Tob Control. Author manuscript; available in PMC 2019 November 28.

Should flavors be banned in combustible and electronic cigarettes? Evidence on adult smokers and recent quitters from a discrete choice experiment

John Buckell, PhD[1], **Joachim Marti, PhD**[2], and **Jody L Sindelar, PhD**[3]

[1]John Buckell, Postdoctoral Associate, Yale University, School of Public Health, New Haven, CT, USA

[2]Joachim Marti, Honorary Senior Lecturer, Imperial College, London, United Kingdom

[3]Jody L Sindelar, Professor, Yale University, School of Public Health, New Haven, CT, USA

Abstract

Objectives: To provide much-needed, policy-relevant estimates of alternative flavor bans on combustible cigarettes (combustibles) and electronic cigarettes (e-cigarettes hereafter) and their impacts on the demand for both cigarette types. Currently, there is little information on these impacts. Such information is timely as the FDA is considering banning flavors in e-cigarettes and/or banning menthol in combustibles.

Participants: A nationally-representative sample of 2,031 adult smokers and recent quitters.

Setting: Data collection is online.

Design/Methods: A discrete choice experiment to generate choice data and to estimate preferences for flavors and other attributes of both types of cigarettes. Using the estimates, we predict the impact of alternative flavor bans and compare results to the current treatment of flavors.

Main Outcome Measures: Choices of combustible cigarettes, e-cigarettes or neither of these.

Results: Banning flavors in e-cigarettes, but allowing menthol to remain in combustibles, would result in the greatest increase in the selection of combustible cigarettes (8.3%); and a decline in the use of e-cigarettes (11.1%). A ban on menthol combustibles would produce the greatest reduction (4.8%) in the use of combustibles with an increase in e-cigarettes (3.5%) and “none” (1.3%). A ban on all flavors but tobacco in both cigarette types would increase the choice of none the most (5.2%) but would increase combustibles (2.7%) and decrease e-cigarettes (−7.9%).

Conclusions: A ban on flavored e-cigarettes alone would drive smokers to combustible cigarettes, arguably the more harmful way of obtaining nicotine. A ban on menthol combustibles would be more effective in reducing smoking. A ban on all flavors in both cigarette types would reduce the smoking/vaping rates, but the smoking rate would be higher than the status quo.

Corresponding Author: John Buckell, P.O. Box 208034, New Haven, CT 06520-8034, john.buckell@yale.edu.

[1]We combine the categories of sweet and fruit because: together they incorporate many of the flavors of e-cigarettes available; historically they have been regulated differentially from menthol; and this is consistent with previous literature (Bonhomme et al., 2016; Huang et al., 2016; Pepper et al., 2016). We also test for the validity of pooling them as explained below.

Policymakers should use these results to guide the choice of flavor bans in light of their stance on the potential health impacts both types of cigarettes.

INTRODUCTION

Currently in the U.S., electronic-cigarettes (e-cigarettes) are available in over 7,000 flavors,[1] but all flavors except menthol are banned in combustible cigarettes (combustibles). E-cigarettes, which are relatively new, are increasingly popular in the U.S. but have been largely unregulated. This is in contrast to combustible cigarettes, which have a very long history, have become less popular over time, and are now highly regulated by the U.S. government. The growth in ecigarette use has led to concern over their impacts on the health of the public and interest in regulating them. Some cities and counties have already implemented bans on flavored cigarettes of both types. At the national level, the Center for Tobacco Products (CTP) of the Federal Drug Agency (FDA) has that gained authority over both cigarettes types and is considering banning flavors in e-cigarettes and menthol in combustibles.[2]

With the potential for nationwide flavor bans on e-cigarettes and a ban on menthol in combustibles, it is important to consider the impact of alternative bans on both combustibles and e-cigarettes. However, e-cigarette regulation is complicated due to: 1) varying views as to the extent to which e-cigarettes are less harmful than combustibles,[3–6] and 2) the potential substitutability or complementarity of combustibles and e-cigarettes as a function of flavors.

The current, stark difference in the availability of flavors by cigarette type could well be affecting the choice of combustibles, e-cigarettes, or of not using either. Thus, to the extent that flavors make cigarettes of both types more appealing,[7–9] alternative flavor bans could potentiate the public health impact of bans on either cigarette type either positively or negatively. Specifically, a ban on only flavored e-cigarettes might drive those who like flavors toward menthol combustibles, the more harmful choice; or towards simply quitting use of e-cigarettes. Alternatively, a ban on only menthol combustibles might drive menthol smokers to flavored e-cigarettes, the less harmful type, or simply to quit using combustibles. Thus, flavor bans could improve, or harm, public health and thus need to be designed carefully with solid predictions on the potential impacts.

This study provides needed, quantitative information on the likely impact of alternative flavor bans. Specifically, we provide policy-relevant predictions of the impact of alternative flavor bans on the choice of combustible cigarettes, e-cigarettes, and neither of these. We estimate the impacts of a set of five alternative flavor bans on choice of cigarette type as compared to the status quo (see Table 1).

To examine the potential impacts of alternative flavor ban policies across combustible and e-cigarettes, we conduct an online discrete choice experiment (DCE). The DCE approach makes it possible to predict the impact of alternative policies that are not currently in place. Specifically, we collect data online from a nationally-representative sample of 2,031 U.S. smokers and recent quitters, ages 18 to 64. Using the data from the experiment and the accompanying survey that we conduct, we estimate preferences for flavors and cigarette types while controlling for other characteristics of both types of cigarettes. We also assess heterogeneity across individual characteristics. Using these regression results, we predict the demand for combustibles and e-cigarettes under alternative policies banning flavors. For each policy, we then predict the percentage of each cigarette type that is selected based on our model results and calculate the percentage change in choices. Then, we discuss which flavor policy bans would be optimal under alternative criteria for protecting public health.

