

# E-Cigarettes and Smoking Cessation in Adolescent Smokers: Do E-Cigarettes Reduce Harm or Not?

**Li-Yin Lin**

National Taipei University of Nursing and Health Sciences

**Yu-Ning Chien**

Fu Jen Catholic University

**Yi-Hwa Chen**

Taipei Medical University

**Russell Shean**

Taipei Medical University

**Chi-Yi Wu**

National Health Research Institutes, Zhunan Town

**Shih-Chang Huan**

Chung-Hua Institution for Economic Research

**Hung-Yi Chiou** (✉ [hychiou@nhri.edu.tw](mailto:hychiou@nhri.edu.tw))

National Health Research Institutes, Zhunan Town

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## Article

**Keywords:** e-cigarettes, smoking cessation, cigarettes, smokers, adolescents, Taiwan

**Posted Date:** June 6th, 2022

**DOI:** <https://doi.org/10.21203/rs.3.rs-1633284/v1>

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# Abstract

Smokers of any age can reap substantial health benefits from quitting or reducing their smoking. E-cigarettes have been promoted as a potentially promising product for tobacco harm reduction because e-cigarettes deliver nicotine vapor without many of the hazardous chemical combustion byproducts produced by combustible cigarette smoking. However, there remains an ongoing debate on whether the use of e-cigarettes is effective in combustible cigarette smoking cessation or reduction. Our study uses data from the 2014 (baseline) and from the 2016 (follow-up) waves of the Taiwan Adolescent to Adult Longitudinal Study (TAALS), which is a large nationwide representative cohort study of health behaviors among adolescents in Taiwan. We analyzed the data using logistic regression and multivariable regression with a post-stratification weighting procedure. Among the 474 adolescent smokers at baseline, the use of e-cigarettes had no association with smoking cessation (aRR = 0.99, 95% CI = 0.66, 1.50). Furthermore, the use of e-cigarettes was also not associated with change in combustible cigarette consumption among all adolescent smokers at follow-up (Coef. = 0.62, 95% CI = -36.85, 38.09). In summary, our findings suggest that e-cigarettes may not aid tobacco control among adolescent smokers. Policy makers should be cautious of the potential harms that e-cigarette may bring to young people when they are developing e-cigarette regulations.

## 1. Introduction

E-cigarettes have been the most commonly used tobacco product among adolescents in the United States since 2014 [1, 2]. After increasing between 2017 and 2019, use of e-cigarettes went down among middle and high school students in the United States from 2019 to 2020 [3–5]. However, in 2020, 19.6% of high school students in the United States, still reported that they used e-cigarettes in the past 30 days [6]. Epidemiological studies in Asia have suggested a relatively low prevalence of e-cigarette use: < 1% in Indonesia and Malaysia in 2011[7], and 2.3% in Hong Kong in 2014 [8]. In Taiwan, the prevalence of e-cigarette use among adolescents (ages 12–17) is around 0.8% according to the 2014 National Survey of Substance Use in Taiwan [9]. A different study, the Taiwan Global Youth Tobacco Survey (TGYTS) estimated a higher prevalence. TGYTS found that prevalence of current use of e-cigarettes among adolescents (ages 12–18) in Taiwan was on average 3.1% between 2014 and 2016, with 52% being dual users of combustible cigarettes and e-cigarettes[10]. Electronic cigarettes (e-cigarettes) have gained the attention of smokers due to their ability to closely simulate the behavioral experience of smoking, as well as for their ability to deliver a dose of nicotine without involving the combustion of tobacco.

### 1.1 Why e-cigarettes cause health concerns

For adolescents, e-cigarettes may be an attractive alternative to combustible cigarettes because e-cigarettes are perceived as less harmful and are available in many different flavors [11]. Most e-cigarettes work in a similar way. Puffing activates a battery-powered heating device. This heats up the liquid in a cartridge, turning it into vapors that are inhaled [12, 13]. Vaping exposes the lungs to a variety of chemicals. These may include the main active chemicals in tobacco (nicotine) or marijuana (THC), added

flavors, and other ingredients that are added to vaping liquids. Also, other chemicals can be produced during the vaporization process [14, 15]. One harmful chemical that has been found in e-cigarettes is called vitamin E acetate, which is sometimes used as an additive in THC-containing vape products. The Center of Disease Control (CDC) has identified it as a “chemical of concern” among people with vaping-associated lung injuries [16]. A 2014 American Association policy statement reviewed e-cigarette safety and concluded that a variety of evidence suggests that e-cigarettes are likely significantly less toxic than traditional cigarettes, with the caveats that more evidence is needed and that certain components of e-cigarettes, particularly some flavorings and propylene glycol, may be toxic when inhaled [17].

