Association between Peer Cigarette Smoking and Electronic Cigarette Smoking among Adolescent Nonsmokers: A National Representative Survey

Jun Hyun Hwang, Soon-Woo Park*

Department of Preventive Medicine, Catholic University of Daegu School of Medicine, Daegu, Republic of Korea

* parksw@cu.ac.kr

Abstract

We assessed the association between electronic cigarette (e-cigarette) use and peer cigarette smoking, a major risk factor for the initiation of cigarette smoking in adolescents. Data from the 2013 Korea Youth Risk Behavior Web-based Survey of 65,753 nonsmokers aged 13–18 years were analyzed using multiple logistic regression. A total of 3.8% of the Korean adolescents were ‘ever e-cigarette’ users and 1.2% were current users. Adjusted odds ratios (ORs) for current and ever e-cigarette use compared to those whose closest friends were non-smokers ranged from 2.05 (95% confidence interval [CI], 1.82–2.30) to 5.50 (95% CI, 4.77–6.34), and from 2.23 (95% CI, 1.77–2.81) to 7.82 (95% CI, 5.97–10.25) for those who had ‘some’ close friends to ‘most/all’ friends who smoked, respectively. The slopes of the adjusted ORs for e-cigarette use in ‘never smokers’ were more than twice as steep as those in ‘former smokers’, showing a significant interaction effect between the proportion of smoking closest friends and cigarette smoking status (never or former smokers) (p<0.001 for interaction). Peer cigarette smoking had a significant association with e-cigarette use in adolescent nonsmokers, and this association was greater on never smokers than former smokers.

Introduction

Since the development of electronic cigarettes (e-cigarettes) in early 2000 and their introduction as an alternative to cigarettes, scientific evidences on their safety, smoking cessation effects, and adverse reactions have been accumulating [1–3]. Nevertheless, the e-cigarette market has grown rapidly through aggressive marketing using mass media such as the Internet [1,4–6]. In particular, e-cigarette companies are expanding the e-cigarette market primarily by targeting and marketing to adolescents and other young age groups through sponsorship of youth-oriented events, the development of e-cigarette flavors that appeal to youth, and lax youth e-cigarette purchase accessibility through online and offline stores [7,8].
According to the United States National Youth Tobacco Survey (NYTS), ‘ever e-cigarette’ use in high school students doubled in 1 year from 4.7% in 2011 to 10.0% in 2012 [9] while the estimated number of adolescent ever e-cigarette users among ‘never cigarette smokers’ more than tripled from 79,000 in 2011 to 263,000 in 2013 [10]. McMillen et al. reported that the prevalence of current e-cigarette use in the 18–24 age group in the U.S. was 0.0% in 2010, but increased to 14.2% in 2013 [11]. Both the prevalence and margin of increase in the 18–24 age group were higher than for higher age groups. The 2013 Canadian Tobacco, Alcohol and Drugs Survey reported that younger age groups (15–24 years old) had higher current and ever e-cigarette use than older age groups (greater than 25 years old). These studies indicate that younger age groups have greater exposure to e-cigarettes [12].

Even if the continued debate about the efficacy of e-cigarettes as an alternative to cigarettes is excluded, the hypothesis that e-cigarettes are a gateway drug to cigarettes in nonsmokers has been proposed as a problem associated with e-cigarettes [5,13,14]. According to Bunnell et al. [10], intention to smoke cigarettes was 1.7 times higher in e-cigarette ever users than e-cigarette never users among adolescent never smokers. Dutra et al. [15] also reported that adolescent e-cigarette users showed high odds ratios (ORs) for current or ever cigarette smoking. According to Lee et al. [16], the OR of adolescent current e-cigarette users for current cigarette smokers was 64.9 times higher than that of e-cigarette never users. The NYTS study also supported the hypothesis [17] that e-cigarette ever users were more open to future cigarette smoking. Recent longitudinal studies in US and Swiss also supported that adolescent e-cigarette users were more likely to be cigarette smokers at follow-up assessments (6 or 12 month after baseline) [18–21]. Therefore, it is important to prevent adolescent never smokers from initiating e-cigarette use or former smokers from reinitiating cigarette smoking through e-cigarette use. To do so, it is necessary to identify the nonsmoker groups who are more likely to use e-cigarettes.