We add to the literature in many ways. Most importantly, and in contrast to most of the literature on flavor bans, we examine the impact of flavor bans, in both types of cigarettes, on both types of cigarettes. That is, we focus on how flavors (and flavor bans) by cigarette type affect the complementarity and substitutability of choices across cigarette types. Specifically, we consider a comprehensive range of flavor ban policies that could reasonably be implemented by the FDA. Other studies have examined the impact of banning only menthol combustible cigarettes[10–13] on the use of combustibles only. D'Silva et al. examined the impact of a ban of menthol in combustible cigarettes on use of combustibles and e-cigarettes by menthol smokers in Minnesota. One study[14] evaluated the impact of the 2009 U.S. menthol ban on tobacco use in adolescents. A DCE[15] examined the impact of an e-cigarette flavors ban on all flavors, except for menthol and tobacco, on the use of combustibles and e-cigarettes.

We also add to the literature by collecting a large, current, nationally-representative data set composed of current and former smokers. In addition, we contribute by using the estimated heterogeneity on the impact of these bans across smoking status and socio-economic and demographic characteristics to help make our predictions more realistic.

METHODS

Design/Methods

Discrete Choice Experiment (DCE)—The DCE is an experimental method which is used to the estimate the causal effect of flavors and other cigarette attributes on the choice of cigarette type and then to predict the impact of flavored-cigarette ban alternatives.[16] In the DCE, respondents choose their preferred cigarette type from a set of four options of cigarettes types described by each four attributes: flavor, health impact by cigarette type, amount of nicotine, and price. See Table 2; Fig. 1.

In this best-best DCE,[17] respondents are asked to respond to choice scenarios by choosing their top two favorites among combustible cigarettes, e-cigarettes and "none of these" ("none" hereafter). Because the choice options take the form of a specific cigarette, this is a 'labeled' experiment, which is beneficial for realism.[18] To optimally reduce the number of choice scenarios, we used a D-efficient survey design which generated 36 scenarios.[19] Respondents are randomized to three blocks of choices; each had different sets of scenarios, seen in a different order. Thus, an individual responds to 12 separate scenarios.

The specific flavors were chosen to emulate cigarette types currently available in the U.S. market: tobacco only 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.[8,21–21] Note that tobacco is the underlying flavor for all combustible cigarettes but must be added to e-cigarettes to characterize this flavor. In the paper, when we refer to flavors we are referring to all but tobacco, regardless of the type of cigarette we are referring to.

Health risk was expressed as years of life lost by an average user. For combustible cigarettes, this was 10 to reflect the known harm. For e-cigarettes, the four levels are: 2, 5, 10 and unknown; these reflected the lower health risk of e-cigarettes and separately the degree of uncertainty.[22] The levels of nicotine were low, medium, and high. Both types of cigarettes were available in these levels. A level of "none" was provided for e-cigarettes as nicotine-free options are available in e-cigarettes. Finally, we defined price as the price paid for 20 combustible cigarettes or the equivalent volume of e-cigarettes (using a conversion ratio of 1 disposable cigarette/1 e-cigarette refill to 30 cigarettes). The prices are displayed in Table 2.

A survey was also administered to collect socioeconomic data and smoking behavior information on each respondent. Descriptive statistics are reported in Table 3.

We took steps to increase the quality of the choice data collected. Prior to the DCE, detailed narrative and visual information describing the cigarette types (combustible or e-cigarette) and their features were provided. Next, we defined terminology for "cigarette type," "flavor," "tobacco," or "menthol" and "flavored-cigarette" (the partnership of a flavor and a cigarette type, e.g. "menthol e-cigarette"). 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. "please 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, or equivalent e-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 of several hundred observations.[23] To make our sample nationally-representative, respondents were drawn to match proportions of smokers in regional/demographic quotas. The quotas were derived from data from the 2014 Behavioral Risk Factor Surveillance System (BRFSS) based on six regions, gender, and age bands.

Analysis

We used exploded multinomial logit models to analyze respondents' choices. We specified our initial model to be a function of cigarette-specific terms and attributes. To align our model with the FDA's policy options, we imposed two features on the model. First, we combined fruit and sweet flavors into a single group as they are commonly considered jointly. Second, by interacting the *"cigarette-type constant-terms"* with each of the flavors, we are able to examine the cigarette type and flavor pairings directly. We refer to these combinations as *"flavored-cigarette constantterms."* Use of both of these improved the fit of the model. We are primarily interested in the estimates of the flavored-cigarette constant-terms: menthol combustible cigarette, tobacco e-cigarette, menthol e-cigarette, and fruit/ sweet e-cigarette. Each of these constants represents the preference for each flavored-cigarette relative to a tobacco combustible cigarette (the reference case) at the sample level. See Appendix A for the model specification.

We then interacted these flavored-cigarette constant-terms with a rich set of sociodemographic variables that were collected in the survey. This allows us to estimate the degree and type of heterogeneity by smoking status and socio-economic and demographic characteristics. We then use these estimates in our predictions, which increases their realism. All the levels of the attributes are treated as binary except for price which is treated as a continuous variable. We use the resulting model to make predictions of the impacts of the set of policies. All analyses are conducted in Nlogit (version 6).

Policy Predictions

The estimated choice models are used to predict market shares of each cigarette type and "none." We first predict smoking choices under the status quo and then impose the set of policy scenarios (Table 1) to predict the smoking choices under the alternative scenarios. For instance, if we are analyzing a ban on all e-cigarette flavors but not on tobacco ("Alternative 5" in Table 1), 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 smoking choices. These shifts in smoking choices reveal the impact of each policy.

