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# BMJ Open

## Product Attributes Important to Adult Consumers' Use of Electronic Nicotine Delivery Systems: a Discrete Choice Experiment

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Manuscripts

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5 **Systems: a Discrete Choice Experiment**  
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**Author Contributions:** CK, LMR, ELS, KC, MLB, GAZ and AOG all contributed to the conceptualization and design of the survey. CK and KC assisted with data collection. CK,

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LMR, ELS, KC, CJW, CE, CM, MLB, GAZ and AOG participated in the analysis of the data.

All authors contributed to the content and reviewed the manuscript prior to submission.

For peer review only

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2  
3 **ABSTRACT, word count 300**  
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6 **Objective:** To understand the importance of electronic nicotine delivery systems (ENDS)  
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8 product attributes to adult consumers in the United States by age and gender.  
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11 **Design:** Cross-sectional survey with a discrete choice experiment (best-worst, case 2, scaling) of  
12  
13 19 choice tasks in which participants answered what would make them most want to use and  
14  
15 least want to use an ENDS product.  
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19 **Setting and Participants:** A national sample of adults (age 18+) in the United States who had  
20  
21 tried an ENDS product at least once.  
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25 **Measures:** We included nine ENDS attributes with levels that varied across the 19 choice tasks.  
26  
27 We performed a multinomial logistic regression to obtain overall importance scores, attribute-  
28  
29 level part-worth utilities, and most important attribute.  
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32  
33 **Results:** Of 660 participants, 81% were white, 51% female, and 37% had at least a 4-year  
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35 college degree with an average age of 42.0 years (SD ±19.4). The attributes had the following  
36  
37 importance: *Health Effects* 17.6%; *General Effects* 14.1%; *Cessation Aid* 12.6%; *Purchase Price*  
38  
39 12.1%; *Monthly Cost* 12.0%; *Nicotine Content* 11.4%; *Flavor Variety* 8.4%; *Device Traits* 7.2%;  
40  
41 *Modifications* 4.6%. *Health Effects* was the most important attribute for all ages and genders  
42  
43 ( $p < 0.05$ ); variation in other important attributes existed by age, though not gender.  
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47 **Conclusion:** This study identified the importance of nine ENDS attributes. Perceived *health*  
48  
49 *effects* of ENDS use appeared most important, and *modifications* was least important. Variation  
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51 by consumer group existed, which may allow for targeted interventions to modify ENDS use.  
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3 **Key Words:** electronic nicotine delivery system, e-cigarettes, vaping, importance, attributes,  
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5 part-worth utilities, preference  
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8 **Strengths and Limitations of the Study:**  
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11 **Article Summary:**  
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- 13  
14 • Consumers find different attributes of ENDS products important to their use.  
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16 • Perceived harms of ENDS use appeared most important to their choice of ENDS  
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18 products, and modifiability was least important.  
19  
20 • Variation by consumer group existed, which may allow for targeted interventions to  
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22 modify ENDS use.  
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24 • Limitations include the convenience sample of United States ENDS users, and the use of  
25  
26 an experimental design as opposed to direct purchasing observations.  
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31 **Data Sharing: Data can be requested from Christine\_Kistler@med.unc.edu**  
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## INTRODUCTION, word count=3477

Though its health effects remain unclear, the use of electronic nicotine delivery systems (ENDS) in the United States (U.S.) continues to grow even in the face of impending regulation.<sup>1</sup> While the use of combustible tobacco cigarettes has declined, the U.S. ENDS market now exceeds \$8 billion.<sup>2 3</sup> The rise in the use of ENDS has occurred despite mixed evidence about its harm reduction effects or use as a tobacco cessation aid.<sup>4</sup> Given the uncertainty around ENDS, initial regulations were piece-meal and varied from state to state. However, in 2016, the Food and Drug Administration (FDA) issued a regulation deeming ENDS to fall under its authority.<sup>5</sup> These regulations will impose a variety of restrictions on ENDS manufacturing, sales, and marketing. Notably, however, the FDA has postponed implementation of some of the rule's requirements, citing the possibility that ENDS have the "potential to make a notable public health difference."<sup>6</sup> As the potential benefits and harms of ENDS become clear, regulators and public health groups will need to understand how their proposed regulations will likely affect consumers' use. Consumers use ENDS due to a variety of product attributes that may be amenable to regulation or public health campaigns.<sup>7</sup> Regulators and public health groups need to know the incremental role of individual product attributes on the decision to use ENDS products so that they can make evidence-based policies depending on how they want to modify ENDS use.

A widely-used method in behavioral economics to understand consumer use is through discrete choice experiments (DCE).<sup>8 9</sup> Once the relationship between consumers' use and product attributes is understood, regulators can consider whether and how to address the attributes most important to the most consumers to either increase or decrease product use. While DCEs have been conducted to examine consumers' attitudes towards combustible tobacco regulations and smoking cessation,<sup>10-14</sup> only one has examined potential ENDS use.<sup>15</sup> This recently published



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3 study conducted in Canada examined only four ENDS attributes: flavor, nicotine content, health  
4 warnings and price;<sup>15</sup> finding that health risks and efficacy as a tobacco cessation aid were the  
5 two most important attributes to consumers. However, this study only examined four attributes  
6 and included non-smokers and non-ENDS users.  
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12 Knowledge from our formative qualitative work was used to create a DCE with a larger number  
13 of attributes, focused on ENDS users. We examined the list of a dozen attributes important to  
14 consumers we developed from a recent structured content analysis.<sup>16</sup> Among these twelve  
15 attributes, we found nine attributes that appeared related to the ENDS device itself.<sup>16</sup> We chose  
16 to look at the device-related attributes because these attributes may be more easily regulated than  
17 other psycho-social attributes such as the ability to vape in public or as a social outlet.<sup>17 18</sup> We  
18 designed and fielded a DCE study using a best-worst scaling experiment, among a national U.S.  
19 sample of ENDS users.  
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## 31 **METHODS**

### 32 **Study Design and Participant Involvement**

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35 We conducted a one-time survey of the importance of ENDS product attributes. The attributes  
36 used in the DCE were developed through focus groups.<sup>19</sup> The study involved participants in a  
37 pre-test phase using an academic mass email system. Twelve individuals pretested the survey  
38 between May 9<sup>th</sup> and May 14<sup>th</sup>, 2016. Incentive for completing the survey included possibly  
39 receiving 1 of 4 gift cards valued at \$50 each. Feedback from the pretest led to both condensing  
40 and simplifying the language of the survey. Clarity of the survey was again improved after  
41 another round of testing with 75 survey panelists recruited from Research Now, a research  
42 survey company, between August 15<sup>th</sup> and 16<sup>th</sup>, 2016. The second episode of testing also led to  
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3 language alterations surrounding questions on the flavor attribute and its levels. The final version  
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5 of the survey was fielded using the survey panel between August 26<sup>th</sup> and August 31<sup>st</sup>, 2016.

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8 Participants were remunerated from Research Now, in accordance with their usual rate. The  
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10 institutional review board at the University of North Carolina at Chapel Hill approved this study.

### 11 12 13 **Participants**

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16 We recruited 660 members of the Research Now survey panel aged 18 and older who reported  
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18 having used ENDS at least once in their lifetime to complete the ENDS survey. Research Now is  
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20 one of the major online survey panel companies with over 140 million finished surveys annually.  
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22 Participants had to live in the United States and be able to complete an electronic survey in  
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24 English. We specifically oversampled for older adults and minimum quotas to ensure near equal  
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26 balance of gender.  
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### 29 30 31 **Survey Design**

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33 The survey was designed to include a best-worst scaling experiment related to ENDS use  
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35 followed by a series of tobacco and ENDS-related questions. The survey included nineteen best-  
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37 worst scaling choice tasks, followed by questions on each participant's demographics,  
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39 personality, current and past use of ENDS and tobacco products, and prior attempts to quit  
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41 tobacco use. Sawtooth Software was used to design the survey. Prior to the best-worst tasks, the  
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43 survey provided an explanation for each of the attributes, as well as an example task involving  
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45 car attribute preference followed by an example of a best-worst scaling task (Figure 1). [Insert  
46  
47 Figure 1] The participants were told that some of the attributes were real but others were not and  
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49 were asked, for the purposes of the study, to pretend they were all real, and imagine each choice  
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51 task as a new device. As opposed to other types of DCE methods where consumers choose  
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3 between ENDS products, for each of the nineteen choice tasks, participants selected one of five  
4 listed attribute levels that they felt most likely to encourage and least likely to encourage their  
5 use of a theoretical ENDS product. While other approaches such as a classical DCE would also  
6 yield importance scores, past studies demonstrated user fatigue and attribute dominance due to  
7 complex and overwhelming survey questions, whereas best-worst scaling, though not case 2, has  
8 been used in other areas of tobacco control.<sup>20-23</sup> Additionally, best-worst scaling case 2  
9 methodology was preferred because it leads to scores on a common scale, permitting direct  
10 comparison between all attribute levels within the study, not just direct comparisons among  
11 levels within the same attribute (as is the case for other DCE methods).<sup>24 25</sup> The 660 participants  
12 received 1 of 50 versions of the survey- using a partial profile design. Overall, each attribute  
13 level was seen about 3 times per participant (2.97), and each valid cross-attribute pair was seen  
14 not quite half the time by each participant (0.42 times). Reliable best-worst utilities can be  
15 obtained as long as each participant sees each level about 3 times.<sup>26</sup> The order of attributes  
16 varied across the survey blocks so that positional balance was maintained.

### Best-worst Scaling Attributes and Levels

The nine attributes were included with a definition in the survey. They were:

1. Health effects of e-cigarettes use: This is how much the device affects your health, specifically, the harms to your body as compared to tobacco cigarettes. Imagine these harms are things like cancer, lung diseases, circulation problems, heart attacks, and strokes. These options range from less harmful to your body than tobacco cigarettes to more harmful.

