



## ■ Original Article

# The Relationship between Electronic Cigarette Use with or without Cigarette Smoking and Alcohol Use among Adolescents: Finding from the 11th Korea Youth Risk Behavior Web-based Survey

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**Background:** Electronic cigarette (EC) consumption ('vaping') is rapidly increasing, not only in adults but also in adolescents. Little is known about the association between vaping and problem behaviors such as drinking.

**Methods:** We used data from the 11th Korea Youth Risk Behavior Web-based Survey, which was conducted in 2015 and included 68,043 participants who were Korean middle and high school students. The survey assessed EC, cigarette, and alcohol use. Multiple regression analysis was used to examine risk of current drinking and problem drinking across the following categories of users: never user (never used either product), former user (use of EC or cigarettes in the past, but not currently), vaping only, smoking only, and dual user (current use of both products).

**Results:** EC only users were 1.2% in males, and 0.3% in females. Dual user of both conventional cigarettes and ECs were 5.1% in males, and 1.2% in females. Drinking frequency, drinking quantity per once, and problem drinking were higher among vapers than non-vapers and former-vapers, moreover, were higher among daily vapers than intermittent vapers. Compared to never users, EC only users were higher on risk of current drink and problem drink. The dual users were highest on risk of current drink.

**Conclusion:** Vaping is independently associated with alcohol use problems in Korean students, even those not currently smoking. Moreover, dual use of cigarettes and ECs is strongly associated with alcohol use problems. Therefore, vaping students should be concerned about their hidden alcohol use problems.

**Keywords:** Adolescent Behavior; Alcohol Drinking; Electronic Nicotine Delivery Systems; Smoking

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## INTRODUCTION

Electronic cigarettes (ECs) are electronic devices through which individuals inhale a nicotine solution by vaporizing it. This device was developed by a Chinese pharmacist, Hon Lik, in 2003, introduced to the press in 2007, and then sold in earnest from 2008.<sup>1)</sup> Unlike conventional cigarettes, ECs do not have a combustion process, and many smokers use it to reduce smoking.

ECs are increasing in popularity around the world. In 2014, the percentage of adults who had ever tried ECs was 12.6%, and the percentage of current vapers was 3.7% in the United States.<sup>2)</sup> In particular, the number of adolescent vapers is rising significantly. According to statistics from the Centers for Disease Control and Prevention (United States), the percentage of high school students using ECs increased from 1.5% to 16.0% between 2011 and 2015. The 2015 rate is well above the conventional cigarette smoking rate of 9.3%.<sup>3)</sup> The use of ECs is also increasing among Korean adolescents. In a study on 444 Korean middle and high school students in 2008, the percentage of teenagers who used ECs was 0.5%,<sup>4)</sup> and according to the 11th Korea Youth Risk Behavior Web-based Survey (KYRBWS-XI), conducted in 2015, the percentage increased to 9.8%.<sup>5)</sup>

In principle, it is illegal to sell EC liquid containing nicotine to adolescents in Korea, but the law is relatively lax.<sup>6)</sup> Adolescents can purchase it from a local market or store, or purchase it online. According to the 2015 KYRBWS-XI, only 14.5% of vapers used nicotine-free liquid, and most of them were bought by friends, obtained from seniors, purchased at EC shops, or purchased online.<sup>5)</sup>

Korean adolescent vapers tend to have higher economic status and receive more allowance per week than smokers.<sup>7)</sup> Most Korean adolescent vapers responded that they use ECs because they believed them to be less harmful than conventional cigarettes and would help them quit smoking.<sup>8)</sup> However, the effectiveness of EC smoking has not yet been proven, and some studies have shown that the use of ECs is not associated with smoking cessation or reduction.<sup>9)</sup> In one study, the dual use of conventional cigarettes and ECs showed greater dependence on ECs than cigarettes alone.<sup>9)</sup> In addition, ECs contain harmful substances such as nicotine and diethylene glycol, which may cause addiction.<sup>10)</sup> It is of concern that adolescents may start using other substances or develop risk behavior by using ECs.<sup>11)</sup>

Drinking is one of the most common problem behaviors. It is already well known that drinking in adolescence can negatively affect the individual's physical and mental well-being and educational life.<sup>12)</sup> The relationship between drinking and smoking in adolescents has been studied extensively;<sup>13)</sup> however, to the best of our knowledge, there is still little research on the link between vaping and drinking among Korean adolescents.

