Research Paper

E-cigarette use is associated with susceptibility to tobacco use among Australian young adults

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ABSTRACT

Background: Calls have been made to relax current Australian regulations related to e-cigarettes to increase the accessibility of the devices for smoking cessation purposes. However, e-cigarettes have been found to increase risk of initiation of conventional cigarette smoking, especially among young adults. To assist in guiding the development of policy in Australia, the present study examined whether e-cigarette use among Australian young adults who have never smoked a tobacco cigarette is associated with susceptibility to future tobacco cigarette use.

Method: An online web panel provider recruited 519 never smokers aged 18–25 years (55% female; average age = 21.21 years, SD = 2.32). Respondents completed an online survey that assessed their curiosity about tobacco smoking, willingness and intentions to smoke, and a number of individual and social factors. Cross-sectional regression analyses were conducted to assess the association between e-cigarette use and susceptibility to tobacco cigarette use while controlling for multiple covariates.

Results: Curiosity about tobacco smoking, willingness to smoke, and intentions to smoke were significantly higher among users of e-cigarettes than never users. The relationship between e-cigarette use and susceptibility to future tobacco cigarette use remained significant after controlling for numerous covariates.

Conclusion: E-cigarette use, even just one or two puffs, has the potential to increase susceptibility to tobacco cigarette use among Australian young adults. Findings suggest that increasing the availability of e-cigarettes by relaxing current strict regulations surrounding their sale may have unintended consequences.

Introduction

Tobacco smoking is one of the leading causes of preventable illness and premature death globally (Benziger, Roth, & Moran, 2016; Gravely et al., 2017). Over the past few decades, tobacco control efforts such as taxes and smoke-free laws have been successful in significantly reducing smoking prevalence (Gravely et al., 2017). However, a novel form of smoking via the use of electronic cigarettes (e-cigarettes) has been identified as both an opportunity and a threat for tobacco control (World Health Organization Framework Convention on Tobacco Control, 2014).

E-cigarettes use a heating element to vaporise a solution that typically comprises nicotine, flavouring, water, additives, and propylene glycol and/or vegetable glycerine (Hajek, Etter, Benowitz, Eissenberg, & McRobbie, 2014). Although e-cigarettes are likely to be less harmful than conventional tobacco cigarettes (Glasser et al., 2017), they have been found to contain a number of substances known to be harmful to humans including diethylene glycol, formaldehyde, tobacco-specific nitrosamines, nicotine, and heavy metals (Chivers, Janka, Franklin, Mullins, & Larcombe, 2019; El-Hellani et al., 2016; Goniewicz et al., 2014; Hess et al., 2017; Kosmider et al., 2016; Offermann, 2015; Schripp, Markewitz, Uhde, & Salthammer, 2013). Furthermore, there is considerable heterogeneity in quality control, product content, and product labelling (Czoli, Goniewicz, Palumbo, White, & Hammond, 2018; El-Hellani et al., 2016). Concerns have therefore been raised that these products represent an unnecessary source of exposure to harmful constituents (Lindblom, 2015).

Other issues associated with the introduction of e-cigarettes have

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also been identified. These include the potential for the renormalisation of smoking behaviours (Gilreath et al., 2016; Gostin & Glasner, 2014; Sæbø & Scheffels, 2017), the appeal of the devices to youth (Fiore, Schroeder, & Baker, 2014), and increased susceptibility to tobacco cigarette smoking among never smokers (Bunnell et al., 2015; Leventhal et al., 2015; Primack, Soneji, Stoolmiller, Fine, & Sargent, 2015). In terms of the renormalisation of smoking behaviours and appeal to youth, it has been suggested that the marketing of e-cigarettes and the use of these devices in places where conventional cigarette smoking is prohibited may enhance the attractiveness of smoking behaviours (Sæbø & Scheffels, 2017; World Health Organization Framework Convention on Tobacco Control, 2014). This is of particular concern in the context of youth, with evidence indicating that e-cigarettes, and more specifically the various flavours of e-liquids and the innovative nature of the devices, appeal to younger populations (Fiore et al., 2014; Kong, Morean, Cavallo, Camenga, & Krishnan-Sarin, 2015; Rass, Pacek, Johnson, & Johnson, 2015).

