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

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

ABSTRACT, word count 300

Objective: To understand the importance of electronic nicotine delivery systems (ENDS) product attributes to adult consumers in the United States by age and gender.

Design: Cross-sectional survey with a discrete choice experiment (best-worst, case 2, scaling) of 19 choice tasks in which participants answered what would make them most want to use and least want to use an ENDS product.

Setting and Participants: A national sample of adults (age 18+) in the United States who had tried an ENDS product at least once.

Measures: We included nine ENDS attributes with levels that varied across the 19 choice tasks. We performed a multinomial logistic regression to obtain overall importance scores, attribute-level part-worth utilities, and most important attribute.

Results: Of 660 participants, 81% were white, 51% female, and 37% had at least a 4-year college degree with an average age of 42.0 years (SD ±19.4). The attributes had the following importance: *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%. *Health Effects* was the most important attribute for all ages and genders ($p<0.05$); variation in other important attributes existed by age, though not gender.

Conclusion: This study identified the importance of nine ENDS attributes. Perceived *health effects* of ENDS use appeared most important, and *modifications* was least important. Variation by consumer group existed, which may allow for targeted interventions to modify ENDS use.

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

Strengths and Limitations of the Study:

Article Summary:

- Consumers find different attributes of ENDS products important to their use.
- Perceived harms of ENDS use appeared most important to their choice of ENDS products, and modifiability was least important.
- Variation by consumer group existed, which may allow for targeted interventions to modify ENDS use.
- Limitations include the convenience sample of United States ENDS users, and the use of an experimental design as opposed to direct purchasing observations.

Data Sharing: Data can be requested from Christine_Kistler@med.unc.edu

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.[1] While the use of combustible tobacco cigarettes has declined, the U.S. ENDS market now exceeds $8 billion.[2 3] The rise in the use of ENDS has occurred despite mixed evidence about its harm reduction effects or use as a tobacco cessation aid.[4] 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.[5] 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."[6] 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.[7] 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). [8 9] 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 of decrease product use. While DCEs have been conducted to examine consumers' attitudes towards combustible tobacco regulations and smoking cessation,[10-14] only one has examined potential ENDS use.[15] This recently published

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

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

METHODS

Study Design and Participant Involvement

We conducted a one-time survey of the importance of ENDS product attributes. The attributes used in the DCE were developed through focus groups.[19] The study involved participants in a pre-test phase using an academic mass email system. Twelve individuals pretested the survey between May 9th and May 14th, 2016. Incentive for completing the survey included possibly receiving 1 of 4 gift cards valued at $50 each. Feedback from the pretest led to both condensing and simplifying the language of the survey. Clarity of the survey was again improved after another round of testing with 75 survey panelists recruited from Research Now, a research survey company, between August 15th and 16th, 2016. The second episode of testing also led to

language alterations surrounding questions on the flavor attribute and its levels. The final version of the survey was fielded using the survey panel between August 26th and August 31st, 2016. Participants were remunerated from Research Now, in accordance with their usual rate. The institutional review board at the University of North Carolina at Chapel Hill approved this study.

Participants

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

Survey Design

The survey was designed to include a best-worst scaling experiment related to ENDS use followed by a series of tobacco and ENDS-related questions. The survey included nineteen best-worst scaling choice tasks, followed by questions on each participant's demographics, personality, current and past use of ENDS and tobacco products, and prior attempts to quit tobacco use. Sawtooth Software was used to design the survey. Prior to the best-worst tasks, the survey provided an explanation for each of the attributes, as well as an example task involving car attribute preference followed by an example of a best-worst scaling task (Figure 1). [Insert Figure 1] The participants were told that some of the attributes were real but others were not and were asked, for the purposes of the study, to pretend they were all real, and imagine each choice task as a new device. As opposed to other types of DCE methods where consumers choose