## **1.2. Issues related to e-cigarettes use and combustible tobacco control**

In our previous study, we found that e-cigarette use was associated with an increased odds of smoking initiation among adolescents in Taiwan [18]. The European Tobacco Products Directive has stated: “Electronic cigarettes can develop into a gateway to nicotine addiction and ultimately traditional tobacco consumption, as they mimic and normalize the action of smoking” [12], while the Australian National Health and Medical Research Council concluded that actions should be taken to minimize the harm of e-cigarettes to users and to protect vulnerable groups such as youth [13].

On the other hand, e-cigarettes may have potential roles to play in both combustible cigarette smoking cessation and tobacco harm reduction [13, 19]. A major UK clinical trial published in 2019 found that, when combined with face-to-face counseling support, people who used e-cigarettes to quit combustible cigarette smoking were twice as likely to succeed as people who used other nicotine replacement products, such as gum or patches [20]. In a nationally representative US Population Assessment of Tobacco and Health (PATH) Study, that 3093 quit attempters, found using Electronic Nicotine Delivery System (ENDS) to quit cigarettes increased the probability of persistent cigarette abstinence ( $\geq 30$  days) [21].

Although some studies suggest that the use of e-cigarette as a smoking cessation aid appear to be useful [22], e-cigarettes may raise a public health concern if their use leads to increases in youth combustible smoking initiation or consumption in excess of what would have happened in the absence of e-cigarettes [23, 24]. In a literature review on the e-cigarette phenomenon, researchers found there was a need for further research to answer key questions about the safety, patterns of use, effectiveness for combustible tobacco smoking cessation and regulatory issues associated with the use of e-cigarettes, especially as it relates to adolescents [12]. The aim of our study is to investigate the association between e-cigarette use and combustible tobacco smoking cessation or reduction.

## **2. Materials And Methods**

### **2.1. Data Source**

Our study uses data from the Taiwan Adolescent to Adult Longitudinal Study (TAALS), a large nationally representative long-term longitudinal cohort study of health behaviors among adolescents in Taiwan that was conducted between 2014 and 2016 [25]. At baseline, the TAALS survey interviewed students in the first year of middle school and students in the first year of high school. Since our participants are minors (age less than 16 years), informed consent form was collected from both a parent/or legal guardian and the participant for study participation. During the first wave of the formal cohort study, 6903 middle school students and 11,742 high school students were interviewed, for a total of 18,645 students. During the second wave, the same cohort of students was re-interviewed in their third year of middle school and third year of high school. A total of 16,265 students were interviewed (6381 middle school students and 9884 high school students), representing a follow-up completion rate of 87.21%. After excluding participants with incomplete records, a final analysis was conducted on 14,109 students. Among those 14,109 students, 474 students were current smokers at the baseline, of whom 331 students used only combustible cigarettes, while the remaining 143 students used both combustible cigarettes and e-cigarettes. Among the 474 students who were current smokers, 362 students were still current smokers and the remaining 112 students had quit smoking at follow-up (See Figure 1). A more complete description of the TAALS Cohort and methodology is described in one of our previous publications [25]. This study was approved by the Joint Institutional Review Board of Taipei Medical University, Taiwan (TMU-JIRB-201410043).

## 2.2. Measures

### 2.2.1. Definitions of Smoking Cessation and Changes in Total Monthly Combustible Tobacco Consumption

Two main variables were being examined: smoking cessation and total monthly combustible tobacco consumption. The following methods were used to measure smoking cessation. First, participants were being asked "Have you ever smoked a cigarette?" and if they answered yes, they were being asked "In the last 30 days how many days have you smoked cigarettes?". Participants who had smoked any number of cigarettes in the last 30 days were defined as current smokers. At follow-up, participants were identified as either current smoker or quit smoking. Smoking cessation was defined as participants who indicated that they were current smokers at baseline, but then indicated that they hadn't smoked any cigarettes in the last 30 days at follow-up.

