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# Adverse childhood experiences and electronic cigarette use among young Australian women

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## ABSTRACT

Researchers have identified positive relationships between childhood adversities and smoking, problem drinking and illicit drug abuse. Nonetheless, to our knowledge, in no studies has there been an examination of the association between adverse childhood experiences (ACEs) and e-cigarette use. This study aimed to investigate the association between ACEs and e-cigarette use.

Data from the Australian Longitudinal Study on Women's Health were used. Study respondents (N = 8915) from the 1989–95 cohort (third wave) aged 19–26 years completed an online survey in 2015. Multivariate logistic regression analysis was used to examine the association between ACEs and e-cigarette use, adjusted for socio-demographic variables and smoking status.

Participants who reported past year e-cigarette use were more likely to report childhood psychological abuse (Adjusted odds ratio (AOR) = 1.45, 99%CI: 1.11, 1.90), physical abuse (AOR = 1.30, 99%CI, 1.03, 1.82), or sexual abuse (AOR = 1.41, 99%CI, 1.02, 1.95). All abuse types associated with past year e-cigarette use were also associated with ever e-cigarette use. Ever e-cigarette use was also associated with household substance abuse (AOR = 1.35, 99%CI, 1.08, 1.68), witnessing domestic violence (AOR = 1.28, 99%CI, 1.01, 1.69), or having a mentally ill household member (AOR = 1.28, 99%CI, 1.05, 1.58) compared with those who were not. A positive dose-response relationship was observed between the number of ACEs and the odds of e-cigarette use.

This study identified an association between ACEs and e-cigarette use. Improvements in supportive parenting skills and the provision of counselling services for those exposed to ACEs may help avert health-harming behaviours, including e-cigarette use.

## 1. Introduction

There is evidence that traumatic events occurring during childhood (before age 18) can increase the risk of poor health outcomes during adult life (Felitti et al., 1998). Such traumatic events are collectively called Adverse Childhood Experiences (ACEs); these broadly comprise childhood abuse and household dysfunction. Childhood abuse includes physical, psychological and sexual abuse, while household dysfunction include household substance abuse, household mental illness, parental separation/divorce, incarcerated household members and witnessing domestic violence. Globally, child abuse is documented as a serious public health, human rights, legal and societal issue (Makaruk et al., 2018). In addition to genetic and nutritional factors childhood brain development can be affected by childhood adversity, with high levels of stress during childhood interfering with the normal development of

brain structures (Maté, 2012).

Researchers have identified a positive association between ACEs and physical health (e.g., diabetes, coronary heart disease, stroke) (Campbell et al., 2016; Felitti et al., 1998), mental health (e.g., depression, anxiety disorder, post-traumatic stress disorder, and suicidal ideation) (Campbell et al., 2016; Felitti et al., 1998) and risky behaviours (e.g., multiple sexual partners, sexually transmitted infection, abortion, and substance use) (Bleil et al., 2011; Campbell et al., 2016; Felitti et al., 1998).

The prevalence of at least one reported ACE among women in the USA ranges from 54.6% to 60.9% (Ford et al., 2011; Ye and Reyes-Salvail, 2014), while the prevalence is as high as 85% in Brazil (Soares et al., 2016). In recent research, Loxton and colleagues found that the prevalence of reporting at least one type of ACE in Australia among a cohort of women born 1973–1978 was 41% (Loxton et al., 2018).

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The first study of ACEs and adult health outcomes was conducted by Felitti and colleagues in 1998 in San Diego, Southern California to investigate the relationship between ACEs and leading causes of death in adults (Felitti et al., 1998). In subsequent studies, researchers have identified strong positive relationships between ACEs and substance use including smoking (Alcalá et al., 2016; Campbell et al., 2016; Ford et al., 2011; Fuller-Thomson et al., 2013) problem alcohol use (Campbell et al., 2016; Fang and McNeil, 2017), and illicit drug use (Alcalá et al., 2016). To our knowledge, no prior study has assessed the relationship between ACEs and e-cigarette use. Nicotine found in cigarettes reaches the brain and binds to nicotinic cholinergic receptors, stimulating the release of neurotransmitters such as adrenaline and dopamine (Benowitz, 2009). It is thus plausible that people who have experienced childhood traumatic stress may use nicotine in later life to produce pleasurable feelings that offset undesirable psychological experiences (Felitti et al., 1998).

Using longitudinal study designs researchers have found that e-cigarette use can lead to conventional cigarette smoking among young people (Lozano et al., 2017; Unger et al., 2016). There is no convincing evidence supporting the efficacy of e-cigarettes for long-term smoking cessation or the safety of e-cigarettes; there is also little evidence regarding the health consequences of e-cigarettes compared to those of traditional tobacco products (McKee and Capewell, 2015; Schraufnagel et al., 2014). On the other hand, there are studies which support e-cigarette use as an aid to smoking cessation. For example, in a cross-sectional study conducted in England among 5863 study participants, it was concluded that the rate of smoking cessation was higher among e-cigarette users compared to those who used other forms of nicotine replacement therapy (Brown et al., 2014). Researchers in this field have recommended the efficacy of e-cigarettes for smoking cessation be scientifically examined before policy is developed governing the sale and use of these products (Middlekauff, 2015; National Academies of Sciences and Medicine, 2018).

In most Australian states there is some form of legal restriction and ban on the supply, possession, and use of nicotine in e-cigarettes (Douglas et al., 2015). However, controlling e-cigarettes is difficult because many products are available online through international markets (Dunlop et al., 2016).

This study investigated the association between ACEs and e-cigarette use among young Australian women. The two hypotheses examined in this study were as follows:

- Individual categories of ACEs will be positively associated with both past year and ever e-cigarette use
- There will be a dose-response relationship between the number of reported ACEs and both past year and ever e-cigarette use

## 2. Methods

### 2.1. Study design

This study used data from the new national cohort of young Australian women born between 1989 and 95 collected as part of the Australian Longitudinal Study on Women's Health (ALSWH). ALSWH involves > 57,000 women in four cohorts. When surveys began in 1996, the original cohorts were aged 18–23, 45–50 and 70–75. In 2012/13 over 17,000 women aged 18–23 years were recruited to form the new 1989–95 birth cohort. The new cohort are surveyed annually and to date have completed five surveys. At baseline in 2012–13, a total of 17,011 study participants responded to the online survey. The study is funded by the Australian Department of Health and conducted jointly by the University of Newcastle and the University of Queensland (<http://www.alswh.org.au/about/methods>). This analysis included all 1989–95 birth cohort participants (N = 8915) who completed the third survey, where participants responded to a range of physical, mental, psychological, emotional health and health behaviour related questions

including e-cigarette use. The attrition for the third wave was 47% of participants in the baseline survey. Respondents were less likely to participate if they were less educated, were challenged by financial management, were smokers or reported very high levels of psychological distress at baseline (Loxton et al., in press).

