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Address for Correspondence:
Sang-Heon Kim, MD, PhD
Division of Pulmonary Medicine and Allergy, Department of Internal Medicine, Hanyang University College of Medicine, 222 Wangsimni-ro, Seongdong-gu, Seoul 04763, Korea.
Email: sangheonkim@hanyang.ac.kr

Hyun Lee, MD, PhD
Division of Pulmonary Medicine and Allergy, Department of Internal Medicine, Hanyang University College of Medicine, 222 Wangsimni-ro, Seongdong-gu, Seoul 04763, Korea.
Email: namuhanayeyo@naver.com

*Jong Geol Jang, Sun-Kyung Lee, and Sung Jun Chung contributed equally to this work.

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ORCID iDs
Jong Geol Jang
https://orcid.org/0000-0001-8040-5363
Sun-Kyung Lee
https://orcid.org/0000-0003-0033-1339
Sung Jun Chung
https://orcid.org/0000-0001-8636-446X

Trends of Electronic-Cigarette and Heated Tobacco Product Use Among Korean Adults From 2013 to 2023: A Cross-Sectional Study

Jong Geol Jang,[1*] Sun-Kyung Lee,[2,3*] Sung Jun Chung,[2,4*] Yoomi Yeo,[2] Kyung Soo Hong,[1] Bumhee Yang,[5] Sang Hyuk Kim,[6] Ahn June Hong,[1] Hyung Koo Kang,[4] Tai Sun Park,[2] Kyung Hoon Min,[6] Tae-Hyung Kim,[2] Jang Won Sohn,[2] Ho Joo Yoon,[2] Sang-Heon Kim,[2] and Hyun Lee[2]

[1]Division of Pulmonology and Allergy, Department of Internal Medicine, Yeungnam University Medical Center, Yeungnam University College of Medicine, Daegu, Korea
[2]Department of Internal Medicine, Hanyang University College of Medicine, Seoul, Korea
[3]Department of Mathematics, College of Natural Sciences, Hanyang University, Seoul, Korea
[4]Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine, Ilsan Paik Hospital, Inje University College of Medicine, Goyang, Korea
[5]Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine, Chungbuk National University Hospital, Chungbuk National University College of Medicine, Cheongju, Korea
[6]Division of Pulmonary, Allergy, and Critical Care Medicine, Department of Internal Medicine, Korea University Guro Hospital, Korea University College of Medicine, Seoul, Korea

ABSTRACT

Background: While awareness and use of electronic cigarettes and heated tobacco products (EC/HTP) have increased in Korea over the past decade, studies on the yearly prevalence of such use are limited, as are those identifying factors associated with their use.
Methods: In this study, we analyzed the prevalence, trends, and factors associated with EC/HTP use over a 10-year period (2013–2023) using the Korea National Health and Nutrition Examination Survey. The yearly prevalence of EC/HTP use was assessed, and factors related to EC/HTP use were identified.
Results: Over the study period, EC/HTP use increased, especially use by males and younger study subjects, to 7.3% in 2023. While conventional cigarette use declined consistently from 24.1% in 2013 to 18.7% in 2023, EC/HTP use fluctuated; however, the overall trend was increasing, particularly among individuals in their 20s and 30s. Groups associated with EC/HTP use as identified on multivariable analyses were former smoking (adjusted odds ratio [aOR], 66.01; $P < 0.001$), current smoking (aOR, 152.43), younger age (aOR, 7.34 for ages 20–29 years; $P < 0.001$ and aOR, 7.42 for ages 30–39 years; $P < 0.01$; the reference group was those 60 years or older), higher body mass index (aOR, 1.30; $P < 0.001$), unmarried (aOR, 1.53; $P < 0.001$), and employed in managerial/professional and service/sales positions (aOR, 2.66 and 2.63, respectively; $P < 0.001$ for both).
Conclusion: EC/HTP use in Korea has risen significantly, particularly among younger males, and conventional cigarette use has declined. Key factors include ever-smoking status, younger age, male, elevated BMI, unmarried, and specific occupational roles. These trends highlight the need for targeted interventions and public health strategies to address shifting modes of tobacco use.

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Yoomi Yeo
https://orcid.org/0000-0002-2447-2067
Kyung Soo Hong
https://orcid.org/0000-0003-2931-6861
Bumhee Yang
https://orcid.org/0000-0003-2537-4706
Sang Hyuk Kim
https://orcid.org/0000-0002-0410-8524
Ahn June Hong
https://orcid.org/0000-0001-7104-8325
Hyung Koo Kang
https://orcid.org/0000-0001-9671-0944
Tai Sun Park
https://orcid.org/0000-0001-7383-7934
Kyung Hoon Min
https://orcid.org/0000-0003-0610-2182
Tae-Hyung Kim
https://orcid.org/0000-0002-3863-7854
Jang Won Sohn
https://orcid.org/0000-0001-7132-2988
Ho Joo Yoon
https://orcid.org/0000-0002-4645-4863
Sang-Heon Kim
https://orcid.org/0000-0001-8398-4444
Hyun Lee
https://orcid.org/0000-0002-1269-0913

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Disclosure

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Jang JG, Lee SK, Chung SJ. Data curation: Yeo Y. Formal analysis: Hong KS. Investigation: Yang B. Methodology: Kim SH, Hong AJ. Project administration: Kang HK. Resources: Park TS, Min KH. Software: Kim TH. Supervision: Kim SH, Lee H. Validation: Sohn JW, Yoon HJ. Writing - original draft: Jang JG, Lee SK. Writing - review & editing: Kim SH, Lee H.