RESULTS

Model Estimates

Table 4 shows the results from the cigarette choice models. Panel A displays the coefficients for flavored-cigarette types and "none" as well as for the attribute levels: price, nicotine, and health. The flavored-cigarette coefficients are measures of the preferences for the cigarette/ flavor pairs relative to the omitted tobacco combustible cigarette. On average, combustible cigarettes are preferred to e-cigarettes; that is, all the e-cigarette constant-terms are negative and significant, reflecting a relative, general dislike of flavors. However, menthol combustible cigarettes are disliked less than the other three flavored e-cigarettes. Specifically, adult smokers have the following preferences for e-cigarette flavors: tobacco, fruit/sweet, and then menthol last. Findings also indicate that adult smokers prefer: lower cigarette prices, healthier outcomes, and a medium level of nicotine.

Panel B presents the full set of interaction terms. There is substantial preference heterogeneity across individuals' characteristics. Specifically, younger adult smokers and recent quitters (we more concisely refer to below as 'smokers') have preferences for menthol combustible cigarettes and all flavored (including tobacco) e-cigarettes. Older adult smokers prefer tobacco combustible cigarettes. African Americans, those with higher education, and those who report low health prefer menthol combustible cigarettes. Those with higher education also prefer e-cigarettes of all flavors.

There is further heterogeneity in preferences by smoking status. Those with quit attempts prefer e-cigarettes of all flavors. Unsurprisingly, both dual users and vapers (those using only e-cigarettes) show very strong preferences for all types of e-cigarettes. Indeed, vapers prefer e-cigarettes to combustible cigarettes. Specifically, the coefficient for the interactions of vapers and tobacco e-cigarettes is positive and greater than constant-term for tobacco e-cigarettes, which is negative. Thus, all else being equal, vapers prefer tobacco e-cigarettes to tobacco combustible cigarettes. It is also the case that fruit/sweet e-cigarettes are preferred to tobacco combustible cigarettes by vapers, but not to menthol e-cigarettes. Last, recent quitters have a strong aversion to menthol combustible cigarettes.

Testing and Robustness

A number of formal tests are applied to test 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[24] of the multinomial logit (MNL)); tests of the utility function specification; and validity checks. In all cases, test results support the findings reported in the tables. The informal validity test, is that we note the similarity of our findings to those elsewhere in the literature: young adults and recent quitters' preference for non-tobacco flavors[18,25–30] and older adults' dislike of flavors;[20,31–32] African Americans' preference for menthol;[33–34] that e-cigarettes are preferred by those that have undergone higher education;[25,27] and that e-cigarettes are preferred by quit attempters and dual users.[35–38] Details are presented in Appendix B.

Policy Predictions

Table 5 displays the predicted market shares across the set of flavor bans. Each panel displays the following: Panel A repeats the description of the set of bans from Table 1; Panel B provides the predictions of the impact of bans on cigarette type 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. Note that the predicted shares of cigarette type choices under the set of current flavor bans are, as seen in the first row of panel B of Table 5: 45.2% for combustible cigarettes, 37.5% for e-cigarettes, and 17.2% for "none."

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

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

Policymakers seeking to minimize the use of both cigarette types should ban all flavors in both cigarette types (policy Alternative 1). In Alternative 1, the highest choice of “none” is at 22.4%. In this case, as seen in Panel C, e-cigarette choice declines by 7.9% and instead, people increase their choice of combustibles by 2.7% and “none” by 5.2%.

An e-cigarette ban on all flavors but tobacco is an inferior option for either of the above goals, as Alternative 5 indicates. This is important to note as this is a policy that the FDA has considered in the past and may again. Although this comprehensive ban would result in the second-largest reduction in selecting either cigarette types, selection of combustibles would increase from 45.2% to 53.3%. Unfortunately, 8.3% would change from e-cigarettes to combustibles and only around 3.0% would change from e-cigarette to “none.” Thus, this policy would likely drive current e-cigarette users toward both cigarette types more than toward abstinence.

DISCUSSION

Findings

These results indicate that flavors of combustibles and e-cigarettes drive choices across cigarette types and selecting neither. In turn, flavor bans drive choice of cigarette choices. 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 preference models indicate the following: Adult smokers and recent quitters in our sample on average prefer combustible cigarettes to e-cigarettes. Further, they tend on average to prefer tobacco to sweet, fruit and menthol flavors. However, there is substantial heterogeneity in flavor preferences, with some individuals deriving substantial utility from flavors. These results, including the estimated heterogeneity, are used to predict the impact of the alternative bans.

The predictions suggest that banning all flavors in e-cigarettes except tobacco, while allowing menthol to remain in combustibles, would result in the greatest increase in the selection of combustible cigarettes but a decline in the use of e-cigarettes. By comparison, a ban only on menthol combustible cigarettes would produce the greatest reduction in the use of combustibles, and much of this movement from combustibles would be to e-cigarettes with a smaller percentage moving toward “none.” Thus, it is likely that a menthol ban on combustibles would most improve public health given that combustible cigarettes impose the most significant harms. A ban on non-tobacco flavors in both types of cigarettes would increase the choice of opting-out (“none”) the most but would also increase the use of combustibles and reduce the choice of e-cigarettes by a relatively large amount. These predictions highlight the importance of simultaneously considering both: 1) the impact of flavor bans on combustibles and e-cigarettes simultaneously; and 2) the impact on both cigarettes types as well as “none.”