### 2.2. Recruitment of study participants

Study participants were mainly recruited via social media including Facebook, YouTube, and Twitter. Emails were also sent to the previous cohorts, the ALSWH professional network, ALSWH collaborators and professional bodies to refer eligible study subjects to participate. Traditional media such as posters, business cards, leaflets, newspapers, television, and radio were also used to recruit eligible study participants. The majority of participants (70%) were recruited via Facebook. To be eligible, women had to have a Medicare card, agree to provide personal data, agree to participate in follow up survey and had to provide consent for external data linkage. Women who agreed to participate were sent an information sheet and consent form, in order to obtain written online consent. Detailed recruitment procedures are discussed elsewhere (Loxton et al., 2015; Mishra et al., 2014). Participants were broadly similar to the 2011 Australian census data regarding geographical distribution, age, and marital status but over representative of women with a university degree (Mishra et al., 2014). Ethics approval for the ALSWH was granted by the University of Queensland's and the University of Newcastle's Human Research Ethics Committees, and The Department of Health Human Research Ethics Committee. Written online informed consent was secured from all study participants.

### 2.3. Measures

#### 2.3.1. Outcome variables

The outcome variables for this study were past year and ever e-cigarette use. To measure past year e-cigarette use, respondents were asked "Have you used battery operated electronic cigarettes (e-cigarettes) in the last 12 months?" with possible responses of "yes" or "no". Ever e-cigarette use was assessed by asking "Have you ever used battery operated electronic cigarettes?" with the same possible responses.

#### 2.3.2. Exposure variables

Eight ACEs were measured in this study. The ACEs can be broadly categorized as childhood abuse (child maltreatment) or household dysfunction. Childhood abuse included psychological abuse (2 items), physical abuse (2 items) and sexual abuse (4 items), while household dysfunction encompassed household substance abuse (2 items), household mental illness (2 items), parental separation/divorce (1 item), incarcerated household members (1 item) and witnessing domestic violence (8 items). Participants were classified as exposed to a given ACE if they replied "yes" to one or more of the items in that category. All of the questions relating to ACEs referred to the respondent's experiences prior to reaching 18 years. The total ACE score was created by totalling the number of individual ACE types reported, for a maximum of eight (8). Based on this, the ACE score was categorized as 0, 1, 2, 3, and 4 or more. Researchers found a good test-retest reliability for both individual and cumulative ACE scores suggesting reliability of measurements (Pinto et al., 2014). Items used to define ACEs are presented in Table 1.

#### 2.3.3. Covariates

In previous research it has been shown that socio-demographic factors such as age, education, employment, and residence are risk factors for e-cigarette use among younger people (Filippidis et al., 2017; Melka et al., 2019). Conventional tobacco smoking has also been identified as a risk factor for subsequent e-cigarette use (Filippidis et al., 2017; Jiang et al., 2016). Parental education and parental household

**Table 1**  
ACEs category (collected in the third survey).

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**Abuse/child maltreatment**

1. **Psychological abuse:** At least one “yes” response” for the following questions:
  - Did a parent/adult often swear at, insult, or put you down?
  - Did a parent/adult often act in a way that made you afraid that you would be physically hurt?
2. **Physical abuse:** At least one “yes” response” for the following questions:
  - Did a parent/adult: Often push, grab, shove, or slap you?
  - Did a parent/adult: Often hit you so hard that you had marks or were injured?
3. **Sexual abuse:** At least one “yes” response” for the following questions:
  - Did an adult/5-year older person ever touch or fondle you in a sexual way?
  - Did an adult/5-year older person ever have you touch their body in a sexual way?
  - Did an adult/5-year older person ever attempt oral, anal, or vaginal intercourse with you?
  - Did an adult/5-year older person ever actually have oral, anal, or vaginal intercourse with you?

**Household dysfunction**

4. **Substance abuse (living with someone with substance abuse):** At least one “yes” response” for the following questions:
    - Did you live with anyone who was a problem drinker or alcoholic?
    - Did you live with anyone who used street drugs?
  5. **Witnessing domestic violence:** At least one “yes” response” for the following questions:
    - Was your mother (or stepmother): Sometimes, often, or very often pushed, grabbed, slapped, or had something thrown at her?
    - Was your mother (or stepmother): Sometimes, often, or very often kicked, bitten, hit with a fist, or hit with something hard?
    - Was your mother (or stepmother): Ever repeatedly hit over at least a few minutes?
    - Was your mother (or stepmother): Ever threatened with, or hurt by, a knife or gun?
    - Was your father (or stepfather): Sometimes, often, or very often pushed, grabbed, slapped, or had something thrown at him?
    - Was your father (or stepfather): Sometimes, often, or very often kicked, bitten, hit with a fist, or hit with something hard?
    - Was your father (or stepfather): Ever repeatedly hit over at least a few minutes?
    - Was your father (or stepfather): Ever threatened with, or hurt by, a knife or gun?
  6. **Living with someone with mental illness:** At least one “yes” response” for the following questions:
    - Was a household member depressed or mentally ill?
    - Did a household member attempt suicide?
  7. **Living with someone who went to jail/prison:**
    - Did a household member go to prison?
  8. **Parental separation or divorce**
    - During your childhood, did your parents’ divorce or permanently separate?
- 

Note: All the ACEs were an event encountered during the first 18 years of life.

income have been strongly associated with adolescent smoking (Soteriades and DiFranza, 2003). Parental education and parental financial hardship have also been associated with children experiencing ACEs (Halfon et al., 2017; Leung et al., 2008). For these reasons, in this study we included socio-demographic parental education, family financial hardship during childhood and smoking status (ever smoker vs never smoker) as model covariates. Participants were asked to report their age in years and this was included in the analysis as a continuous variable. Other covariates included highest level of education (less than Year 12, year 12 or equivalent, trade/certificate/diploma, university degree), employment status (employed, unemployed), mother’s education (less than year 12, year 12 or equivalent, trade/certificate/diploma, university degree, don’t know) father’s education (less than year 12, year 12 or equivalent, trade/certificate/diploma, university degree, don’t know), and parental financial hardship during primary school. Participants were asked to rate the family’s ability to manage on the available income during childhood (primary school) with the following options: ‘It was easy’, ‘It was not too bad’, ‘It was difficult some of the time’, ‘It was difficult all the time’, ‘It was impossible’, and ‘Don’t know’. The options were regrouped for analysis as follows: easily managing income (‘It was easy’, ‘It was not too bad’), difficulty managing income (‘It was difficult some of the time’, ‘It was difficult all the time’, ‘It was impossible’) and ‘Don’t know’.