Given that friends’ cigarette smoking is a strong predictor of smoking initiation in adolescents [22–24], this peer influence is also suspected to significantly influence e-cigarette use in nonsmoking adolescents. However, there are few studies on this topic. To the best of our knowledge, the only cohort study on e-cigarette use related to peer group smoking is from Germany. This study reported that the OR of ever e-cigarette use in participants with smoker friends was 2.06 times (overall, including both former smokers and never smokers) or 1.78 times (never smokers) higher than in participants with no smoker friends [25]. In the U.S., a cross-sectional study of psychosocial factors for e-cigarette use showed that both e-cigarette and cigarette use among friends were strongly associated with current e-cigarette use in adolescents. The study showed that the ORs for current e-cigarette use increased with increasing number of friends who smoked tobacco products and ranged from 104 times (3 or 4 out of 4 closest friends smoked e-cigarettes) or 11.2 times (3 or 4 out of 4 closest friends smoked cigarettes) higher than those with no closest friends who smoked e-cigarettes or cigarettes [26]. However, the previous two studies were limited because they did not consider the effects of prior cigarette experience on e-cigarette use. Cigarette smoking status categorized as current, former or never smoker is not only closely associated with factors related to e-cigarette use but is in itself a strong risk factor for e-cigarette use [11,16,27]. Therefore, smoking status should be considered when analyzing factors related to e-cigarette use.

It is difficult to disentangle the impact of peer cigarette smoking and cigarette smoking status on youth e-cigarette use. In order to remedy this issue, and account for the effect of cigarette smoking status, it is necessary to restrict analyses of the impact of peer smoking on e-cigarette use to non-current smokers and to stratify these analyses into never and former cigarette smoking youth. Therefore, we used nationally representative data from Korean adolescents to investigate the association between peer cigarette smoking and e-cigarette use by nonsmokers and determine whether such association are also dependent on past cigarette experience.
Materials and Methods

Study population

Data were analyzed from the 10th Korea Youth Risk Behavior Web-based Survey (KYRBS-X) conducted in 2014 by the Korea Centers for Disease Control and Prevention. The KYRBS is a nationally representative, self-reported, and anonymous online survey that was administered to Korean students enrolled in grades 7 to 12. The KYRBS uses a stratified multistage probability sampling design to produce nationally representative statistics on health behaviors in Korean adolescents. A total of 72,060 students from 799 schools (400 middle schools and 399 high schools) completed the KYRBS-X (response rate = 97.2%) [28]. Additional details about the sampling methodology and survey procedure are available elsewhere [29]. After excluding current smokers, the study population included 65,753 nonsmokers (7,660 former smokers and 58,093 never smokers). Here, nonsmokers were defined as adolescents who reported not smoking in the past month. This secondary data analysis was exempt from review by the Institutional Review Board of the Daegu Catholic University Medical Center (CR-15-084).

Measures

E-cigarette use. The e-cigarette use outcome variable was evaluated in two ways for current and ever e-cigarette use. First, ever e-cigarette use was defined as a "yes" response to the following question: "Have you ever used e-cigarettes?" Second, among ever smokers, participants who selected "yes" to the question "During the past 30 days, have you used e-cigarettes?" were considered current e-cigarette users.

Smoking-related factors. Peer cigarette smoking was assessed using responses to the following question: "Do any of your closest friends smoke tobacco?" Participants were provided with four possible answers: 1) None of them, 2) Some of them, 3) Most of them, and 4) All of them. Here, because the sample size of the 'all' group (0.8%) was too small to be separately categorized, this group and the 'most' group (5.0%) were combined (most/all). Cigarette smoking status among nonsmokers was classified into former smokers or never smokers using a composite measure of the two questions: "Have you ever tried cigarette smoking, even one or two puffs?" and "During the past 30 days, how many days did you smoke, even one puff?" Those who answered "yes" to the first question and "had not smoked in the past 30 days" to the second question were classified as former smokers. Those who answered "no" to the first question were classified as never smokers. Participants with a family member such as a parent, sibling, or grandparent who currently smoked cigarettes were considered to be living with a household member that used tobacco.

Other characteristics. Other covariates were categorized into two domains: sociodemographic and lifestyle. Sociodemographic variables included sex, school type (middle school, general high school, or vocational high school), region of residence (metropolitan city, city, or province), and perceived academic performance (high, middle, or low; classified using the question, "During the past 12 months, how would you rate your academic performance?"). Lifestyle and psychosocial factors included frequency of alcohol drinking per month (never, less than 6 times, or 6 or more times), experience of drug use (yes or no; classified using the question, Have you ever taken a drug or inhaled butane gas/bond habitually or intentionally), and perceived stress level (low, middle, or high; classified using the question, "How much stress do you usually feel?").

