

Impact of flavours, device, nicotine levels and price on adult e-cigarette users' tobacco and nicotine product choices

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ABSTRACT

Introduction To understand the impact of e-cigarette devices, flavours, nicotine levels and prices on adult e-cigarette users' choices among closed-system and open-system e-cigarettes, cigarettes and heated tobacco products (HTPs).

Methods Online discrete choice experiments were conducted among adult (≥18 years) e-cigarette users (n=2642) in August 2020. Conditional logit regressions were used to assess the relative impact of product attributes and the interactions between product attributes and user characteristics, with stratified analyses to examine differences by smoking status and primarily used e-cigarette device and flavour.

Results On average, participants preferred non-tobacco and non-menthol flavours most, preferred open-system over closed-system e-cigarettes and preferred regular nicotine level over low nicotine level. However, the preference varied by demographics, smoking status and the primarily used e-cigarette device and flavour. The differences in preference among products/devices were larger than the difference among flavours or nicotine levels. Participants who primarily used closed-system e-cigarettes exhibited similar preferences for closed-system and open-system e-cigarettes, but those who primarily used open-system e-cigarettes preferred much more open-system over closed-system e-cigarettes. HTP was the least preferred product, much lower than cigarettes in general, but participants living in states where IQOS is being sold had similar preferences to cigarettes and HTPs.

Conclusions People are unlikely to switch to another product/device because of the restriction of flavour or nicotine level. If non-tobacco and non-menthol flavours were banned from open-system e-cigarettes, users may switch to menthol flavour e-cigarettes. Intervention strategies should be tailored to specific groups.

INTRODUCTION

E-cigarettes and heated tobacco products (HTPs) could reduce tobacco-related harms, if their use is less harmful than smoking tobacco and if large numbers of smokers who would not otherwise quit switched completely to using these products,¹ and youth or young adults who would otherwise initiate into smoking initiated into using e-cigarettes or HTPs instead. Although the long-term health effects of e-cigarette use are not clear, they are generally believed to be less harmful than cigarettes and other combustible tobacco.^{2,3} HTP use is relatively new, especially in the USA, and evidence of its harm is limited, although it is likely less

harmful than smoking because the emissions from HTP generally contain lower levels of toxicants.^{4,5} However, the marketing of e-cigarettes and HTPs may still increase public health harms: (1) may prompt smokers to avoid or delay quitting use of all tobacco/nicotine products; (2) may increase relapse by former smokers who would otherwise not relapse; and (3) may increase risk of nicotine addiction among youth or adults who would not otherwise use any tobacco/nicotine products, especially if that initiation led to smoking combustible tobacco products.⁶

It is crucial for Food and Drug Administration (FDA) and other tobacco policymakers to understand how people will respond to different product and policy options. In particular, a premarket tobacco application (PMTA) order from FDA will be required for all e-cigarettes to stay on the US market. Accordingly, FDA needs knowledge relating to how different restrictions or requirements it might place on e-cigarettes in the PMTA orders would likely affect future tobacco/nicotine product use among current and potential users.

A tobacco/nicotine product can be defined by a set of attributes that are determinants of consumer choice. One important attribute is flavour. The roles of added flavours in increasing youth initiation and overall tobacco use are well established.^{7–12} The wide range of non-tobacco flavours in e-cigarettes contributed to the growth of use by youth and young adults.^{8,10,11} Besides, smokers have identified non-tobacco flavours as a major reason that they initially tried e-cigarettes and continue to use them, either instead of smoking or through dual use.¹³ According to a systematic review,⁸ added flavours are more important among youth and young adults compared with older adults, and specific flavour preferences vary among youth and younger adults compared with older adults and among non-users and smokers. In the USA, federal law prohibits cigarettes and HTPs from having any characterising flavours except menthol and tobacco.¹⁴ Recently, several states and local governments have implemented additional flavour restrictions, ranging from banning all flavours for all tobacco/nicotine products to banning only non-menthol flavours for e-cigarettes.¹⁵ Adding to this complex situation, FDA initiated a temporary enforcement policy in 2020 that effectively banned flavours other than menthol and tobacco for cartridge-based, closed-system e-cigarettes (ie, those with reloadable cartridges or pods of prefilled e-liquid), leaving disposable e-cigarettes (ie, cigalike, used one time then discarded) and open-system e-cigarettes (ie,



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with a refillable chamber that can be filled with e-liquid and can be readily modified by users) without flavour restrictions.

