



# Patterns of e-cigarette use, biochemically verified smoking status and self-reported changes in health status of a random sample of vapes shops customers in Greece

Eleni Diamantopoulou<sup>1</sup> · Anastasia Barbouni<sup>1</sup> · Kyriakoula Merakou<sup>1</sup> · Areti Lagiou<sup>2</sup> · Konstantinos Farsalinos<sup>1,3,4</sup> 

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## Abstract

To understand the population impact of e-cigarettes, it is important to examine the profile of e-cigarette users. The purpose was to examine the characteristics, patterns of e-cigarette use and smoking status of a random sample of vapes shops customers in Greece. Fourteen vapes shops were randomly selected in the region of Athens. Every third customer buying products for personal use was recruited by a researcher visiting the vapes shops. Current smoking status was assessed by measuring exhaled carbon monoxide (eCO), with a value  $\geq 7$  ppm being used to classify subjects as current smokers. A questionnaire was used to examine past smoking status, patterns of e-cigarette use, changes in health status and experienced side effects. Logistic regression analysis was performed to identify correlates of being a former smoker. A total of 309 participants were analyzed, with 82.5% being daily e-cigarette users. The vast majority (98%) were smokers before e-cigarette use initiation, with 69.6% of them having eCO  $< 7$  ppm (former smokers). Only 1% were never smokers, and 1% had quit smoking before e-cigarette use initiation; all of them had eCO  $< 7$  ppm. Most participants were using third-generation devices (61.8%) and were using non-tobacco flavors (58.9%). The average liquid consumption was 5 mL/day. Most participants experienced health benefits, mainly improvement in physical status, exercise capacity, olfactory and gustatory senses, while the most common side effects were throat irritation and cough. The strongest correlate of being a former smoker was daily e-cigarette use. Vapes shops customers in Greece are mainly current and former smokers with the majority of them having quit smoking. E-cigarette use by never smokers is rare and none of them subsequently initiate smoking.

**Keywords** Electronic cigarettes · Smoking · Smoking cessation · Nicotine · Vapes shops · Greece

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✉ Konstantinos Farsalinos  
kfarsalinos@gmail.com

<sup>1</sup> National School of Public Health, Alexandras Av. 196, 11521 Athens, Greece

<sup>2</sup> University of West Attica, 12243 Aigaleo, Greece

<sup>3</sup> Onassis Cardiac Surgery Center, Sygrou 356, 17674 Kallithea, Greece

<sup>4</sup> Department of Pharmacy, University of Patras, 26500 Rio, Greece

## Introduction

Awareness and use of e-cigarette has increased rapidly in recent years. In the European Union, 11.6% of the population aged 15 years or older (approximately 48.5 million citizens) had tried e-cigarettes, and 1.8% were current users in 2014 [1]. Growing awareness and use of e-cigarettes has also been observed in the USA [2], while in Great Britain there were 3.2 million adult e-cigarette users (6.2% of the adult population), including 1.7 million former smokers (52% of all users), in 2018 [3]. The rising popularity of e-cigarettes has been a controversial public health issue. There is a lot of debate on whether e-cigarettes represent part of the solution in the smoking problem, used as a risk reduction strategy, or whether they simply attract non-smokers, and may increase their chance of initiating smoking [4]. Additionally, their effect on smoking cessation and reduction is also a matter of debate and disagreement. Obviously, a public health benefit

might exist if the majority of consumers are smokers and use it as an aid to reduce or stop smoking. On the contrary, it would be problematic from a public health perspective if the majority of consumers are non-smokers, especially if the use of e-cigarettes predisposes them to the onset of smoking. It is therefore particularly important to examine the characteristics and profile of e-cigarette consumers.

Surveys of e-cigarette users show substantial smoking cessation rates [5, 6], but these studies suffer from self-selection bias and do not recruit representative samples of all consumers. Other cohort or randomized controlled studies suffer from substantial biases and represent methodologies that are probably not the best in examining the effects of a behavioral change represented by e-cigarettes substituting for smoking [4, 7]. Therefore, real-world studies on e-cigarette users might represent a useful alternative, especially if limitations such as self-selection and inaccurate self-report of the smoking status can be overcome.