Statistical analysis

Multivariate logistic regression was conducted to estimate the relationship between peer cigarette smoking and e-cigarette use after adjusting for covariates including sex, school, location,
perceived academic performance, alcohol intake, drug experience, perceived stress level, cigarette smoking status, and current smoking household member. In order to assess the association with peer cigarette smoking from the perspective of both simple smoking experience and current e-cigarette use, two different models were used to assess risk factors for current and ever e-cigarette use. Because cigarette smoking status is closely associated with e-cigarette use, an interaction model between peer cigarette smoking and cigarette smoking status was used to estimate the association between peer cigarette smoking and e-cigarette use according to cigarette smoking status. All analyses were performed using SPSS version 19.0 (IBM, Armonk, NY, USA) and a p-value of < 0.05 was considered significant. Complex SPSS sampling procedures were used to accurately represent the adolescent population in Korea.

Results

Among adolescent nonsmokers, 3.8% and 1.2% were ever and current e-cigarette users, respectively. Ever e-cigarette use was significantly higher in former smokers (19.9% vs. 1.6% for never smokers; p < 0.01) and in those with a current smoking household member (4.2% vs. 3.2%; p < 0.01). Current e-cigarette use was also significantly higher in former smokers (6.3% vs. 0.5% in never smokers; p < 0.01) and those with a current smoking household member (1.3% vs. 1.1%; p < 0.05). The prevalence of ever or current e-cigarette use significantly increased as the proportion of closest friend smokers increased (p < 0.01). Therefore, 19.8% or 8.7% of nonsmokers with most/all smoking closest friends were ever or current e-cigarette users, respectively. With the exception of location, all other well-known risk factors for cigarette smoking or e-cigarette use were significantly associated with e-cigarette use (Table 1).

After adjusting for all of the covariates, former smokers were more likely to be ever (adjusted OR = 7.89; 95% confidence interval [CI], 7.17–8.69) or current e-cigarette users (adjusted OR = 5.32; 95% CI, 4.52–6.27) than never smokers. A dose-response relationship between the proportion of closest friend smokers and e-cigarette use was observed. Specifically, adjusted ORs for ever e-cigarette use increased from 2.05 (95% CI, 1.82–2.30) for participants with some closest friends who smoked to 5.50 (95% CI, 4.77–6.34) for those who reported most or all of their closest friends smoked. Similarly, adjusted ORs for current e-cigarette use increased from 2.23 (95% CI, 1.77–2.81) to 7.82 (95% CI, 5.97–10.25) across these groups (Table 2).

The prevalence of e-cigarette use increased steadily with an increase in the proportion of smoking closest friends among both never smokers and former smokers. Under the same condition of the proportion of smoking closest friends, the prevalence of ever or current e-cigarette use was consistently higher in former smokers than never smokers. However, the rate of increase of e-cigarette use prevalence in never smokers was greater than that in former smokers. In particular, while the prevalence of ever e-cigarette use in former smokers increased 3.3 times (from 10.95% in those with no smoking closest friends to 36.61% in those with most/all closest friends), it increased 15.5 times (from 0.68% to 10.57%) in never smokers (Fig 1).

The results from the interaction model between peer cigarette smoking and cigarette smoking status are shown in Fig 2. Regardless of cigarette smoking experience, the adjusted ORs for current or ever e-cigarette use increased significantly with increasing proportion of smoking closest friends in never smokers (p < 0.001 for trend). This significant association was also present in former smokers. However, a significant interaction between the proportion of smoking closest friends and cigarette smoking status was observed in both ever and current e-cigarette use models (p < 0.001 for interaction) and the slopes of the adjusted ORs for current or ever e-cigarette use in never smokers were more than twice as steep as those in former smokers (Fig 2).
Table 1. Summary statistics of variables by e-cigarette status among nonsmokers.