## ENDS Best-Worst Scaling

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3 2. General Effects of E-Cigarette Use: This is how an e-cigarette affects you overall after  
4 you use it. Options include that it helps you breathe easier and your clothes do not smell  
5 like tobacco to it does not help you breathe easier and your clothes do smell like tobacco.  
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- 10 3. Quitting Tobacco: This is how much the device can help a person quit using tobacco. It  
11 can range from helping 7 out of 10 people quit smoking to not helping a person quit at  
12 all.  
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- 16 4. Purchase Price of the Device: This is how much a person can expect to spend when  
17 starting to use the product, including the device and any other necessary pieces. The costs  
18 range from \$5 to \$175.  
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- 24 5. Monthly Cost of Use: This is how much a person can expect to spend each month with  
25 routine use of an e-cigarette. The costs range from \$5 to \$100 per month to use.  
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- 29 6. Nicotine Content: This is how much nicotine is available to use in the electronic vapor  
30 product. Choices range from high levels to none.  
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- 33 7. Flavor Variety: This is how many different types of e-juice flavors that the e-cigarette is  
34 available in. E-juice flavors may be one of the following, flavorless/unflavored; tobacco  
35 or menthol flavors, or many other flavors such as fruit, candy, coffee, and others.  
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- 40 8. Device Traits: This is how a device looks and feels as you use it, including the feel of  
41 inhaling the device, holding the device, its appearance, and other traits. These options  
42 range from a user experience much like a tobacco cigarette to a user experience very  
43 different from a tobacco cigarette.  
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- 49 9. Modifications: Some e-cigarettes can be modified. This is how much you can alter the e-  
50 cigarette to meet your needs. This doesn't include refilling or replacing an e-juice  
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3 cartridge. Choices include being able to modify the device and not being able to modify  
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5 the device.  
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8 For the rest of the paper, we will refer to these nine as *health effects, general effects,*  
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10 *cessation aid, purchase price, monthly cost, nicotine content, flavor variety, device traits, and*  
11 *modifications*.<sup>16</sup> We chose to divide cost into a separate purchase price and monthly cost  
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13 attributes because of the variation that can be seen in each; the focus group members  
14  
15 mentioned the two attributes separately as well. Rates of tobacco cessation for ENDS  
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17 products were drawn from the evidence that ENDS are often used as a tobacco cessation aid,  
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19 regardless of actual effectiveness. It is worth noting that medications prescribed for assisting  
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21 in tobacco cessation (e.g., bupropion, varenicline, nicotine containing products) have only a 2  
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23 out of 10 success rate at best.<sup>27</sup>  
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### 30 **Other Measures**

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32 Participants responded to questions about sex, age, race and ethnicity, perceptions of general  
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34 health,<sup>28</sup> education level, and yearly household income. The survey then collected details about  
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36 each participants' tobacco and ENDS use behaviors. Items included the heaviness of smoking  
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38 index, which asks participants "At present, how long after waking do you wait before having  
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40 your first cigarette (in mins)?" and "How many cigarettes do you smoke per day at present?"<sup>29</sup>  
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42 and other questions from the National Adult Tobacco Survey Questionnaire, 2012-2013, such as  
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44 age of first cigarette, number of cigarettes smokes per day, and smoking days per month.<sup>30</sup>  
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### 49 **Analysis**

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52 In DCEs, respondents are given tasks that combine possible varieties of product attributes and  
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54 asked to make a choice; in our case, which attribute of the product was important to their use.  
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3 With enough choice tasks, estimated importance scores can be generated, indicating which  
4 attribute most influenced their choices. The statistical model underlying best-worst scaling  
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6 assumes that the relative choice probability of a given pair of best-worst choices is proportional  
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8 to the distance between the two attribute levels on the latent utility scale. The pair of attribute  
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10 levels chosen maximizes the difference in the part-worth utilities for a given choice task. These  
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12 distances between attribute levels are modelled as a difference model, with variations on best-  
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14 worst scaling sometimes called “maximum difference scaling”.<sup>31</sup> Using a multinomial regression  
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16 model, these differences can provide the part-worth utilities relative to a single attribute level,  
17  
18 rather than relative to the sample mean.<sup>24</sup> Part-worth utilities are zero-centered numerical values  
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20 that represent the relative desirability of the levels within each attribute. The higher the number,  
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22 the more desirable the attribute’s level is to participants. Importance scores were then calculated,  
23  
24 based on the difference between minimum and maximum part-worth utilities within an  
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26 attribute.<sup>25 32</sup> The total importance of all attributes to a decision is 100%, with each attribute a  
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28 percentage of that total importance. Most important attribute was determined by comparing the  
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30 importance scores for each individual, defining the attribute with the largest importance score as  
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32 most important. In order to examine changes in attribute importance by age and gender, we  
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34 performed a dependent z-test of proportions to compare the most important attribute to the next  
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36 highest ranked attribute by age and gender.  
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## 45 RESULTS

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48 Of 900 individuals surveyed, 660 participants had used ENDS at least one time. Participants had  
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50 a mean age of 42 ((SD) ± 19.4), with a range from 18 to 82 years-old, and were evenly split  
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52 female versus male (51% v 49%) (Table 1) [insert Table 1]. Most participants were white (81%),  
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54 making less than \$60,000 annually (60%), and self-reported very good or excellent health (60%).  
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Sixty-four percent had used ENDS in the last 30 days. Almost all participants (92%) reported a history of traditional tobacco products and most (85%) had tried to quit tobacco in the past 12 months. Pearson's  $\chi^2$  tests of the relation between age and tobacco use characteristics found statistically significant ( $p < .05$ ) differences between sub-groups of young (18-24), middle-aged (25-49), and older (50+) adults. For example, young adult participants were more likely to have used ENDS in the last 30 days ( $p = .036$ ) and to have used flavored ENDS ( $p = .012$ ). Older adults were less likely to use ENDS ( $p < .001$ ) and more likely to smoke one pack/day of traditional tobacco ( $p < .001$ ) (see table 2).

### **Importance of ENDS attributes overall and by subgroup**

The overall importance scores for the nine attributes are found in Figure 2. [Insert Figure 2] The attributes had the following importance distribution: *Health Effects* 17.6%; *General Effects* 14.1%; *Cessation Aid* 12.6%; *Purchase Price* 12.1%; *Monthly Cost* 12.0%; *Nicotine Content* 11.4%; *Flavor Variety* 8.4%; *Device Traits* 7.2%; *Modifications* 4.6%. Independent t-tests of the importance scores by gender found that when compared with males, female participants were more likely to give importance to *Health Effects* ( $\Delta+9.7\%$ ;  $p < .001$ ) and *General Effects* ( $\Delta+8.1\%$ ;  $p = .002$ ), and less likely to give importance to *Purchase Price* ( $\Delta-8.3\%$ ;  $p = .011$ ) and *Monthly Cost* ( $\Delta-6.8\%$ ;  $p = .008$ ).

Numerous statistically significant differences were found by age sub-groups. Younger adults compared with middle-aged and older adults together were more likely to give importance to *Modifications* ( $\Delta+22\%$ ;  $p = .004$ ) and less likely to give importance to *Purchase Price* ( $\Delta-11\%$ ;  $p = .006$ ). Middle-aged adults compared with young and older adults together were more likely to give importance to *Modifications* ( $\Delta+24\%$ ;  $p = .001$ ) and less likely to give importance to *Health Effects* ( $\Delta-5\%$ ;  $p = .027$ ). Older adults compared with middle-aged and young adults

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3 together were more likely to give importance to *Purchase Price* ( $\Delta+11\%$ ;  $p = .004$ ) and less  
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5 likely to give importance to *Modifications* ( $\Delta-34\%$ ;  $p < .001$ ).  
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### 8 **Part-worth utilities of ENDS attribute levels**

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11 The part-worth utility scores for the levels of the nine attributes are shown in Table 2. [Insert  
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13 Table 2] *Health Effects* had the level with the highest part-worth utility of 88.96 (90% CI: 84.79,  
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15 93.13), followed by *General Effects* with a level at 58.37 (90% CI: 55.07, 61.68), and *Purchase*  
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17 *Price* at 52.41 (90% CI: 49.12, 55.70). *Cessation Aid* had the level with the lowest part-worth  
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19 utility of  $-49.11$  (90% CI:  $-52.46$ ,  $-45.75$ ), followed by *Health Effects* at  $-47.27$  (90% CI:  
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21  $-49.69$ ,  $-44.86$ ).  
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### 26 **Most important ENDS attribute overall and by sub-group**

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29 After examining the importance scores for each individual, *Health Effects* was the most  
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31 important attribute for 49% of participants (Table 3). [Insert Table 3] *Nicotine Content* was next  
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33 most frequent (13%) and *Purchase Price* was third (12%). A goodness-of-fit  $\chi^2$  test determined  
34  
35 that the nine attributes differed from expected and thus were not equally distributed among  
36  
37 participants ( $p < .001$ ). Also, dependent z-tests of the proportions of the second through ninth  
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39 ranked attributes against *Health Effects* found that all were significantly lower ranked and were  
40  
41 less likely to be chosen as most important (Range:  $\Delta-83\%$ - $99\%$ ;  $p < .001$ ). Aside from *Nicotine*  
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43 *Content* compared with *Health Effects*, stepped tests of each attribute against its nearest found  
44  
45 that only *Device Traits* ( $p = .005$ ) and *Modifications* ( $p = .020$ ) were statistically significantly  
46  
47 less important.  
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53 The nine attributes also statistically significantly differed from the expected distribution by the  
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55 sub-groups for age and gender ( $p < .001$ ). Pearson's  $\chi^2$  tests of the relation between the age sub-  
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3 groups and most important attribute found that *General Effects* was the most important attribute  
4  
5 for younger adults as compared to other ages ( $p < .001$ ). Compared to younger and older adults,  
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7 *General Effects* was less likely to be the most important attribute for middle aged adults ( $p = .029$ )  
8  
9 and *Flavor Variety* was more likely to be most important ( $p = .018$ ). Compared to both younger  
10  
11 and middle-aged adults, *Health Effects* was more likely to be most important ( $p = .016$ ) and *Flavor*  
12  
13 *Variety* less likely ( $p = .003$ ). There were no statistically significant differences in the distribution  
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15 of most important attributes by gender though *Health Effects* ( $p = .061$ ) and *Cessation Aid* ( $p =$   
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17  $.075$ ) approached significance.  
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## 21 DISCUSSION