## 2.4. Data analysis

Descriptive statistics with chi-squared or student *t*-tests were used to characterize study participants by e-cigarette use and background variables. Chi-square test was used to compare individuals with missing and complete data by outcome variable (e-cigarette use) (result not shown). There was a statistically significant difference between individuals with complete and missing data across the variables compared in terms of outcome variables (history of e-cigarettes use). Study participants with missing values were more likely to use e-cigarettes. However, since the non-response rate for many of the exposure variables (ACEs) and other covariates was lower than 5% while it was < 10% for some of the variables, complete case analyses have performed. Logistic regression was conducted to estimate unadjusted and adjusted odds ratios representing associations of individual ACEs or the cumulative ACE score with past year or ever e-cigarette use. For each outcome variable of interest (past year and ever e-cigarette use), three sets of models were fitted. In the first set of models, separate bivariate logistic regression models were fitted for each of the 8 ACE variables and the ACE score. In the second set of models, sociodemographic variables (age, education level, and employment status), parental education level and family’s ability to manage income during childhood were included. The third and final set of models included smoking status in addition to covariates included in the second model. Associations between dependent and independent variables were presented as crude and adjusted odds ratios with 99% confidence intervals. By using 99% CIs, we have implicitly specified a significance threshold of 0.01 rather than 0.05. This accounts for 5 independent hypothesis tests, which should be ample to account for multiple testing, given the known correlation between different ACEs. Given the number of significance tests, we set  $\alpha = 0.01$  (i.e., 99% confidence interval for odds ratios excluding 1) (Langkamp et al., 2010). Data were analysed in 2018/19. All data analysis was performed using Stata version 15 (Stata Corp. 2017. Stata Statistical Software: Release 15. College Station, TX: Stata Corp LLC).

## 3. Results

Table 2 presents frequencies of e-cigarette use by selected respondent characteristics. The mean age of the study participants was 22.5. The prevalence of past year e-cigarette use among the study participants was 6.4% while the ever e-cigarette use was 11.1%. The prevalence of at least one reported ACE was 65.2%, while the prevalence of 4 or more ACEs was 14.7% (Fig. 1). Both the prevalence of past year and ever e-cigarette use increased with the number of ACEs (Fig. 2).

In logistic regression analyses, there was a statistically significant association between individual ACE categories and the past year and ever e-cigarette use after adjusting for sociodemographic and parental education level during childhood. However, after adjusting for smoking status, the odds ratio associated with each category of ACE and past or ever e-cigarette use was attenuated (Table 3). In the fully adjusted model the three childhood abuse variables (psychological, physical and sexual abuse) were positively associated with both past year and ever e-cigarette use. In a separate analysis, specific categories and cumulative ACE scores were strongly associated with traditional tobacco smoking after controlling for sociodemographic factors (result not shown). In the fully adjusted analysis, the odds of past year e-cigarette use were 1.5 times higher for study participants exposed to psychological abuse (Adjusted Odds Ratio (AOR) = 1.45, 99%CI: 1.11, 1.90), 1.3 times higher for study participants exposed to physical abuse (AOR = 1.30, 99%CI, 1.03, 1.82) and 1.4 times higher for study participants exposed to sexual abuse (AOR = 1.41, 99%CI, 1.02, 1.95) compared with those who were not. Study participants who grew up in a family with a history of substance abuse were 1.4 times more likely to report ever e-cigarette use compared to their counterparts (AOR = 1.35, 99%CI, 1.08, 1.68). The odds of ever e-cigarette use were 1.3 times greater for

**Table 2**  
Frequency of e-cigarette use by selected participant characteristics.

Variables	Past year e-cigarette use		p-Value	Ever e-cigarette use		p-Value
	Yes n (%)	No n (%)		Yes n (%)	No n (%)	
Age of respondents						
19–22	329 (57.7)	4099 (49.1)	p < 0.001	544 (54.9)	3884 (49.0)	p < 0.001
23–26	241 (42.3)	4246 (50.9)		446 (45.1)	4041 (51.0)	
Highest level of education						
Less than year 12	52 (9.1)	260 (3.1)	p < 0.001	83 (8.4)	229 (2.9)	p < 0.001
Year 12 or equivalent	159 (27.9)	2202 (26.4)		281 (28.4)	2080 (26.3)	
Trade/certificate/diploma	201 (35.3)	2251 (27.0)		357 (36.1)	2095 (26.4)	
University degree	133 (23.3)	3416 (40.9)		228 (23.0)	3321 (41.9)	
Missing	25 (4.4)	216 (2.6)		41 (4.1)	200 (2.5)	
Currently unemployed						
Yes	111 (19.5)	1013 (12.1)	p < 0.001	188 (19.0)	936 (11.8)	p < 0.001
No	434 (76.1)	7115 (85.3)		761 (76.9)	6788 (85.7)	
Missing	25 (4.4)	217 (2.6)		41 (4.1)	201 (2.5)	
Mother's highest level of education						
Less than year 12	150 (26.3)	2019 (24.2)	p = 0.008	263 (26.6)	1906 (24.1)	p < 0.001
Year 12 or equivalent	77 (13.5)	1140 (13.7)		145 (14.7)	1072 (13.5)	
Trade/certificate/diploma	120 (21.1)	1703 (20.4)		199 (20.1)	1624 (20.5)	
University degree	163 (28.6)	2889 (34.6)		282 (28.5)	2770 (35.0)	
Don't know	46 (8.1)	475 (5.7)		77 (7.8)	444 (5.6)	
Missing	14 (2.5)	119 (1.4)		24 (2.4)	109 (1.4)	
Father's highest level of education						
Less than year 12	166 (29.1)	1959 (23.5)	p < 0.001	265 (26.77)	1860 (23.5)	p < 0.001
Year 12 or equivalent	60 (10.5)	941 (11.3)		111 (11.21)	890 (11.2)	
Trade/certificate/diploma	94 (16.5)	1486 (17.8)		155 (15.66)	1425 (18.0)	
University degree	129 (22.6)	2700 (32.4)		236 (23.84)	2593 (32.7)	
Don't know	73 (12.8)	698 (8.4)		134 (13.54)	637 (8.04)	
Missing	48 (8.4)	561 (6.7)		89 (8.9)	520 (6.5)	
Family ability to manage income						
Easily managing income	287 (50.4)	4829 (57.9)	p < 0.001	485 (49.0)	4631 (58.4)	p < 0.001
Difficulty managing income	244 (42.8)	3198 (38.3)		437 (44.1)	3005 (37.9)	
Don't know	23 (4.0)	192 (2.3)		41 (4.1)	174 (2.2)	
Missing	16 (2.8)	126 (1.5)		27 (2.7)	115 (1.5)	
Smoking status						
Ever smoked	423 (74.2)	1782 (21.3)	p < 0.001	722 (72.9)	1483 (18.7)	p < 0.001
Never smoked	147 (25.8)	6563 (78.7)		268 (27.1)	6442 (81.3)	