Keywords: Cigarette Smoking; Electronic Cigarettes; Heated Tobacco Products; Prevalence; Cross-Sectional Study

INTRODUCTION

Cigarette smoking is the primary cause of most chronic respiratory diseases[1] and contributes significantly to the global disease burden.[2] Fortunately, the prevalence of cigarette smoking has been steadily decreasing in many countries[3]; however, the mode of tobacco use has shifted to the use of electronic cigarettes (ECs) and heated tobacco products (HTPs) worldwide.[4-7] ECs are electronic devices that vaporize a liquid (e-liquid) to produce an inhalable aerosol ("vapor")[8] and encompass a wide ranges of types, including disposable, pod, tank, and mod.[9] Users can control the nicotine concentration of the e-liquid in these ECs. HTPs ("heat-not-burn" tobacco), e.g., Philip Morris International's IQOS, are heat-processed tobacco leaf sticks that produce nicotine-containing aerosols without combustion.

These novel products have been marketed as safer alternatives to conventional combustible cigarettes due to the reduction or absence of combustion-related toxicants.[10,11] However, recent findings have demonstrated that ECs and HTPs (EC/HTP) are not harmless. Regular EC use is associated with symptoms of bronchitis and shortness of breath,[12] and a recent meta-analysis found that EC users have elevated risks of cardiovascular disease and stroke that are comparable to those of smokers.[13]

The popularity of EC/HTP is growing globally, and EC/HTP have become the second most popular tobacco products, especially among adolescents and young adults.[14,15] These products are contributing to a new generation of nicotine-addicted users. The attractiveness of EC/HTP, with their wide range of flavors and their reduced odor, has led to increased use among young adults who have never smoked conventional cigarettes and has contributed to long-term tobacco dependence among users.[16,17] These products have also increased the risk of relapse among former smokers.[18] The potential harm associated with regular use of EC/HTP and the rising number of new smokers are sources of concern and pose new challenges for tobacco control efforts.

ECs were introduced to the Korean market in the late 2000s and have been popular since the early 2010s, while HTPs were introduced in 2017.[19] While awareness and use of these products have increased over the past decade, comprehensive data analyses of the use of EC/HTP in Korea are limited. In this study, to address this knowledge gap, we aimed to analyze trends in EC/HTP use among Korean adults from product introduction to recent years and to identify key sociodemographic risk factors associated with use using nationwide survey data.

METHODS

Study population

The Korea National Health and Nutrition Examination Survey (KNHANES) is a nationwide cross-sectional survey designed to investigate the health and nutritional status of Koreans. This survey process has been conducted regularly since 1998 by the Korea Centers for Disease Control and Prevention. The KNHANES used a multistage, stratified probability sampling method to represent the entire Korean population. Each KNHANES cycle was conducted

with a newly selected sample of participants. Because participants are independently recruited in every cycle, duplicate participation across survey years is extremely unlikely.[20-25] In this study, we used data from the KNHANES VI to IX (2013–2015, 2016–2018, 2019–2021, 2022–2023).

The flow chart for identifying our final study population that included 64,940 participants; 2,020 EC users; and 60,920 non-users is presented in **Fig. 1**. From an initial pool of 82,790 potential participants, we excluded individuals aged ≤ 19 years (n = 15,627), those with missing weight data (n = 2,550), and those with missing EC use data (n = 1,853).

Assessment of tobacco product use

Smoking status was assessed via a participant questionnaire. Participants were first asked about their cigarette smoking history: "Have you smoked more than five packs of tobacco (100 cigarettes) in your lifetime?" Those answering "yes" were then asked: "Do you smoke daily, some days, or did you smoke in the past but not currently?" Current cigarette smokers were defined as those who responded "yes" to the first question and "daily" or "some days" to the second question. Similarly, for HTP use, participants were asked, "Have you ever used an HTP, e.g., IQOS, Glo, Lil?" Those responding "yes" were then asked: "Do you use the HTP daily, some days, or did you use it in the past but not currently?" To assess EC use, participants were asked: "Have you ever used a nicotine-containing EC?" Those responding "yes" were then asked: "Have you used a nicotine-containing EC in the past month?" Current EC users were defined as those responding "yes" to both questions.

Covariates

Sociodemographic characteristics assessed were age, gender, marital status, education level, residential area, family income, smoking status, and alcohol consumption. Marital status was classified into unmarried, married, and widowed/separated/divorced. Education level was categorized as less than high school or high school and higher. Residential area was classified as either urban or rural. Family income was assessed based on monthly household income and categorized into two groups, high, ≥ 50th percentile and low, < 50th percentile. Alcohol consumption was categorized into three groups, and individuals who consumed more than 30 g of alcohol per day were classified as heavy drinkers. Body mass index (BMI)

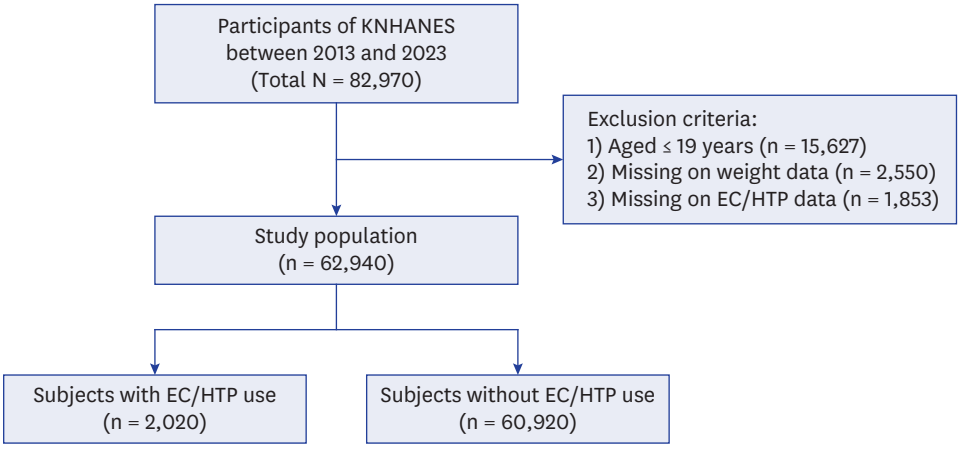

Fig. 1. Flow chart of participant selection.
KNAHES = Korea National Health and Nutrition Examination Survey, EC = electronic cigarette, HTP = heated tobacco product.