In terms of increased susceptibility to tobacco cigarette smoking, e-cigarettes may serve as a gateway product to conventional tobacco use and contribute to the development of a new population of cigarette smokers via exposure to nicotine and the behavioural and sensory cues associated with smoking (Bunnell et al., 2015; Leventhal et al., 2015; Primack et al., 2015). There is substantial evidence supporting the "gateway hypothesis", with longitudinal research conducted in the US indicating that use of e-cigarettes among young adults significantly predicts initiation of tobacco cigarette smoking among non-smokers and higher risk of more frequent and heavy smoking among current smokers (Leventhal et al., 2016; Loukas, Marti, Cooper, Pasch, & Perry, 2018; Primack et al., 2018). An alternative explanation for the relationship between e-cigarette use and subsequent tobacco cigarette smoking is based on "common liability theory", which postulates that users of multiple drugs share predisposing characteristics and it is these characteristics that result in a propensity for drug use rather than use of any one drug predicting use of another (Vanyukov et al., 2012). Common liability theory has been used to argue that the relationship between e-cigarette use and subsequent conventional cigarette smoking results from a common predisposition to drug use among susceptible individuals and, as such, any correlation observed between the variables is spurious (Etter, 2018). However, longitudinal studies have observed that the strongest association between e-cigarette use and smoking initiation occurs among youth who are least susceptible to smoking (Barrington-Trimis et al., 2016; Wills, Sargent, Gibbons, Pagano, & Schweitzer, 2017), a finding that is incompatible with common liability theory.

In Australia, the context of the present study, the sale of e-cigarettes that contain nicotine is prohibited in all jurisdictions. E-cigarettes that do not contain nicotine are regulated in the same way as tobacco in all jurisdictions, with the exception of Western Australia where the sale of non-nicotine e-cigarettes is prohibited. Calls have been made to relax these strict regulations to increase the accessibility of the devices for smoking cessation purposes (Mendelsohn, 2016). However, previous research suggests that young adults do not use e-cigarettes primarily for smoking cessation (Biener, Song, Sutfin, Spangler, & Wolfson, 2015; Kong et al., 2015; Schmidt, Reidmohr, Harwell, & Helgerson, 2014; Sutfin et al., 2015), raising concerns that relaxing Australian laws has the potential to increase harm to youth and young adults (Wolfenden, Stockings, & Yoong, 2018). Furthermore, given the consequences associated with the introduction of e-cigarettes outlined above, increasing the availability and accessibility of the devices by relaxing regulations has the potential to increase risk of initiation of conventional cigarette smoking in this population segment, as has been the case in jurisdictions where the regulatory environment is less strict (Leventhal et al., 2016; Loukas et al., 2018; Primack et al., 2018).

Present study

One of the most important advances in the tobacco control field has been the denormalisation of smoking behaviours (Fairchild, Bayer, & Colgrove, 2014). This denormalisation is potentially threatened by the increasing popularity of e-cigarettes (Barrington-Trimis et al., 2016; Voigt, 2015; World Health Organization Framework Convention on Tobacco Control, 2014). To date, research examining the potential for e-cigarettes to act as a gateway substance to conventional tobacco smoking among young people has been conducted in countries with liberal regulations on the sale and use of e-cigarettes (e.g., the US and UK) rather than those with more restrictive regulatory environments (e.g., Australia and Canada). To extend the existing evidence base, the present study sought to assess the extent to which e-cigarette use among Australians aged 18–25 years who have never smoked a conventional tobacco cigarette is associated with susceptibility to future tobacco cigarette use. Susceptibility to tobacco use is a well-documented milestone along the trajectory to established cigarette smoking (Pierce, Choi, Gilpin, Farkas, & Merritt, 1996) and is operationalised as (i) curiosity about smoking, (ii) willingness to smoke, and (iii) intentions to smoke (Nodora et al., 2014; Pierce, Distefan, Kaplan, & Gilpin, 2005). Several social and behavioural characteristics were included as covariates in the present study to minimise the extent to which the results could be attributed to 'common liability'. There is a lack of research assessing moderators of the association between e-cigarette use and each of the three susceptibility variables outlined above. Potential moderators of this relationship were therefore also examined in the present study to inform prevention efforts.

Young adults were chosen as the population segment of interest for two reasons. First, they are the most prevalent users of e-cigarettes relative to other age groups (Jaber et al., 2018). Second, young adulthood represents a critical period for the establishment of health and risk behaviours that persist through to adulthood (Delnevo, Giovenco, Ambrose, Corey, & Conway, 2015), including tobacco use (Coleman et al., 2015; Foldes et al., 2010; Hammond, 2005; Rath, Villanti, Abrams, & Vallone, 2012). This developmental period is therefore crucial for prevention and intervention efforts (Orlando, Tucker, Ellickson, & Klein, 2004).