In a study on 1,941 high school students in Hawaii, the rates of drinking and binge drinking were higher among vapers than non-vapers, and was lower among smokers.<sup>14)</sup> In addition, a study on 3,102 adolescents from New York and Connecticut found that vapers were more likely to engage in alcohol, binge drinking, smoking, marijuana,

and hookahs than non-users. In this study, vaping and the smoking were found to be statistically similar to drinking and binge drinking.<sup>15)</sup> However, the analysis of conventional smoking, which may have a large impact on drinking and EC use, has not been sufficiently conducted in the above studies.

The purpose of this study was to analyze the relationship between vaping and drinking, which is a typical problem of adolescents, by using the 2015 KYRBWS-XI, which presents epidemiological data of Korean adolescents. In addition, we aimed to determine whether vaping is related to drinking even if the effect of conventional smoking is excluded. The results of this study can be used as a basis for future research and for the establishment of EC countermeasures.

## METHODS

### 1. Study Participants

The 2015 KYRBWS-XI was an anonymous, self-administered online survey conducted with students from middle school to high school to understand their health behaviors and other related aspects, such as smoking, drinking, obesity, eating habits, and physical activity level. The KYRBWS-XI defined the target population as middle and high school students nationwide as of April 2015. The participants were divided based on tiers, sample distribution, and sampling stages. We surveyed 70,362 students from 400 middle schools and 400 high schools, and 68,043 (96.7%) responded to the survey.<sup>5)</sup> The KYRBWS-XI consisted of 15 domains and 125 indicators. The questions and indicators were developed through a regional consultative committee based on domestic and international data. The smoking and drinking domains comprised 24 and eight items, respectively. A questionnaire on the use of ECs was included in the 7th survey in 2011. For the present study, ethical approval was not required because the KYRBWS survey data are publicly available. All the participants signed an informed consent form.

### 2. Definition of Variables

#### 1) Dependent variables

To determine the factors related to EC and alcohol use among adolescents, we used smoking-related factors identified in previous studies on the relationship between smoking and drinking. The dependent variables of the present study were current drinking and problem drinking. Current drinking status was based on the question "In the last 30 days, how many days did you have more than one drink?" If they answered 1 or more days, they were categorized under the current drinking group. Problem drinking status was categorized by the CRAFFT (car, relax, alone, forget, friends, trouble) screening test.<sup>16)</sup> Items on the CRAFFT screening test are based on the question "Have you ever had any of the following experiences during the last 12 months?" The experiences were "experience of drinking alcohol to relieve stress or to get fit," "experience of drinking alcohol alone," "experience of being advised to stop drinking by family or friends," "experi-

ence of driving a motorcycle, bicycle, or car, or being driven by another drunk person,” “experience of being disturbed by drinking,” and “experience of drinking and fighting with others.” If the participants had two or more experiences, they were categorized under the problem drinking group.

In the univariate analysis, current drinkers were divided into daily drinkers and intermittent drinkers by the question “How many days did you have more than one drink during the last 30 days?” If they answered “daily,” they were categorized as daily drinkers; otherwise they were categorized as intermittent drinkers. Non-current drinkers were divided into never drinkers and former drinkers. In the question “Have you ever had more than one drink? (Except for a few sips in rites or sacraments),” if they answered “yes,” they were categorized as former drinkers; otherwise they were categorized as never drinkers. Drinking quantity per intake as a variable was divided into nondrinkers, less than two glasses of soju, three glasses or more but less than one bottle, and one bottle or more by the question “In the last 30 days, what is the average amount of alcohol you consumed?”

### 2) Independent variables

The independent variables were smoking and vaping status. The questions asked were “In the last 30 days, how many days have you used ECs?” and “How many days have you smoked a cigarette in the last 30 days?” If the participants answered “1 or more days,” they were categorized as current vapers and current smokers, respectively. For the questions “Have you ever used ECs?” and “Have you ever smoked a cigarette?” if they answered “Yes,” they were categorized as vaping experienced and smoking experienced, respectively. On the basis of these questions, they were categorized into five groups: never user (never used either product), former user (formerly used EC or cigarette but not currently), vaping only (vaping but not smoking currently), smoking only (smoking but not vaping currently), and dual user (use of both products currently). We categorized the students into these groups in order to determine whether vaping was independently related with the problem of alcohol consumption.