between ENDS products, for each of the nineteen choice tasks, participants selected one of five listed attribute levels that they felt most likely to encourage and least likely to encourage their use of a theoretical ENDS product. While other approaches such as a classical DCE would also yield importance scores, past studies demonstrated user fatigue and attribute dominance due to complex and overwhelming survey questions, whereas best-worst scaling, though not case 2, has been used in other areas of tobacco control.[20-23] Additionally, best-worst scaling case 2 methodology was preferred because it leads to scores on a common scale, permitting direct comparison between all attribute levels within the study, not just direct comparisons among levels within the same attribute (as is the case for other DCE methods).[24 25] The 660 participants received 1 of 50 versions of the survey- using a partial profile design. Overall, each attribute level was seen about 3 times per participant (2.97), and each valid cross-attribute pair was seen not quite half the time by each participant (0.42 times). Reliable best-worst utilities can be obtained as long as each participant sees each level about 3 times.[26] The order of attributes 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.

2. General Effects of E-Cigarette Use: This is how an e-cigarette affects you overall after you use it. Options include that it helps you breathe easier and your clothes do not smell like tobacco to it does not help you breathe easier and your clothes do smell like tobacco.
3. Quitting Tobacco: This is how much the device can help a person quit using tobacco. It can range from helping 7 out of 10 people quit smoking to not helping a person quit at all.
4. Purchase Price of the Device: This is how much a person can expect to spend when starting to use the product, including the device and any other necessary pieces. The costs range from $5 to $175.
5. Monthly Cost of Use: This is how much a person can expect to spend each month with routine use of an e-cigarette. The costs range from $5 to $100 per month to use.
6. Nicotine Content: This is how much nicotine is available to use in the electronic vapor product. Choices range from high levels to none.
7. Flavor Variety: This is how many different types of e-juice flavors that the e-cigarette is available in. E-juice flavors may be one of the following, flavorless/unflavored; tobacco or menthol flavors, or many other flavors such as fruit, candy, coffee, and others.
8. Device Traits: This is 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. These options range from a user experience much like a tobacco cigarette to a user experience very different from a tobacco cigarette.
9. Modifications: 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. Choices include being able to modify the device and not being able to modify the device.

For the rest of the paper, we will refer to these nine as *health effects, general effects, cessation aid, purchase price, monthly cost, nicotine content, flavor variety, device traits*, and *modifications*.[16] We chose to divide cost into a separate purchase price and monthly cost attributes because of the variation that can be seen in each; the focus group members mentioned the two attributes separately as well. Rates of tobacco cessation for ENDS products were drawn from the evidence that ENDS are often used as a tobacco cessation aid, regardless of actual effectiveness. It is worth noting that medications prescribed for assisting in tobacco cessation (e.g., bupropion, varenicline, nicotine containing products) have only a 2 out of 10 success rate at best.[27]

Other Measures

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

Analysis

In DCEs, respondents are given tasks that combine possible varieties of product attributes and asked to make a choice; in our case, which attribute of the product was important to their use.

With enough choice tasks, estimated importance scores can be generated, indicating which attribute most influenced their choices. The statistical model underlying best–worst scaling assumes that the relative choice probability of a given pair of best-worst choices is proportional to the distance between the two attribute levels on the latent utility scale. The pair of attribute levels chosen maximizes the difference in the part-worth utilities for a given choice task. These distances between attribute levels are modelled as a difference model, with variations on best–worst scaling sometimes called "maximum difference scaling".[31] Using a multinomial regression model, these differences can provide the part-worth utilities relative to a single attribute level, rather than relative to the sample mean.[24] Part-worth utilities are zero-centered numerical values that represent the relative desirability of the levels within each attribute. The higher the number, the more desirable the attribute's level is to participants. Importance scores were then calculated, based on the difference between minimum and maximum part-worth utilities within an attribute.[25 32] The total importance of all attributes to a decision is 100%, with each attribute a percentage of that total importance. Most important attribute was determined by comparing the importance scores for each individual, defining the attribute with the largest importance score as most important. In order to examine changes in attribute importance by age and gender, we performed a dependent *z*-test of proportions to compare the most important attribute to the next highest ranked attribute by age and gender.

