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ABSTRACT

E-cigarettes are available in over 7,000 flavors, whereas all flavors but menthol are banned in combustible cigarettes. The FDA recently requested a ban on e-cigarette flavors, but was rejected. The FDA is again considering this ban and also a ban on menthol in combustible cigarettes, but there is little information on the impacts of alternative bans on the market for combustible and e-cigarettes. Our study provides these much-needed estimates. We conduct a discrete choice experiment on a nationally representative sample of 2,031 adult smokers and recent quitters that we collected. We estimate preferences for flavors and other attributes and use these preferences to predict the demand for each cigarette type and for "none of these." We then predict the impact of alternative bans and compare results for the current treatment of flavors to results for the alternative bans. We find that the recently denied FDA ban would result in increased choice of combustible cigarettes, the most harmful alternative. However, a ban on menthol in combustibles would result in the greatest reduction in smoking of combustibles. Our results are timely and policy-relevant, suggesting which flavor bans are likely to be most effective in protecting public health.

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INTRODUCTION

Currently in the U.S., e-cigarettes are available in over 7,000 flavors, but all flavors except menthol are banned in combustible cigarettes. 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 e-cigarette use has led to concern over their impacts on the health of the public and interests in regulating them at different levels of the government.[1] At the national level, the Center for Tobacco Products of the Federal Drug Agency (FDA) that recently gained authority over tobacco products and is considering banning flavors in both e-cigarettes and also menthol in combustibles. Banning flavors has also been suggested by public health experts (Ribisl et al., 2016a). However, e-cigarette regulation is complicated by lack of evidence about their impact on health and varying perceptions as to the extent to which e-cigarettes are less harmful than combustibles (Kenkel, 2016; Ribisl et al., 2016b).

The Health Impact of E-cigarettes

Differences in the health impact of e-cigarettes can occur either due to differences that are inherent to the cigarette itself or related to how and why e-cigarettes are used. E-cigarettes are believed to be inherently less harmful to both the user and those around them because they do not burn tobacco (Royal College of Physicians, 2016). It is the burning of tobacco and its addictiveness due to nicotine that result in cancer and other health harms. Instead of burning tobacco, e-cigarettes use a heating filament to vaporize a liquid that make them less harmful. And consequently, e-

[1] There are also 79 countries that have implemented some e-cigarette regulations and Kennedy et al. (2017). For example, the UK implemented a minimum age of 18 for e-cigarettes (Department of Health, 2015)

cigarettes do not produce harmful secondhand smoke. Also, because e-cigarettes typically, but not always, contain nicotine, there may be less concern about addiction.

In addition to the inherent differences between e-cigarettes and combustibles, there are important differences in how they are used that could affect public health. E-cigarettes are used in ways that are beneficial to health to the extent that: 1) smokers switch to e-cigarettes, 2) smokers use them as a cessation device, and 3) youths may choose them over combustibles. These benefits not only help the smoker, or would-be-smoker, but also the non-smoker due to the lack of secondhand smoke. However, in contrast, e-cigarettes may be harmful to public health to the extent that they: attract new smokers (adult or youth) of combustibles and serve as method for current smokers of combustibles to skirt bans on smoking in public places and thus maintain their addiction. The net effect of these offsetting impacts is unknown.

Although there is insufficient evidence to draw clear conclusions on the impact of the offsetting effects of e-cigarettes on smoker behavior, there is nonetheless evidence for several of the above points. First, evidence suggests that current smokers on the whole may be either helped or unaffected by e-cigarettes (Shahab et al., 2017; Goniewicz et al., 2017). Second, recent studies find that current smokers use e-cigarettes as a harm reduction method and/or as a cessation device (Hartman-Boyce et al., 2016; Zhu et al., 2017). In fact, e-cigarettes are more attractive to smokers than some of the alternative cessation medications and nicotine replacement therapy devices.

Regarding adult use, e-cigarettes are used almost exclusively by current smokers and recent quitters (Glasser et al., 2017). Indeed, because e-cigarettes are rarely banned in public places, current smokers may use e-cigarettes to maintain their nicotine addiction despite smoking bans (Marti et al., 2016).

Evidence is not yet clear as to the net impact of e-cigarettes on youths. E-cigarettes may attract mainly those youths who would have used combustibles, thus offering relative protection. Alternatively, e-cigarettes may serve as a gateway to the use of combustibles (Gostin and Glasnet, 2014). Surprisingly, it is estimated that most youths (up to 80 percent) "vape" e-cigarettes without nicotine (Meich et al., 2017), which mitigates the concern about the gateway effect, as there is much less risk of nicotine addiction and, perhaps reducing the risk later use of combustibles.

