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Factors associated with electronic cigarette use among adolescents with asthma in the Republic Of Korea

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ABSTRACT

Objectives: Despite the rapid increase in electronic cigarette (e-cigarette) smoking, little is known about the factors associated with their use, particularly in adolescents with asthma. Our study investigated the prevalence of, and factors associated with asthma.

Methods: We analyzed data from the Korean Youth Risk Behavior Web-based Survey of 44,479 adolescents with physician-diagnosed asthma and 445,692 subjects without asthma. Sociodemographic factors, psychosocial factors, and e-cigarette smoking patterns were investigated by self-report questionnaires. Multiple logistic regression was used to investigate the factors associated with ever or current e-cigarette risks in adolescents with asthma, with adjustment for confounding factors.

Results: Significantly more subjects had a smoking habit in the asthma group than in the non-asthma group. Among the adolescents with asthma, 4,420 (9.9%) smoked e-cigarettes (ever-users), and 1,962 (4.4%) smoked e-cigarettes within the last 30 days (current users). Multiple logistic regression showed that both ever and current e-cigarette use were significantly associated with male gender, higher family income, residence in an urban area, alcohol drinking, substance use experience, sexual experience, and friends' smoking. Current e-cigarette use was also significantly associated with high caffeine intake, no regular exercise, and experience of violence in adolescents with asthma.

Conclusions: E-cigarette smoking behavior was significantly more frequent in adolescents with asthma than in those without asthma, and multiple psychosocial factors were associated with e-cigarette smoking. Our results could inform e-smoking control programs and help identify adolescents with asthma at high risk of e-cigarette smoking, to ultimately prevent and reduce this behavior.

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Introduction

Electronic cigarettes (e-cigarettes) are battery-powered nicotine delivery systems sold in many countries, including South Korea (1). The rate of e-cigarette use had increased rapidly in adolescents (2,3). This increase in e-cigarette smoking is a concern, particularly among adolescents with asthma. Asthma is a chronic inflammatory airway disease that affects 4.0% of adolescents in the South Korea (4). Smoking during adolescence increases the risk of new-onset asthma (5), and adolescents with asthma who smoke are at an increased risk of poor health outcomes, such as increased asthma exacerbations, as well as a higher medical burden (6). E-cigarettes are battery-operated aerosolized nicotine delivery devices (7). The rapid growth in popularity of e-cigarettes is a concern

worldwide, including in South Korea (particularly in adolescents) (8). According to a recent tobacco control survey, most e-cigarette users are young and believe that e-cigarettes are less harmful than conventional cigarettes (9). The health effects of e-cigarette smoking are controversial. Some clinicians have strongly advocated that asthma sufferers who smoke conventional cigarettes transition to e-cigarettes, to decrease the medical burden associated with smoking-induced asthma exacerbations (10–12). However, e-cigarette aerosols include complex mixtures of chemicals, and it is unknown whether long-term e-cigarette use exacerbates (or even improves) asthma. E-cigarettes are a relatively safer option than conventional cigarettes, particularly in adolescents (who tend to consider them harmless) (13). A recent study showed that e-cigarettes are regarded more positively,

and that their use is more common among adolescents with asthma (12.4%) than adolescents without asthma (10.2%) (14). A higher rate of e-cigarette use in adolescents with versus without asthma was seen in the USA (15), Canada (16), and South Korea (17). Although e-cigarettes may decrease the use of conventional cigarettes in adults, the high prevalence of e-cigarette usage in adolescents with versus without asthma is a concern. In South Korea, e-cigarette users are frequently adolescents with asthma, who have a relatively high likelihood of being absent from high school due to asthma exacerbations (17). Zbikowski SM et al. have shown that the prevalence of cigarette smoking is higher in adolescents with physician-diagnosed asthma than in those without asthma in USA adolescents (18). Living in a family including current smokers, having close friends who smoke, and positive beliefs about smoking are risk factors for smoking among adolescents with asthma (18), but little is known about the factors associated with e-cigarette use in this population. Furthermore, few studies have investigated the sociodemographic and psychosocial variables associated with e-cigarette smoking in adolescents with asthma (17,19). E-cigarettes are still fairly new, and more studies are needed over a longer period of time to know what the long-term health effects of e-cigarette. Long-term effects of e-cigarettes are still unknown, e-cigarettes can pose health risks to the adolescent user. While the possible long-term health effects of e-cigarettes aren't yet clear, there have been recent reports of serious lung disease in some people using e-cigarettes or other vaping (20,21). Identifying groups at risk of e-cigarette use represents the first step toward targeted interventions to reduce this behavior. Thus, we investigated the prevalence of, and factors associated with, e-cigarette smoking in adolescents with asthma using data from the Korean Youth Risk Behavior Web-based Survey (KYRBWS).

