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Prevalence, patterns and determinants of electronic cigarette and heated tobacco product use in Greece: a cross-sectional survey

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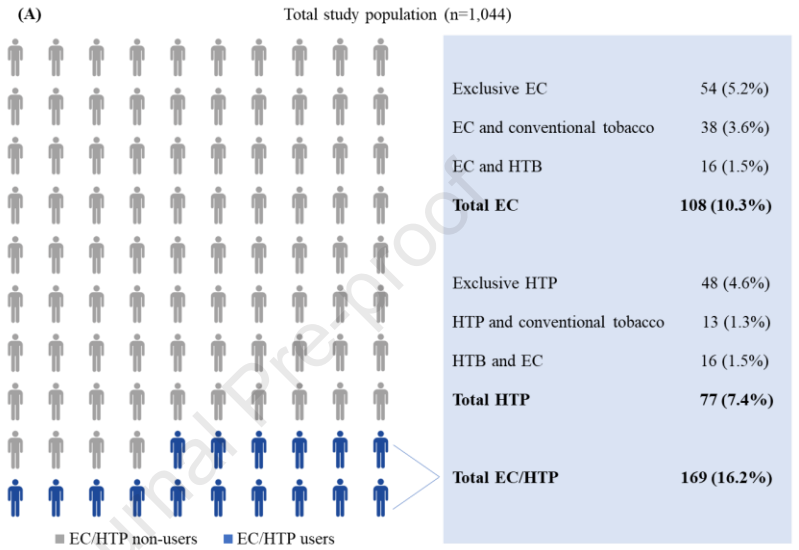
Prevalence, patterns and determinants of electronic cigarette and heated tobacco product use in Greece: a cross-sectional survey, by Panagiotakos D., et al.

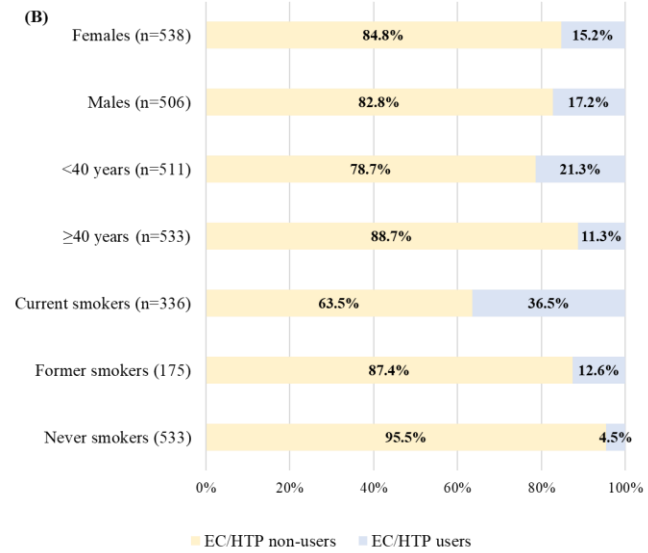
16%

reported use of e-cigarettes/heated tobacco products

17% men

15% women





Do you believe that use of e-cigarettes/heated tobacco products is less harmful than cigarette smoking?

53%

Yes, total study population

80%

Yes, among e-cigarette users

59%

Yes, among cigarette smokers

The present study revealed a high prevalence of e-cigarette/heated tobacco product use in Greece. The increased use among the youth, their frequent use in combination with conventional tobacco products, and the interest of non-smokers in these products are important issues that indicate the value of longitudinally monitoring e-cigarette/heated tobacco product use and patterns in the general population.

Prevalence, patterns and determinants of electronic cigarette and heated tobacco product use in Greece: a cross-sectional survey

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ABSTRACT

Background: Electronic cigarettes (EC) and heated tobacco products (HTP) have been introduced in the global market as safer nicotine delivery systems; however, there is skepticism about their link to smoking and long-term risks. The aims of the present study were to evaluate the prevalence, patterns, and determinants of EC/HTP use in Greece. **Methods**: This was a cross-sectional survey of 1,044 individuals aged ≥15 years old, who were randomly selected from the general Greek population. The study was conducted in May 2022 and participants were assessed through face-to-face interviews using a questionnaire designed to collect information on smoking and EC/HTP use, as well as sociodemographic, lifestyle, and medical data. **Results**: Use of EC/HTP was reported by 16.2% of participants, was slightly more prevalent in males (17.2%) compared to females (15.2%), and significantly more prevalent in <40-year-olds (21.3%) compared to ≥40-year-olds (11.3%). Most EC/HTP users (72.8%) were current smokers, 13.0% were former smokers and 14.2% were never smokers. Among users, 60.6% used nicotine-containing products, 30.2% used EC/HTP in parallel with conventional tobacco, and 56.9% used EC/HTP for the first time while being <25 years old. In multiple logistic regression analysis, younger age, being employed, being a former/current smoker, adopting a Western-type diet, and believing that EC/HTP are less harmful than conventional tobacco products and can help toward smoking cessation emerged as significant determinants of EC/HTP use. **Conclusions**: EC/HTP are commonly used in combination with conventional tobacco, are quite popular among the youth, and also appeal to a small fraction of non-smokers.

Keywords: electronic cigarettes; heated tobacco products; electronic nicotine delivery systems; smoking prevalence; smoking determinants; Greece.