Flavor Availability in Cigarettes and E-cigarettes

One important difference between the two cigarette types that may affect net harm of e-cigarettes is the availability of flavors in e-cigarettes. All flavors but menthol have been banned in combustibles at the federal level, but none have been banned for e-cigarettes nationally in the U.S. This stark difference likely impacts the choice of combustibles, e-cigarettes, or abstinence. Thus, to the extent that flavors make e-cigarettes more appealing (Berg et al., 2014; Berg, 2016; Patel et al., 2016), they could potentiate the public health impact of e-cigarettes either positively or negatively. Specifically, a ban on flavored e-cigarettes might drive those who like flavors toward combustibles. Or such a ban might reduce the overall smoking rate by eliminating a popular alternative. Similarly, a ban on only menthol combustibles might drive menthol smokers to e-cigarettes.[2] The first effect would be relatively harmful; the second beneficial. If all flavors are banned, both smokers and youths who have not yet initiated use of either cigarette type might be more inclined to abstain from both.

[2] Menthol cigarettes are used disproportionately by African American smokers and by youths (Rock et al 2010; Giovino et al., 2013). It is thought that the 'cooling effect' of menthol makes smoking less harsh for first-time smokers, thus the appeal to youths; menthol cigarettes are falsely believed to be healthier, which may increase its appeal (Anderson, 2011).

Thus, a disruption to the status quo of flavor availability due to flavor bans is likely to drive smokers to different cigarette choices, or to choose none. Consequently, it is difficult to know the net impact of flavor bans due to the multiple, potentially offsetting impacts. There are no empirically-based predictions of the net impact of different flavor bans. Yet to ensure the most positive impact of such bans, it is important to understand the offsetting, net effects.

FDA Regulations Concerning Flavors: The Current Landscape

In 2016, the FDA gained the authority to regulate e-cigarettes and other tobacco products.[3] Prior to this, the FDA had the authority to regulate only if e-cigarettes were marketed for therapeutic purposes (though none were), and this was done by another branch of the FDA.[4] The authority to regulate e-cigarettes followed the FDA being granted the authority to regulate the manufacturing, marketing, and sales of other tobacco products through the 2009 Family Smoking Prevention and Tobacco Control Act. The Tobacco Control Act mandated that in regulating tobacco products, the new branch of the FDA had to pursue the goal of protecting the health of the public. This means that the FDA is to consider the societal impact and not only assess the safety and effectiveness of drugs or devices, as required in other branches of the FDA. In addition, the FDA must produce a full cost-benefit analysis prior to implementing a regulation (White House, 2011; Chaloupka et al., 2014). Thus, the full impact of regulations needs to be considered and quantified, including impacts on those who could be newly drawn into or out of cigarette use and the impact of secondhand smoke.

To protect the health of the public, in May 2016 the FDA requested a ban on flavors in e-cigarettes and other newly covered products, at least until the agency had time to fully review the

[3] Pipe tobacco and hookah were also covered.
[4] The FDA branch that regulate pharmaceutical is the Center for Drug Evaluation and Research.

impact of so-called characterizing flavors.[5] But this request to ban flavors was denied by the White House Office of Management and Budget. The reasons for the denial are not publicly known. Thus, the current situation is that flavors are not available in combustible cigarettes with the exception of menthol, but in contrast there are no FDA restrictions on e-cigarette flavors.

Despite the recent dismissal of the FDA's request, the issue of flavor bans is still relevant and, in fact, timely. It is important to note that the FDA recently issued a statement indicating that it is seeking approaches to regulating child-appealing flavors in e-cigarettes and may consider banning menthol in combustibles FDA (2017). This has also been suggested in the literature (Ribisl et al., 2016a). However, in the absence of national bans on flavors in e-cigarettes, cities and counties in the U.S. have passed flavor bans on e-cigarettes and combustibles. Among the cities with flavor bans are Berkeley, Hayward, and Manhattan Beach in California; Chicago; New York; Boston/Cambridge; and Minneapolis/St. Paul. Other locations include California's Santa Clara and Yolo Counties. In addition, some of these cities have also passed bans on menthol cigarettes (Tobacco Control Legal Consortium, 2017).[6] Thus, given the recent FDA statement and actions at other levels of government, it is timely to consider the impact of alternative flavor bans on public health.