The following self-reported questions were used to measure total monthly combustible tobacco consumption: 1. "In the last 30 days, how many days did you smoke cigarettes?", and 2. "In the last 30 days, on the days you smoked cigarettes, on average how many cigarettes did you smoke each day?". From these questions, we measured the number of smoking days per month and average number of cigarettes smoked per smoking day. We multiplied the average number of cigarettes smoked per smoking day by the number of smoking days per month to calculate the total monthly combustible tobacco consumption. Next we subtracted the total number of cigarettes smoked each month at follow-up from

the number of cigarettes smoked each month at baseline to calculate the change in total monthly combustible cigarette consumption.

### 2.2.2. Independent variables at baseline: current e-cigarette use and current use of other tobacco products

In this study, we asked participants at baseline if they are current users of e-cigarettes or other tobacco products. We measured current e-cigarette use by asking: “In the last 30 days how many days have you used e-cigarettes?” and participants responding between 1–30 days, were classified as current e-cigarette users. We measured current other tobacco products use by asking “In the past 30 days have you used other tobacco products (such as: cigars, cigarillos, pipes or water pipes)?”

### 2.2.3. Demographic characteristics variables

This study also recorded the following demographic characteristic variables for all participants: sex, depression, peer support, age, father’s highest education level (junior high or below, high school, university or higher), mother’s ethnicity (Han Chinese, Aboriginal Taiwanese, or New Immigrant), father’s occupation status (full-time, part-time, unemployed), and family living arrangement status (living with both mother and father, living with both parents and grandparents, living with a single parent, living with only grandparents, and living with someone other than direct kin).

## 2.3. Statistical Analysis

The logistic regression was used to evaluate the causal inference between the use of e-cigarettes and future smoking cessation among adolescents. To ensure our analytic results remain nationally representative of adolescents in Taiwan, we used weighted values to conduct weighted adjustment. For a detailed description on how weighted adjustment was performed, please refer to Chein et al. [25]. We used risk ratio (RR) and risk difference (RD) instead of odds ratio (OR) because the use of RR and RD can better reflect the relative and absolute probability change in smoking cessation in the presence of e-cigarettes. Here the adjust risk ratio (aRR) and adjust risk difference (aRD) were performed using the “adjrr” command in STATA statistical software (version 16 MP, StataCorp LLC)[26]. *P*-value of < 0.05 was considered significant.

## 3. Results

### 3.1. Characteristics of study participants

In Table 1, the majority of participants among current e-cigarettes users at baseline had never used other tobacco products (63.6%), were senior high school students (81.8%), were male (76.9%), had their father’s highest education level above senior high school, had their mother’s ethnicity being Han Chinese (81.8%), had their parents working full-time (87.4%), and lived with parents or extended family (64.3%). The majority of participants among non-current e-cigarette users at baseline had never used other tobacco products (90.9%), were male (77.0%), were senior high school students (85.2%), had their father’s highest

education level above senior high school (50.5%), had their mother's ethnicity being Han Chinese (81.6%), had their parents working full-time (91.5%), and lived with parents or extended family (63.4%). In addition, participants from the current e-cigarettes users at baseline group had a mean CES-D scale of  $8.8 \pm 2.9$ , a mean peer support score of  $13.2 \pm 2.6$ , and a mean age of  $17.8 \pm 1.3$ . Participants from the non-current e-cigarette users at baseline group had a mean CES-D scale of  $8.4 \pm 2.8$ , a mean peer support score of  $13.6 \pm 2.4$ , and a mean age of  $18.0 \pm 1.3$ .

Table 1

Demographic characteristics of current smokers stratified by current e-cigarette use—unweighted data (n = 474).

