

# **Should flavors be banned in cigarettes and e-cigarettes? Evidence on adult smokers and recent quitters from a discrete choice experiment**

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## **Word Count:**

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## **WHAT THIS PAPER ADDS**

### **Section 1. What is already known from the literature**

- Menthol cigarettes are appealing to some smokers; and flavors are a key aspect of the appeal of e-cigarettes.
- Banning menthol in cigarettes is likely to reduce smoking rates. Banning characterizing flavors in cigarettes has reduced adolescent smoking; banning characterizing flavors in e-cigarettes has limited impact on adult smokers' cigarette and e-cigarette choices.
- Almost 40% of smokers are dual or poly users. Evidence suggests smokers may substitute between tobacco products following relative price changes. However, with one exception, the substitutability between product types following alternative flavor bans has not been investigated in the literature.

### **Section 2. What this study adds**

- We study preferences of current adult smokers and recent quitters for flavors in cigarettes and e-cigarettes and make predictions on the use of both products for a range of alternative flavor bans.
- Our results indicate possible substitution between cigarettes and e-cigarettes as flavor availability varies.
- Our findings suggest that banning menthol in cigarettes while allowing flavors in e-cigarettes is likely to produce the greatest reduction in cigarettes smoking. However, banning flavors in both product types is likely to have the greatest reduction on overall use of cigarettes and e-cigarettes.

## **ABSTRACT**

**Objectives:** To provide policy-relevant estimates of impacts of alternative flavor bans on preferences and demand for cigarettes and e-cigarettes in adult smokers and recent quitters.

**Methods:** A best-best discrete choice experiment is used to elicit smokers' and recent quitters' preferences for flavors, price, health impact, and nicotine level in cigarettes and e-cigarettes. Choice of tobacco products and an opt-out option were examined. An efficient design yielded 36 choice sets. Exploded logit choice models were estimated. Flavor bans are modelled by restricting flavor coefficients in the estimated model.

**Setting and participants:** A sample of 2,031 adult smokers and recent quitters was recruited to complete an online survey and DCE.

**Results:** Current smokers and recent quitters, on average, prefer cigarettes and menthol cigarettes over flavored e-cigarettes. However, there is substantial preference heterogeneity by younger adults (ages 18-25), race/ethnicity and respondents with higher education. Our predictions suggest that a ban on menthol cigarettes would produce the greatest reduction in the choice of cigarettes (-5.2%), but with an accompanying increase in e-cigarettes use (3.8%). In contrast, banning flavors in e-cigarettes, while allowing menthol in cigarettes would result in the greatest increase in the selection of cigarettes (8.3%), and a decline in the use of e-cigarettes (-11.1%). A ban on all flavors but tobacco in both products would increase 'opting-out' the most (5.2%) but would also increase choice of cigarettes (2.7%) and decrease choice of e-cigarettes (-7.9%).

**Conclusions:** A ban on flavored e-cigarettes alone would likely increase the choice of cigarettes in smokers, arguably the more harmful way of obtaining nicotine, whereas a ban on menthol cigarettes alone would likely be more effective in reducing the choice of cigarettes. A ban on all flavors in both products would likely reduce the smoking/vaping rates, but the use of cigarettes

would be higher than in the status quo. Policymakers should use these results to guide the choice of flavor bans in light of their stance on the potential health impacts both products.

## INTRODUCTION

Currently in the U.S., e-cigarettes are available in over 7,000 flavors,<sup>1</sup> but all characterizing flavors except menthol are banned in cigarettes. E-cigarettes are increasingly popular in the U.S., but are largely unregulated. This is in contrast to cigarettes, which have become less popular over time, but are highly regulated by the U.S. government. Although e-cigarettes are considered to be less harmful than cigarettes, there are concerns that they may lead to initiation of e-cigarettes, in particular by those who had not used nicotine products in the past.<sup>2</sup> The introduction of e-cigarettes has led to use of multiple products estimated to be 38.8% of adult tobacco users. Among those, 23% are dual cigarettes/e-cigarettes users, the most common combination.<sup>3</sup> Research shows that almost three quarters of young adults initiating e-cigarettes use a flavored product.<sup>4</sup>