With the potential for nationwide flavor bans for e-cigarettes, it is important to consider the impact of alternative bans in order to choose those that are most beneficial. An optimal flavor ban could serve to protect the health of society, while other bans might either be harmful or not be the best approach. To select the best ban, the impact of alternative bans on the combustible and e-cigarettes must be considered in tandem; flavors may drive choice of cigarette type and affect the

[5] Note that without added "characterizing" flavors, the primary taste of e-cigarettes would be the solvent used; tobacco is not typically considered a "characterizing" flavor in e-cigarettes.

[6] The European Union, Alberta in Canada and a few other countries, have bans on menthol in e-cigarettes (European Parliament, 2014) and globaltobaccocontrol.org.

desire to abstain. Thus, quantitative information is needed on the likely impact of alternative flavor bans, however, such information is not currently available.

We address the need for information on the likely impact of alternative flavor bans for e-cigarettes and combustibles. Specifically, we provide useful predictions of the impact of alternative flavor bans on the use 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. These estimates provide empirical guidance on the selection of optimal flavor bans to protect public health.

To examine the potential impacts of alternative flavor ban policies across combustible and e-cigarettes, we conduct an online discrete choice experiment (DCE). Specifically, we collect data from a 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 and heterogeneity across individual characteristics. Using these regression results, we predict the demand for combustible and e-cigarette types under alternative policies banning flavors while controlling for other characteristics of both types of cigarettes.

The five flavor banning policies that we examine are displayed in Table 1. This set of bans includes: those currently in place; the FDA's recently proposed ban; and four alternative flavor bans for either or both combustible and e-cigarettes. For each policy, we predict the percentage of each type that is selected based on our model results. Then, we discuss which flavor policy bans would be optimal under alternative criteria for protecting public health.

We add to the literature in a number of ways. While some studies have examined the potential impact of a ban on menthol combustible cigarettes (O'Connor et al., 2012; Da'Silva et al., 2015; Levy et al., 2011; Kotlyar et al., 2015), only Da'Silva examined the impact on e-cigarette use.

Pesko et al. (2016) studied flavors and e-cigarettes, but did not make predictions. Studies have also examined the impact of flavors on combustible cigarette use (Courtmanche et al., 2017) and the prevalence of flavored tobacco product use (Villanti et al., 2017), but neither examined the impact of potential bans on flavored e-cigarettes. We not only examine flavor bans on both types of cigarettes, but we also examine the impact on choice of cigarette type. We also add to the literature by collecting a large, current, nationally representative data set composed of current and former smokers. In addition, we are the first to study how preferences for flavored cigarettes vary across individual characteristics in a single study; the results across groups offer valid comparisons. Thus, our methods are rigorous and our results are policy-relevant and timely.

METHDOS

Data and Sampling

We recruited a sample of 2,031 adult smokers and recent quitters online.[7] To be eligible, current smokers and recent quitters had to have smoked at least 100 cigarettes, or equivalent e-cigarettes, in their lifetime. Respondents had to be between ages 18 and 64 and U.S. residents. 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 (de Bekker-Grob et al., 2015). 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 Behavioral Risk Factor Surveillance System (BRFSS) based on six geographical regions (New England, Mid-Atlantic, Midwest, South, Southwest, and West), gender, and age bands (18–34, 35–49 and 50–64).

Discrete Choice Experiment

[7] The survey firm Qualtrics was used.

We use a discrete choice experiment (DCE) with a survey conducted alongside. DCE is a preference elicitation technique that allows estimation of the causal effect of products' characteristics on individuals' choices (in this case, the impact of cigarette flavors on cigarette choices; see Louviere et al., 2000). It has been applied to health and health behaviors (Amaya-Amaya et al., 2008; Louviere and Lancsar, 2009; de Bekke-Grob et al., 2012; Clark et al., 2014; Vass et al., 2016), and in tobacco product studies (Ida and Goto, 2009; Regmi et al., 2017). The DCE approach is used to estimate the effect of flavors on the choice of cigarette type and then to predict the impact of flavored cigarette ban alternatives.