INTRODUCTION

Tobacco is the second most commonly used addictive substance with more than 1 billion smokers globally (1). Tobacco can be used through a variety of combustible products (cigarettes, rolling tobacco, cigars, cigarillos, pipes and waterpipes) and noncombustible products [electronic cigarettes (EC), heated tobacco products (HTP), and other formulations developed for chewing, dipping or snuffing], of which cigarettes are the most popular and account for approximately 80% of all tobacco products used (2). Cigarette smoking is a well-established risk factor for morbidity and mortality. Accumulated evidence supports a causal association between cigarette smoking and the incidence of cardiovascular disease (CVD), different types of cancer, and respiratory diseases, most importantly chronic obstructive pulmonary disease (COPD) (3, 4). Moreover, it has been estimated that cigarette smoking is responsible for approximately 8 million deaths per year, which correspond to 50% of all avoidable deaths in smokers, while it is the second leading risk factor for disability adjusted life-years after hypertension (5, 6). Therefore, smoking reduction and ideally cessation is a cornerstone measure for health risk reduction (7) and is universally recommended by health organizations as a means to promote wellness, quality of life and longevity (8-10).

While the prevalence of cigarette smoking has gradually declined in most high-income countries since the 1990s, in part due to public health campaigns emphasizing on the addictive role of nicotine in maintaining tobacco smoking and the relationship between tobacco use and detrimental health effects (1), the use of EC followed by the use of HTP have contrariwise increased since their introduction in the global market as “safer” (compared to cigarettes) nicotine products which can be used for assisting people to transition away from the more harmful combustible cigarettes (11, 12). For instance, based on the extrapolation of data from 49 countries, the projected worldwide number of EC users was 68 million in 2020 (~0.9% of the worldwide population) and expected to rise to 86 million in 2023, indicative of a significant

uptake of EC despite the fact that they have only been available on most markets for a decade (13). Another analysis of the Eurobarometer Survey 93.2 among individuals 15 years or older across all 27 European Union Member States and the United Kingdom revealed a prevalence of ever, current and daily use of HTP of 6.5%, 1.3% and 0.7%, respectively (14). Most importantly, EC/HTP seem to be popular among younger individuals, including adolescents, and concerns have been expressed on whether they could represent a gateway to smoking among the youth that might undermine efforts toward tobacco control (15, 16).

The direct adverse physiologic effects of EC use on the respiratory system have now been well documented (17), and significant concerns remain regarding their long-term health effects. Furthermore, evidence of the efficacy of EC and HTP for smoking cessation is limited and skepticisms exists on whether they actually represent a viable harm-reduction strategy alternative to cigarette smoking (12, 18), given that EC and HTP use has been shown to facilitate relapse and smoking initiation (19). According to a 2020 position paper of the European Association of Preventive Cardiology (EAPC), EC should not be regarded as cardiovascular safe products and their impact on long-term smoking cessation lacks sufficient evidence (20). One year later (2021), the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) of the European Commission reviewed the most recent scientific and technical information on EC and concluded that there is only weak/moderate evidence to support their use in quitting/reducing smoking and moderate evidence that they represent a gateway to smoking among younger people; the evidence was also rated moderate for the risk of local irritative damage to the respiratory tract and CVD, and weak to moderate for the risk of carcinogenicity of the respiratory tract due to exposure to nitrosamines, acetaldehyde and formaldehyde contained in EC (21). Regarding HTP, in 2019, the European Respiratory Society (ERS) concluded that “even though HTP may perhaps be less harmful for smokers, they nevertheless remain both harmful and highly addictive, and there may be a risk that smokers

will switch to HTP instead of quitting"; this statement was based on chemical analyses of HTP showing that they emit substantial levels of irritant substances and potential carcinogens, in vitro and animal studies showing detrimental effects of HTP on respiratory and vascular endothelial function, and human studies showing that HTP might undermine smoking cessation effort and maintenance, are a temptation for non-smokers and minors, and impose a risk of re-normalization of smoking and dual use with conventional tobacco products (22).

Although several previous epidemiological studies have provided robust data on EC and HTP use in the USA (18, 23, 24) and many European countries (14, 25-27), there is relatively limited data for EC/HTP in Greece, one of the leading tobacco-producing and consuming countries in the European Union (28). Mapping the use of EC/HTP (both exclusive and combined with conventional tobacco products), exploring the sociodemographic, lifestyle and clinical characteristics of EC/HTP users, and identifying the main reasons and determinants of EC/HTP use, are crucial from a public health perspective. Thus, the objectives of the present study were to evaluate the prevalence and patterns of EC/HTP use, explore popular beliefs on EC/HTP in relation to smoking cessation and health, and identify the major reasons and determinants of EC/HTP use in a representative sample of the Greek general population.

METHODS

Design and setting

This was a cross-sectional epidemiological survey conducted in Greece under the auspices of Harokopio University of Athens and the "George D. Behrakis" Research Lab of the Hellenic Cancer Society. The sampling was random, on a feasibility basis, stratified by age and sex, according to the Greek adult population (census 2021). In order to obtain a geographically representative sample, participants were recruited from all major regions of Greece, namely Attica (n=692, 66.3%), Peloponnese (n=249, 12.2%), Central Greece (n=52, 5.0%), Western

Greece (n=45, 4.3%), Aegean (n=44, 4.2%), Macedonia and Thrace (n=25, 2.4%), Epirus and Thessaly (n=23, 2.2%), Ionian Islands (n=19, 1.8%) and Crete (n=17, 1.6%). The study was conducted in May 2022 and participants were assessed through face-to-face interviews using a questionnaire designed to collect detailed information on conventional smoking habits and EC/HTP use, as well as basic sociodemographic, medical, and dietary data.