The effects of FDA's incomplete ban and various bans at a local level are largely unknown, although initial evidence indicates that FDA's actions may have prompted some youth and adult to switch from the banned flavour and closed-system e-cigarettes to unbanned flavours (eg, swift from mint to menthol) and disposable or open-system e-cigarettes.^{16 17} Initial study also suggested that local flavour bans cannot sharply reduce the availability or use of flavoured tobacco products among residents due to retailer non-compliance and the availability of banned products outside the localities' borders.¹⁸

Beyond flavour, e-cigarette devices, nicotine levels and prices are important attributes. Youth and other early-stage e-cigarette users may prefer closed-system and disposable e-cigarettes while more established users, especially those who are also current or former smokers, prefer advanced devices such as open-system e-cigarettes.⁸ As nicotine level, evidence shows that non-smokers and inexperienced e-cigarette users preferred less or no nicotine in e-cigarettes compared with cigarette smokers and experienced e-cigarette users.⁸ Although FDA considered reducing nicotine levels in cigarettes,^{19 20} so far there are no federal, state or local laws that regulate nicotine levels in any tobacco/nicotine products. As prices and relative prices, raising prices through tax increases is one of the most effective ways to reduce tobacco use.²¹ All states currently tax conventional tobacco products and more than half have some tax on e-cigarettes.²² At the federal level, no taxes have yet been imposed on e-cigarettes, but HTPs are taxed as cigarettes at the same rate per 'stick'. Some evidence indicates that raising e-cigarette prices by imposing taxes may decrease e-cigarette use but also increase the use of other tobacco/nicotine products if those substitute products' taxes and prices do not increase comparably.^{23–25}

The discrete choice experiment (DCE) is an economic tool designed to elicit preferences or choices in response to hypothetical choice scenarios that offer specific limited options to estimate the parameters of different choice behaviours.^{26 26 27} DCEs have been used to examine preferences for e-cigarettes among the general population and specific population subgroups (eg, adults or youth, smokers, non-smokers or people who ever tried e-cigarettes),^{28–31} and to examine how people may choose between cigarettes and e-cigarettes under various conditions (eg, if a flavour is not available for a certain product).^{32–36} However, no DCEs have included HTPs as a tobacco/nicotine product, and only one DCE study²⁹ has examined the impact of different types of e-cigarette devices (ie, cigarette-like vs open-system e-cigarettes). Only two studies^{32 34} have applied DCEs to gain insights into the impacts of different e-cigarette policies.

Using two DCEs with different restricting of e-cigarette flavours, this study aimed to determine the likely impact on the product choices among different types of adult e-cigarette users, and how choice patterns varied among different demographic groups and those with different smoking practices and history.

METHODS

Survey design

Participants were recruited through Amazon Mechanical Turk (MTurk),³⁷ an online crowdsourcing platform. Inclusion criteria were: at least 18 years old; currently use flavoured e-cigarettes at least once per week; and ≥90% approval rating from previous MTurk tasks. Eligible participants were given access to the survey, hosted by Qualtrics.³⁸ The survey was active in MTurk between

27 August and 8 September 2020. Each approved participant was compensated \$1.

Besides basic demographic information, the survey included questions regarding participants' current and past tobacco/nicotine use practices and preferences. For e-cigarettes, we collected the most used flavours, the most used types of e-cigarette devices and use frequency. For cigarette, we asked if the participants were current, former or never smokers, and asked current smokers about their frequency of use. We collected participants' residential zip code by which the urbanisation level of the neighbourhood was classified as urban, suburban or rural.³⁹ IQOS, the only authorised HTP in the USA, is currently available in Atlanta (Georgia), Richmond (Virginia) and Charlotte (North Carolina).⁴⁰ Thus, we divided the USA into five regions including an HTP-sale region composed of Georgia, Virginia and North Carolina, South excluding the aforementioned three states, West, Midwest and Northeast.⁴¹

Experimental design

A DCE (referred as the first DCE) was designed to resemble FDA's current ban on all capsule-based e-cigarettes with added flavours other than menthol and tobacco such as fruit, coffee and candy (referred to as 'non-TM flavors'). Tobacco flavour was included as distinctive from 'non-flavor' consistent with FDA classification.⁴² In this DCE, besides tobacco, menthol and non-flavoured versions, open-system e-cigarettes, rather than closed-system e-cigarettes, are allowed to have non-TM flavours. For comparison purposes, we conducted a second DCE where non-TM flavours were not available for both open-system and closed-system e-cigarettes, to represent FDA's possible future policy that may extend the flavour ban to all e-cigarettes through its pending PMTA orders.