In our DCE, respondents are asked to respond to choice scenarios by choosing their favorite among combustible cigarettes and e-cigarettes or "choose none of these" options.[8] The choice scenarios were generated based on the principle of D-optimality, which is common for DCEs (Hensher et al., 2015), resulting in 36 choice scenarios. Respondents are randomized to three blocks, such that each respondent responds to 12 scenarios.[9] In the scenarios, each of the cigarette types is described by four attributes: flavor, health impact of smoking, amount of nicotine, and price. In turn, each of these attributes has specific values, termed "levels." For example, *flavor* is an attribute, and *tobacco, menthol*, *fruit,* and *sweet* are levels. The set of cigarette types and attributes is kept constant throughout each choice scenario, but the levels vary for each scenario.

Respondents' choices form the data set that is used in our models to estimate the value of preferences for the cigarette types and attribute levels. To increase the effective sample size, respondents chose a first and second choice in each scenario; this is referred to as a best-best DCE

[8] Because the choice options take the form of a specific cigarette, this is a 'labeled' experiment, which is beneficial for realism (de Bekker-Grob et al., 2010)

[9] This also helps to alter the order in which respondents face scenarios, though recent evidence finds that this does not appear to be an issue (Pesko et al., 2016)

(Ghijben et al., 2014). That is, 2,031 respondents answer 12 choice scenarios each (n=24,372), but as they make two choices per scenario rather than one, there is more preference information gathered per observation. See Fig. 1 for a sample choice scenario.

We took several steps to increase the quality of responses. Prior to asking our sample to respond to the DCE, we provided respondents with a detailed narrative and visual information. We describe the cigarette types and their features used in the study, ensuring all respondents had an equal base level of knowledge prior to responding. Next, we are clear with the terminology (note that we use the same terminology throughout the paper). We use “cigarette type” as a general term for combustible cigarettes and e-cigarettes. By “flavor” we mean a flavor of cigarette independent of its type,[10] e.g. “tobacco” or “menthol.” By “flavored cigarette” we mean the partnership of a flavor and a cigarette type, e.g. “tobacco combustible cigarette” or “menthol e-cigarette.” Lastly, a sample experimental task is provided before the full experiment, giving respondents practice in responding.

The experimental design includes the cigarette types, attributes, and levels, as seen in Table 2. The four attributes selected are considered key factors in consumer decisions. They are: flavors, health risk, amount of nicotine, and price. The specific flavors were chosen to emulate cigarette types currently available in the U.S. market: tobacco and menthol for cigarettes; and tobacco, menthol, fruit, and sweet for e-cigarettes. While there are many flavors of e-cigarettes available (Zhu et al., 2014; Kruseman et al., 2017), the overwhelming majority of these can be classified as menthol, fruit, or sweet (Berg, 2016; Bonhomme et al., 2016; Pepper et al., 2016). Health risk was expressed as years of life lost by the average user. For combustible cigarettes, this was set at 10 to reflect the known harm. For e-cigarettes, four levels were used: 2, 5, 10 and unknown; these

[10] Note that tobacco is a flavor that needs to be specifically added to the e-cigarette. This is in contrast to the combustible cigarette which has a tobacco flavor naturally.

options reflect both the lower health risk of e-cigarettes and that their exact risk is not known (Dinakar and O'Connor, 2016), helping to make the choices realistic. The levels of nicotine are low, medium, and high. Both types of cigarettes are currently available in these levels. In addition, a level of "none" was provided for e-cigarettes to make the choices realistic, 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.[11] We scanned the market for current prices and developed a representative set. The prices used are $4.99, $7.99, $10.99, and $13.99. The ".99" suffix connotes a retail purchase experience.

To complement the DCE, a survey was administered to collect socioeconomic data and smoking behavior information on each respondent. These data allow the study of response heterogeneity across these personal characteristics. Descriptive statistics of our sample are reported in Table 2.

In addition to the above quality enhancements we also used "forced responses" to prevent respondents from skipping through large sections of the survey. And we also used a minimum time threshold[12] 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"). Failed checks resulted in individuals being ejected from the survey.

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

[11] We used a conversion ratio of 1 disposable cigarette/1 e-cigarette refill to 30 cigarettes.
[12] Which is 1/3 of the median time taken in the pilot

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,

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

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 ($ECIG$) 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.[13] 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:

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

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 $\beta_{price}, \beta_{nicotine,}$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

[13] 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.

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),

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

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.