Method

Sample and recruitment

As part of a broader study assessing tobacco cigarette and e-cigarette use among Australian young adults (Jongenelis et al., 2019) an ISO-accredited web panel provider (PureProfile) recruited 519 never smokers aged 18–25 years (55% female; average age = 21.21 years, *SD* = 2.32) in August and September of 2016. Among these never smokers, 429 had never used an e-cigarette, 90 had used an e-cigarette at least once, and 20 were current users (i.e., had used an e-cigarette in the last 30 days at a frequency of at least monthly). The study received approval from a university Human Research Ethics Committee and all respondents provided informed consent prior to participation.

Measures

Outcome variables

The dependent variables under investigation were curiosity about smoking a tobacco cigarette, willingness to smoke a tobacco cigarette, and intentions to smoke a tobacco cigarette in the next six months. These variables are considered strong indicators of susceptibility to smoking and have been used in previous studies (Bold et al., 2017; Pierce et al., 1996). Curiosity was assessed by asking respondents: *How curious are you about smoking tobacco cigarettes?* with responses made on a scale of 1 (*not at all curious*) to 5 (*very curious*). Willingness to smoke tobacco cigarettes was measured by asking respondents to imagine they

were with a group of friends and there were some tobacco cigarettes they could have if they wanted. Respondents were then asked to indicate how willing they would be to *(i) take one puff, (ii) smoke a whole cigarette,* and *(iii) take some cigarettes to try later.* Responses to all three items were made on a scale of 1 (*not at all willing*) to 5 (*very willing*). For analysis purposes, a "willingness" variable was created comprising the grand mean of these three items. Use intentions were measured by asking those surveyed to respond to the statement *I intend to smoke a tobacco cigarette in the next 6 months* (response options: 1 = *definitely not* to 4 = *definitely yes*).

Independent variables

E-cigarette use was the primary independent variable of interest to the present study, with several individual and social variables included as covariates.

E-cigarette use. Respondents were asked if they had ever used an e-cigarette. Those who responded in the affirmative were subsequently asked if they had used one in the last 30 days and at what frequency (*daily, weekly, fortnightly, monthly, less than monthly*). As noted above, respondents who reported using e-cigarettes in the last 30 days at a frequency of at least monthly were classified as current users.

Individual variables. Respondents were asked to report their gender, age, and postcode. Postcode data were used to calculate socioeconomic status (SES) as per the Australian Bureau of Statistics' Socio-Economic Index for Areas *Index of Relative Disadvantage* (Australian Bureau of Statistics, 2018). Sensation seeking traits were measured using an adapted version of the Brief Sensation Seeking Scale (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002). Respondents answered four items (e.g., *I love to have new and exciting experiences, even if I have to break the rules*) on a scale of 1 (*strongly disagree*) to 5 (*strongly agree*). Cronbach's alpha for scores on this scale was 0.82. A grand mean comprising responses to all items was created for analysis purposes.

Positive cigarette expectancies were measured by asking respondents to indicate the extent to which they agreed or disagreed with statements such as *Smoking tobacco cigarettes makes people feel more relaxed* (response options: 1 = *strongly disagree* to 5 = *strongly agree*) (adapted from Pokhrel, Little, Fagan, Muranaka, & Herzog, 2014; Wills, Knight, Williams, Pagano, & Sargent, 2015). Cronbach's alpha for scores on this scale was 0.95. A grand mean comprising responses to all items was created for analysis purposes. Belief in the harm associated with tobacco cigarettes was assessed with a single item that asked respondents to indicate how harmful they believe tobacco cigarettes are to health (1 = *not at all harmful* to 5 = *very harmful*; *don't know*). Respondents were also asked to indicate the addictiveness of tobacco cigarettes (response options: 1 = *not at all addictive* to 5 = *very addictive*; *don't know*). A 5-point semantic differential scale (adapted from Farrelly et al., 2015) was used to assess general attitudes to tobacco cigarette use. Respondents were asked to rate the use of cigarettes on several characteristics (*boring/fun, unenjoyable/enjoyable, stupid/smart, uncool/cool, unattractive/attractive*), each presented in random order (Cronbach's alpha = 0.95). A grand mean was produced, with a higher score indicative of a more favourable attitude to tobacco cigarettes.