| Characteristic                              | All<sup>a</sup>                   | E-cigarette use<sup>b</sup> |       |       |
|--------------------------------------------|-----------------------------------|-----------------------------|-------|-------|
| Respondents                                | 65,753 (100.0)                    | Never                       | 63,384 (96.2) | 2,369 (3.8) | 752 (1.2) |
| Socio-demographic factors                  |                                   | Ever                        | 1,882 (6.2)<sup>c</sup> | 634 (2.1)<sup>c</sup> |
| Sex                                        |                                   | Current                     | 487 (1.4) | 118 (0.4) |
| Male                                       | 31,611 (49.4)                     | 29,729 (93.8)               | 1,239 (4.6) | 380 (1.5) |
| Female                                     | 34,142 (50.6)                     | 33,655 (98.6)               | 307 (7.4) | 117 (2.7) |
| School                                     | 34,543 (50.7)                     | 33,720 (97.5)               | 823 (2.5)<sup>c</sup> | 255 (0.8)<sup>c</sup> |
| Middle school                               | 26,592 (41.8)                     | 25,353 (95.4)               | 1,239 (4.6) | 380 (1.5) |
| General high school                        | 4,618 (7.5)                       | 4,411 (92.6)                | 307 (7.4) | 117 (2.7) |
| Location                                   | 34,215 (52.2)                     | 32,983 (96.3)               | 1,232 (3.7) | 405 (1.3) |
| Metropolitan city                          | 28,350 (43.9)                     | 27,309 (96.1)               | 1,041 (3.9) | 310 (1.2) |
| City                                       | 3,188 (3.9)                       | 3,092 (97.1)                | 96 (2.9) | 37 (1.2) |
| Province                                   | 25,307 (38.5)                     | 24,586 (97.0)               | 721 (3.0)<sup>c</sup> | 206 (0.9)<sup>c</sup> |
| Perceived academic performance             | 18,755 (28.6)                     | 18,182 (96.8)               | 573 (3.2) | 187 (1.1) |
| High                                       | 21,691 (33.0)                     | 20,616 (94.8)               | 1,075 (5.2) | 359 (1.8) |
| Middle                                     |                                   |                             |         |         |
| Low                                        |                                   |                             |         |         |
| Lifestyle and psychosocial factors         |                                   |                             |         |         |
| Frequency of alcohol drinking (per month)  |                                   |                             |         |         |
| Never                                      | 58,276 (88.3)                     | 56,735 (97.3)               | 1,541 (2.7)<sup>c</sup> | 431 (0.8)<sup>c</sup> |
| <6                                         | 6,284 (9.8)                       | 5,649 (89.6)                | 635 (10.4) | 224 (3.6) |
| ≥6                                         | 1,193 (1.9)                       | 1,000 (82.8)                | 193 (17.2) | 97 (8.9) |
| Experience of drug use                     | 371 (0.6)                         | 266 (74.1)                  | 85 (25.9)<sup>c</sup> | 49 (15.3)<sup>c</sup> |
| Yes                                        | 65,382 (99.4)                     | 63,098 (96.4)               | 2,284 (3.6) | 703 (1.2) |
| No                                         |                                   |                             |         |         |
| Perceived stress level                     |                                   |                             |         |         |
| High                                       | 23,823 (36.2)                     | 22,870 (95.8)               | 953 (4.2)<sup>c</sup> | 290 (1.3)<sup>c</sup> |
| Middle                                     | 28,601 (43.7)                     | 27,678 (96.7)               | 923 (3.3) | 279 (1.0) |
| Low                                        | 13,329 (20.1)                     | 12,836 (96.1)               | 493 (3.9) | 183 (1.5) |
| Smoking-related factors                    |                                   |                             |         |         |
| Cigarette smoking status                   |                                   |                             |         |         |
| Former                                     | 7,660 (11.8)                      | 6,187 (80.1)                | 1,473 (19.9)<sup>c</sup> | 456 (6.3)<sup>c</sup> |
| Never                                      | 58,093 (88.2)                     | 57,197 (98.4)               | 896 (1.6) | 296 (0.5) |
| Closest friend smoking                     |                                   |                             |         |         |
| None                                       | 39,415 (58.4)                     | 38,948 (98.8)               | 467 (1.2)<sup>c</sup> | 119 (0.3)<sup>c</sup> |
| Some                                       | 22,778 (35.8)                     | 21,574 (94.6)               | 1,204 (5.4) | 328 (1.5) |
| Most/All                                   | 5,959 (5.8)                       | 2,862 (80.2)                | 698 (19.8) | 305 (8.7) |
| Household member current smoking           |                                   |                             |         |         |
| Yes                                        | 38,550 (58.1)                     | 36,995 (95.8)               | 1,555 (4.2)<sup>c</sup> | 489 (1.3)<sup>b</sup> |
| No                                         | 27,203 (41.9)                     | 26,389 (96.8)               | 814 (3.2) | 263 (1.1) |

Abbreviations: e-cigarette, electronic cigarette.
Data are presented as unweighted N (weighted percentage).
<sup>a</sup>Percentages are by column.
<sup>b</sup>Percentages are by row. Ever e-cigarette use indicates having ever tried an e-cigarette and current e-cigarette use indicates having used an e-cigarette in the past 30 days.
<sup>c</sup>p<0.01.
<sup>d</sup>p<0.05.
doi:10.1371/journal.pone.0162557.t001
The adjusted ORs in interaction terms (Former ⨉ Some, Former ⨉ Most/All) were significantly lower than 1.0 in both the ever and current e-cigarette use models; this means that former smokers are less likely to be affected by the proportion of closest smoking friends.
compared to never smokers. The interaction effect was larger in the most/all group than the some group. Specifically, the adjusted ORs in interaction terms for Former $\times$ Most/All (ever e-cigarette use, 0.39; current e-cigarette use, 0.26) were lower than those for Former $\times$ Some (ever e-cigarette use, 0.69; current e-cigarette use, 0.54) (Table 3).