Strengths and Limitations

The key strength of this study is that it makes needed, policy-relevant, predictions about a set of flavor bans. We are the only study that we know of that examines alternative bans in the U.S. in both types of cigarettes and the impact of these on the choice of combustibles, e-cigarettes or 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 nationally-representative data set of current and former adult smokers. Our models allow for rich heterogeneity in preferences which makes our predictions more realistic. In addition, we have conducted our experiment in line with best practices[39] 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 flavor bans across both combustible 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,[40] but we help address this by analyzing current and recent smokers who frequently make such real-world decisions.[41] Second, the meaning of the "none" option is somewhat ambiguous. Third, the study does not examine the use of alternative 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. 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.

Policy

The predictions of this study are timely given that the FDA has been actively considering flavor bans on both e-cigarettes and menthol in combustible cigarettes.[2] This interest by the FDA is part of a broader movement toward adopting flavor bans; they have been imposed at county and municipal levels within the U.S. and bans on menthol combustible cigarettes have been announced or implemented by the EU, Canada, and other countries.[42–43]

According to our predictions, a ban on flavored e-cigarettes alone would drive more smokers to combustible cigarettes, which arguably are the more harmful way of obtaining nicotine.[44–45] In addition, results suggest that such a ban may reduce the appeal of e-cigarettes to those who are seeking to quit. In contrast, a ban on menthol combustible cigarettes would be a more effective approach to reduce smoking. Alternatively, a ban on non-tobacco flavors in both cigarette types would reduce the joint smoking/vaping rates, but the smoking rate would be higher than the status quo. Policymakers should determine their stance on the relative, potential health impacts, on both types of cigarettes and then can use these results to guide the choice of a flavor ban.

CONCLUSIONS

Our results have important policy implications for flavor bans. We conclude that flavor bans can be effective levers to affect smokers' choices. Alternative flavor bans can either enhance protection of the health of the public or worsen it. These results have some perhaps surprising implications that could prove valuable to lawmakers and regulators in crafting the best policies for public health.

ACKNOWLEDGMENTS

This research was supported by grant number P50DA036151 from the National Institute on Drug Abuse (NIDA) and the FDA Center for Tobacco Products (CTP) to Yale University. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health or Food and Drug Administration. We thank Kurt Petschke, Yale School of Public Health, for his additional assistance.

APPENDICES

Appendix A: Cigarette Type Choice Model

Respondents were asked to select their preferred cigarette type in choice scenarios, so they are assumed to be maximizing their utility when making choices (Louviere et al., 2000). We defined a general cigarette type utility function that relates individuals' choices to their preferences for cigarette types and attributes:

$$Utility(cigarette) = f(cigarette\ type,\ flavor,\ price,\ nicotine,\ health\ risk) \quad (1)$$

This utility function serves as the basis for the empirical model. From (1), we can straightforwardly build an econometric model to put numerical values on individuals' ordinal preferences (Hensher et al., 2015). Here, *utility* comprises an observed and unobserved component, V_{ijc} and ε_{ijc}, respectively. We then defined the observed component in terms of the attributes and cigarette types,

$$\begin{aligned} U_{ijc}(cigarette) &= V_{ijc} + \varepsilon_{ijc} \\ &= \beta_{flavor} \,.\, Flavor_{jc} + \beta_{price} \,.\, \mathrm{Price}_{jc} + \beta_{nicotine} \,.\, Nicotine_{jc} \\ &+ \beta_{Health\ risk} . Health\ Risk_{jc} + ECIG + None - of - these \\ &+ \varepsilon_{ijc} \end{aligned} \quad (2)$$

where V_{ijc} is the utility that respondent *i* derives from cigarette type *j* in choice scenario *c*.

The utility is related to the cigarette's attributes, namely flavor (*Flavor*), price (*Price*), level of nicotine (*Nicotine*), and health risk (*Health Risk*); β_{price} are the preferences for the attributes to be estimated. Next, individuals' underlying preferences were estimated for e-cigarettes (4567) and the "none of these" option (None – of - these). The omitted cigarette type is combustible cigarette, and thus these coefficients show the preference for these options relative to a combustible cigarette. ε_{ijc} is an error term that is assumed to follow a type-I extreme value distribution to facilitate estimation.

As noted above, we are interested in the impact of flavored cigarette ban alternatives. Thus, we redefined the choice model (2) to capture preferences for flavored cigarettes directly, rather than for cigarette types and flavors separately. To do this, we redefined V_{ijc} using (a) flavored cigarette constant terms (which are combinations of flavors and cigarette type constant terms); and (b) combined fruit/sweet flavors. We therefore estimate parameters separately for the set of cigarette type and flavor pairs as indicated below, with tobacco combustible cigarette as the omitted category. The flavored cigarette type utility function is defined as

$$\begin{aligned} U_{ijc}(\,flavored\ cigarette\,) &= V_{ijc} + \varepsilon_{ijc} \\ &= Men\_Ccig + Tob\_Ecig + Men\_Ecig + Fru\_Ecig + None - of - \ these \\ &+ \beta_{price} \cdot Price_{jc} + \beta_{\text{nicotine}} \cdot Nicotine_{jc} + \beta_{Health\ risk}\ \cdot\ Health\ Risk_{jc} \\ &+ \varepsilon_{ijc} \end{aligned} \quad (3)$$

The four flavored cigarette constants each represent the preference for a flavored cigarette type relative to a tobacco flavored combustible cigarette (the omitted category). These constants are: *Men_Ccig*, which captures the relative preference for menthol combustible cigarettes, and *Tob_Ecig*, *Men_Ecig*, and *Fru_Ecig*, which capture relative preference for, respectively, tobacco, menthol, and fruit/sweet flavored e-cigarettes. Further, the preference for not choosing any of the flavored cigarettes, relative to the omitted tobacco combustible cigarette, was captured by *None – of - these*. The terms β_{price}, $\beta_{nicotine}$, and $\beta_{health\ risk}$ capture preferences for the attributes of price, nicotine content, and health risk, respectively.