RESULTS

Of 900 individuals surveyed, 660 participants had used ENDS at least one time. Participants had a mean age of 42 ((SD) ± 19.4), with a range from 18 to 82 years-old, and were evenly split female versus male (51% v 49%) (Table 1) [insert Table 1]. Most participants were white (81%), making less than $60,000 annually (60%), and self-reported very good or excellent health (60%).

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 χ^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* (Δ+9.7%; $p < .001$) and *General Effects* (Δ+8.1%; $p = .002$), and less likely to give importance to *Purchase Price* (Δ−8.3%; $p = .011$) and *Monthly Cost* (Δ−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* (Δ+22%; $p = .004$) and less likely to give importance to *Purchase Price* (Δ−11%; $p = .006$). Middle-aged adults compared with young and older adults together were more likely to give importance to *Modifications* (Δ+24%; $p = .001$) and less likely to give importance to *Health Effects* (Δ−5%; $p = .027$). Older adults compared with middle-aged and young adults

together were more likely to give importance to *Purchase Price* (Δ+11%; $p = .004$) and less likely to give importance to *Modifications* (Δ−34%; $p < .001$).

Part-worth utilities of ENDS attribute levels

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

Most important ENDS attribute overall and by sub-group

After examining the importance scores for each individual, *Health Effects* was the most important attribute for 49% of participants (Table 3). [Insert Table 3] *Nicotine Content* was next most frequent (13%) and *Purchase Price* was third (12%). A goodness-of-fit χ^2 test determined that the nine attributes differed from expected and thus were not equally distributed among participants ($p < .001$). Also, dependent *z*-tests of the proportions of the second through ninth ranked attributes against *Health Effects* found that all were significantly lower ranked and were less likely to be chosen as most important (Range: Δ−83%-99%; $p < .001$). Aside from *Nicotine Content* compared with *Health Effects*, stepped tests of each attribute against its nearest found that only *Device Traits* ($p = .005$) and *Modifications* ($p = .020$) were statistically significantly less important.

The nine attributes also statistically significantly differed from the expected distribution by the sub-groups for age and gender ($p < .001$). Pearson's X^2 tests of the relation between the age sub-

groups and most important attribute found that *General Effects* was the most important attribute for younger adults as compared to other ages ($p < .001$). *Compared to younger and older adults, General Effects* was less likely to be the most important attribute for middle aged adults ($p = .029$) and *Flavor Variety* was more likely to be most important($p = .018$). Compared to both younger and middle-aged adults, *Health Effects* was more likely to be most important ($p = .016$) and *Flavor Variety* less likely ($p = .003$). There were no statistically significant differences in the distribution of most important attributes by gender though *Health Effects* ($p = .061$) and *Cessation Aid* ($p = .075$) approached significance.

DISCUSSION

In our study of US adult ENDS consumers, we found that *Health Effects* had the highest importance to consumers' choice of an ENDS product. Other than cost (i.e., *Purchase Price* and *Monthly Cost*), the attributes with the highest importance scores hinged on consumers' perceptions of efficacy as a harm reduction strategy (*Health Effects)*, health benefit (*General Effects*), and tobacco cessation (*Cessation Aid*), respectively. Consumers of different ages varied in importance they placed on different ENDS product characteristics. As more evidence about these products' ability to benefit or harm consumers is more fully understood, public health initiatives could target these perceptions. Variation by consumer group existed, which may allow for targeted interventions to reduce or enhance ENDS use in any given consumer group.

ENDS products are marketed as healthier than combustible tobacco products, [33] but the evidence regarding the impact of ENDS products on human health is slowly emerging. National Academies of Science, Engineering, and Medicine recently released a report on the public health consequences of ENDS products.[34] While there is substantial evidence that, except for nicotine, exposure to potentially toxic substances from ENDS is significantly lower compared with