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23 In our study of US adult ENDS consumers, we found that *Health Effects* had the highest  
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25 importance to consumers' choice of an ENDS product. Other than cost (i.e., *Purchase Price* and  
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27 *Monthly Cost*), the attributes with the highest importance scores hinged on consumers'  
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29 perceptions of efficacy as a harm reduction strategy (*Health Effects*), health benefit (*General*  
30  
31 *Effects*), and tobacco cessation (*Cessation Aid*), respectively. Consumers of different ages varied  
32  
33 in importance they placed on different ENDS product characteristics. As more evidence about  
34  
35 these products' ability to benefit or harm consumers is more fully understood, public health  
36  
37 initiatives could target these perceptions. Variation by consumer group existed, which may allow  
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39 for targeted interventions to reduce or enhance ENDS use in any given consumer group.  
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46 ENDS products are marketed as healthier than combustible tobacco products,<sup>33</sup> but the evidence  
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48 regarding the impact of ENDS products on human health is slowly emerging. National  
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50 Academies of Science, Engineering, and Medicine recently released a report on the public health  
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52 consequences of ENDS products.<sup>34</sup> While there is substantial evidence that, except for nicotine,  
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54 exposure to potentially toxic substances from ENDS is significantly lower compared with  
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3 combustible tobacco products, there is also substantial evidence that exposure to ENDS aerosols  
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5 can induce lung dysfunction and oxidative stress in human tissue.<sup>35</sup> The long-term effects on  
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7 cardiovascular outcomes, cancer or other health conditions are unclear. Our work should add a  
8  
9 sense of urgency to the push for ongoing research into the evidence for and against ENDS  
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11 products as a harm reduction strategy. The idea that an ENDS product was less harmful than  
12  
13 tobacco cigarettes was extremely important to participants' choice. The level, that the product  
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15 was "less harmful on my body as compared to tobacco cigarettes", had the highest part-worth  
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17 utility of any attribute (88.96). Moreover, the level that the product "had the same amount of  
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19 harm on my body as compared to tobacco cigarettes" caused people to avoid choosing that  
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21 product and had a negative utility (-22.45). Both the *Health Effects* and the use as a *Cessation*  
22  
23 *Aid* had levels that are likely healthier and of more help in cessation than the evidence suggests.  
24  
25 Yet in general, perceptions, including misperceptions, affect smokers' behavior.<sup>36</sup> The look and  
26  
27 feel of cigarette packaging appears to influence consumers' use and may affect their perceptions'  
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29 of the healthiness and harm of the cigarettes within.<sup>37</sup> A study of combustible tobacco labeling  
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31 revealed that "additive-free" or "natural" labels on current cigarette brands were misperceived to  
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33 be possibly less harmful than other brands of cigarettes and may reduce the efficacy of public  
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35 health initiatives.<sup>38</sup> Even efforts by the Federal Trade Commission to prohibit language that  
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37 might create misperceptions of reduced harm in tobacco cigarettes has been unsuccessful.<sup>36</sup> This  
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39 (mis)perception of harm and health appears to strongly influence the choice of ENDS products.  
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41 Further efforts, including those studying clear labeling and health warnings, are needed to  
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43 explore how to align ENDS users' perceptions of ENDS products with the evidence.  
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52 While *Health Effects* had the highest importance score, the combined importance of *Purchase*  
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54 *Price* and *Monthly Cost* was greater than *Health Effects*, so the importance of financial burden on  
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3 ENDS use should not be underestimated. If we combine the two cost-related attributes, *Purchase*  
4 *Price* and *Monthly Cost*, overall cost's importance score would be 24.1% as compared to 17.6%  
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6 for *Health Effects*. A recent study of the cross-price elasticity of ENDS and tobacco cigarettes  
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8 found that ENDS are partially substitutable for cigarettes.<sup>39</sup> However, the availability of ENDS  
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10 also reduced the number who reported they would quit smoking if cigarette costs increased by  
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12 20% (50.2% to 30.0%), revealing that ENDS may discourage smokers from quitting  
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14 completely.<sup>40</sup> Additionally, increases in the cost of ENDS products may shift consumers back  
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16 towards combustible tobacco, though recent simulations found no relationship between cigarette  
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18 prices and ENDS use.<sup>41</sup> Taxation may reduce ENDS use but further work is needed to model the  
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20 consequences of price increases on ENDS use.  
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27 Potentially meaningful differences were found in the importance of ENDS product attributes and  
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29 the most important attribute by different age groups. Younger and middle-aged adults found  
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31 *Modifications* to be more important than older adults. While we did not see gender differences  
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33 for attribute preferences, a Canadian DCE study of young women found that pack structure was  
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35 the most important attribute driving ENDS use.<sup>14</sup> The shape and structure of the device and  
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37 packaging may be more important to a younger population. Younger adults were more likely to  
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39 have *General Effects* as their most important attribute while *Flavor Variety* was more likely to be  
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41 most important to middle-aged adults and significantly less likely to be most important to older  
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43 adults. A systematic review of studies of consumers' preference for flavor found flavor to be  
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45 likely important to young people.<sup>7</sup> However, as with our own qualitative study, which was  
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47 included in the review, many of the included studies did not have experimental designs.<sup>16</sup>  
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50 Interestingly, another Canadian DCE study of ENDS use found that younger smokers perceived  
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52 cherry flavor as less harmful while older adults found tobacco flavor less harmful.<sup>15</sup> While we  
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3 found *Flavor Availability* was more important to middle-aged adults, we did not find older adults  
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5 favored tobacco flavoring. However, both of these studies found that attributes related to the  
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7 users' health (*health effects* in our case and health warnings in the Canadian study) were more  
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9 important than flavor, and thus efforts to regulate flavors may not reduce ENDS use as much as  
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11 other regulations on other attributes, such as health effects.  
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15 Our study has several important limitations. First, our study examines choice behavior and not  
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17 actual purchase behavior. While we drew from a national online survey panel, our respondent  
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19 population is limited to a convenience sample. Additionally, best-worst scaling can be subject to  
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21 attribute non-attendance, where participants either fail to pay attention to an attribute or  
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23 attributes, or attribute dominance, where participants only pay attention to a single attribute. We  
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25 found that only about 2% of participants did not attend to the majority of attributes, though about  
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27 16% failed to attend to at least one attribute. No participant showed dominance behavior. While  
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29 there was some attribute non-attendance, best-worst scaling inclines participants to make  
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31 judgements about more attributes and does not invite as much attribute non-attendance or  
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33 dominance as can be seen in other standard DCEs. However, it seems more likely that socially  
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35 desirable responses could bias respondents' choices within best-worst scaling than other DCEs  
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37 might.<sup>24</sup>  
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## 43 CONCLUSION

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46 A variety of ENDS product attributes are important to consumers. *Health Effects* had the highest  
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48 importance to consumers' choice of an ENDS product. Other than cost, the attributes with the  
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50 highest importance scores hinged on consumers' perceptions of efficacy as a harm reduction  
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52 strategy (*Health Effects*), general benefit (*General Effects*), and tobacco cessation (*Cessation*  
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54 *Aid*), respectively. Consumers differed by age group in some of the more important attributes.  
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3        Though the overall importance of ENDS product attributes was similar, efforts to increase or  
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5        decrease ENDS use could be tailored to these group differences.  
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## ENDS Best-Worst Scaling

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Table 1. Participants' Demographic Characteristics, N (%)

Characteristics	Total, N=660	Age 18-24, N=169	Age 25-49, N=242	Age 50+, N= 249
Age, mean (SD)	42.0 (19.4)	22.2 (1.6)	32.1 (7.7)	65.0 (6.9)
Female	334 (51%)	90 (53%)	120 (49%)	124 (50%)
Race				
White	532 (81%)	113 (67%)	191 (79%)	228 (92%)
Black	42 (6%)	14 (8%)	18 (7%)	10 (4%)
Asian-American	40 (6%)	20 (12%)	18 (7%)	2 (1%)
Other	46 (7%)	22 (13%)	15 (6%)	9 (4%)
Hispanic or Latino/Latina	94 (14%)	42 (25%)	45 (19%)	7 (3%)
College degree or higher	247 (37%)	37 (22%)	113 (47%)	97 (38%)
Overall Health, very good or excellent	396 (60%)	110 (65%)	160 (66%)	126 (51%)
Annual Household Income,				
\$0 to \$29,999	149 (23%)	52 (31%)	51 (21%)	46 (18%)
\$30,000 to \$59,999	247 (37%)	75 (44%)	85 (35%)	87 (35%)
\$60,000 to \$89,999	156 (24%)	25 (15%)	73 (30%)	58 (23%)
\$90,000 or more	106 (16%)	17 (10%)	33 (14%)	58 (23%)
Knowledge that quitting smoking with help is more successful than without	310 (47%)	75 (44%)	108 (45%)	127 (51%)
Used ENDS in last 30 days <sup>1</sup>	387 (64%)	109 (71%)	153 (69%)*	125 (54%)*
Used flavored ENDS in last 30 days, of current ENDS users <sup>2</sup>	296 (70%)	93 (79%)*	134 (79%)*	69 (52%)*
Anticipates ENDS use in next year	478 (72%)	121 (72%)	193 (80%)*	164 (66%)*
Ever used traditional tobacco products	607 (92%)	154 (91%)	221 (91%)	232 (93%)
Age at first cigarette, mean (SD) <sup>1</sup>	17 (6)	16 (3)	18 (5)	18 (8)

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## ENDS Best-Worst Scaling

Smokes more than 1 pack/day <sup>3</sup>	54 (12%)	3 (3%)*	12 (8%)*	39 (23%)*
First smoke within 30 minutes of waking <sup>3</sup>	256 (59%)	48 (44%)*	89 (59%)	119 (70%)*
Tobacco quit attempt in past 12 months <sup>3</sup>	369 (85%)	87 (79%)*	130 (85%)	152 (89%)

Note. \*  $p < .05$ ; Test versus total. <sup>1</sup> n=607, 154, 221, and 232, respectively; <sup>2</sup> n=420, 117, 170, and 133, respectively; <sup>3</sup> n=432, 110, 152, and 170, respectively.