In specification (3), preferences are estimated at the sample level. In addition to this basic model, we introduced heterogeneity across personal characteristics. Specifically, we interact sociodemographic and smoking behavior variables with the flavored cigarette constants in the utility function. The full list of items that are interacted with the flavored cigarette constants are given in Table 3 and results are presented in Table 4, panel B. We used estimates of these interaction terms to make the policy predictions.

Finally, we define the choice model which gives the probability of choice as a function of the relative utilities (which are, as above, a function of flavored cigarette and attribute preferences). Because respondents make two sequential choices without replacement, we use the exploded, or rank order, logit model (Luce and Suppes, 1965; Yoo and Doiron, 2013),

$$P_{ijc}(rank1, 2) = \frac{e^{V_{ijc}}}{\sum_{j=1}^{J} e^{V_{ijc}}} \cdot \frac{e^{V_{ijc}}}{\sum_{j=2}^{J} e^{V_{ijc}}} \quad (4)$$

where P_{ijc} is the probability that individual *i* ranks cigarette type *j* first or second in choice scenario *c*. The first term is the probability that cigarette type *j* is ranked first (which is akin to the multinomial logit model for a single choice). The second term is the probability that cigarette type *j* is ranked second when the first choice has been removed from the options.

Appendix B: Testing and Robustness

In addition to the data quality measures that were used, statistical testing for model specification, and correspondence of our findings to the literature, further statistical tests and empirical robustness analyses were conducted and our findings were confirmed. First, alternative model structures were estimated, including the multinomial logit based only on respondents' first choice and the exploded logit with an adjustment for scaling differences between the first and second choices (Yoo and Doiron, 2013). We further estimated a model with random parameters to allow for unobserved heterogeneity. In addition, we estimated a model that discarded the recent quitters. In all cases, we find the results to be very similar to those presented.

In addition, our specification of the paired flavored cigarettes was tested (rather than flavors as attributes and cigarette types separately). We use pairwise testing of all flavored cigarette constants and find that we can reject the null that the two coefficients are equal per pair in every test (at the one percent level). We observe an improvement in model fit when moving from a model with flavors as attributes and cigarette types separately to the model in Table 3 (although it is not statistically significant). We also test our categories of flavors. In preliminary modeling, we find no differences between preferences for fruit and sweet flavors. Using a Wald test, we are unable to reject the null that the two coefficients were equal. In addition, we find that preferences for fruit/sweet were statistically distinct from menthol. These tests support the categorization of sweet and fruit together that we use. In summary, our treatment of flavors is in line with policymakers' options, but also consistent with the literature and is statistically supported.

Several internal validity checks supported our results. First, we used a series of follow-up questions to check for consistency between choice task responses—e.g. health is self-reported by our sample as one of the leading reasons for using e-cigarettes. Second, we checked that our estimated coefficients are in line with theoretical a priori expectations, that is, price coefficients are negative, respondents preferred healthier cigarettes and that those who report using ecigarettes prefer e-cigarettes to combustible cigarettes.

REFERENCES

1. Krüsemann EJ, Visser WF, Cremers JW, et al. Identification of flavour additives in tobacco products to develop a flavour library. Tob Control Published Online First: 11 February 2017. doi: 10.1136/tobaccocontrol-2016-052961.
2. Food and Drug Administration. FDA announces comprehensive regulatory plan to shift trajectory of tobacco-related disease, death. Food and Drug Administration 2017 https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm568923.htm (accessed 15th November 2017).
3. Kenkel DS. Healthy Innovation: Vaping, Smoking, and Public Policy. J Policy Anal Manage 2016;35(2):473–479. doi:10.1002/pam.21895. [PubMed: 26985459]
4. Ribisl KM, Seidenberg AB, Orlan EN. Recommendations for U.S. public policies regulating electronic cigarettes. J Policy Anal Manage 2016 Mar 1;35(2):479–489. doi: 10.1002/pam.21898. [PubMed: 26985460]
5. Royal College of Physicians. Nicotine without smoke: Tobacco harm reduction. London: Royal College of Physicians 2016 https://www.rcplondon.ac.uk/projects/outputs/nicotinewithout-smoke-tobacco-harm-reduction-0 (accessed 15th November 2017).
6. NHS Health Scotland. Consensus statement on e-cigarettes. Edinburgh: NHS Health Scotland 2017 http://www.healthscotland.scot/media/1576/e-cigarettes-consensusstatement_sep-2017.pdf (accessed 15th November 2017).
7. Berg CJ, Barr DB, Stratton E, et al. Attitudes toward E-Cigarettes, Reasons for Initiating E-Cigarette Use, and Changes in Smoking Behavior after Initiation: A Pilot Longitudinal Study of Regular Cigarette Smokers. Open J Prev Med 2014;4(10):789–800. doi: 10.4236/ojpm.2014.410089. [PubMed: 25621193]

8. Berg CJ. Preferred flavors and reasons for e-cigarette use and discontinued use among never, current, and former smokers. Int J Public Health 2016;61(2):225–236. doi: 10.1007/s00038-015-0764-x. [PubMed: 26582009]

9. Patel D, Davis KC, Cox S, et al. Reasons for current E-cigarette use among U.S. adults. Prev Med 2016;93:14–20. doi: 10.1016/j.ypmed.2016.09.011. [PubMed: 27612572]