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was calculated by dividing weight in kilograms by height in meters squared. Occupation was classified into five categories: agriculture or fishery workers; manual laborers; skilled labor or machine operators; manager, professional, or office workers; and service or sales workers. Chronic health conditions included asthma; history of tuberculosis; hypertension or dyslipidemia; cardiovascular disease such as myocardial infarction or angina; and chronic kidney disease. Classification of presence or history of all chronic health conditions was based on physician diagnoses as reported by the participant.[26-29]

Statistical analysis

Data are described as weighted percentages with standard errors, and the intergroup differences were compared using Pearson's χ^2 test. To evaluate factors associated with EC/HTP use, univariable and multivariable logistic regression analyses were performed. In our multivariable model, age, gender, BMI, conventional cigarette smoking status, alcohol consumption, family income, residential area, education level, marital status, occupation type, and comorbidities were included. To address potential bias arising from the inclusion of never-smokers in the comparison group, we additionally performed subgroup analyses restricted to ever-smokers (current or former) and to current smokers only, comparing dual users of EC/HTPs with non-dual users.

We implemented weight adjustments in all analyses and determined statistical significance as a two-sided *P* value < 0.05. All analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC, USA).

Ethics statement

The study protocol was approved by the Institutional Review Board (IRB) of Yeungnam University Hospital (IRB No. 2025-04-009). The requirement for informed consent was waived because all patient records were anonymized before use.

RESULTS

Baseline characteristics

This study included 62,940 adults: 2,020 EC/HTP users and 60,920 non-users (**Fig. 1**). **Table 1** is a presentation of the baseline characteristics of the study participants. Participants who used EC/HTP were more likely to be younger, male, current or ex-smokers, and have higher BMI than non-users. EC/HTP users had a higher proportion of individuals with high incomes and higher education levels and were more likely to reside in urban areas and to be unmarried. EC/HTP users were more commonly engaged in managerial, professional, office, service, or sales work. Regarding health-related behaviors, EC/HTP users were more likely to be heavy alcohol consumers and less likely to undergo regular health examinations. Except for asthma, EC/HTP users had fewer comorbidities than non-users.

In addition, subgroup analyses were conducted among ever-smokers and current smokers (**Supplementary Tables 1** and **2**). Although the absolute values differed, the overall trends in demographic and behavioral characteristics between EC/HTP users and non-users were consistent with those observed in the total population.

Furthermore, in a subgroup analysis comparing exclusive EC/HTP users with dual users who also smoked conventional cigarettes, dual users tended to be younger, had higher education

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Table 1. Baseline characteristics of the study population

Variables	Total (N = 62,940)	EC/HTP use		*P* value
		Yes (n = 2,020)	No (n = 60,920)	
Age, yr	47.7 ± 0.1	36.7 ± 0.2	48.0 ± 0.1	< **0.001**
20–29	17.7 (0.3)	30.7 (1.2)	17.1 (0.3)	< **0.001**
30–39	17.4 (0.3)	31.4 (1.2)	16.8 (0.3)	
40–49	19.7 (0.3)	24.1 (1.1)	19.5 (0.3)	
50–59	19.7 (0.2)	10.4 (0.7)	20.1 (0.2)	
≥ 60	25.5 (0.3)	3.3 (0.34)	26.5 (0.3)	
Gender, male	49.6 (0.2)	84.2 (0.9)	48 (0.2)	< **0.001**
BMI, kg/m^2	24 ± 0.0	25 ± 0.1	23.9 ± 0.0	< **0.001**
< 18.5	5 (0.1)	3.9 (0.5)	5.1 (0.1)	
18.5–22.9	37.6 (0.2)	28.6 (1.1)	38 (0.2)	
≥ 23	57.4 (0.3)	67.5 (1.2)	56.9 (0.3)	
Smoking status				< **0.001**
Never	56.9 (0.2)	1.3 (0.3)	59.5 (0.2)	
Former	22.4 (0.2)	32.2 (1.2)	21.9 (0.2)	
Current	20.7 (0.2)	66.5 (1.2)	18.6 (0.2)	
Alcohol consumption				< **0.001**
Non-drinker	9.2 (0.2)	1 (0.2)	9.6 (0.2)	
Light-moderate drinker	75.6 (0.2)	67.5 (1.2)	76 (0.2)	
Heavy drinker	15.1 (0.2)	31.6 (1.2)	14.4 (0.2)	
Family income				< **0.001**
Low	38.9 (0.5)	27.2 (1.2)	39.4 (0.5)	
High	61.1 (0.5)	72.8 (1.2)	60.6 (0.5)	
Residential region				< **0.001**
Urban	84 (0.7)	88.8 (1.1)	83.8 (0.8)	
Rural	16 (0.7)	11.2 (1.1)	16.2 (0.8)	
Education level				< **0.001**
High school or less	58.5 (0.4)	48.5 (1.3)	58.9 (0.4)	
> High school	41.5 (0.4)	51.5 (1.3)	41.1 (0.4)	
Marital status				< **0.001**
Unmarried	24 (0.3)	46.1 (1.4)	22.9 (0.3)	
Married	65.5 (0.3)	50.1 (1.4)	66.2 (0.3)	
Widowed/separated/divorced	10.5 (0.2)	3.9 (0.5)	10.8 (0.2)	
Type of occupation				< **0.001**
Manager/professional/office worker	43.5 (0.5)	50.4 (1.4)	43.1 (0.5)	
Service/sales worker	21.4 (0.3)	23.8 (1.3)	21.3 (0.3)	
Agriculture/fishery worker	4.4 (0.3)	0.9 (0.2)	4.7 (0.3)	
Skilled labor/machine operation	17.8 (0.3)	18.6 (1.2)	17.7 (0.3)	
Manual laborer	12.9 (0.2)	6.4 (0.7)	13.3 (0.2)	
Regular health examinations				< **0.001**
No	33.4 (0.3)	41.1 (1.3)	33 (0.3)	
Yes	66.6 (0.3)	58.9 (1.3)	67 (0.3)	
Comorbidities				
Asthma	2.9 (0.1)	3.2 (0.5)	2.9 (0.1)	0.472
History of pulmonary tuberculosis	3.5 (0.1)	2.2 (0.5)	3.5 (0.1)	**0.022**
Hypertension	20.2 (0.2)	9 (0.6)	20.7 (0.2)	< **0.001**
Dyslipidemia	16.5 (0.2)	9.3 (0.7)	16.8 (0.2)	< **0.001**
Cardiovascular disease	2.2 (0.1)	1.2 (0.3)	2.2 (0.1)	**0.015**
Chronic kidney disease	1 (0.1)	0.5 (0.2)	1 (0.1)	**0.048**