Table 2. Final ENDS attributes, levels, and mean utilities, n=660

ENDS Attributes	Levels of ENDS Attributes	Part-worth Utilities, Mean (95% CI)
Harms of Use	Less harmful on my body as compared to tobacco cigarettes	88.96 (84.79, 93.13)
	Unknown harm on my body as compared to tobacco cigarettes	-19.24 (-21.32, -17.17)
	Same amount of harm on my body as compared to tobacco cigarettes	-22.45 (-24.90, -19.99)
	More harmful on my body as compare to tobacco cigarettes	-47.27 (-49.69, -44.86)
General Effects of Use	Helps me breathe easier AND my clothes don't smell like tobacco	58.37 (55.07, 61.68)
	Helps me breathe easier, BUT my clothes smell like tobacco	-3.50 (-5.78, -1.22)
	Does not help me breathe easier, BUT my clothes don't smell like tobacco	-12.35 (-14.78, -9.93)
	Does not help me breathe easier BUT still makes my clothes smell like tobacco	-42.52 (-45.15, -39.89)
Tobacco Cessation	7 of 10 people are able to quit tobacco cigarettes	41.92 (39.36, 44.47)
	5 of 10 people are able to quit tobacco cigarettes	19.98 (18.20, 21.76)

## ENDS Best-Worst Scaling

	2 of 10 people are able to quit tobacco cigarettes	-12.79 (-14.84, -10.73)
	People are not able to quit smoking tobacco cigarettes	-49.11 (-52.46, -45.75)
Purchase Price of Product	\$5 one-time purchase	52.41 (49.12, 55.70)
	\$55 one-time purchase	12.40 (11.02, 13.77)
	\$115 one-time purchase	-26.04 (-27.92, -24.17)
	\$175 one-time purchase	-38.76 (-40.95, -36.57)
Monthly Cost of Use	\$5 per month to use	47.50 (44.72, 50.29)
	\$25 per month to use	16.68 (15.00, 18.37)
	\$65 per month to use	-22.16 (-23.91, -20.42)
	\$100 per month to use	-42.03 (-44.37, -39.68)
Nicotine Content	None (0 mg/ml)	10.89 (6.83, 14.96)
	Low (6 mg/ml)	18.29 (16.16, 20.41)
	Medium (12 mg/ml)	2.11 (-0.01, 4.23)
	High (24 mg/ml)	-31.30 (-35.12, -27.47)
Flavor Availability	Available in fruit, candy, coffee, wine and other flavors	15.88 (13.32, 18.44)
	Available in tobacco and menthol flavors	13.50 (11.94, 15.05)
	Available without any flavoring	-29.38 (-32.27, -26.48)
Device Design	Very similar in size, weight, appearance, and feel to a tobacco cigarette	12.85 (11.16, 14.54)
	Somewhat similar in size, weight, appearance, and feel to a tobacco cigarette	14.47 (12.87, 16.07)
	Not similar at all in size, weight, appearance and feel to a tobacco cigarette	-27.32 (-29.98, -24.66)
Modifiability	Various parts can be modified	12.46 (10.68, 14.23)
	It cannot be modified	-12.46 (-14.23, -10.68)

**Table 3. Most Important Attribute, n (%)**

<b>ENDS Characteristics</b>	<b>Total N=660</b>	<b>Age 18-24 N=169</b>	<b>Age 25-49 N=242</b>	<b>Age 50+ N=249</b>	<b>Male N=326</b>	<b>Female N=334</b>
Harms of Use	326 (49%)	74 (44%)	114 (47%)	138 (55%) <sup>a</sup>	149 (46%)	177 (53%)
Nicotine Content	85 (13%)*	26 (15%)	32 (13%)	27 (11%)	42 (13%)	43 (13%)
Purchase Price of Product	77 (12%)	14 (8%)	30 (12%)	33 (13%)	42 (13%)	35 (10%)
General Effects of Use	56 (9%)	26 (15%) <sup>a</sup>	13 (5%) <sup>a</sup>	17 (7%)	24 (7%)	32 (10%)
Tobacco Cessation Aid	45 (7%)	11 (6%)	16 (7%)	18 (7%)	28 (9%)	17 (5%)
Flavor Availability	32 (5%)	10 (6%)	18 (7%) <sup>a</sup>	4 (2%) <sup>a</sup>	18 (5%)	14 (4%)
Monthly Cost of Use	27 (4%)	7 (4%)	11 (5%)	9 (4%)	17 (5%)	10 (3%)
Device Design	10 (2%)*	1 (1%)	6 (2%)	3 (1%)	6 (2%)	4 (1%)
Modifiability	2 (0%)*	0 (0%)	2 (1%)	0 (0%)	0 (0%)	2 (1%)

Note. \*  $p < .05$  versus next higher ranked attribute for total sample. <sup>a</sup>  $p < .05$  versus total sample for age groups.

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For peer review only

Please imagine this is a new e-cigarette that has just become available for purchase. When you look at the 5 features of the e-cigarette, which feature makes you most want to use the e-cigarette and which feature makes you least want to use the e-cigarette.

(1 of 19)

PICK ONE FROM EACH COLUMN

E-cigarette	Most makes me want to use	Least makes me want to use
\$5 one-time purchase	<input type="radio"/>	<input type="radio"/>
It cannot be modified	<input type="radio"/>	<input type="radio"/>
Does not help me breathe easier AND still makes my clothes smell like tobacco	<input type="radio"/>	<input type="radio"/>
5 of 10 people are able to quit tobacco cigarettes	<input type="radio"/>	<input type="radio"/>
Somewhat similar in size, weight appearance, and feel to a tobacco cigarette	<input type="radio"/>	<input type="radio"/>

Click the forward arrow button to continue...



Figure 1. Example of a Best-worst Scaling Case 2 Task

250x184mm (300 x 300 DPI)

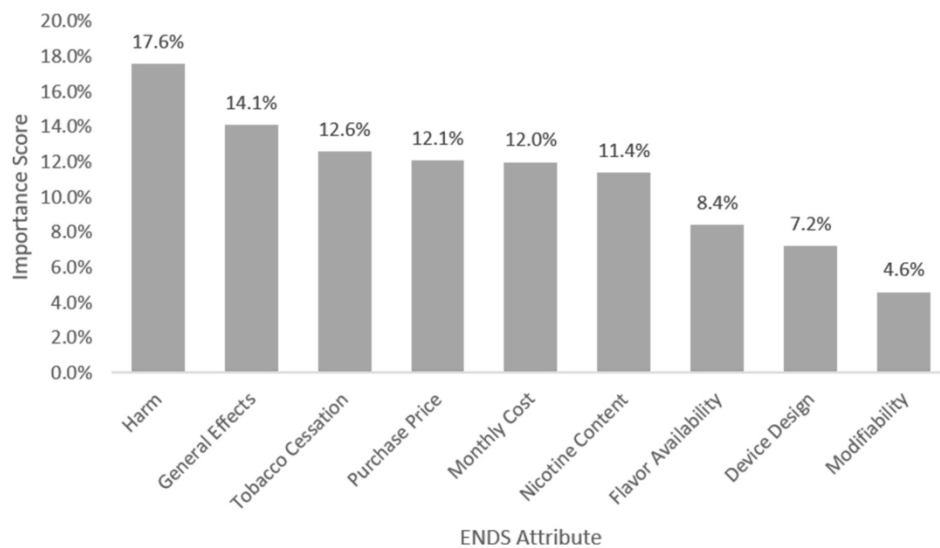


Figure 2. Importance of ENDS characteristics, n=660

152x88mm (300 x 300 DPI)

Appendix Table 1. ENDS Characteristics and Definitions

ENDS Characteristics	Provided Definition
Harms of Use	How much the device affects your health, specifically the harms to your body as compared to tobacco cigarettes. Imagine these harms are like cancer, lung diseases, circulation problems, heart attacks, and strokes.
General Effects of Use	How an e-cigarette affects you overall after you use it.
Tobacco Cessation Aid	How much the device can help a person quit using tobacco.
Purchase Price of Product	How much a person can expect to spend when starting to use the product, including the device and any other necessary pieces.
Monthly Cost of Use	How much a person can expect to spend each month with routine use of an e-cigarette
Nicotine Content	How much nicotine is available to use in the electronic vapor product.
Flavor Availability	How many different types of e-juice flavors that the e-cigarette is available in.
Device Design	How a device looks and feels as you use it, including the feel of inhaling the device, holding the device, its appearance, and other traits.
Modifiability	Some e-cigarettes can be modified. This is how much you can alter the e-cigarette to meet your needs. This doesn't include refilling or replacing an e-juice cartridge.

# BMJ Open

## Product Attributes Important to U.S. Adult Consumers' Use of Electronic Nicotine Delivery Systems: a Discrete Choice Experiment

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Manuscripts



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3 **1 Product Attributes Important to U.S. Adult Consumers' Use of Electronic Nicotine**

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5 **2 Delivery Systems: a Discrete Choice Experiment**

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2 **Author Contributions:** CK, LMR, ELS, KC, MLB, GAZ and AOG all contributed to the  
3 conceptualization and design of the survey. CK and KC assisted with data collection. CK,  
4 LMR, ELS, KC, CJW, CE, CM, MLB, GAZ and AOG participated in the analysis of the data.  
5 All authors contributed to the content and reviewed the manuscript prior to submission.