		Current Smokers at Baseline (n = 474)				<i>p</i> -value
		Current E-Cigarettes users at Baseline (n = 143)		Not Current E-Cigarettes users at Baseline (n = 331)		
		n	%	n	%	
Quit Smoking at Follow-Up	Yes	34	23.8	78	23.6	0.960
	No	109	76.2	253	76.4	
Ever used other tobacco products (e.g. cigars, water pipe, pipe, cigarillos ) at baseline	Yes	52	36.4	30	9.1	< 0.001***
	No	91	63.6	301	90.9	
School Type	Junior High	27	18.9	49	14.8	0.267
	Senior High	116	81.1	282	85.2	
Sex	Male	110	76.9	255	77.0	0.978
	Female	33	23.1	76	23.0	
Father's Highest Education Level	Below Junior High School	49	34.3	87	26.3	0.202
	Senior or Vocational High School	60	42.0	167	50.5	
	Above College	34	23.8	77	23.3	
Mother's Ethnicity	Han Chinese	117	81.8	270	81.6	0.804
	Indigenous	19	13.3	38	11.5	
	Foreigner	7	4.9	23	6.9	
Parents' Employment Status	Full-time	125	87.4	303	91.5	0.153
	Part-time	5	3.5	13	3.9	
	Unemployed	13	9.1	15	4.5	

Note: CES-D Scale: Center for Epidemiologic Studies Depression Scale. \*\*\* denotes *p*-value < 0.001; \*\* denotes *p*-value < 0.01; \* denotes *p*-value < 0.05.

Family Living Arrangement	Parents or Extended Family	92	64.3	210	63.4	0.752
	Single Parent	30	21.0	78	23.6	
	Grandparents	8	5.6	21	6.3	
	Other Relatives	13	9.1	22	6.6	
		Mean	SD	Mean	SD	p-value
CES-D Scale		8.8	2.9	8.4	2.8	0.170
Peer Support Score		13.2	2.6	13.6	2.4	0.135
Age		17.8	1.3	18.0	1.3	0.050

Note: CES-D Scale: Center for Epidemiologic Studies Depression Scale. \*\*\* denotes  $p$ -value < 0.001; \*\* denotes  $p$ -value < 0.01; \* denotes  $p$ -value < 0.05.

### 3.2. Association between use of e-cigarettes at baseline and smoking cessation in adolescent smokers

In Table 2, our findings indicated that for all current adolescent smokers, using e-cigarettes was not associated with smoking cessation as compared to current adolescent smokers who did not use e-cigarettes (aRR = 0.99 ; CI = 0.66, 1.50). Among junior high students who smoke, the use of e-cigarettes at baseline was not associated with smoking cessation as compared to junior high students who smoke but did not use e-cigarettes (aRR = 0.72 ; CI = 0.41, 1.28). Among high school students who smoke, the use of e-cigarettes was also not associated with smoking cessation as compared to high school students who smoked but were non-e-cigarette users (aRR = 1.06 ; CI = 0.66, 1.72).

Table 2

Logistic regression model for adjusted risk ratios (aRR) of smoking cessation a stratified by age-weighted estimates (Current smokers at baseline, n = 474).

	All Students			Junior High			Senior High		
	aRR	95% CI	p-value	aRR	95% CI	P	aRR	95% CI	p-value
<b>Unadjusted Model</b>									
Current Use of E-Cigarettes at Baseline	1.00	0.69–1.47	0.98	0.79	0.42–1.48	0.46	1.05	0.67–1.64	0.84
<b>Adjusted Model</b>									
Current Use of E-Cigarettes at Baseline	0.99	0.66–1.50	0.97	0.72	0.41–1.28	0.27	1.06	0.66–1.72	0.80
<p>Note: aRR is adjusted risk ratios. CES-D Scale: Center for Epidemiologic Studies Depression Scale. *** denotes. <math>p</math>-value &lt; 0.001; ** denotes <math>p</math>-value &lt; 0.01; * denotes <math>p</math>-value &lt; 0.05. a. In this model, 1 is defined as successful smoking cessation and 0 is defined as still a current smoker. Therefore, an odds ratio of &gt; 1 shows an increased probability of smoking cessation and an odds ratio of &lt; 1 shows a decreased probability of smoking cessation. The multivariable logit regression model was adjusted for ever use of other tobacco products, depression (CES-D), peer support, father's education, mother's ethnicity, parents' employment status, sex, age, and family living arrangement.</p>									

