



Factors Associated with Former and Current E-Cigarette Use Among Lifetime Cigarette-Smoking College Students

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Abstract

Concurrent electronic cigarette (e-cigarette) and cigarette use has been rising among college students. Thus, we investigated the following aims in a sample of 533 Korean college students: (a) characteristics of cigarette consumption in three e-cigarette use groups, (b) perceived relative harm of e-cigarettes and the greatest reason for e-cigarette use (EU), and (c) factors associated with EU among lifetime cigarette smokers. We conducted descriptive statistics, analysis of variance, Fisher's exact test, and multinomial logistic regression. EU was significantly associated with lifetime and past 30-day cigarette smoking and the number of cigarette-smoking days and cigarettes smoked. Most e-cigarette users considered e-cigarettes as less harmful. Main reasons for EU were no smell, lower harm, and feasibility to use in non-smoking areas. Finally, EU among lifetime cigarette smokers was strongly associated with male sex, younger age, and greater numbers of cigarette-smoking days. Anti-smoking education and anti-smoking regulations should be systematically implemented on campus.

Keywords Electronic cigarette use · Cigarette smoking · Dual use · Harm perception · College student

Despite the recent trends showing a decrease in cigarette use among young adults, electronic cigarette (e-cigarette) use has been on the rise in this age group (U.S. Department of Health and Human Services [USDHHS], 2016). For example, in national studies comparing e-cigarette use across age groups in the USA and Canada, the rates of both lifetime and current e-cigarette use have been highest in the young adult group (Phillips et al., 2017; Reid et al., 2017; Schoenborn & Gindi, 2015; Sharapova et al., 2018). Similarly, a national study in South Korea found (a) generally rising trends in lifetime and current e-cigarette

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use among young adults over time and (b) the highest rates of lifetime and current e-cigarette use in young adulthood (Ministry of Health and Welfare [MHW] & Korea Centres for Disease Control and Prevention [KCDC], 2020).

Despite the increasing trend in e-cigarette use, there has been considerable debate about positive and negative aspects of e-cigarettes in the literature (Case et al., 2017; Polosa et al., 2013). The positive aspects include a decrease in cigarette consumption, alleviation of cigarette withdrawal symptoms, and harm reduction as compared to conventional cigarette use (Cahn & Siegel, 2011; Pokhrel et al., 2014; Polosa et al., 2013). The negative aspects include increased risk of cigarette use and the existence of potential harm (Soneji et al., 2017; USDHHS, 2016). Specifically, the potential harm of e-cigarette use includes adverse influences of (a) inhalation of e-cigarette compounds (e.g., solvents and adulterants) and (b) new toxicants produced through a chemical reaction (USDHHS, 2016).

Thus, it is urgent to enhance the understanding of e-cigarette use among young adults. In particular, attention should be given to college-attending young adults, considering the following reasons. First, they have been tobacco companies' youngest legal marketing target (Rigotti et al., 2005). Second, they may be more easily attracted to novel features of e-cigarettes, such as USB re-chargeability (Jun & Kim, 2020; Lee et al., 2017a; Sutfin et al., 2013). Finally, they may consider e-cigarettes as an alternative to conventional cigarettes (Llanes et al., 2019).

In investigating e-cigarette use among college students, another important issue to note is their greater tendency to simultaneously use multiple tobacco products. About 70% of college students were found to concurrently use cigarettes and other tobacco products (Li et al., 2018). Cigarettes and e-cigarettes were the most common tobacco products used together (Kasza et al., 2017; Kinouani et al., 2017). Despite the prevalent concurrent use of cigarettes and e-cigarettes (hereafter referred to as “dual use”) among college students (Awan, 2016; Case et al., 2017; Cooper et al., 2017; Ilic et al., 2020; Kenne et al., 2017; Kinouani et al., 2017; Littlefield et al., 2015; Sutfin et al., 2013), not much is currently known about this phenomenon (Maglia et al., 2018; Robertson et al., 2019; Wills & Sargent, 2017).