As shown in table 1, in both DCEs, we asked participants to choose one among four hypothetical products: cigarettes, closed-system e-cigarettes, open-system e-cigarettes and HTPs. Disposable e-cigarettes were combined with closed-system e-cigarettes because of their similarities and to simplify the DCE. Participants could also choose 'none of the above' as an opt-out if they were not satisfied with any products presented in the choice set, under the premise that these products were the only options for them.

Each product had three attributes including flavour, nicotine level and price. In both DCEs, cigarettes and HTPs were offered either with tobacco or menthol flavour (the only two flavours legally permitted for those products) and closed-system

Table 1 Discrete choice experiment (DCE): products, attributes and levels

	Cigarettes	Closed-system e-cigarettes	Open-system e-cigarettes	Heated tobacco products (HTP)
Flavour	▶ Tobacco ▶ Menthol	▶ Tobacco ▶ Menthol ▶ Non-flavoured	▶ Tobacco ▶ Menthol ▶ Non-flavoured ▶ Non-TM flavours*	▶ Tobacco ▶ Menthol
Nicotine level	▶ Regular ▶ Low			
Price	▶ Current market price ▶ 50% higher than the current market price			

*Non-TM flavours refer to flavours other than menthol and tobacco such as fruit, coffee and candy. This flavour was offered for open-system e-cigarettes in the first DCE, but not in the second DCE.

e-cigarettes were offered either in tobacco, menthol or non-flavoured versions. As aforementioned, in the first DCE, open-system e-cigarettes were offered in either tobacco, menthol, non-flavoured or non-TM flavours, and in the second DCE, the option of non-TM flavours was not offered. For all products, there are two nicotine levels including regular and low. Because there is no clear price per pack parallel for the prices of e-cigarettes and HTPs, especially they may have separate prices for the devices and nicotine sources, for all products there are two price levels including current market price (as perceived by the participant) and 50% higher than the current market price.

Because each of the four products is distinct and available with different flavours, we designed a labelled choice DCE, which is more appropriate than the unlabelled choice DCE when evaluating specific alternatives.^{28 32–34 36 43} For the first DCE, we used a fractional factorial design of 24 distinct choice sets divided into four blocks of six choice sets. For the second DCE, we used a fractional factorial design of 36 distinct choice sets divided into four blocks of nine choice sets. Both factorial experimental designs resulted in a D-efficiency of 100% and were generated using dedicated macros for marketing research for SAS V.9.2 and above.⁴⁴ Participants were randomly assigned to one of the four blocks and each participant evaluated 15 (with 6 plus 9) menus of choices for the two DCEs.

Statistical analysis

A conditional logit regression was conducted to assess the effects of flavours, price, nicotine level and product/device on the choice of tobacco/nicotine products. Besides the main effects model, a second model evaluated the interactions between products and individual characteristics to assess heterogeneity in preferences within the sample. Further, stratified models were conducted by (1) the primarily used device and flavour of e-cigarettes; (2) smoking status; and (3) region of residence.

RESULTS

As shown in table 2, among the 2642 participants, the majority were male (64%), between 18 and 34 years old (51%), White (44%), Black (31.3%), with a bachelor's degree and above (79.5%) and living in urban areas (80.6%). The mean age was 36.6 years. About 47% of participants were daily users of e-cigarettes and 53% were weekly users. About 41% were daily smokers, 47% were weekly smokers, and 7% and 4.5% were former and never smokers, respectively. About one-fifth of participants reported using disposable e-cigarettes as their primary e-cigarette device, 44% used closed-system e-cigarettes other than disposables and 35% used open-system e-cigarettes. Non-TM flavours were the most commonly reported flavour (44.5%), followed by tobacco (32%), menthol (19.7%) and non-flavoured (3.7%).