combustible tobacco products, there is also substantial evidence that exposure to ENDS aerosols can induce lung dysfunction and oxidative stress in human tissue.[35] The long-term effects on cardiovascular outcomes, cancer or other health conditions are unclear. Our work should add a sense of urgency to the push for ongoing research into the evidence for and against ENDS products as a harm reduction strategy. The idea that an ENDS product was less harmful than tobacco cigarettes was extremely important to participants' choice. The level, that the product was "less harmful on my body as compared to tobacco cigarettes", had the highest part-worth utility of any attribute (88.96). Moreover, the level that the product "had the same amount of harm on my body as compared to tobacco cigarettes" caused people to avoid choosing that product and had a negative utility (-22.45). Both the *Health Effects* and the use as a *Cessation Aid* had levels that are likely healthier and of more help in cessation than the evidence suggests. Yet in general, perceptions, including misperceptions, affect smokers' behavior.[36] The look and feel of cigarette packaging appears to influence consumers' use and may affect their perceptions' of the healthiness and harm of the cigarettes within.[37] A study of combustible tobacco labeling revealed that "additive-free" or "natural" labels on current cigarette brands were misperceived to be possibly less harmful than other brands of cigarettes and may reduce the efficacy of public health initiatives.[38] Even efforts by the Federal Trade Commission to prohibit language that might create misperceptions of reduced harm in tobacco cigarettes has been unsuccessful.[36] This (mis)perception of harm and health appears to strongly influence the choice of ENDS products. Further efforts, including those studying clear labeling and health warnings, are needed to explore how to align ENDS users' perceptions of ENDS products with the evidence.

While *Health Effects* had the highest importance score, the combined importance of *Purchase Price* and *Monthly Cost* was greater than *Health Effects*, so the importance of financial burden on

ENDS use should not be underestimated. If we combine the two cost-related attributes, *Purchase Price* and *Monthly Cost,* overall cost's importance score would be 24.1% as compared to 17.6% for *Health Effects*. A recent study of the cross-price elasticity of ENDS and tobacco cigarettes found that ENDS are partially substitutable for cigarettes.[39] However, the availability of ENDS also reduced the number who reported they would quit smoking if cigarette costs increased by 20% (50.2% to 30.0%), revealing that ENDS may discourage smokers from quitting completely.[40] Additionally, increases in the cost of ENDS products may shift consumers back towards combustible tobacco, though recent simulations found no relationship between cigarette prices and ENDS use.[41] Taxation may reduce ENDS use but further work is needed to model the consequences of price increases on ENDS use.

Potentially meaningful differences were found in the importance of ENDS product attributes and the most important attribute by different age groups. Younger and middle-aged adults found *Modifications* to be more important than older adults. While we did not see gender differences for attribute preferences, a Canadian DCE study of young women found that pack structure was the most important attribute driving ENDS use.[14] The shape and structure of the device and packaging may be more important to a younger population. Younger adults were more likely to have *General Effects* as their most important attribute while *Flavor Variety* was more likely to be most important to middle-aged adults and significantly less likely to be most important to older adults. A systematic review of studies of consumers' preference for flavor found flavor to be likely important to young people.[7] However, as with our own qualitative study, which was included in the review, many of the included studies did not have experimental designs.[16] Interestingly, another Canadian DCE study of ENDS use found that younger smokers perceived cherry flavor as less harmful while older adults found tobacco flavor less harmful.[15] While we

found *Flavor Availability* was more important to middle-aged adults, we did not find older adults favored tobacco flavoring. However, both of these studies found that attributes related to the users' health (*health effects* in our case and health warnings in the Canadian study) were more important than flavor, and thus efforts to regulate flavors may not reduce ENDS use as much as other regulations on other attributes, such as health effects.

Our study has several important limitations. First, our study examines choice behavior and not actual purchase behavior. While we drew from a national online survey panel, our respondent population is limited to a convenience sample. Additionally, best-worst scaling can be subject to attribute non-attendance, where participants either fail to pay attention to an attribute or attributes, or attribute dominance, where participants only pay attention to a single attribute. We found that only about 2% of participants did not attend to the majority of attributes, though about 16% failed to attend to at least one attribute. No participant showed dominance behavior. While there was some attribute non-attendance, best-worst scaling inclines participants to make judgements about more attributes and does not invite as much attribute non-attendance or dominance as can be seen in other standard DCEs. However, it seems more likely that socially desirable responses could bias respondents' choices within best-worst scaling than other DCEs might.[24]

CONCLUSION

A variety of ENDS product attributes are important to consumers. *Health Effects* had the highest importance to consumers' choice of an ENDS product. Other than cost, the attributes with the highest importance scores hinged on consumers' perceptions of efficacy as a harm reduction strategy (*Health Effects)*, general benefit (*General Effects*), and tobacco cessation (*Cessation Aid*), respectively. Consumers differed by age group in some of the more important attributes.