The literature has indicated that e-cigarette use could be associated with diverse characteristics in young adults, including college students: male sex, younger age, lower physical activity, greater sensation seeking, cigarette smoking, and drinking (Case et al., 2017; Jeon et al., 2016; Li et al., 2018; Pokhrel et al., 2020; Ramo et al., 2015; Saddleson et al., 2015; Sutfin et al., 2013). Although an association between e-cigarette and income has been rarely investigated in previous studies of young adults, the negative association between them has been found in empirical studies of those \geq aged 18 years (Jaber et al., 2018; Stallings-Smith & Ballantyne, 2019).

Given the aforementioned facts, this phenomenon should be better understood among college students. In particular, a better understanding of this phenomenon is important among Korean college students, due to the following characteristics in Korea: (a) high acceptance levels of male smoking in Korean culture, (b) strong social pressure to smoke among young adults, (c) the use of smoking as important means for communication and socialization among male college students, and (d) higher smoking risks due to a sense of freedom and independence after college entrance (Huh et al., 2013; Park, 2019; Shin & Kim, 2017).

Thus, we investigated the following aims among Korean college students: (a) characteristics of cigarette consumption (e.g., past 30-day cigarette smoking and number of cigarettes smoked) among three groups divided by e-cigarette smoking status (i.e., e-cigarette non-users, former e-cigarette users, and current e-cigarette users), (b) differences in

“perceived relative harm of e-cigarettes compared with cigarettes and the greatest reason for e-cigarette use” between former and current e-cigarette users, and (c) factors strongly associated with former and current e-cigarette use among lifetime cigarette smokers.

Methods

Study Design and Sample

After obtaining an institutional review board approval (KHSIRB-16–053[EA]), we collected cross-sectional data using a convenience sampling method. Specifically, we recruited our participants from five colleges located in Gyeonggi province or Seoul, Korea. First, during eight days from September 12, 2016, we posted printed fliers of our study for sample recruitment, after obtaining approval of posting our fliers from these universities. As study participants, we included those who (a) were attending colleges and (b) heard about e-cigarettes because e-cigarette awareness was a prerequisite to collecting data on e-cigarette use (Lotrean, 2015; Singh et al., 2017). We excluded those who (a) were attending the college affiliated with researchers of this study and (b) had a job at the time of the survey. These exclusion criteria were needed due to an ethical issue, such as potential coercion (Ferguson et al., 2004; Long & Johnson, 2007), and characteristics of Korean college education, respectively. Specifically, in Korea, most students enter college right after high school graduation and study full-time in their mid-20’s (Korean Educational Statistics Service, n.d.; Moon, 2015; Oh & Kim, 2016). In the next step, during three months from October to December in 2016, we administered a paper questionnaire to 550 recruited participants after obtaining informed consent. Five hundred and forty of them returned the completed survey questionnaire.

Finally, we analyzed data obtained from 533 college students after excluding incomplete data ($n=7$). Specifically, the number of participants analyzed in our study varied depending on our study aims. We used (a) the total sample ($N=533$) to investigate characteristics of cigarette consumption in three groups divided by e-cigarette smoking status, (b) 76 lifetime e-cigarette users (defined as those who had ever used e-cigarettes in lifetime) to investigate perceived harm of e-cigarettes and the greatest reason for e-cigarette use, and (c) 132 lifetime cigarette smokers to investigate factors strongly associated with e-cigarette use. Table 1 presents our sample characteristics. Of 401 lifetime cigarette non-users, approximately 40% were male, the mean age was 21.29 years old, and the average monthly household income was 5,607,000 Korean won, which was approximately equivalent to 5264 US dollars (FX Exchange Rate, n.d.). Of 132 lifetime cigarette users, approximately 78% were male, the mean age was 21.39 years old, and the average monthly household income was 5,201,000 Korean won. For more detailed sample characteristics, refer to Table 1.