In the univariate analysis, we used vaping status as a variable. Current vapers were divided into daily vapers and intermittent vapers. Participants were asked “How many days did you use an EC during the last 30 days?” If they answered “daily,” they were categorized as daily vapers; otherwise, they were categorized as intermittent vapers.

### 3) Confounding variables

Other confounding variables included sex, school grade, city scale, economic status, weekly allowance, academic performance, stress perception, and grief status. School grade was divided into middle school and high school. City scale was divided into metropolis, medium cities, and other countries. Economic status, academic performance, and stress perception were divided into high, middle-high, middle, middle-low, and low by the questions “What is your family’s economic status?” “How was your academic performance in the last 12 months?” and “How often do you feel stressed?” Answers to the

question “What is your average weekly allowance?” were categorized into “Less than 10,000 Korean won (KRW),” “10,000 or more KRW but less than 20,000 KRW,” “20,000 or more KRW but less than 40,000 KRW,” and “40,000 or more KRW.” Grief status was measured by the question “Did you ever feel sad or desperate enough to stop your daily

Table 1. Characteristics of study participants

Characteristic	Male (n=35,204)	Female (n=32,839)	Total (N=68,043)
School grade			
Middle school	47.1 (1.5)	46.9 (1.7)	47.0 (0.8)
High school	52.9 (1.5)	53.1 (1.7)	53.0 (0.8)
City scale			
Metropolis	43.5 (1.6)	43.6 (1.7)	43.6 (0.8)
Medium cities	49.9 (1.6)	50.4 (1.7)	50.1 (0.9)
Countries	6.6 (0.9)	6.1 (0.8)	6.3 (0.5)
Economic status			
High	10.8 (0.3)	7.3 (0.2)	9.1 (0.2)
Middle-high	28.0 (0.4)	26.4 (0.4)	27.2 (0.3)
Middle	44.7 (0.4)	49.0 (0.4)	46.8 (0.3)
Middle-low	13.1 (0.3)	14.3 (0.3)	13.7 (0.2)
Low	3.4 (0.1)	3.0 (0.1)	3.2 (0.1)
Weekly allowance (Korean won)			
<10,000	31.6 (0.5)	32.5 (0.5)	32.0 (0.3)
<20,000	27.7 (0.3)	28.2 (0.3)	27.9 (0.2)
<40,000	22.2 (0.3)	21.9 (0.3)	22.0 (0.2)
≥40,000	18.5 (0.4)	17.5 (0.4)	18.0 (0.2)
School performance			
High	13.9 (0.3)	11.2 (0.2)	12.6 (0.2)
Middle-high	24.1 (0.3)	26.1 (0.3)	25.1 (0.2)
Middle	26.8 (0.3)	29.1 (0.3)	27.9 (0.2)
Middle-low	23.5 (0.3)	23.8 (0.3)	23.6 (0.2)
Low	11.7 (0.2)	9.8 (0.2)	10.8 (0.2)
Current drinking			
No	80.0 (0.4)	86.9 (0.4)	83.3 (0.3)
Yes	20.0 (0.4)	13.1 (0.4)	16.7 (0.3)
Problem drinking*			
No	92.7 (0.3)	95.3 (0.2)	94.0 (0.2)
Yes	7.3 (0.3)	4.7 (0.2)	6.0 (0.2)
Smoking and vaping status			
Never user	72.7 (0.6)	90.6 (0.4)	81.3 (0.5)
Former user	14.2 (0.3)	5.9 (0.2)	10.2 (0.2)
Vaping only	1.2 (0.1)	0.3 (0.0)	0.8 (0.0)
Smoking only	6.9 (0.2)	2.0 (0.1)	4.5 (0.2)
Dual user	5.1 (0.2)	1.2 (0.1)	3.2 (0.1)
Stress perception			
High	7.3 (0.2)	10.4 (0.2)	8.8 (0.1)
Middle-high	22.2 (0.3)	31.3 (0.3)	26.6 (0.2)
Middle	45.0 (0.3)	43.0 (0.3)	44.1 (0.2)
Middle-low	20.0 (0.3)	13.5 (0.2)	16.9 (0.2)
Low	5.4 (0.1)	1.8 (0.1)	3.7 (0.1)
Grief status†			
No	80.3 (0.3)	72.2 (0.3)	76.4 (0.2)
Yes	19.7 (0.3)	27.8 (0.3)	23.6 (0.2)

Values are presented as weighted % (standard error).