Ethics

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Harokopio University of Athens (code: #39, date: 10.05.2022).

Participants

The study sample consisted of 1,044 individuals with a mean age of 43.2 ± 20.0 years (range: 15-98 years) and a sex distribution of 538 (51.5%) females and 506 (48.5%) males.

Smoking and EC/HTP use

Participants were classified into never smokers, former smokers, occasional smokers (<7 cigarettes/week) and regular smokers (≥1 cigarette/day). For former smokers, duration of smoking cessation was categorized as <6 months or ≥6 months. For regular smokers, smoking volume was categorized as 1-10 cigarettes/day, 11-20 cigarettes/day or >20 cigarettes/day. For both former and current smokers, the age of smoking onset (<10 years, 10-14 years, 15-18 years, 19-25 years and >25 years), the type of tobacco product used (cigarette, rolling tobacco, cigar/cigarillo, pipe and hookah), and the effect of the COVID-19 pandemic on smoking (increase, decrease, no effect, cessation or switch to EC/HTP) were assessed.

Participants also responded to whether they currently used EC/HTP; possible answers were only EC, only HTP, EC combined with conventional tobacco, HTP combined with conventional tobacco, both EC and HTP, or no use. For users of EC/HTP, the age of first use (<10 years, 10-14 years, 15-18 years, 19-25 years and >25 years), the frequency of use (occasional or daily), the duration of use (<1 month, 1-6 months, 6-12 months, >12 months),

the use of EC/HTP containing nicotine (always, sometimes, never), the main reason of EC/HTP onset (use by friends, use by family, smoking cessation effort, lower cost compared to conventional tobacco products, media/advertising, less health harm compared to conventional tobacco products, absence of smoke odor or other reason) and the effect of the COVID-19 pandemic on EC/HTP use (increase, decrease, no effect or cessation) was evaluated. Participants' beliefs on EC/HTP were assessed through the following yes/no questions: "Do you believe that EC/HTP are less harmful than conventional tobacco products?", "Do you believe that the use of EC/HTP sustains nicotine addiction?", "Do you believe that the use of EC/HTP can help toward smoking cessation?", and "Do you believe that the use of EC/HTP can facilitate the onset of cannabis use, especially among young people?".

Sociodemographic factors, medical status, and lifestyle habits

Participants' sociodemographic characteristics, namely date of birth, sex, educational level, and employment status, were also recorded. Age was calculated as a continuous variable but also grouped in the following categories: ≤19 years, 20-30 years, 30-40 years, 40-50 years, 50-60 years, 60-70 years and >70 years. Educational level was characterized as low (elementary/primary education, ≤6 years of education), medium (lower and upper secondary education, 7-12 years of education) and high (tertiary education, >12 years of education), while participants were categorized into five groups according to their employment status: unemployed (including students), housekeepers, occasionally employed, fully employed and pensioners. The presence of hypertension, dyslipidemia, diabetes mellitus, renal disease, asthma and COPD was also recorded based on participants' official medical records.

Dietary habits were assessed through three questions. The first two questions emphasized on the habitual frequency of fruit and vegetable consumption; possible answers were never/rarely, 1-3 times/month, 1 time/week, 2-3 times/week, 4-6 times/week and ≥1 times/day. The portion size for fruits corresponded to 1 medium apple, pear or peach, 1 small

banana, 2 mandarins, apricots or figs, 1 slice of melon or watermelon or 1 cup of cherries, strawberries or grapes, while the portion size for vegetables corresponded to 1 cup of raw vegetables (e.g., tomato, lettuce, cabbage, etc.) or ½ cup of boiled vegetables (e.g., greens, broccoli, zucchini, artichokes, etc.). The third question aimed at evaluating total diet quality and participants were asked to characterize their habitual dietary pattern as one of the following: a Mediterranean-style diet (characterized by high amounts of olive oil, fruits, vegetables, legumes, whole grains, nuts and seeds and limited amounts of meat products; a vegetarian diet (complete absence or very limited amounts of animal-based products); a mixed diet (including a balanced proportion of both animal- and plant-based food products) and a Western-type diet (characterized by high amounts of meat products, refined grains and processed foods).

Statistical analysis

Participants' age is presented as mean ± standard deviation given a normal distribution in the study sample according to the Kolmogorov-Smirnov test. All other analyzed variables were categorical and are presented as absolute number (relative frequency). Between-group differences were tested through the Student's t-test for age and the Pearson's chi-squared test for categorical variables. When differences between groups were significant, post-hoc pairwise comparisons were performed using the Bonferroni correction criterion to adjust for multiplicity. Multiple logistic regression analysis was also used to identify the most important determinants of the use of EC/HTP; age (<30-year-olds / 30-50-year-olds / >50-year-olds), sex (females / males), educational level (low / medium / high), occupational status (not employed / employed), dietary habits (Western-type diet / prudent diet), conventional smoking (never smokers / former smokers / occasional current smokers / regular current smokers), the presence of any chronic disease (yes / no), and beliefs on e-cigarettes/HTP (i.e., believing that EC/HTP are less harmful than conventional tobacco products; believing that the use of EC/HTP sustains nicotine addiction; believing that the use of EC/HTP can help toward smoking cessation; and believing

that the use of EC/HTP can facilitate the onset of cannabis use, especially among young people; yes / no) served as the independent variables, and results are presented as odds ratios (OR) with their corresponding 95% confidence intervals (CI). All reported p-values were based on two-sided tests and compared to a significance level of 5%. The STATA software version 15 (StataCorp. 2017. College Station, TX, USA) was used for analyses.