As table 3 shows, participants preferred open-system e-cigarettes, followed closely by closed-system e-cigarettes, considerably more than cigarettes, and HTPs were a distant fourth. Regarding flavours, participants preferred non-TM flavours, followed by menthol, tobacco and non-flavoured. Participants also preferred the current market price over the 50% increase and, to a lesser extent, preferred a regular nicotine level over lower nicotine level. In both DCEs, these differences in participant preferences across product types (especially between preferences for either e-cigarette type and for cigarettes or HTPs) were substantially larger than the differences across flavours. For example, in the second DCE, the difference between the most preferred open-system e-cigarettes and cigarettes (0.74) was

Table 2 Characteristics of participants (n=2642)

Category	Item	%
Gender	Female	36.0
	Male	64.0
Age group (years)	18–34	50.6
	35–54	41.8
	55 and above	7.6
Race /ethnicity	White	44.0
	Black	31.3
	Asian	4.1
	Hispanic	16.5
	Other and mixed race	4.1
Educational attainment	High school and below	6.1
	Above high school and below bachelor's degree	14.4
	Bachelor's degree and above	79.5
Household income	Less than \$24 999	9.4
	\$25 000–\$49 999	31.7
	\$50 000–\$74 999	35.0
	\$75 000–\$99 999	18.5
	\$100 000 or more	5.4
Urbanisation*	Urban	80.6
	Suburban	13.4
	Rural	6.1
US census region	West	32.1
	Midwest	15.8
	Northeast	17.8
	South†	26.3
	HTP-sale region‡	8.2
Different types of the use of e-cigarettes and cigarettes/cigars§	Daily use of both products	29.4
	Daily smoker and weekly use of e-cigarette	11.7
	Weekly smoker and daily use of e-cigarette	11.1
	Weekly use of both products	36.3
	Former smoker and daily use of e-cigarette	4.4
	Former smoker and weekly use of e-cigarette	2.6
	Never smoker and daily use of e-cigarette	2.4
	Never smoker and weekly use of e-cigarette	2.1
Primary e-cigarette device	Disposable	20.4
	Closed-system e-cigarette other than disposable	44.4
	Open-system e-cigarette	35.0
	Others	0.3
Primary e-cigarette flavour	Tobacco flavour	32.1
	Menthol flavour	19.7
	Non-flavoured	3.7
	Non-TM flavours (eg, fruit, coffee and candy)	44.5

*Urbanisation level of the neighbourhood was classified as urban, suburban or rural using the rural-urban commuting area (RUCA) codes.²⁹

†South region: three states were excluded—Georgia, Virginia and North Carolina.

‡HTP-sale region is composed of three states including Georgia, Virginia and North Carolina. IQOS, the only authorised HTP in the USA, is currently available in Atlanta (Georgia), Richmond (Virginia) and Charlotte (North Carolina).⁴⁰

§For e-cigarettes, daily use refers to the use of e-cigarettes every day or most days in a week; weekly use refers to the use of e-cigarettes less than most days but at least once a week. For cigarette/cigar smoking, daily smoker refers to those who smoke every day or most days in a week; weekly smoker refers to those who smoke less than most days in a week.

HTP, heated tobacco product.

more than three times the difference between the most preferred menthol flavour and the least preferred non-flavoured option (0.23). In the first DCE, the difference between open-system and closed-system e-cigarettes (0.17) was larger than the difference between the non-TM flavours option and either menthol or tobacco flavour. The difference of the results between the first and second DCEs shows that when non-TM flavours were further removed from open-system e-cigarettes, the preference for menthol was higher while the preference for the non-flavoured option was lower, that is, banning non-TM flavours

Table 3 Conditional logit regressions of tobacco/nicotine product choice for two DCEs

		Coefficient estimate (SE)	
		First DCE	Second DCE
Product/device	Cigarettes	0	0
	Closed-system e-cigarettes	0.56 (0.026)**	0.61 (0.021)**
	Open-system e-cigarettes	0.73 (0.027)**	0.74 (0.02)**
	Heated tobacco products	-0.40 (0.03)**	-0.44 (0.025)**
Flavour	Tobacco	0	0
	Menthol	0.05 (0.023)**	0.12 (0.018)**
	Non-flavoured	-0.09 (0.023)**	-0.11 (0.023)**
	Non-TM flavours	0.14 (0.043)**	NA
Price	Current market price	0	0
	50% higher	-0.22 (0.020)**	-0.28 (0.016)**
Nicotine level	Regular	0	0
	Low	-0.11 (0.019)**	-0.07 (0.016)**

Boldface indicates statistical significance, with *p<0.05; **p<0.01.
DCE, discrete choice experiment; NA, not applicable.

would primarily prompt previous users of non-TM flavours to switch to menthol.