\*Measured by the CRAFFT (car, relax, alone, forget, friends, trouble) screening test.

†Measured by the question “Did you ever feel sad or desperate enough to stop your daily activities for more than 2 weeks during the last 12 months?”

activities for more than 2 weeks during the last 12 months?" These variables can act as confounders. So those were applied to the analysis sequentially.

### 3. Statistical Analysis

To analyze data, we used the statistical package Stata ver. 13.1 (Stata Corp., College Station, TX, USA). The KYRBWS provides a method of representing the population in the survey. We used 'composite sample analysis,' the weighting method recommended by "analyses guidelines for KYRBWS,"<sup>5)</sup> and the expected frequency at which the weight of each variable was applied was calculated. The chi-square ( $\chi^2$ ) test was used to confirm the relationship between vaping status and drinking-related variables such as, drinking status, drinking quantity per intake, and problem drinking.

Lastly, a multiple logistic regression analysis was conducted to analyze the relationship between vaping and smoking status and problem drinking and current drinking. In this analysis, sex was stratified and corrected with the other confounding variables. In model 1, it was adjusted to the demographic variables of school grade, city scale, economic status, and weekly allowance. In model 2, it was adjusted to academic performance, stress perception, grief status, and the variables used in model 1. The significance level was  $P < 0.05$ . All analyses were conducted using Stata ver. 14.0 (Stata Corp.).

## RESULTS

### 1. The General Characteristics of Participants

In this study, 68,043 students responded to the KYRBWS-XI. The general characteristics of the participants are shown in Table 1. There were 35,204 male students and 32,839 female students. Out of all the participants, 47% were middle school students and 53% were high school students. Most of the participants resided in metropolis areas (43.6%),

followed by medium cities (50.1%), and other countries (6.3%).

Of the total respondents, 20% male students and 13.1% female students were current drinkers, and 7.3% male students and 4.7% female students were problem drinkers. With regard to smoking, percentages of former users, vaping-only users, smoking-only users, and dual users were 14.2%, 1.2%, 6.9%, and 5.1% in male students, respectively, and 5.9%, 0.3%, 2.0%, and 1.2% in female students, respectively. Of the male students, 1.3% used ECs daily and 4.9% used them occasionally, whereas 0.3% female students used ECs daily and 1.2% used them occasionally. All the variables measured were more common in male students.

### 2. Univariate Analysis of Electronic Cigarette and Alcohol Use Parameters

The participants were divided into four groups according to their vaping status, and their drinking status, drinking quantity per intake, and problem drinking are shown in Table 2. Among never users, former users, intermittent users, and daily users, daily users drunk frequently, drunk large quantities at a time, and also were often problem drinking.

### 3. Multivariate Analysis of Electronic Cigarette Use and Current Drinking

In the former user group, the risk of current drinking was 2.4 (95% confidence interval [CI], 2.2–2.7) in male students and 3.6 (95% CI, 3.2–4.1) in female students, compared with the never user group (Table 3). In the vaping-only group, the risk of current drinking was 6.5 (95% CI, 5.1–8.2) in male students and 10.8 (95% CI, 6.5–18.0) in female students, compared with the never user group. In the dual-user group, the risk of current drinking was 16.7 (95% CI, 14.3–19.4) in male students and 24.3 (95% CI, 7.4–33.9) in female students, compared with the never user group. These associations decreased when adjusted for confounding variables, but were still statistically significant.