10. O'Connor RJ, Bansal-Travers M, Carter LP, et al. What would menthol smokers do if menthol in cigarettes were banned? Behavioral intentions and simulated demand. Addiction 2012;107(7):1330–1338. doi: 10.1111/7.1360-0443.2012.03822.x. [PubMed: 22471735]

11. D'Silva J, Amato MS, Boyle RG. Quitting and Switching: Menthol Smokers' Responses to a Menthol Ban. Tobacco Regulatory Science 2015;1(1):54–60. doi: 10.18991/TRS.1.1.6

12. Levy DT, Pearson JL, Villanti AC, et al. Modeling the future effects of a menthol ban on smoking prevalence and smoking-attributable deaths in the United States. Am J Public Health 2011;101(7):1236–1240. doi: 10.2105/AJPH.2011.300179. [PubMed: 21566034]

13. Kotlyar M, Mills AM, Shanley R, et al. Smoker Response to a Simulated Ban of Menthol Cigarettes: A Pilot Study. Tobacco Regulatory Science 2015;1(3):236–242.

14. Courtemanche CJ, Palmer MK, Pesko MF. Influence of the Flavored Cigarette Ban on Adolescent Tobacco Use. Am J Prev Med 2017;52(5):e139–e146. doi: 10.1016/j.amepre.2016.11.019. [PubMed: 28081999]

15. Kenkel D, Peng S, Pesko M, et al. Mostly Harmless Regulation? Electronic Cigarettes, Public Policy and Consumer Welfare. NBER Working Paper Series 2017(23710).

16. Louviere JJ, Hensher D, Swait J. Stated choice methods and applications. New York: Cambridge University Press 2000.

17. Ghijben P, Lancsar E, Zavarsek S. Preferences for Oral Anticoagulants in Atrial Fibrillation: A Best–Best Discrete Choice Experiment. PharmacoEconomics 2014;32(11):1115–1127. doi: 10.1007/240273-014-0188-0. [PubMed: 25027944]

18. de Bekker-Grob EW, Hol L, Donkers B, et al. Labeled versus Unlabeled Discrete Choice Experiments in Health Economics: An Application to Colorectal Cancer Screening. Value Health 2010;13(2):315–323. doi: 10.1111/j.1524-4733.2009.00670.x. [PubMed: 19912597]

19. Hensher D, Rose JM, Greene W. Applied Choice Analysis. Second ed. Cambridge: Cambridge University Press 2015.

20. Bonhomme MG, Holder-Hayes E, Ambrose BK, et al. Flavoured non-cigarette tobacco product use among US adults: 2013–2014. Tob Control 2016;25(Suppl 2):ii4–ii13. doi: 10.1136/tobaccocontrol-2016-053373. [PubMed: 27794065]

21. Pepper JK, Ribisl KM, Brewer NT. Adolescents' interest in trying flavoured e-cigarettes. Tob Control 2016 11;25(Suppl2):ii62–ii66. doi: 10.1136/tobaccocontrol-2016-053174. [PubMed: 27633762]

22. Dinakar C, O'Connor GT. The Health Effects of Electronic Cigarettes. N Engl J Med 2016;375(14):1372–1381. doi: 10.1056/NEJMra1502466. [PubMed: 27705269]

23. de Bekker-Grob E, Donkers B, Jonker M, et al. Sample Size Requirements for Discrete-Choice Experiments in Healthcare: A Practical Guide. Patient 2015;8(5):373–384. doi: 10.1007/s40271-015-0118-z. [PubMed: 25726010]

24. Train K Discrete choice methods with simulation. Cambridge: Cambridge University Press 2009.

25. Carrieri V, Jones AM. Smoking for the poor and vaping for the rich? Distributional concerns for novel nicotine delivery systems. Economics Letters 2016;149:71–74. doi: 10.1016/j.econlet.2016.10.012.

26. Huang L-L, Baker HM, Meernik C, et al. Impact of non-menthol flavours in tobacco products on perceptions and use among youth, young adults and adults: a systematic review. Tob Control 2017;26(6):709–719. doi: 10.1136/tobaccocontrol-2016-053196. [PubMed: 27872344]

27. Hartwell G, Thomas S, Egan M, et al. E-cigarettes and equity: a systematic review of differences in awareness and use between sociodemographic groups. Tob Control Published online first 21dec2016. doi: 10.1136/tobaccocontrol-2016-053222.

28. Villanti AC, Johnson AL, Ambrose BK, et al. Flavored Tobacco Product Use in Youth and Adults: Findings From the First Wave of the PATH Study (2013–2014). Am J Prev Med 2017;53(2):139–151. doi: 10.1016/j.amepre.2017.01.026. [PubMed: 28318902]

