Patterns of flavored e-cigarette use among adults vapers in the United States: an internet survey.

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Introduction

Electronic cigarettes (e-cigarettes) have been marketed in recent years as alternative to smoking products and have rapidly grown in popularity in several countries including the United States (US) [1-3]. Characteristically, they are the most popular smoking cessation aid in the US [4,5]. E-cigarettes consist mainly of a battery and an atomizer where liquid is stored and gets evaporated by energy supplied to an electrical resistance. The liquid contains mainly propylene glycol and glycerol, with the option to include nicotine. A major characteristic of the e-cigarette market is the availability of a variety of flavorings in e-liquids. Besides tobacco-like flavors, the consumer can choose flavors consisting of fruits, sweets, drinks and beverages and many more. This is thought to be a major feature accounting for the appeal of e-cigarettes to adult smokers as an alternative to continuing to smoke cigarettes. An estimated 7700 unique e-liquid flavors were identified in 2014 [6] and it is very likely that the number has further increased in recent years. Evidence from cross-sectional surveys of dedicated e-cigarette users suggests that smokers tend to initiate e-cigarette use with tobacco-flavored e-cigarettes but transition to exclusive or predominant use of non-tobacco flavored products—particularly fruit, sweet, and dessert flavors—with increased frequency and duration of e-cigarette use [3,7,8]. Dedicated e-cigarette users who are also former smokers report that switching between flavors within the same day is common and that regular use of multiple e-liquid flavors was associated with significantly higher odds of having quit smoking, with fruit and sweet flavors being the most popular choices among established long-term vapers [8].

The availability of so many different flavorings has been criticized by authorities stating that there is a potential to attract youngsters. This could potentially habituate youth to the effects of nicotine, and in turn, youth who would otherwise not have smoked in the absence of flavored e-

cigarettes will “graduate” to use of more harmful tobacco products, such as cigarettes, that deliver nicotine more efficiently [9]. Studies have shown that the majority of youth and young adults who have ever tried an e-cigarette started their use with fruit or sweet flavors rather than a tobacco flavor, while rates of use of flavored tobacco products are higher among youth and young adults than among older adults [7,10,11]. To address the public health impact of flavorings in e-cigarette liquids and make appropriate regulatory decisions, the US FDA issued an advance notice of proposed rulemaking (ANPRM) on March 21, 2018, to obtain information related to the role that flavors play in the population’s use of tobacco products. This ANPRM is seeking data, research results, comments, and other information about, among other things, the extent to which certain flavors may attract youth to initiate use of a tobacco product and the extent to which certain flavors may help adult cigarette smokers quit or reduce cigarette use and switch to potentially less harmful products. FDA is seeking this information to inform regulatory actions that FDA might take with respect to flavored tobacco products under the Federal Food, Drug, and Cosmetic Act, as amended by the Tobacco Control Act.

The purpose of this study was to obtain information on patterns of flavored e-cigarette use in a large sample of dedicated adult e-cigarette users residing in the US. The study sample is important since any overly restrictive regulatory decisions (e.g. ban on popular flavors) could have unintended consequences among established adult vapers who may have reduced or quit smoking with the help of e-cigarettes. A recent overview on e-cigarettes reported that their public health impact can be largely identified using the formula [12]:

$$\textit{Public health impact}_{EC} = (\textit{hazard}_{SM\text{-}EC} \times \textit{smoking cessation}) - (\textit{hazard}_{EC} \times \textit{use among non-smokers}) - (\textit{hazard}_{SM} \times \textit{smoking initiation})$$

where EC: electronic cigarette; SM: smoking; SM-EC: difference in hazard between smoking and electronic cigarette use; $hazard_{SM}$: refers to smoking initiation due to e-cigarettes (gateway to smoking effect). The formula identifies the risk reduction in smokers who quit with the help of e-cigarettes as one of the determinants of their public health impact. Therefore, the regulatory framework should consider the balance between protecting population subgroups from unintended (from a public health perspective) use and causing harm to people who use e-cigarettes as smoking substitutes.

Methodology

Study sample and online platform

The study sample consisted of individuals aged 18 and older living in the US who have ever used an e-cigarette (even a single puff). Participants were invited to complete an online questionnaire that was available through Dacima Survey software (Dacima, Montreal, Quebec, Canada). Of note, this tool is FDA 21 CFR Part 11 compliant (http://www.dacimasoftware.com/products/dacima-survey). Before entering the main survey questionnaire, participants had to read an informed consent form and check that they agreed to participate. The informed consent presented the purpose of the survey, the names and contact details of the study investigators, information about who is eligible to take part and how survey data will be used, assurances of participant anonymity and confidentiality. Subsequently, participants were asked if they are permanent residents of the US, their age and if they have ever used an e-cigarette (even once or twice). Participants satisfying the inclusion criteria (adults, permanent residents of the US and having used an e-cigarette) were directed to the main

questionnaire. No financial or other incentive was offered in exchange for participation. The study was approved by the ethics committee of the University of Patras in Greece.

The questionnaire was open for participation from April 3rd to May 2nd, 2018. The survey link was promoted by major US e-cigarette advocacy, consumer and business groups and associations in order to attract US residents who are using e-cigarettes. No personal identifying details were collected, besides the usual demographic information collected in any type of cross-sectional survey (see Results section). The IP address was recorded with the purpose of removing double entries.

Questionnaire design

The questionnaire assessed in detail the past and current smoking status of participants. Participants were defined as current smokers if they were smoking in the past 30 days. Former smokers were defined as people who had ever smoked (even 1 or 2 puffs) but had not smoked in the past 30 days. Never smokers were those who responded that they had never smoked a tobacco cigarette.

All participants were by definition ever e-cigarette users. The patterns of use and reasons for e-cigarette use initiation were recorded. Specifically, the age of e-cigarette use initiation, regular e-cigarette use and daily e-cigarette was recorded. Additionally, participants were asked to report whether they use e-cigarettes at the time of the survey every day, some days or not at all. A specific question among former smokers examined whether they were using e-cigarettes at the time of quitting smoking. This question was considered important to more accurately identify former smokers who had quit smoking with the help of e-cigarettes. Questions about e-cigarette

flavors use were asked in 3 sections addressing 3 different periods: A. At the time of e-cigarette use initiation; B. At the time of survey participation; C. At the time of quitting smoking. The latter was recorded only for former smokers who responded that they were using e-cigarettes at the time of quitting.

Results

Descriptive analysis for all participants

After removing double entries through the IP address, the study sample consisted of 69,233 adult e-cigarette users living in the US. The reported residence state of participants is presented in **Table 1**. Only 0.7% (n = 506) did not report their residence state (missing data). Participant demographics are presented in **Table 2**.

Table 1. Residence state of all participants (n = 69,233).

States	%
Alabama	2.4%
Alaska	0.2%
Arizona	2.4%
Arkansas	1.2%
California	6.4%
Colorado	1.7%
Connecticut	1.0%
Delaware	0.3%
District of Columbia	0.1%
Florida	5.6%
Georgia	3.8%
Hawaii	0.4%
Idaho	0.7%
Illinois	4.0%
Indiana	2.9%
Iowa	1.4%
Kansas	0.9%

Kentucky	2.6%
Louisiana	1.2%
Maine	0.4%
Maryland	1.9%
Massachusetts	1.7%
Michigan	3.1%
Minnesota	1.3%
Mississippi	1.0%
Missouri	2.2%
Montana	0.3%
Nebraska	0.7%
Nevada	1.0%
New Hampshire	0.6%
New Jersey	2.0%
New Mexico	0.5%
New York	4.5%
North Carolina	3.0%
North Dakota	0.2%
Ohio	5.5%
Oklahoma	1.8%
Oregon	1.1%
Pennsylvania	4.5%
Rhode Island	0.3%
South Carolina	1.6%
South Dakota	0.3%
Tennessee	4.5%
Texas	6.7%
Utah	1.1%
Vermont	0.2%
Virginia	2.9%
Washington	2.1%
West Virginia	1.1%
Wisconsin	1.8%
Wyoming	0.3%
Missing (no response)	0.7%

Table 2. Participant demographics (n = 69,233)