Methods

Study participants

The data for this study were obtained from the nationwide KYRBWS for the period 2013–2017, where the respondents were all aged 13–18 years. The KYRBWS is an anonymous, internet-based, self-administered structured questionnaire aim to investigate health-risk behaviors and has been conducted by the Korea Centers for Disease and Prevention. The KYRBWS was administered to a nationally representative sample of middle- and high-school students, using a complex sampling design involving stratification,

clustering and multistage sampling. A representative sample of students from the 7–12th grade was selected in 800 middle and high schools (primary sampling units) and from 192 strata identified using the stratified multistage cluster sampling method. The samples in this study were derived from the following datasets: 9th KYRBWS 2013 ($N=75\,149$, 96.4% response rate); 10th KYRBWS 2014 ($N=75\,149$, 97.2% response rate); 11th KYRBWS 2015 ($N=70\,362$, 96.7% response rate); 12th KYRBWS 2016 ($N=67\,983$, 96.4% response rate) and 13th KYRBWS 2017 ($N=64\,991$, 95.8% response rate). We excluded participants with incomplete information on self-questionnaires.

After the survey procedures had been explained in full, all participants provided written informed consent, either directly or via their parents or legal guardians. The participants completed the online self-report survey in a school computer room. Those answering “yes” to the question “Have you ever been diagnosed with asthma by a doctor?” were classified as asthma sufferers. Participants who provided no socioeconomic or psychosocial data were excluded, such that 44 479 adolescents with asthma and 445 692 without asthma were included in the final analysis.

Socioeconomic and demographic factors

The survey captured data on socioeconomic factors [age, sex, type of school (middle, high, or vocational school; boys only, girls only, or coeducation school), family income, area of residence, living situation (i.e. with or without parents), and self-rated academic achievement], health behaviors (smoking, alcohol, and regular exercise status, and experience of sexual intercourse and illicit substance use) and psychological factors (self-rated health, stress, happiness, and depression). The area of residence was divided into urban and rural. Alcohol drinking was assessed by the question: “Have you ever drunk alcohol, even once?” If the respondent answered “Yes”, the following question was also asked: “On how many days did you drink alcohol in the past month?”. Those who answered “On more than 1 day” were classified into the alcohol drinking group (22). Academic achievement and family income were assessed by the questions: “How would you rate your academic achievement over the last year?”, and “How would you assess the socioeconomic status of your family?”, respectively; for both questions, the answer options were high (medium-high to high), medium, and low (medium-low to low). Regular exercise status was determined by the following question: “On how many

of the last 7 days did you perform activity that caused an increase in breathing or heart rate for at least 60 min?”. The participant was considered to engage in regular exercise if they answered “ ≥ 3 times/week”, but not if they answered “ < 3 times/week”. (23). Sexual experience was classified as “Yes” or “No” according to the following question: “Have you ever had sexual intercourse?”. The substance use categories were “never experienced” and “ever experienced”, depending on the response to the question “Have you ever inhaled/taken drugs such as amphetamines, glue, high-dose cold medicine, marijuana, stimulants, hallucinogens, heroin, butane gas, or anxiolytics, for the purpose of dieting or to elevate your mood?” (24). Experience of violence (“Never experienced” or “Experienced”) was determined by the response to the question “Have you ever been threatened with violence, or been a victim of physical violence that required medical or clinical treatment during the past 12 months?” (25). Stress level was determined by the question which was validated (26) “Do you experience stress in your life?”. The stress level was categorized as “Low stress” (no or mild stress) or “High stress” (moderate to very high stress). Self-rated health status was assessed by the question: “How do you feel about your health?” and categorized as “Good” (good to very good), “Fair”, or “Poor” (poor to very poor). Self-rated happiness was categorized as “Happy” (moderately happy to very happy) or “Unhappy” (unhappy to very unhappy). Depression was defined according to the Korean version of the World Health Organization Composite International Diagnostic Interview–Short Form, which is a validated, cost-effective screening tool suitable for use in health surveys such as the KYRBWS (27). The presence of depression (“Yes” or “No”) was determined by the question “Did you feel sad, blue, or depressed for a period lasting for more than 2 weeks in the past 12 months?”. Caffeine intake was categorized as “Highly frequent” (≥ 5 times/week), “Moderately frequent” (1–4 times/week), or “Infrequent” (< 1 time/week) (28). Junk food consumption was categorized as “Infrequent” (≤ 2 times/week) or “Frequent” (≥ 3 times/week) (28).