RESULTS

Prevalence and patterns of EC/HTP use

The prevalence of EC/HTP use in the total study sample and according to sex, age and conventional smoking habits is illustrated in **Figure 1**. Use of EC/HTP was reported by 169 participants (16.2%); 108 (10.3%) used EC and 77 (7.4%) used HTP (numbers and corresponding percentages refer to exclusive users, users of both EC/HTP and conventional tobacco products, and users of both EC and HTP). EC/HTP use was slightly more prevalent in males (17.2%) compared to females (15.2%), and significantly more prevalent in <40-year-olds (21.3%) compared to ≥40-year-olds (11.3%). The prevalence of EC/HTP use showed a decreasing trend with increasing age; in specific, the percentage of users was 19.7% in ≤19-year-olds, 23.2% in 20–30-year-olds, 19.1% in 30–40-year-olds, 16.8% in 40–50-year-olds, 13.5% in 50–60-year-olds, 8.9% in 60-70-year-olds and 4.8% in >70-year-olds, and a similar age-stratified pattern was evident both in females (11.1% in <19-year-olds, 22.3% in 20–30-year-olds, 22.9% in 30–40-year-olds, 13.7% in 40–50-year-olds, 14.0% in 50–60-year-olds, 4.3% in 60-70-year-olds and 3.4% in >70-year-olds) and males (27.5% in <19-year-olds, 24.2% in 20–30-year-olds, 15.9% in 30–40-year-olds, 21.2% in 40–50-year-olds, 12.8% in 50–60-year-olds, 12.7 % in 60-70-year-olds and 6.0% in >70-year-olds). In detail, use of EC was 17.1% in ≤19-year-olds (exclusive use: 10.5%), 14.3% in 20–30-year-olds (exclusive use: 5.9%), 13.2% in 30–40-year-olds (exclusive use: 8.6%), 12.8% in 40–50-year-olds (exclusive

use: 8.0%), 6.7% in 50–60-year-olds (exclusive use: 1.6%), 3.9% in 60-70-year-olds (exclusive use: 2.0%) and 2.4% in >70-year-olds (exclusive use: 1.6%), while use of HTP was 5.3% in ≤19-year-olds (exclusive use: 2.6%), 12.1% in 20–30-year-olds (exclusive use: 7.0%), 6.6% in 30–40-year-olds (exclusive use: 5.3%), 4.8% in 40–50-year-olds (exclusive use: 4.0%), 8.3% in 50–60-year-olds (exclusive use: 5.7%), 5.0% in 60-70-year-olds (exclusive use: 1.0%) and 2.4% in >70-year-olds (exclusive use: 1.6%). When analyses were stratified according to conventional smoking status, 36.5% of current smokers (40.2% of occasional smokers and 35.3% of regular smokers), 12.6% of former smokers and 4.5% of never smokers reported using EC/HTP.

Among users of EC/HTP (n=169), 55.6% reported a daily use (the rest 44.4% were occasional users) and 41.5% reported a long-term use of >12 months (17.0% were users for 6-12 months, 29.2% were users for 1-6 months, while 12.3% were users for <1 month). Regarding the type of products used, 69.8% used exclusively EC/HTP (32.0% used only EC, 28.4% used only HTP and 9.4% used both EC and HTP), while the rest 30.2% used EC/HTP in parallel with conventional tobacco products (22.5% used both EC and conventional tobacco and 7.7% used both HTP and conventional tobacco). Moreover, 60.6% of EC/HTP users reported always using nicotine-containing products, 13.4% reported always using nicotine-free products and 26.0% reported a mixed use. Regarding the age of first exposure, less than half (43.1%) of EC/HTP users reported trying these products for the first time while being >25 years old, while 29.9%, 22.8% and 4.2% were first exposed at the ages of 19-25, 15-18 and <14 years, respectively. During the COVID-19 pandemic, 31.0% of EC/HTP users increased their habitual use, 42.4% maintained their habitual use, 10.8% reduced their habitual use, 5.1% ceased use, while 10.8% initiated use. The most frequently reported reasons for the initiation of EC/HTP use were use by friends (31.9%), smoking cessation effort (28.9%) and the belief that EC/HTP are less harmful compared to conventional tobacco (17.5%), followed by the absence of smoke odor (6.6%), media/advertising (1.8%) and the lower cost of EC/HTP (1.8%).