Policy Predictions

To make policy predictions, we use the flavored cigarette choice model in (4) with sociodemographic and smoking behavior interactions. The estimated choice model yields the predicted probability of a participant choosing each cigarette type (or “none of these”) in each choice scenario; the cigarette type with the highest probability of selection is the model’s prediction of the individual’s choice. By aggregating these predicted choices across the sample, we observe the “choice shares” or “market shares” for combustible cigarettes and e-cigarettes, and “none of these” across all choices.

To make predictions that correspond to the different policy bans, we first predict the status quo from the model. We then impose the set of policy scenarios on the model and predict the new market shares. We base our predictions on coefficients only when they are positive and significant. This yields behaviorally plausible policy predictions: banning a product the respondent does not like is unlikely to change behavior, whereas banning a product that is liked is likely to change behavior.

RESULTS

Model Estimates

Table 4 shows the results from the cigarette choice models— for both the basic model without interactions and the interacted model. For both models, panel A displays the coefficient values for variables that are common across the two models, that is, coefficients for flavored cigarette types and "none of these" as well as the attribute levels: price, nicotine, and health. Tobacco combustible cigarette is the omitted category. Model diagnostic information is also presented. There are 2,031 individuals, each facing 12 choice scenarios, yielding 24,372 observations (there are of course 48,744 choices analyzed since respondents made two choices per task).

In panel A, the coefficients are the preferences for the cigarette/flavor pairs relative to the omitted tobacco combustible cigarette. On average, combustible cigarettes are preferred to e-cigarettes; specifically, all of the e-cigarette constants are negative (disliked) and significantly so. Menthol combustible cigarettes appear to be disliked less than the three flavored e-cigarettes. Of the e-cigarettes, the tobacco flavored is disliked the least, followed by fruit/sweet, followed by menthol, reflecting a general dislike of flavors. Also, seen in panel A is that smokers are, on average, averse to higher cigarette prices, prefer healthier outcomes, and prefer a medium level of nicotine. These are seen in the negative and significant coefficients and is consistent with theory and previous research.

In panel B, the full set of interaction terms introduced to the model from equation (4) are presented. A likelihood ratio test confirms that this specification is preferred in terms of fit to the model without these interactions. There is substantial preference heterogeneity across individuals' characteristics. Specifically, younger adult smokers and recent quitters[14] have preferences for menthol combustible cigarettes and all flavored e-cigarettes, which is in keeping with the literature (Carrieri and Jones, 2016; Huang et al., 2016; Hartwell et al., 2016; Pesko et al., 2016; Villanti et al., 2017). Older adult smokers prefer tobacco flavored combustible cigarettes, which is also consistent with extant literature (Bonhomme et al., 2016; Harrell et al., 2017). African Americans like menthol, which is consistent with previous literature (Rock et al., 2010; Giovino et al., 2013). This preference for menthol is stronger than that for fruit/sweet flavored e-cigarettes (larger coefficients). Asians have a slight preference for flavored e-cigarettes in general. Those with higher education prefer menthol combustible cigarettes and e-cigarettes of all flavors (Carrieri and Jones, 2016; Hartwell et al., 2016). Those who report low health prefer menthol combustible cigarettes.

There is interesting heterogeneity in preferences across smoking status. Those who have attempted quitting show a preference for e-cigarettes (all flavors), which is in keeping with the use of e-cigarettes as a cessation aid (Beard et al., 2016; Marti et al., 2016; Hartman-Boyce et al., 2016; Zhu et al., 2017). They are indifferent between tobacco and menthol combustible cigarettes. Unsurprisingly, both dual users and vapers (those using only e-cigarettes) show very strong

[14] To be precise regarding our sample, we use the terms 'smokers and recent quitters', however, to prevent the reader from having to read this multiple times, we refrain from repeating this each time in the next few sentences and use shorter, though less precise, phrases.

preferences for all types of e-cigarette, and vapers prefer e-cigarettes to combustible cigarettes.[15] Lastly, recent quitters display a preference for fruit/sweet flavored e-cigarettes, but not for other flavored e-cigarettes. Recent quitters have a strong aversion to menthol combustible cigarettes.

As confirmed by a likelihood ratio test, our preferred specification with interactions improves the fit from the model which has only cigarette type constant terms ("LL (constants only)" in Table 3, panel A; see Greene, 2009). The coefficients in the basic model and the model with heterogeneity are very similar, which is a sign of reliability.