**Discussion**

This study showed that the proportion of closest friends who smoked had a significant relationship with e-cigarette use in adolescent nonsmokers. Both ever and current e-cigarette use increased significantly as the proportion of closest friend smokers increased, regardless of past

---

**Fig 1.** Prevalence of ever (A) or current (B) e-cigarette use according to the proportion of closest smoking friends among nonsmokers.

doi:10.1371/journal.pone.0162557.g001
smoking experience. This finding is consistent with results from a German cohort study that indicated peer cigarette smoking affected lifetime e-cigarette use [25]. Furthermore, our results suggest that in adolescents peer group cigarette smoking plays an important role in not only cigarette smoking but also in e-cigarette use. In particular, considering that the adjusted OR of peer group cigarette smoking was higher among the analyzed variables, the results were consistent with previous results that indicated peer group cigarette smoking can have a significant influence on various types of adolescent smoking such as smokeless tobacco [30, 31].

In a longitudinal study conducted with 12-year-old adolescents in the United States, as friend compliance (measured with the following question; “I do what my friends want me to do, even if I really don’t want to.”) increased, the use of smokeless tobacco also increased [32]. In addition, another cross-sectional study of U.S. adolescents showed that approval and use of e-cigarettes and cigarettes among friends were strongly associated with e-cigarette use [26]. These findings suggest that not only directly assessed peer smoking but also perceived peer smoking among friends can significantly influence the use of e-cigarettes.

### Table 3. Evaluation of the interaction effect between peer cigarette smoking and cigarette smoking status for current and ever e-cigarette use.

|                | Ever e-cigarette use | Current e-cigarette use |
|----------------|-----------------------|--------------------------|
|                | Adjusted odds ratios (95% confidence intervals)* | Adjusted odds ratios (95% confidence intervals)* |
| Closest friend smoking (A) | | |
| None           | Reference             | Reference                |
| Some           | 2.37 (2.03–2.75)      | 2.75 (2.04–3.70)         |
| Most/All       | 8.82 (7.27–10.70)     | 15.25 (10.83–21.48)     |
| Cigarette smoking status (B) | | |
| Never          | Reference             | Reference                |
| Former         | 12.44 (10.21–15.16)   | 11.80 (8.18–17.02)       |
| Interaction(A×B) | | |
| Former × Some  | 0.69 (0.53–0.85)      | 0.54 (0.35–0.82)         |
| Former × Most/All | 0.39 (0.30–0.51) | 0.26 (0.17–0.41) |

*Adjusted for sex, school, location, perceived academic performance, alcohol intake, drug experience, perceived stress level, and current smoking household member.
influence or psychosocial factors regardless of cigarette use can influence the use of cigarette alternatives including e-cigarettes.

In addition to peer group cigarette smoking acting as a direct pathway to adolescent cigarette smoking, an alternative or indirect pathway to adolescent cigarette smoking can occur via e-cigarette use. Several longitudinal studies among adolescents or young adults in US or Swiss reported recently that e-cigarette use in adolescent non-smokers or never-smokers was closely associated with both willingness to smoke and smoking initiation [18–21]. Moreover, this phenomenon can be accelerated by the renormalization strategy from aggressive e-cigarette marketing.

In the past several decades, efforts have been made to establish desirable social norms about smoking through denormalization strategies, which are main strategies used in global tobacco control [33]. Tobacco industry denormalization strategies have also shown a reduction in the rate of adolescent cigarette smoking [34]. However, the psychological barriers to cigarette use formed through denormalization strategies has been threatened by e-cigarette company renormalization strategies through various marketing techniques [35]. As a result, there is the risk that lowered psychological barriers from renormalization strategies increase the likelihood of cigarette smoking via e-cigarette use (indirect pathway), rather than through peer group cigarette smoking (direct pathway).