those who had witnessed domestic violence compared to their counterparts. (AOR = 1.28, 99%CI, 1.01, 1.69). Study participants who lived with a mentally ill family member had 1.3-times increased odds of

reporting ever e-cigarette use compared to study participants living with family members with no history of mental illness (AOR = 1.28, 99%CI, 1.05, 1.58) (Table 3). This study confirmed the presence of a

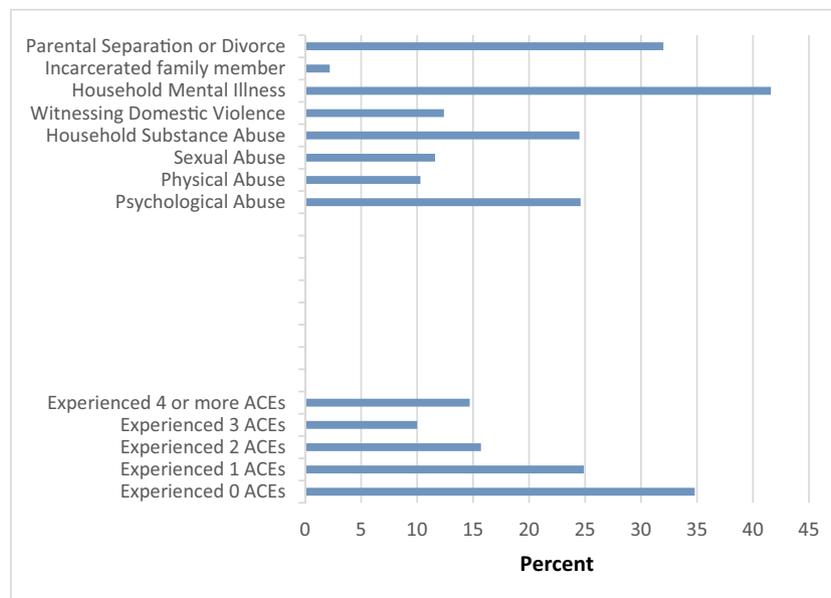


Fig. 1. Prevalence of individual ACEs and the number of ACEs experienced by young Australian women.

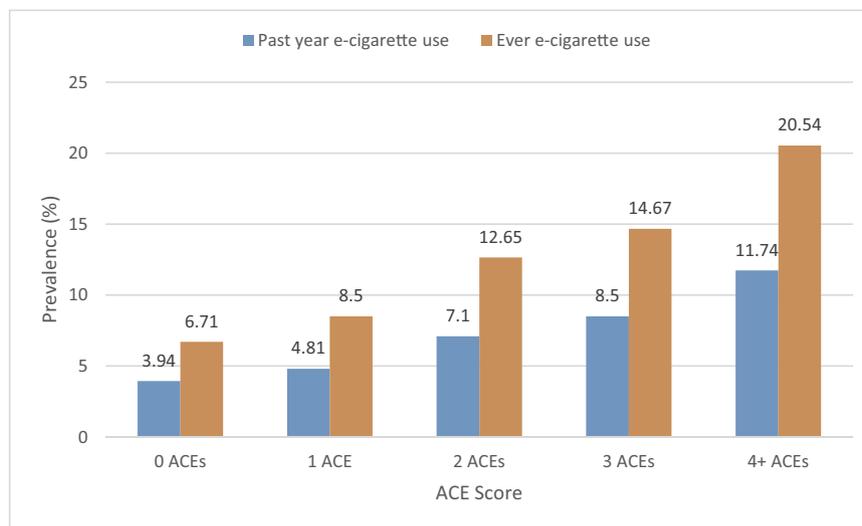


Fig. 2. Prevalence of past year and ever e-cigarette use by ACE score among Australian young women.

strong dose-response relationship between the number of ACEs and past year or ever e-cigarette use. For instance, the odds of past year e-cigarette use and ever e-cigarette use were 1.6 times (AOR = 1.60, 99%CI, 1.12, 2.29) and 1.9 times greater (AOR = 1.86, 99%CI, 1.39, 2.48) respectively among study participants who reported four or more ACEs, compared to those who reported no ACEs (Table 4).