29. Pesko MF, Kenkel DS, Wang H, et al. The effect of potential electronic nicotine delivery system regulations on nicotine product selection. Addiction 2016;111(4):734–744. doi: 10.1111/add.13257. [PubMed: 26639526]
30. Shang C, Huang J, Chaloupka FJ, et al. The impact of flavour, device type and warning messages on youth preferences for electronic nicotine delivery systems: evidence from an online discrete choice experiment. Tob Control Online first 2017. doi: 10.1136/tobaccocontrol-2017-053754.
31. Harrell MB, Loukas A, Jackson CD, et al. Flavored Tobacco Product Use among Youth and Young Adults: What if Flavors Didn't Exist? Tob Regul Sci 2017;3(2):168–173. doi: 10.18001/TRS.3.2.4. [PubMed: 28775996]
32. Czoli CD, Goniewicz M, Islam T, et al. Consumer preferences for electronic cigarettes: results from a discrete choice experiment. Tob Control 2016;25(e1):e30–e36. doi: 10.1136/tobaccocontrol-2015-052422. [PubMed: 26490845]
33. Rock VJ, Davis SP, Thorne SL, et al. Menthol cigarette use among racial and ethnic groups in the United States, 2004–2008. Nicotine Tob Res 2010;12 Suppl 2:S117–124. doi: 10.1093/ntr/ntq204. [PubMed: 21177368]
34. Giovino GA, Villanti AC, Mowery PD, et al. Differential trends in cigarette smoking in the USA: is menthol slowing progress? Tob Control 2015;24(1):28–37. doi: 10.1136/tobaccocontrol-2013-051159. [PubMed: 23997070]
35. Beard E, West R, Michie S, et al. Association between electronic cigarette use and changes in quit attempts, success of quit attempts, use of smoking cessation pharmacotherapy, and use of stop smoking services in England: time series analysis of population trends. BMJ 2016;354:i4645. doi: 10.1136/bmj/i4645. [PubMed: 27624188]
36. Marti J, Buckell J, Maclean JC, et al. To 'Vape' or Smoke? A Discrete Choice Experiment Among U.S. Adult Smokers. National Bureau of Economic Research Working Paper Series 2016;No. 22079.
37. Hartmann-Boyce J, McRobbie H, Bullen C, et al. Electronic cigarettes for smoking cessation. Cochrane Database of Syst Rev. 2016;9:CD010216. doi: 10.1002/14651858.CD010216.pub3.
38. Zhu S-H, Zhuang Y-L, Wong S, et al. E-cigarette use and associated changes in population smoking cessation: evidence from US current population surveys. BMJ 2017;358:j3262. doi: 10.1136/bmj.j3262. [PubMed: 28747333]
39. Johnson F, Lancsar E, Marshall D, et al. Constructing Experimental Designs for Discrete-Choice Experiments: Report of the ISPOR Conjoint Analysis Experimental Design Good Research Practices Task Force. Value Health 2013;16(1):3–13. doi: 10.1016/j.jval.2012.08.2223. [PubMed: 23337210]
40. Harrison G Real choices and hypothetical choices In: Hess S, Daly A, eds. Handbook of Choice Modelling. Cheltenham: Edwards Elgar Publishing 2014.
41. McFadden D The New Science of Pleasure: Consumer Choice Behavior and the Measurement of Well-Being In: Hess S, Daly A, eds. Handbook of Choice Modelling. Cheltenham: Edward Elgar 2014.
42. Public Health Law Center. U.S. Sales Restrictions on Flavored Tobacco Products (2017). Public Health Law Center 2017 http://www.publichealthlawcenter.org/resources/us-salesrestrictions-flavored-tobacco-products-2017 (accessed 15th November 2017).
43. Public Health Law Center. How Other Countries Regulate Flavored Tobacco Products (2015). Public Health Law Center 2015 http://www.publichealthlawcenter.org/resources/how-other-countries-regulate-flavoredtobacco-products-2015 (accessed 15th November 2017).
44. Goniewicz ML, Gawron M, Smith DM, et al. Exposure to Nicotine and Selected Toxicants in Cigarette Smokers Who Switched to Electronic Cigarettes: A Longitudinal Within-Subjects Observational Study. Nicotine Tob Res 2017;19(2):160–167. doi: 10.1093/ntr/ntw160. [PubMed: 27613896]
45. Shahab L, Goniewicz ML, Blount BC, et al. Nicotine, carcinogen, and toxin exposure in long-term e-cigarette and nicotine replacement therapy users: A cross-sectional study. Ann Intern Med 2017;166(6):390–400. doi: 10.7326/M16-1107. [PubMed: 28166548]

WHAT THIS PAPER ADDS

Section 1. What is already known from the literature

- There is some evidence on the impact of flavor bans for combustible cigarettes on combustible cigarette use and for electronic-cigarettes on electronic-cigarette use; but these studies do not address the substitutability and complementarity of demand across cigarette types.
- One discrete choice experiment (DCE) examined the impact of banning flavors in electronic-cigarettes on use of both combustible and electronic-cigarettes, finding that such bans would reduce the use of electronic-cigarettes by a small but statistically significant effect.

Section 2. What this study adds

- Using an online DCE, we make quantitative predictions for smokers and vapers about the impact of five alternative flavor bans on the use of combustible cigarettes and the use of electronic cigarettes.
- Our experiment is conducted in a large, current, nationally-representative data set composed of current and former smokers that was collected for the purpose of these predictions.