	Mean / %
Age	34.6
Gender	
Male	72.4%
Female	26.5%
Marital status	
Married	40.6%
Never married	44.9%
Divorced	11.2%
Separated	2.2%
Widowed	0.9%
Employment status	
Not currently working for pay	16.9%
Full-time working, at least 35h/week	70.8%
Part-time working, 15-34h/week	9.9%
Part-time working, < 15h/week	2.1%
Education	
Less than high school	0.9%
Some high school, no diploma	4.0%
GED	7.6%
High school graduate—diploma	25.3%
Some college but no degree	32.9%
Associate degree—occupational/vocational	9.4%
Associate degree—academic program	5.5%
Bachelor's degree (ex: BA, AB, BS)	10.0%
Master's degree (ex: MA, MS, MEng,Med, MSW)	2.1%
Professional school degree (ex: MD,DDS, DVM, JD)	0.5%
Doctorate degree (ex: PhD, EdD)	0.3%
Currently enrolled in a degree program	
Yes	9.6%
No	85.8%
Household income per 12 months	
Less than $10,000	6.7%
$10,000 to $14,999	6.2%
$15,000 to $24,999	10.9%
$25,000 to $34,999	13.1%
$35,000 to $49,999	15.7%
$50,000 to $74,999	18.3%
$75,000 to $99,999	10.4%
$100,000 to $149,999	8.6%
$150,000 to $199,999	2.5%
$200,000 or more	2.0%

The smoking history of participants is presented in **Table 3**. Almost 95% of participants reported that they were ever smokers. The majority had quit smoking, while 61% of current smokers were occasional smokers (smoking on some days). Only 5.2% of the study sample reported being never smokers. The smoking status of the participants is presented in **Figure 1**. Former smokers who were using e-cigarettes at the time of smoking cessation are presented as a separate bar in **Figure 1**. Almost 92% of former smokers reported that they were using e-cigarettes at the time of quitting.

Table 3. Smoking history and current smoking status of the participants (n = 69,233).

	%	95% CI	N
Ever smoked a cigarette (even 1 or 2 puffs)			
Yes	94.8%	94.6-94.9%	65600
No (1)	5.2%	5.0-5.4%	3633
Established smokers (smoked > 100 cigarettes)	81.6%	81.3-81.9%	56469
Current (past 30-day) smokers	13.4%	13.1-13.7%	9300
Now smoking (2)			
Every day	1.9%	1.8-2.0%	1335
Some days	8.2%	8.0-8.4%	5685
Not at all	3.3%	3.2-3.4%	2280
Former smokers (3)	81.3%	81.0-81.6%	56300
Quit time for former smokers			
Within past 12 months	13.1%	12.8-13.4%	9056
More than 12 months ago	68.2%	67.9-68.5%	47244

(1) Classified as never smokers.
(2) Responders were current (past 30-day) smokers.
(3) Former smokers were defined as ever smokers (even 1 or 2 puffs) who are not current (past 30-day) smokers.

Figure 1. Smoking status of the study participants (n = 69,233).

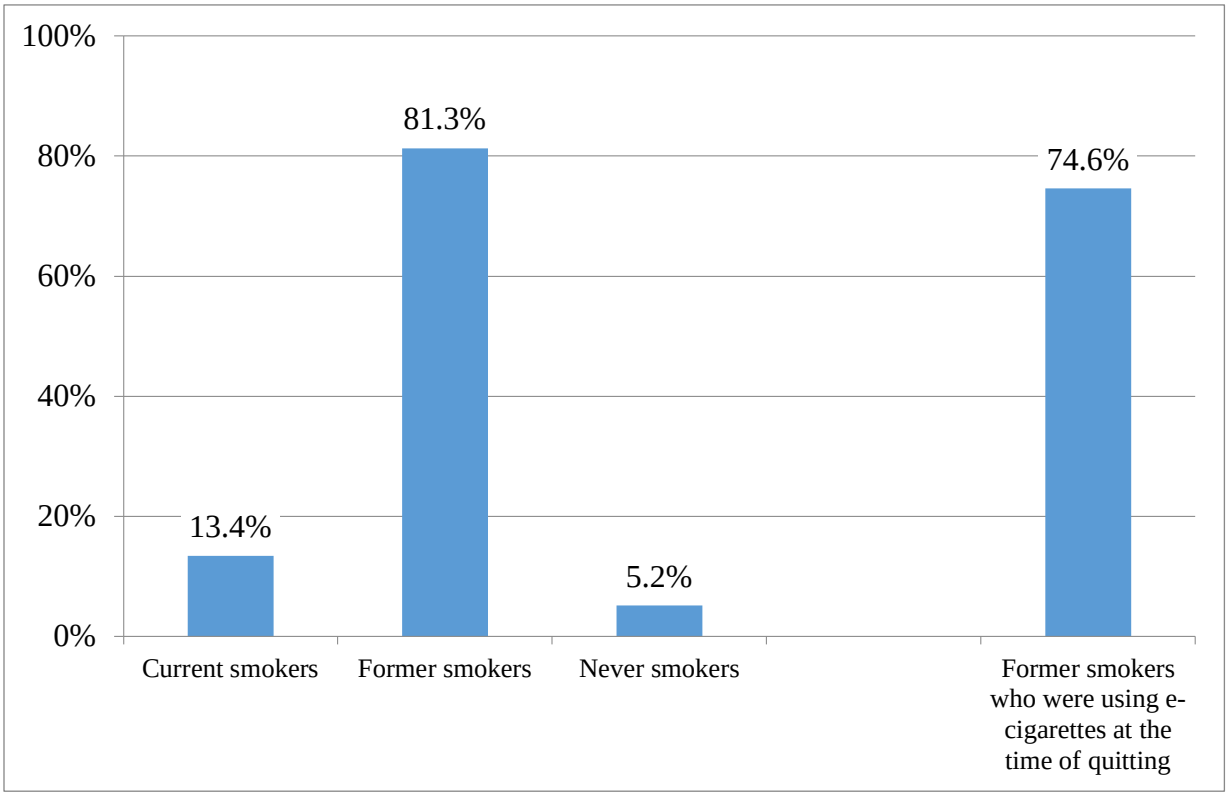


Table 4 presents the e-cigarette use characteristics and reasons for e-cigarette use initiation. The average age of e-cigarette use initiation was approximately 30 years. The vast majority of participants (almost 99%) were using e-cigarettes in the past 30 days, with most using them every day. The main reasons for initiating e-cigarette use were to quit smoking, because e-cigarettes might be less harmful than smoking for themselves or for people around them. Of note, a substantial proportion of participants responded that flavors were also a reason to initiate e-cigarette use. It should be mentioned that the question was not formatted in a way to examine the importance of each reason and responders could choose all options that were applicable to them.

Table 4. E-cigarette use characteristics and reasons for e-cigarette use initiation (n = 69,233).

	Mean or %	SD or 95% CI	N
Age of first time e-cigarette use	30.3	11.2	69233
Ever used e-cigarettes fairly regularly	99.1%	99.0-99.2%	68589
Age of regular e-cigarette use	31.2	11.1	68589
E-cigarette use in past 30-days (even 1 or 2 puffs)	98.9%	98.8-99.0%	68473
Now use e-cigarettes			
Every day	93.5%	93.3-93.7%	64754
Some days	5.2%	5.0-5.4%	3575
Not at all	0.2%	0.2-0.2%	144
Age of everyday e-cigarette use	31.5	13.7	64754
Reasons for initiating e-cigarette use			
To help me quit smoking	89.2%	89.0-89.4%	61784
To help me cut down smoking but not quit completely	21.6%	21.3-21.9%	14969
To use in places where smoking is prohibited	23.6%	23.3-23.9%	16321
Because e-cigarettes might be less harmful to me than smoking	86.9%	86.6-87.2%	60129
Because e-cigarettes might be less harmful to people around me than smoking	83.6%	83.3-83.9%	57888
E-cigarettes have flavors I like	78.4%	78.1-78.7%	54254
Vapor from e-cigarettes smells better than cigarette smoke	85.7%	85.4-86.0%	59336
To save money compared to smoking	73.0%	72.7-73.3%	50552
People in media or public figures use e cigarettes	7.8%	7.6-8.0%	5416
I was told using e-cigarettes feels like smoking	15.8%	15.5-16.1%	10935
Using e-cigarettes is more acceptable to non smokers	33.9%	33.5-34.3%	23504
People important to me were using e-cigarettes	21.6%	21.3-21.9%	14960
To use while socializing	18.5%	18.2-18.8%	12817
The advertising for e-cigarettes was appealing to me	7.5%	7.3-7.7%	5201
I was curious to try an e-cigarette	45.8%	45.4-46.2%	31695
I read information about the health benefits of switching from smoking to e-cigarette use	60.2%	59.8-60.6%	41705
People told me using e-cigarettes helped them quit smoking	77.7%	77.4-78.0%	53819
A health professional advised me to switch from smoking	23.5%	23.2-23.8%	16267
I liked than e-cigarettes came with a variety of flavors	83.6%	83.3-83.9%	57879
Someone who uses e-cigarettes recommended I buy one	52.1%	51.7-52.5%	36082
I liked the look of e-cigarettes	28.1%	27.8-28.4%	19445
I read good reviews online about e-cigarette products	47.1%	46.7-47.5%	32596