In Figs. 2, we used adjusted risk difference (aRD) to examine the effect that use of e-cigarettes has on the likelihood of adolescent smokers quitting smoking. The results of our research showed that for current adolescent smokers, using e-cigarettes was not associated with smoking cessation as compared to current adolescent smokers who did not use e-cigarettes (24.4% and 24.6%, respectively) (aRD = -0.2%; CI: -0.10, 0.10;  $p$  = 0.97). When we further stratified by age, among junior high students who smoke, the use of e-cigarettes was not associated with smoking cessation (aRD = 11.4%; CI: 0.31 – 0.08,  $p$  = 0.25). Similarly, among high school students who smoke, the use of e-cigarettes was also not associated with smoking cessation (aRD = 1.4%; CI: 0.10, 0.13;  $p$  = 0.80).

### 3.3. Association between the change in cigarette consumption and the use of e-cigarettes

In Table 3, we further performed a regression model to investigate whether or not the use of e-cigarettes can aid in reducing combustible cigarette consumption. Among all students, e-cigarette use was found to have no association with change in cigarette consumption (Coef. = 0.62; CI = - 36.85, 38.09). Among junior high school students, e-cigarette use was not associated with change in cigarette consumption (coef. = 66.42; CI = - 2.76, 135.60). Similarly, among high school students, e-cigarette use was also not associated with change in cigarette consumption (coef. = 13.46; CI = - 51.49, 24.56).

Table 3

Multivariable regression model for change in total monthly combustible cigarette consumption from baseline to follow-up stratified by age-weighted estimates (Current smokers at baseline and follow-up,  $n = 362$ ).

	All Students		Junior High		High School	
	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI
<b>Unadjusted Model</b>						
Current Use of E-Cigarettes at Baseline	6.30	-30.95–43.55	38.36	-39.83–116.55	-0.51	-42.09–41.08
<b>Adjusted Model</b>						
Current Use of E-Cigarettes at Baseline	0.62	-36.85–38.09	66.42	-2.76–135.60	-13.46	-51.49–24.56
Note: CES-D Scale: Center for Epidemiologic Studies Depression Scale. *** denotes $p$ -value < 0.001; ** denotes $p$ -value < 0.01; * denotes $p$ -value < 0.05. The multivariable regression model was adjusted for ever use of other tobacco products, depression (CES-D), peer support, father's education, mother's ethnicity, parents' employment status, sex, age, and family living arrangement.						

## 4. Discussion

Our present study tested two hypotheses: (1) whether the use of e-cigarettes at baseline can be helpful in combustible cigarette smoking cessation, and (2) how the use of e-cigarettes at baseline affects combustible tobacco consumption at follow-up among adolescent smokers. Our results suggested that the use of e-cigarettes at baseline was not associated with smoking cessation in adolescent smokers. Moreover, the use of e-cigarettes at baseline was not associated with change in combustible cigarette consumption among adolescent smokers.

Evidence from observational studies has been mixed regarding the association between e-cigarette use and combustible cigarette smoking cessation. Some studies show that e-cigarettes may be helpful in reducing combustible tobacco consumption and increasing the likelihood of combustible cigarette smoking cessation [19, 27]. However, other observational studies showed that e-cigarettes were not associated with increased combustible cigarette smoking cessation in both youth and adult populations [28, 29]. As for adolescents, the 2012 National Youth Tobacco Survey in Taiwan didn't find any statistically significant association between e-cigarette use and intention to quit combustible cigarette smoking among current youth smokers [30]. Similarly, the findings from the 2014 National Youth Tobacco Survey also concluded that, among current adolescent smokers, using flavored e-cigarettes was associated with lower odds of intention to quit combustible tobacco use in the next 12 months compared with non-e-cigarettes users (aOR = 0.6;  $p = .006$ ) [29]. Our study also showed similar results in that the use of e-cigarettes in younger adolescents, (i.e. junior high school students), was not associated with a statistically increased odds of quitting and was not associated with a statistically significant probability of decreasing combustible cigarettes consumption. Because the association between e-cigarette use and

smoking cessation behavior remains unclear, more empirical research is warranted to help form evidence-based regulatory policy on e-cigarettes use for adolescents.