Measures

E-Cigarette Use

We constructed this variable based on a study by Sutfin et al. (2013). Our respondents were asked two questions about lifetime e-cigarette use and current e-cigarette use (defined as having used e-cigarettes during the past 30 days). Using this information, we categorized respondents into three groups: (a) those who had never used e-cigarettes in lifetime (non-users), (b)

Table 1 Sample characteristics ($N=533$)

Characteristic	Frequency (%) or mean (standard deviation)			
	Lifetime cigarette non-use ($n=401$)		Lifetime cigarette use ($n=132$)	
Sex ^a				
Male	160	(39.90)	103	(78.03)
Female	241	(60.10)	29	(21.97)
Age (unit: year)	21.29	(1.76)	21.39	(2.12)
Average monthly household income (unit: 10,000 won)	560.70	(277.70)	520.10	(250.90)
Exercise during the past week ^a				
No	276	(68.83)	47	(35.61)
Yes	125	(31.17)	85	(64.39)
Sensation seeking ^b	2.74	(0.67)	3.07	(0.55)
Number of days drank during the past 30 days	3.77	(4.21)	5.13	(3.70)

^aFrequency and percentage

^bMeasured on a 5-point Likert scale, indicating that greater scores represent higher sensation seeking

those who had used e-cigarettes in lifetime but did not use them during the past 30 days (former users), and (c) those who had used e-cigarettes in lifetime and during the past 30 days (current users).

Perceived Relative Harm of E-Cigarettes

We constructed this variable based on previous studies on college students (Smith et al., 2007; Sutfin et al., 2013). Former and current e-cigarette users were directed to choose one of the four potential responses to a question asking perceived relative harm of e-cigarettes compared with cigarettes. The potential responses included “equally as harmful as cigarettes,” “less harmful than cigarettes,” “more harmful than cigarettes,” and “do not know.”

The Greatest Reason for E-Cigarette Use

We constructed this variable based on previous studies on college students (Lotrean, 2015; Sutfin et al., 2015). Former and current e-cigarette users were directed to choose one main reason out of the six reasons for using e-cigarettes. The six reasons included (a) “I use e-cigarettes due to curiosity,” (b) “e-cigarettes are less harmful than cigarettes,” (c) “e-cigarette use is allowed in non-smoking areas,” (d) “e-cigarettes are helpful for smoking cessation,” (e) “e-cigarettes are helpful for reducing cigarette consumption,” and (f) “e-cigarettes do not smell.”

Covariates Potentially Associated with E-Cigarette Use

Demographics Specifically, we used three demographics: sex (male or female), age, and the average monthly household income. Age and household income were measured continuously.

Cigarette Use We assessed four cigarette-related characteristics using questions, which have been widely used to monitor tobacco use (International Agency for Research on Cancer & World Health Organization, 2008). First, we assessed lifetime smoking by asking if respondents had ever tried cigarette smoking, even one puff (yes or no). In the next step, lifetime smokers were directed to report (a) the number of cigarettes smoked in their lifetime (“< 100 cigarettes” or “≥ 100 cigarettes”), (b) past 30-day cigarette smoking (yes or no), and (c) the number of days smoked during the past 30 days (0–30 days).

Other Covariates We used three smoking-related factors: exercise during the past week (yes or no), sensation seeking, and the number of days drank during the past 30 days (0–30 days). Sensation seeking was measured using a translated version of the Brief Sensation Seeking Scale (BSSS), consisting of eight items assessing experience seeking, boredom susceptibility, thrill/adventure seeking, and disinhibition (Hoyle et al., 2002; Yu, 2011). Each item was measured on a 5-point Likert scale. We calculated the mean score of the eight items and a greater score indicated higher sensation seeking (Cronbach’s alpha = 0.69).

Data Analysis

First, we conducted descriptive statistics (means, frequencies, or percentages) to investigate sample characteristics (StataCorp, 2019). Second, to investigate (a) characteristics of cigarette consumption in three e-cigarette use groups and (b) perceived relative harm of e-cigarettes and the greatest reason for e-cigarette use, we conducted either “analysis variance with Tukey’s test for post hoc analysis” or “Fisher’s exact test due to small samples in some cells” (Kraska-Miller, 2013; Littell et al., 2002; Reinard, 2006; Stokes et al., 2001).

Finally, to investigate factors strongly associated with e-cigarette use, we conducted multinomial logistic regression analysis using the three groups divided by e-cigarette smoking status (i.e., e-cigarette non-users, former e-cigarette users, and current e-cigarette users) among lifetime cigarette smokers (Allison, 2012). In this analysis, using e-cigarette non-use as the reference group, we obtained two sets of regression results for our dependent variable: one for former e-cigarette use versus e-cigarette non-use and the other for current e-cigarette use versus e-cigarette non-use. In this analysis, we used seven independent variables, which were presented in Table 4. In our model, we had considered including diverse factors related to cigarette smoking. However, we could not do so due to the existence of multicollinearity among them. Thus, we kept “the number of cigarette-smoking days” in our final model, since multicollinearity implies that highly correlated variables measure the identical underlying domain (Allison, 1999).