In Greece, e-cigarettes are regulated based on the European Union 2014 Tobacco Products Directive, which was implemented into national legislation in 2016. A recent study reported that 5.0% of the adult population are current e-cigarette users, with 62.2% of them being former smokers and 36.3% being current smokers (dual users) [8]. E-cigarettes are mainly available from two sources in the country, the Internet and specialized e-cigarette stores (vapeshops). Unlike other countries in Europe and America, there are very limited or no e-cigarette products in supermarkets, kiosks, pharmacies or other department stores. Considering the characteristics of the e-cigarette market in Greece, the purpose of this study was to determine the characteristics and smoking status, objectively verified by measuring exhaled carbon monoxide (eCO), of a random sample of e-cigarette users, customers of a random sample of vapeshops in Athens.

## Methods

### Study design and participants

The study design involved randomly selecting 14 vapeshops in the region of Athens. For this purpose, a list of 132 vapeshops was created with information derived from the Greek Association of e-cigarette Businesses (SEEHT), and from an online search to find other vapeshops in the region. The vapeshops were numbered in alphabetical order according to their address, and 14 vapeshops were selected through a random number generation. A letter was sent to each store seeking written permission to visit the shop and recruit their customers as participants in the study. All shops accepted being included in the study.

The main researcher visited the stores on average three times a week, either during morning or afternoon hours (in a random order), with the selection of the shop for each visit also being randomly chosen at the beginning of each week through a random number generator from the list of the 14 selected vapeshops. In total, three to four visits were made to each store until the study was completed, and each visit lasted for an average of 3–4 h. The study was conducted from September 2016 to March 2017.

Study participants were customers visiting the vapeshops. The only inclusion criteria were being adults ( $\geq 18$  years) and to have visited the vapeshop to purchase products for personal use. To ensure random recruitment, every third customer of the vapeshop was asked to participate in the study. In case of refusal to participate, the next third customer was selected for recruitment. Each participant received detailed information about the study purpose and design. The study was approved by the ethics committee of the National School of Public Health in Greece, and all participants signed a written informed consent before participation.

### Procedures

Initially, biochemical confirmation of the current smoking status of each participant was performed by measuring exhaled carbon monoxide using a calibrated device (piCO Smokerlyzer, Bedfont Scientific, Kent, UK). These measurements were used to classify subjects according to their smoking status. A cutoff point of 7 ppm was used for the classification [9]. Current smokers were those who reported smoking tobacco cigarettes and had eCO  $\geq 7$  ppm. Former smokers were those who reported a past smoking history, but had eCO levels  $< 7$  ppm. Never smokers were those who reported no past smoking and had eCO  $< 7$  ppm.

Subsequently, participants filled out a questionnaire that was available online in a major survey website (<http://www.surveymonkey.com>). The questionnaire was completed on-site, by using a tablet provided by the researcher to the participants. It comprised three main sections and was based on a large online survey performed in 2013 [6]. Initially, demographics were recorded, including age, gender, and level of education. Then, questions were aimed at exploring the past smoking history and smoking status at the time of initiating e-cigarette use. An additional response option identified former smokers who had quit before initiating e-cigarette use. Participants were also asked about previous visits to smoking cessation clinics and smoking cessation aids used in quit attempts made before e-cigarette use initiation. To understand their perceived difficulty in quitting smoking, they were asked “Before initiating e-cigarette use, how easy or difficult did you consider quitting smoking?”, with response options being “very difficult”, “difficult”, “easy” and “very easy”. In the third section, the questions

were related to the participants' patterns and experience of using e-cigarettes. Reasons for initiating use were recorded by reporting the importance for each response option using a Likert scale with "not at all important" scored as 1, "somewhat important" scored as 2, "important" scored as 3, "very important" scored as 4 and "extremely important" scored as 5 in the analysis. With this scoring system, a higher score signaled higher importance to the specific reason for initiating e-cigarette use. Participants were classified according to frequency of current e-cigarette use as daily or occasional (less than daily) users, without considering the amount of daily consumption as a criterion for the classification. Included were questions to assess participants' opinion about the risk profile of e-cigarettes, with response options addressing both relative harm to tobacco cigarettes and absolute harm (being completely harmless). The type of products used, including device type, flavorings and nicotine levels, were recorded. A specific question addressed the patterns of e-cigarette inhalation. Besides the mouth-to-lung pattern, which is similar to smoking tobacco cigarettes, a pattern of directly inhaling to the lungs while taking the puff has been developed, using atomizers with high airflow (to limit the resistance to flow) and high aerosol yield. This pattern has been called "direct lung inhalation" and, to the best of our knowledge, no study has examined the prevalence of this pattern among e-cigarette users. Finally, participants were asked to report the perceived changes in health status and side effects experienced after initiating e-cigarette use.