On the other hand, our findings in older adolescents, (i.e. students from high school), suggest that e-cigarettes use may have some effect on combustible cigarette smoking cessation and reducing combustible tobacco consumption. However, this benefit must be balanced with the risk of younger adolescents, who are not current smokers and who were unlikely to try combustible cigarettes, experimenting with e-cigarettes and developing nicotine addictions. A recent nationwide study of youth drug use in the US, found that among several different ages of adolescents, only 5–10% of adolescents who had used e-cigarettes reported they used them for the purpose of reducing their combustible tobacco consumption. The majority stated that they used e-cigarettes because they wanted to see what they were like or liked the flavor [31]. Furthermore, epidemiological studies and population surveys also indicate that many e-cigarettes users with the initial intention of quitting ended up becoming dual users, especially in places where smoking is prohibited [32, 33]. A web-based survey consisted of 4444 students from 8 colleges in North Carolina was completed in 2009 showed that e-cigarette use was not associated with intentions to quit smoking among a subsample of conventional cigarette smokers. Unlike older, more established cigarette smokers, e-cigarette use by college students does not appear to be motivated by the desire to quit cigarette smoking [34].

E-cigarettes may have a role as a bridging product which perpetuates or initiates nicotine addiction. A study conducted by Truth Initiative and the US Centers for Disease Control and Prevention found that nearly all e-cigarettes sold by U.S. retailers contained nicotine, with the average nicotine concentration in e-cigarette products increasing from 2.10–4.34% between 2013 to 2018 [35]. E-cigarette products containing no nicotine accounted for only 1% or less of the market share. The majority of youth e-cigarette users think they vaped only flavoring, not nicotine, according to the University of Michigan 2016 Monitoring the Future Study [35]. In Taiwan, nicotine containing e-cigarettes are illegal, but not well regulated and are widely available. According to a study conducted by the Taiwanese Food and Drug administration, out of a sample of 3062 e-cigarettes purchased from by retailers, about 80% contained nicotine. [36]. The high nicotine concentrations found in e-cigarettes have their own health risks, and developing a nicotine addiction in early adolescence, may increase the risk of consuming combustible cigarettes later in life.

While e-cigarettes have been widely used as an aid to quit combustible tobacco smoking, it is also important to consider the long-term safety of e-cigarettes. In the United States, many e-cigarette users make modifications to their devices or use vaping liquids from unregulated (home-made) sources [37]. Even for the legal market, there are often a large array of chemicals that are in vaping liquids, and the health effects of these chemicals is not yet well investigated[38]. In the United States, there has been an alarming increase in severe lung disease associated with vaping and e-cigarette use [39]. Many of these cases appear to be associated with users making modifications to their devices or using unregulated liquids containing nicotine or THC [40]. Given the severity of these lung conditions, which are not seen with traditional cigarette smoking, we believe that more research is needed before we can say that e-

cigarettes are indeed less harmful than traditional cigarettes. Additionally, many non-smokers who begin using e-cigarettes develop nicotine dependence and end up becoming dual users of both traditional cigarettes and e-cigarettes and are therefore exposed to both the negative health effects of each [10].

The effectiveness of e-cigarettes as a tool of combustible tobacco cessation or reduction may vary significantly among different populations. A previous study from the United States found that e-cigarette use was associated with an increased likelihood of quitting traditional cigarette smoking among adult smokers attempting to quit smoking [21]. We believe that social and cultural factors play a significant role in the effectiveness of using e-cigarettes in smoking cessation and that's why our study obtains opposite results. Additionally, there may be important differences between adolescents and adults especially in terms of whether or not they have already developed nicotine dependence and therefore whether e-cigarettes represent a quitting aid or a possible gateway drug [41]. It's also possible that e-cigarettes are a useful tool among cigarette users only if the users are also strongly motivated to quit [42].

A limitation of our study is that despite TAALS being a nationally representative survey of Taiwanese adolescents, there were a low number of participants who smoked in our study population because the Taiwanese adolescent smoking rate is low at approximately 3.4%. As a result, out of our original cohort of 14,109 records, there were only 474 participants who smoked at baseline and therefore only 474 participants whose records could be analyzed to examine the effect of e-cigarette use on smoking cessation. Additionally, our study questionnaire lacks information regarding father's smoking status, which is also an important factor affecting adolescents' attitude towards smoking.