In particular, the present study showed that the influence of peer group cigarette smoking on e-cigarette use was over 2 times higher in never smokers than former smokers and this difference could be explained by renormalization. In other words, psychological barriers to e-cigarette use have already been lowered in former smokers as a result of their past smoking experience. Consequently, former smokers may perceive e-cigarette use as non-deviant behavior; therefore, the role of renormalization strategies by e-cigarette companies may be nonsignificant in former smokers compared to never smokers. In contrast, in never smokers, the threshold of psychological barriers that recognizes e-cigarette use as deviant behavior may be lower than that for cigarette use due to renormalization strategies. As a result, it is believed that even never smokers who were not influenced by peer group cigarette smoking to initiate cigarette smoking may react to e-cigarette use and show a stronger response to peer influence than former smokers. Specifically, having more friends who were cigarette smokers was associated with a greater response margin to e-cigarette use regardless of past cigarette experience. Because having a greater number of peer group cigarette smokers leads to lower negative perceptions about cigarette smoking [36], these results suggest that the interaction between peer group cigarette smoking and e-cigarette renormalization had a more substantial influence on diminishing psychological barriers.

Because the present study was cross-sectional, it was unable to evaluate whether there was a causal relationship between peer group cigarette smoking and e-cigarette use. Moreover, because it posed no questions about social norms or perceptions about cigarettes or e-cigarettes, it was difficult to directly identify the cause of the differential influence of peer group cigarette smoking on e-cigarette use between former and never smokers. Thus, there is a need for continued study of this subject in the future. Despite these limitations, the present study had the following advantages. First, the study used nationally representative data from a large-scale survey including 2,369 ever e-cigarette users and 752 current e-cigarette users. Second, after excluding current smokers, analyses were performed by dividing the subjects into former and never smokers. This enabled accurate assessments of peer group cigarette smoking on e-cigarette use, including simultaneous analysis of the interaction between peer group cigarette smoking and cigarette smoking status. Finally, when comparisons were made with comparable 2011 U.S. NYTS data [15,16], it was revealed that e-cigarette use in Korean adolescents (4.7%) was more than 4 times higher than in U.S. adolescents (1.1%). Furthermore, among current
smokers, the dual user rate (36.6%) was much higher than that of U.S. adolescents (10.6%). Moreover, the rate of current e-cigarette only users was higher in Korean adolescents (1.1%) than in U.S. adolescents (0.6%). Considering that e-cigarettes are widely marketed through the Internet and South Korea is globally an Internet powerhouse [37], South Korea is at risk for dramatic increases in future e-cigarette use. That being the case, the present study was meaningful in that it is the first to assess factors related to e-cigarette use in Korean adolescents.

**Conclusion**

Peer group cigarette smoking had an important relationship with adolescent e-cigarette use and this relationship was greater on never smokers than former smokers. These findings give warning that peer group cigarette smoking can be combined with e-cigarette renormalization strategies to enable the expansion of the e-cigarette market by reaching adolescent never smokers who would otherwise not be interested in cigarette use. Not only did e-cigarette users have positive perceptions of e-cigarettes, they also had liberal views on future cigarette smoking and had high potential to become dual users [15–17,27,38]. Therefore, it is essential to continue to study e-cigarettes to accurately assess their health hazards and use e-cigarette denormalization strategies to instill proper e-cigarette perceptions in adolescents. This will mitigate adolescents' expanded use of e-cigarettes and prevent cigarette smoking in this group.

**Author Contributions**

**Conceptualization:** SWP JHH.

**Formal analysis:** JHH.

**Funding acquisition:** SWP.

**Methodology:** JHH.

**Writing – original draft:** JHH.

**Writing – review & editing:** SWP JHH.

**References**

1. Grana R, Benowitz N, Glantz SA (2014) E-cigarettes: a scientific review. Circulation 129: 1972–1986. doi: 10.1161/CIRCULATIONAHA.114.007667 PMID: 24821826

2. Kalkhoran S, Glantz SA (2016) E-cigarettes and smoking cessation in real-world and clinical settings: a systematic review and meta-analysis. Lancet Respir Med 4: 116–128. doi: 10.1016/S2213-2600(15)00521-4 PMID: 26776875

3. Chatham-Stephens K, Law R, Taylor E, Melstrom P, Bunnell R, Wang B, et al. (2014) Notes from the field: calls to poison centers for exposures to electronic cigarettes—United States, September 2010-February 2014. MMWR Morb Mortal Wkly Rep 63: 292–293. PMID: 24699766

4. Richardson A, Ganz O, Vallone D (2015) Tobacco on the web: surveillance and characterisation of online tobacco and e-cigarette advertising. Tob Control 24: 341–347. doi: 10.1136/tobaccocontrol-2013-051246 PMID: 24532710