**Table 2.** Association between vaping frequency and alcohol use parameters

Variable	Vaping status				P-value*
	None (n=29,766)	Former (n=3,351)	Current (n=2,287)		
			Intermittent (n=1,664)	Daily (n=623)	
Drinking status					
None	64.38 (0.4)	14.33 (0.6)	11.73 (0.8)	7.06 (1.3)	<0.001
Former	23.4 (0.3)	38.34 (0.9)	19.28 (1.0)	13.22 (1.6)	
Intermittent	12.11 (0.3)	46.66 (1.0)	67.42 (1.2)	64.47 (2.4)	
Daily	0.1 (0.0)	0.67 (0.1)	1.57 (0.3)	15.26 (1.8)	
Drinking quantity per intake					
None	87.78 (0.2)	52.67 (1.0)	31.01 (1.2)	20.27 (2.0)	<0.001
≤2 Cups	6.26 (0.1)	9.09 (0.5)	12.33 (0.8)	6.98 (1.2)	
<1 Bottles	3.14 (0.1)	11.97 (0.5)	17.13 (1.0)	14.48 (2.1)	
≥1 Bottles	2.82 (0.1)	26.28 (0.9)	39.53 (1.4)	58.27 (2.5)	
Problem drinking <sup>†</sup>					
No	96.94 (0.1)	74.54 (0.8)	60.54 (1.3)	41.82 (2.4)	<0.001
Yes	3.06 (0.1)	25.46 (0.8)	39.46 (1.3)	58.18 (2.4)	

Values are presented as weighted % (standard error) by univariate analysis.

\*Derived from chi-square analyses. <sup>†</sup>Measured by the CRAFFT (car, relax, alone, forget, friends, trouble) screening test.

**Table 3.** Association between smoking and vaping status and current drinking\*

Smoking and vaping status	No. of participants	Weighted prevalence % (standard error)	OR or adjusted OR (95% confidence interval) <sup>†</sup>		
			Crude	Model 1 <sup>‡</sup>	Model 2 <sup>§</sup>
<b>Male</b>					
Never user	25,764	10.5 (0.3)	1 (Ref)	1 (Ref)	1 (Ref)
Former user	4,938	27.3 (0.8)	3.2 (2.9–3.5)	2.5 (2.3–2.7)	2.4 (2.2–2.7)
Vaping only	403	48.8 (2.8)	8.1 (6.5–10.1)	6.8 (5.4–8.6)	6.5 (5.1–8.2)
Smoking only	2,415	59.1 (1.2)	12.3 (11.0–13.7)	8.5 (7.6–9.5)	8.0 (7.2–9.0)
Dual user	1,684	75.6 (1.3)	26.3 (22.6–30.5)	17.9 (15.4–20.9)	16.7 (14.3–19.4)
<b>Female</b>					
Never user	29,768	9.4 (0.3)	1 (Ref)	1 (Ref)	1 (Ref)
Former user	1,651	33.8 (1.4)	4.9 (4.3–5.6)	3.9 (3.4–4.4)	3.6 (3.2–4.1)
Vaping only	96	60.0 (6.0)	14.1 (8.7–22.8)	12.2 (7.5–20.1)	10.8 (6.5–18.0)
Smoking only	641	72.2 (2.0)	24.9 (20.2–30.7)	19.1 (15.3–23.8)	16.2 (13.0–20.1)
Dual user	383	78.1 (2.6)	34.3 (25.4–46.3)	28.1 (20.1–39.2)	24.3 (17.4–33.9)

OR, odds ratio; Ref, reference.

\*By multivariable analysis. <sup>†</sup>Derived from multiple logistic regression analysis. <sup>‡</sup>Adjusted for school grade, size of city, economical status, and allowance per week. <sup>§</sup>Adjusted for covariates in model 1 and school performance, stress, and depression.**Table 4.** Association between smoking and vaping status and problem drinking\*

Smoking and vaping status	No. of participants	Weighted prevalence % (standard error)	OR or adjusted OR (95% confidence interval) <sup>†</sup>		
			Crude	Model 1 <sup>‡</sup>	Model 2 <sup>§</sup>
<b>Male</b>					
Never user	25,764	1.7 (0.1)	1 (Ref)	1 (Ref)	1 (Ref)
Former user	4,938	9.1 (0.5)	5.9 (5.1–6.9)	4.4 (3.8–5.1)	4.2 (3.6–4.9)
Vaping only	403	15.6 (1.9)	10.9 (8.1–14.7)	8.1 (6.0–11.1)	7.4 (5.4–10.1)
Smoking only	2,415	31.3 (1.1)	27.0 (23.2–31.3)	17.0 (14.5–19.8)	15.5 (13.3–18.0)
Dual user	1,684	47.8 (1.4)	54.2 (46.4–63.3)	33.7 (28.6–39.7)	29.6 (25.1–35.0)
<b>Female</b>					
Never user	29,768	2.1 (0.1)	1 (Ref)	1 (Ref)	1 (Ref)
Former user	1,651	16.4 (1.0)	8.9 (7.5–10.6)	6.9 (5.8–8.2)	6.1 (5.1–7.2)
Vaping only	96	32.3 (5.4)	21.9 (13.4–35.7)	17.8 (10.6–29.8)	14.5 (8.6–24.7)
Smoking only	641	51.1 (2.3)	47.7 (38.6–58.9)	34 (27.0–42.7)	26.9 (21.3–33.9)
Dual user	383	55.2 (2.9)	56.3 (43.3–73.2)	40.8 (30.0–55.5)	33.5 (24.7–45.5)