E-cigarettes looked easy to use	42.0%	41.6-42.4%	29087

Table 5 presents the e-cigarette equipment and flavors used by the participants at e-cigarette use initiation. Most participants initiated e-cigarette use with advanced devices (variable voltage/wattage) or eGO-style batteries. A small minority used first generation (cigarette-like, "ciga-like") devices. The most popular nicotine concentration at initiation was 1-6 mg/mL followed by 18-24 mg/mL. For most participants, it was easy to find the flavors of preference at e-cigarette use initiation, which is expected considering the unrestricted large variability available until now. Participants were asked to report all different flavors that they were using regularly, but they were also subsequently asked to report the single most regularly used flavor. The most popular flavors were fruit and dessert/pastry/bakery, while only approximately 20% reported using tobacco flavors. Similarly, fruit and dessert/pastry/bakery were the most popular single flavors used most often at e-cigarette use initiation.

Table 5. E-cigarette equipment and flavors use at e-cigarette use initiation (n = 69,233).

	%	95% CI	N
First device used			
Disposable	8.1%	7.8-8.3%	5635
Rechargeable ciga-like with prefilled cartridges	17.5%	17.2-17.8%	12135
eGo-style	32.5%	32.2-32.8%	22477
Pod mod	1.2%	1.1-1.3%	811
Mechanical device	3.7%	3.6-3.8%	2544
Variable voltage/wattage (advanced personal vaporizer)	35.6%	35.2-36.0%	24657
Something else	1.4%	1.3-1.5%	974
Initial nicotine concentration			
0 mg/mL	4.1%	4.0-4.2%	2827
1-6 mg/mL	38.1%	37.7-38.5%	26411
7-12 mg/mL	17.5%	17.2-17.8%	12117

13-17 mg/mL	4.5%	4.3-4.7%	3083
18-24 mg/mL	26.1%	25.8-26.4%	18088
25-49 mg/mL	3.3%	3.2-3.4%	2294
50 mg/mL or more	0.6%	0.5-0.7%	402
How difficult was it to find the flavor you like at e-cigarette use initiation?			
Very difficult	3.1%	3.0-3.2%	2133
Difficult	9.9%	9.7-10.1%	6836
Neither easy nor difficult	21.8%	21.5-22.1%	15078
Easy	27.1%	26.8-27.4%	18742
Very easy	38.2%	37.8-38.6%	26444
Flavors choices (used regularly) at e-cigarette use initiation			
Tobacco	20.8%	20.5-21.1%	14373
Menthol	21.9%	21.6-22.2%	15133
Mint/wintergreen	13.8%	13.5-14.1%	9581
Fruit	82.8%	82.5-83.1%	57320
Dessert/pastry/bakery	68.6%	68.3-68.9%	47509
Candy/chocolate/sweet	52.2%	51.8-52.6%	36160
Spice	12.5%	12.2-12.7%	8659
Coffee	26.4%	26.1-26.7%	18306
Alcohol/cocktail	7.5%	7.3-7.7%	5211
Non alcoholic/non coffee drink	18.7%	18.4-19.0%	12980
Unflavored	1.0%	0.9-1.1%	715
Other	17.3%	17.0-17.6%	12006
Single flavor most often used at e-cigarette use initiation			
Tobacco	7.7%	7.5-7.9%	5301
Menthol	6.3%	6.1-6.5%	4382
Mint/wintergreen	1.9%	1.8-2.0%	1306
Fruit	48.5%	48.1-48.9%	33574
Dessert/pastry/bakery	25.8%	25.5-26.1%	17872
Candy/chocolate/sweet	4.1%	39.5-42.5%	2823
Spice	1.0%	0.9-1.1%	726
Coffee	2.3%	2.2-2.4%	1570
Alcohol/cocktail	0.3%	0.3-0.3%	220
Non alcoholic/non coffee drink	1.1%	1.0-1.2%	779
Unflavored	0.1%	0.1-0.1%	89
Other	0.9%	0.8-1.0%	591

Table 6 presents the e-cigarette equipment and flavors used by the participants at the time of survey participation. The patterns were for the most part similar to the data at e-cigarette use initiation. Even more participants were using advanced devices (variable voltage/wattage) at the

time of survey participation. Use of disposable or rechargeable first generation devices was rare. By far the most popular nicotine concentration at initiation was 1-6 mg/mL, which is compatible with the well-documented gradual transition to lower nicotine concentration over time. The most popular flavors were again fruit and dessert/pastry/bakery. Use of tobacco flavors was less prevalent compared to e-cigarette use initiation, which has also been documented in other surveys. In fact, only 2% of participants reported that the single most often used flavor at the time of survey participation was a tobacco flavor. Many participants reported using multiple flavors within the same day.

Table 6. E-cigarette equipment and flavors use at the time of survey participation (n = 69,233).

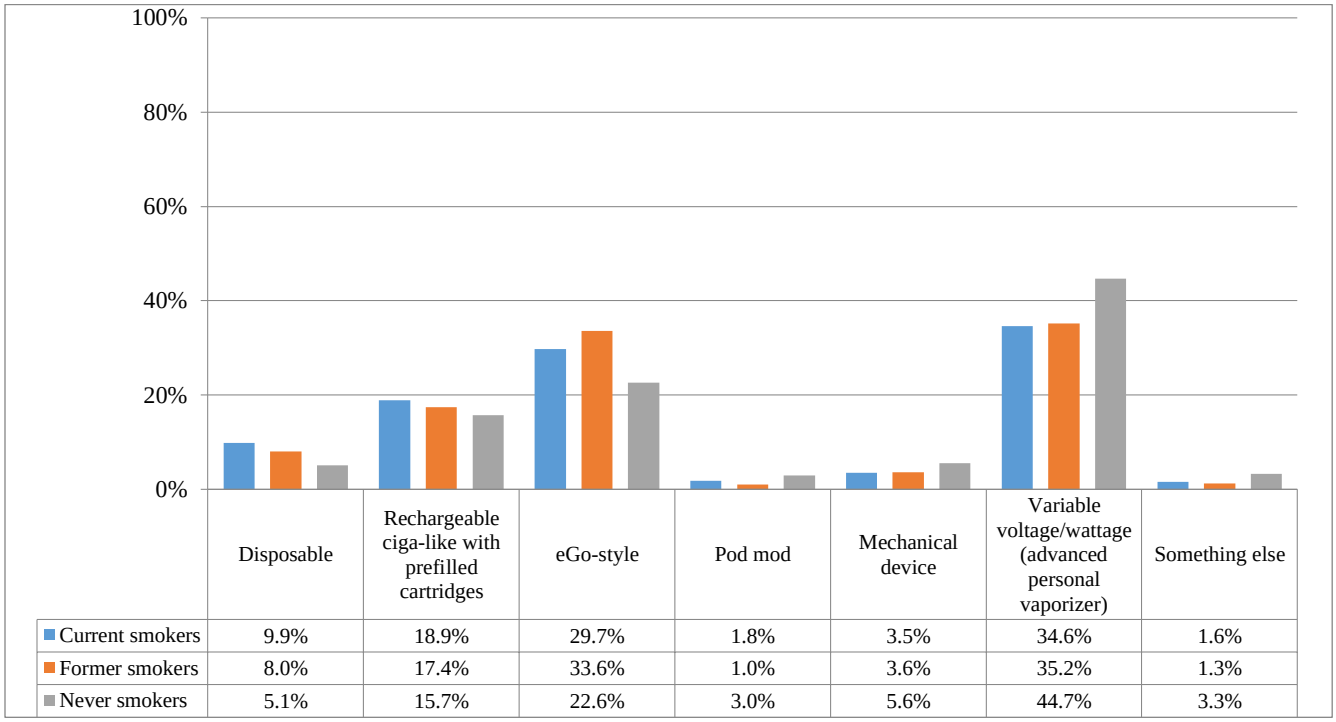
	%	95% CI	N
Device used now			
Disposable	0.2%	0.2-0.2%	155
Rechargeable ciga-like with prefilled cartridges	3.1%	3.0-3.2%	2179
eGo-style	3.5%	3.4-3.6%	2409
Pod mod	3.0%	2.9-3.1%	2059
Mechanical device	10.7%	10.5-10.9%	7388
Variable voltage/wattage (advanced personal vaporizer)	76.7%	76.4-77.0%	53128
Something else	1.5%	1.4-1.6%	1011
Nicotine concentration now			
0 mg/mL	6.2%	6.0-6.4%	4258
1-6 mg/mL	82.4%	82.1-82.7%	57057
7-12 mg/mL	4.7%	4.5-4.9%	3238
13-17 mg/mL	0.8%	0.7-0.9%	561
18-24 mg/mL	1.7%	1.6-1.8%	1172
25-49 mg/mL	1.3%	1.2-1.4%	928
50 mg/mL or more	1.1%	1.0-1.2%	762
Flavors choices (used regularly) now			
Tobacco	7.8%	7.6-8.0%	5395
Menthol	13.3%	13.0-13.6%	9217
Mint/wintergreen	9.6%	9.4-9.8%	6616
Fruit	83.0%	82.7-83.3%	57447
Dessert/pastry/bakery	70.5%	70.2-70.8%	48823