For peer review only

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3 1 **ABSTRACT, word count 300**  
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6 2 **Objective:** To understand the importance of electronic nicotine delivery systems (ENDS)  
7  
8 3 product attributes to adult consumers in the United States by age and gender.  
9

10  
11 4 **Design:** Cross-sectional survey with a discrete choice experiment (best-worst, case 2, scaling) of  
12  
13 5 19 choice tasks in which participants answered what would make them most want to use and  
14  
15 6 least want to use an ENDS product.  
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18  
19 7 **Setting and Participants:** A national sample of adults (age 18+) in the United States who had  
20  
21 8 tried an ENDS product at least once.  
22  
23

24 9 **Measures:** We included nine ENDS attributes with levels that varied across the 19 choice tasks.  
25  
26 10 We performed a multinomial logistic regression to obtain overall importance scores, attribute-  
27  
28 11 level part-worth utilities, and most important attribute.  
29  
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31  
32 12 **Results:** Of 660 participants, 81% were white, 51% female, and 37% had at least a 4-year  
33  
34 13 college degree with an average age of 42.0 years (SD ±19.4). The attributes had the following  
35  
36 14 importance: *Health Effects* 17.6%; *General Effects* 14.1%; *Cessation Aid* 12.6%; *Purchase Price*  
37  
38 15 12.1%; *Monthly Cost* 12.0%; *Nicotine Content* 11.4%; *Flavor Variety* 8.4%; *Device Traits* 7.2%;  
39  
40 16 *Modifications* 4.6%. *Health Effects* was the most important attribute for all ages and genders  
41  
42 17 ( $p < 0.05$ ); variation in other important attributes existed by age, though not gender.  
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46 18 **Conclusion:** This study identified the importance of nine ENDS attributes. Perceived *health*  
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48 19 *effects* of ENDS use appeared most important, and *modifications* was least important. Variation  
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50 20 by consumer group existed, which may allow for targeted interventions to modify ENDS use.  
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## 1 Strengths and Limitations of the Study:

- 2 • Large US sample using a robust experimental design, a best-worst scaling case 2 method,  
3 incorporating large numbers of relevant attributes of electronic nicotine delivery systems  
4 (ENDS)
- 5 • Consumers found different attributes of ENDS products important to their use.
- 6 • Perceived harms of ENDS use appeared most important to their choice of ENDS  
7 products, and modifiability was least important.
- 8 • Variation by consumer group existed, which may allow for targeted interventions to  
9 modify ENDS use.
- 10 • Limitations include the convenience sample of United States ENDS users, and the use of  
11 an experimental design which may invite more socially acceptable responses as opposed  
12 to direct purchasing observations.

13 **Key Words:** electronic nicotine delivery system, e-cigarettes, vaping, importance, attributes,  
14 part-worth utilities, preference

15 **Data Sharing:** Data can be requested from [Christine Kistler@med.unc.edu](mailto:Christine.Kistler@med.unc.edu)

## 1 INTRODUCTION, word count=3785

2 Though its health effects remain unclear, the use of electronic nicotine delivery systems (ENDS)  
3 in the United States (U.S.) continues to grow even in the face of impending regulation.<sup>1</sup> While  
4 the use of combustible tobacco cigarettes has declined, the U.S. ENDS market now exceeds \$8  
5 billion.<sup>2 3</sup> The rise in the use of ENDS has occurred despite mixed evidence about its harm  
6 reduction effects or use as a tobacco cessation aid.<sup>4</sup> Given the uncertainty around ENDS, initial  
7 regulations were piece-meal and varied from state to state. However, in 2016, the Food and  
8 Drug Administration (FDA) issued a regulation deeming ENDS to fall under its authority.<sup>5</sup> These  
9 regulations will impose a variety of restrictions on ENDS manufacturing, sales, and marketing.  
10 Notably, however, the FDA has postponed implementation of some of the rule's requirements,  
11 citing the possibility that ENDS have the "potential to make a notable public health difference."<sup>6</sup>  
12 As the potential benefits and harms of ENDS become clear, regulators and public health groups  
13 will need to understand how their proposed regulations will likely affect consumers' use.  
14 Consumers use ENDS due to a variety of product attributes that may be amenable to regulation  
15 or public health campaigns.<sup>7</sup> Regulators and public health groups need to know the incremental  
16 role of individual product attributes on the decision to use ENDS products so that they can make  
17 evidence-based policies depending on how they want to modify ENDS use.  
18 A widely-used method in behavioral economics to understand consumer use is through discrete  
19 choice experiments (DCE).<sup>8 9</sup> Once the relationship between consumers' use and product  
20 attributes is understood, regulators can consider whether and how to address the attributes most  
21 important to the most consumers to either increase or decrease product use. While DCEs have  
22 been conducted to examine consumers' attitudes towards combustible tobacco regulations and  
23 smoking cessation,<sup>10-14</sup> only one has examined potential ENDS use.<sup>15</sup> This recently published

1 study conducted in Canada examined only four ENDS attributes: flavor, nicotine content, health  
2 warnings and price;<sup>15</sup> finding that health risks and efficacy as a tobacco cessation aid were the  
3 two most important attributes to consumers. However, this study only examined four attributes  
4 and included non-smokers and non-ENDS users.

5 Knowledge from our formative qualitative work was used to create a DCE with a larger number  
6 of attributes, focused on ENDS users. We examined the list of a dozen attributes important to  
7 consumers we developed from a recent structured content analysis.<sup>16</sup> Among these twelve  
8 attributes, we found nine attributes that appeared related to the ENDS device itself.<sup>16</sup> We chose  
9 to look at the device-related attributes because these attributes may be more easily regulated than  
10 other psycho-social attributes such as the ability to vape in public or as a social outlet.<sup>17 18</sup> We  
11 designed and fielded a DCE study using a best-worst scaling experiment, among a national U.S.  
12 sample of ENDS users.

## 13 **METHODS**

### 14 **Study Design**

15 We conducted a one-time survey including a best-worst scaling, case 2 design DCE of the  
16 importance of ENDS product attributes. The final version of the survey was fielded using the  
17 Research Now survey panel between August 26<sup>th</sup> and August 31<sup>st</sup>, 2016. Participants were  
18 remunerated from Research Now, in accordance with their usual rate. The institutional review  
19 board at the University of North Carolina at Chapel Hill approved this study.

### 20 **Patient and Public Involvement**

21 The attributes used in the DCE were developed through focus groups conducted as part of prior  
22 research.<sup>19</sup> The study involved participants in a pre-test phase using an academic mass email

1 system. Twelve individuals pretested the survey between May 9<sup>th</sup> and May 14<sup>th</sup>, 2016. Incentive  
2 for completing the survey included possibly receiving 1 of 4 gift cards valued at \$50 each.  
3 Feedback from the pretest led to both condensing and simplifying the language of the survey.  
4 Clarity of the survey was again improved after another round of testing with 75 survey panelists  
5 recruited from Research Now, a research survey company, between August 15<sup>th</sup> and 16<sup>th</sup>, 2016.  
6 The second episode of testing also led to language alterations surrounding questions on the flavor  
7 attribute and its levels to ensure comprehension. Participants were not involved in the  
8 recruitment to or conduct of the study. Participants in the final version of the survey did not  
9 receive their study results.

## 10 **Participants**

11 We recruited 660 members of the Research Now survey panel aged 18 and older who reported  
12 having used ENDS at least once in their lifetime to complete the ENDS survey. Research Now is  
13 one of the major online survey panel companies with over 140 million finished surveys annually.  
14 Participants had to live in the United States and be able to complete an electronic survey in  
15 English. We specifically oversampled for older adults and minimum quotas to ensure near equal  
16 balance of gender.

## 17 **Survey Design**

18 The survey was designed to include a best-worst scaling experiment related to ENDS use  
19 followed by a series of tobacco and ENDS-related questions. The survey included nineteen best-  
20 worst scaling choice tasks, followed by questions on each participant's demographics,  
21 personality, current and past use of ENDS and tobacco products, and prior attempts to quit  
22 tobacco use. Sawtooth Software was used to design the survey. Prior to the best-worst tasks, the



1 survey provided an explanation for each of the attributes, as well as an example task involving  
2 car attribute preference followed by an example of a best-worst scaling task (Figure 1). [Insert  
3 Figure 1] The participants were told that some of the attributes were real but others were not and  
4 were asked, for the purposes of the study, to pretend they were all real, and imagine each choice  
5 task as a new device. As opposed to other types of DCE methods where consumers choose  
6 between ENDS products, for each of the nineteen choice tasks, participants selected one of five  
7 listed attribute levels that they felt most likely to encourage and least likely to encourage their  
8 use of a theoretical ENDS product. While other approaches such as a classical DCE would also  
9 yield importance scores, past studies demonstrated user fatigue and attribute dominance due to  
10 complex and overwhelming survey questions, whereas best-worst scaling, though not case 2, has  
11 been used in other areas of tobacco control.<sup>20-23</sup> Additionally, best-worst scaling case 2  
12 methodology was preferred because it leads to scores on a common scale, permitting direct  
13 comparison between all attribute levels within the study, not just direct comparisons among  
14 levels within the same attribute (as is the case for other DCE methods).<sup>24 25</sup> The 660 participants  
15 received 1 of 50 versions of the survey- using a partial profile design. We sought efficiency by  
16 using a computer search algorithm to generate a design that showed each of a given attribute's  
17 levels an equal number of times (one-way level balance) and each pairing of a given attribute  
18 level with the levels of other attributes an equal number of times (two-way level balance, which  
19 reduces correlations among the attributes). These two criteria will maximize both level balance  
20 and orthogonality, the two constituents of design efficiency for experimental design for a set of  
21 single profiles. Overall, each attribute level was seen about 3 times per participant (2.97), and  
22 each valid cross-attribute pair was seen not quite half the time by each participant (0.42 times).  
23 Reliable best-worst utilities can be obtained as long as each participant sees each level about 3

1 times.<sup>26</sup> The order of attributes varied across the survey blocks so that positional balance was  
2 maintained.

### 3 **Best-worst Scaling Attributes and Levels**

4 The nine attributes were included with a definition in the survey. Their definitions can be found  
5 in the Appendix, Table 1. For the rest of the paper, we will refer to these nine as *health effects*,  
6 *general effects*, *cessation aid*, *purchase price*, *monthly cost*, *nicotine content*, *flavor variety*,  
7 *device traits*, and *modifications*.<sup>16</sup> We chose to divide cost into a separate purchase price and  
8 monthly cost attributes because of the variation that can be seen in each; the focus group  
9 members mentioned the two attributes separately as well. Rates of tobacco cessation for ENDS  
10 products were drawn from the evidence that ENDS are often used as a tobacco cessation aid,  
11 regardless of actual effectiveness. It is worth noting that medications prescribed for assisting in  
12 tobacco cessation (e.g., bupropion, varenicline, nicotine containing products) have only a 2 out  
13 of 10 success rate at best.<sup>27</sup> Nicotine content levels were drawn from the current spectrum of  
14 labelled nicotine concentrations.<sup>28</sup> In addition to the actual concentration, we included a label of  
15 “none”, “low”, etc, to denote where in the range of concentrations, a particular concentration  
16 falls.