Testing and Robustness

In addition to the data quality measures described above, 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 the 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

[15] This can be seen as the positive coefficient for the interaction of vaper and tobacco e-cigarette is greater than the negative coefficient for tobacco e-cigarettes. Thus, all else equal, tobacco e-cigarettes are preferred to tobacco combustible cigarettes by vapers. This is also true for fruit/sweet e-cigarettes, but not for menthol.

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 e-cigarettes prefer e-cigarettes to combustible cigarettes.

Policy Predictions

Table 5 displays the predicted market shares across the set of flavor bans. For the convenience of the reader, Table 5, panel A displays the information from Table 1 on the status quo flavor policy and the set of alternative flavor bans. Panel B presents predictions of the impact of these flavor bans on cigarette type choice shares. Panel C displays the percentage change in the choice shares between the current policy and each of the proposed policies; these are calculated directly from panel B.

Policymakers can use these predictions to design optimal flavor bans based on their policy goals. However, the optimal policy also depends on the policymaker's view of e-cigarettes as a harm reduction device and how this view defines their objective. We see two likely goals: 1) to minimize the selection of combustible cigarettes, as they are arguably the most dangerous, and 2) to maximize the choice of abstaining, which we proxy with “none of these.” For using either of these goals as selection criterion, the table provides the needed information.

The predicted shares of cigarette type choices under the current set of flavor bans are, as seen in the first row of panel B of Table 5: 45.2 percent for combustible cigarettes, 37.5 percent for e-cigarettes, and 17.2 percent for “none of these.” Note that these choice shares are roughly in line with the reported smoking statuses in Table 3. Exact matches would not be expected since we are experimentally varying products’ attributes, respondents are making two discrete choices, and the smoking categories are not perfectly comparable across the two measures. But the similarity is nonetheless encouraging.

The results from panel B of Table 5 indicate that policymakers seeking to minimize the use of combustible cigarettes should ban only menthol (policy alternative 3). This results in the lowest choice of combustible cigarettes—at 40.0 percent—across the policy options, which represents a 5.2 percent reduction in the percentage of choices that are combustible cigarettes (panel C). Of this reduction, the majority goes to e-cigarettes at 3.8 percent, with the remaining choices being “none of these" at 1.6 percent.

Policymakers seeking to minimize the use of all cigarette types should ban all flavors in both cigarette types (policy Alternative 1). In Alternative 1, as seen in panel B, 22.4 percent of the choices would be “none of these”; this is the highest choice of “none of these.” Those who prefer e-cigarettes for their flavors are predicted to change their choice of cigarette type (or choose none) when these flavors are banned. Specifically, as seen in panel C, e-cigarette choice declines by 7.9 percent; instead, people increase their choice of combustible cigarettes by 2.7 percent and “none of these” by 5.2 percent. Thus, when denied their first choice of flavored e-cigarettes, they select their next preferred alternatives, with some choosing combustible cigarettes and almost twice as many choosing “none of these.”

Importantly, Table 5 indicates that the recent comprehensive e-cigarette flavor ban proposed by the FDA would not maximize either of the above goals. Although the comprehensive ban would result in the second-largest reduction in selecting either cigarette type, as seen in panel B (20.2 percent of the choices would be “none of these”), the selection of combustible cigarettes would increase from 45.2 percent to 53.4 percent (see panel B). Unfortunately, as seen in panel C, 8.3 percent would change from e-cigarettes to combustible cigarettes—the most dangerous type—and only around 3.0 percent would choose “none of these.” Thus, this policy would likely drive current e-cigarette users toward cigarettes more than toward abstinence.

DISCUSSION AND CONCLUSIONS

Flavor bans for e-cigarettes and menthol in combustibles are pressing policy issues that have received relatively little empirical study. Now that the FDA has the power to regulate flavors in both combustible and e-cigarettes, it has again been considering flavor bans for all types of cigarettes (FDA, 2017). Thus, there is an urgent need for an analysis of the impact of flavor bans on public health. Despite the need for this information, there are no studies predicting the impacts of alternative bans on the use of combustibles, e-cigarettes, and neither. We provide such information for adult smokers and recent quitters using a DCE and a large, nationally representative survey.

Findings

We find that flavors themselves serve as an attribute that drives choices across combustibles and e-cigarettes and choosing none. We conclude that flavor bans can be effective levers that affect smokers’ choices. Alternative flavor bans can either enhance protection of the health of the public or worsen it. Specifically, our results indicate that banning flavors in e-cigarettes, while allowing them to remain in combustibles, would result in the greatest increase in smoking of combustible cigarettes; and the use of e-cigarettes would decline (10.3 percent).