Candy/chocolate/sweet	46.3%	45.9-46.7%	32064
Spice	9.2%	9.0-9.4%	6394
Coffee	19.3%	19.0-19.6%	13385
Alcohol/cocktail	6.9%	6.7-7.1%	4746
Non alcoholic/non coffee drink	13.5%	13.2-13.8%	9368
Unflavored	0.9%	0.8-1.0%	630
Other	11.5%	11.2-11.7%	7945
Single flavor used most often now			
Tobacco	2.1%	2.0-2.2%	1481
Menthol	2.5%	2.4-2.6%	1734
Mint/wintergreen	1.2%	1.1-1.3%	862
Fruit	49.0%	48.6-49.4%	33893
Dessert/pastry/bakery	35.3%	34.9-35.7%	24436
Candy/chocolate/sweet	4.4%	4.2-4.6%	3062
Spice	0.6%	0.5-0.7%	389
Coffee	1.3%	1.2-1.4%	903
Alcohol/cocktail	0.3%	0.3-0.3%	206
Non alcoholic/non coffee drink	0.8%	0.7-0.9%	552
Unflavored	0.2%	0.2-0.2%	131
Other	1.0%	0.9-1.1%	680
Frequency of using different flavors			
Use multiple flavors in the same day	42.0%	41.6-42.4%	29112
Change flavors every 2-3 days	21.1%	20.8-21.4%	14574
Change flavors every 4-5 days	6.7%	6.5-6.9%	4642
Change flavors every week	9.4%	9.2-9.6%	6474
Change flavors every 2 weeks	8.2%	8.0-8.4%	5701
Change flavors every month	11.3%	11.1-11.5%	7826

Comparison between current, former and never smokers

Device choice and flavors preference was analyzed according to the smoking status of the participants at the time of survey participation. Cross-tabulations and chi-square tests were used in the comparison. **Figure 2** shows the device choice at e-cigarette use initiation. Small but statistically significant differences were found between groups.

Figure 2. Choice of device at e-cigarette use initiation among current smokers, former smokers and never smokers (n = 69,233).

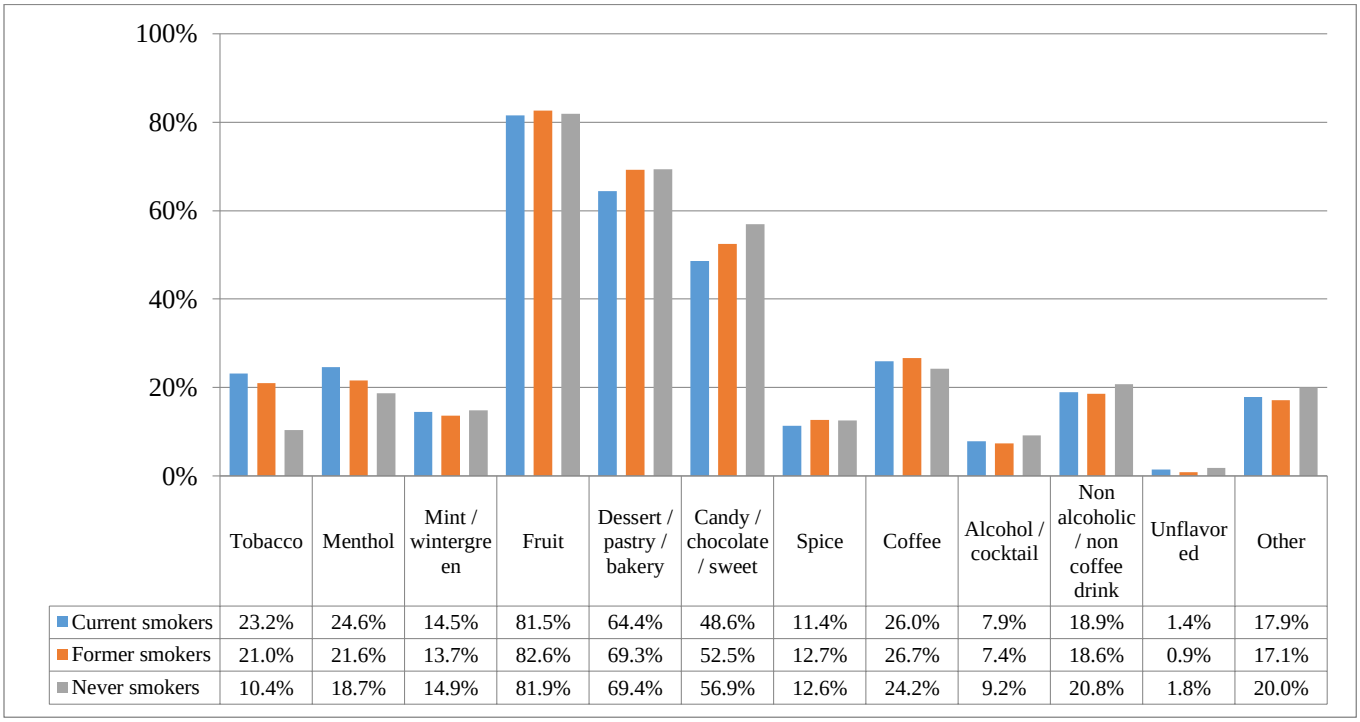


	Disposable	Rechargeable ciga-like with prefilled cartridges	eGo-style	Pod mod	Mechanical device	Variable voltage/wattage (advanced personal vaporizer)	Something else
Current smokers	9.9%	18.9%	29.7%	1.8%	3.5%	34.6%	1.6%
Former smokers	8.0%	17.4%	33.6%	1.0%	3.6%	35.2%	1.3%
Never smokers	5.1%	15.7%	22.6%	3.0%	5.6%	44.7%	3.3%

Advanced devices (variable voltage/wattage) were the most popular option for all groups, followed by eGo-style devices. Never smokers were more likely than former and current smokers to initiate e-cigarette use with advanced devices, while former smokers were more likely than current and never smokers to initiate with eGo-style devices.