This growth in e-cigarettes use has led to concern over their impact on the health of the public and interest in regulating them. Some cities and counties have already implemented bans on the sale of flavored cigarettes and e-cigarettes. At the national level, the Center for Tobacco Products (CTP) of the Food and Drug Administration (FDA) is considering banning flavors in tobacco products.<sup>5</sup> However, flavor regulation is complicated due to the potential substitutability or complementarity of products as a function of flavors as well as varying views on the extent to which e-cigarettes are less harmful than cigarettes.<sup>6-9</sup> Flavors appeal to some consumers.<sup>10-12</sup> That there are stark differences in the availability of flavors across products complicates predictions about the potential impacts of alternative flavors bans on public health. With the exception of Kenkel et al.,<sup>13</sup> who found limited switching due to a flavor ban in e-cigarettes, empirical evidence is lacking on e-cigarettes. Studies examining menthol cigarette bans<sup>14-19</sup> found evidence of a reduction in smoking in the long-run,<sup>16</sup> while Kotlyar et al.<sup>17</sup> found that African-American smokers would likely switch to non-menthol products instead of quitting. Other studies found that banning

flavors in cigarettes reduced adolescent cigarette use;<sup>18</sup> one study found a reduction of youth and young adults' self-reported use of both cigarettes and e-cigarettes if all flavors were banned in all tobacco products.<sup>19</sup>

In this study, we provide policy-relevant predictions of the impact of flavor bans on the choice of cigarettes and e-cigarettes. Specifically, we estimate the impact on product choices of a set of flavor bans that could be implemented by the FDA. We use an online discrete choice experiment (DCE) on 2,031 U.S. smokers (i.e. smoked at least 100 cigarettes in their lifetime) and recent quitters (i.e. quit smoking in the last 12 months) ages 18 to 64; the sampling was matched to a national smoking survey. We estimate preferences for flavors in cigarettes and e-cigarettes while controlling for other attributes of both products, and study how these preferences vary with individual characteristics. We then predict the demand for cigarettes and e-cigarettes under alternative policies banning flavors and discuss which flavor policy bans would be optimal under alternative criteria for protecting public health.

In contrast to most of the literature on flavor bans, we examine their impact on both cigarettes and e-cigarettes. That is, we focus on how product-specific flavors and their bans affect the complementarity and substitutability of choices across products. We also add to the tobacco literature that uses experimental approaches to examine substitutability across tobacco products<sup>20-21</sup>. For example, previous studies used auction-based experiments online,<sup>22</sup> in the field<sup>21,23-24</sup> or in person,<sup>25-26</sup> and purchasing tasks online.<sup>27-28</sup> They find evidence of a significant substitutability as a function of price,<sup>28</sup> as a function of the frequency of use of similar products,<sup>22</sup> and the level of nicotine.<sup>23</sup> Several papers have used their online Experimental Tobacco Market Place (EMP) to study substitutability<sup>22,29</sup> and have found substitutability between cigarettes and e-cigarettes as price varies.

In sum, our DCE approach allows us to predict the impact of alternative policies that are not currently in place and to focus on substitutability driven by flavor bans. In addition, our large, up-to-date, data set of current and former smokers, matched to a national survey, allows us to estimate the heterogeneity in impact of these bans across smoking status and individual characteristics.

## **METHODS**

A discrete choice experiment (DCE) is a survey-based experimental approach aimed at eliciting individual preferences for goods and services.<sup>30</sup> In a DCE, respondents make a series of choices across products described using a set of attributes and levels. The relative importance of each attribute and the value of alternative options can be derived from the choices, using choice models. The approach has been extensively applied in health policy and public health research,<sup>31</sup> in tobacco research,<sup>32</sup> and e-cigarettes.<sup>33-35</sup> A strength of DCE is that it allows examination of the likely impact of alternative policies that are not currently in-place.

In this study, we aim to estimate the causal effect of flavors and other attributes on the choice of cigarettes and e-cigarettes, and then to predict the impact of flavored-cigarette ban alternatives.<sup>30</sup> In this DCE, respondents choose their preferred option from a set of four products described by four attributes: flavor, health impact, amount of nicotine, and price. See Table 1; Fig. 1.