### 17 **Other Measures**

18 Participants responded to questions about sex, age, race and ethnicity, perceptions of general  
19 health,<sup>29</sup> education level, and yearly household income. The survey then collected details about  
20 each participants’ tobacco and ENDS use behaviors. Items included the heaviness of smoking  
21 index, which asks participants "At present, how long after waking do you wait before having  
22 your first cigarette (in mins)?" and "How many cigarettes do you smoke per day at present?"<sup>30</sup>

1 and other questions from the National Adult Tobacco Survey Questionnaire, 2012-2013, such as  
2 age of first cigarette, number of cigarettes smoked per day, and smoking days per month.<sup>31</sup>

### 3 **Analysis**

4 In DCEs, respondents are given tasks that combine possible varieties of product attributes and  
5 asked to make a choice; in our case, which attribute of the product was important to their use.  
6 With enough choice tasks, estimated importance scores can be generated, indicating which  
7 attribute most influenced their choices. The statistical model underlying best-worst scaling  
8 assumes that the relative choice probability of a given pair of best-worst choices is proportional  
9 to the distance between the two attribute levels on the latent utility scale. The pair of attribute  
10 levels chosen maximizes the difference in the part-worth utilities for a given choice task. These  
11 distances between attribute levels are modelled as a difference model, with variations on best-  
12 worst scaling sometimes called “maximum difference scaling”.<sup>32</sup> Using a multinomial regression  
13 model, these differences can provide the part-worth utilities relative to a single attribute level,  
14 rather than relative to the sample mean.<sup>24</sup> Part-worth utilities are zero-centered numerical values  
15 that represent the relative desirability of the levels within each attribute. The higher the number,  
16 the more desirable the attribute’s level is to participants. Importance scores were then calculated,  
17 based on the difference between minimum and maximum part-worth utilities within an  
18 attribute.<sup>25 33</sup> The total importance of all attributes to a decision is 100%, with each attribute a  
19 percentage of that total importance. Most important attribute was determined by comparing the  
20 importance scores for each individual, defining the attribute with the largest importance score as  
21 most important. In order to examine changes in attribute importance by age and gender, we  
22 performed a dependent z-test of proportions to compare the most important attribute to the next  
23 highest ranked attribute by age and gender.

## 1 RESULTS

2 Of 900 individuals surveyed, 660 participants had used ENDS at least one time. Participants had  
3 a mean age of 42 ((SD)  $\pm$  19.4), with a range from 18 to 82 years-old, and were evenly split  
4 female versus male (51% v 49%) (Table 1) [insert Table 1]. Most participants were white (81%),  
5 making less than \$60,000 annually (60%), and self-reported very good or excellent health (60%).  
6 Sixty-four percent had used ENDS in the last 30 days. Almost all participants (92%) reported a  
7 history of traditional tobacco products and most (85%) had tried to quit tobacco in the past 12  
8 months. Pearson's  $\chi^2$  tests of the relation between age and tobacco use characteristics found  
9 statistically significant ( $p < .05$ ) differences between sub-groups of young (18-24), middle-aged  
10 (25-49), and older (50+) adults. For example, young adult participants were more likely to have  
11 used ENDS in the last 30 days ( $p = .036$ ) and to have used flavored ENDS ( $p = .012$ ). Older  
12 adults were less likely to use ENDS ( $p < .001$ ) and more likely to smoke one pack/day of  
13 traditional tobacco ( $p < .001$ ) (see table 2).

### 14 Importance of ENDS attributes overall and by subgroup

15 The overall importance scores for the nine attributes are found in Figure 2. [Insert Figure 2] The  
16 attributes had the following importance distribution: *Health Effects* 17.6%; *General Effects*  
17 14.1%; *Cessation Aid* 12.6%; *Purchase Price* 12.1%; *Monthly Cost* 12.0%; *Nicotine Content*  
18 11.4%; *Flavor Variety* 8.4%; *Device Traits* 7.2%; *Modifications* 4.6%. Independent t-tests of the  
19 importance scores by gender found that when compared with males, female participants were  
20 more likely to give importance to *Health Effects* ( $\Delta+9.7\%$ ;  $p < .001$ ) and *General Effects*  
21 ( $\Delta+8.1\%$ ;  $p = .002$ ), and less likely to give importance to *Purchase Price* ( $\Delta-8.3\%$ ;  $p = .011$ ) and  
22 *Monthly Cost* ( $\Delta-6.8\%$ ;  $p = .008$ ).

1 Numerous statistically significant differences were found by age sub-groups. Younger adults  
2 compared with middle-aged and older adults together were more likely to give importance to  
3 *Modifications* ( $\Delta+22\%$ ;  $p = .004$ ) and less likely to give importance to *Purchase Price* ( $\Delta-11\%$ ;  
4  $p = .006$ ). Middle-aged adults compared with young and older adults together were more likely  
5 to give importance to *Modifications* ( $\Delta+24\%$ ;  $p = .001$ ) and less likely to give importance to  
6 *Health Effects* ( $\Delta-5\%$ ;  $p = .027$ ). Older adults compared with middle-aged and young adults  
7 together were more likely to give importance to *Purchase Price* ( $\Delta+11\%$ ;  $p = .004$ ) and less  
8 likely to give importance to *Modifications* ( $\Delta-34\%$ ;  $p < .001$ ).

### 9 **Part-worth utilities of ENDS attribute levels**

10 The part-worth utility scores for the levels of the nine attributes are shown in Table 2. [Insert  
11 Table 2] *Health Effects* had the level with the highest part-worth utility of 88.96 (90% CI: 84.79,  
12 93.13), followed by *General Effects* with a level at 58.37 (90% CI: 55.07, 61.68), and *Purchase*  
13 *Price* at 52.41 (90% CI: 49.12, 55.70). *Cessation Aid* had the level with the lowest part-worth  
14 utility of  $-49.11$  (90% CI:  $-52.46$ ,  $-45.75$ ), followed by *Health Effects* at  $-47.27$  (90% CI:  
15  $-49.69$ ,  $-44.86$ ).

### 16 **Most important ENDS attribute overall and by sub-group**

17 After examining the importance scores for each individual, *Health Effects* was the most  
18 important attribute for 49% of participants (Table 3). [Insert Table 3] *Nicotine Content* was next  
19 most frequent (13%) and *Purchase Price* was third (12%). A goodness-of-fit  $\chi^2$  test determined  
20 that the nine attributes differed from expected and thus were not equally distributed among  
21 participants ( $p < .001$ ). Also, dependent z-tests of the proportions of the second through ninth  
22 ranked attributes against *Health Effects* found that all were significantly lower ranked and were

1 less likely to be chosen as most important (Range:  $\Delta$ -83%-99%;  $p < .001$ ). Aside from *Nicotine*  
2 *Content* compared with *Health Effects*, stepped tests of each attribute against its nearest found  
3 that only *Device Traits* ( $p = .005$ ) and *Modifications* ( $p = .020$ ) were statistically significantly  
4 less important.

5 The nine attributes also statistically significantly differed from the expected distribution by the  
6 sub-groups for age and gender ( $p < .001$ ). Pearson's  $\chi^2$  tests of the relation between the age sub-  
7 groups and most important attribute found that *General Effects* was the most important attribute  
8 for younger adults as compared to other ages ( $p < .001$ ). Compared to younger and older adults,  
9 *General Effects* was less likely to be the most important attribute for middle aged adults ( $p = .029$ )  
10 and *Flavor Variety* was more likely to be most important ( $p = .018$ ). Compared to both younger  
11 and middle-aged adults, *Health Effects* was more likely to be most important ( $p = .016$ ) and *Flavor*  
12 *Variety* less likely ( $p = .003$ ). There were no statistically significant differences in the distribution  
13 of most important attributes by gender though *Health Effects* ( $p = .061$ ) and *Cessation Aid* ( $p =$   
14  $.075$ ) approached significance.

## 15 **DISCUSSION**

16 In our study of US adult ENDS consumers, we found that *Health Effects* had the highest  
17 importance to consumers' choice of an ENDS product. Other than cost (i.e., *Purchase Price* and  
18 *Monthly Cost*), the attributes with the highest importance scores hinged on consumers'  
19 perceptions of efficacy as a harm reduction strategy (*Health Effects*), health benefit (*General*  
20 *Effects*), and tobacco cessation (*Cessation Aid*), respectively. Consumers of different ages varied  
21 in importance they placed on different ENDS product characteristics. As more evidence about  
22 these products' ability to benefit or harm consumers is more fully understood, public health

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3 1 initiatives could target these perceptions. Variation by consumer group existed, which may allow  
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5 2 for targeted interventions to reduce or enhance ENDS use in any given consumer group.  
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8 3 ENDS products are marketed as healthier than combustible tobacco products,<sup>34</sup> but the evidence  
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10 4 regarding the impact of ENDS products on human health is slowly emerging. National  
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12 5 Academies of Science, Engineering, and Medicine recently released a report on the public health  
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14 6 consequences of ENDS products.<sup>35</sup> While there is substantial evidence that, except for nicotine,  
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16 7 exposure to potentially toxic substances from ENDS is significantly lower compared with  
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18 8 combustible tobacco products, there is also substantial evidence that exposure to ENDS aerosols  
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20 9 can induce lung dysfunction and oxidative stress in human tissue.<sup>36</sup> The long-term effects on  
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22 10 cardiovascular outcomes, cancer or other health conditions are unclear. Our work should add a  
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24 11 sense of urgency to the push for ongoing research into the evidence for and against ENDS  
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26 12 products as a harm reduction strategy. The idea that an ENDS product was less harmful than  
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28 13 tobacco cigarettes was extremely important to participants' choice. The level, that the product  
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30 14 was "less harmful on my body as compared to tobacco cigarettes", had the highest part-worth  
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32 15 utility of any attribute (88.96). Moreover, the level that the product "had the same amount of  
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34 16 harm on my body as compared to tobacco cigarettes" caused people to avoid choosing that  
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36 17 product and had a negative utility (-22.45). Both the *Health Effects* and the use as a *Cessation*  
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38 18 *Aid* had levels that are likely healthier and of more help in cessation than the evidence suggests.  
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40 19 Yet in general, perceptions, including misperceptions, affect smokers' behavior.<sup>37</sup> The look and  
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42 20 feel of cigarette packaging appears to influence consumers' use and may affect their perceptions'  
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44 21 of the healthiness and harm of the cigarettes within.<sup>38</sup> A study of combustible tobacco labeling  
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46 22 revealed that "additive-free" or "natural" labels on current cigarette brands were misperceived to  
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48 23 be possibly less harmful than other brands of cigarettes and may reduce the efficacy of public  
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1 health initiatives.<sup>39</sup> Even efforts by the Federal Trade Commission to prohibit language that  
2 might create misperceptions of reduced harm in tobacco cigarettes has been unsuccessful.<sup>37</sup> This  
3 (mis)perception of harm and health appears to strongly influence the choice of ENDS products.  
4 Further efforts, including those studying clear labeling and health warnings, are needed to  
5 explore how to align ENDS users' perceptions of ENDS products with the evidence.