Figure 3 presents the choice of flavors at e-cigarette use initiation according to the smoking status at the time of survey participation. For all groups, fruit flavors were the most popular, followed by dessert/pastry/bakery and candy/chocolate/sweet flavors. Never smokers were statistically more likely to choose these flavors at e-cigarette use initiation, but the differences were small.

Figure 3. Choice of flavors at e-cigarette use initiation among current smokers, former smokers and never smokers (n = 69,233).

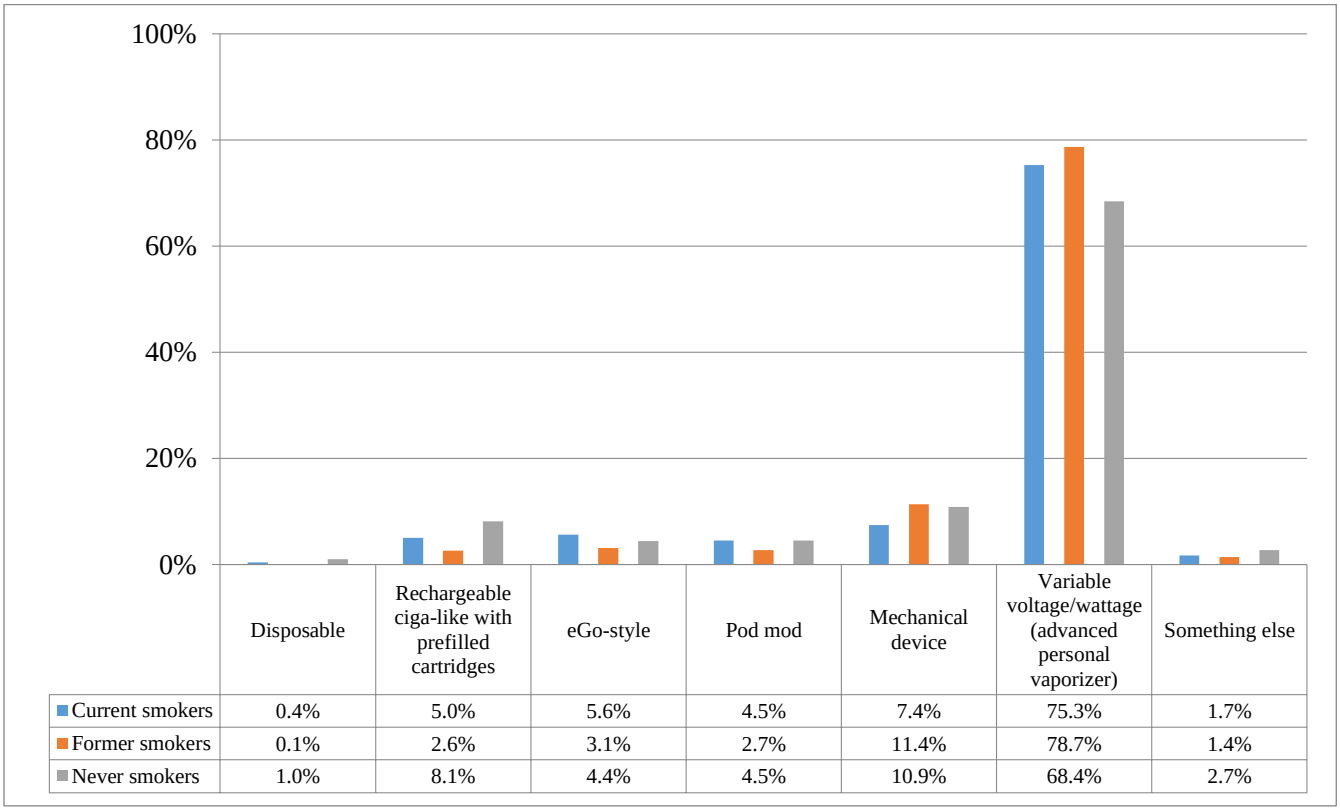


	Tobacco	Menthol	Mint / wintergreen	Fruit	Dessert / pastry / bakery	Candy / chocolate / sweet	Spice	Coffee	Alcohol / cocktail	Non alcoholic / non coffee drink	Unflavored	Other
Current smokers	23.2%	24.6%	14.5%	81.5%	64.4%	48.6%	11.4%	26.0%	7.9%	18.9%	1.4%	17.9%
Former smokers	21.0%	21.6%	13.7%	82.6%	69.3%	52.5%	12.7%	26.7%	7.4%	18.6%	0.9%	17.1%
Never smokers	10.4%	18.7%	14.9%	81.9%	69.4%	56.9%	12.6%	24.2%	9.2%	20.8%	1.8%	20.0%

Tobacco flavors were more prevalent among current compared to former and never smokers, and were least prevalent among never smokers.

Figure 4 shows the device choice at the time of survey participation according to the smoking status. Small but statistically significant differences were found between groups. Advanced devices were by far the more popular overall, but were statistically less prevalent among never compared to former and current smokers. Disposables or rechargeable ciga-like devices were rarely used at the time of survey participation.

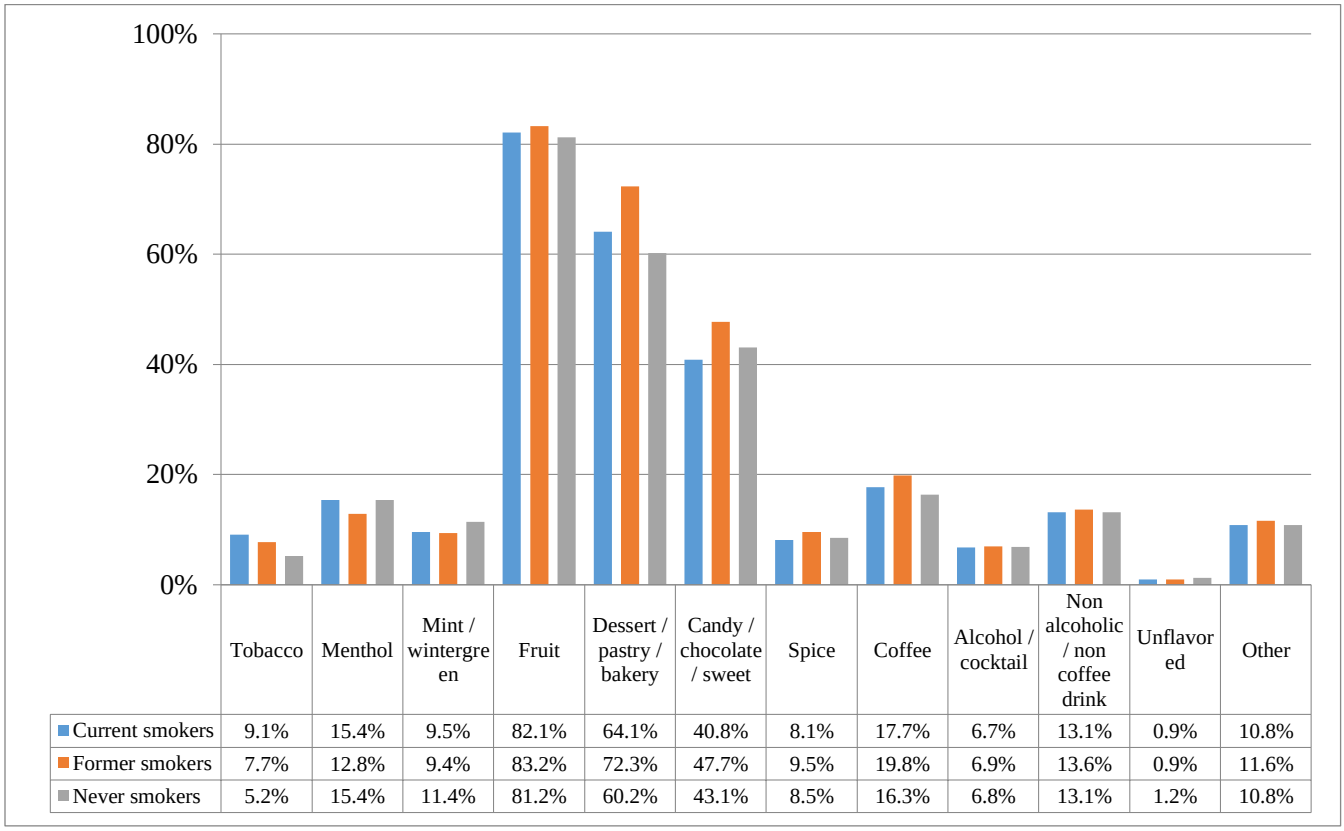
Figure 4. Choice of device at the time of survey participation among current smokers, former smokers and never smokers (n = 69,233).