Conventional smoking patterns

Of the total 1,044 participants, 533 (51.0%) were never smokers, 175 (16.8%) were former smokers and 336 (32.2%) were current smokers. Among former smokers (n=175), 20 (11.4%) had ceased smoking for <6 months and 155 (88.6%) for ≥6 months. Among current smokers (n=336), 87 (25.9% of current smokers and 8.3% of the total study sample) were occasional smokers and 249 (74.1% of current smokers and 23.9% of the total study) were regular smokers. The most prevalent tobacco products used were cigarettes (76.8%), followed by roll-your-own tobacco (16.4%). Smoking prevalence was 29.7% among females and 34.8% among males (P=0.081), while the prevalence of regular smokers was 21.0% and 26.9%, respectively (P=0.026), and that of former smokers was 11.2% and 22.7%, respectively (P<0.001). Among regular smokers (n=249), 36.5% smoked 1-10 cigarettes/day, 44.2% smoked 11-20 cigarettes/day and 19.3% smoked >20 cigarettes/day; the respective frequencies were 45.1%, 41.6% and 13.3% in females, and 29.4%, 46.3% and 24.3% in males (P=0.015). Among former and current smokers (n=511), the COVID-19 pandemic resulted in an increase in smoking in 27.7%, a decrease in smoking in 12.1%, smoking cessation in 8.9%, a switch to EC/HTP in 5.6%, while 45.7% reported that their typical smoking remained unchanged.

Other characteristics of the study population

Most participants (90.2%) had a medium or high educational status (>6 years of education), and more than half (57.0%) were employed (occasionally or fully). The prevalence of hypertension, dyslipidemia, diabetes mellitus, renal disease, asthma, and COPD was 15.8%, 23.3%, 4.5%, 1.2%, 7.1% and 2.2%, respectively, and 34.9% of participants had at least one of the aforementioned chronic diseases. Regarding dietary habits, the most prevalent dietary pattern was the mixed one (balanced proportion of both animal- and plant-based food products) (61.4%), followed by the Mediterranean-style diet (19.4%) and the Western-type diet (17.6%), while only 1.5% of the study sample were vegetarians.

Sociodemographic, lifestyle and clinical characteristics of EC/HTP users

The descriptive characteristics of the study sample according to EC/HTP use are presented in **Table 1**. Compared to non-users, participants who currently used EC/HTP were younger, had a higher educational level, were more likely to be employed rather than being housekeepers or pensioners, exhibited a higher prevalence of occasional or regular conventional smoking, reported a lower consumption of fruits and vegetables, were more likely to adopt a Western-type rather than a mixed diet (all P<0.005), and exhibited a trend for lower rates of chronic diseases although this was significant only for the presence of hypertension (P<0.001).

Participants' beliefs on EC/HTP

Participants' beliefs on EC/HTP, both in the total study sample and according to sex (females vs. males), age (<40-year-olds vs. ≥40-year-olds), use of EC/HTP (users vs. non-users) and smoking (current smokers vs. non-smokers), are illustrated in **Figure 2**. Approximately half of the study sample (52.8%) believed that EC/HTP are less harmful than conventional tobacco products, and this belief was significantly more prevalent among younger participants compared to older (58.0% vs. 47.4%, P=0.001), among EC/HTP users compared to non-users (80.2% vs. 46.7%, P<0.001), and among smokers compared to non-smokers (58.5% vs. 49.9%, P=0.015). Most participants (74.3%) believed that EC/HTP use sustains nicotine addiction, and this belief was slightly more prevalent among EC/HTP users and smokers. Moreover, less than half of the study sample (42.2%) believed that EC/HTP use can help toward smoking cessation, and the percentage of positive responders was almost twice as high among EC/HTP users compared to non-users (60.5% vs. 32.3%, P<0.001). Regarding the belief that EC/HTP can facilitate cannabis use, only 27.7% of the study sample responded positively, and the percentage of positive responders was significantly lower among younger compared to older participants (21.2% vs. 34.9%, P<0.001), among EC/HTP users compared to non-users (11.8% vs. 31.5%, P<0.001), and among smokers compared to non-smokers (13.1% vs. 35.6%, P<0.001).

Determinants of EC/HTP use

Several parameters were finally explored as potential determinants of the use of EC/HTP in multiple logistic regression analysis (**Table 2**). Age (OR: 4.083, 95%CI: 2.067-8.062, for <30-year-olds compared to >50-year-olds), occupational status (OR: 2.316, 95%CI: 1.278-4.197, for employed compared to unemployed individuals), conventional smoking (OR: 4.095, 95%CI: 1.820-9.217, for former smokers, OR: 13.23, 95%CI: 5.843-29.94, for current occasional smokers and OR: 9.965, 95%CI: 5.207-19.07, for current regular smokers compared to never smokers), dietary habits (OR: 1.886, 95%CI: 1.084-3.280, for a Western-type diet compared to a prudent diet, i.e. a Mediterranean-style, mixed or vegetarian diet), believing that EC/HTP are less harmful than conventional tobacco products (OR: 3.837, 95%CI: 2.097-7.021) and believing that EC/HTP can help toward smoking cessation (OR: 2.227, 95%CI: 1.305-3.800) emerged as important determinants of using EC/HTP. Believing that EC/HTP can facilitate the onset of cannabis use tended to be associated with lower odds of EC/HTP use (OR: 0.547, 95%CI: 0.278-1.075), whereas sex, educational level, the presence of chronic diseases and believing that EC/HTP can sustain nicotine addiction were not significant predictors.