In this best-best DCE,<sup>36</sup> respondents were asked to respond to scenarios by choosing their two favorite options among cigarettes, e-cigarettes and “none of these” (“none” hereafter). Note that the “none” option appears twice to allow respondents to opt-out of both their first and second choice. Because the choice options are specific products, this is a ‘labeled’ experiment, which is beneficial for realism.<sup>37</sup> We used a D-efficient survey design which generated 36 different choice sets.<sup>38</sup> To reduce response burden, respondents were randomized to one of three blocks of 12

Table 1: Experimental design: attributes and levels that were varied throughout the choice scenarios

	E-cigarette	Combustible cigarette
Flavor	Plain tobacco Menthol Fruit Sweet	Plain tobacco Menthol
Life years lost by average user	10 5 2 Unknown	10
Level of nicotine	High Medium Low None	High Medium Low
Price	\$4.99 \$7.99 \$10.99 \$13.99	\$4.99 \$7.99 \$10.99 \$13.99



Fig. 1: Example Choice Scenario

Option 1: Tobacco Cigarette	Option 2: Tobacco Cigarette
 <ul style="list-style-type: none"> <li>• Flavor: <b>Tobacco</b></li> <li>• Nicotine level: <b>High</b></li> <li>• Die earlier: <b>10 years</b></li> </ul>	 <ul style="list-style-type: none"> <li>• Flavor: <b>Tobacco</b></li> <li>• Nicotine level: <b>Low</b></li> <li>• Die earlier: <b>10 years</b></li> </ul>
\$13.99	\$7.99
Option 3: E-cigarette	Option 4: E-cigarette
 <ul style="list-style-type: none"> <li>• Flavor: <b>Menthol</b></li> <li>• Nicotine level: <b>High</b></li> <li>• Die earlier: <b>5 Years</b></li> </ul>	 <ul style="list-style-type: none"> <li>• Flavor: <b>Fruit</b></li> <li>• Nicotine level: <b>Medium</b></li> <li>• Die earlier: <b>2 years</b></li> </ul>
\$13.99	\$10.99

First preference

Second preference

☐

Option 1: Tobacco Cigarette

☐
☒

Option 2: Tobacco Cigarette

☐
☐

Option 3: E-cigarette

☐
☐

Option 4: E-cigarette

☒
☐

None of these

☐
☐

None of these

☐

choices, each had different sets of scenarios seen in a different order. Kruskal-Wallis tests indicated the randomization was applied correctly.

The specific flavors were chosen to reflect currently available flavored products in the U.S.: tobacco and menthol for cigarettes; and tobacco, menthol, fruit, and sweet for e-cigarettes. The overwhelming majority of the many e-cigarette flavors can be classified as menthol, fruit, or sweet.<sup>11,39-40</sup> Note that tobacco is the underlying flavor for all cigarettes but must be added to e-cigarettes. In the paper, when we refer to flavors we are referring to all but tobacco.

Health risk was expressed as years of life lost by an average user. For cigarettes, this was 10 to reflect the known harm.<sup>41</sup> For e-cigarettes, the four levels are: 2, 5, 10 and unknown; these reflected the likely lower health risk of e-cigarettes and the uncertainty surrounding true health effects.<sup>42</sup> The levels of nicotine were low, medium, and high for both products. A level of “none” was provided for e-cigarettes as nicotine-free options are available. We did not use quantitative levels of nicotine (e.g. in mg) as this was confusing to respondents. The qualitative levels used convey sufficient, ordered information. Finally, we defined price as the price paid for 20 cigarettes or the equivalent volume of e-cigarettes (using a conversion ratio of 1 disposable cigarette/1 e-cigarette refill to 30 cigarettes).<sup>43</sup> We used this to make the prices of cigarettes realistic and the comparisons meaningful. Levels are based on market prices.<sup>44</sup> The prices are displayed in Table 1. Note the design accounts for the imbalance in the definition of attributes.<sup>45</sup> A survey was administered to collect socioeconomic data and smoking behavior information on each respondent.

We took steps to increase the quality of the choice data collected. Prior to the DCE, detailed narrative and visual information describing the products (cigarettes or e-cigarettes) and their features were provided (see Appendix D for details). A sample experiment task was provided

giving respondents practice in responding. We also used “forced responses” to prevent respondents from skipping through the survey. And we used a minimum time threshold to remove respondents who rushed through. Finally, we used attention filters embedded in the survey to check that respondents were paying attention (e.g. “select option two to show that you are paying attention”).