Cigarette smoking

“Current smokers” were those who had smoked more than 100 cigarettes in their lifetime and had smoked in the last 30 days. “Former smokers” were those who had smoked more than 100 cigarettes in their lifetime but had not smoked in the past 30 days. “Non-smokers” were those who had smoked less than 100 cigarettes in their lifetime (29). The threshold of 100

cigarettes is used by the USA Centers for Disease Control and Prevention to differentiate current/former smokers from never smokers. E-cigarette smoking status was determined by asking adolescents if they had ever smoked an e-cigarette, and whether they had smoked an e-cigarette in the past 30 days. “Never-users” were those who had never tried an e-cigarette. “Ever-users” were those who had tried an e-cigarette, but had not smoked one in the last 30 days. “Current users” were those who had smoked an e-cigarette in the past 30 days (3). Secondhand smoking exposure was determined by the question “On how many of the last 7 days were family members smoking when you were at home?” Secondhand smokers were those who had not encountered smoking at home on between 1 and 7 days. Friends’ smoking status was assessed by the following question: “Do any of your close friends smoke?” Friends’ smoking status was categorized as “None” or “Some to all friends”. The first experience with smoking was categorized as: “Before or during elementary school” or “During middle or high school”. Smoking cessation attempts was classified as “Yes” or “No” based on the question “Have you tried to stop smoking in the past 12 months?”. Experience with a smoking cessation education program was classified as “Yes” or “No” according to the question “Have you enrolled in a smoking prevention or cessation education program within the last 12 months?” For the question on the reason for smoking e-cigarettes, i.e. “What is the main reason for using e-cigarettes?”, the responses options were as follows: “It seems to be healthier than conventional cigarettes”, “To quit smoking conventional cigarettes”, “Because I can smoke them indoors”, “It is easier to obtain e-cigarettes than conventional cigarettes”, “Good taste”, “Good flavors”, “It does not smell bad”, “Curiosity”, and “Other”. The means of acquisition of e-cigarettes was categorized as “Obtained from friends,” “Bought in a store,” or “Other.” The “other” category included picking up e-cigarettes found on the road, obtaining e-cigarettes from adults, or finding e-cigarettes in the home.

Data analysis

Descriptive statistics were generated for categorical variables (frequencies and proportions) and continuous data are shown as means with standard deviations. The chi-square test and independent samples *t*-test were used to compare the adolescents with and without asthma. A multivariate logistic regression analysis was performed to identify the factors predicting use of e-cigarettes among adolescents with asthma.

Table 1. Demographic characteristics of adolescents with or without asthma.