For the following analyses presented in tables 4 and 5, we only reported the results from the first DCE because the corresponding results from the second DCE were very similar.

Table 4 Conditional logit regressions of tobacco/nicotine product choice for the first DCE, with interactions between products/devices and demographics

		Coefficient estimate (SE)		
		Closed-system e-cigarettes	Open-system e-cigarettes	Heated tobacco products
Constant for product		0.46 (0.109)**	0.79 (0.105)**	-0.7 (0.137)**
Gender	Male (ref)	0	0	0
	Female	0.02 (0.051)	-0.01 (0.05)	0.06 (0.064)
Age groups	18–34 (ref)	0	0	0
	35–54	0.04 (0.052)	0.02 (0.05)	-0.03 (0.064)
	≥55	-0.21 (0.096)*	-0.11 (0.091)	-0.16 (0.121)
Race/ethnicity	White (ref)	0	0	0
	Black	-0.07 (0.058)	-0.24 (0.056)**	-0.1 (0.073)
	Asian	0.16 (0.133)	0.15 (0.127)	0.09 (0.166)
	Hispanic	0.05 (0.072)	-0.06 (0.069)	0.15 (0.088)
	Other race	-0.04 (0.129)	-0.04 (0.123)	-0.02 (0.162)
Household income	Low (ref)			
	High	0.13 (0.05)*	0.23 (0.048)**	0.24 (0.063)**
Educational attainment	Low (ref)	0	0	0
	High	0.05 (0.064)	-0.16 (0.061)**	0.12 (0.082)
Urbanisation†	Urban	0	0	0
	Suburban	-0.08 (0.073)	-0.11 (0.07)	0.05 (0.089)
	Rural	0.01 (0.107)	0.09 (0.101)	-0.02 (0.135)
US census region	West	0	0	0
	Midwest	-0.03 (0.078)	0.18 (0.074)*	-0.08 (0.099)
	Northeast	-0.07 (0.064)	0.03 (0.062)	-0.03 (0.08)
	South‡	-0.02 (0.071)	-0.1 (0.07)	-0.04 (0.09)
	HTP-sale region§	0.08 (0.099)	0.2 (0.095)*	0.29 (0.118)*

The constant for each product is displayed on the first row, and the coefficients for flavour, price and nicotine level are omitted because they are very similar to the values in table 3. The reference product is a cigarette (value=0). Household income: low (<\$50 000) and high (≥\$50 000). Educational attainment: low (below bachelor's degree) and high (bachelor's degree and above). Boldface indicates statistical significance.

*p<0.05; **p<0.01.

†⁴⁰Urbanisation level of the neighbourhood was classified as urban, suburban or rural using the rural-urban commuting area (RUCA) codes.³⁹

‡South region: three states were excluded—Georgia, Virginia and North Carolina.

§HTP-sale region is composed of three states (Georgia, Virginia and North Carolina). IQOS, the only authorised HTP in the USA, is currently available in Atlanta (Georgia), Richmond (Virginia) and Charlotte (North Carolina).⁴⁰

DCE, discrete choice experiment; HTP, heated tobacco product.

As table 4 shows, e-cigarettes, as well as HTPs, were less preferred by older adults than by younger and middle-aged adults and there were no significant differences between male and female preferences. Open-system e-cigarettes were less preferred by Blacks compared with all other ethnic groups, and Asians had the strongest preference for both types of e-cigarette and HTPs. E-cigarettes and HTPs were also preferred more strongly by participants with higher household income compared with their counterparts. HTPs and open-system e-cigarettes were preferred by participants from the HTP-sale region.