Data are presented as weighted means ± standard errors or number (%).
Values in bold indicate statistically significant differences between EC/HTP users and non-users ($P < 0.05$).
EC = electronic cigarette, HTP = heated tobacco product, BMI = body mass index.

levels, were more likely to be unmarried, and undergo regular health examinations less frequently (**Supplementary Table 3**).

In addition, when comparing EC-only and HTP-only users, HTP-only users were overall younger, more likely to be current smokers, and more likely to undergo regular health

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examinations, whereas EC-only users included more ex-smokers and had a higher proportion of married individuals (**Supplementary Table 4**).

Yearly trends of EC/HTP use in comparison to conventional cigarettes

Over the 10-year period from 2013 to 2023, the overall prevalence of EC/HTP use was 4.4%. This prevalence was higher in younger individuals, males, and current or ex-smokers (**Fig. 2**).

The yearly prevalence of conventional cigarette smoking showed a steady decline throughout the study period, decreasing from 24.1% in 2013 to 18.7% by 2023 (**Fig. 3A**). However, the prevalence of EC/HTP use exhibited an increasing trend (**Fig. 3A**) from 1.1% in 2013 to 3.7% in 2015, decreased to about 2% in 2016 and 2017, and rose again to 3.6% in 2018 and 6.6% in 2019. By 2023, the prevalence of EC/HTP use was 7.3%, the highest prevalence during the study period. HTP use, first measured in 2019, was 5.1% in 2019, declined to 3.8% in 2021, and subsequently rose to 4.8% in both 2022 and 2023. EC use decreased slightly to around 2.6% in 2019 and then reached a plateau, remaining consistently around 3% until 2023 in which the prevalence was 3.3% (**Fig. 3A**).

Stratified analyses of yearly trends of EC/HTP use in comparison to conventional cigarettes according to gender and age

Males consistently had a higher prevalence of EC/HTP use than females throughout the 2013-2023 study period. The change in the prevalence of EC/HTP between 2013 and 2023 was substantially greater among males than females; in 2013, only 2.0% of men and 0.3% of women reported EC use. However, by 2023, EC/HTP use had increased to 11.7% among men and 2.9% among women (**Fig. 3B**).

The trends of conventional cigarette use between 2013 and 2023 differed notably across age groups (**Fig. 3C**), declining among adults in their 20s (25.9% to 21.3%) and in those in their 30s (32.2% to 18.4%) but remained relatively consistent in those aged in their 50s (22.5% to 22.7%) and those aged ≥ 60 years (13.0% to 11.8%). However, EC/HTP use increased markedly from 2013 to 2023 among younger adults, from 0.8% to 12.8% in those in their 20s,

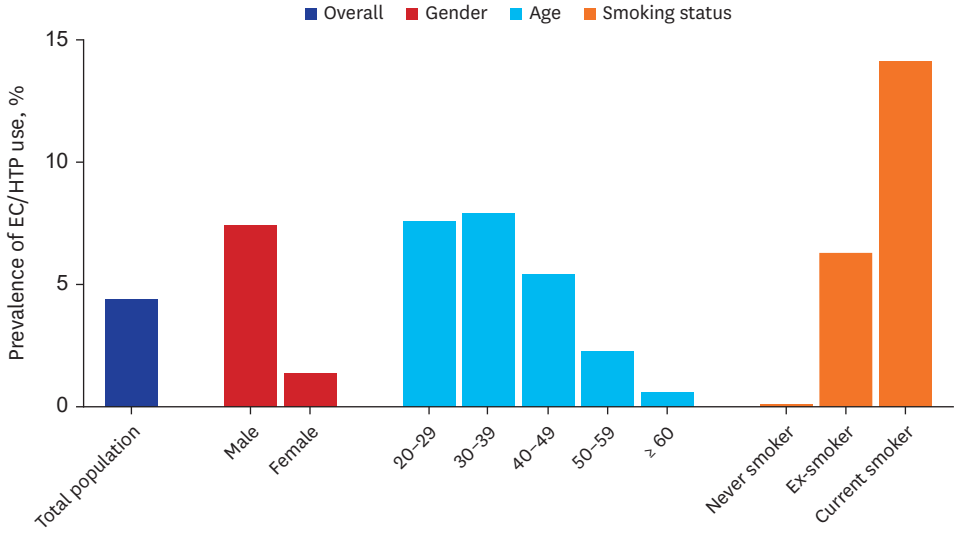

Fig. 2. The overall prevalence of conventional cigarette and EC/HTP use during the study period.
EC = electronic cigarette, HTP = heated tobacco product.