	No asthma (n = 445692)	Asthma (n = 44479)	P-value
Sex			<0.001
Boy	224460 (50.4)	25390 (57.1)	
Girl	221232 (49.6)	19089 (42.9)	
Age	15.0 ± 1.8	14.9 ± 1.7	<0.001
School			<0.001
Middle school	223619 (50.2)	23518 (52.9)	
Academic high school	176478 (39.6)	16702 (37.6)	
Vocational high school	45595 (10.2)	4259 (9.6)	
School type			<0.001
Boys school	76003 (17.1)	8630 (19.4)	
Girl school	78482 (17.6)	6469 (14.5)	
Coeducation	291197 (65.3)	29380 (66.1)	
Residence			<0.001
Rural	44327 (9.9)	4072 (9.2)	
Urban	401365 (90.1)	40407 (90.8)	
Living			<0.001
Living without parents	21265 (4.8)	2364 (5.3)	
Living with parents	424427 (95.2)	42115 (94.7)	
Family income			<0.001
Low	84311 (18.9)	9099 (20.5)	
Medium	212012 (47.6)	19768 (44.4)	
High	149369 (42.1)	15612 (35.1)	
Subjective academic achievement			<0.001
Low	159438 (35.8)	15547 (35.0)	
Middle	124139 (27.9)	11788 (26.5)	
High	162115 (30.4)	17144 (38.5)	
Alcohol	75267 (16.9)	8275 (18.6)	<0.001
Caffeine energy drink			<0.001
Infrequent (<1 time/week)	4341 (1.0)	655 (1.5)	
Moderate (1-4 times/week)	32188 (7.2)	3430 (7.7)	
Highly (≥5 times/week)	409263 (91.8)	40394 (90.8)	
Junk food consumption			<0.001
Infrequent (≤2 times/weeks)	382124 (85.7)	37507 (84.3)	
Frequent (≥3 times/week)	63568 (14.3)	6972 (15.7)	
Regular exercise	204651 (45.9)	22134 (49.8)	<0.001
Sexual experience	17932 (4.0)	2344 (5.3)	<0.001
Substance use	3879 (0.9)	793 (1.8)	<0.001
Violence experience	10028 (2.2)	1659 (3.7)	<0.001
Perceived stress			<0.001
Moderate to severe	172760 (38.8)	19182 (43.1)	
None to mild	272932 (61.2)	25297 (56.9)	
Perceived happiness			<0.001
Happy	402111 (90.2)	38969 (87.6)	
Unhappy	43581 (9.8)	5510 (12.4)	
Experiences of depressive mood for 2 or more continuous weeks	122863 (27.6)	14688 (33.0)	<0.001

Values are presented as number (%) or mean ± standard deviation. Alcohol drinking was defined drink alcohol even once in last month. Regular exercise status was determined by the following question: "On how many of the last 7 days did you perform activity that caused an increase in breathing or heart rate for at least 60 min?". The participant was considered to engage in regular exercise if they answered "≥ 3 times/week". The substance use categories were defined on the response to the question "Have you ever inhaled/taken drugs such as amphetamines, glue, high-dose cold medicine, marijuana, stimulants, hallucinogens, heroin, butane gas, or anxiolytics, for the purpose of dieting or to elevate your mood?". Experience of violence was determined by the response to the question "Have you ever been threatened with violence, or been a victim of physical violence that required medical or clinical treatment during the past 12 months?". Stress level was determined by the question "Do you experience stress in your life?". Self-rated health status was assessed by the question: "How do you feel about your health?". Self-rated happiness was categorized as "Happy" (moderately happy to very happy) or "Unhappy" (unhappy to very unhappy). The presence of depression was determined by the question "Did you feel sad, blue, or depressed for a period lasting for more than 2 weeks in the past 12 months?".

The odds ratios (ORs) and 95% confidence intervals (CIs) were calculated after adjusting for socioeconomic factors [age, sex, type of school (middle, high, or vocational school; southern, girls only, or coeducation school), family income, area of residence, living with parents, and self-rated academic achievement], health behaviors (smoking, alcohol, and regular exercise status, and experience of sexual intercourse and illicit substance use), and psychological factors (self-rated health, stress, happiness, and depression). All statistical analyses were conducted using the SPSS for Windows

software package (ver. 21.0; SPSS Inc., Chicago, IL, USA). P values < 0.05 were considered significant.

Results

Sociodemographic characteristics of the participants

Table 1 summarizes the sociodemographic data of the participants. Male gender, middle and co-education school types, living in an urban area, living without

Table 2. Cigarette and electronic cigarette patterns of adolescents with or without asthma.