## 5. Conclusions

This nationwide, representative study in Taiwan indicated there was no association between use of e-cigarettes and smoking cessation in adolescent smokers. Furthermore, the use of e-cigarettes was also not association with change in combustible cigarette consumption among adolescent smokers. Meanwhile, e-cigarettes may hinder-tobacco control efforts and therefore, e-cigarette regulations should pay special attention-to the potential health effects of e-cigarette use among adolescents. It is essential for public health professionals and policymakers to understand the epidemiology of e-cigarette use and relevant correlates within each subgroup of age and smoking status to meet tobacco control policy goals.

## Declarations

**Contributors:** Conceptualization, L.-Y. L., Y.-N.C. and H.-Y.C.; methodology, L.-Y.L., Y.-N.C. and H.-Y.C.; validation, L.-Y.L. and Y.-N.C.; formal analysis, Y.-N.C and C.-S.H.; investigation, L.-Y.L. and Y.-N.C.; resources, H.-Y.C.; data curation C.-Y.W. and H.-Y.C.; writing—original draft preparation, L.-Y.L., Y.-N.C., and R.S.; writing—review and editing, L.-Y.L., R.S. and H.-Y.C.; supervision, H.-Y.C. All authors have read and agreed to the published version of the manuscript.

**Role of Funding:** The work was supported by the Health Promotion Administration, Ministry of Health and Welfare, Taiwan (Grant Number: MOHW105-HPA-H-114-133708), from Taiwan's Health and Welfare Surcharge on Tobacco Products—Grant Number: 03724606—Project Code: 1051218-107), and grants R01DA043950 from the US National Institute of Drug Abuse and P50CA180890 from the US National Cancer Institute, and the US Food and Drug Administration (FDA) Center for Tobacco Products. The content is solely the responsibility of the authors and does not necessarily represent the official views of Health Promotion Administration, US National Institutes of Health (NIH), or the US Food and Drug Administration. The funding agencies had no role in study design, data collection, analysis, and interpretation, or writing of this study. The corresponding author had full access to all data in the study and had final responsibility for the decision to submit for publication.

**Institutional Review Board Statement:** The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Taipei Medical University Joint Institutional Review Board (TMU JIRB), No. 201410043.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The data that support the findings of this study are available from the Taiwan Health Promotion Administration but are restricted for research use only. The data are not publicly available. Data are available from the authors upon reasonable request and with permission of the Taiwan Health Promotion Administration.

**Acknowledgments:** The authors thank the Taiwan Health Promotion Administration for collecting the data and providing access to their database for this study

**Conflicts of Interest:** The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results”.

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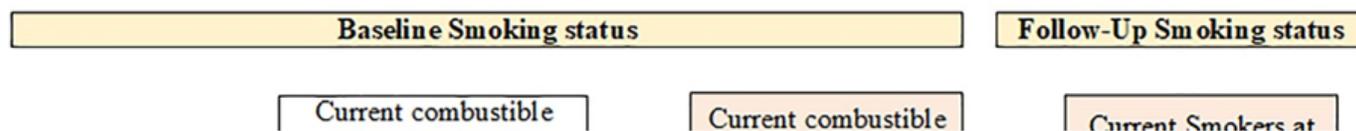
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## Figures



### Figure 1

Participants stratified by smoking status – Unweighted data (N = 14,109)

Note:  $\phi$  is the sample size which is used to analyze the association between use of e-cigarettes at baseline and smoking cessation in adolescent smokers.  $\psi$  is the sample size which is used to analyze the change in total monthly combustible cigarette consumption from baseline to follow-up.



**Figure 2**

Logistic regression model for adjusted risk differences (aRD) of smoking cessation stratified by age—weighted estimates (Current smokers at baseline,  $n = 474$ ).

Note: Models were adjusted by ever use of other tobacco products, depression (CES-D), peer support, father’s education, mother’s ethnicity, parents’ employment status, sex, age, and family living arrangement.