

## Accepted Manuscript

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PII: S0306-4603(18)31018-9  
DOI: <https://doi.org/10.1016/j.addbeh.2019.02.012>  
Reference: AB 5910  
To appear in: *Addictive Behaviors*  
Received date: 10 September 2018  
Revised date: 5 February 2019  
Accepted date: 13 February 2019

Please cite this article as: G. Chan, J. Leung, C. Gartner, et al., Correlates of electronic cigarette use in the general population and among smokers in Australia – Findings from a nationally representative survey, *Addictive Behaviors*, <https://doi.org/10.1016/j.addbeh.2019.02.012>

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**Correlates of electronic cigarette use in the general population and among smokers in  
Australia – Findings from a nationally representative survey**

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**Abstract**

**Aims:** In Australia, sales of nicotine containing electronic cigarettes (also known as e-cigarette) are banned unless approved as a therapeutic good. The aims of this study were to estimate the prevalence of e-cigarette use and its correlates in Australia using a nationally representative survey.

**Method:** We analysed data from the largest drug use survey in Australia (the National Drug Strategy Household Survey [NDSHS]; N = 22,354) .

**Results:** We estimated that 227,000 Australians (1.2% of the population) were current e-cigarettes users, and 97,000 (0.5%) used them daily. Individuals who were male, younger, had higher level of psychological distress, and smoked were more likely to use electronic cigarettes. Among smokers, an intention to quit and reduction in smoking was associated with experimentation and daily use of e-cigarette, but not with occasional use. Recent quitting was associated with daily use.

**Conclusion:** Overall, the prevalence of e-cigarette use was low in 2016 in Australia. Smoking status was the strongest correlates of e-cigarette use. Patterns of vaping were differentially associated with an intention to quit smoking, smoking reduction and recent quitting. Some smokers may attempt to use e-cigarettes to cut-down their tobacco use, and those who vaped daily were mostly likely to be recent quitters.

## Introduction

The prevalence of electronic cigarette (e-cigarette) use, known as vaping, has increased dramatically in many developed countries while the prevalence of tobacco smoking has steadily decreased (1, 2). Proponents support e-cigarettes as a promising cessation aid or a less harmful substitute for combustible tobacco. Opponents argue that e-cigarettes may renormalize smoking among young people and hinder quit attempts in smokers by encouraging dual use of e-cigarette with cigarettes (3). A consensus report by the US National Academies of Science, Engineering and Medicine concluded that there was observational evidence that smokers who switch to e-cigarettes will reduce their exposure to harmful chemicals and that they may be an effective cessation aid, but youth who vape are at greater likelihood of also experimenting with smoking (4).

In most developed countries, such as the UK and USA, e-cigarettes can be sold and used as consumer products (5-7). Australia has taken a more restrictive approach to e-cigarettes and remains the only Westernized democracy that prohibits the sale, and possession or use of non-therapeutic nicotine containing e-cigarettes (8). E-cigarettes that don't contain nicotine can be sold in most states and territories as consumer products, however one state has also banned the sale of nicotine-free e-cigarettes.

The distinctive regulatory environment in Australia reduces the generalizability of studies done in other countries to the Australian context. Yet, few empirical e-cigarette studies have been conducted in Australia, and most were not based on population samples (9-11). The aim of this study is to:

1. estimate the prevalence of vaping based on data from the latest and largest nationally representative survey on substance use in Australia and identify correlates of use;
2. examine the association between vaping, intention to quit smoking, and reduction in smoking among smokers and recent quitters (participants who reported past year smoking but no current smoking).

## Method

### Sample

The data were drawn from the 2016 National Drug Strategy Household Survey (NDSHS) dataset. Households were randomly selected using a multistage stratified design based on statistical local areas in every State and Territory. Detailed information on methods of the NDSHS can be found elsewhere (12). The response rate was 51.1% and this was comparable to past NDSHS and other international surveys of alcohol and drug use (13, 14). Sample weights were applied to the data to align the sample with the demographic profile of the Australian population. The NDSHS was approved by the Australian Institute of Health and Welfare Health Ethics committee. Our analysis includes all participants aged 18 years and over ( $N=22,354$ ; 54% Female;  $M_{age}=51$ ).