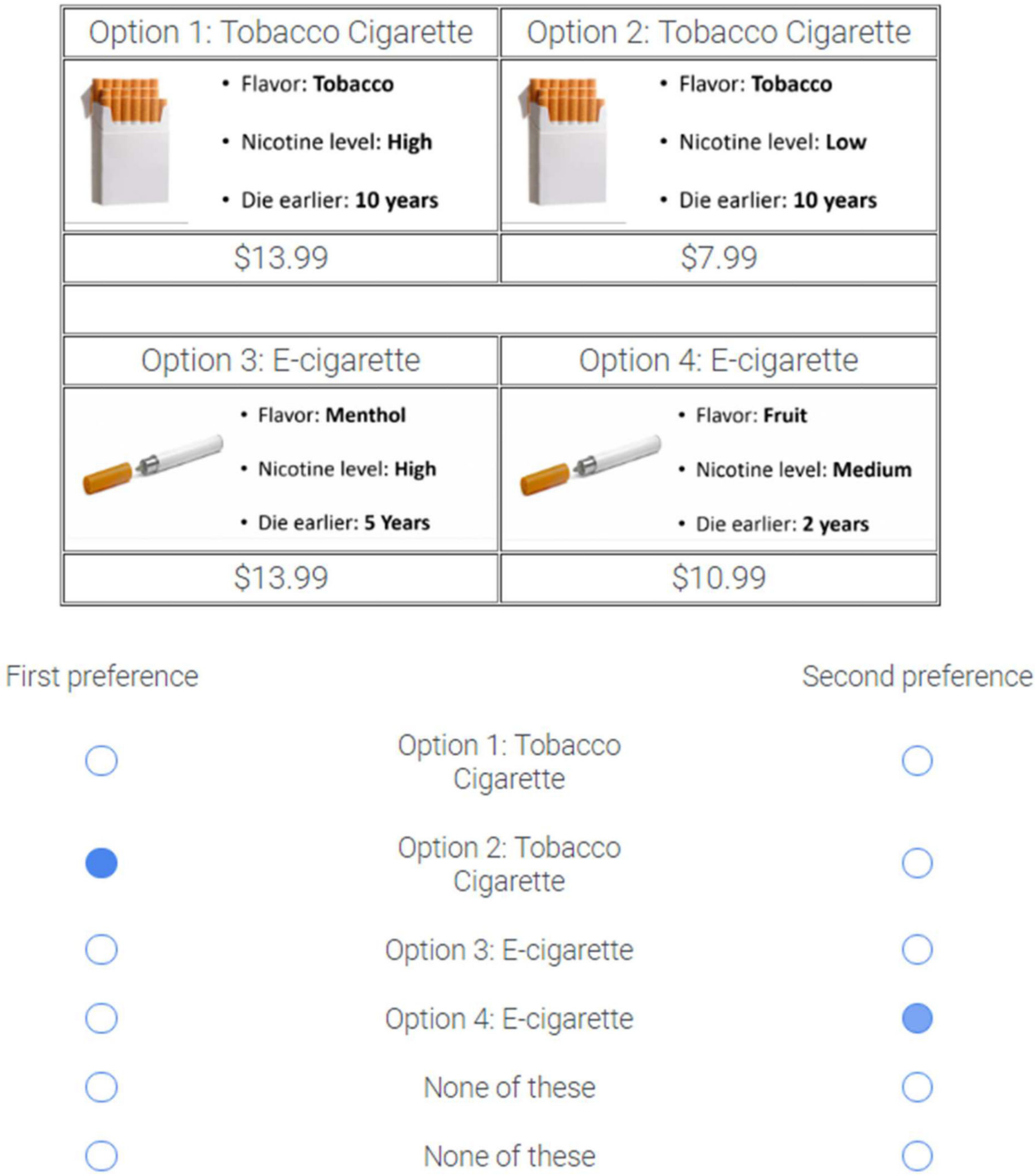

Fig. 1:
Example Choice Scenario

Table 1:

Potential flavor bans policy options[1]

	Permitted flavors by cigarette type			
	Combustible cigarettes		E-cigarettes	
Policy	**Menthol**	**Fruit/sweet**	**Menthol**	**Fruit/sweet**
Current US Policy: ban fruit/sweet in ccig	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 ccig 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

[1]We do not consider banning tobacco for several reasons including that it the flavor is inherent in the tobacco leaves of combustibles and that the focus of banning flavors on e-cigarettes has been on sweet and fruit, with a ban on menthol a real possibility.

Table 2:

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

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

Table 3:

Descriptive statistics of respondent characteristics

Variable	Mean (%)
Sociodemographic variables	
Young (age < 26)	0.11
Old (age > 54)	0.20
Female	0.54
Black	0.09
Asian	0.03
American Indian	0.02
Other race	0.02
No race not reported	0.00
Hispanic	0.08
Higher education	0.48
Income > mean income ($55,000)	0.39
Household size > 2	0.56
Self-reported health < 3	0.36
Smoking-related variables	
One or more attempt(s) to quit in the past year	0.58
Combustible cigarette only user	0.51
Use both combustible cigarettes and e-cigarettes (dual user)	0.31
E-cigarette only user (vaper)	0.07
Recent Quitter	0.11

Table 4:

Flavored cigarette choice models

Panel A	Cigarette choice model		Cigarette choice model with interactions	
Parameters	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)	***
Diagnostic information				
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	0.37 (0.112)	***	0.26 (0.099)	***	0.41 (0.139)	***	0.61 (0.109)	***
Older adult	−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)	

Panel A	Cigarette choice model		Cigarette choice model with interactions					
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)	
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)	

Notes: Dependent variable: cigarette choice. Reference (omitted) flavored cigarette: tobacco combustible 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 cigarette 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:

*** $p<0.01$

** $p<0.05$

* $p<0.01$.

Table 5:

Policy predictions of cigarette type choice shares and percentage changes in shares across alternative flavors

	Panel A Permitted flavors by cigarette type				Panel B Cigarette type choice shares (%)			Panel C 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
Policy										
Current US policy	Allowed	Banned	Allowed	Allowed	45.2	37.5	17.2	n/a	n/a	n/a
Alternative 1[b]	Ban	Ban	Ban	Ban	47.9	29.6	22.4	2.7	−7.9	5.2
Alternative 2	Ban	Ban	Allow	Ban	45.8	32.8	21.4	0.6	−4.7	4.2
Alternative 3[a]	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 cigarette type”, shows the availability of menthol and fruit/sweet flavors for combustible cigarettes and e-cigarettes: “Allowed” or “Allow” shows when the flavor is permitted; “Banned” or “Ban” shows when the flavor is banned. Panel B, “Cigarette type 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 U.S. policy to the policy scenario, which is the difference between the current policy and the predicted policy share(s).

[a] denotes the policy with the largest predicted reduction in combustible cigarette choice

[b] denotes the policy with the largest increase in the “None of these” option. There may be error from rounding in the estimates.