By comparison, we find that a ban on menthol combustible cigarettes would produce the greatest reduction (4.8 percent) in the use of combustible cigarettes across the flavor bans that we study. Much of this movement from combustible cigarettes would be to e-cigarettes (3.5 percent) and the remainder would be toward "none" (1.3 percent). Given that combustible cigarettes impose the most significant harms on those who smoke them, reducing the smoking rate would likely increase the health of the public. Our results suggest that policymakers need to consider simultaneously the impact of flavor policies on combustibles, e-cigarettes, and abstinence.

Strengths and Limitations

We add to the literature in several ways including using robust methods to address timely policy questions empirically that have not been fully studied. Specifically, we make needed predictions about a wide set of flavors across e-cigarettes and combustibles. Use of the DCE approach is one of the few ways that allows for examination of the set of counterfactual flavor policies. We collected our own data from a nationally representative sample comprising current and former smokers. Using these data, we present the only available estimates of alternative flavors bans across both combustible and e-cigarettes for the U.S. In addition, we present what we believe are the first estimates of how preferences for flavored cigarettes vary across individual characteristics; furthermore, because we estimate the effects within a single sample using the same methods, our comparisons across groups are more comparable and consistent than what could be gleaned from multiple studies. In addition, we have conducted our experiment in line with best practice (Johnson et al., 2013), found evidence of internal and external validity of the results, and applied a broad range of robustness checks and sensitivity analyses.

Despite the above strengths, our study has several limitations. First, DCEs rely on hypothetical choice: we observe stated choices and not real-world behaviors. Thus, there is a risk of hypothetical bias (Harrison, 2014). To help address this concern, our sample includes current and recent smokers, individuals who have made such real-world decisions. In addition, DCEs tend to perform well when the range of options is small and familiar to the respondents (McFadden, 2014), which is the case here since all respondents are current or recent smokers. A second limitation is that, while the demographics of our sample are nationally representative, smokers in our sample smoke slightly more heavily than the U.S. average. Third, while the impact on adult smokers and recent quitters is an important consideration, our results are pertinent only to these groups. Youth smoking decisions should be examined separately, but that was beyond the scope of this study. Fourth, the meaning of the "none of these" option is somewhat ambiguous. Lastly, 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.

Policy

Our results have important policy implications for flavor bans. According to our predictions, a ban on flavored e-cigarettes would drive smokers to combustible cigarettes, which have been found to be the more harmful way of getting nicotine (Goniewicz et al., 2017; Shahab et al., 2017). In addition, such a ban reduces the appeal of e-cigarettes to those who are seeking to quit; e-cigarettes have proven useful as a cessation device for these individuals (Hartmann-Boyce et al., 2016; Zhu et al., 2017), and we find that quitters have a preference for flavored e-cigarettes.

However, these results refer to adult smokers and recent quitters, not those under age 18. With 36.5 million adult smokers in the U.S., policy that protects the health of those over 18 is critical.

To best apply our findings to protect public health, policymakers should determine their stance on the potential health impacts of e-cigarettes. Specifically, is their main aim to encourage smokers of combustible cigarettes to switch to e-cigarettes to reduce the harms to their health? Or is the primary aim to reduce the use of either type of cigarettes? Given the goals of regulators, our predictions provide information that is not otherwise available but is needed by policymakers. This information is timely, given that cities and counties are adopting flavor ban policies and that the FDA has been actively considering bans on both e-cigarettes and menthol in combustible cigarettes. Our 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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Table 1: Potential flavor bans policy options

	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
Proposed FDA Policy: ban all ecig flavors	Allow	Ban	Ban	Ban
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