## Statistical analysis

The sample was divided into current and former smokers according to the definitions mentioned above. Results are reported for the whole sample and for each of the subgroups. The sample size varied by variable because of missing data; therefore, for some questions, the sum of responses was less than 100%. Continuous variables were reported as mean (SD) or median (IQR) and categorical variables as number (percentage). Cross tabulations and Chi square tests were used to compare groups for categorical variables and Student's *t* test for continuous variables. A backward stepwise logistic regression analysis was performed to examine the correlates of being a former smoker. The dependent variable was being a current or former smoker. Independent variables were age, gender, education, duration of smoking, daily tobacco cigarette consumption before e-cigarette use, perceived difficulty to quit smoking before e-cigarette use initiation, duration and frequency of e-cigarette use, type of e-cigarette device and nicotine levels used at initiation and at the time of the survey, use of non-tobacco flavors at the time of the survey and perceived e-cigarette harmfulness. A *P* value of  $<0.05$  was considered statistically significant and

all analyses were performed with commercially available software (SPSS v. 22, Chicago IL, USA).

## Results

### Characteristics and eCO of study participants

A total of 314 adult subjects participated in the study. Of these, 309 responded to the question about their smoking habits before initiating e-cigarette use and were included in the analysis. The demographic characteristics and current and past smoking status of the participants are shown in Table 1. The majority were men, with an average age of 36.3 years. A total of 98.0% of the participants were smokers before initiating e-cigarette use. Only three of the participants (1.0%) said they had never smoked in the past, while three participants reported they had stopped smoking before initiating e-cigarette use. Of the 303 participants who reported smoking prior to e-cigarette use initiation, 285 (92.2% of all participants) were daily smokers, while only 18 (5.8%) were occasional smokers. Daily smokers had an average daily consumption of 25 cigarettes per day. Only 18 participants (5.8%) had previously visited a smoking cessation clinic, while half had attempted to quit smoking without the use of any medications or other aids. Most participants (94.0%) reported that they thought it would be difficult or very difficult to quit smoking before using the e-cigarette. Supplementary Fig. 1 displays the self-perceived difficulty in quitting smoking before initiating e-cigarette use.

Figure 1 displays the classification of participants into current and former smokers according to eCO measurements. Approximately 70% of participants with a history of smoking had eCO  $<7$  ppm, which classified them as former smokers. It should be noted that all six participants who were never smokers ( $n=3$ ) or had quit smoking before initiating e-cigarette use ( $n=3$ ) had eCO  $<7$  ppm. No statistically significant difference was observed in the baseline characteristics and past smoking history between current and former smokers (Table 1).

### Patterns of e-cigarette use

Participants' patterns of e-cigarette use are shown in Table 2. The most important reason for starting an e-cigarette was to quit or reduce smoking, followed by reduction in cost compared to smoking and to reduce second-hand exposure of others to smoke. For the latter, a statistically significant difference was observed between groups, with former smokers scoring this reason higher than current smokers. Statistically significant differences between groups were also observed for perceptions of e-cigarettes being harmful, with more former smokers