As table 5A shows, in general, participants who primarily used closed-system e-cigarettes exhibited similar preferences for closed-system and open-system e-cigarettes, whereas participants who primarily used open-system e-cigarettes much more strongly preferred open-system over closed-system e-cigarettes. Participants who primarily used open-system e-cigarettes and non-TM flavours were different from other groups in having the strongest preferences for menthol and non-TM flavours, and being the most sensitive to a 50% price increase and the least sensitive to nicotine levels. Participants primarily using closed-system e-cigarettes with tobacco, menthol or non-flavoured were the least price sensitive, with a 50% increase having a quite small negative effect. While participants who primarily used closed-system or open-system e-cigarettes with non-TM flavours preferred HTPs less than cigarettes, participants who primarily used open-system e-cigarettes with only

Table 5 Stratified conditional logit regressions of tobacco/nicotine product choice for the first DCE**A. Stratified by the primarily used device and flavour of e-cigarettes**

		Coefficient estimate (SE)			
		Used closed-system e-cigarettes† with tobacco, menthol and non-flavoured (n=1008)	Used closed-system e-cigarettes with non-TM flavours (n=702)	Used open-system e-cigarettes with tobacco, menthol and non-flavoured (n=455)	Used open-system e-cigarettes with non-TM flavours (n=469)
Product/device	Cigarettes	0	0	0	0
	Closed-system e-cigarettes	0.55 (0.038)**	0.66 (0.05)**	0.54 (0.066)**	0.46 (0.072)**
	Open-system e-cigarettes	0.39 (0.043)**	0.69 (0.054)**	1.14 (0.066)**	1.17 (0.068)**
	Heated tobacco products	-0.59 (0.047)**	-0.39 (0.06)**	-0.05 (0.071)	-0.25 (0.08)**
Flavour	Tobacco	0	0	0	0
	Menthol	0 (0.035)	0.04 (0.045)	0.08 (0.055)	0.22 (0.061)**
	Non-flavoured	-0.2 (0.048)**	-0.03 (0.058)	-0.13 (0.073)	0.1 (0.077)
	Non-TM flavours	-0.12 (0.07)	0.26 (0.081)**	-0.11 (0.098)	0.8 (0.103)**
Price	Current market	0	0	0	0
	50% higher	-0.08 (0.031)*	-0.29 (0.038)**	-0.13 (0.047)**	-0.64 (0.052)**
Nicotine	Regular	0	0	0	0
	Low	-0.11 (0.031)**	-0.09 (0.038)*	-0.18 (0.047)**	-0.05 (0.05)

B. Stratified by smoking status

		Coefficient estimate (SE)			
		Daily smoker (n=1088)	Weekly smoker (n=1250)	Former smoker (n=185)	Never smoker (n=119)
Product/device	Cigarette	0	0	0	0
	Closed-system e-cigarette	0.39 (0.038)**	0.65 (0.038)**	0.89 (0.116)**	1.39 (0.171)**
	Open-system e-cigarette	0.55 (0.04)**	0.78 (0.04)**	1.3 (0.117)**	1.68 (0.174)**
	Heated tobacco product	-0.63 (0.046)**	-0.23 (0.043)**	-0.08 (0.133)	-0.05 (0.206)
Flavour	Tobacco	0	0	0	0
	Menthol	0.02 (0.035)	0.05 (0.033)	0.04 (0.097)	0.69 (0.141)**
	Non-flavoured	-0.12 (0.046)**	-0.09 (0.043)*	-0.09 (0.118)	0.21 (0.157)
	Non-TM flavours	0.002 (0.064)	0.10 (0.060)	0.66 (0.161)**	1.16 (0.224)**
Price	Current market	0	0	0	0
	50% higher	-0.16 (0.03)**	-0.21 (0.028)**	-0.48 (0.081)**	-0.83 (0.118)**
Nicotine	Regular	0	0	0	0
	Low	-0.12 (0.03)**	-0.11 (0.028)**	-0.25 (0.079)**	0.14 (0.108)