### Measures

*Current e-cigarette use* was measured using the question “How often, if at all, do you currently use electronic cigarettes?”, with response options: “Daily/At least weekly (but not daily)/At least monthly (but not weekly)/less than monthly/I used to use them, but no longer use/I only tried them once or twice/Never”. For the first set of analyses examining prevalence and correlates of vaping in the population (described in the analysis section), the first four responses were recoded as “Current use” and the last three were recoded as “No current use” in the model examining

current vaping. In the model examining current daily vaping, the first response was coded as “Current daily use”. In the second set of the analyses focusing only on past year smokers, we coded this variable into four categories: the first response was coded as “*Daily use*”; the second to the fourth responses were coded as “*Occasional use*”; the fifth and sixth as “*Tried but no current use*” and the last as “*No use*”.

*Reduction in tobacco use* was measured using the question “In the last 12 months, have you reduced the amount of tobacco you smoke in a day? Yes/No”. *Intention to quit* was measured using the question “Are you planning on giving up smoking?” with responses: “No, I have already given up/Yes, within 30 days/Yes, after 30 days, but within the next 3 months/Yes, but not within the next 3 months/No, I am not planning to give up”. These two variables were used in the second set of analyses which focused only on past year smokers. Since there is strong dependency between these two items (those who reported having given up smoking would have reduced tobacco use), responses from these two items were combined to form a new variable with five levels: “No intention to quit and no reduction in smoking”, “Intended to quit and no reduction in smoking”, “Not intended to quit but reduced smoking”, “Intended to quit and reduce smoking” and “No longer smoke”.

*Smoking status* was derived from participants’ self-reported tobacco smoking and coded into 4 levels: “Current daily smoker”, “Current non-daily smoker”, “Ex-smoker” (defined as those who reported smoking more than 100 cigarette in their lifetime and no current smoking) and “Non-smoker” (defined as those who reported smoking less than 100 cigarette in their lifetime).

*Psychological distress* (Low/Moderate/High/Very high) was measured using 10 items from the Kessler psychological distress scale (15). *General health* was measured using the question “In

general, would you say your health is Excellent/Very good/Good/Fair/Poor?”. *Alcohol risk* was measured using three items based on the Alcohol Use Disorder Identification Test – Consumption (AUDIT-C) (16), and categorized into “No risk (No alcohol use)/ Low risk (AUDIT-C score <4 for men and <3 for women)/ High risk (score  $\geq$ 4 for men and  $\geq$ 3 for women)”. *Cannabis use* was measured using the item “Have you used Marijuana/ Cannabis in the last 12 months? Yes/ No”. *Regionality* (Major cities/Inner regional/Outer regional or more remote) and *socio-economic index for area* (Least advantaged/ 2<sup>nd</sup>/ 3<sup>rd</sup>/ 4<sup>th</sup>/ Most advantaged quintile) were coded based on classification from the Australian Bureau of Statistics (17, 18). *Marital status* was coded as “Never married/Divorced or separate or widowed/Married or De facto”. *Education level* was coded as “Completed high school/ not completed high school”. *Language background* was coded as “English/Language other than English”. *Employment status* was coded as “Not in labour force (not looking for work)/Unemployed or looking for work/Employed”. *Indigenous status* was coded as “Indigenous/Not indigenous”.

## Analysis

All analyses were conducted using STATA 14 with the *svy* command to account for the complex survey design. Two sets of regression analyses were run to address the study aims. In the first set, we used the full sample to examine the association between vaping and respondent characteristics such as demographic, substance use, and health related variables. In the second set, we focused on past-year smokers (defined as those who reported smoked over 100 cigarettes in their lifetime and smoked in past 12-month; including recent quitters who reported smoking in past 12 months but no current smoking, N=4215) and examined the association between vaping and intention to quit smoking and reduction in smoking.

Overall, none of the variables had more than 6% of the data missing. Multiple imputations by chained equations with deletion based on all analysis variables were used to fill in missing values in 20 datasets using the STATA *mi* command (19).