	Disposable	Rechargeable ciga-like with prefilled cartridges	eGo-style	Pod mod	Mechanical device	Variable voltage/wattage (advanced personal vaporizer)	Something else
Current smokers	0.4%	5.0%	5.6%	4.5%	7.4%	75.3%	1.7%
Former smokers	0.1%	2.6%	3.1%	2.7%	11.4%	78.7%	1.4%
Never smokers	1.0%	8.1%	4.4%	4.5%	10.9%	68.4%	2.7%

Figure 5 presents the choice of flavors at the time of survey participation according to the smoking status at the time of survey participation. Again, fruit flavors were the most popular, followed by dessert/pastry/bakery and candy/chocolate/sweet flavors. Tobacco flavors prevalence was substantially lower compared to the period of e-cigarette use initiation for all groups. Dessert/pastry/bakery and candy/chocolate/sweet flavors were more prevalent among former compared to current and never smokers.

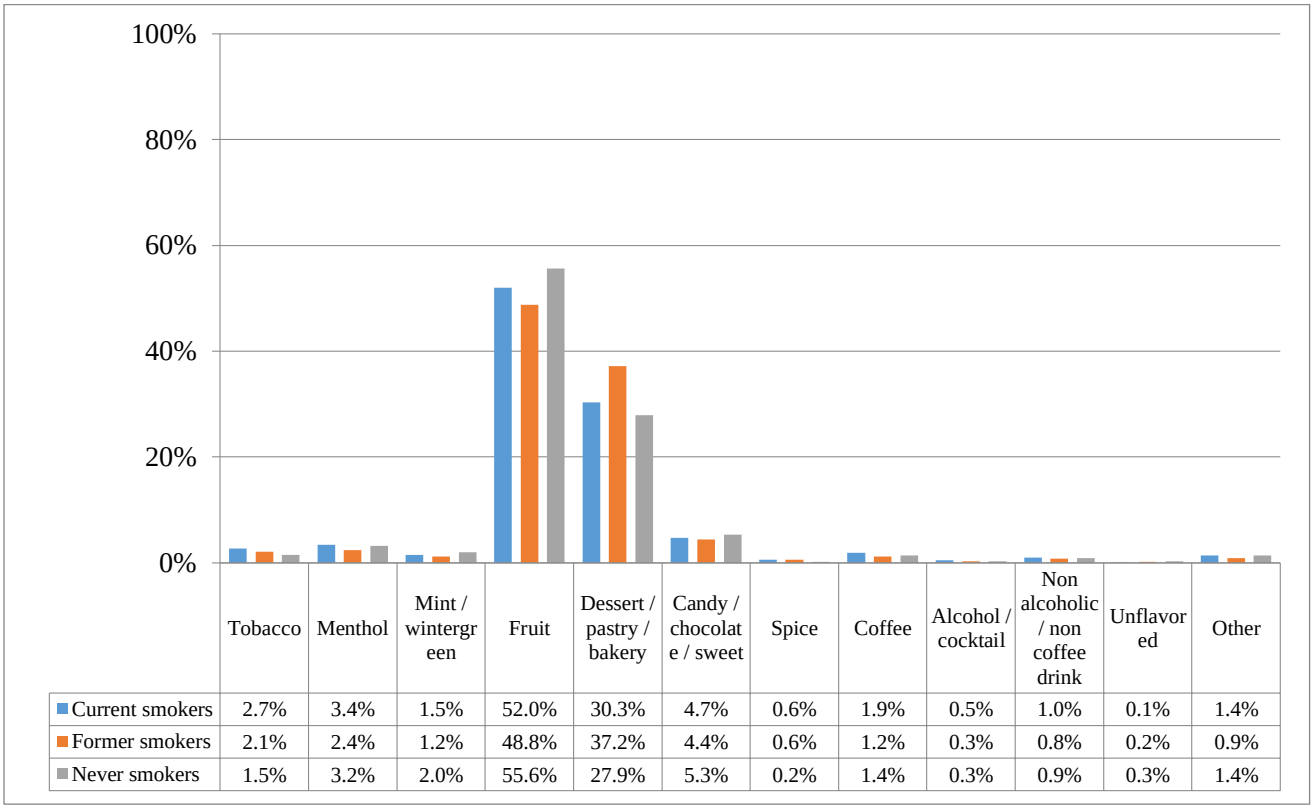
Figure 5. Choice of flavors at the time of survey participation among current smokers, former smokers and never smokers (n = 69,233).



	Tobacco	Menthol	Mint / wintergreen	Fruit	Dessert / pastry / bakery	Candy / chocolate / sweet	Spice	Coffee	Alcohol / cocktail	Non alcoholic / non coffee drink	Unflavored	Other
Current smokers	9.1%	15.4%	9.5%	82.1%	64.1%	40.8%	8.1%	17.7%	6.7%	13.1%	0.9%	10.8%
Former smokers	7.7%	12.8%	9.4%	83.2%	72.3%	47.7%	9.5%	19.8%	6.9%	13.6%	0.9%	11.6%
Never smokers	5.2%	15.4%	11.4%	81.2%	60.2%	43.1%	8.5%	16.3%	6.8%	13.1%	1.2%	10.8%

Figure 6 presents the choice of the one most often used flavor at the time of survey participation according to the smoking status at the time of survey participation. Fruit flavors were the most popular, followed by dessert/pastry/bakery. Minimal use of tobacco flavors was observed in all groups.

Figure 6. Choice of the one flavor most often used at the time of survey participation among current smokers, former smokers and never smokers (n = 69233).



	Tobacco	Menthol	Mint / wintergreen	Fruit	Dessert / pastry / bakery	Candy / chocolate / sweet	Spice	Coffee	Alcohol / cocktail	Non alcoholic / non coffee drink	Unflavored	Other
Current smokers	2.7%	3.4%	1.5%	52.0%	30.3%	4.7%	0.6%	1.9%	0.5%	1.0%	0.1%	1.4%
Former smokers	2.1%	2.4%	1.2%	48.8%	37.2%	4.4%	0.6%	1.2%	0.3%	0.8%	0.2%	0.9%
Never smokers	1.5%	3.2%	2.0%	55.6%	27.9%	5.3%	0.2%	1.4%	0.3%	0.9%	0.3%	1.4%

Former smokers who were using e-cigarettes at the time of quitting

A sub-analysis of the survey focused on former smokers who were using e-cigarettes at the time of smoking cessation. They represented 74.6% of the study sample (n = 51,641, **Figure 1**).

Table 7 presents the e-cigarette use patterns, equipment and flavors used by this subgroup of study participants at the time of quitting smoking. From all former smokers, 8.3% reported that they were not using e-cigarettes at the time of quitting; they were excluded from the present

analysis. The vast majority of the former smokers analyzed reported that they would definitely or probably still be smoking today if they had never started using e-cigarettes. The majority were using advanced e-cigarette devices. The most popular nicotine concentration at the time of quitting was 1-6 mg/mL, followed by 18-24 mg/mL. The vast majority considered finding the flavor of preference as an extremely or very important factor in their attempt to quit smoking. The most popular flavor choices at the time of quitting smoking were fruit flavors, followed by dessert/pastry/bakery. Only 15% of participants were using tobacco flavors. Fruit and dessert/pastry/bakery were also the most prevalent choices that were particularly helpful for quitting smoking and to avoid relapse to smoking.

Table 7. E-cigarette use patterns, equipment and flavors use by former smokers at the time of quitting smoking (n = 51,641).