Results

Characteristics of Cigarette Consumption in Three E-Cigarette Use Groups

We found statistically significant relationships of all four cigarette-related characteristics with e-cigarette use (Table 2). First, 100% of former and current e-cigarette users were lifetime cigarette smokers, whereas only 12.25% of e-cigarette non-users were lifetime cigarette smokers. Second, the percentage of those who had smoked at least 100 cigarettes in their lifetime was highest among current e-cigarette users (100%), followed by former e-cigarette users (76.92%) and e-cigarette non-users (33.93%). Third, the percentage of past 30-day cigarette smokers was highest among former e-cigarette users (92.31%), followed by current e-cigarette users (89.19%) and e-cigarette non-users (25.00%). Finally, the number of cigarette-smoking days during the past 30 days significantly differed across three types of e-cigarette users, $F(2, 129) = 28.37, p < 0.0001$. The number of cigarette-smoking days was highest among current e-cigarette users (23.95 days), followed by former e-cigarette users (19.69 days) and e-cigarette non-users (6.05 days). In post hoc comparisons, the number of cigarette-smoking days was significantly higher among former and current e-cigarette users than among e-cigarette non-users.

Perceived Relative Harm of E-Cigarettes and the Greatest Reason for E-Cigarette Use

Of former or current e-cigarette users ($n = 76$), 65.79% considered e-cigarettes to be less harmful than cigarettes, whereas 18.42% considered e-cigarettes to be more harmful

Table 2 Characteristics of cigarette consumption in three E-cigarette use groups

Characteristic of cigarette use	Frequency (%) or mean (standard deviation)						p-value	Post hoc
	E-cigarette non-use ¹	Former e-cigarette use ²	Current e-cigarette use ³					
Lifetime smoking ($N = 533$) ^a								
No	401 (87.75)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	<.0001	—	
Yes	56 (12.25)	39 (100.00)	37 (100.00)	37 (100.00)	37 (100.00)			
Number of cigarettes smoked in lifetime ^{a, c}								
Less than 100 cigarettes	37 (66.07)	9 (23.08)	0 (0.00)	0 (0.00)	0 (0.00)	<.0001	—	
100 cigarettes or more	19 (33.93)	30 (76.92)	37 (100.00)	37 (100.00)	37 (100.00)			
Smoking during the past 30 days ^{a, c}								
No	42 (75.00)	3 (7.69)	4 (10.81)	4 (10.81)	4 (10.81)	<.0001	—	
Yes	14 (25.00)	36 (92.31)	33 (89.19)	33 (89.19)	33 (89.19)			
Number of cigarette-smoking days during the past 30 days ^{b, c}	6.05 (11.97)	19.69 (12.62)	23.95 (11.72)	23.95 (11.72)	23.95 (11.72)	<.0001	1 < 2, 3	

The superscripted numbers in column heads refer to the numbers used for illustrating significant differences in the “Post hoc” column

^aFrequency and percentage obtained using Fisher’s exact test

^bMean and standard deviation obtained using analysis of variance

^cObtained analyzing 132 lifetime smokers

(Table 3). We found statistically significant differences in perceived relative harm of e-cigarettes between former and current e-cigarette users. About 36% of former e-cigarette users considered e-cigarettes to be more harmful than cigarettes. In contrast, none of current e-cigarette users considered e-cigarettes to be more harmful and about 76% of them considered e-cigarettes to be less harmful.

As the greatest reason for e-cigarette use, the majority of e-cigarette users reported “no smell of e-cigarettes” (36.84%), “lower harm of e-cigarettes compared to cigarettes” (28.95%), and “feasibility to use e-cigarettes in non-smoking areas” (13.16%). We found statistically significant differences in the greatest reason for e-cigarette use between former and current e-cigarette users. Specifically, although more than 50% of former e-cigarette users chose “lower harm of e-cigarettes,” none of current e-cigarette users chose it. Instead, as the greatest reason, about 89% of current e-cigarette users chose e-cigarette smoking in non-smoking areas, reduction of cigarette consumption, or no smell of e-cigarettes.

