking cessation success fitted to responses from participants in the 2019 NDSHS who attempted to quit smoking in the 12 months before the survey

Study variable	Model 1 aOR (95% CI)	P-value	Model 2 aOR (95% CI)	P-value	Model 3 aOR (95% CI)	P-value
E-cigarettes for smoking cessation	1.68 (1.09–2.60)	0.019	1.98 (1.27–3.10)	0.003	–	–
E-cigarette source (reference group = no e-cigarettes)						
Overseas/unknown website	–	–	–	–	2.24 (1.02–4.93)	0.046
Other source	–	–	–	–	1.59 (0.96–2.64)	0.072
Covariates						
Gender = female	1.16 (0.85–1.58)	0.342	1.16 (0.85–1.58)	0.341	1.17 (0.86–1.59)	0.324
Marital status = married or <i>de-facto</i>	1.27 (0.93–1.75)	0.138	1.26 (0.92–1.74)	0.151	1.29 (0.94–1.78)	0.117
Age factor (reference group = 14–30 years)						
Mid-age (31–50 years)	1.27 (0.84–1.91)	0.261	1.29 (0.85–1.94)	0.234	1.28 (0.85–1.93)	0.242
Senior (51+ years)	1.00 (0.60–1.66)	0.989	1.01 (0.60–1.70)	0.963	0.97 (0.58–1.63)	0.904
Psychological distress (reference group = low)						
Medium	1.18 (0.84–1.67)	0.337	1.17 (0.83–1.66)	0.375	1.21 (0.86–1.71)	0.282
High/very high	0.85 (0.58–1.26)	0.418	0.85 (0.57–1.25)	0.407	0.86 (0.58–1.26)	0.435
Educational level (reference group = I)						
II	0.91 (0.55–1.51)	0.716	0.90 (0.54–1.49)	0.673	0.88 (0.53–1.46)	0.630
III	1.19 (0.79–1.80)	0.414	1.19 (0.79–1.81)	0.410	1.16 (0.76–1.75)	0.488
IV	1.06 (0.65–1.70)	0.825	1.06 (0.65–1.70)	0.731	1.01 (0.63–1.63)	0.958
Employment status (reference group = employed)						
Unemployed	1.24 (0.70–2.20)	0.465	1.23 (0.69–2.20)	0.475	1.26 (0.71–2.25)	0.429
Retired	1.36 (0.83–2.21)	0.224	1.36 (0.83–2.22)	0.223	1.48 (0.91–2.40)	0.117
Other	0.81 (0.52–1.24)	0.328	0.81 (0.53–1.26)	0.312	0.82 (0.53–1.26)	0.361
Remoteness (reference group = city)						
Inner regional	1.17 (0.80–1.71)	0.413	1.18 (0.80–1.72)	0.401	1.17 (0.80–1.71)	0.417
Outer regional/remote	0.71 (0.45–1.13)	0.154	0.72 (0.45–1.14)	0.179	0.71 (0.44–1.13)	0.147
Alcohol 3+ days per week	0.94 (0.68–1.30)	0.717	0.95 (0.69–1.31)	0.762	0.95 (0.69–1.31)	0.760
Non-daily smoking	2.71 (1.95–3.77)	< 0.001	2.77 (1.99–3.86)	< 0.001	2.69 (1.93–3.75)	< 0.001
First cigarette < 16 years	1.10 (0.82–1.49)	0.513	1.09 (0.81–1.47)	0.571	1.11 (0.83–1.50)	0.480
Avoid others' cigarette smoke (reference group = never)						
Sometimes	1.57 (1.15–2.13)	0.005	1.56 (1.14–2.12)	0.005	1.54 (1.13–2.10)	0.006
Always	1.30 (0.77–2.17)	0.326	1.30 (0.77–2.18)	0.323	1.30 (0.78–2.18)	0.321
Asked doctor for help to quit	0.90 (0.53–1.53)	0.706	0.91 (0.54–1.55)	0.736	0.88 (0.52–1.50)	0.642
NRT (e.g. gum, patch, spray, lozenge)	0.76 (0.49–1.16)	0.197	0.76 (0.50–1.17)	0.216	0.75 (0.49–1.15)	0.183
Cessation pill (e.g. Zyban, Champix)	1.22 (0.70–2.12)	0.484	1.24 (0.71–2.16)	0.454	1.22 (0.70–2.13)	0.476
Used quit smoking smartphone app	1.74 (1.01–3.01)	0.046	1.78 (1.03–3.08)	0.038	1.73 (1.00–3.00)	0.052
Called Quitline	0.49 (0.19–1.28)	0.145	0.50 (0.19–1.28)	0.149	0.49 (0.18–1.32)	0.150

Model 1 classifies all people who reported attempting to quit using e-cigarettes as an e-cigarette user. Model 2 is equivalent to model 1, except that people who reported using e-cigarettes but have only used e-cigarettes once or twice were classified as not using e-cigarettes. Model 3 is equivalent to model 1, except people who reported predominantly sourcing e-cigarettes from overseas websites and those who used other sources are classified as separate classes of e-cigarette user. NDHS = National Drug Strategy Household Survey; CI = confidence interval; NRT = nicotine replacement therapy.

The instances of abstinence fitted in this study are self-reported. However, self-reported smoking has been deemed mainly reliable [26]. Also, pressure on respondents to falsely report smoking abstinence in a population survey is likely to be lower than for randomized controlled trials (RCTs) for smoking cessation aids [27–29]. Imperfect recall of failed cessation attempts may be more of an issue than

inaccurate reporting of outcomes. It is possible that people who do not use a cessation aid may be more inclined to discount or fail to recall an unsuccessful quit attempt [30]. By the same argument, people who actively used e-cigarettes with the intention of quitting would presumably be more likely to recall an unsuccessful cessation attempt than those who made unaided attempts. This behaviour would be expected

to negatively bias any estimate of the effect of e-cigarette use on smoking cessation and so not change the main findings of this study.

While comparable studies [6,13] have used a similar abstinence measure, inferring a successful cessation attempt based on abstinence of a month or more is unlikely to be the most relevant criteria to assess the effect of e-cigarettes on smoking cessation. Relapse to smoking following extended periods of abstinence is known to be common. If smokers who use e-cigarettes for quit attempts are more or less likely than others to relapse after extended abstinence, the effect of e-cigarettes on permanent smoking cessation will be different to their effect on short-term abstinence.

CONCLUSIONS

The use of e-cigarettes for a smoking cessation attempt was positively associated with past-year smoking cessation success of Australian smokers who attempted to quit in 2019 despite restrictive regulations regarding their use.

DECLARATION OF INTERESTS

None.

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AUTHOR CONTRIBUTIONS

Mark S. Chambers: Conceptualization; data curation; formal analysis; investigation; methodology; project administration.

ORCID

Mark S. Chambers  <https://orcid.org/0000-0001-9121-6111>

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher’s website.

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