C. Stratified by the region of residence

		Coefficient estimate (SE)				
		HTP-sale region‡ (n=217)	West (n=848)	Midwest (n=415)	Northeast (n=470)	South§ (n=692)
Product/device	Cigarette	0	0	0	0	0
	Closed-system e-cigarette	0.73 (0.095)**	0.56 (0.045)**	0.54 (0.067)**	0.54 (0.05)**	0.55 (0.06)**
	Open-system e-cigarette	0.99 (0.099)**	0.64 (0.047)**	0.8 (0.068)**	0.78 (0.052)**	0.66 (0.064)**
	Heated tobacco product	-0.001 (0.104)	-0.42 (0.053)**	-0.49 (0.08)**	-0.43 (0.058)**	-0.42 (0.07)**
Flavour	Tobacco	0	0	0	0	0
	Menthol	0.09 (0.079)	0.1 (0.04)*	0.03 (0.06)	-0.01 (0.044)	0.06 (0.054)
	Non-flavoured	-0.07 (0.105)	0.02 (0.052)	-0.07 (0.076)	-0.25 (0.059)**	-0.1 (0.07)
	Non-TM flavours	0.07 (0.141)	0.22 (0.073)**	0.38 (0.105)**	-0.01 (0.08)	0.02 (0.1)
Price	Current market	0	0	0	0	0
	50% higher	-0.19 (0.068)**	-0.14 (0.03)**	-0.38 (0.05)**	-0.15 (0.038)**	-0.35 (0.046)**
Nicotine level	Regular	0	0	0	0	0
	Low	-0.13 (0.068)*	-0.03 (0.03)	-0.16 (0.05)**	-0.19 (0.038)**	-0.09 (0.046)*

Boldface indicates statistical significance. In all subtables, each column reported the result of one conditional logit regression specific for one group.

* p<0.05; **p<0.01.

†Disposable e-cigarette was included.

‡HTP-sale region is composed of three states—Georgia, Virginia and North Carolina. IQOS, the only authorised HTP in the USA, is currently available in Atlanta (Georgia), Richmond (Virginia) and Charlotte (North Carolina).¹⁰

§South region: three states were excluded—Georgia, Virginia, and North Carolina.

DCE, discrete choice experiment; HTP, heated tobacco product.

tobacco, menthol or non-flavoured had no significant preference for cigarettes over HTPs (perhaps because both cigarettes and HTPs offer the same tobacco and menthol flavours these primarily open-system e-cigarette users were already primarily using).

Because mild differences were found between daily and weekly users of e-cigarettes, [table 5B](#) reported the results of models stratified by different smoking practices (ie, those who were never vs former, weekly and daily smokers). Overall, never or less frequent use of cigarettes was associated with greater preferences for e-cigarettes over cigarettes, cigarettes over HTPs, and non-TM flavours or menthol over tobacco flavour or non-flavoured, and the more sensitive they were to price changes. While not statistically significant, only never-smoker e-cigarette users preferred a low nicotine level to regular nicotine level, with former smokers having the strongest preference for regular nicotine level.

[Table 5C](#) reports the results of models stratified by the region of residence. Responses of participants from the HTP-sale region differed from participants from the other four regions. First, participants from the HTP-sale region did not prefer cigarettes over HTPs while participants from the other four regions preferred cigarettes markedly compared with HTPs, and participants from the HTP-sale region also had a slightly higher preference for e-cigarettes compared with other regions. Second, different from other regions, participants from the HTP-sale region had no significant difference in preferences based on flavours.

DISCUSSION

We found e-cigarette users have a strong preference for e-cigarettes compared with other product types, and the preference difference among products/devices is larger than the difference between flavours and between nicotine levels. This indicates that people are unlikely to switch to another product/device because of the restriction of flavour or nicotine levels, rather they may switch to another flavour for the sake of the product and device. HTPs, as a relatively new product, were less preferred compared with both cigarettes and e-cigarettes in general. However, participants living in states where IQOS is being sold had similar preferences to cigarettes and HTPs. This indicates that although HTPs are still new to the US market, they are likely to be accepted in places of or near their test markets. Further study is needed to determine whether smokers who do not or will not use e-cigarettes could still be prompted to use an HTP, instead.

Additionally, people who primarily used open-system e-cigarettes preferred open-system e-cigarettes much more than closed-system e-cigarettes while people who primarily used closed-system e-cigarettes preferred similarly for the two devices. This indicates that it is relatively easier for people to switch from closed-system to open-system e-cigarettes than to switch from open-system to closed-system e-cigarettes. This is consistent with a previous finding that less experienced e-cigarette users preferred disposable devices and experienced e-cigarette users preferred ‘modifiable’ and advanced devices.^{8 45} Compared with closed-system e-cigarettes, open-system e-cigarettes allow the users to manipulate the device and to customise flavour recipes. Additionally, the preference of the group who primarily used open-system e-cigarettes and non-TM flavours was different from the other groups (eg, highly sensitive to price change). Future intervention may leverage on this finding.