Though the overall importance of ENDS product attributes was similar, efforts to increase or 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				
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[1]	*387 (64%)*	109 (71%)	153 (69%)*	125 (54%)*
Used flavored ENDS in last 30 days, of current ENDS users[2]	*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)[1]	*17 (6)*	16 (3)	18 (5)	18 (8)

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

Note. * $p < .05$; Test versus total. [1] n=607, 154, 221, and 232, respectively; [2] n=420, 117, 170, and 133, respectively; [3] 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)

	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 (%)

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%)[a]	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%)[a]	13 (5%)[a]	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%)[a]	4 (2%)[a]	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. [a] $p < .05$ versus total sample for age groups.

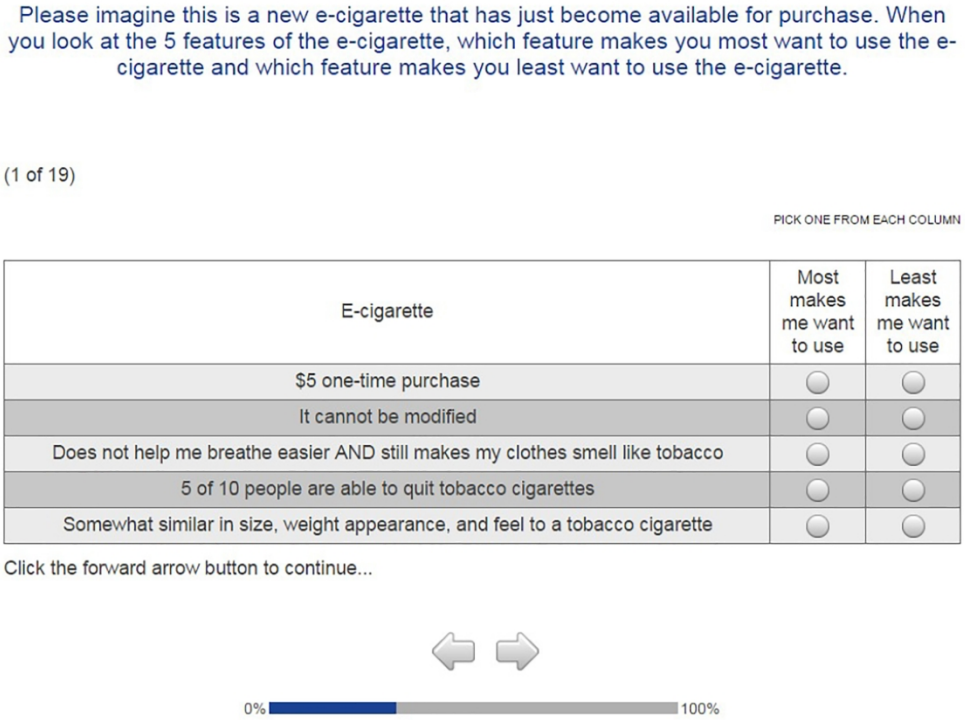

Figure 1. Example of a Best-worst Scaling Case 2 Task

250x184mm (300 x 300 DPI)