## Results

Among the 22,354 participants, 269 reported current vaping and 117 reported daily vaping. It was estimated that 227,000 Australians (1.2% of the population 18 years old or above; 95% confidence interval [1.03% - 1.40%]) were current e-cigarette users and 97,000 (0.5%; 95% CI [0.4%-0.7%]) vaped daily. Among daily users, 18% were non-smokers, 32% were daily smokers, 11% were non-daily smokers, and 38% were ex-smokers. Table 1 shows the results from logistic regression analyses predicting current vaping and current daily vaping. The unadjusted models indicated that those less likely to vape were older, female, in a *de facto* relationship or married. By contrast those more likely to vape had higher levels of psychological distress, poorer general health, high levels of alcohol risk, used cannabis, were past or current daily smokers, and who were employed or looking for employment (relative to those not in the labour force). In the adjusted model, only gender, age, psychological distress, cannabis use and smoking status remained statistically significant. For the current daily use model, the results were similar, except that indigenous participants was significantly more likely to be currently vape daily.

Among past-year smokers, 70.0% reported no vaping; 25.7% had tried but did not vape currently; 2.7% reported occasional vaping and 1.6% reported daily vaping. Table 2 shows the results from the multinomial logistic regressions predicting different patterns of vaping among smokers. The reference category was “No e-cigarette use”. Results from the adjusted model showed that,



among smokers, those who reported intention to quit smoking and reduced smoking were more likely to report trying e-cigarettes with no current vaping. Those who reported having intention to quit smoking and no reduction in smoking, and those who reported no current smoking (no longer smoked), were more likely to report daily vaping.

### Discussion

The prevalence of vaping was substantially lower than in other countries such as the US (20) and UK (21), possibly because of a more restrictive e-cigarette regulations in Australia. Males and younger people were more likely to use e-cigarettes and these findings are consistent with existing literature from other countries (22). Indigenous Australians in this study were also more likely to use e-cigarettes daily compared to non-Indigenous Australians. This finding is different to that reported in a 2013 national survey of Indigenous Australians (23) which found that Indigenous Australians who smoked were less likely to have ever tried an e-cigarette than a general population sample of smokers. This difference may be explained by differences in the sampling strategies for each of these studies. The methods used by the 2013 study, which utilised local community health workers in Indigenous communities to recruit and survey participants, would have achieved better representation of Indigenous people residing in smaller communities, where access to e-cigarettes is likely to be lower.

As seen in other countries, smoking status was the factor most strongly associated with e-cigarette use in our study (24). Psychological distress was also associated with e-cigarette use. Other studies have also found higher prevalence of ever use of e-cigarettes associated with having a mental health condition (25). This may be because smokers with greater psychological distress have more difficulty quitting (26) and hence may be more likely to seek new potential

aids, such as use of e-cigarettes, to quit or reduce smoking than smokers without psychological distress (27).

Among smokers, an intention to quit smoking and reported past year reduction in smoking were significantly associated with experimentation and daily use. Recent quitting was also associated with daily use. However, neither variable was associated with occasional use. These results suggest that smokers' reasons for vaping may differ as a function of vaping frequency. This is consistent with a recent study on the topology of e-cigarettes users (28), and consistent with studies showing that vaping was associated with reductions in the number of cigarettes smoked per day in some smokers but not others (29). It is possible that among those who only vape occasionally, the key motivation may be to vape where they cannot smoke rather than to quit (30). Those who intended to quit might experiment with vaping but only those who vaped daily quit. Our findings are similar to those reported in other studies showing that only daily vaping is associated with reduced smoking and quit success (31).

### *Strengths and Limitations*

Despite using a large nationally representative sample, there were some limitations to this study. First, the NDSHS is based on self-report data, so levels of e-cigarette use may be under-reported given the legal restrictions on use of e-cigarettes containing nicotine. Second, the NDSHS excludes participants without a fixed home address and therefore does not capture high-risk populations, such as homeless people. Third, nicotine concentration, level of nicotine dependence and reasons for stopping vaping were not measured. Lastly, the cross-sectional nature of the survey precludes any conclusion about causation.

### **Conclusion**

The prevalence of vaping was low in 2016 in Australia, likely reflecting the ban on sales of nicotine-containing e-cigarettes. Being male, young, being either a current or ex-smoker, and having a higher level of psychological distress were associated with increased odds of current vaping. Among smokers, patterns of vaping were differentially associated with an intention to quit, reduction in smoking and recent quitting.