## **Participants**

We recruited a sample of 2,031 adult smokers and recent quitters online using the survey firm Qualtrics. To be eligible, current smokers and recent quitters had to have smoked at least 100 cigarettes in their lifetime and had to be U.S. residents between ages 18 and 64. Our sample-size is large relative to other choice experiments in health, and it is in excess of minimum sample size calculations.<sup>46</sup> Respondents were matched to proportions of smokers in regional/demographic quotas using data from the 2014 Behavioral Risk Factor Surveillance System (BRFSS) based on six regions, gender, and age bands. Details are provided in Appendix A.

## **Analysis**

We used exploded multinomial logit models to analyze respondents’ choices. Each of the 2,031 individuals made 2 choices in 12 choice scenarios. Thus, there were 48,744 choices from 24,372 observations. We specified our initial model to be a function of product-specific terms and attributes. To align our model with the FDA’s policy options, we impose two features on the model. First, we combined fruit and sweet flavors into a single group as they are commonly considered jointly.<sup>34-35</sup> Second, by interacting the “*product constant-terms*” with each of the

flavors we were able to examine the product-flavor pairings directly. We referred to these combinations as “*flavored-product constant-terms*.” Use of both of these improved the fit of the model. We are primarily interested in the estimates of the flavored-product constant-terms: menthol cigarette, tobacco e-cigarette, menthol e-cigarette and fruit/sweet e-cigarette. Each of these constants represents the preference for each flavored-product relative to a tobacco cigarette (the reference case) at the sample level. See Appendix B for the model specification.

We then interacted these flavored-product constant-terms with sociodemographic variables that were collected in the survey. This allowed us to estimate heterogeneity by smoking status and socio-economic and demographic characteristics, which increases the realism of our predictions. Attributes were dummy-coded with the exception of price which was treated as a continuous variable. We believe that dummy-coding is a better approach compared to effects-coding as the interpretation of the reference category is clearer.<sup>47</sup> We used the resulting model to make the predictions of the impacts of the set of policies. All analyses were conducted using Nlogit ® (version 6.0).

## **Policy Predictions**

The estimated choice models were used to predict what percentage of the sample chose each product type and the option of none. Using the estimated utilities from the choice model, we estimated the probability that each product would be chosen by each individual in each choice scenario<sup>48</sup>. These are called *choice probabilities* and they sum to 1 across all options, in each choice scenario. The sample-average choice probability for each product is the model’s prediction of how many individuals will choose that product. These are called *choice shares* which are estimated using our models. When making our predictions, we model regulation alternatives by restricting

flavors and recalculating the choice shares. The differences between the base and the revised choice shares across policy options are the model's prediction of the FDA policies.

We first predicted choices under the status quo and then imposed the set of policy scenarios (Table 2) to predict the smoking choices under the alternative bans. Alternative 1 reflects a comprehensive ban on all flavors. Alternative 2 reflects a policy where only menthol would be allowed for both products. The other scenarios reflect a ban on menthol cigarettes only (Alternative 3), often considered as a policy option; a ban on menthol in both cigarettes and e-cigarettes (Alternative 4) as is the case in Canada; and a flavor ban specific to e-cigarettes with a status-quo for cigarettes (Alternative 5). For instance, to analyze a ban on all e-cigarette flavors but not on tobacco ("Alternative 5" in Table 2), we set the coefficients on flavors in e-cigarettes to zero and use the estimated model to obtain revised choice probabilities, which yield shifts in choices. These shifts reveal the potential impact of each policy.

## **RESULTS**

### **Model Estimates**

Table 3 shows the results from the choice models. Panel A displays the coefficients for flavored-products and "none" as well as for the attribute levels: price, nicotine, and health. The flavored-product coefficients are measures of the preferences for the product-flavor pairs relative to the omitted tobacco cigarette. On average, cigarettes are preferred to e-cigarettes; that is, all the e-cigarette constant-terms are negative and significant. And, menthol cigarettes are preferred to the three flavored e-cigarettes. Also, adult smokers prefer, from most to least: tobacco, fruit/sweet, and menthol e-cigarette flavors. Findings also indicate that adult smokers prefer: lower prices, healthier outcomes, (relative to 10 years of life lost, the reference category) and a medium level of nicotine (which is the reference category).