#### 4. Discussion

To our knowledge, this is the first study to investigate the relationship between ACEs and e-cigarette use using extensive national Australian data. The prevalence of at least one ACE was higher (41%) compared to findings reported by Loxton and colleagues among Australian women aged 18–23 years old (Loxton et al., 2018). The prevalence of four or more adverse childhood experiences was comparable with values reported elsewhere (13.7%) (Campbell et al., 2016; Fang and McNeil, 2017). All of the ACEs relating to childhood abuse (psychological, physical, and sexual abuse) were associated with past year or ever e-cigarette use among young Australian women. While we identified no previous studies investigating the relationship between ACEs and e-cigarette use, researchers have found that physical, emotional and sexual abuse are stronger predictors of smoking among women (Fuller-Thomson et al., 2013). Similarly, in this study, all ACE categories were strongly associated with conventional tobacco smoking

after controlling for sociodemographic factors, parental education and parental financial hardship during childhood. Moreover, there was a dose-dependent relationship between the cumulative ACE score and tobacco smoking (results not shown). After adjusting for participants' smoking status, the odds ratios associated with each of the ACE categories and ACE score were attenuated. The attenuation of odds ratios suggests that the positive relationship between ACEs and e-cigarette use is substantially mediated by conventional cigarette smoking. Other evidence has also shown that e-cigarette use is more prevalent among ever and current smokers compared to never smokers (Filippidis et al., 2017; Jiang et al., 2016). In order to cope with anxiety and depression, individuals exposed to childhood adversities may be more likely to use nicotine to reduce negative emotions via the stimulation of neurotransmitters such as epinephrine and dopamine (Anda et al., 2010). The findings of the current study emphasize the importance of protecting children from psychological, physical and sexual abuse during childhood in order to prevent subsequent substance use and other adverse outcomes.

Growing up in a family with a history of substance abuse was a risk factor for ever e-cigarette use. In previous studies, researchers also identified a positive association between a history of substance abuse by a family member and smoking and heavy drinking (Anda et al., 1999; Campbell et al., 2016). Witnessing domestic violence during childhood was an important risk factor for substance use such as

Table 3  
Associations of individual ACEs with past year and ever e-cigarette use among young Australian women.

ACE categories (reference = no)	n	Past year e-cigarette use			Ever e-cigarette use		
		Model 1 OR (99% CI)	Model 2 AOR (99% CI)	Model 3 AOR (99% CI)	Model 1 OR (99% CI)	Model 2 AOR (99% CI)	Model 3 AOR (99% CI)
Psychological abuse	8698	2.27 (1.80, 2.87)	1.91 (1.48, 2.46)	1.45 (1.11, 1.90)	2.12 (1.76, 2.55)	1.78 (1.46, 2.18)	1.36 (1.09, 1.69)
Physical abuse	8698	2.32 (1.73, 3.11)	1.81 (1.31, 2.49)	1.30 (1.03, 1.82)	2.13 (1.67, 2.70)	1.71 (1.31, 2.22)	1.22 (1.01, 1.62)
Sexual abuse	8635	2.40 (1.81, 3.18)	1.95 (1.43, 2.65)	1.41 (1.02, 1.95)	2.49 (2.00, 3.11)	2.05 (1.60, 2.62)	1.50 (1.15, 1.96)
Household substance abuse	8751	2.02 (1.60, 2.56)	1.67 (1.29, 2.16)	1.18 (0.90, 1.54)	2.24 (1.87, 2.69)	1.87 (1.53, 2.29)	1.35 (1.08, 1.68)
Witnessing domestic violence	8751	1.85 (1.39, 2.47)	1.45 (1.06, 1.99)	1.15 (0.82, 1.61)	1.98 (1.58, 2.49)	1.59 (1.24, 2.04)	1.28 (1.01, 1.69)
Mentally ill household member	8751	1.54 (1.23, 1.94)	1.34 (1.06, 1.71)	1.13 (0.88, 1.46)	1.64 (1.38, 1.96)	1.50 (1.24, 1.80)	1.28 (1.05, 1.58)
Incarcerated household member	8751	1.52 (0.80, 2.90)	1.14 (0.56, 2.32)	0.77 (0.37, 1.59)	1.66 (1.01, 2.75)	1.27 (0.73, 2.20)	0.83 (0.46, 1.49)
Parental separation or divorce	8753	1.58 (1.25, 1.98)	1.33 (1.03, 1.70)	1.05 (0.81, 1.37)	1.68 (1.40, 2.00)	1.39 (1.14, 1.69)	1.11 (0.89, 1.38)

n = the number of respondents responded for each of the ACE categories.

OR, odds ratio; AOR, adjusted odds ratio; CI, confidence interval.

Model 1: Unadjusted odds ratio of association between ACEs and e-cigarette use.

Model 2: Association between ACEs and e-cigarette use adjusted for age, education level, employment status, mother's education during childhood, father's education during childhood, family's ability to manage income during childhood.

Model 3: Association between ACEs and e-cigarette use adjusted for variables in model 2 plus cigarette smoking status.

**Table 4**  
Association of number of adverse childhood experiences and past and ever e-cigarette use.

ACE score	n	Past year e-cigarette use			Ever e-cigarette use		
		Model 1 OR (99% CI)	Model 2 AOR (99% CI)	Model 3 AOR (99% CI)	Model 1 AOR (99% CI)	Model 2 AOR (99% CI)	Model 3 AOR (99% CI)
0	2994	1.0 [reference]	1.0 [reference]	1.0 [reference]	1.0 [reference]	1.0 [reference]	1.0 [reference]
1	2141	1.23 (0.86, 1.76)	1.19 (0.83, 1.72)	1.05 (0.78, 1.40)	1.29 (1.04, 1.69)	1.26 (1.01, 1.56)	1.06 (0.84, 1.34)
2	1352	1.86 (1.29, 2.68)	1.81 (1.33, 2.46)	1.30 (0.95, 1.79)	2.01 (1.51, 2.67)	1.89 (1.48, 2.40)	1.39 (1.07, 1.80)
3	859	2.26 (1.52, 3.37)	2.12 (1.49, 3.00)	1.45 (1.01, 2.10)	2.39 (1.75, 3.26)	2.15 (1.63, 2.84)	1.51 (1.12, 2.05)
4 and more	1261	3.24 (2.33, 4.51)	2.82 (2.02, 3.93)	1.60 (1.12, 2.29)	3.59 (2.77, 4.66)	3.15 (2.43, 4.08)	1.86 (1.39, 2.48)

OR, odds ratio; AOR, adjusted odds ratio; CI, confidence interval.

Model 1: Unadjusted odds ratio of association between ACEs and e-cigarette use.

Model 2: Association between ACEs and e-cigarette use adjusted for age, education level, employment status, mother's education during childhood, father's education during childhood, family's ability to manage income during childhood.