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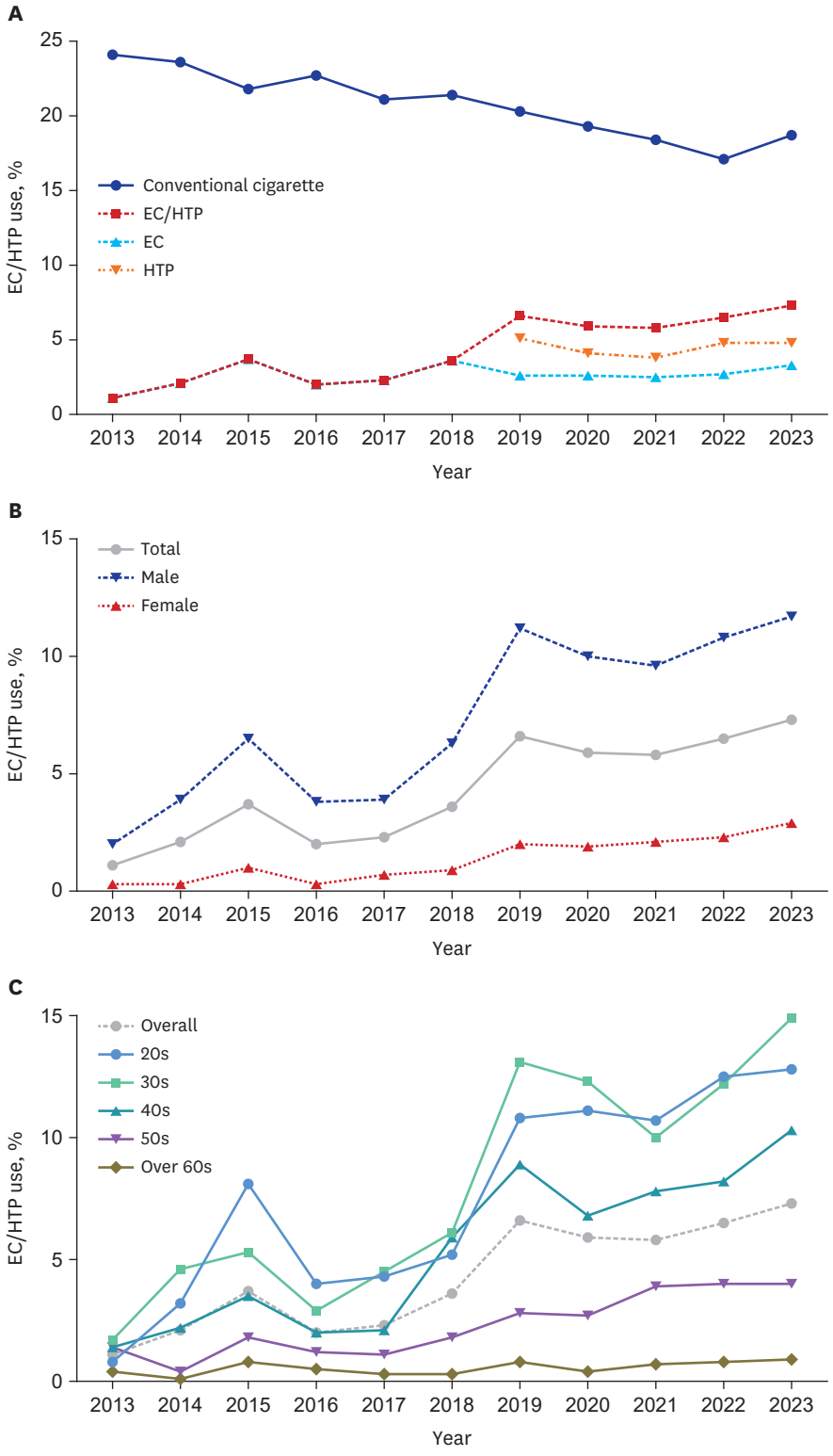

Fig. 3. Trends in prevalence of electronic cigarette and heated tobacco product use between 2013 and 2023. (**A**) Trends in the prevalence of tobacco product use. (**B**) Gender-stratified trends in the prevalence of electronic cigarette and heated tobacco product use. (**C**) Age-stratified trends in the prevalence of electronic cigarette and heated tobacco use.
EC = electronic cigarette, HTP = heated tobacco product.

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1.7% to 14.9% in those in their 30s, and 1.4% to 10.3% in those in their 40s; but prevalence among older adults, 4% in those in their 50s and 0.9% in those ≥ 60-years-old, remained low.