Factors Strongly Associated with Former and Current E-Cigarette Use

Table 4 presents factors significantly associated with e-cigarette use among lifetime cigarette smokers after the adjustment for covariates. We found that sex and age were significantly associated with current e-cigarette use. Specifically, the risk of current e-cigarette use relative to the risk of e-cigarette non-use was 87% lower among female college students than among their male counterparts (odds ratio [OR] 0.13; 95% confidence interval [CI] 0.03–0.64). A one-year increase in age was significantly associated with a 31% decrease in the risk of current e-cigarette use relative to the risk of e-cigarette non-use (OR 0.69; 95% CI 0.49–0.98). In addition, we found that the number of cigarette-smoking days during the past 30 days was significantly associated with both former and current e-cigarette use. With

Table 3 Perceived relative harm of E-cigarettes and the greatest reason for E-cigarette use ($n=76$)

Variable	Frequency (%)						<i>p</i> -value
	Total ($n=76$)	Former e-cigarette use ($n=39$)		Current e-cigarette use ($n=37$)			
Perceived relative harm as compared to cigarettes ^a							
E-cigarettes are equally as harmful as cigarettes	2 (2.63)	2 (5.13)	0 (0.00)	<.0001			
E-cigarettes are less harmful than cigarettes	50 (65.79)	22 (56.41)	28 (75.68)				
E-cigarettes are more harmful than cigarettes	14 (18.42)	14 (35.90)	0 (0.00)				
I do not know	10 (13.16)	1 (2.56)	9 (24.32)				
The greatest reason for e-cigarette use ^a							
I use e-cigarettes due to curiosity	2 (2.63)	2 (5.13)	0 (0.00)	<.0001			
E-cigarettes are less harmful than cigarettes	22 (28.95)	22 (56.41)	0 (0.00)				
E-cigarette use is allowed in non-smoking areas	10 (13.16)	0 (0.00)	10 (27.03)				
E-cigarettes are helpful for smoking cessation	6 (7.89)	2 (5.13)	4 (10.81)				
E-cigarettes are helpful for reducing cigarette consumption	8 (10.53)	0 (0.00)	8 (21.62)				
E-cigarettes do not smell	28 (36.84)	13 (33.33)	15 (40.54)				

^aFrequency and percentage obtained using Fisher’s exact test

Table 4 Factors associated with former and current E-cigarette use among lifetime cigarette smokers (*n* = 132)

Variable	Former e-cigarette use			Current e-cigarette use			
	OR	95% CI		OR	95% CI		<i>p</i> -value
		Lower	Upper		Lower	Upper	
Sex (reference = male)	0.52	0.17	1.61	0.13	0.03	0.64	.0125
Age (unit: year)	0.91	0.67	1.24	0.69	0.49	0.98	.0357
Average monthly household income (unit: 10,000 won)	1.00 ^b	1.00 ^b	1.00 ^b	1.00 ^b	1.00 ^b	1.00 ^b	.2146
Exercise during the past week (reference = no)	1.56	0.49	4.94	0.51	0.13	2.08	.3498
Sensation seeking ^a	3.41	0.86	13.56	0.61	0.16	2.33	.4670
Number of cigarette-smoking days during the past 30 days	1.06	1.02	1.11	1.12	1.06	1.18	< .0001
Number of days drank during the past 30 days	1.07	0.92	1.24	1.02	0.86	1.20	.8542

OR, odds ratio; CI, confidence interval

Reference category of the dependent variable, E-cigarette non-use

^aMeasured on a 5-point Likert scale, indicating that greater scores represent higher sensation seeking

^bValues were listed as 1.00 due to rounding

a one-day increase in cigarette-smoking days, the risks of former and current e-cigarette use (relative to the risk of e-cigarette non-use) were increased by 6% (OR 1.06; 95% CI 1.02–1.11) and 12% (OR 1.12; 95% CI 1.06–1.18), respectively.