Table 2: Potential flavor bans policy options\*\*

<u>Policy</u>	Flavors by Product			
	Cigarettes (cig)		E-cigarettes (ecig)	
	Menthol	Fruit/sweet	Menthol	Fruit/sweet
Current US Policy: ban fruit/sweet in cig	Allowed	Banned	Allowed	Allowed
Alternative 1: ban all flavors	Ban	Ban	Ban	Ban
Alternative 2: only allow menthol ecig	Ban	Ban	Allow	Ban
Alternative 3: ban all cig flavors	Ban	Ban	Allow	Allow
Alternative 4: only allow fruit/sweet ecig	Ban	Ban	Ban	Allow
Alternative 5: ban all ecig flavors	Allow	Ban	Ban	Ban

\*\* We focus on menthol and sweet/fruit bans as cigarettes are tobacco-flavored and as the policy focus has been primarily on these flavors.

Panel B presents the full set of interaction terms. As above, the reference category is a tobacco cigarette. There is substantial preference heterogeneity across individuals' characteristics. Specifically, younger adult smokers prefer menthol cigarettes and all flavored (including tobacco) e-cigarettes. Older adult smokers prefer tobacco cigarettes. African Americans, those with higher education, and those who report low health prefer menthol cigarettes. Those with higher education also prefer e-cigarettes of all flavors.

There is further heterogeneity in preferences by smoking status. Those with one or more quit attempts in the past year prefer e-cigarettes of all flavors. Unsurprisingly, both dual users and vapers (those using only e-cigarettes) show very strong preferences for all e-cigarettes. Further, vapers prefer e-cigarettes to cigarettes. Specifically, the coefficient for the interactions of vaper and tobacco e-cigarette is positive and greater in absolute magnitude than the negative constant-term for tobacco e-cigarettes. Thus, all else equal, vapers prefer tobacco e-cigarettes to tobacco cigarettes (though insignificantly). Also, vapers prefer fruit/sweet e-cigarettes to tobacco cigarettes, but not to menthol e-cigarettes. Last, recent quitters have a strong aversion to menthol cigarettes.

### **Testing and Robustness**

A number of formal tests are applied to assess the sensitivity of the results. Broadly, these include: tests of the model structure by comparing the reported estimates to those obtained from a mixed logit (that relaxes the independence from irrelevant alternative (IIA) assumption<sup>48</sup> of the multinomial logit (MNL); tests of the utility function specification; and validity checks. In all cases, test results support the findings in the tables. As an informal validity test we note that our findings are similar to those in the literature: young adults prefer non-tobacco flavors<sup>34-36,49-52</sup> and older adults prefer tobacco flavor;<sup>19,36,39</sup> African Americans' prefer menthol;<sup>52-53</sup> those with higher education prefer e-cigarettes;<sup>49,51</sup> and quit attempters and dual users prefer e-cigarettes.<sup>44,55-57</sup> Details are presented in Appendix C.

Table 3: Flavored product choice models

Panel A				
	Cigarette choice model		Cigarette choice model with interactions	
<u>Parameters</u>	Coef. (s.e.)	Sig.	Coef. (s.e.)	Sig
Constant: menthol combustible cigarette	-0.38 (0.035)	**	PANEL (b)	
Constant: tobacco e-cigarette	-0.55 (0.037)	**	PANEL (b)	
Constant: menthol e-cigarette	-0.88 (0.058)	**	PANEL (b)	
Constant: fruit/sweet e-cigarette	-0.71 (0.040)	**	PANEL (b)	
Constant: none of these	-1.87 (0.049)	**	-1.93 (0.052)	**
Price	-0.08 (0.002)	**	-0.08 (0.003)	**
Nicotine: none	-0.15 (0.024)	**	-0.15 (0.026)	**
Nicotine: low	-0.04 (0.019)		-0.04 (0.019)	
Nicotine: high	-0.06 (0.015)	**	-0.06 (0.015)	**
Health: unknown	0.30 (0.033)	**	0.31 (0.032)	**
Health: 2 life years lost	0.37 (0.036)	**	0.38 (0.036)	**
Health: 5 life years lost	0.18 (0.027)	**	0.19 (0.028)	**
<u>Diagnostic information</u>				
K	12		72	
Observations	24,372		24,372	
LL (constants only)	-79549.34		-79549.34	
LL (fitted model)	-78188.91		-75969.00	