Model 3: Association between ACEs and e-cigarette use adjusted for variables in model 2 plus cigarette smoking status.

smoking and binge drinking during later life (Crouch et al., 2018; Ford et al., 2011). Likewise in this study, the odds of ever e-cigarette use were 28% greater for those who had witnessed domestic violence compared to their non-exposed counterparts. In this study, a family history of mental illness was also one of the factors positively associated with ever e-cigarette use. Previous studies have also found that a family history of mental illness was a risk factor for substance use such as smoking and alcohol abuse (Fuller-Thomson et al., 2013; Rehkopf et al., 2016).

Several previous studies have concluded that health risk behaviours such as smoking, problem drinking, and illicit drug use increased with an increase in the number of ACEs (Fang and McNeil, 2017; Ford et al., 2011). Similarly, in this study there was a dose-response relationship between ACEs and past and ever e-cigarette use. The ACE score may reflect the accumulated exposure of the developing brain to the activated stress response, which has been suggested as the main pathway by which ACEs exert their effects on adult behaviours (Anda et al., 2010). The presence of a strong dose-response association between the number of ACEs and e-cigarette use magnifies the importance of designing strategies and interventions that can address all forms of ACEs.

Previous studies have identified socio-demographic factors, smoking status, peer and parental smoking as a risk factor for e-cigarette use (Filippidis et al., 2017; Jiang et al., 2016). Previous studies have examined the association between smoking and childhood adversities, no studies have investigated the association between ACEs and e-cigarette use. The findings of this study add to the existing evidence that establishes the association of childhood adversities with use of other substances, such as alcohol, tobacco, and illicit drugs. The finding highlights the importance of considering childhood adversities along with other risk factors while designing strategies and interventions to target the prevention of nicotine addiction through use of e-cigarettes.

Researchers have previously concluded that ACEs were an important pathway for many health-harming behaviours and morbidities. For instance, the historical ACEs study conducted by Felitti and colleagues identified that ACEs were important risk factors for a range of health risk behaviours and disorders such as smoking, obesity, physical inactivity, depression, and suicide attempts (Felitti et al., 1998). Traumatic events during childhood can affect brain development by altering the normal structure and chemical activity of the neurotransmitters (Perry, 2009). Since the underdeveloped brain is not able to cope naturally, this can lead to negative coping strategies, such as substance use and other health-harming behaviours (Shonkoff et al., 2011). The effects of maltreatment on brain development depend on factors such as the age of the child during the abuse, the severity of abuse and the chronicity of abuse (Shonkoff et al., 2011).

Childhood adversities are a source of social, emotional and cognitive impairment that can, in turn, lead to the adoption of health risk behaviours. In the long term, health risk behaviours could result in

disease, disability, social problems, and premature death (Rose et al., 2014). Some of the strategies proposed to reduce the impact of ACEs include offering financial support to families, provision of quality care and education early in life, enhancing parental nurturing skills to promote healthy child development, training clinicians to regularly investigate ACEs using trauma informed practice, and strengthening legal protections for children (Fortson et al., 2016; Jorm and Mulder, 2018).

## 5. Limitations

This study is to be interpreted with the following limitations. The first limitation is the cross-sectional nature of the study. Most of the ACE related questions are related to sensitive issues, which can influence the respondents and lead to them offering more socially acceptable answers. In addition, the high attrition rate for the third survey could affect the generalizability of the findings to the general population. Due to the retrospective nature of reporting ACEs, some recall bias is also expected. However, researchers have found good test-retest reliability for both individual and cumulative ACE scores, suggesting the reliability of measurements (Pinto et al., 2014). Data concerning the type of e-cigarette device used and its contents were not collected, so whether the device contained nicotine of any concentration could not be ascertained. However, in a recent study, researchers identified that 6 out of 10 "nicotine free e-liquids" in Australia contain nicotine (Chivers et al., 2019).

The recruitment of study participants using the internet and social media may result in self-selection bias. Compared to 2011 Australian census data, study participants of this cohort were over-representative of women with tertiary education, which could reduce the generalizability of results to Australian women of the same age. Since the recruitment of the study participants was not conducted randomly, data were not weighted to balance the overrepresentation of women with tertiary (university) education. Notwithstanding these limitations, this study is the first of its kind to investigate the relationship between ACEs and e-cigarette use using national data and suggests there is an important relationship between adverse childhood experiences and e-cigarette use during early adult life.

## 6. Conclusion

The findings of the current study are consistent with previous studies linking the experience of childhood adversities with substance use such as traditional tobacco smoking, alcohol, and illicit drug use. Evidence has shown that people experiencing stress and anxiety use nicotine for mood modulation (Cosci et al., 2011). Therefore, individuals exposed to childhood adversities may use nicotine to control their level of arousal and undesirable mood states in later life. The findings of this study highlight the importance of protecting children from childhood adversities and early identification and interventions

for children exposed to adversities in order to minimize substance abuse, including electronic cigarette use, during later life. Family practitioners and clinicians should adopt a practical guidance role in educating parents, child care providers, policymakers and the general public about the devastating consequences of childhood adversities. Moreover, strategies should be in place to help people with a history of childhood adversities to adopt positive coping mechanism rather than health-harming behaviours including nicotine addiction.

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## Contributors

All authors conceived the manuscript topic. Alemu Melka wrote the first draft of the paper and Catherine Chojenta, Elizabeth Holliday, and Deborah Loxton further reviewed and revised the subsequent drafts of the paper critically and provided feedback on the manuscript. Data analysis and interpretation of the findings was carried out by Alemu Melka, Catherine Chojenta, Elizabeth Holliday, and Deborah Loxton. Final approval of the version for publication was made by Alemu Melka, Catherine Chojenta, Elizabeth Holliday, and Deborah Loxton.

## Declaration of Competing Interest

None.