DISCUSSION

In the present study, we aimed to evaluate the prevalence, patterns, and determinants of EC/HTP use in a representative sample of the Greek general population. Our findings revealed a 16.2% use of EC/HTP in Greece, which was significantly more prevalent in younger individuals, especially ≤19-year-olds (19.7%) and 20–30-year-olds (23.2%). Among users of EC/HTP, 6 out of 10 used nicotine-containing products, ~30% used EC/HTP in parallel with conventional tobacco, and more than half reported an early exposure, i.e., used these products for the first time while being <25 years old. The dominant reasons for EC/HTP use were prompt by friends, smoking cessation effort, and the belief that EC/HTP are less harmful compared to

conventional tobacco products. Among various parameters, younger age, being employed, being a former/current conventional smoker, adopting a Western-type dietary pattern, and considering that EC/HTP are less harmful than conventional tobacco products and can help toward smoking cessation emerged as significant positive determinants of current EC/HTP use. The findings of the present cross-sectional survey are of major importance from a public health perspective, to emerge authorities and legislation bodies to take immediate and effective actions against EC/HTP, a potential "new threat" for the health of the general population.

EC/HTP use has been rising over the past years in most developed countries, especially among the youth, and this has been a matter of intense debate within the public health community. According to the Special Eurobarometer 506 survey, utilizing data from 1,016 face-to-face interviews performed in Greece in 2020, the prevalence of ever/current use of EC among individuals aged ≥15 years was 17%/2%, while that of HTP was 9%/2% (29). Two years later (2022) our study revealed a higher prevalence of current EC use (10.3%) and current HTP use (7.4%) in a representative sample of the Greek population, indicative of a rising trend in the use of novel electronic nicotine delivery systems in Greece. Moreover, our results indicate that the prevalence of EC/HTP use was highest among ≤19-year-olds (19.7%), 20–30-year-olds (23.2%) and 30-40-year-olds (19.1%). The first age group (≤19-year-olds) may represent adolescents who use these products due to curiosity, peer pressure or the sense of fashion associated with the use of novel devices (30-32). This is also supported by the fact that the most frequently reported reason for the onset of EC/HTP use in our study sample was use by friends, indicative of the social dimension of novel nicotine delivery systems. Another possible explanation is the flavoring of EC/HTP, which has been reported to be highly appealing to adolescents (30-32). Accordingly, the two latter age groups (20-40 year-olds) might be indicative of young adults who intend to quit on conventional cigarettes use by switching to EC/HTP, based on common perceptions regarding their lower hazard potential and their ability

to facilitate smoking cessation (33-36). In line with this, the second and third most frequently reported reasons for the onset of EC/HTP use in our study were smoking cessation effort and believing that EC/HTP are less harmful than conventional tobacco products.

The "gateway hypothesis", suggesting that the use of EC/HTP during adolescence can develop into a gateway to nicotine addiction and ultimately traditional tobacco consumption (37), has been a matter of intense debate in the scientific community. This hypothesis, coupled with the fact that novel nicotine delivery systems are particularly popular among the youth (15, 16), as also supported by our results (EC/HTP use was 19.7% among ≤19-year-olds), has raised questions on the potential long-term hazards of these products, although there is still no robust evidence to confirm or reject this hypothesis. For instance, longitudinal studies have revealed that ever use of EC is positively associated with subsequent experimentation with, initiation and/or escalation of conventional cigarette use among adolescents within 6-12 months (38-41). However, although trying EC may increase the likelihood of conventional smoking among some youth, the aggregate effect at the population level appears to be rather small, possibly due to the significant reduction in conventional smoking observed among the youth during the period of vaping's ascendance. Indicatively, a 2018 analysis of 4 cross-sectional surveys in Greece revealed a 33% decrease in conventional smoking among individuals aged 16-24 years from 2009 (a time period when EC were only available in the European market for a few years) to 2014 (42). Similarly, data from the Centers for Disease Control and Prevention indicate that the use of conventional cigarettes (any use during the past 30 days) has significantly decreased from 2011 to 2020 among middle school students (from 4.3% to 1.6%) and high school students (from 15.8% to 4.6%) in the USA, and so has the use of EC from 2019 to 2020 among middle school students (from 10.5% to 4.7%) and high school students (from 27.5% to 19.6%) suggesting a decreasing trend after initial experimentation (43, 44). Although this declining trend in conventional smoking among adolescents questions the hypothesis that EC/HTP can

facilitate smoking initiation, it can be attributed to the implementation of school-based intervention programs toward tobacco use control, and cannot totally discard the possibility that EC/HTP might be associated with susceptibility to conventional cigarettes.

Novel electronic delivery systems have been introduced in the market as safer products which can assist smokers to quit on combustible cigarettes. Meta-analyses of randomized controlled clinical trials have revealed that EC with nicotine can significantly increase smoking quit rates compared to nicotine replacement therapy, EC without nicotine and usual care/no treatment (45). On the contrary, no studies have so far reported on cigarette smoking cessation after HTP use, thus their effectiveness for this purpose remains largely uncertain (46). To be considered as a viable alternative to conventional smoking, novel electronic nicotine delivery systems should ideally be used i) as a complete substitute for conventional combustible tobacco products, and ii) only among smokers, since use by non-smokers would result in greater health risks compared to no use. An important finding of our study is that a significant proportion of EC/HTP users (30.2%) used these products in parallel with conventional tobacco. This observation raises concerns that the use of EC/HTP is not always a substitute for but sometimes an addition to smoking, and this dual use has been shown to be at least as harmful as that of exclusive conventional smoking. For instance, several studies have shown that using conventional tobacco products alone or in combination with EC is associated with higher concentrations of potentially harmful tobacco constituents in the human body, higher levels of inflammatory and oxidative stress markers in blood and urine samples, increased aortic stiffness and blood pressure, and, consequently a higher risk of developing CVD, compared to using EC alone (47-50), highlighting the importance of quitting the use of both for smokers to experience health benefits. Another interesting finding of the present survey is that EC/HTP use was not evident only among former smokers (12.6%) and current smokers (36.5%), as expected, but also among 4.5% of never smokers. This observation suggests that novel electronic nicotine