**Table 1** Characteristics and smoking status of the study participants

Characteristics	Whole sample <i>N</i> (%) or mean (SD)	Current smokers	Former smokers	<i>P</i>
<i>N</i>	309	92	211	
Gender				
Males	215 (69.6%)	66 (72.5%)	145 (69.0%)	0.367
Females	92 (29.8%)	25 (27.5%)	65 (31.0%)	
Age (years)	36.3 (11.9)	37.0 (12.3)	36.3 (11.8)	0.633
Education				
Secondary school (or less)	8 (2.6%)	4 (4.3%)	4 (1.9%)	0.234
High school	87 (28.2%)	32 (34.8%)	55 (26.2%)	
Technical/university education	157 (50.8%)	41 (44.6%)	113 (53.8%)	
Postgraduate education	56 (18.1%)	15 (16.3%)	38 (18.1%)	
Smoking status at the time of electronic cigarette use initiation				
Daily smoker	285 (92.2%)	89 (96.7%)	196 (92.9%)	0.290
Occasional smoker	18 (5.8%)	3 (3.3%)	15 (7.1%)	
Former smoker <sup>a</sup>	3 (1.0%)			
Never smoker	3 (1.0%)			
Smoking duration (years)	16.7 (10.9)	17.5 (11.3)	16.5 (10.7)	0.435
Daily cigarette consumption before e-cigarette initiation <sup>b</sup>	20 (15–35)	20 (15–35)	20 (13–34)	0.440 <sup>c</sup>
Daily cigarette consumption at the time of the survey <sup>b</sup>		6 (3–11)		< 0.001 <sup>d</sup>
Managed to quit smoking for > 1 month before e-cigarette use initiation	110 (35.6%)	35 (38.0%)	75 (35.7%)	0.699
Visited a smoking cessation clinic before initiating e-cigarette use	18 (5.8%)	6 (6.9%)	12 (6.2%)	0.822
Smoking cessation attempts before electronic cigarette use initiation				
NRTs	22 (7.1%)	7 (7.6%)	15 (7.1%)	0.878
Oral smoking cessation medications	3 (1.0%)	2 (2.2%)	1 (0.5%)	0.169
Psychological support	7 (2.3%)	3 (3.3%)	4 (1.9%)	0.467
No aid (by themselves)	155 (50.2%)	48 (52.2%)	105 (49.8%)	0.700
Other	6 (1.9%)	1 (1.1%)	5 (2.4%)	0.461

<sup>a</sup>Participants responded that they had quit smoking before initiating electronic cigarette use

<sup>b</sup>Values are median (IQR)

<sup>c</sup>Mann–Whitney *U* test

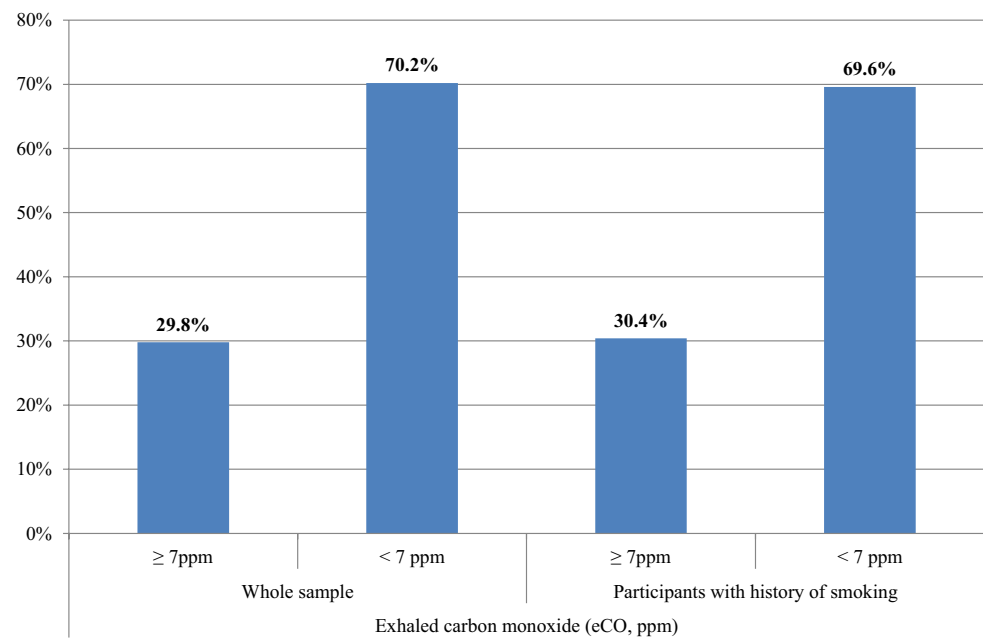
<sup>d</sup>Comparison in cigarette consumption before e-cigarette initiation and time of the survey using Wilcoxon signed ranks test

considering e-cigarettes to be absolutely harmless or substantially less harmful than smoking. The vast majority of participants were daily e-cigarette users with higher prevalence observed in former compared to current smokers. Third-generation e-cigarette devices were the most popular choice at the time of the survey and most participants used nicotine-containing e-cigarettes. The average daily liquid consumption was 5.1 (SD 5.8) mL with no difference between groups. Of note, the majority of participants reported that the measure of e-cigarette consumption was liquid volume. The most popular flavor options were tobacco, followed by fruit and sweet/desserts. More than half of the participants reported using at least one non-tobacco flavor.