Discussion

Characteristics of Cigarette Consumption in Three E-Cigarette Use Groups

We found that, compared to e-cigarette non-users, former and current e-cigarette users were higher in (a) percentages of lifetime and past 30-day cigarette smoking, (b) percentages of those who smoked at least 100 cigarettes in lifetime, and (c) numbers of cigarette-smoking days. Our findings are in accordance with the literature, indicating that dual use of cigarettes and e-cigarettes was prevalent among college students in other countries (Awan, 2016; Case et al., 2017; Cooper et al., 2017; Ilic et al., 2020; Kenne et al., 2017; Kinouani et al., 2017; Littlefield et al., 2015; Sutfin et al., 2013). For example, a study of French college students found that 84.50% of former e-cigarette users and 95.92% of current e-cigarette users were either former or current cigarette smokers (Kinouani et al., 2017). Another two studies of college students found that 54.75% and 90.00% of lifetime e-cigarette users were either former or current cigarette users in the USA and Serbia, respectively (Ilic et al., 2020; Kenne et al., 2017).

The prevalent dual use indicates that the main purpose of e-cigarette use among college students may be not cigarette smoking cessation. Indeed, two empirical studies found that the intention to quit cigarette smoking was not a statistically significant factor explaining e-cigarette use among past 30-day cigarette smokers attending colleges in both bivariate and multivariate analyses (Lotrean, 2015; Sutfin et al., 2013).

Perceived Relative Harm of E-Cigarettes and the Greatest Reason for E-Cigarette Use

In our study, 66% of e-cigarette users had lower harm perception of e-cigarettes relative to cigarettes, which is in line with the literature. In two studies of ever e-cigarette users attending colleges, 44.91% in the USA and 48.21% in Spain reported that e-cigarettes were safer than cigarettes (Rodriguez et al., 2017; Sutfin et al., 2013). Based on the literature, the status of e-cigarette and cigarette use seemed associated with the harm perception of e-cigarettes: lowest perceived harm among e-cigarette users, followed by cigarette users and cigarette non-users (Awan, 2016; Cooper et al., 2017; Lotrean, 2015). Specifically, in a study of US college students, e-cigarette-only users and dual users were highly likely to report harm of e-cigarettes as none or low compared to cigarette-only users (Cooper et al., 2017). In addition, in Saudi Arabia and Romania, portions of college students perceiving e-cigarettes as less harmful were higher among past 30-day cigarette smokers than among past 30-day and lifetime cigarette non-smokers (Awan, 2016; Lotrean, 2015). Another notable finding in our study was that more than three fourths of current e-cigarette users perceived e-cigarettes to be less harmful than cigarettes. Also, none of current e-cigarette users perceived e-cigarettes to be more harmful, whereas 36% of former e-cigarette users perceived e-cigarettes to be more harmful than cigarettes. Our finding is consistent with the literature, indicating that lower harm perceptions of e-cigarettes increase the possibility of continuing e-cigarette use (Elton-Marshall et al., 2020).

We also found that about 79% of e-cigarette users smoked e-cigarettes due to no smell, lower harm, and feasibility to use e-cigarettes in smoke-free areas. Our finding is generally in line with previous studies of college students conducted in other countries (i.e., France, Romania, Saudi Arabia, and the USA; Awan, 2016; Kinouani et al., 2017; Lotrean, 2015; Sutfin et al., 2015). In these studies, as reasons for e-cigarette use, the majority of cigarette smokers reported curiosity, peer influences, better health, and feasibility to use e-cigarettes in smoke-free spaces, whereas relatively small portions of cigarette smokers reported the curtailment of cigarette consumption or cigarette smoking cessation (Awan, 2016; Kinouani et al., 2017; Lotrean, 2015; Sutfin et al., 2015). In addition, we found that about 89% of current e-cigarette users smoked it for the purposes of smoking in smoke-free spaces, curtailment in cigarette consumption, and no smell. This finding is consistent with what another Korean study found: current e-cigarette users attending colleges did not smoke it for cigarette smoking cessation (An, 2019).