delivery systems also appeal to a small fraction of individuals with no history of tobacco use. A similar pattern has been reported in the United Kingdom; according to data from the Action on Smoking and Health (ASH), in 2022 only 1.3% of never smokers were current vapers, amounting to 8.1% of vapers (51). The use of EC/HTP among non-smokers remains poorly studied; however, it seems to be rationalized by the higher risk of conventional smoking, and driven by both psychosocial and functional factors, including a sense of connection and belonging, relief of stress and anxiety, a potential beneficial impact on appetite management and weight control, and the enjoyment of the products' unique characteristics, such as the variety of flavors and other physical attributes of devices (52-55). Regardless of the reason of use, whether EC/HTP use in non-smokers is just transient/experimental or can increase the likelihood of smoking initiation in the long-term requires further investigation.

Among various parameters, the most important determinants of using EC/HTP in the present survey were younger age, being employed, being a former or current smoker, adopting a Western-type diet, and believing that EC/HTP are less harmful than conventional tobacco products and can help toward smoking cessation. In other words, our study suggests that the profile of a user of EC/HTP in Greece is a young working male or female, who used to smoke or currently smokes, has poor dietary habits and believes that novel electronic nicotine delivery systems are not as harmful. The fact that users of EC/HTP are predominantly former/current smokers and exhibit poorer dietary habits compared to non-users is an important point to consider, since it is well-established that individual unhealthy behaviors tend to cluster into unhealthy lifestyle patterns which can have a significant impact on health (56-58); a fact that has already been reported for the Greek population, too (51). This observation, coupled with the fact that EC/HTP are sometimes advertised as harmless, organic, natural or even health promoting (especially the fruit-flavored ones) and therefore compatible with a healthy lifestyle in social media (59, 60), and the fact that EC/HTP users have common misperceptions, such as

that aerosol from EC is water vapor, that the nicotine present in EC/HTP is artificial and does not come from tobacco, and that EC/HTP can improve physical fitness (61-63), is highly alarming. Whether users of EC/HTP might perceive this habit as healthy and able to counteract other unhealthy lifestyle habits, or they represent young individuals who are gradually deviating from traditional healthy lifestyle habits, remains to be tested in future studies.

The present study is among the few that have so far explored the prevalence, patterns, and determinants of EC/HTP use, worldwide. The inclusion of an adequate sample of the Greek general population which was representative of all major country regions, both sexes, and most age groups (15-98 years), as well as the comprehensive assessment of participants' smoking habits and EC/HTP use are strong points of the present work. The main limitation of our study lies in its cross-sectional design, which does not allow us to draw conclusions on etiological associations, explore longitudinal trends of EC/HTP use in Greece, evaluate the impact of prospective changes in participants' characteristics (e.g., socioeconomic status, lifestyle habits, conventional smoking) on the long-term use of EC/HTP, or assess the impact of EC/HTP on smoking cessation and health status. Additional limitations of the present work include the assessment of participants' characteristics through a questionnaire, which can be susceptible to misreporting, including recall bias; the lack of data on other important parameters, such as participants' financial level, physical activity habits and body weight status, which could also correlate with or have an impact on EC/HTP use; the lack of data on flavored EC/HTP which seem to be particularly popular among younger individuals, especially adolescents; and the lack of data on participants' experimentation with EC/HTP or past use of EC/HTP.

In conclusion, the present study estimated a 16.2% prevalence of EC/HTP use in Greece, which is probably among the highest documented in Europe. The high use of EC/HTP among the youth, the use of EC/HTP in combination with conventional tobacco products, and the interest of a small fraction of non-smokers in EC/HTP, are important issues that designate the

need of longitudinally monitoring EC/HTP use and patterns in the general population, the importance of adopting a comprehensive tobacco control strategy in Greece, and the need for an efficient regulation of EC/HTP until robust evidence of their long-term safety emerges.

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FIGURE LEGENDS

Figure 1. Prevalence of EC/HTP use (A) in the total study sample and (B) according to sex, age and conventional smoking.

EC, electronic cigarettes; HTP, heated tobacco products.

Figure 2. Participants' beliefs on EC/HTP. Data are presented as relative frequency of positive responders to the four questions utilized.

EC, electronic cigarettes; HTP, heated tobacco products.