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Table 1. Logistic regression predicting current e-cigarette use and current daily use (N=22,354).

	Current e-cigarettes use (N = 269)				Current daily e-cigarette use (N = 117)			
	Unadjusted OR <sup>a</sup>	95% CI	Adjusted OR	95% CI	Unadjusted OR	95% CI	Adjusted OR	95% CI
Female (vs Male)	0.46***	(0.34, 0.63)	0.53***	(0.37, 0.75)	0.35***	(0.21, 0.60)	0.40**	(0.23, 0.70)
Age	0.97***	(0.96, 0.97)	0.97***	(0.95, 0.99)	0.98*	(0.96, 0.99)	0.98	(0.95, 1.01)
Psychological distress (Ref: Low)								
Moderate	1.37	(0.96, 1.99)	1.01	(0.67, 1.52)	1.39	(0.78, 2.46)	1.14	(0.59, 2.21)
High	3.06***	(1.78, 5.24)	1.78*	(1.03, 3.07)	4.09***	(1.78, 9.41)	2.78**	(1.48, 5.23)
Very high	4.14***	(2.44, 7.03)	1.80	(0.94, 3.44)	2.95*	(1.05, 8.26)	1.67	(0.48, 5.84)
General health (Ref: Excellent)								
Very good	1.44	(0.91, 2.28)	1.19	(0.74, 1.93)	1.93	(0.96, 3.87)	1.48	(0.73, 3.02)
Good	1.77*	(1.08, 2.89)	1.08	(0.65, 1.80)	2.18	(0.97, 4.90)	1.11	(0.52, 2.39)
Fair	1.95**	(1.15, 3.31)	1.12	(0.61, 2.09)	1.90	(0.82, 4.38)	0.88	(0.34, 2.29)
Poor	2.24*	(1.04, 4.85)	1.29	(0.52, 3.21)	4.02*	(1.33, 12.19)	1.69	(0.45, 6.35)
Marital status (Ref: Never married)								
Divorced/ Separate/ Widowed	0.58	(0.32, 1.08)	1.35	(0.57, 3.21)	1.26	(0.49, 3.24)	2.18	(0.70, 6.80)
Married/ De facto	0.32***	(0.23, 0.45)	0.71	(0.44, 1.14)	0.52*	(0.30, 0.90)	0.93	(0.41, 2.13)
Completed high school	0.72	(0.52, 1.00)	0.69	(0.47, 1.01)	0.47**	(0.28, 0.78)	0.50*	(0.29, 0.86)
Language background (Ref: English)								
Language other than English	0.81	(0.36, 1.83)	1.16	(0.59, 2.34)	1.48	(0.50, 4.34)	2.10*	(1.03, 4.25)
Regionality (Ref: Major cities)								
Inner regional	1.04	(0.70, 1.53)	0.97	(0.63, 1.50)	1.02	(0.56, 1.88)	0.88	(0.46, 1.67)
Outer regional or more remote	1.15	(0.58, 2.29)	0.92	(0.51, 1.66)	1.75	(0.63, 4.92)	0.97	(0.52, 1.83)
Alcohol risk (Ref: No risk)								
Low	0.91	(0.45, 1.83)	0.73	(0.41, 1.28)	0.56	(0.21, 1.46)	0.49*	(0.25, 0.86)