The literature also indicates that continuation of e-cigarette use is highly likely to occur among goal-oriented e-cigarette users rather than among non-goal-oriented users (e.g., curiosity; Lee et al., 2017b; Pepper et al., 2014). This is the case for our study, finding that none of current e-cigarette users chose curiosity as the greatest reason. Although a relatively small portion of our participants chose curiosity as the greatest reason, special attention should be paid to high interest in new trends and technology among young adults in understanding e-cigarette use (Awan, 2016; Sutfin et al., 2015; Zickuhr, 2011). This is because they may be easily attracted to e-cigarettes due to their novel features, including designs. Indeed, a US study found that some young adults perceived an e-cigarette as a toy (McDonald & Ling, 2015).

Factors Strongly Associated with E-Cigarette Use

Our study found significant relationships of (a) male sex and younger age with current e-cigarette use and (b) a greater number of cigarette-smoking days with both former and current e-cigarette use. First, the higher risk of e-cigarette use among male college students found in our study is consistent with the literature. For example, another Korean study consistently found male college students had greater risks of e-cigarette use and dual use than female college students (Jeon et al., 2016). Similarly, most previous studies conducted in other countries found significantly higher risks of both ever and current e-cigarette use among male college students than among female counterparts (Awan, 2016; Brozek et al., 2019; Ickes et al., 2020; Saddleson et al., 2015), although two studies of college students failed to find a significant sex difference in e-cigarette use (Case et al., 2017; Li et al., 2018). In addition, in US studies of cigarette-smoking young adults, males were highly likely than females to report past 30-day e-cigarette use or more frequent e-cigarette use (Doran & Brikmanis, 2016; Ramo et al., 2015).

The greater likelihoods of e-cigarette use among males may be attributable partly to the following three reasons. First, men are more likely than women to try new information technology (Goswami & Dutta, 2015; Shaouf & Altaqqi, 2018) and become early adopters (Rich, 2010). Due to the unique and convenient features of e-cigarettes (Lee et al., 2017a), men may be more easily attracted to e-cigarettes. Second, levels of harm perception are lower among males than among females (Perikleous et al., 2018). Indeed, an empirical study investigating risk assessment among US college students found that, compared to females, males reported a lower probability of negative outcomes and less severity of potential negative outcomes (Harris et al., 2006). Finally, Korean smoking culture may be

associated with greater risk of e-cigarette use among males. In Korea, smoking has long been permissible among men rather than among women (Kim et al., 2005). Consistent with this smoking culture, proportions of current cigarette smokers and levels of social nicotine dependence have been much higher among male college students than among female college students in Korea (Jo & Kim, 2015; MHW & KCDC, 2020). This phenomenon found in Korea also exists in other countries: In Malaysia and Saudi Arabia, where female smoking is considered socially unacceptable, e-cigarette use was more prevalent among male college students than among their female counterparts (Awan, 2016; Wan Puteh et al., 2018).

In our study, younger age was another factor strongly associated with greater risks of e-cigarette use. The relationships of age or college year with e-cigarette use among college students have been mixed in the literature, finding (a) negative relationships (Case et al., 2017; Ickes et al., 2020; Saddleson et al., 2015), (b) positive relationships (Ilic et al., 2020), and (c) insignificant relationships (Jeon et al., 2016; Li et al., 2018; Sutfin et al., 2013). Despite the fact, the direction of the statistically significant associations was mostly negative in the literature. For example, 1st- and 2nd-year college students in the USA were at greater risk of current e-cigarette use, compared to 3rd- to 5th-year students (Ickes et al., 2020); age of US college students was inversely associated with risk of current e-cigarette use (Case et al., 2017).

Although further research is needed for better understanding the mechanisms explaining this association, the socio-ecological model (SEM), which emphasizes the important influences of ecological factors on human development (Allen et al., 2017; Bronfenbrenner, 1979; Kilanowski, 2017), may partly explain the negative association between age and e-cigarette use. Consistent with the SEM, the current literature has indicated that college freshmen are particularly at risk for drug use potentially due to reduced parental influences, increased autonomy, their social environments including peers, and wide availability of drugs (e.g., easy access to drugs and increased opportunities to use drugs; Arria et al., 2017; Suerken et al., 2014). Indeed, in an empirical study following first-year college students for 8 years, exposure to opportunities for drug use, including marijuana, consistently decreased over time; use of the given opportunity of marijuana consistently decreased over time, although the use of the given opportunity of other drugs relatively remained stable with age (Allen et al., 2017).