Panel B	Menthol combustible cigarette		Tobacco e-cigarette		Menthol e-cigarette		Fruit/sweet e-cigarette	
	Coef. (s.e.)	Sig.	Coef. (s.e.)	Sig.	Coef. (s.e.)	Sig.	Coef. (s.e.)	Sig.
Constant for each flavored cigarette	-0.76 (0.106)	**	-1.12 (0.087)	**	-1.72 (0.133)	**	-1.48 (0.101)	**
Younger adult (<25)	0.37 (0.112)	**	0.26 (0.099)	**	0.41 (0.139)	**	0.61 (0.109)	**
Older adult (>54)	-0.52 (0.109)	**	-0.20 (0.086)	*	-0.19 (0.129)		-0.62 (0.107)	**
Female	0.14 (0.078)		0.05 (0.065)		-0.08 (0.094)		-0.02 (0.076)	
African American	0.52 (0.110)	**	0.09 (0.117)		0.61 (0.147)	**	0.31 (0.119)	*
Asian	0.22 (0.214)		0.36 (0.210)		0.46 (0.261)		0.43 (0.222)	
Hispanic	-0.02 (0.132)		-0.04 (0.116)		0.18 (0.162)		-0.03 (0.131)	
Other	0.12 (0.252)		-0.17 (0.208)		-0.28 (0.275)		-0.39 (0.242)	
Higher education	0.21 (0.084)	*	0.14 (0.070)	*	0.25 (0.098)	*	0.24 (0.081)	**
High income	0.14 (0.085)		0.07 (0.070)		0.07 (0.102)		0.08 (0.084)	
Household >2	0.19 (0.081)	*	0.18 (0.068)	**	0.33 (0.098)	**	0.27 (0.079)	**
Low SR health	0.21 (0.080)	**	-0.02 (0.071)		0.09 (0.100)		-0.02 (0.080)	
Quit attempts	0.00 (0.079)		0.16 (0.069)	*	0.19 (0.099)		0.19 (0.079)	*
Use both combustible and e-cigarettes (dual user)	0.16 (0.084)		0.59 (0.069)	**	0.65 (0.101)	**	0.83 (0.081)	**
Use only e-cigarettes (vaper)	-0.10 (0.171)		1.22 (0.145)	**	1.63 (0.183)	**	1.69 (0.156)	**
Recent quitter	-0.59 (0.150)	**	0.13 (0.120)		0.18 (0.175)		0.19 (0.144)	

*Notes:* Dependent variable: product choice. Reference (omitted) product: tobacco cigarette. Panel A shows the basic exploded logit model with no interactions and the base coefficients for the fully interacted model. It also displays diagnostic information on the number of parameters (K), observations and log-likelihood (LL) values of the constants only (i.e. market share) model and the respective fitted models. Panel B shows the flavored product constant-terms' interactions with sociodemographic and smoking status variables. Coef. denotes the coefficient estimates; s.e. denotes standard errors, clustered at the individual level, in parentheses. Sig. – significance: \*\*p<0.01, \*p<0.05. Reference categories: age: 25-54; gender: male; race: white; ethnicity: non-Hispanic; education: lower education; income: low income (<\$55,000); household size: <3; Low SR health: medium or high SR health; Quit attempts: no quit attempts in the past year; smoker categories: smoker of cigarettes (only).

## Policy Predictions

Table 4 displays the predicted choice shares across the set of flavor bans for sample averages. Each panel displays the following: Panel A repeats the description of the set of bans from Table 2; Panel B provides the predictions of the impact of bans on choice shares; and Panel C provides the percentage changes in the choice shares comparing the current policy to each of the alternative bans (calculated from Panel B). Each row relates to one of the potential policies described. As seen in the first row of panel B of Table 5, the predicted choice shares under the set of current flavor bans are: 45.2% for cigarettes, 37.5% for e-cigarettes, and 17.2% for “none.” This compares to 51% of cigarettes-only users, 31% of dual-users and 7% of e-cigarettes-only users in our sample (see Appendix A), suggesting that a portion of the predicted share of e-cigarettes reflects dual users’ preferences.