6 While *Health Effects* had the highest importance score, the combined importance of *Purchase*  
7 *Price* and *Monthly Cost* was greater than *Health Effects*, so the importance of financial burden on  
8 ENDS use should not be underestimated. If we combine the two cost-related attributes, *Purchase*  
9 *Price* and *Monthly Cost*, overall cost's importance score would be 24.1% as compared to 17.6%  
10 for *Health Effects*. A recent study of the cross-price elasticity of ENDS and tobacco cigarettes  
11 found that ENDS are partially substitutable for cigarettes.<sup>40</sup> However, the availability of ENDS  
12 also reduced the number who reported they would quit smoking if cigarette costs increased by  
13 20% (50.2% to 30.0%), revealing that ENDS may discourage smokers from quitting  
14 completely.<sup>41</sup> Additionally, increases in the cost of ENDS products may shift consumers back  
15 towards combustible tobacco, though recent simulations found no relationship between cigarette  
16 prices and ENDS use.<sup>42</sup> Taxation may reduce ENDS use but further work is needed to model the  
17 consequences of price increases on ENDS use.

18 Potentially meaningful differences were found in the importance of ENDS product attributes and  
19 the most important attribute by different age groups. Younger and middle-aged adults found  
20 *Modifications* to be more important than older adults. While we did not see gender differences  
21 for attribute preferences, a Canadian DCE study of young women found that pack structure was  
22 the most important attribute driving ENDS use.<sup>14</sup> The shape and structure of the device and  
23 packaging may be more important to a younger population. Younger adults were more likely to



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3 1 have *General Effects* as their most important attribute while *Flavor Variety* was more likely to be  
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5 2 most important to middle-aged adults and significantly less likely to be most important to older  
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7 3 adults. A systematic review of studies of consumers' preference for flavor found flavor to be  
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9 4 likely important to young people.<sup>7</sup> However, as with our own qualitative study, which was  
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11 5 included in the review, many of the included studies did not have experimental designs.<sup>16</sup>  
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13 6 Interestingly, another Canadian DCE study of ENDS use found that younger smokers perceived  
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15 7 cherry flavor as less harmful while older adults found tobacco flavor less harmful.<sup>15</sup> While we  
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17 8 found *Flavor Availability* was more important to middle-aged adults, we did not find older adults  
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19 9 favored tobacco flavoring. However, both of these studies found that attributes related to the  
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21 10 users' health (*health effects* in our case and health warnings in the Canadian study) were more  
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23 11 important than flavor, and thus efforts to regulate flavors may not reduce ENDS use as much as  
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25 12 other regulations on other attributes, such as health effects.  
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27 13 Our study has several important limitations. First, our study examines choice behavior and not  
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29 14 actual purchase behavior. While we drew from a national online survey panel, our respondent  
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31 15 population is limited to a convenience sample. Additionally, best-worst scaling can be subject to  
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33 16 attribute non-attendance, where participants either fail to pay attention to an attribute or  
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35 17 attributes, or attribute dominance, where participants only pay attention to a single attribute. We  
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37 18 found that only about 2% of participants did not attend to the majority of attributes, though about  
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39 19 16% failed to attend to at least one attribute. No participant showed dominance behavior. While  
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41 20 there was some attribute non-attendance, best-worst scaling inclines participants to make  
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43 21 judgements about more attributes and does not invite as much attribute non-attendance or  
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45 22 dominance as can be seen in other standard DCEs. However, it seems more likely that socially  
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47 23 desirable responses could bias respondents' choices within best-worst scaling than other DCEs  
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1 might.<sup>24</sup> Lastly, while we did extensive pre-testing, it is possible that different participants  
2 interpreted different attributes and levels differently. For example, it is possible that participants  
3 viewed the monthly cost of use in relation to their own use and thus the responses to monthly  
4 cost may need to be viewed with caution.

## 5 CONCLUSION

6 A variety of ENDS product attributes are important to consumers. *Health Effects* had the highest  
7 importance to consumers' choice of an ENDS product. Other than cost, the attributes with the  
8 highest importance scores hinged on consumers' perceptions of efficacy as a harm reduction  
9 strategy (*Health Effects*), general benefit (*General Effects*), and tobacco cessation (*Cessation*  
10 *Aid*), respectively. Consumers differed by age group in some of the more important attributes.  
11 Though the overall importance of ENDS product attributes was similar, efforts to increase or  
12 decrease ENDS use could be tailored to these group differences.

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Table 1. Participants' Demographic Characteristics, N (%)

Characteristics	Total, N=660	Age 18-24, N=169	Age 25-49, N=242	Age 50+, N= 249
Age, mean (SD)	42.0 (19.4)	22.2 (1.6)	32.1 (7.7)	65.0 (6.9)
Female	334 (51%)	90 (53%)	120 (49%)	124 (50%)
Race				

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## ENDS Best-Worst Scaling

White	532 (81%)	113 (67%)	191 (79%)	228 (92%)
Black	42 (6%)	14 (8%)	18 (7%)	10 (4%)
Asian-American	40 (6%)	20 (12%)	18 (7%)	2 (1%)
Other	46 (7%)	22 (13%)	15 (6%)	9 (4%)
Hispanic or Latino/Latina	94 (14%)	42 (25%)	45 (19%)	7 (3%)
College degree or higher	247 (37%)	37 (22%)	113 (47%)	97 (38%)
Overall Health, very good or excellent	396 (60%)	110 (65%)	160 (66%)	126 (51%)
Annual Household Income,				
\$0 to \$29,999	149 (23%)	52 (31%)	51 (21%)	46 (18%)
\$30,000 to \$59,999	247 (37%)	75 (44%)	85 (35%)	87 (35%)
\$60,000 to \$89,999	156 (24%)	25 (15%)	73 (30%)	58 (23%)
\$90,000 or more	106 (16%)	17 (10%)	33 (14%)	58 (23%)
Knowledge that quitting smoking with help is more successful than without	310 (47%)	75 (44%)	108 (45%)	127 (51%)
Used ENDS in last 30 days <sup>1</sup>	387 (64%)	109 (71%)	153 (69%)*	125 (54%)*
Used flavored ENDS in last 30 days, of current ENDS users <sup>2</sup>	296 (70%)	93 (79%)*	134 (79%)*	69 (52%)*
Anticipates ENDS use in next year	478 (72%)	121 (72%)	193 (80%)*	164 (66%)*
Ever used traditional tobacco products	607 (92%)	154 (91%)	221 (91%)	232 (93%)
Age at first cigarette, mean (SD) <sup>1</sup>	17 (6)	16 (3)	18 (5)	18 (8)
Smokes more than 1 pack/day <sup>3</sup>	54 (12%)	3 (3%)*	12 (8%)*	39 (23%)*
First smoke within 30 minutes of waking <sup>3</sup>	256 (59%)	48 (44%)*	89 (59%)	119 (70%)*
Tobacco quit attempt in past 12 months <sup>3</sup>	369 (85%)	87 (79%)*	130 (85%)	152 (89%)

Note. \*  $p < .05$ ; Test versus total. <sup>1</sup> n=607, 154, 221, and 232, respectively; <sup>2</sup> n=420, 117, 170, and 133, respectively; <sup>3</sup> n=432, 110, 152, and 170, respectively.

Table 2. Final ENDS attributes, levels, and mean utilities, n=660

ENDS Attributes	Levels of ENDS Attributes	Part-worth Utilities, Mean (95% CI)
Harms of Use	Less harmful on my body as compared to tobacco cigarettes	88.96 (84.79, 93.13)
	Unknown harm on my body as compared to tobacco cigarettes	-19.24 (-21.32, -17.17)

## ENDS Best-Worst Scaling

	Same amount of harm on my body as compared to tobacco cigarettes	-22.45 (-24.90, -19.99)
	More harmful on my body as compare to tobacco cigarettes	-47.27 (-49.69, -44.86)
General Effects of Use	Helps me breathe easier AND my clothes don't smell like tobacco	58.37 (55.07, 61.68)
	Helps me breathe easier, BUT my clothes smell like tobacco	-3.50 (-5.78, -1.22)
	Does not help me breathe easier, BUT my clothes don't smell like tobacco	-12.35 (-14.78, -9.93)
	Does not help me breathe easier BUT still makes my clothes smell like tobacco	-42.52 (-45.15, -39.89)
Tobacco Cessation	7 of 10 people are able to quit tobacco cigarettes	41.92 (39.36, 44.47)
	5 of 10 people are able to quit tobacco cigarettes	19.98 (18.20, 21.76)
	2 of 10 people are able to quit tobacco cigarettes	-12.79 (-14.84, -10.73)
	People are not able to quit smoking tobacco cigarettes	-49.11 (-52.46, -45.75)
Purchase Price of Product	\$5 one-time purchase	52.41 (49.12, 55.70)
	\$55 one-time purchase	12.40 (11.02, 13.77)
	\$115 one-time purchase	-26.04 (-27.92, -24.17)
	\$175 one-time purchase	-38.76 (-40.95, -36.57)
Monthly Cost of Use	\$5 per month to use	47.50 (44.72, 50.29)
	\$25 per month to use	16.68 (15.00, 18.37)
	\$65 per month to use	-22.16 (-23.91, -20.42)
	\$100 per month to use	-42.03 (-44.37, -39.68)
Nicotine Content*	None (0 mg/ml)	10.89 (6.83, 14.96)
	Low (6 mg/ml)	18.29 (16.16, 20.41)
	Medium (12 mg/ml)	2.11 (-0.01, 4.23)
	High (24 mg/ml)	-31.30 (-35.12 -27.47)

## ENDS Best-Worst Scaling

Flavor Availability	Available in fruit, candy, coffee, wine and other flavors	15.88 (13.32, 18.44)
	Available in tobacco and menthol flavors	13.50 (11.94, 15.05)
	Available without any flavoring	-29.38 (-32.27, -26.48)
Device Design	Very similar in size, weight, appearance, and feel to a tobacco cigarette	12.85 (11.16, 14.54)
	Somewhat similar in size, weight, appearance, and feel to a tobacco cigarette	14.47 (12.87, 16.07)
	Not similar at all in size, weight, appearance and feel to a tobacco cigarette	-27.32 (-29.98, -24.66)
Modifiability	Various parts can be modified	12.46 (10.68, 14.23)
	It cannot be modified	-12.46 (-14.23, -10.68)

Note: \*Nicotine levels corresponded to what the current literature designated as low, medium and high levels of nicotine.