Finally, we found a positive relationship of a number of cigarette-smoking days with both former and current e-cigarette use. The existing literature generally supports our finding: Four studies of young adults, including college students, found the positive bivariate or multivariate association (Li et al., 2018; Littlefield et al., 2015; Ramo et al., 2015; Sutfin et al., 2015), except for one study finding the insignificant association (Doran & Brikmanis, 2016). For example, Li et al. (2018) found that heavier cigarette smoking was significantly associated with a greater risk of current e-cigarette use among cigarette-smoking college students.

This positive association between cigarette smoking and e-cigarette use may serve as another important evidence supporting that the main reason for e-cigarette use among college students is not cigarette smoking cessation. As potential mechanisms explaining this phenomenon, Ramo et al. (2015) propose that heavier cigarette smoking in young adulthood may be associated with the exploration of a new means for tobacco use and less sensitivity to the risk of trying new tobacco products. Indeed, two empirical studies support the first potential mechanism, finding the positive association between the number of other tobacco products used and the number of cigarettes smoked among young adults (Doran & Brikmanis, 2016; Petersen et al., 2020). In addition, two empirical studies of college

students may partly support the second mechanism, finding lower harm perception of e-cigarettes among past 30-day cigarette smokers than among past 30-day and lifetime non-smokers (Awan, 2016; Lotrean, 2015).

Strengths and Limitations of the Study

Our study contributes to the body of knowledge in two ways. First, our study provides important insight into factors strongly associated with e-cigarette use among college students. Second, we could better understand the associations between cigarette and e-cigarette use by using diverse measures of cigarette use (e.g., lifetime and past 30-day smoking) among Korean college students. Indeed, Sutfin et al. (2013) emphasize the use of more detailed cigarette smoking measures when investigating relationships of cigarette use with e-cigarette use.

Despite these strengths, our findings should be interpreted in light of three limitations. First, due to the use of a cross-sectional research design, we could not draw causal inferences. Second, we collected our data using a convenience sample, and thus caution is needed in generalizing our study findings. Finally, we collected data using a self-report questionnaire. Thus, measurement errors might exist because college students could under-report their substance use. However, this might not be a serious issue, because young adults' report of substance use in an anonymous survey was generally found to be valid and reliable (Ramo et al., 2011, 2012).

Conclusions

We found that all characteristics of cigarette smoking used in our study were positively associated with e-cigarette use. In addition, most e-cigarette users considered e-cigarettes to be less harmful than cigarettes and smoked them due to no smell, lower harm, and feasibility to use in non-smoking areas. Finally, male sex, younger age, and a greater number of cigarette-smoking days were strongly associated with e-cigarette use among lifetime cigarette smokers.

Health professionals should implement multi-faceted approaches to tackle this issue. First, given a current lack of anti-smoking education programs targeting Korean college students (Shin & Kim, 2017), health professionals should systematically provide anti-smoking education targeting this population. Given prevalent dual use among Korean college students, health professionals should develop and implement anti-smoking education programs concurrently focusing on cigarettes and e-cigarettes. Second, policy makers should implement strict anti-smoking regulations on campus, because, in Korea, (a) governmental anti-smoking policies have been ineffective on campus, and (b) about 67% of college students were found to smoke even in smoke-free areas on campus (MHW & Sahmyook University, 2016; Shin & Kim, 2017).

Future research should be directed toward further investigating e-cigarette use to better understand this relatively new phenomenon among college students. Specifically, it is necessary to investigate e-cigarette use by collecting more detailed information (e.g., frequency and amount of e-cigarette use) from a large sample. While doing so, it is important to use a more refined research design (e.g., the use of representative samples and the collection of longitudinal data) to obtain more accurate findings and draw causal inferences.

Author Contribution Sunhee Park and Ahnna Lee designed the study and conducted statistical analyses. Sunhee Park, Ahnna Lee, and Junghee Kim conducted literature searches. Sunhee Park and Junghee Kim wrote the manuscript. All authors read and approved the final manuscript.

Data Availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

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

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

Conflict of Interest The authors declare no competing interests.

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