Social variables. Pressure perceived from others to smoke cigarettes was assessed by asking respondents: *Do the following people or groups place any pressure on you about smoking tobacco cigarettes?* Five different social groups were presented – *my family, my friends, my partner (if applicable), my colleagues (if applicable),* and *society.* Responses to each were made on a scale of 1 (*pressure me not to use*) to 5 (*pressure me to use*). Cronbach's alpha for scores on this scale was 0.92. A "social pressure" variable was created comprising the grand mean of scores for all five social groups. The grand means of scores for respondents for whom the 'partner' and 'colleagues' items were not applicable were calculated

based on their responses to the applicable items.

Use of tobacco cigarettes among (i) family members, (ii) friends, and (iii) those living in the home were measured using the following items: *How many members of your immediate family currently smoke tobacco cigarettes (either socially or regularly)?* (response options: 0 = *0* to 5 = *more than 4*); *How many of your 4 closest friends currently smoke tobacco cigarettes (either socially or regularly)?* (response options: 0 = *0* to 4 = *4*); and *Does anyone who lives with you now currently smoke tobacco cigarettes (either socially or regularly)?* (*yes* or *no* response options). The question *In general, to what extent do people who are important to you disapprove of smoking tobacco cigarettes?* was used to assess respondents' perceptions of others' disapproval, with responses made on a scale of 1 (*not at all*) to 5 (*a great deal*).

Statistical analysis

Descriptive statistics were calculated to determine the extent to which respondents were curious about smoking, willing to smoke, and intended to smoke in the next six months. As previous research suggests that lacking a firm intention to not smoke is a robust predictor of increased risk of actual use (Wakefield et al., 2004), descriptive statistics were also calculated determining respondents' abstinence commitment for the next six months (i.e., responding 'definitely not' on the item assessing intentions to smoke). Independent samples *t*-tests were conducted to assess differences in susceptibility by e-cigarette user status (never user vs. ever user, never user vs. current user). Comparisons were not made between ever users and current users as these groups were not mutually exclusive.

Hierarchical multiple linear regression analyses were conducted to assess whether ever e-cigarette use and current e-cigarette use were significantly associated with curiosity about smoking, willingness to smoke, and intentions to smoke in the next six months. Analyses were conducted for each outcome separately, with individual and social covariates entered in Step 1 and either ever e-cigarette use or current e-cigarette use entered in Step 2. The PROCESS macro available in SPSS was used to assess for moderating effects, with variables centred prior to analysis.

Results

Descriptive statistics

Overall, curiosity about smoking and willingness to smoke were low (Table 1). Ever and current users of e-cigarettes were significantly more curious about smoking and willing to smoke than those who had never used an e-cigarette. One in five (22%) ever users of e-cigarettes and three in five (60%) current users of e-cigarettes intended to smoke a tobacco cigarette in the next six months compared to just 3% of never users.

E-cigarette use and susceptibility to tobacco smoking

Ever e-cigarette use (Table 2) and current e-cigarette use (Table 3) were significantly associated with all variables assessing susceptibility to tobacco cigarette use. These relationships were significant even when controlling for all individual and social covariates. In the model assessing ever e-cigarette use, however, other variables were found to be more important correlates of susceptibility to tobacco use. These variables were both individual and social in nature, and included harm perceptions, perceived social pressure to smoke tobacco cigarettes, having friends and family members who smoke tobacco cigarettes, and living with someone who smokes tobacco cigarettes. Of these, harm perceptions appeared to be most important, with greater harm perceptions associated with being less curious about tobacco cigarette use, less willing to smoke tobacco cigarettes, and weaker intention to smoke in the future. By contrast, current e-cigarette use was found to be the

Table 1
Susceptibility to tobacco cigarette use, stratified by e-cigarette user status.

| | E-cigarette user status | | | | | | | |
| | Overall (*n* = 519) | | Never user (*n* = 429) | | Ever user (*n* = 90) | | Current user (*n* = 20) | |
	M (*SD*)	%	M (*SD*)	%	M (*SD*)	%	M (*SD*)	%
Curiosity	1.61 (1.04)	31[a]	1.46[†] (0.89)	26[a]	2.30 (1.38)	57[a]	3.70 (0.98)	95[a]
Willingness	1.46 (0.87)	34[b]	1.35[†] (0.74)	29[b]	1.99 (1.19)	56[b]	3.10 (1.21)	85[b]
Intention to use	1.28 (0.61)	6[c]	1.19[†] (0.49)	3[c]	1.67 (0.90)	22[c]	2.50 (0.95)	60[c]
Lack of firm intention to abstain	N/A	20[d]	N/A	16[d]	N/A[d]	41[d]	N/A	80[d]