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## References

- Alcalá, H.E., von Ehrenstein, O.S., Tomiyama, A.J., 2016. Adverse childhood experiences and use of cigarettes and smokeless tobacco products. *J. Community Health* 41 (5), 969–976. <https://doi.org/10.1007/s10900-016-0179-5>.
- Anda, R.F., Croft, J.B., Felitti, V.J., Nordenberg, D., Giles, W.H., Williamson, D.F., Giovino, G.A., 1999. Adverse childhood experiences and smoking during adolescence and adulthood. *JAMA* 282 (17), 1652–1658. <https://doi.org/10.1001/jama.282.17.1652>.
- Anda, R.F., Butchart, A., Felitti, V.J., Brown, D.W., 2010. Building a framework for global surveillance of the public health implications of adverse childhood experiences. *Am. J. Prev. Med.* 39 (1), 93–98. <https://doi.org/10.1016/j.amepre.2010.03.015>.
- Benowitz, N.L., 2009. Pharmacology of nicotine: addiction, smoking-induced disease, and therapeutics. *Annu. Rev. Pharmacol. Toxicol.* 49, 57–71. <https://doi.org/10.1146/annurev.pharmtox.48.113006.094742>.
- Bleil, M.E., Adler, N.E., Pasch, L.A., Sternfeld, B., Reijo-Pera, R.A., Cedars, M.I., 2011. Adverse childhood experiences and repeat induced abortion. *Am. J. Obstet. Gynecol.* 204 (2), 122.e121–122.e126. <https://doi.org/10.1016/j.ajog.2010.09.029>. (Epub 2010 Nov 11).
- Brown, J., Beard, E., Kotz, D., Michie, S., West, R., 2014. Real-world effectiveness of e-cigarettes when used to aid smoking cessation: a cross-sectional population study. *Addiction* 109 (9), 1531–1540. <https://doi.org/10.1111/add.12623>.
- Campbell, J.A., Walker, R.J., Egede, L.E., 2016. Associations between adverse childhood experiences, high-risk behaviors, and morbidity in adulthood. *Am. J. Prev. Med.* 50 (3), 344–352. <https://doi.org/10.1016/j.amepre.2015.07.022>.
- Chivers, E., Janka, M., Franklin, P., Mullins, B., Larcombe, A., 2019. Nicotine and other potentially harmful compounds in “nicotine-free” e-cigarette liquids in Australia. *Med. J. Aust.* 210 (3), 127–128. <https://doi.org/10.5694/mja2.12059>.
- Cosci, F., Pistelli, F., Lazzarini, N., Carrozzi, L., 2011. Nicotine dependence and psychological distress: outcomes and clinical implications in smoking cessation. *Psychol. Res. Behav. Manag.* 4, 119. <https://doi.org/10.2147/PRBM.S14243>.
- Crouch, E., Radcliff, E., Strompolis, M., Wilson, A., 2018. Adverse childhood experiences (ACEs) and alcohol abuse among South Carolina adults. *Subst Use Misuse* 53 (7), 1212–1220. <https://doi.org/10.1080/10826084.2017.1400568>.
- Douglas, H., Hall, W., Gartner, C., 2015. E-cigarettes and the law in Australia. *Aust. Fam. Physician* 44 (6), 415. <https://www.ncbi.nlm.nih.gov/pubmed/26209995>.
- Dunlop, S., Lyons, C., Dessaix, A., Currow, D., 2016. How are tobacco smokers using e-cigarettes? Patterns of use, reasons for use and places of purchase in New South Wales. *Med. J. Aust.* 204 (9), 355. <https://doi.org/10.5694/mja16.00616>.
- Fang, L., McNeil, S., 2017. Is there a relationship between adverse childhood experiences and problem drinking behaviors? Findings from a population-based sample. *Public Health* 150, 34–42. <https://doi.org/10.1016/j.puhe.2017.05.005>.
- Felitti, V.J., Anda, R.F., Nordenberg, D., Williamson, D.F., Spitz, A.M., Edwards, V., Marks, J.S., 1998. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: the Adverse Childhood Experiences (ACE) study. *Am. J. Prev. Med.* 14 (4), 245–258. [https://doi.org/10.1016/S0749-3797\(98\)00017](https://doi.org/10.1016/S0749-3797(98)00017).
- Filippidis, F.T., Laverly, A.A., Gerovasili, V., Vardavas, C.I., 2017. Two-year trends and predictors of e-cigarette use in 27 European Union member states. *Tob. Control.* 26 (1), 98–104. <https://doi.org/10.1136/tobaccocontrol-2015-052771>.
- Ford, E.S., Anda, R.F., Edwards, V.J., Perry, G.S., Zhao, G., Li, C., Croft, J.B., 2011. Adverse childhood experiences and smoking status in five states. *Prev. Med.* 53 (3), 188–193. <https://doi.org/10.1016/j.ypmed.2011.06.015>.
- Fortson, B.L., Klevens, J., Merrick, M.T., Gilbert, L.K., Alexander, S.P., 2016. Preventing Child Abuse and Neglect: A Technical Package for Policy, Norm, and Programmatic Activities. <https://doi.org/10.15620/cdc.38864>.
- Fuller-Thomson, E., Filippelli, J., Lue-Crisostomo, C., 2013. Gender-specific association between childhood adversities and smoking in adulthood: findings from a population-based study. *Public Health* 127 (5), 449–460. <https://doi.org/10.1016/j.puhe.2013.01.006>.
- Halfon, N., Larson, K., Son, J., Lu, M., Bethell, C., 2017. Income inequality and the differential effect of adverse childhood experiences in US children. *Acad. Pediatr.* 17 (7), S70–S78. <https://doi.org/10.1016/j.acap.2016.11.007>.
- Jiang, N., Wang, M.P., Ho, S.Y., Leung, L.T., Lam, T.H., 2016. Electronic cigarette use among adolescents: a cross-sectional study in Hong Kong. *BMC Public Health* 16 (1), 202. <https://doi.org/10.1186/s12889-016-2719-4>.
- Jorm, A.F., Mulder, R.T., 2018. Prevention of mental disorders requires action on adverse childhood experiences. *Aust N Z J Psychiatry* 52 (4), 316–319. <https://doi.org/10.1177/0004867418761581>.
- Langkamp, D.L., Lehman, A., Lemeshow, S., 2010. Techniques for handling missing data in secondary analyses of large surveys. *Acad. Pediatr.* 10 (3), 205–210. <https://doi.org/10.1016/j.acap.2010.01.005>.
- Leung, P.W., Wong, W.C., Chen, W., Tang, C.S., 2008. Prevalence and determinants of child maltreatment among high school students in southern China: a large scale school based survey. *Child Adolesc. Psychiatry Ment. Health* 2 (1), 27. <https://doi.org/10.1186/1753-2000-2-27>.
- Loxton, D., Powers, J., Anderson, A.E., Townsend, N., Harris, M.L., Tuckerman, R., ... Byles, J., 2015. Online and offline recruitment of young women for a longitudinal health survey: findings from the Australian Longitudinal Study on Women's Health 1989–95 cohort. *J. Med. Internet Res.* 17 (5). <https://doi.org/10.2196/jmir.4261>.
- Loxton, D., Townsend, N., Dolja-Gore, X., Forder, P., Coles, J., 2018. Adverse childhood experiences and healthcare costs in adult life. *J Child Sex Abus* 1–15. <https://doi.org/10.1080/10538712.2018.1523814>.
- Loxton, D., Harris, M.L., Forder, P., Powers, J., Townsend, N., Byles, J., Mishra, G., 2019. Factors influencing web-based survey response for a longitudinal cohort of young women born between 1989 and 1995. *J. Med. Internet Res.* <https://doi.org/10.2196/preprints.11286>. (in press).
- Lozano, P., Barrientos-Gutierrez, I., Arillo-Santillan, E., Morello, P., Mejia, R., Sargent, J.D., Thrasher, J.F., 2017. A longitudinal study of electronic cigarette use and onset of conventional cigarette smoking and marijuana use among Mexican adolescents. *Drug Alcohol Depend.* 180, 427–430. <https://doi.org/10.1016/j.drugalcdep.2017.09.001>.
- Makaruk, K., Włodarczyk, J., Sethi, D., Michalski, P., Szredzińska, R., Karwowska, P., 2018. Survey on adverse childhood experiences and associated health-harming behaviours among Polish students. World Health Organisation, <http://www.euro.who.int/en/countries/poland/publications/survey-of-adverse-childhood-experiences-and-associated-health-harming-behaviours-among-polish-students-2018>, Accessed date: 10 February 2019.
- Maté, G., 2012. Addiction: childhood trauma, stress and the biology of addiction. *J Rester Med* 1 (1), 56–63. <https://doi.org/10.14200/jrm.2012.1.1005>.
- McKee, M., Capewell, S., 2015. Evidence about electronic cigarettes: a foundation built on rock or sand? *BMJ* 351, h4863. <https://doi.org/10.1136/bmj.h4863>.
- Melka, A.S., Chojenta, C.L., Holliday, E.G., Loxton, D.J., 2019. Predictors of E-cigarette use among young Australian women. *Am. J. Prev. Med.* 56 (2), 293–299. <https://doi.org/10.1016/j.amepre.2018.09.019>.
- Middlekauff, H.R., 2015. COUNTERPOINT: does the risk of electronic cigarettes exceed potential benefits? *No. Chest* 148 (3), 582–584. <https://doi.org/10.1378/chest.15-0540>.
- Mishra, G.D., Hockey, R., Powers, J., Loxton, D., Tooth, L., Rowlands, I., ... Dobson, A., 2014. Recruitment via the Internet and social networking sites: the 1989–1995 cohort of the Australian longitudinal study on women's health. *J. Med. Internet Res.* 16 (12). <https://doi.org/10.2196/jmir.3788>.
- National Academies of Sciences, E., & Medicine, 2018. Public Health Consequences of E-cigarettes. National Academies Press. <https://www.nap.edu/catalog/24952/public-health-consequences-of-e-cigarettes>, Accessed date: 5 February 2019.
- Perry, B.D., 2009. Examining child maltreatment through a neurodevelopmental lens: clinical applications of the neurosequential model of therapeutics. *J. Loss Trauma* 14