Regarding flavours, the findings indicate that among e-cigarette users who smoke or are former smokers, there is little preference difference for menthol or non-TM flavours compared with tobacco flavour, but non-TM flavours are much more appealing than menthol or tobacco among never-smoker e-cigarette users. These findings were consistent with prior DCEs^{30 33} and empirical⁴⁵ studies. The comparison between the results from our two DCEs indicated that when non-TM flavours are banned, users of the banned flavour e-cigarettes tend to switch to menthol flavour e-cigarettes rather than quit or increase their smoking. Similarly, a broader ban of both non-TM and menthol flavours would likely prompt most users of the banned flavours to switch to tobacco flavour rather than quit or switch. Never-smoker users might be prompted to quit all use as they could no longer get their much more strongly preferred non-TM flavour or menthol—especially if cigarettes or cigars with menthol or non-TM flavours were no longer legally available—but some might switch to non-flavoured e-cigarettes. Our finding that the difference in preferences in e-cigarette device is larger than the difference across flavours is contrary to a prior DCE study²⁹ that found flavour is more important than the device in decisions to use e-cigarettes among youth. Further investigation is warranted to determine whether this inconsistency is due to the different study populations (ie, adults vs youth) in the two studies.

Using two DCEs, our results on the preference difference under different policy scenarios are more reliable than previous studies that used one DCE to predict the difference among multiple policies.^{32 34} When there was only one DCE, one way is to manipulate the coefficients (ie, by setting the share of the banned option to zero and rescaling the shares of other options) and another way is to use a subset of the choice set data (ie, by removing the choice sets that included the banned option). However, for DCEs that were fractional factorial designed, the first way may not meet the independence of irrelevant alternatives assumption inherent in DCE design, and the second way is unlikely to be suitable for the orthogonal and balanced fractional factorial design that was implemented in the original DCE.

Our research has several limitations. First, as a method to elicit ‘stated’ rather than ‘revealed’ preferences, a DCE is vulnerable to self-report bias, and the bias may be more significant among people who have no experience with certain products or attributes (eg, those who have never smoked or used HTPs). Second, our DCEs may oversimplify related characteristics. We did not examine products such as cigars and the influence of brands. We assume an independent relationship between products and their attributes although the same flavour could be experienced differently using different products/devices and the nicotine levels may not be directly comparable between different products. Third, the generalisability of our findings may be limited by our convenience sample. Compared with a nationally representative flavoured e-cigarette users from the 2018 Tobacco Use Supplement to the Current Population Survey data,⁴⁶ our participants were similar in age and gender, but with higher proportions of Blacks, people with high educational attainment and moderate household income. Our participants had similar vaping frequency, and the distribution of flavours used, but had lower proportions of former and never smokers than the nationally representative sample. Fourth, our findings may have been impacted by the COVID-19 pandemic.

Nevertheless, our findings provide evidence to inform tobacco regulation, particularly for FDA’s PMTA orders and

state and local governments' policy on flavour restrictions and taxes. The findings relating to consumers' relative preferences for different products/devices and product attributes, as well as the substitutability between products and the trade-off between different attributes, may be valuable to best balance the potential benefits and harms of various tobacco/nicotine products. The findings might be relevant to the development of the new European Union directive on tobacco control and possible new restrictions on flavours. More broadly, what FDA does will provide a respected, research-based model for the rest of the world to consider given that the FDA is the largest, most broadly empowered science-based government tobacco regulatory entity with a public health mandate.

What this paper adds

- ▶ E-cigarette users preferred non-tobacco and non-menthol flavours most, preferred open-system over closed-system e-cigarettes and preferred regular nicotine level over low nicotine level.
- ▶ E-cigarette users are unlikely to switch to another product/device because of the restriction of flavour or nicotine level, as our finding indicated that for e-cigarette users the differences in preference among products/devices were larger than the differences among flavours or nicotine levels.
- ▶ If non-tobacco and non-menthol flavours were banned from open-system e-cigarettes, people who primarily used these flavours and open-system e-cigarettes may switch to menthol flavour and keep using open-system e-cigarettes.
- ▶ Heated tobacco product (HTP) was the least preferred product, much lower than cigarettes in general, but participants living in states where IQOS is being sold had similar preferences to cigarettes and HTPs.

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