	%	95% CI	N
At the time of quitting smoking, were you using e-cigarettes: (1)			
Every day	85.1%	84.8-85.4%	47933
Some days	6.6%	6.4-6.8%	3708
Not at all (2)	8.3%	8.1-8.5%	4659
If you had never started using e-cigarettes, would you still be smoking today?			
Definitely yes	72.2%	71.8-72.6%	37265
Probably yes	23.9%	23.5-24.3%	12359
Probably no	1.7%	1.6-1.8%	881
Definitely no	2.2%	2.1-2.3%	1136
Device used at time of quitting smoking			
Disposable	1.9%	1.8-2.0%	1005
Rechargeable ciga-like with prefilled cartridges	9.8%	9.5-10.1%	5044
eGo-style	26.8%	26.4-27.2%	13827
Pod mod	1.2%	1.1-1.3%	625
Mechanical device	5.2%	5.0-5.4%	2666
Variable voltage/wattage (advanced personal vaporizer)	54.4%	54.0-54.8%	28081
Something else	0.8%	0.7-0.9%	393
Nicotine concentration at time of quitting smoking			

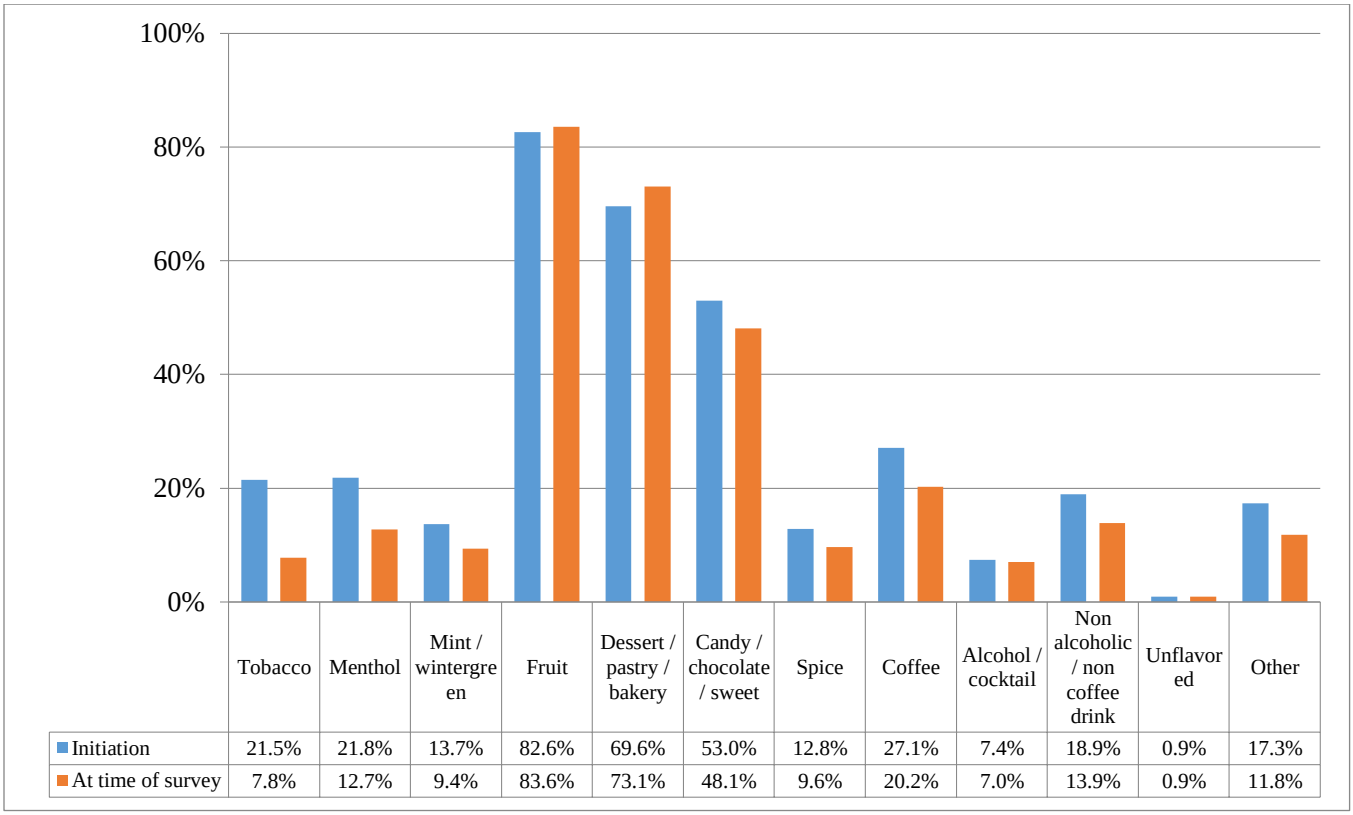
0 mg/mL	1.5%	1.4-1.6%	798
1-6 mg/mL	46.9%	46.5-47.3%	24220
7-12 mg/mL	19.3%	19.0-19.6%	9973
13-17 mg/mL	4.2%	4.0-4.4%	2161
18-24 mg/mL	23.1%	22.7-23.5%	11927
25-49 mg/mL	2.7%	2.6-2.8%	1418
50 mg/mL or more	0.7%	0.6-0.8%	365
How important was finding an e-cigarette/e-liquid flavor you liked in your attempt to quit smoking?			
Extremely important	69.7%	69.3-70.1%	35979
Very important	17.6%	17.3-17.9%	9070
Important	8.7%	8.5-8.9%	4508
Slightly important	3.1%	3.0-3.2%	1579
Not important	1.0%	0.9-1.1%	505
Flavors choices (used regularly) at time of quitting smoking			
Tobacco	15.0%	14.7-15.3%	7763
Menthol	18.2%	17.9-18.5%	9394
Mint/wintergreen	11.5%	11.2-11.8%	5934
Fruit	83.3%	83.0-83.6%	43012
Dessert/pastry/bakery	68.0%	67.6-68.4%	35106
Candy/chocolate/sweet	44.5%	44.1-44.9%	22986
Spice	9.6%	9.3-9.9%	4951
Coffee	19.9%	19.6-20.2%	10298
Alcohol/cocktail	5.9%	5.7-6.1%	3050
Non alcoholic/non coffee drink	13.1%	12.8-13.4%	6766
Unflavored	0.7%	0.6-0.8%	349
Other	9.2%	9.0-9.4%	4761
Single flavor used most often at time of quitting smoking			
Tobacco	5.1%	4.9-5.3%	2617
Menthol	4.7%	4.5-4.9%	2430
Mint/wintergreen	1.6%	1.5-1.7%	841
Fruit	49.3%	48.9-49.7%	25483
Dessert/pastry/bakery	30.3%	29.9-30.7%	15657
Candy/chocolate/sweet	4.1%	3.9-4.3%	2105
Spice	1.1%	1.0-1.2%	593
Coffee	1.8%	1.7-1.9%	953
Alcohol/cocktail	0.3%	0.3-0.3%	142
Non alcoholic/non coffee drink	0.9%	0.8-1.0%	476
Unflavored	0.1%	0.1-0.1%	40
Other	0.6%	0.5-0.7%	304
Flavors choices that were particularly helpful for quitting smoking			
Tobacco	9.3%	9.0-9.6%	4813
Menthol	11.7%	11.4-12.0%	6020
Mint/wintergreen	7.4%	7.2-7.6%	3820
Fruit	60.8%	60.4-61.2%	31393
Dessert/pastry/bakery	48.9%	48.5-49.3%	25277

Candy/chocolate/sweet	29.7%	29.3-30.1%	15327
Spice	7.1%	6.9-7.3%	3649
Coffee	13.9%	13.6-14.2%	7201
Alcohol/cocktail	4.7%	4.5-4.9%	2438
Non alcoholic/non coffee drink	9.6%	9.3-9.9%	4943
Unflavored	0.5%	0.4-0.6%	264
Other	8.0%	7.8-8.3%	4130
Flavors choices that were particularly helpful to avoid relapse to smoking			
Tobacco	7.3%	7.1-7.5%	3792
Menthol	11.5%	11.2-11.8%	5925
Mint/wintergreen	8.8%	8.6-9.0%	4525
Fruit	72.1%	71.7-72.5%	37244
Dessert/pastry/bakery	61.9%	61.5-62.3%	31958
Candy/chocolate/sweet	40.6%	40.2--41.0%	20981
Spice	9.2%	9.0-9.4%	4735
Coffee	19.1%	18.8-19.4%	9857
Alcohol/cocktail	6.6%	6.4-6.8%	3425
Non alcoholic/non coffee drink	12.9%	12.6-13.2%	6641
Unflavored	0.7%	0.6-0.8%	363
Other	9.3%	9.0-9.6%	4816

(1) Data on participants who were using e-cigarettes every day or on some days when quitting smoking are presented in the rest of the table.
(2) These participants were excluded from the rest of the analysis in the present table.