### Changes in health status and side effects

Tables 3 and 4 present self-reported changes in health status and side effects after initiating e-cigarette use, respectively. Improvements were mostly reported for physical status in general, exercise capacity, olfactory and gustatory senses and breathing, with no difference between groups. In most of the questions, none of the participants reported deterioration in their health status after initiation of e-cigarette use. Compared to current smokers, more former smokers reported improvements in sexual performance, mood, memory and quality of sleep, but in general less than half of the participants reported improvements in these parameters. Approximately half of the participants experienced at least one side

**Fig. 1** Exhaled carbon monoxide (eCO) measurements. Participants who reported current smoking and had  $eCO \geq 7$  ppm were classified as current smokers, while participants with past smoking history and  $eCO < 7$  ppm were classified as former smokers



effect after e-cigarette use initiation. The most common was cough, followed by throat irritation. All other side effects were infrequent. No difference was observed between current and former smokers for any side effect.

### Correlates of being a former smoker

The correlates of being a former smoker are presented in Table 5. The strongest positive correlate was daily use of e-cigarettes, while higher nicotine concentration at e-cigarette use initiation was also positively associated with being a former smoker. Nicotine concentration at the time of the survey and duration of smoking were negatively associated with being a former smoker.

### Discussion

To the best of our knowledge, this is the first study recruiting a random sample of vapes shops customers from randomly selected vapes shops to objectively assess their smoking status and examine their characteristics and patterns of e-cigarette use. While other studies have examined vapes shops customers [10–12], those were convenient samples that may not represent the average e-cigarette user. The study identified that almost all customers were smokers at e-cigarette use initiation, while the majority were frequent (daily) e-cigarette users and were no longer smoking, as verified by eCO. The small minority of customers who were not smoking at e-cigarette use initiation remained smoke-free at the time of the survey.

Vapes shops, together with Internet shops, represent the major source of e-cigarette products globally. Vapes shops represent a key source of information about e-cigarettes [13] with most employees and owners being e-cigarette users who can share their experience and knowledge with customers and encourage smokers to quit with the help of e-cigarettes [14–16]. This could represent an educational environment for smokers to learn more about e-cigarettes and make appropriate choices based on self-needs and preference. The Greek e-cigarette market is largely dominated by vapes shops, with availability of products in other retail stores being limited. This could explain the high proportion of vapes shops customers being former smokers. In fact, the prevalence of former smokers in this study is similar to a population-representative study in Greece that was recently published and identified that 62.2% of current e-cigarette users were former smokers [8]. However, the current study assessed the smoking status objectively, by measuring eCO. The same population study also found that 98.5% of current e-cigarette users in Greece were smokers before e-cigarette use initiation [8], which is in agreement with the findings of the study herein. These findings appear reassuring for the concerns that e-cigarettes might be appealing to never smokers. Additionally, the fact that e-cigarette users who were not smoking at the time of initiation had  $eCO < 7$  ppm rejects the gateway to smoking concerns, at least for adults. Finally, it is possible that for those who had quit smoking before e-cigarette use initiation, e-cigarettes may represent an aid to prevent relapse to smoking. More research is needed specifically for this population subgroup.

Another factor that might explain the high rate of smoking cessation observed in this study is that most vapes shop