Table 1. Descriptive characteristics of participants according to EC/HTP use (n=1,044).			
	Use of EC/HTP		
	No (n=875)	**Yes (n=169)**	**p-value**
Age, years	44.7 ± 20.4	35.6 ± 15.8	<0.001
Age group, n (%)			
<19 years	61 (7.0)	15 (8.9)	
20-30 years	209 (23.9) [a]	63 (37.3) [b]	
30-40 years	123 (14.1)	29 (17.2)	<0.001
40-50 years	104 (11.9)	21 (12.4)	
50-60 years	167 (19.1)	26 (15.4)	
60-70 years	92 (10.5) [a]	9 (5.3) [b]	
>70 years	119 (13.6) [a]	6 (3.6) [b]	
Sex, n (%)			
Males	419 (47.9)	87 (51.5)	0.392
Females	456 (52.1)	82 (48.5)	
Educational level, n (%)			
Low	97 (11.1) [a]	5 (3.0) [b]	<0.001
Medium	283 (32.3) [a]	38 (22.5) [b]	
High	495 (56.6) [a]	126 (74.6) [b]	
Occupational status, n (%)			
Unemployed	172 (19.7)	33 (19.5)	
Housekeepers	66 (7.5) [a]	4 (2.4) [b]	<0.001
Occasionally employed	77 (8.8) [a]	32 (18.9) [b]	
Fully employed	396 (45.3)	90 (53.3)	
Pensioners	164 (18.7) [a]	10 (5.9) [b]	
Smoking, n (%)			
Never smokers	509 (58.2) [a]	24 (14.2) [b]	
Former smokers	153 (17.5)	22 (13.0)	<0.001
Occasional smokers	52 (5.9) [a]	35 (20.7) [b]	
Regular smokers	161 (18.4) [a]	88 (52.1) [b]	
Consumption of fruits, n (%)			
Never/rarely	11 (1.3)	5 (3.0)	
1-3 times/month	61 (7.0) [a]	33 (19.5) [b]	
1 time/week	114 (13.0)	23 (13.6)	<0.001
2-3 times/week	209 (23.9) [a]	53 (31.4) [b]	
4-6 times/week	164 (18.7)	26 (15.4)	
≥1 times/day	316 (36.1) [a]	29 (17.2) [b]	
Consumption of vegetables, n (%)			
Never/rarely	7 (0.8)	1 (0.6)	
1-3 times/month	21 (2.4) [a]	9 (5.3) [b]	0.018
1 time/week	53 (6.1) [a]	18 (10.7) [b]	
2-3 times/week	262 (29.9)	51 (30.2)	

4-6 times/week	218 (24.9)	47 (27.8)	
≥1 times/day	314 (35.9) [a]	43 (25.4) [b]	
Total diet quality			
Mediterranean-style diet	177 (20.2)	26 (15.4)	
Mixed diet	551 (63.0) [a]	90 (53.2) [b]	<0.001
Vegetarian diet	13 (1.5)	3 (1.8)	
Western-type diet	134 (15.3) [a]	50 (29.6) [b]	
Presence of disease, n (%)			
Hypertension	154 (17.6)	11 (6.6)	<0.001
Dyslipidemia	212 (24.2)	32 (18.8)	0.133
Diabetes mellitus	43 (4.9)	4 (2.4)	0.158
Renal disease	12 (1.4)	0 (0.0)	0.126
Asthma	68 (7.8)	6 (3.6)	0.057
Chronic obstructive pulmonary disease	21 (2.4)	2 (1.2)	0.322

Data are presented as absolute number (relative frequency) for categorical variables and mean ± standard deviation for age (normally distributed numerical variable).

*p-values for the comparisons between groups, as derived from the Pearson's chi-squared test for categorical variables and the Student's independent samples t-test for age.

[a,b] Different superscripts indicate significant between-group differences according to post hoc pairwise comparisons adjusted by the Bonferroni correction for multiple tests.

EC, electronic cigarettes; HTP, heated tobacco products.

Table 2. Determinants of the use of EC/HTP (n=1,044).

		OR	95% CI	p-value
Age	>50 years	ref.		
	30-50 years	1.153	0.588-1.367	0.679
	<30 years	4.083	2.067-8.062	<0.001
Sex	Males	ref.		
	Females	0.834	0.508-1.367	0.471
Educational level	Low	ref.		
	Medium	1.332	0.239-7.433	0.744
	High	2.074	0.383-11.24	0.398
Occupational status	Not employed [a]	ref.		
	Employed	2.316	1.278-4.197	0.006
Dietary habits	Prudent diet [b]	ref.		
	Western-type diet	1.886	1.084-3.280	0.025
Smoking	Never smokers	ref.		
	Former smokers	4.095	1.820-9.217	0.001
	Occasional smokers	13.28	5.843-29.94	<0.001
	Regular smokers	9.965	5.207-19.07	<0.001
Presence of any chronic disease	No	ref.		
	Yes [c]	1.095	0.608-1.971	0.763
Belief that EC/HTP are less harmful than conventional tobacco	No	ref.		
	Yes	3.837	2.097-7.021	<0.001
Belief that EC/HTP can help toward smoking cessation	No	ref.		
	Yes	2.227	1.305-3.800	0.003
Belief that EC/HTP can sustain nicotine addiction	No	ref.		
	Yes	1.426	0.771-2.639	0.258
Belief that EC/HTP can facilitate cannabis use	No	ref.		
	Yes	0.547	0.278-1.075	0.080

Results are presented as odds ratios with their 95% confidence intervals and p-values, as derived from multiple logistic regression analysis.

[a] Unemployed participants, housekeepers and pensioners we grouped as not employed.

[b] The Mediterranean-style, mixed and vegetarian diets were grouped as prudent.

[c] Presence of any of the following: hypertension, dyslipidemia, diabetes mellitus, renal disease, asthma, and chronic obstructive pulmonary disease.

EC, electronic cigarettes; HTP, heated tobacco products.