	No asthma (n = 445692)	Asthma (n = 44479)	P-value
Smoking status			<0.001
Never (no cigarettes or electronic cigarettes)	353317 (79.3)	34047 (76.5)	
Former cigarette only	38174 (8.6)	3988 (9.0)	
Former electronic cigarette only	3816 (0.9)	427 (1.0)	
Former dual (cigarette and electronic cigarette)	7986 (1.8)	881 (2.0)	
Former cigarette and current electronic cigarette	1933 (0.4)	231 (0.5)	
Former electronic cigarette and current cigarette	9869 (2.2)	1150 (2.6)	
Current cigarette only	17846 (4.0)	2024 (4.6)	
Current electronic cigarette only	1526 (0.3)	190 (0.4)	
Current dual (cigarette and electronic cigarette)	11225 (2.5)	1541 (3.5)	
Electronic cigar use			<0.001
Nonuse	409337 (91.8)	40059 (90.1)	
Former use	22671 (4.9)	2458 (5.5)	
Current use	14684 (3.3)	1962 (4.4)	
Electronic cigar experience start			<0.001
Elementary school	3660 (9.8)	641 (14.5)	
Middle school	20470 (54.8)	2869 (64.9)	
High school	13225 (35.5)	910 (30.5)	
Electronic cigar use reason			<0.001
Less harmful	7284 (19.5)	906 (20.5)	
Helpful for quit smoking	3997 (10.7)	499 (11.3)	
Indoor smoking convenience	3474 (9.3)	442 (10.0)	
Purchasing convenience	523 (1.4)	106 (2.4)	
More taste	3959 (10.6)	460 (10.4)	
Good odor	3848 (10.3)	468 (10.6)	
Less cigarette smell	2802 (7.5)	318 (7.2)	
For curiosity	8890 (23.8)	884 (20.0)	
Others	2578 (6.9)	337 (7.6)	
Electronic cigarettes access method			0.008
Get from friends	12551 (33.6)	1189 (26.9)	
Buy in a store	13784 (36.9)	1706 (38.6)	
Others	11020 (29.5)	1525 (34.5)	
Parental smoking	39167 (42.4)	4440 (41.6)	0.041
Friends' smoking	37874 (41.0)	4715 (45.2)	<0.001
Secondhand smoking	145385 (32.6)	15494 (34.8)	<0.001
Smoking cessation trial	65217 (70.6)	7344 (70.4)	0.787
Smoking prevention program	276717 (62.1)	28393 (63.8)	<0.001

Values are presented as number (%). Current smokers" were those who had smoked more than 100 cigarettes in their lifetime and had smoked in the last 30 days. "Former smokers" were those who had smoked more than 100 cigarettes in their lifetime but had not smoked in the past 30 days. Electronic cigarette smoking status was determined by asking adolescents if they had ever smoked an e-cigarette, and whether they had smoked an e-cigarette in the past 30 days. "Never-users" were those who had never tried an electronic cigarette. "Ever-users" were those who had tried an e-cigarette, but had not smoked one in the last 30 days. "Current users" were those who had smoked an e-cigarette in the past 30 days. Secondhand smoking exposure was determined by the question "On how many of the last 7 days were family members smoking when you were at home?" Secondhand smokers were those who had not encountered smoking at home on between 1 and 7 days. Friends' smoking status was assessed by the following question: "Do any of your close friends smoke?" Friends' smoking status was categorized as "None" or "Some to all friends".

parents, low socioeconomic status, higher education status of the mother and father, and high academic achievement were significantly more frequent in adolescents with asthma than in those without asthma. Alcohol intake, regular exercise, caffeine, junk food, illicit substance use, and sexual experience were significantly more frequent in adolescents with asthma than in those without. Regarding psychological factors, poor self-rated health, high stress and unhappiness levels, experience of violence, and depressed mood were significantly more frequent in adolescents with asthma than in those without.

Prevalence of e-cigarette use

Table 2 compares the cigarette use data of the adolescents with and without asthma. Adolescents with asthma smoked significantly more frequently than those without asthma. A total of 4,420 (9.9%) adolescents with asthma

smoked e-cigarettes (ever-users), and 1,962 (4.4%) smoked e-cigarettes within the past 30 days (current users). The age of initial e-cigarette use was significantly younger in adolescents with than without asthma.

Reasons for smoking e-cigarettes

The main reason for e-cigarette use among adolescents with asthma was "It seems to be healthier than conventional cigarettes"; moreover, the asthma group cited this reason significantly more frequently than the adolescents without asthma.

Sources of e-cigarettes, parents'/friends' smoking pattern, and secondhand smoking status

We observed a significant difference in the rates of acquiring e-cigarettes from a store. Adolescents with

Table 3. Adjusted odd ratio for factors associated electronic cigarette use among adolescent asthma.