Results show that policymakers seeking to minimize the use of cigarettes should ban only menthol in cigarettes (policy Alternative 3). This results in the lowest choice of cigarettes which, at 40.0%, represents a 5.2% reduction in the percentage of cigarette choices (Panel C). Of this reduction, the majority goes to e-cigarettes at 3.8%, with the remaining going to “none” at 1.6%.

Under alternative 1, the use of both products is minimized leading to the highest choice of “none” at 22.4%. In this case, e-cigarette choice declines by 7.9% and instead, people increase their choice of cigarettes by 2.7% and “none” by 5.2%. See in Panel C.

Importantly, a ban on all e-cigarette flavors but tobacco is an inferior option for either of the above goals, as Alternative 5 indicates. Although this comprehensive ban would result in the largest reduction in selecting either product, selection of cigarettes would increase from 45.2% to 53.5%. Unfortunately, 8.3% would change from e-cigarettes to cigarettes and only around 3.0% would change from e-cigarette to “none.” Thus, this policy would likely drive current e-cigarette

users toward vaping or smoking more than toward abstinence. However, as above, part of the change from e-cigarettes to cigarettes might be more people becoming dual users instead of an increase in cigarettes-only use.

## **DISCUSSION**

### **Findings and Policy Implications**

These results indicate that flavors of cigarettes and e-cigarettes drive choices across products and opting-out (i.e. selecting neither). Consequently, flavor bans drive the choice of product. These findings are derived from a discrete choice experiment that generates the choice data used to estimate preferences which are in turn used to make the predictions. Results from the choice models indicate the following on average for our sample. Adult smokers and recent quitters prefer cigarettes to e-cigarettes, which is in keeping with national smoking statistics.<sup>3</sup> Further, they tend to prefer tobacco to sweet, fruit and menthol flavors. However, there is substantial heterogeneity in flavor preferences, with some individuals preferring flavors. These results, including the estimated heterogeneity, are used to predict the impact of alternative bans. The patterns of preferences that we found are also found in the wider literature.<sup>11,13,34,40,58-59</sup>

Policymakers can use these predictions to inform the selection of optimal flavor-bans based on their policy goals. Such goals will likely depend on the policymakers' view of the relative impact on health of both products. We posit two likely goals, to: 1) minimize the selection of cigarettes, arguably the most harmful to health, and 2) maximize the choice of abstaining, which we proxy with the opt-out option (i.e. "none"). Our predictions suggest that banning all flavors in e-cigarettes

Table 4: Policy predictions of product choice shares and percentage changes in product choice shares across alternative flavors

Policy	Panel A				Panel B			Panel C		
	Permitted flavors by product				Product choice shares (%)			Change in choice shares (%)		
	Combustible Cigarettes		E-cigarettes							
	Menthol	Fruit/sweet	Menthol	Fruit/sweet	Combustible Cigarette	E-cigarette	None of these	Combustible Cigarette	E-cigarette	None of these
Current US policy	Allowed	Banned	Allowed	Allowed	45.2	37.5	17.2	n/a	n/a	n/a
Alternative 1 <sup>b</sup>	Ban	Ban	Ban	Ban	47.9	29.6	22.4	2.7	-7.9	5.2
Alternative 2	Allow	Ban	Allow	Ban	45.8	32.8	21.4	0.6	-4.7	4.2
Alternative 3 <sup>a</sup>	Ban	Ban	Allow	Allow	40.0	41.3	18.8	-5.2	3.8	1.6
Alternative 4	Ban	Ban	Ban	Allow	41.7	38.8	19.4	-3.5	1.3	2.2
Alternative 5	Allow	Ban	Ban	Ban	53.5	26.4	20.2	8.3	-11.1	3