Factors associated with EC/HTP use

In the multivariable analysis, current smoking was the strongest factor associated with EC use (adjusted odds ratio [aOR], 152.43; 95% confidence interval [CI], 79.12–293.66; $P < 0.001$). Former smoking was also associated with EC use (aOR, 66.01; 95% CI, 33.76–129.08; $P < 0.001$). Younger age was also significantly associated with EC use; individuals aged 20–29 years had an aOR of 5.79 with a 95% CI of 3.76–8.91, and P was < 0.001 in this analysis. Those aged 30–39 years displayed an aOR of 5.85 with a 95% CI of 3.94–8.67, and P was < 0.001. Those aged 40–49 years displayed an aOR of 4.28 with a 95% CI of 2.93–6.25, and P was < 0.001. Those aged ≥ 60 years comprised the reference group for these analyses (**Table 2**).

Additionally, BMI ≥ 23 kg/m^2 (aOR, 1.34; 95% CI, 1.13–1.59; $P < 0.001$; the reference group was the 18.5–22.9 BMI group) was associated with increased EC use. Unmarried status (aOR,1.44; 95% CI, 1.17–1.78; $P < 0.001$ compared to the married reference group) and employment as a manager, professional, or office worker (aOR, 2.82; 95% CI, 1.45–5.48; $P = 0.002$) or as a service or sales worker (aOR, 2.63; 95% CI, 1.35–5.13; $P = 0.005$) were significantly associated with increased EC use. The reference group for the employment status analysis was comprised of agriculture or fishery workers.

In a subgroup analysis restricted to ever-smokers, factors associated with EC/HTP use were similar to those observed in the overall population (**Supplementary Table 5**). In an additional subgroup analysis limited to current smokers, younger age, higher BMI, and unmarried status were associated with EC/HTP use (**Supplementary Table 6**). Overall, the direction and magnitude of most associations were consistent with those in the main analysis.

Furthermore, among EC/HTP users, we investigated factors associated with dual use compared with exclusive EC/HTP use. In this analysis, individuals aged 20–29 years were less likely to be dual users (aOR, 0.025; 95% CI, 0.12–0.87), while higher education level, hypertension, and dyslipidemia was significantly associated with increased odds of dual use (**Supplementary Table 7**).

DISCUSSION

This nationwide study analyzed data from 62,940 adults, 2,020 EC/HTP users and 60,920 non-users. Assessments included baseline characteristics, EC/HTP use prevalence trends, and factors associated with EC/HTP use over a 2013–2023 study period. While use of conventional cigarette steadily declined from 24.1% (2013) to 18.7% (2023), EC/HTP use increased from 1.1% (2013) to 7.3% (2023). This increasing trend was particularly profound for younger adults and males. Multivariable analyses revealed significant associations between EC/HTP use and former smoking (aOR, 66.01), current smoking (aOR, 152.43), younger age (aOR, 7.34 for 20–29-year-olds), male gender (aOR, 1.36), elevated BMI (aOR, 1.30), unmarried status (aOR, 1.53), and employment in managerial/professional or service/sales positions (aORs, 2.66 and 2.63, respectively). These findings underscore the rising trend of EC/HTP use and highlight key demographic and behavioral factors for public health interventions.

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Table 2. Factors associated with EC/HTP use in adults

Variables	Univariable		Multivariable	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Age group, yr				
20–29	14.32 (11.47–17.87)	< **0.001**	**5.79 (3.76–8.91)**	< **0.001**
30–39	14.86 (11.90–18.56)	< **0.001**	**5.85 (3.94–8.67)**	< **0.001**
40–49	9.87 (7.88–12.35)	< **0.001**	**4.28 (2.93–6.25)**	< **0.001**
50–59	4.11 (3.24–5.27)	< **0.001**	**2.02 (1.38–2.96)**	< **0.001**
≥ 60	Reference		Reference	
Gender				
Female	Reference		Reference	
Male	5.7 (5.05–6.54)	< **0.001**	**1.22 (0.99–1.50)**	**0.058**
BMI, kg/m^2				
< 18.5	1.02 (0.79–1.34)	0.863	1.01 (0.66–1.54)	0.856
18.5–22.9	Reference		Reference	
≥ 23	1.57 (1.41–1.76)	< **0.001**	**1.34 (1.13–1.59)**	**0.002**
Conventional cigarette smoking		< **0.001**		< **0.001**
Never	Reference		Reference	
Former	66.28 (45.05–97.51)		66.01 (33.76–129.08)	
Current	162.12 (109.98–239.00)		152.43 (79.12–293.66)	
Alcohol consumption				
Non-drinker	Reference		Reference	
Light-moderate drinker	8.85 (5.57–14.06)	< **0.001**	0.75 (0.40–1.41)	0.369
Heavy drinker	21.87 (13.74–34.81)	< **0.001**	0.84 (0.45–1.58)	0.594
Family income				
Low	Reference		Reference	
High	1.74 (1.55–1.96)	< **0.001**	1.15 (0.96–1.38)	0.128
Residential area				
Urban	1.53 (1.28–1.83)	< **0.001**	1.25 (0.97–1.62)	0.091
Rural	Reference		Reference	
Education level				
High school or less	Reference		Reference	
> High school	1.52 (1.37–1.69)	< **0.001**	1.00 (0.84–1.19)	0.996
Marital status				
Married	Reference		Reference	
Unmarried	2.65 (2.38–2.96)	< **0.001**	**1.44 (1.17–1.77)**	< **0.001**
Widowed/separated/divorced	0.47 (0.37–0.61)	< **0.001**	0.90 (0.59–1.36)	0.603
Type of occupation				
Agriculture/fishery worker	Reference		Reference	
Manual laborer	2.60 (1.45–4.68)	**0.002**	1.97 (0.95–3.93)	0.055
Skilled labor/machine operation	5.69 (3.24–9.98)	< **0.001**	1.70 (0.88–3.95)	0.118
Manager/professional/office worker	6.35 (3.68–10.96)	< **0.001**	**2.82 (1.45–5.48)**	**0.002**
Service/sales worker	6.07 (3.48–10.59)	< **0.001**	**2.63 (1.35–5.13)**	**0.005**
Health screening				
Yes	0.71 (0.63–0.79)	< **0.001**	0.90 (0.76–1.06)	0.214
History or presence of comorbidities				
Asthma	1.11 (0.83–1.50)	0.472	1.13 (0.72–1.77)	0.591
Pulmonary tuberculosis	0.62 (0.41–0.94)	**0.023**	0.86 (0.53–1.39)	0.540
Hypertension	0.38 (0.32–0.44)	< **0.001**	0.91 (0.71–1.17)	0.467
Dyslipidemia	0.51 (0.43–0.60)	< **0.001**	1.16 (0.89–1.50)	0.271
Cardiovascular disease	0.54 (0.32–0.89)	**0.017**	1.72 (0.92–3.23)	0.091
Chronic kidney disease	0.50 (0.24–1.01)	0.053	1.70 (0.41–7.04)	0.462