5. Yamin CK, Bitton A, Bates DW (2010) E-cigarettes: a rapidly growing Internet phenomenon. Ann Intern Med 153: 607–609. doi: 10.7326/0003-4819-153-9-201011020-00011 PMID: 21041581

6. Lee S, Kimm H, Yun JE, Jee SH (2011) Public health challenges of electronic cigarettes in South Korea. J Prev Med Public Health 44: 235–241. doi: 10.3961/jpmp.2011.44.6.235 PMID: 22143173

7. McCarthy M (2014) E-cigarette companies target youth, US congressional study finds. Bmj 348: g2871. doi: 10.1136/bmj.g2871 PMID: 24755576

8. Durbin RJ, Waxman HA, Rockefeller JD IV, Blumenthal R, Markey EJ, Brown S, et al. Gateway to addiction? A survey of popular electronic cigarette manufacturers and targeted marketing to youth.
9. Centers for Disease Control and Prevention (2013) Notes from the field: electronic cigarette use among middle and high school students—United States, 2011–2012. MMWR Morb Mortal Wkly Rep 62: 729–730. PMID: 24005229

10. Bunnell RE, Agaku IT, Arriazola RA, Apelberg BJ, Caraballo RS, Corey CG, et al. (2015) Intentions to smoke cigarettes among never-smoking US middle and high school electronic cigarette users: National Youth Tobacco Survey, 2011–2013. Nicotine Tob Res 17: 228–235. doi: 10.1093/ntr/ntu166 PMID: 25143298

11. McMillen RC, Gottlieb MA, Shafer RM, Winickoff JP, Klein JD (2015) Trends in Electronic Cigarette Use Among U.S. Adults: Use is Increasing in Both Smokers and Nonsmokers. Nicotine Tob Res 17: 1195–1202. doi: 10.1093/ntr/ntu213 PMID: 25381306

12. Czoli CD, Reid JL, Rynard VL, D. H (2015) E-cigarettes in Canada—Tobacco Use in Canada: Patterns and Trends, Special Supplement. Waterloo, ON: Propel Centre for Population Health Impact, University of Waterloo.

13. Henningfield JE, Zaatari GS (2010) Electronic nicotine delivery systems: emerging science foundation for policy. Tob Control 19: 89–90. doi: 10.1136/tc.2009.035279 PMID: 20378582

14. Etter JF, Bullen C, Flouris AD, Laugesen M, Eissenberg T (2011) Electronic nicotine delivery systems: a research agenda. Tob Control 20: 243–248. doi: 10.1136/tc.2010.042168 PMID: 21415064

15. Dutra LM, Glantz SA (2014) Electronic cigarettes and conventional cigarette use among U.S. adolescents: a cross-sectional study. JAMA Pediatr 168: 610–617. doi: 10.1001/jamapediatrics.2013.5488 PMID: 24604023

16. Lee S, Grana RA, Glantz SA (2014) Electronic cigarette use among Korean adolescents: a cross-sectional study of market penetration, dual use, and relationship to quit attempts and former smoking. J Adolesc Health 54: 684–690. doi: 10.1016/j.jadohealth.2013.11.003 PMID: 24274973

17. Coleman BN, Apelberg BJ, Ambrose BK, Green KM, Choiniere CJ, Bunnell R, et al. (2015) Association between electronic cigarette use and openness to cigarette smoking among US young adults. Nicotine Tob Res 17: 212–218. doi: 10.1093/ntr/ntu211 PMID: 25378683

18. Leventhal AM, Strong DR, Kirkpatrick MG, Unger JB, Sussman S, Riggs NR, et al. (2015) Association of Electronic Cigarette Use With Initiation of Combustible Tobacco Product Smoking in Early Adolescence. JAMA 314: 700–707. doi: 10.1001/jama.2015.8950 PMID: 26284721

19. Primack BA, Sonjei S, Stoolmiller M, Fine MJ, Sargent JD (2015) Progression to Traditional Cigarette Smoking After Electronic Cigarette Use Among US Adolescents and Young Adults. JAMA Pediatr 169: 1018–1023. doi: 10.1001/jamapediatrics.2015.1742 PMID: 26348249

20. Wills TA, Sargent JD, Knight R, Pagano I, Gibbons FX (2016) E-cigarette use and willingness to smoke: a sample of adolescent non-smokers. Tob Control 25: e52–59. doi: 10.1136/tobaccocontrol-2015-052349 PMID: 26261237