OR, odds ratio; Ref, reference.

\*By multivariable analysis. <sup>†</sup>Derived from multiple logistic regression analysis. <sup>‡</sup>Adjusted for school grade, city scale, economical status, and weekly allowance. <sup>§</sup>Adjusted for covariates in model 1 and school performance, stress perception, and grief status.

In the dual-user group, the risk of current drinking was 2.1 (95% CI, 1.8–2.5) in male students and 1.5 (95% CI, 1.1–2.1) in female students, compared with the smoking-only group (data not shown). The risk of current drinking in both male and female students was statistically significant after adjustment.

#### 4. Multivariate Analysis of Electronic Cigarette Use and Problem Drinking

In the former user group, the risk of current drinking was 4.2 (95% CI, 3.6–4.9) in male students and 6.1 (95% CI, 5.1–7.2) in female students, compared with the never user group (Table 4). In the vaping-only group, the risk of current drinking was 7.4 (95% CI, 5.4–10.1) in male students and 14.5 (95% CI, 8.6–24.7) in female students, compared with the never user group. In the dual-user group, the risk of current drinking was 29.6 (95% CI, 25.1–35.0) in male students and 33.5 (95% CI, 24.7–45.5) in female students, compared with the never user group.

These associations decreased when adjusted for confounding variables, but were still found to be statistically significant.

In the dual-user group, the risk of current drinking was 1.9 (95% CI, 1.7–2.2) in male students and 1.3 (95% CI, 0.9–1.7) in female students, compared with the smoking-only group (data not shown). A P-value 0.118 for female students was not statistically significant.

## DISCUSSION

The purpose of this study was to determine whether EC use in Korean adolescents was independently associated with drinking with and without conventional cigarette use. Among students who used only ECs, problem drinking and current drinking were higher than in those who did not use cigarettes or ECs, or used them in the past. However, these students who used only ECs showed a lower association than those who only used cigarettes. When compared with those who only



used cigarettes, students who used both cigarettes and ECs showed higher current drinking and problem drinking in the male students, and only higher current drinking in the female students.

In Korea, not only is it considered unethical, but it is also illegal for juveniles to drink alcohol. However, in addition to current drinking, it was necessary to evaluate whether adolescents had problems due to alcohol abuse or dependence. The validated CRAFFT screening test was used as an independent variable to screen for alcohol issues.<sup>16)</sup> The results showed that both current drinking and problem drinking are significantly associated with ECs, and problem drinking is more related. The difference suggests that vaping is more closely related to whether adolescents demonstrate alcohol abuse or dependence problems than just drinking.

Comparing the results between sexes, the use of ECs among female students shows a higher risk of alcohol consumption and problem drinking than in male students. This sex difference has also been found in other studies that analyzed the association between smoking and other problem behaviors in Korean students.<sup>17)</sup> In Korea, male students tend to have problem behaviors such as smoking or drinking, whereas female students tend to do the same but in small clusters. Thus, the association between problem behaviors in female students is stronger than that of male students, and our findings revealed that vaping also belongs to these clustered behaviors. Therefore, the use of ECs may be more useful in detecting risky behavior in girls.

The dual-user group had a significantly higher probability of current drinking and problem drinking in both sexes. According to a previous study, the experience of risky behaviors of adolescents such as drugs and sexual experiences in addition to alcohol-related problems was higher in the dual-user group.<sup>18)</sup> This finding suggests that students who engage in risky behaviors are more likely to use cigarettes and ECs. It also suggests that students with dual use may use ECs in schools and other non-smoking areas. Previous studies have revealed that students felt a need to smoke in non-smoking areas for the purpose of using ECs,<sup>1)</sup> and this is one of the reasons for the high risk of alcohol problems in the dual-user group.