Data are presented as OR (95% CI).
Values in bold indicate statistically significant differences between EC/HTP users and non-users ($P < 0.05$).
EC = electronic cigarette, HTP = heated tobacco product, OR = odds ratio, CI = confidence interval, BMI = body mass index.

Despite accumulating evidence that EC/HTP are unsafe, the global trend of increasing EC/HTP use, especially in the young population, is expected to present a global health burden. Because of this, our report provides important epidemiological data showing the increasing prevalence of EC/HTP use, especially in younger adults, and the decreasing prevalence of

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conventional cigarette smoking in Korea. The most recent data indicate that the current prevalence of EC use in Korea, 3.3% in our study, is lower than that in the United States, in which the prevalence of EC use was 4.4% in 2017, 5.1% in 2020, and 6.9% in 2021.[14,30] A recent meta-analysis that included 125 studies reported that the global prevalence of EC use was 10.2% with regional differences, 12.7% in Europe, 12% in North America, 8.2% in Oceania, and 4% in South America.[31] HTP use has a different geographical variation pattern than EC use. HTPs were introduced in Japan in 2014 and in Korea in 2017. The prevalence of HTP use in Japan rapidly increased to 11.3% in 2019 from 0.2% in 2015.[32] Although having a later introduction date, Korea's prevalence trend for HTP use is similar to Japan's. HTPs quickly gained a share of the Korean tobacco market, significantly contributing to the overall increase in non-combustible tobacco product use observed in our study. In the United States and Western Europe, however, the prevalence of HTP use was lower. One meta-analysis reported that current HTP use was 1.15% in Europe.[5] In the United States, awareness of HTPs is growing; current HTP use in the United States is still low, however, occurring in about 3% of adult tobacco users and well below 1% of the adult population in 2021.[33] Although these patterns of EC and HTP use vary nationally, the prevalence of use for both are increasing globally, including in Korea.

Although the unweighted number of EC/HTP users in our dataset was 2,020 and may appear modest, the weighted prevalence estimates in our study were generally consistent with previously reported Korean studies that also used KNHANES data.[34] In addition, a nationwide study using the Korea Community Health Survey reported e-cigarette prevalence estimates of 1.2% in 2014–2015, 2.6% in 2018–2019, and 1.1% in 2020–2021.[35] In comparison, our study showed slightly higher estimates of 2.1%, 3.6%, and 2.6% during the corresponding periods, approximately a 1% difference. This modest discrepancy in prevalence estimates can be explained by differences in survey methodology and questionnaire design between the two datasets. Despite these differences in absolute values, the overall temporal trend was similar across both datasets.

An advantage of our study is that we comprehensively evaluated factors associated with EC/HTP use. We considered a variety of demographic data and used a data source that represented the entire national population. Our analyses identified key factors associated with EC/HTP use in Korea, providing insights into the specific demographic groups in which the use of novel tobacco products has risen dramatically. Younger age was one of the strongest associated factors; adults in their 20s and 30s had significantly higher odds of EC/HTP use compared to those ≥ 60 years. This age-related pattern aligns with findings from other countries. In the United States, for instance, EC use is significantly higher among adults aged 18–34; this prevalence peaks among those 21–24-years-old.[4] One explanation for this pattern is that the younger population perceives EC/HTP as being less harmful than conventional cigarettes.[36] Availability of a variety of EC/HTP flavors, new user curiosity, peer pressure, and perceived stress relief or relaxation are other potential reasons for EC use by the younger population.[37,38] A Korean survey evaluated reasons for initiation and regular use of HTPs. The primary reasons for initiating use included curiosity and use by family members or friends, and the predominant reasons for regular use were to avoid the foul smell associated with conventional cigarette use and to avoid the harmful effects of conventional cigarette smoking.[39]

However, a notable difference between the use of EC/HTP in Korea and the United States was the prevalence of use by those in their 40s. In contrast to the United States in which EC use

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prevalence substantially decreases among adults aged over 35 years, the 10.3% prevalence among Koreans in their 40s was comparable to the 12.8% of those in their 20s and the 14.9% of those in their 30s. This phenomenon is probably caused by increased HTP rather than EC use as EC use among individuals in their 40s, 3.5%, was notably lower than among those in their 20s, 6.7%, and among those in their 30s, 8.6%. However, HTP use prevalence was similar across these age groups (20s: 8.4%, 30s: 8.4%, and 40s: 7.2%). There are a few possible explanations for this distinctive prevalence pattern. First, HTPs were introduced to Korea before the United States. This has resulted in greater public awareness of and familiarity with these products in Korea compared to many other regions.[11,18,33] A second possible explanation is the presence of differences in product accessibility and market environment between Korea and other countries. In Korea, EC users typically purchase e-liquids at specialty EC stores; and HTP tobacco sticks are readily available at nearly all convenience stores. In 2024, Korea had approximately 48,722 convenience stores, 1.06 stores per 1,000 population, a substantially higher density compared to that of the United States, 0.45 stores per 1,000 persons.[40,41] This ease of access probably facilitates HTP use among middle-aged Korean adults, and tobacco control policies that address EC and HTP usage patterns and market accessibility in Korea are necessary.