Note. N/A = not applicable. E-cigarette 'ever user' and 'current user' subgroups are not mutually exclusive.
[a] Selected 2, 3, 4, or 5 on a scale of 1 (*not at all curious*) to 5 (*very curious*).
[b] Selected 2, 3, 4, or 5 on a scale of 1 (*not at all willing*) to 5 (*very willing*) on at least 1 of the 'willingness' items.
[c] Selected 3 or 4 on a scale of 1 (*definitely not*) to 4 (*definitely yes*).
[d] Selected 2, 3, or 4 on a scale of 1 (*definitely not*) to 4 (*definitely yes*).
[†] Significantly different to ever and current users at $p < .001$.

most important correlate of susceptibility to tobacco cigarette smoking in the model assessing its contribution. Specifically, the regression coefficients associated with the relationships between current e-cigarette use and the susceptibility variables were larger than or equal to those observed for all other independent variables, including harm perceptions.

E-cigarette use and susceptibility to tobacco smoking – moderating effects

Analyses were conducted to determine if the relationship between e-cigarette use and susceptibility to tobacco use was moderated by any of the independent variables assessed in the present study (Table 4). A Bonferonni-adjusted alpha level of .004 was used to control for the family-wise error rate. Perceived pressure to use tobacco cigarettes was found to be an important moderator, significantly affecting the strength of the relationship between (i) ever e-cigarette use and all three susceptibility variables and (ii) current e-cigarette use and willingness to smoke. In all instances, the relationship between ever or current e-cigarette use and the susceptibility variable under investigation was stronger among those who perceived greater pressure from others to smoke. The variables of social disapproval, number of family members who smoke, and living with someone who smokes also acted as moderators, albeit between fewer relationships.

Discussion

To examine the potential for e-cigarette use to act as a gateway to conventional tobacco cigarette smoking among young adults, the present study examined susceptibility to future tobacco cigarette use among young adult e-cigarette users. Several covariates were included in analyses to account for the possibility that e-cigarette users and smokers share similar individual and social characteristics that increase their susceptibility to product use. Results provide evidence relating to the possible consequences of relaxing regulations around e-cigarettes and thus have the potential to inform current policy debate in Australia.

E-cigarette use has been found to be a clear and consistent indicator of subsequent initiation of tobacco cigarette use among youth living in countries with permissive regulatory environments (Best et al., 2018; Conner et al., 2018; Leventhal et al., 2015; Loukas et al., 2018; Primack et al., 2015, 2018). The present results from an Australian sample of young adults support this research and the assertion that e-cigarette use may act as a gateway to traditional cigarette use (Primack et al., 2015). After accounting for a wide range of individual and social covariates, e-cigarette use (both ever use and current use) remained significantly associated with susceptibility to tobacco cigarette smoking. Respondents who had ever used e-cigarettes or were current users of the devices were significantly more curious about trying a tobacco cigarette, significantly more willing to smoke, and reported significantly

greater intention to smoke in the next six months compared to never e-cigarette users. Furthermore, the vast majority of current e-cigarette users lacked a firm intention to not smoke in the next six months, and nearly two-thirds reported that they will probably or definitely smoke a tobacco cigarette in the future.

Figures from the Australian National Drug Strategy Household Survey on age of smoking initiation indicate that among adults who report being daily smokers, 20% initiated their cigarette use after reaching adulthood (Australian Institute of Health & Welfare, 2017). Based on these figures, it can be suggested that a large majority of young adult never smokers surveyed in the present study were at low risk of smoking initiation. The results indicating that 60% of current e-cigarette users intended to smoke tobacco cigarettes in the next six months suggest e-cigarette use has the potential to increase risk of smoking initiation among young adults who would otherwise be at low risk. This finding is incompatible with common liability theory and the argument that the link between e-cigarette use and tobacco cigarette smoking is due to the presence of a common predisposition to drug use among susceptible individuals (Etter, 2018). Rather, the results of the present study are consistent with research that has found the strongest association between e-cigarette use and smoking initiation occurs among youth with the lowest risk of smoking (Barrington-Trimis et al., 2016; Wills et al., 2017), and provide further support for the proposition that e-cigarette use may be contributing to rather than ameliorating the "tobacco epidemic" among young adults (Dutra & Glantz, 2014). The findings suggest that relaxing the current strict regulations surrounding the sale of e-cigarettes in Australia may have the unintended consequence of contributing to smoking initiation among youth. Although it has been suggested that deregulating e-cigarettes could facilitate higher rates of smoking cessation (Mendelsohn, 2016), there is insufficient evidence that e-cigarettes are an effective cessation therapy (National Academies of Sciences, Engineering, & Medicine, 2018). The results of the present study indicate that until such evidence is available, protecting youth from the harms associated with e-cigarettes by maintaining existing regulations should be a public health priority.