We conducted a univariate analysis to determine whether there was a positive correlation between the frequency of vaping and drinking (Table 2). To observe this in detail, we divided current drinking into drinking status and drinking quantity per intake. We found that the frequency of drinking, former drinking, and the rate of problem drinking increased markedly with the increase in the frequency of vaping. This positive correlation shows the link between alcohol and ECs more clearly.

In Korea, there is a lack of research on the relationship between drinking and vaping among adolescents. Wills et al.<sup>14)</sup> and Camenga et al.<sup>15)</sup> have conducted studies in other countries. Both studies, similar to the present study, revealed that users of ECs are more likely to drink and binge drink compared with nonvapers. In the study by Camenga et al.,<sup>15)</sup> the current cigarette smoker group had 10.00 times (95% CI, 5.42–18.45) the probability of current drinking compared with the never smoker group, and was similar to the smoking-only group of the

present study (adjusted odds ratio [aOR], 9.5; 95% CI, 8.6–10.5). However, in the current EC users group, the probability of current drinking compared with the never smokers group was 17.88 (95% CI, 10.25–31.18). This result was similar to that of the dual-user group (aOR, 18.3; 95% CI, 16.0–20.1) rather than the vaping-only group (aOR, 7.3; 95% CI, 6.0–9.0) of the present study. The study by Camenga et al.<sup>15)</sup> did not distinguish between single EC users and dual users, and considering that 57 of the 76 EC users (75%) in the study were currently dual users, it is also possible to explain the similarity of dual users in the present study. The study by Wills et al.<sup>14)</sup> was analyzed by an Analysis of variance (ANOVA), so it was not able to compare the detailed risk. However as in the present study, the likelihood of current drinking and binge drinking was higher in the order of never user, vaping only, smoking only, and dual user. In the present study, logistic regression analysis included ethnicity, sex, grade, family structure, parental education, parental support, academic involvement, self-control, familial conflict, smoking associated factors, and marijuana use for confounders. Even after adjustment, vaping was independently associated with drinking and binge drinking. Although we did not use the exact same variables, it supports the validity of our findings that vaping is independently associated with drinking.

In adolescents, many problem behaviors are shown clustered. In the study by Sean et al.,<sup>19)</sup> other problem behaviors (truancy, poor grades, marijuana use, illicit drug use, nonmedical prescription drug use) were analyzed in multiple logistic regression analyses.<sup>19)</sup> In that study, similar to the present study, vaping was independently associated with increased risk of drinking. Furthermore, vaping was associated with increased risk of other problem behaviors besides drinking.

Our research has several strengths. First, because it used Korean domestic data, the results can be applied directly to domestic clinical treatment or policy making. Second, because EC users were divided into single users and dual users, it shows how ECs are independently related to alcohol use. It also shows how the probability of having a drinking problem increases when cigarette users use ECs. In addition, students who had used ECs or cigarettes in the past were also classified, so that they could be compared with never users or EC users. Third, we stratified the analysis by sex. Considering that drinking, smoking, and EC use profiles between Korean male and female students are very different, stratification analysis by sex increased the validity of the analysis. In addition, after adjustment by a number of variables, results were statistically significant and the validity of the analysis was improved.

Because of the limitations of a cross-sectional study, the causal relationship between ECs and alcohol is unknown. The items of the KYRBWS-XI used in this study did not include questions related to the presence of nicotine in ECs; therefore, it is difficult to determine whether the association between ECs and alcohol is due to nicotine or the use of ECs. Furthermore, the present study did not examine other problem behaviors. In addition, the data used in the present study can be affected by reporting bias because it was collected with a self-administered online survey. Future studies will require a study design

that can reveal the causal relationship between ECs and alcohol, and also include a questionnaire about the presence of nicotine in ECs.

Nonetheless, our study revealed an independent association of ECs in drinking problems using the KYRBWS-XI, which is a nationally approved survey, on a large number of middle and high school students (68,043 in 800 schools). This result can be used to discover hidden drinking problems and in the counseling of adolescent EC users. We hope that the results of this study will be used to establish management measures and regulatory policies to limit the use of EC in adolescents.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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