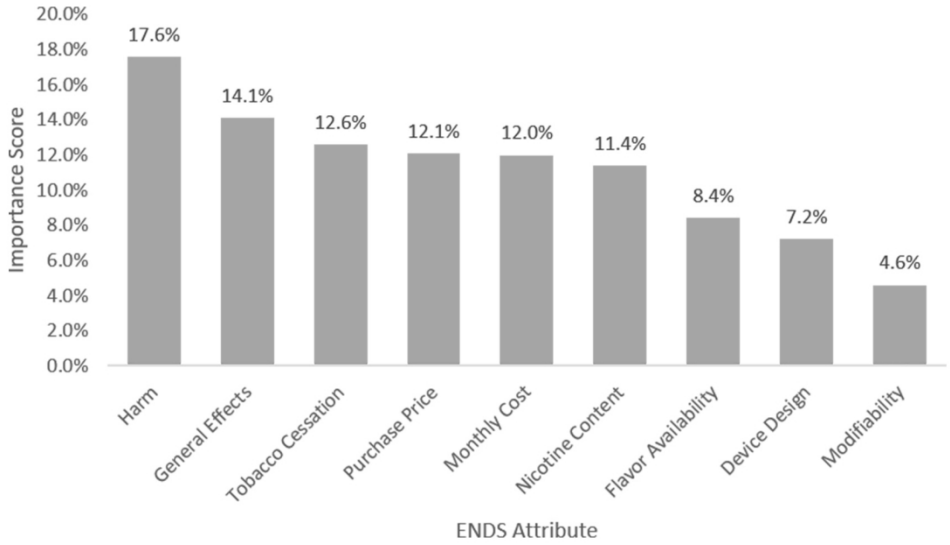

Figure 2. Importance of ENDS characteristics, n=660

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.

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

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ABSTRACT, word count 300

Objective: To understand the importance of electronic nicotine delivery systems (ENDS) product attributes to adult consumers in the United States by age and gender.

Design: Cross-sectional survey with a discrete choice experiment (best-worst, case 2, scaling) of 19 choice tasks in which participants answered what would make them most want to use and least want to use an ENDS product.

Setting and Participants: A national sample of adults (age 18+) in the United States who had tried an ENDS product at least once.

Measures: We included nine ENDS attributes with levels that varied across the 19 choice tasks. We performed a multinomial logistic regression to obtain overall importance scores, attribute-level part-worth utilities, and most important attribute.

Results: Of 660 participants, 81% were white, 51% female, and 37% had at least a 4-year college degree with an average age of 42.0 years (SD ±19.4). The attributes had the following importance: *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%. *Health Effects* was the most important attribute for all ages and genders ($p<0.05$); variation in other important attributes existed by age, though not gender.

Conclusion: This study identified the importance of nine ENDS attributes. Perceived *health effects* of ENDS use appeared most important, and *modifications* was least important. Variation by consumer group existed, which may allow for targeted interventions to modify ENDS use.

Strengths and Limitations of the Study:

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

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

Data Sharing: Data can be requested from Christine_Kistler@med.unc.edu

INTRODUCTION, word count=3785

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.[1] While the use of combustible tobacco cigarettes has declined, the U.S. ENDS market now exceeds $8 billion.[2 3] The rise in the use of ENDS has occurred despite mixed evidence about its harm reduction effects or use as a tobacco cessation aid.[4] 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.[5] 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."[6] 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.[7] 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). [8 9] 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 of decrease product use. While DCEs have been conducted to examine consumers' attitudes towards combustible tobacco regulations and smoking cessation,[10-14] only one has examined potential ENDS use.[15] This recently published

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

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

METHODS

Study Design

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

Patient and Public Involvement

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

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

Participants

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

Survey Design

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

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

times.[26] The order of attributes 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. Their definitions can be found in the Appendix, Table 1. For the rest of the paper, we will refer to these nine as *health effects, general effects, cessation aid, purchase price, monthly cost, nicotine content, flavor variety, device traits*, and *modifications*.[16] We chose to divide cost into a separate purchase price and monthly cost attributes because of the variation that can be seen in each; the focus group members mentioned the two attributes separately as well. Rates of tobacco cessation for ENDS products were drawn from the evidence that ENDS are often used as a tobacco cessation aid, regardless of actual effectiveness. It is worth noting that medications prescribed for assisting in tobacco cessation (e.g., bupropion, varenicline, nicotine containing products) have only a 2 out of 10 success rate at best.[27] Nicotine content levels were drawn from the current spectrum of labelled nicotine concentrations.[28] In addition to the actual concentration, we included a label of "none", "low", etc, to denote where in the range of concentrations, a particular concentration falls.