Analyses revealed that the social variables under investigation were more likely than the individual variables to moderate the relationship between e-cigarette use and susceptibility to tobacco smoking. In most instances, e-cigarette use was significantly associated with susceptibility to tobacco use at all conditional levels of the moderator (i.e., -1SD, Mean, +1SD), however the strength of the relationship between e-cigarette use and susceptibility was amplified when the assessed social factors were also conducive to tobacco use (e.g., when pressure to use tobacco cigarettes was high or when people had a larger number of family members who smoked tobacco cigarettes). These results suggest that efforts to minimise initiation of tobacco smoking in young adults should comprise a comprehensive suite of strategies that in combination reduce the availability of e-cigarettes and continue to denormalise

Table 2
Hierarchical multiple regression analysis of factors associated with susceptibility to tobacco cigarette use (predictor = ever e-cigarette use).

Independent variable	Curiosity				Willingness				Intentions			
	B (SE)	β	95% CI for B	p	B (SE)	β	95% CI for B	p	B (SE)	β	95% CI for B	p
Individual												
Gender	−0.17 (0.09)	−.08	−0.35, 0.00	.053	−0.13 (0.08)	−.07	−0.28, 0.02	.087	−0.09 (0.05)	−.07	−0.18, 0.01	.074
Age	−0.03 (0.02)	−.07	−0.07, 0.01	.115	−0.01 (0.02)	−.01	−0.04, 0.03	.723	−0.01 (0.01)	−.04	−0.03, 0.01	.285
SES (continuous)	0.00 (0.00)	.06	0.00, 0.00	.191	0.00 (0.00)	.00	−0.00, 0.00	.952	0.00 (0.00)	−.01	−0.00, 0.00	.828
Sensation seeking	0.05 (0.05)	.04	−0.06, 0.15	.410	0.03 (0.05)	.03	−0.06, 0.12	.504	0.05 (0.03)	.06	−0.01, 0.10	.125
Positive expectancies	**0.17 (0.05)**	.16	**0.08, 0.26**	**< .001**	**0.13 (0.04)**	.14	**0.05, 0.21**	**.001**	0.04 (0.03)	.06	−0.01, 0.09	.155
Harm perceptions	**−0.29 (0.07)**	−.19	**−0.42, −0.15**	**< .001**	**−0.29 (0.06)**	−.22	**−0.40, −0.17**	**< .001**	**−0.22 (0.04)**	−.25	**−0.29, −0.15**	**< .001**
Addictiveness perceptions	0.04 (0.05)	.04	−0.05, 0.13	.387	−0.02 (0.04)	−.02	−0.09, 0.06	.677	0.00 (0.02)	.00	−0.05, 0.05	.943
General attitudes	−0.02 (0.04)	−.02	−0.10, 0.06	.612	0.03 (0.03)	.04	−0.04, 0.09	.428	0.01 (0.02)	.02	−0.03, 0.05	.709
Social												
Social pressure	**0.21 (0.05)**	.17	**0.11, 0.32**	**< .001**	**0.21 (0.05)**	.19	**0.12, 0.29**	**< .001**	**0.12 (0.03)**	.18	**0.07, 0.18**	**< .001**
Social disapproval	0.03 (0.04)	.04	−0.04, 0.11	.416	0.06 (0.03)	.09	−0.00, 0.12	.059	0.03 (0.02)	.07	−0.01, 0.07	.132
# family members who smoke	**0.09 (0.05)**	.09	**0.00, 0.18**	**.048**	**0.12 (0.04)**	.14	**0.04, 0.19**	**.002**	**0.08 (0.02)**	.14	**0.03, 0.12**	**.002**
# friends who smoke	**0.14 (0.05)**	.14	**0.05, 0.24**	**.004**	**0.14 (0.04)**	.16	**0.06, 0.22**	**< .001**	**0.10 (0.03)**	.17	**0.05, 0.15**	**< .001**
Lives with someone who smokes	**0.45 (0.11)**	.18	**0.23, 0.67**	**< .001**	**0.28 (0.09)**	.13	**0.09, 0.47**	**.003**	**0.21 (0.06)**	.15	**0.09, 0.33**	**< .001**
E-cigarette ever use	**0.28 (0.13)**	.10	**0.03, 0.53**	**.026**	**0.21 (0.11)**	.09	**0.01, 0.42**	**.044**	**0.22 (0.07)**	.14	**0.08, 0.35**	**.001**

Note. Step 1 results not presented. Significant results presented in bold.