*Notes:* Each row corresponds to a policy scenario; these are defined also in Table 1. Panel A, “Permitted flavors by product”, shows the availability of menthol and fruit/sweet flavors for cigarettes and e-cigarettes: “Allowed” or “Allow” shows when the flavor is permitted, “Banned” or “Ban” shows when the flavor is banned. Panel B, “Product choice shares”, shows the percentage of predicted choices for each product. Panel C, “Change in choice shares”, shows the percentage change in predicted choices from the current US policy to the policy scenario, which is the difference between the current policy and the predicted policy share(s). <sup>a</sup> denotes the policy with the largest predicted reduction in cigarette choice; <sup>b</sup> denotes the policy with the largest increase in the “None of these” option. There may be error from rounding in the estimates. See methods for calculation of the choice shares.

except tobacco, while allowing menthol in cigarettes, would result in the greatest increase in the selection of cigarettes but a decline in the use of e-cigarettes. By comparison, a ban only on menthol cigarettes would produce the greatest reduction in the use of cigarettes, and much of this movement from cigarettes would be to e-cigarettes with a smaller percentage opting-out (i.e. selecting “none”). Thus, it is likely that a menthol ban on cigarettes would most improve public health given that cigarettes impose the most significant harms. A ban on non-tobacco flavors in both products would increase the choice of opting-out (“none”) the most but would also increase the use of cigarettes and reduce the choice of e-cigarettes by a relatively large amount. These predictions highlight the importance of simultaneously considering the impact of flavor bans in both cigarette types on cigarettes, e-cigarettes, and choosing none of the products. Our results add to the quite limited literature on FDA flavor bans predictions.<sup>13</sup>

### **Strengths and Limitations**

A key strength of this study is that it makes needed, policy-relevant, predictions about a set of potential flavor bans. We are the only study that we know of that examines alternative bans in the U.S. in both cigarettes and e-cigarettes and the impact of these on the choice of both products and opting-out (“none”). Further, we use the DCE approach which is one of the few approaches that allows for rigorous and quantitative examination of the set of counterfactual flavor ban policies in advance of setting such policies. Also, we collected a large, and national data set of current and former adult smokers which was matched to a national survey. Our models allow for rich heterogeneity in preferences which adds precision to our predictions. In addition, we have conducted our experiment in line with best practices<sup>60</sup> and have applied a broad range of robustness

checks and sensitivity analyses that support our findings. Combining these, we are thus able to make realistic quantitative estimates of the impact of alternative flavors bans across both cigarettes and e-cigarettes for the U.S.

Despite the above strengths, our study has several limitations. First, there is a risk of hypothetical bias in all DCEs,<sup>61</sup> but we help address this by analyzing current and recent smokers who frequently make such real-world decisions.<sup>62-63</sup> Other studies have shown comparability between experimental and real-world behaviors for tobacco.<sup>64-65</sup> Second, the meaning of the “none” option is somewhat ambiguous. While it may reflect a willingness to quit smoking in a given scenario, it may also reflect that the respondent would not choose any of the given options but might use other products. Third, the study does not examine the use of other tobacco products, such as pipe tobacco or hookah. Fourth, we do not observe whether smokers alter their consumption quantity depending on the product selected; for example, in changing to e-cigarettes, smokers may decide to smoke more or less heavily. Fifth, we use generic products instead of brands in the choice sets. The use of brands might have made the tasks more realistic, although using a specific brand can in itself introduce bias. Sixth, our efficient design mitigated attribute imbalance, but did not necessarily fully balance the attributes because of restrictions we imposed; we prioritized the realism of the choice scenarios over the balance of the design to uphold the quality of the data. Last, youth smoking decisions should be examined separately, but is beyond the scope of this study. However, with 36.5 million adult smokers in the U.S., our results are critical for informing policy.

## **CONCLUSIONS**

The predictions of this study are timely, given that the FDA has been actively considering flavor bans in tobacco products.<sup>5</sup> Interest by the FDA is part of a broader movement toward

adopting flavor bans; bans on sales of flavored tobacco products have been imposed at county and municipal levels within the US, and bans on menthol cigarettes have been announced or implemented by the EU, Canada and other countries.<sup>66-67</sup>

Our results have important policy implications for selection of flavor bans in the US. We conclude that flavor bans can be effective levers to affect smokers' choices. Alternative flavor bans can either enhance the protection of the health of the public or worsen it, by driving smokers to alternative products or to abstaining.<sup>68-70</sup> These results have some perhaps surprising implications that could prove valuable to lawmakers and regulators in crafting the best policies for public health.

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