**Table 2** Patterns of e-cigarette use among study participants

Characteristic	Whole sample <i>N</i> (%) or mean (SD)	Current smokers	Former smokers	<i>P</i>
Reasons for initiating EC use <sup>a,b</sup>				
Reduce or quit smoking	4.6 (0.8)	4.5 (0.8)	4.6 (0.8)	0.379
Reduce exposure of others to smoke	3.9 (1.2)	3.6 (1.3)	4.0 (1.2)	0.011
Avoid prohibition in public closed places	3.2 (1.5)	3.0 (1.5)	3.3 (1.4)	0.081
Reduce cost	4.1 (1.2)	4.0 (1.2)	4.2 (1.1)	0.054
Flavors variability	3.6 (1.3)	3.4 (1.3)	3.7 (1.4)	0.134
Perception of e-cigarette harmfulness				
Absolutely harmless	21 (6.8%)	1 (1.1%)	19 (9.4%)	0.031
Substantially less harmful than smoking	149 (48.2%)	41 (46.6%)	104 (51.2%)	
Less harmful than smoking	116 (37.5%)	41 (46.6%)	74 (35.5%)	
Equally harmful to smoking	10 (3.2%)	4 (4.6%)	6 (3.0%)	
More harmful than smoking	1 (0.3%)	1 (1.1%)	0 (0.0%)	
Frequency of e-cigarette use				
Daily	258 (82.5%)	64 (75.3%)	191 (91.4%)	< 0.001
Occasionally	42 (13.6%)	21 (24.7%)	21 (9.8%)	
E-cigarette use duration (months)	13.1 (15.8)	9.7 (13.7)	14.5 (16.4)	0.010
E-cigarette device used now				
First generation (“cigalike”)	28 (9.1%)	8 (8.7%)	19 (9.0%)	0.986
Second generation (eGo-type)	78 (25.2%)	23 (25.0%)	52 (24.6%)	
Third generation (mod, VV, VW)	191 (61.8%)	56 (60.9%)	133 (63.0%)	
E-cigarette device used at initiation				
First generation (“cigalike”)	81 (26.2%)	24 (26.1%)	54 (25.6%)	0.606
Second generation (eGo-type)	113 (36.6%)	30 (32.6%)	81 (38.4%)	
Third generation (mod, VV, VW)	100 (32.4%)	33 (35.9%)	66 (31.3%)	
Nicotine concentration now (mg/mL)	7.2 (4.5)	8.7 (4.5)	6.7 (4.4)	0.001
Use of non-nicotine liquids	19 (6.1%)	2 (2.2%)	14 (6.6%)	0.110
Nicotine concentration at e-cigarette use initiation (mg/mL)	10.3 (5.2)	10.3 (5.2)	10.3 (5.2)	0.692
Daily liquid consumption	5.1 (5.8)	5.1 (5.8)	4.9 (4.3)	0.766
How do you usually measure your daily e-cigarette consumption?				
Number of puffs	16 (5.2%)	6 (6.5%)	10 (4.7%)	0.504
Liquid volume (mL)	260 (84.1%)	73 (79.4%)	182 (86.3%)	
Number of times using the e-cigarette	11 (3.6%)	4 (4.4%)	6 (2.8%)	
Flavors used now				
Tobacco	202 (65.4%)	64 (69.6%)	138 (63.6%)	0.313
Mint/menthol	8 (2.6%)	1 (1.1%)	7 (3.3%)	0.443
Sweet/desserts	121 (39.2%)	28 (30.4%)	90 (42.7%)	0.045
Fruit	94 (39.4%)	22 (23.9%)	69 (32.7%)	0.125
Use of at least one non-tobacco flavor	182 (58.9%)	46 (50.0%)	130 (61.6%)	0.060
Importance of non-tobacco flavors in reducing or quitting smoking				
Not at all/slightly important	96 (31.7%)	36 (39.1%)	60 (28.4%)	0.044
Important/very important	196 (64.7%)	51 (55.4%)	145 (68.7%)	
Pattern of e-cigarette inhalation				
Mouth to lung	179 (57.9%)	58 (63.0%)	121 (57.4%)	0.785
Direct lung inhalation	84 (27.2%)	24 (26.1%)	60 (28.4%)	

VV variable voltage, VW variable wattage

<sup>a</sup>Repeated-measures ANOVA  $F=67.2$ ,  $P<0.001$

<sup>b</sup>Participants were asked to report a score from 1 (not important) to 5 (most important) for each answer option