	Current electronic cigarette use (n = 1962)
Sex	
Girl	Reference
Boy	1.53 (1.08-2.17)
School	
Middle school	Reference
Academic high school	1.08 (0.73-1.61)
Vocational high school	1.05 (0.69-1.61)
School type	
Coeducation	Reference
Girl school	0.77 (0.59-1.01)
Southern school	0.89 (0.49-1.62)
Family income	
Low	Reference
Medium	1.01 (0.76-1.34)
High	1.44 (1.07-1.95)
Residence	
Rural	Reference
Urban	1.52 (1.05-2.20)
Living	
Living with parents	Reference
Living without parents	0.97 (0.62-1.53)
Academic achievement	
High	Reference
Middle	1.45 (1.10-1.93)
Low	1.27 (0.91-1.77)
Alcohol	
No	Reference
Yes	1.87 (1.45-2.40)
Substance use	
No	Reference
Yes	1.06 (1.09-3.90)
Sexual experience	
No	Reference
Yes	1.39 (1.07-1.80)
Caffeine energy drink	
Infrequent (<1 time/week)	Reference
Moderate (1-4 times/week)	1.29 (0.99-1.70)
Highly (≥ 5 times/week)	3.36 (1.88-6.03)
Junk food consumption	
Infrequent (≤ 2 times/weeks)	Reference
Frequent (≥ 3 times/week)	0.95 (0.74-1.22)
Regular exercise	
Yes	Reference
No	1.29 (1.03-1.62)
Perceived stress	
None to mild	Reference
Moderate to severe	0.88 (0.69-1.13)
Perceived happiness	
Happy	Reference
Unhappy	1.10 (0.86-1.40)
Violence experience	
No	Reference
Yes	1.84 (1.23-2.74)
Depressive mood	
No	Reference
Yes	0.98 (0.76-1.25)
Friends' smoking	
No	Reference
Yes	5.09 (2.30-11.29)
Parental smoking	
No	Reference
Yes	0.93 (0.72-1.19)
Secondhand smoking	
No	Reference
Yes	1.02 (0.80-1.30)
Smoking prevention program	
No	Reference
Yes	0.89 (0.70-1.12)

(Continued)

Table 3. Continued.

	Current electronic cigarette use (n = 1962)
Smoking cessation trial	
No	Reference
Yes	1.12 (0.87-1.45)

Values are presented as odds ratio (95% confidence interval). Adjusted by sex, age, school type (middle, high, or vocational school; southern, girls only, or coeducation school), family income, residence area, family structure, and academic achievement], health behavior factors (smoking status, alcohol drinking, regular exercise, sexual experience, illicit drug use, caffeine intake, and junk food consumption) and psychological factors (self-rated stress status, self-rated happiness status, violence experience and depression).

asthma were less likely to obtain e-cigarettes from friends than those without. The parents of adolescents without asthma were significantly more likely to smoke than those of adolescents with asthma, but exposure to secondhand smoke and having friends who smoked were significantly more frequent in adolescents with asthma. Although adolescents with asthma were significantly more likely to participate in a smoking prevention program than those without, smoking cessation attempts did not differ between the two groups.

Factors associated with e-cigarette use

Table 3 shows the adjusted ORs for factors associated with e-cigarette use among adolescents with asthma. According to the multiple logistic regression analysis, both ever and current e-cigarette use were significantly associated with male gender, higher family income, residence in an urban area, alcohol drinking, substance use and sexual experience, and friends' smoking among adolescents with asthma. In addition, current e-cigarette use significantly associated with high caffeine intake, no regular exercise, and experience of violence in adolescents with asthma.

Discussion

Our study utilized a nationally representative cohort of Korean adolescents to investigate the factors associated with e-cigarette use among adolescents with asthma. Almost 4.4% of the sample of 44 470 adolescents with asthma were current e-cigarettes users, and the lifetime prevalence of e-cigarette use was 9.9%. Current e-cigarette use in adolescents with asthma was associated with male gender, higher family income, residence in an urban area, alcohol drinking, substance use and sexual experience, high caffeine intake, no regular exercise, experience of violence, and friends' smoking.

Our study showed associations between certain sociodemographic factors and e-cigarette use in adolescents with asthma, consistent with previous studies. E-cigarette smoking is strongly associated with male gender (30) and living in an urban area (8). Although the reason for the association between male gender and e-cigarette smoking is unknown, the higher risk of e-cigarette smoking among males may be partly explained because males tend to think that e-cigarette smoking is less harmful than conventional smoking (13) partly from greater exposure to e-cigarette commercial advertisements (31). The more frequent e-cigarette use among adolescents with asthma living in an urban area could be partly explained by the easier availability of e-cigarettes relative to rural areas. For instance, although South Korea prohibits purchasing e-cigarettes by internet shopping, other countries have more easily accessible internet e-cigarettes in urban areas (8). Two previous studies showed that e-cigarette smoking might be associated with a lower family income (32,33), but other studies found that having a larger allowance was associated with the purchasing of e-cigarettes by adolescents (34,35). A study of adults reported that e-cigarette smoking was significantly associated with a higher income (9). Further well-designed prospective studies are needed to fully elucidate the association between e-cigarette smoking and socioeconomic status.