		1.85)		1.30)		, 1.55)		, 0.98)
High	2.12*	(1.11, 4.05)	0.78	(0.51, 1.66)	1.28	(0.51 , 3.21)	0.56	(0.30 , 1.03)
Cannabis use (Ref: No)								
Yes	5.99***	(4.26, 8.44)	1.84*	(1.16, 2.93)	5.16***	(2.79 , 9.55)	1.97*	(1.08 , 3.59)
Smoking status (Ref: Non-smoker)								
Current daily smoker	10.56***	(6.33, 17.63)	7.11***	(3.77, 13.40)	8.87***	(3.01 , 26.1 8)	5.94** *	(2.43 , 14.4 9)
Current non-daily smoker	12.90***	(6.61, 25.18)	7.41***	(3.71, 14.81)	14.28***	(3.73 , 54.7 4)	9.99** *	(3.25 , 30.6 8)
Ex-smoker	2.87***	(1.67, 4.94)	3.81***	(2.28, 6.37)	5.53**	(1.89 , 16.1 8)	7.74** *	(3.71 , 16.2 3)
Employment status (Ref: Not in labour force – Not looking for work)								
Unemployed/Looking for work	3.17**	(1.52, 6.62)	1.18	(0.57, 2.43)	4.07*	(1.18 , 13.9 7)	1.99	(0.80 , 4.95)
Employed	2.36***	(1.61, 3.45)	1.51	(0.93, 2.46)	2.28**	(1.23 , 4.23)	2.09	(0.90 , 4.86)
Indigenous status (Ref: Non-Indigenous)								
Indigenous	2.62	(0.80, 8.54)	1.30	(0.47, 3.61)	5.80*	(1.51 , 22.2 2)	2.79*	(1.24 , 6.28 )
Socio-economic status for area (Ref: Least advantaged)								
2nd	0.88	(0.53, 1.45)	0.96	(0.62, 1.49)	0.63	(0.28 , 1.39)	0.83	(0.44 , 1.57)
3rd	0.68	(0.39, 1.18)	0.79	(0.49, 1.29)	0.49	(0.21 , 1.15)	0.64	(0.32 , 1.28)
4th	0.91	(0.55, 1.52)	1.12	(0.71, 1.76)	0.89	(0.40 , 1.98)	1.34	(0.72 , 2.53)
Most advantaged	0.71	(0.42, 1.21)	1.10	(0.67, 1.79)	0.32*	(0.13 , 0.78)	0.60	(0.28 , 1.30)

<sup>a</sup>Odds ratio. \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

Table 2. Association between intention to quit, reduction in smoking and patterns of e-cigarette use among past year smokers (those who reported past year smoking and current smoking, N = 3262, and those who reported past year smoking but no current smoking, N = 953, Total N = 4215). The reference category was “No e-cigarette use” (N = 3034).

Unadjusted	Tried, but no current use (N = 995)		Occasional use (N = 113)		Daily use (N = 73)	
	RRR <sup>a</sup>	95% CI	R	95% CI	RRR	95% CI
Intention to quit/ reduction in smoking (ref: No intention to quit and no reduction in smoking)						
Intended to quit and no reduction in smoking	1.36*	(1.09, 1.69)	1.19	(0.69, 2.06)	3.38*	(1.16, 9.84)
Not intended to quit but reduced smoking	1.16	(0.83, 1.61)	0.79	(0.31, 1.99)	3.17	(0.84, 11.91)
Intended to quit and reduced smoking	1.91***	(1.52, 2.41)	1.69	(0.96, 2.96)	4.08*	(1.36, 12.26)
No longer smoke (recent quitter)	1.11	(0.87, 1.43)	0.58	(0.28, 1.19)	6.30*	(2.19, 18.19)
Adjusted for age, gender, marital status, psychological distress and cannabis use.						
Intention to quit/ reduction in smoking (ref: No intention to quit and no reduction in smoking)						
Intended to quit and no reduction in smoking	1.26*	(1.00, 1.58)	1.15	(0.66, 1.99)	3.43*	(1.17, 10.01)
Not intended to quit but reduced smoking	1.19	(0.84, 1.67)	0.80	(0.31, 2.03)	3.40	(0.90, 12.82)
Intended to quit and reduced smoking	1.59***	(1.25, 2.02)	1.45	(0.82, 2.57)	3.88*	(1.29, 11.73)
No longer smoke (recent quitter)	0.97	(0.75, 1.26)	0.54	(0.26, 1.13)	6.46*	(2.22, 18.77)

<sup>a</sup>Relative risk ratio. \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

**Acknowledgements:** We would like to acknowledge the Australian Institute of Health and Welfare for the provision of the National Drug Strategy Household Survey data. We would also like to acknowledge the Australian Data Archive for access to the NDSHS.

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- The prevalence of e-cigarette use was low in Australia.
- Smoking status was the strongest correlate of e-cigarette use.
- Male, younger age, and psychological distress were associated with e-cigarette use.
- An intention to quit smoking was associated with daily use among smokers.
- Recent quitting was associated with daily e-cigarette use.

ACCEPTED MANUSCRIPT