21. Gmel G, Baggio S, Mohler-Kuo M, Daeppen JB, Studer J (2016) E-cigarette use in young Swiss men: is vaping an effective way of reducing or quitting smoking? Swiss Med Wkly 146: w14271. doi: 10.4414/swm.2016.14271 PMID: 26752454

22. Lee S, Yun JE, Lee JK, Kim IS, Jee SH (2010) The Korean prediction model for adolescents’ future smoking intentions. J Prev Med Public Health 43: 283–291. doi: 10.3961/jpmph.2010.43.4.283 PMID: 20689354

23. Bricker JB, Peterson AV, Robyn Andersen M, Leroux BG, Bharat Rajan K, Sarason IG (2006) Close friends’, parents’, and older siblings’ smoking: reevaluating their influence on children’s smoking. Nicotine Tob Res 8: 217–226. doi: 10.1080/14622200600576339 PMID: 16766414

24. de Vries H, Engels R, Kremer S, Wetzels J, Mudde A (2003) Parents’ and friends’ smoking status as predictors of smoking onset: findings from six European countries. Health Educ Res 18: 627–636. doi: 10.1093/her/cyg032 PMID: 14572021

25. Hanewinkel R, Isensee B (2015) Risk factors for e-cigarette, conventional cigarette, and dual use in German adolescents: a cohort study. Prev Med 74: 59–62. doi: 10.1016/j.ypmed.2015.03.006 PMID: 25770433

26. Barrington-Trimis JL, Berhane K, Unger JB, Cruz TB, Huh J, Leventhal AM, et al. (2015) Psychosocial Factors Associated With Adolescent Electronic Cigarette and Cigarette Use. Pediatrics 136: 308–317. doi: 10.1542/peds.2015-0639 PMID: 26216326

27. Czoli CD, Hammond D, White CM (2014) Electronic cigarettes in Canada: prevalence of use and perceptions among youth and young adults. Can J Public Health 105: e97–e102. PMID: 24886856
28. Ministry of Education, Ministry of Health & Welfare, Korea Centers for Disease Control and Prevention (2014) The 10th Korea youth risk behavior web-based survey, 2014. Chungwon: Korea Centers for Disease Control and Prevention.

29. Kim Y, Choi S, Chun C, Park S, Khang YH, Oh K (2016) Data Resource Profile: The Korea Youth Risk Behavior Web-based Survey (KYRBS). Int J Epidemiol. doi: 10.1093/ije/dyw070 PMID: 27380796

30. Orimadegun AE, Ola OO (2012) Risk factors associated with smokeless tobacco use and cigarette smoking among teenagers in a sub-urban area of south west Nigeria. J Public Health 20: 631–637.

31. Larsen E, RISE J, Lund KE (2013) Risk and protective factors of adolescent exclusive snus users compared to non-users of tobacco, exclusive smokers and dual users of snus and cigarettes. Addict Behav 38: 2288–2294. doi: 10.1016/j.addbeh.2013.02.007 PMID: 23583834

32. Holman LR, Bricker JB, Comstock BA (2013) Psychological predictors of male smokeless tobacco use initiation and cessation: a 16-year longitudinal study. Addiction 108: 1327–1335. doi: 10.1111/add.12164 PMID: 23607490

33. World Health Organization (WHO) WHO framework convention on tobacco control. Elaboration of guidelines for implementation of Article 12 of the convention: Progress report of the working group. 2008. Available: http://www.who.int/gb/fctc/PDF/cop3/FCTC_COP3_8-en.pdf. Accessed 17 July 2015.

34. Malone RE, Grundy Q, Bero LA (2012) Tobacco industry denormalisation as a tobacco control intervention: a review. Tob Control 21: 162–170. doi: 10.1136/tobaccocontrol-2011-050200 PMID: 22345240

35. Fairchild AL, Bayer R, Colgrove J (2014) The renormalization of smoking? E-cigarettes and the tobacco "endgame". N Engl J Med 370: 293–295. doi: 10.1056/NEJMep1313940 PMID: 24350902

36. Piko B (2001) Smoking in adolescence do attitudes matter? Addict Behav 26: 201–217. PMID: 11316377

37. Organization for Economic Cooperation and Development (OECD) OECD Broadband statistics. Penetration Fixed and wireless broadband subscriptions per 100 inhabitants. 2014. Available: http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm. Accessed 6 July 2015.

38. Ambrose BK, Rostron BL, Johnson SE, Portnoy DB, Apelberg BJ, Kaufman AR, et al. (2014) Perceptions of the relative harm of cigarettes and e-cigarettes among U.S. youth. Am J Prev Med 47: S53–60. doi: 10.1016/j.amepre.2014.04.016 PMID: 25044196