Table 3
Hierarchical multiple regression analysis of factors associated with susceptibility to tobacco cigarette use (predictor = current e-cigarette use).

Independent variable	Curiosity				Willingness				Intentions			
	B (SE)	β	95% CI for B	p	B (SE)	β	95% CI for B	p	B (SE)	β	95% CI for B	p
Individual												
Gender	−0.14 (0.09)	−.07	−0.32, 0.03	.105	−0.10 (0.07)	−.06	−0.25, 0.04	.173	−0.06 (0.05)	−.05	−0.16, 0.03	.176
Age	−0.03 (0.02)	−.06	−0.07, 0.01	.130	−0.00 (0.02)	−.01	−0.04, 0.03	.784	−0.01 (0.01)	−.04	−0.03, 0.01	.329
SES	0.00 (0.00)	.06	0.00, 0.00	.130	0.00 (0.00)	.01	−0.00, 0.00	.837	0.00 (0.00)	.00	−0.00, 0.00	.972
Sensation seeking	0.04 (0.05)	.04	−0.06, 0.15	.412	0.03 (0.05)	.03	−0.06, 0.12	.518	0.05 (0.03)	.06	−0.01, 0.10	.119
Positive expectancies	**0.17 (0.05)**	.17	**0.08, 0.27**	**< .001**	**0.14 (0.04)**	.15	**0.06, 0.21**	**< .001**	0.04 (0.03)	.07	−0.01, 0.09	.109
Harm perceptions	**−0.26 (0.07)**	−.17	**−0.40, −0.13**	**< .001**	**−0.26 (0.06)**	−.20	**−0.38, −0.15**	**< .001**	**−0.20 (0.04)**	−.23	**−0.27, −0.13**	**< .001**
Addictiveness perceptions	0.03 (0.04)	.03	−0.06, 0.12	.491	−0.02 (0.04)	−.03	−0.10, 0.05	.541	−0.01 (0.02)	−.01	−0.05, 0.04	.838
General attitudes	−0.02 (0.04)	−.02	−0.09, 0.06	.697	0.03 (0.03)	.04	−0.03, 0.09	.366	0.01 (0.02)	.02	−0.03, 0.05	.566
Social												
Social pressure	**0.18 (0.05)**	.14	**0.07, 0.28**	**< .001**	**0.17 (0.05)**	.16	**0.09, 0.26**	**< .001**	**0.10 (0.03)**	.14	**0.04, 0.15**	**< .001**
Social disapproval	0.02 (0.04)	.03	−0.05, 0.10	.552	0.05 (0.03)	.08	−0.01, 0.12	.086	0.02 (0.02)	.05	−0.02, 0.06	.224
# family members who smoke	0.08 (0.04)	.09	−0.00, 0.17	.057	**0.11 (0.04)**	.14	**0.04, 0.18**	**.003**	**0.07 (0.02)**	.13	**0.03, 0.12**	**.002**
# friends who smoke	**0.14 (0.05)**	.13	**0.04, 0.23**	**.004**	**0.13 (0.04)**	.15	**0.05, 0.21**	**< .001**	**0.10 (0.03)**	.16	**0.05, 0.15**	**< .001**
Lives with someone who smokes	**0.39 (0.11)**	.16	**0.17, 0.61**	**< .001**	**0.21 (0.09)**	.10	**0.03, 0.40**	**.023**	**0.16 (0.06)**	.11	**0.05, 0.28**	**.007**
E-cigarette current use	**1.04 (0.25)**	.19	**0.55, 1.52**	**< .001**	**0.98 (0.21)**	.20	**0.57, 1.38**	**< .001**	**0.80 (0.13)**	.25	**0.54, 1.06**	**< .001**

Note. Step 1 results not presented. Significant results presented in bold.

Table 4
Parameter estimates associated with moderators of the relationship between ever and current e-cigarette use and each of the susceptibility outcome variables.