We found a significant association between having friends, but not parents, who smoked and e-cigarette smoking in adolescents with asthma, consistent with previous studies (36,37). This finding may be partly explained by the fact that adolescents tend to spend more time with their friends than their family (38). Adolescents whose friends use drugs tend to consider e-cigarettes as attractive substances (38). Indeed, Choi and Foster (39) showed that the friends of adolescents who smoke believed that e-cigarettes were less addictive and harmful than conventional cigarettes.

Another interesting finding of our study was that the ORs of the factors associated with e-cigarette smoking were larger for the current e-cigarette smokers with asthma compared to the “ever” e-cigarette adolescent smokers with asthma, consistent with a previous study on former and current e-cigarette smokers (40). Current e-cigarette smokers have less of a tendency toward conventional behavior compared to ever e-cigarette smokers.

Finally, we found that behaviors such as alcohol drinking, substance use, and high caffeine intake, as well as sexual experience, were significantly associated with current e-cigarette smoking in adolescents with asthma. These findings are consistent with previous studies

indicating that adolescents who smoke e-cigarettes are more likely to drink alcohol, use illicit substances, and engage in sexual intercourse (38). As a possible reason for these associations, Wills et al. (38) showed that e-cigarette smokers tend to exhibit risky behaviors due to their high levels of sensation-seeking and low levels of parental support and monitoring. There are two competing models of e-cigarette smoking among adolescents. One model suggests that adolescents who smoke e-cigarettes show more conventional and health-oriented behaviors (41), where choosing e-cigarettes over conventional cigarettes or other illicit substances can be motivated by health concerns. The second model suggests that e-cigarettes may appeal to adolescents for reasons similar to those noted for alcohol or other illicit substances, such as marijuana. Adolescents often rebel against conventional values, seek pleasant physical sensations, and engage in mood-enhancing behaviors. This conceptualization suggests that adolescents using e-cigarettes are also likely to engage in alcohol drinking and substance use, be sexually experienced and have a high caffeine intake.

The adolescents with asthma in our study believed that e-cigarettes can help one to quit conventional smoking, and are less harmful and addictive than conventional cigarettes, despite a lack of scientific evidence to support these views. Although a previous study showed that some e-cigarette smokers use e-cigarettes as a means to quit smoking (42), findings regarding the use of e-cigarettes to overcome nicotine addiction have been equivocal. A recent Italian study showed that 32.5% of subjects using e-cigarettes reduced their consumption of conventional cigarettes by more than 50%, while 22.5% stopped smoking conventional cigarettes completely (43).

Our study had a number of limitations. First, because it used a cross-sectional design, causal relationships could not be established. The study was also subject to the inherent limitations of all observational research. A well-designed prospective study is needed to establish causality. Second, our study used self-report items, so the responses may have been affected by social desirability bias (e.g. regarding smoking or illicit drug use). Second, our study asthma defined by answering “yes” to the question: “Have you ever been diagnosed with asthma by a doctor?” only and not assessed asthma medication, current symptom, spirometry data, asthma control score (ACT) were collected from the participants. However, a strength of our study was its inclusion of nationally representative data from 490 171 adolescents, where these data were

also adjusted for multiple confounders, thus improving the external validity.

In conclusion, the adolescents with asthma in our study smoked e-cigarettes more frequently than non-asthmatic adolescents. Moreover, multiple factors, such as male gender, higher family income, residence in an urban area, alcohol drinking, substance use and sexual experience, high caffeine intake, no regular exercise, experience of violence, and friends' smoking were associated with e-cigarette smoking. Our results could inform e-smoking control programs targeting those who are at risk of e-cigarette smoking. Such interventions, coupled with tobacco control programs have the potential to prevent and reduce use of e-cigarettes, especially in adolescents with asthma (44).

Author contributions

All authors contributed conception, analysis, interpretation, revising, and final approval of the manuscript. CH Han served as a principal investigator and had full access to all of the data in the study. JH Chung take responsibility for the integrity of the data and the accuracy of the data analysis.

Declaration of interest

The authors declare no conflict of interest.

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