**Table 3. Most Important Attribute, n (%)**

ENDS Characteristics	Total N=660	Age 18-24 N=169	Age 25-49 N=242	Age 50+ N=249	Male N=326	Female N=334
Harms of Use	326 (49%)	74 (44%)	114 (47%)	138 (55%) <sup>a</sup>	149 (46%)	177 (53%)



## ENDS Best-Worst Scaling

Nicotine Content	85 (13%)*	26 (15%)	32 (13%)	27 (11%)	42 (13%)	43 (13%)
Purchase Price of Product	77 (12%)	14 (8%)	30 (12%)	33 (13%)	42 (13%)	35 (10%)
General Effects of Use	56 (9%)	26 (15%) <sup>a</sup>	13 (5%) <sup>a</sup>	17 (7%)	24 (7%)	32 (10%)
Tobacco Cessation Aid	45 (7%)	11 (6%)	16 (7%)	18 (7%)	28 (9%)	17 (5%)
Flavor Availability	32 (5%)	10 (6%)	18 (7%) <sup>a</sup>	4 (2%) <sup>a</sup>	18 (5%)	14 (4%)
Monthly Cost of Use	27 (4%)	7 (4%)	11 (5%)	9 (4%)	17 (5%)	10 (3%)
Device Design	10 (2%)*	1 (1%)	6 (2%)	3 (1%)	6 (2%)	4 (1%)
Modifiability	2 (0%)*	0 (0%)	2 (1%)	0 (0%)	0 (0%)	2 (1%)

Note. \*  $p < .05$  versus next higher ranked attribute for total sample. <sup>a</sup>  $p < .05$  versus total sample for age groups.

Figure 1. Example of a Best-worst Scaling Case 2 Task

ENDS Best-Worst Scaling

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Figure 2. Importance of ENDS characteristics, n=660

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Appendix Table 1. ENDS Characteristics and Definitions

For peer review only

Figure 1. Example of a Best-worst Scaling Case 2 Task

Please imagine this is a new e-cigarette that has just become available for purchase. When you look at the 5 features of the e-cigarette, which feature makes you most want to use the e-cigarette and which feature makes you least want to use the e-cigarette.

(1 of 19)

PICK ONE FROM EACH COLUMN

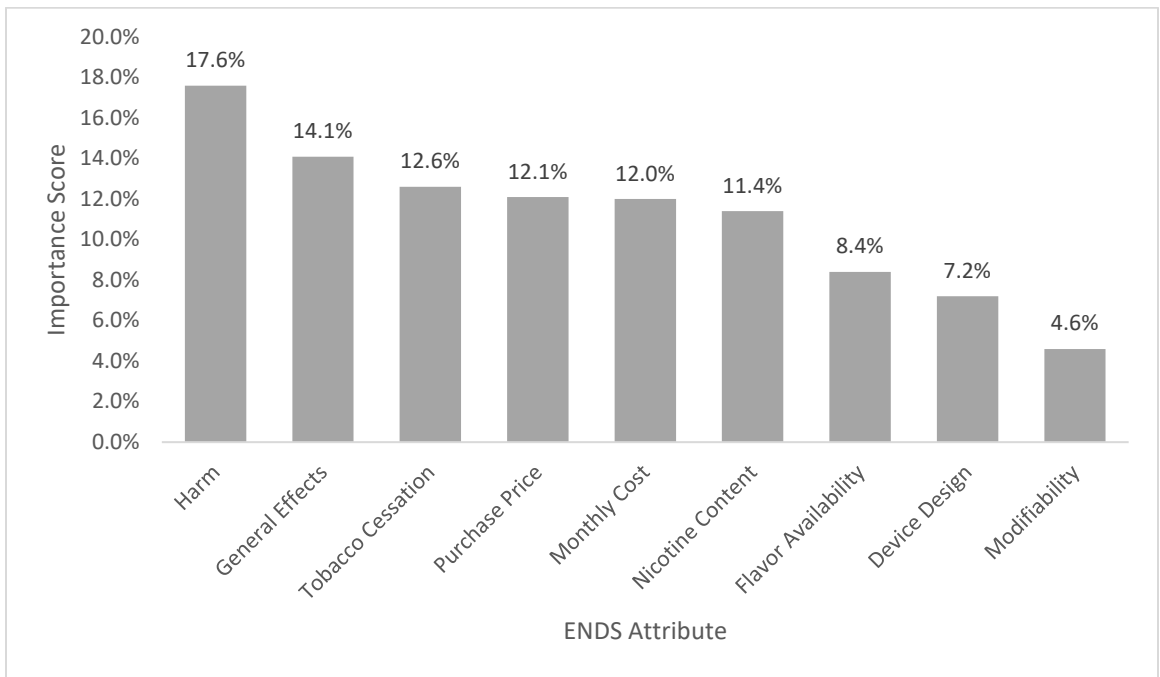
E-cigarette	Most makes me want to use	Least makes me want to use
\$5 one-time purchase	<input type="radio"/>	<input type="radio"/>
It cannot be modified	<input type="radio"/>	<input type="radio"/>
Does not help me breathe easier AND still makes my clothes smell like tobacco	<input type="radio"/>	<input type="radio"/>
5 of 10 people are able to quit tobacco cigarettes	<input type="radio"/>	<input type="radio"/>
Somewhat similar in size, weight appearance, and feel to a tobacco cigarette	<input type="radio"/>	<input type="radio"/>

Click the forward arrow button to continue...

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Figure 2. Importance of ENDS characteristics, n=660



Appendix Table 1. ENDS Characteristics and Definitions

ENDS Characteristics	Provided Definition
Harms of Use	How much the device affects your health, specifically the harms to your body as compared to tobacco cigarettes. Imagine these harms are like cancer, lung diseases, circulation problems, heart attacks, and strokes.
General Effects of Use	How an e-cigarette affects you overall after you use it.
Tobacco Cessation Aid	How much the device can help a person quit using tobacco.
Purchase Price of Product	How much a person can expect to spend when starting to use the product, including the device and any other necessary pieces.
Monthly Cost of Use	How much a person can expect to spend each month with routine use of an e-cigarette
Nicotine Content	How much nicotine is available to use in the electronic vapor product.
Flavor Availability	How many different types of e-juice flavors that the e-cigarette is available in.
Device Design	How a device looks and feels as you use it, including the feel of inhaling the device, holding the device, its appearance, and other traits.
Modifiability	Some e-cigarettes can be modified. This is how much you can alter the e-cigarette to meet your needs. This doesn't include refilling or replacing an e-juice cartridge.

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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	<b>Item No</b>	<b>Location</b>
<b>Title and abstract</b>	1	(a) We included Discrete Choice Experiment in our title (b) We included the overarching results in the abstract
<b>Introduction</b>		
Background/rationale	2	Paragraph 1 of the manuscript, p. 6, lines 2-17
Objectives	3	First section of the abstract and Last paragraph of the introduction, p. 7, lines 5-12
<b>Methods</b>		
Study design	4	First paragraph of the methods “study design” section, p. 7, lines 15-19
Setting	5	First paragraph of the methods, p. 7, lines 15-19
Participants	6	Third paragraph of the methods, “participants” section, p. 8, lines 11-16
Variables	7	Fourth, fifth, and sixth paragraph of the methods, “survey design”, “best-worst scaling attributes and levels”, and “other measures” section, p. 8 lines 18-22 and p.9, lines 1-19
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	We discuss efforts to address bias including providing an explanation of the attributes, an example task, and our choice of best-worst scaling, case 2, in the “survey design” section of the methods, p 8 and 9, lines 18-22 and 1-14
Study size	10	A sample of 660 provides standard error of 0.0907 gave us 80% power to detect as significant utilities at least 0.25 units away from zero.
Quantitative variables	11	Explained in the “other measures” section, p. 11, lines 1-7
Statistical methods	12	(a) Last paragraph of the methods, “analysis” section, p. 11, lines 9-23, and p. 12, lines 1-5 (b) Last sentence of the methods, “analysis” section, p. 12, lines 3-5 (c) Given the focus of the study on the population, missing data was censored from the analysis. (d) N/A (e) N/A
<b>Results</b>		
Participants	13*	(a) Because this is an online survey we are not able to report how many people looked at the survey or were assessed for eligibility. We do know that 900 people completed the survey of whom 660 reported ENDS use, p 13, lines 7-9 (b) N/A (c) N/A
Descriptive data	14*	(a) Table 1 includes demographic data as well as the first paragraph of the results, p 13, lines 7-18 (b) Table 1 includes the demographics of interest and their reduced n
Outcome data	15*	“most important ENDS attribute overall and by sub-group” section in the results, p13, line 21, and p 14, lines 1- 20
Main results	16	(a) “most important ENDS attribute overall and by sub-group” section in the results, p13, line 21, and p 14, lines 1- 20 (b) N/A (c) N/A
Other analyses	17	“most important ENDS attribute overall and by sub-group” section in the results,

p13, line 21, and p 14, lines 1- 20

<b>Discussion</b>		
Key results	18	Paragraph 1 of the discussion, p 14, lines 22-23 and p 15, lines 1- 7
Limitations	19	P 18, lines 19-23 and p 19, lines 1-10.
Interpretation	20	Discussion section contextualizes our findings within the existing literature
Generalisability	21	The ends of paragraphs 1-4 of the discussion all discuss the generalisability of the work and future directions.
<b>Other information</b>		
Funding	22	The acknowledgements section contains the study's funding source on p 19, lines 21-22, and p 20, lines 1-2

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).