Moderator	Ever users			Current users		
	Curiosity	Willingness	Intentions	Curiosity	Willingness	Intentions
Gender	0.09 (0.23)	−0.05 (0.19)	0.20 (0.13)	0.09 (0.47)	0.29 (0.40)	0.61 (0.27)[*]
Age	0.13 (0.05)[*]	0.06 (0.04)	0.08 (0.03)[**]	0.17 (0.11)	0.03 (0.09)	−0.07 (0.06)
SES	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Sensation seeking	0.02 (0.15)	−0.08 (0.12)	0.04 (0.09)	−0.17 (0.39)	0.17 (0.33)	−0.11 (0.23)
Positive expectancies	0.14 (0.13)	0.15 (0.11)	0.13 (0.08)	−0.02 (0.32)	0.64 (0.27)[*]	0.45 (0.19)[*]
Harm perceptions	−0.16 (0.13)	−0.19 (0.11)	−0.20 (0.07)[**]	0.45 (0.19)[*]	0.30 (0.16)	0.11 (0.11)
Addictiveness perceptions	0.25 (0.10)[*]	0.12 (0.09)	0.12 (0.06)[*]	0.71 (0.25)[**]	0.55 (0.21)[**]	0.10 (0.14)
General attitudes	0.03 (0.09)	0.06 (0.08)	0.05 (0.05)	0.22 (0.31)	0.71 (0.26)[**]	0.27 (0.18)
Social pressure	**0.40 (0.13)**[†]	**0.41 (0.10)**[†]	**0.34 (0.07)**[†]	0.40 (0.29)	**0.89 (0.24)**[†]	0.31 (0.17)
Social disapproval	0.18 (0.09)[*]	0.09 (0.07)	0.02 (0.05)	0.59 (0.27)[*]	**0.84 (0.23)**[†]	0.15 (0.16)
# family members who smoke	**0.36 (0.09)**[†]	0.21 (0.08)[*]	**0.19 (0.05)**[†]	0.14 (0.19)	−0.13 (0.16)	−0.28 (0.11)[**]
# friends who smoke	0.23 (0.10)[*]	0.24 (0.08)[*]	0.11 (0.06)	0.15 (0.21)	0.20 (0.17)	−0.08 (0.12)
Lives with someone who smokes	0.44 (0.24)	0.58 (0.20)[*]	0.38 (0.14)[*]	0.21 (0.49)	**1.30 (0.42)**[†]	0.75 (0.29)[**]

[†] Significant at Bonferroni-adjusted alpha level of .004 (presented in bold).
[*] Significant at $p < .05$.
[**] Significant at $p < .01$.

and reduce the attractiveness of smoking behaviours. At the individual level, interventions that increase individuals' confidence in their ability to refuse a cigarette or e-cigarette when offered by relatives or friends (i.e., 'refusal self-efficacy': de Vries, Dijkstra, & Kuhlman, 1988) may assist them to manage the pressure they receive from others to smoke and reduce smoking onset (Hiemstra, Otten, & Engels, 2012). At the population level, anti-smoking campaigns that focus on peer disapproval of smoking may constitute an effective means of preventing initiation (Brennan, Gibson, Kybert-Momjian, Liu, & Hornik, 2017).

Limitations

The present study had several limitations. First, the data were cross-sectional in nature and causality cannot be assumed. Longitudinal research is required to provide more robust evidence for the relationship between e-cigarette use and susceptibility to tobacco cigarette smoking among Australian young adults. Longer-term research is also needed to determine whether e-cigarette use among never smokers has the potential to increase tobacco smoking rates and the associated burden of disease. Second, as the online survey used to administer the measures could be accessed via an invitation email distributed to panel members or via a link on PureProfile's website, it is unknown how many individuals were exposed to the link. As such, response rates could not be calculated. Finally, the number of current e-cigarette users who had never smoked a conventional tobacco cigarette was small ($n = 20$). Although small sample sizes typically lead to non-significant results due to attenuated power, statistically significant results were obtained in the present study. This indicates that the observed effects are likely to be an underestimate of the relationship between e-cigarette use and susceptibility to tobacco use.

Conclusion

The results of this study support previous findings indicating that e-cigarette use may contribute to the initiation of smoking-related behaviours among young adult non-smokers and has the potential to contribute to the development of a new population of tobacco cigarette smokers (Loukas et al., 2018; Primack et al., 2018). Ongoing surveillance of e-cigarettes and their potential to result in tobacco cigarette use is important to ensuring these devices do not undermine decades of effective tobacco control efforts that have produced a substantial decrease in smoking prevalence rates globally.

Authors' contributions

MJ conceptualised the study, conducted the statistical analyses, and took primary responsibility for preparing the manuscript. CK, EJ, DR, and SP advised on the study design and contributed to the writing of the article. All authors have approved the final article.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Statement on the welfare of animals

This article does not contain any studies with animals performed by any of the authors.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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