**Table 3** Self-reported changes in the health status of study participants

Characteristic	Whole sample <i>N</i> (%) or mean (SD)	Current smokers	Former smokers	<i>P</i>
<b>Physical status in general</b>				
Worse	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.452
No change	64 (20.7%)	21 (22.8%)	40 (19.0%)	
Better	234 (75.7%)	68 (73.9%)	163 (77.3%)	
<b>Smell</b>				
Worse	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.806
No change	83 (26.9%)	23 (25.0%)	55 (26.1%)	
Better	214 (69.3%)	66 (71.7%)	147 (69.7%)	
<b>Taste</b>				
Worse	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.267
No change	89 (28.8%)	30 (32.6%)	56 (26.5%)	
Better	208 (67.3%)	58 (63.0%)	147 (69.7%)	
<b>Breathing</b>				
Worse	1 (0.3%)	1 (1.1%)	0 (0.0%)	0.122
No change	84 (27.2%)	29 (31.5%)	53 (25.1%)	
Better	206 (66.7%)	55 (59.8%)	147 (69.7%)	
<b>Appetite</b>				
Worse	3 (1.0%)	2 (2.2%)	1 (0.5%)	0.052
No change	158 (51.1%)	51 (55.4%)	101 (47.9%)	
Better	123 (39.8%)	28 (30.4%)	95 (45.0%)	
<b>Sexual performance</b>				
Worse	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.019
No change	197 (63.8%)	66 (71.7%)	125 (59.2%)	
Better	99 (32.0%)	21 (22.8%)	78 (37.0%)	
<b>Mood</b>				
Worse	1 (0.3%)	0 (0.0%)	1 (0.5%)	0.014
No change	201 (65.0%)	70 (76.1%)	125 (59.2%)	
Better	93 (30.1%)	18 (19.6%)	75 (35.5%)	
<b>Memory</b>				
Worse	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.007
No change	213 (68.9%)	72 (78.3%)	135 (64.0%)	
Better	81 (26.2%)	15 (16.3%)	66 (31.3%)	
<b>Quality of sleep</b>				
Worse	2 (0.6%)	1 (1.1%)	1 (0.5%)	0.001
No change	173 (56.0%)	64 (69.6%)	103 (48.8%)	
Better	117 (37.9%)	21 (22.8%)	96 (45.5%)	
<b>Exercise capacity</b>				
Worse	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.381
No change	74 (23.9%)	24 (26.1%)	46 (21.8%)	
Better	221 (71.5%)	63 (68.5%)	156 (73.9%)	

customers were daily e-cigarette users. This was also observed in a Greek population study [8] and is different from other regions such as the USA or the European Union where only 21% and 60% of current e-cigarette users are daily users, respectively [17, 18]. It is possible that the predominance of vapes shops as the main source of e-cigarette

products, and mostly of advanced and better performing products, may have contributed to the frequent use and high rates of e-cigarette users being former smokers. The frequency of e-cigarette use is an important measure in population studies, since it is positively associated with smoking cessation attempts and success [19, 20]. The latter was verified in the study herein: daily e-cigarette use was the strongest independent correlate of being a former smoker. Nicotine concentration at e-cigarette use initiation was also positively correlated with being a former smoker. This indicates that choosing the appropriate nicotine levels is important in reducing nicotine and smoking cravings. While it might seem paradoxical that nicotine concentration at the time of the survey was negatively associated with being a former smoker, this can be explained by the transition of e-cigarette users who have managed to quit smoking to lower nicotine levels over time [6, 21, 22]. Therefore, this parameter is probably the result of, rather than a cause for, the success in smoking cessation.

The study identified that a quarter of e-cigarette users use a direct lung inhalation pattern of use. This pattern involves directly inhaling the aerosol during puff intake instead of holding the aerosol in the oral cavity and inhaling it after the puff ends. It is associated with very high puff volumes [23] and has been facilitated in recent years by the development of atomizers with increased airflow (to reduce resistance to flow and allow for large puff volumes), large coil and wick mass and use of high power settings (to increase aerosol production per puff). Although aerosol emissions from such atomizers have been measured [24], none has examined realistic puff volumes [23]. More research is needed on this pattern of use since it seems to be quite popular nowadays.

A substantial proportion of participants reported improvement in their health status, mainly in exercise capacity as well as olfactory and gustatory senses. Similar observations were reported in a large convenient sample of e-cigarette users [6]. Side effects were uncommon with the exception of throat irritation and cough, which again have been commonly reported in the past [5, 6]. Despite the random sample design, this study by definition recruited established e-cigarette users. People who may have quit e-cigarette use because of more side effects or benefits that were below their expectations were excluded. Thus, the data on health benefits and side effects represent the population of established e-cigarette users and not all people who have tried e-cigarettes.