Fig. 1: Example Choice Scenario

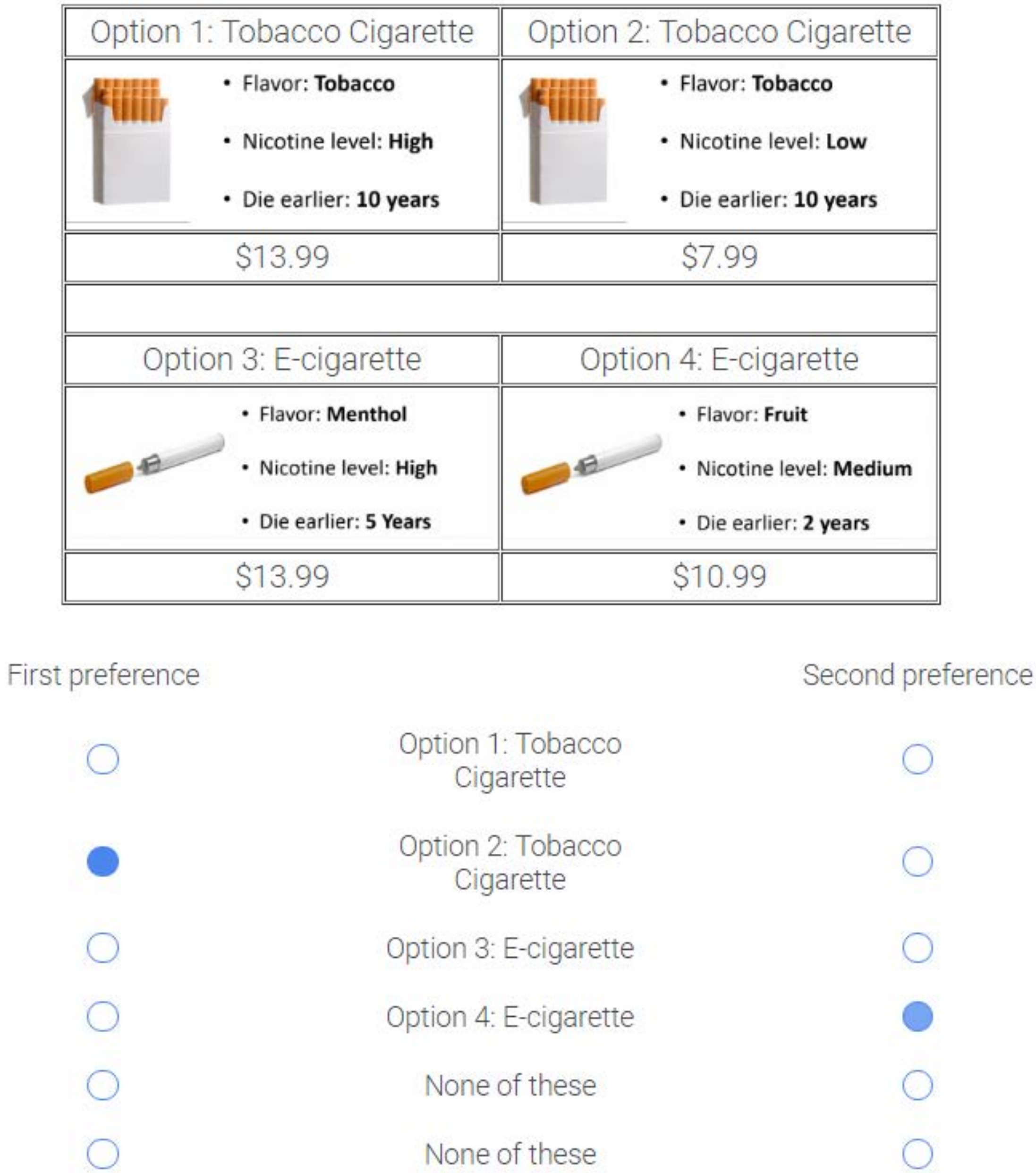

Table 2: Experimental design: attributes and levels that were varied throughout the choice scenarios

	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

Table 3: Descriptive statistics of respondent characteristics

Variable	Mean (%)
<u>Sociodemographic variables</u>	
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
<u>Smoking-related variables</u>	
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 model output from exploded logit models

Panel A

	Cigarette choice model		Cigarette choice model with interactions	
<u>Parameters</u>	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	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)	***
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)	
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)	
Female	0.14 (0.078)	*	0.05 (0.065)		-0.08 (0.094)		-0.02 (0.076)	

Notes: Sig. – significance: *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. Coef. – coefficient; s.e. – clustered standard errors.

Table 5: Policy predictions of cigarette type choice shares and percentage changes in shares across alternative flavors

	Panel A				Panel B			Panel C		
	Permitted flavors by cigarette type				Cigarette type choice shares (%)			Change in choice shares (%)		
	Combustible cigarettes		E-cigarettes							
Policy	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
Proposed FDA policy	Allow	Ban	Ban	Ban	53.5	26.4	20.2	8.3	-11.1	3
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

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 US 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.