- (4), 240–255. <https://doi.org/10.1080/1532502090300435>.
- Pinto, R., Correia, L., Maia, Â., 2014. Assessing the reliability of retrospective reports of adverse childhood experiences among adolescents with documented childhood maltreatment. *J. Fam. Violence* 29 (4), 431–438. <https://doi.org/10.1007/s10896-014-9602-9s>.
- Rehkopf, D.H., Headen, L., Hubbard, A., Deardorff, J., Kesavan, Y., Cohen, A.K., ... Abrams, B., 2016. Adverse childhood experiences and later life adult obesity and smoking in the United States. *Ann. Epidemiol.* 26 (7), 488–492. e485. <https://doi.org/10.1016/j.annepidem.2016.06.003>.
- Rose, S.M.S.-F., Xie, D., Stineman, M., 2014. Adverse childhood experiences and disability in US adults. *PM&R* 6 (8), 670–680. <https://doi.org/10.1016/j.pmrj.2014.01.013>.
- Schraufnagel, D. E., Blasi, F., Drummond, M. B., Lam, D. C., Latif, E., Rosen, M. J., ... Van Zyl-Smit, R. (2014). Electronic cigarettes. A position statement of the forum of international respiratory societies. *Am. J. Respir. Crit. Care Med.*, 190(6), 611–618. doi:<https://doi.org/10.1164/rccm.201407-1198PP>.
- Shonkoff, J.P., Garner, A.S., Child, C. o. P. A. o., Health, F, Committee on Early Childhood, A., & Care, D, 2011. The lifelong effects of early childhood adversity and toxic stress. *Pediatrics* 2011–2663. <https://doi.org/10.1542/peds.2011-2663>.
- Soares, A.L.G., Howe, L.D., Matijasevich, A., Wehrmeister, F.C., Menezes, A.M., Gonçalves, H., 2016. Adverse childhood experiences: prevalence and related factors in adolescents of a Brazilian birth cohort. *Child Abuse Negl.* 51, 21–30. <https://doi.org/10.1016/j.chiabu.2015.11.017>.
- Soteriades, E.S., DiFranza, J.R., 2003. Parent's socioeconomic status, adolescents' disposable income, and adolescents' smoking status in Massachusetts. *Am. J. Public Health* 93 (7), 1155–1160. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1447926/>.
- Unger, J.B., Soto, D.W., Leventhal, A., 2016. E-cigarette use and subsequent cigarette and marijuana use among Hispanic young adults. *Drug Alcohol Depend.* 163, 261–264. <https://doi.org/10.1016/j.drugalcdep.2016.04.027>.
- Ye, D., Reyes-Salvail, F., 2014. Adverse childhood experiences among Hawai'i adults: findings from the 2010 Behavioral Risk Factor Survey. *Hawaii J Med Public Health* 73 (6), 181. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4064343/>.