Other factors associated with risk of EC/HTP use were ever-smoking status, high BMI, unmarried, and employed in managerial/professional or service/sales positions. The association of ever-smoking and EC/HTP use may be due to the common perception that EC/HTP use is less harmful than smoking conventional cigarettes.[42] EC and HTP use are often marketed as a method for reduction or cessation of smoking, increasing the attractiveness to current or former smokers.[43] Males are more likely to be smokers than females[20]; this may translate into greater adoption of EC/HTP by men. Cultural norms and marketing strategies targeting men could also contribute to the observation concerning increased EC/HTP use by men. Elevated BMI has been linked to unhealthy lifestyle practices like smoking or heavy alcohol consumption; EC/HTP use may be one of these unhealthy practices. Also, individuals with higher BMIs may use EC/HTP as a means of weight control. The belief that EC/HTP use is effective for weight control is an unfounded yet persistent myth. Being unmarried may correlate with risk-taking behaviors, including smoking and EC/HTP use; unmarried individuals usually have fewer social constraints or responsibilities and are more likely to engage in behaviors perceived as recreational or experimental. Working in managerial/professional or service/sales job positions may be more stressful or demanding than working in other jobs; this stress may be associated with the use of EC/HTP as a coping mechanism. Social interactions in these employment sectors may promote the idea that vaping or smoking are “normal” behaviors. Additionally, the urban work settings that are usually associated with these employment positions may contribute to increased EC/HTP use because of the easy access afforded by these settings.

Beyond identifying factors associated with overall EC/HTP use, we further evaluated characteristics that distinguished dual users–those who concurrently used conventional cigarettes–from exclusive EC/HTP users. Interestingly, adults aged 20–29 years were less likely to be dual use, suggesting that younger individuals may transition more rapidly to exclusive use of non-combustible products rather than maintaining concurrent cigarette smoking. In contrast, hypertension and dyslipidemia were associated with dual use, raising the possibility that dual users, who are exposed to the combined adverse effects of both EC/HTPs and conventional cigarettes, may have stronger links with metabolic diseases or an increased susceptibility to them. While these findings provide preliminary insight into dual

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users, it is important to note that our study was not primarily designed to investigate dual-use behaviors. Therefore, this additional analysis has limitations and should be interpreted with caution. Further research is needed to more clearly characterize the behavioral patterns and health risks of dual users among Korean adults.

The findings of this study have important clinical implications, emphasizing the need for targeted interventions to address the rising prevalence of EC/HTP use, particularly among younger adults, males, and individuals with a history of smoking. Healthcare providers should consider incorporating tailored counseling on the risks and misconceptions associated with EC/HTP use, especially for individuals in high-risk groups. Public health policies including educational campaigns and EC/HTP availability and marketing restrictions should prioritize strategies for prevention of EC/HTP use. Future research should explore the long-term health effects of EC/HTP use, the verity of the assertion that these products are effective as a smoking cessation method, the effects of the dual use of EC/HTP and conventional cigarettes, and the potential disparities in usage patterns across diverse populations. By filling these knowledge gaps, the more comprehensive understanding will assist in the development of effective strategies to mitigate the health risks associated with EC/HTP use.

Our study has several limitations. First, because this study was cross-sectional, we could not establish a causal relationship between EC/HTP use and the associated sociodemographic factors, nor we could assess health or disease outcomes related to EC/HTP use. Second, as our tobacco product data were acquired from self-reported questionnaires, the study is potentially subject to recall bias and under- or over-reporting of tobacco product use. Third, we combined EC and HTP products into a single category for analysis; thus, our findings may not fully reflect differences in usage patterns or risk factors specific to each product type. Fourth, we could not evaluate behaviors related to alternation of product use, e.g., transitions between conventional cigarettes and EC/HTPs, due to the cross-sectional nature of the dataset. Longitudinal studies are needed to explore transitions between ECs, HTPs, and conventional cigarettes. Finally, since this study was conducted exclusively among Korean adults, the results have limited generalizability to other ethnic groups or countries.

In conclusion, the rising prevalence of EC/HTP use among Korean adults, especially younger adults, highlights the importance of development of public health strategies designed to prevent EC/HTP use. Strengthening regulatory frameworks, implementing educational campaigns, and continuous monitoring of tobacco use trends are essential steps to mitigate the public health risks posed by emerging tobacco products.

SUPPLEMENTARY MATERIALS

Supplementary Table 1
Weighted baseline characteristics among ever-smokers

Supplementary Table 2
Weighted baseline characteristics among current smokers

Supplementary Table 3
Weighted baseline characteristics of exclusive and dual EC/HTP users

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Supplementary Table 4
Weighted baseline characteristics of EC-only and HTP-only users among exclusive EC/HTP users

Supplementary Table 5
Factors associated with EC/HTP use among ever-smokers

Supplementary Table 6
Factors associated with EC/HTP use status among current smokers

Supplementary Table 7
Factors associated with dual use versus exclusive EC/HTP use among EC/HTP users

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