The usual limitations of cross-sectional studies are also applied to this study. While temporality of the smoking status before e-cigarette use was established through the questionnaire design, the study cannot prove that e-cigarette use was the reason for smoking cessation. Several parameters that can affect smoking cessation, such as cigarette dependence, number of previous quit attempts, motivation to quit

**Table 4** Side effects reported by study participants

Side effect	Whole sample N (%) or mean (SD)	Current smokers	Former smokers	P
Throat irritation	52 (16.8%)	17 (18.5%)	34 (16.1%)	0.613
Headache	11 (3.6%)	5 (5.4%)	5 (2.4%)	0.170
Gum bleeding	14 (4.5%)	4 (4.4%)	10 (4.7%)	0.881
Oropharyngeal irritation/ inflammation	5 (1.6%)	3 (3.3%)	2 (1.0%)	0.146
Nose bleeding	1 (0.3%)	0 (0.0%)	1 (0.5%)	0.508
Cough	55 (17.8%)	13 (14.1%)	41 (19.4%)	0.268
Dizziness	10 (3.2%)	4 (4.4%)	6 (2.8%)	0.500
Sleepiness	5 (1.6%)	2 (2.2%)	3 (1.4%)	0.637
Sleeplessness	4 (1.3%)	1 (1.1%)	3 (1.4%)	0.814
Palpitations/tachycardia	15 (4.9%)	4 (4.4%)	11 (5.2%)	0.749
Dyspnea	3 (1.0%)	1 (1.1%)	2 (1.0%)	0.910
Allergic reactions	3 (1.0%)	0 (0.0%)	3 (1.4%)	0.556
Chest pain	3 (1.0%)	1 (1.1%)	2 (1.0%)	0.910
Abdominal pain	3 (1.0%)	0 (0.0%)	3 (1.4%)	0.556
Constipation	4 (1.3%)	1 (1.1%)	3 (1.4%)	0.646
Diarrhea	0 (0.0%)	0 (0.0%)	0 (0.0%)	–
Other	7 (2.3%)	1 (1.1%)	6 (2.8%)	0.349
No side effect	153 (49.5%)	49 (53.3%)	101 (47.9%)	0.388

**Table 5** Correlates of being a former smoker

Characteristic	AOR	95% CI	P
Frequency of e-cigarette use			
Occasional (referent)			
Daily	6.41	2.62–15.71	<0.001
Nicotine concentration at e-cigarette use initiation	1.09	1.01–1.18	0.033
Nicotine concentration at the time of the survey	0.86	0.79–0.93	<0.001
Smoking duration	0.93	0.86–0.99	0.032

aOR adjusted odds ratio

before e-cigarette use initiation and presence of smokers in the household and in the workplace were not asked in the questionnaire; the purpose of this was to keep the questionnaire short and improve participation rate since it was administered and filled in the vapes shops during the customers' visit. Past smoking status (before e-cigarette use initiation) was based on self-report, while the duration of smoking cessation was not recorded. Data on health status were based also on self-reports and were not clinically verified. While the study was performed in vapes shops in Athens, the findings could be applicable to other regions and rural areas in Greece, since the characteristics of the e-cigarette market are identical throughout the country. Finally, as mentioned above, the study recruited established e-cigarette users and,

by definition, excluded those who may have tried e-cigarettes in the past and subsequently abandoned their use; thus, the findings cannot be generalized to the population of all ever e-cigarette users. Users who exclusively buy products from online shops were also excluded from the study, and it is unclear if the findings are representative of these consumers.

In conclusion, this study of a random sample of adult vapes shops customers in Athens showed that the vast majority were current and former smokers, with most of them being able to quit smoking after e-cigarette use initiation. The study failed to identify any gateway to smoking effects for the small minority of customers who had never smoked or had quit smoking before e-cigarette use initiation. Health benefits and limited side effects were reported, which could be a motivation for sustained e-cigarette use. The study indicates that e-cigarette use in Greece has positive public benefits, which is in agreement with a recently published population study.

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### Compliance with ethical standards

**Conflict of interest** The authors report no conflicts of interest for the past 36 months.

**Human and animal rights statement** The study was approved by the ethics committee of the National School of Public Health in Athens, Greece.



**Informed consent** All participants signed a written informed consent before participating to the study.

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