Figure 7 presents the transitions in flavors choice from e-cigarette use initiation to the time of survey participation by former smokers who were using e-cigarettes at the time of quitting smoking. Small increase in prevalence of fruit and dessert/pastry/bakery use was observed over time, as well as a substantial decrease in the use of tobacco flavors. As shown in the table above, fruit, dessert/pastry/bakery and candy/chocolate/sweet were the most prevalent flavors used by this subgroup of participants.

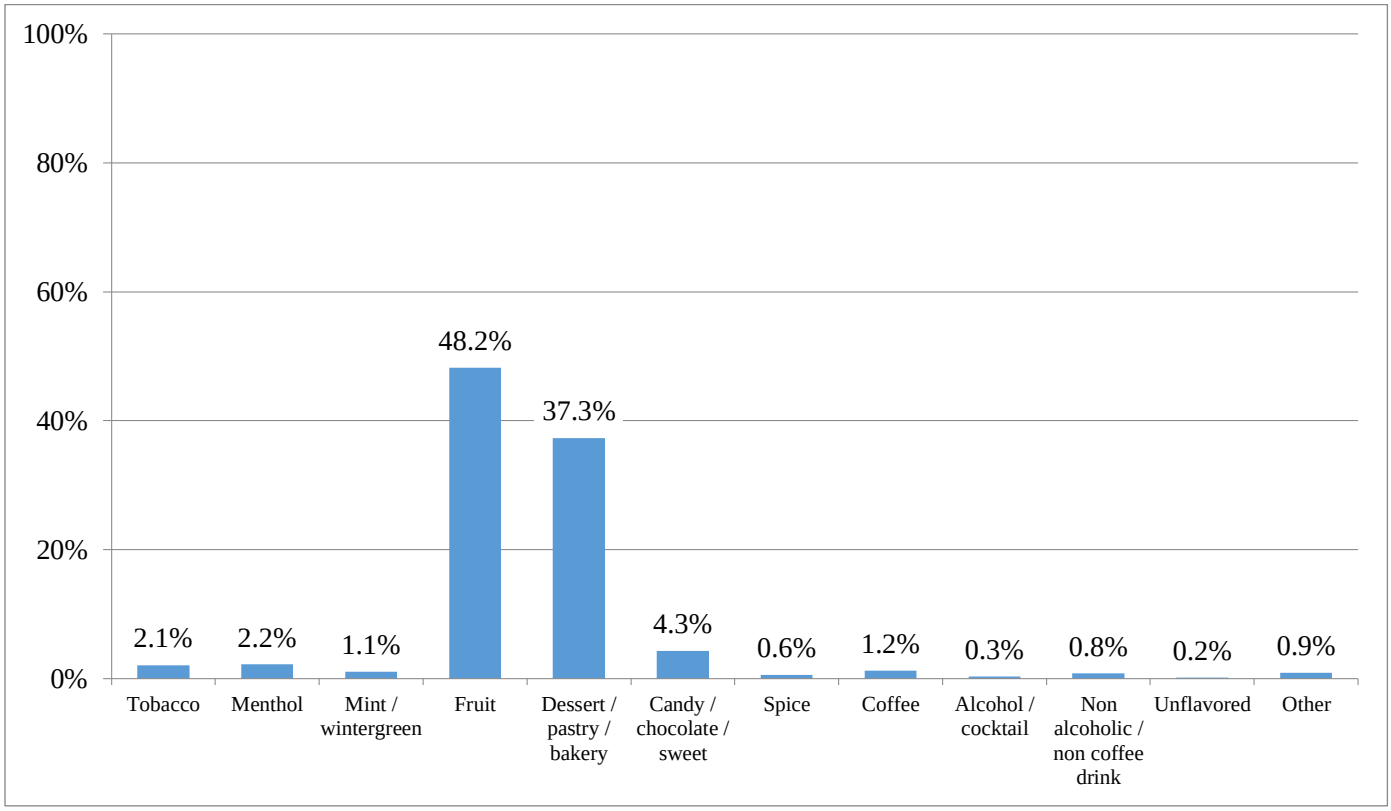
Figure 7. Transitions in flavors choice from e-cigarette use initiation to the time of survey participation by former smokers who were using e-cigarettes at the time of quitting smoking (n = 51,641).



	Tobacco	Menthol	Mint / wintergreen	Fruit	Dessert / pastry / bakery	Candy / chocolate / sweet	Spice	Coffee	Alcohol / cocktail	Non alcoholic / non coffee drink	Unflavored	Other
Initiation	21.5%	21.8%	13.7%	82.6%	69.6%	53.0%	12.8%	27.1%	7.4%	18.9%	0.9%	17.3%
At time of survey	7.8%	12.7%	9.4%	83.6%	73.1%	48.1%	9.6%	20.2%	7.0%	13.9%	0.9%	11.8%

Figure 8 shows the one flavor most often used at the time of survey participation by former smokers who were using e-cigarettes at the time of quitting smoking. Again, fruit flavors were the most popular, followed by dessert/pastry/bakery. Use of tobacco flavors was rare.

Figure 8. Choice of the one flavor most often used at the time of survey participation by former smokers who were using e-cigarettes at the time of quitting smoking (n = 51,641).



Discussion

This is by far the largest survey ever performed on e-cigarette use in terms of sample size, with almost 70,000 participants. The main findings of the study are that non-tobacco flavors, especially fruit and dessert/pastry/bakery flavors, are the most prevalent choices of the adult established, dedicated US e-cigarette users who participated to this study. They are particularly popular not only during long-term e-cigarette use but also at the period of e-cigarette use initiation. Additionally, these flavors are very popular among former smokers who were using e-

cigarettes at the time of smoking cessation. Fruit and dessert/pastry/bakery flavors were also considered particularly important in their effort to quit smoking and to prevent relapse to smoking. Tobacco flavors are generally used by a minority of the study participants, and their use prevalence decreased substantially over time. The patterns of e-cigarette flavors use observed herein are in agreement with a recent cross-sectional study examining the responses of more than 20,000 participants from the US [13]. Since the regulation on e-cigarette flavors should consider the balance between protecting from unintended use (e.g. by adolescents or never smokers) and avoiding adverse effects and potential harm (e.g. by preventing smokers from switching to e-cigarettes in a harm reduction approach to quitting smoking), we hope the FDA will find the data presented in this study useful in preparing the appropriate regulatory framework. The data raise the possibility that an overly-restrictive regulation, such as banning the sales of specific flavor groups (especially fruit and dessert/pastry/bakery flavors), might prevent smokers from switching to e-cigarette use or may increase the relapse rate among former smokers who have managed to quit with the help of e-cigarettes.

A major limitation of the study is the cross-sectional design and the recruitment of a convenience sample of dedicated e-cigarette users. The sample is not representative of the general US adult population and the study was not designed or intended to estimate the prevalence or frequency of e-cigarette flavors use. The flavor preferences and patterns of e-cigarette use reported by the present sample of dedicated e-cigarette users may more closely represent those of the 21.3% of current e-cigarette users in the USA who use e-cigarettes daily and not the majority who are infrequent users or experimenters [14]. Still, this survey presents the patterns of use of a very large sample of adult US e-cigarette users, most of which self-reported that they were successful in quitting smoking with the help of e-cigarettes. While flavors seem to play an important role in

their smoking cessation attempt, it should be mentioned that other characteristics, such as the more prevalent use of advanced e-cigarette devices compared to ciga-likes, may also contribute to a successful quit attempt.

In conclusion, this cross-sectional study of a very large sample of adult US e-cigarette users, most of which were former smokers, identified the importance of non-tobacco flavors in e-cigarette use initiation and sustained use, and their contribution to smoking cessation and relapse prevention. This information should be considered by regulators in order to avoid unintentional adverse effects of over-restrictive regulation on e-cigarette flavors.

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