Other Measures

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

and other questions from the National Adult Tobacco Survey Questionnaire, 2012-2013, such as age of first cigarette, number of cigarettes smokes per day, and smoking days per month.[31]

Analysis

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

RESULTS

Of 900 individuals surveyed, 660 participants had used ENDS at least one time. Participants had a mean age of 42 ((SD) ± 19.4), with a range from 18 to 82 years-old, and were evenly split female versus male (51% v 49%) (Table 1) [insert Table 1]. Most participants were white (81%), making less than $60,000 annually (60%), and self-reported very good or excellent health (60%). Sixty-four percent had used ENDS in the last 30 days. Almost all participants (92%) reported a history of traditional tobacco products and most (85%) had tried to quit tobacco in the past 12 months. Pearson's χ^2 tests of the relation between age and tobacco use characteristics found statistically significant ($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* (Δ+9.7%; $p < .001$) and *General Effects* (Δ+8.1%; $p = .002$), and less likely to give importance to *Purchase Price* (Δ−8.3%; $p = .011$) and *Monthly Cost* (Δ−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* (Δ+22%; $p = .004$) and less likely to give importance to *Purchase Price* (Δ−11%; $p = .006$). Middle-aged adults compared with young and older adults together were more likely to give importance to *Modifications* (Δ+24%; $p = .001$) and less likely to give importance to *Health Effects* (Δ−5%; $p = .027$). Older adults compared with middle-aged and young adults together were more likely to give importance to *Purchase Price* (Δ+11%; $p = .004$) and less likely to give importance to *Modifications* (Δ−34%; $p < .001$).

Part-worth utilities of ENDS attribute levels

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

Most important ENDS attribute overall and by sub-group

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

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

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

DISCUSSION

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

initiatives could target these perceptions. Variation by consumer group existed, which may allow for targeted interventions to reduce or enhance ENDS use in any given consumer group.

ENDS products are marketed as healthier than combustible tobacco products, [34] but the evidence regarding the impact of ENDS products on human health is slowly emerging. National Academies of Science, Engineering, and Medicine recently released a report on the public health consequences of ENDS products.[35] While there is substantial evidence that, except for nicotine, exposure to potentially toxic substances from ENDS is significantly lower compared with combustible tobacco products, there is also substantial evidence that exposure to ENDS aerosols can induce lung dysfunction and oxidative stress in human tissue.[36] The long-term effects on cardiovascular outcomes, cancer or other health conditions are unclear. Our work should add a sense of urgency to the push for ongoing research into the evidence for and against ENDS products as a harm reduction strategy. The idea that an ENDS product was less harmful than tobacco cigarettes was extremely important to participants' choice. The level, that the product was "less harmful on my body as compared to tobacco cigarettes", had the highest part-worth utility of any attribute (88.96). Moreover, the level that the product "had the same amount of harm on my body as compared to tobacco cigarettes" caused people to avoid choosing that product and had a negative utility (-22.45). Both the *Health Effects* and the use as a *Cessation Aid* had levels that are likely healthier and of more help in cessation than the evidence suggests. Yet in general, perceptions, including misperceptions, affect smokers' behavior.[37] The look and feel of cigarette packaging appears to influence consumers' use and may affect their perceptions' of the healthiness and harm of the cigarettes within.[38] A study of combustible tobacco labeling revealed that "additive-free" or "natural" labels on current cigarette brands were misperceived to be possibly less harmful than other brands of cigarettes and may reduce the efficacy of public

health initiatives.[39] Even efforts by the Federal Trade Commission to prohibit language that might create misperceptions of reduced harm in tobacco cigarettes has been unsuccessful.[37] This (mis)perception of harm and health appears to strongly influence the choice of ENDS products. Further efforts, including those studying clear labeling and health warnings, are needed to explore how to align ENDS users' perceptions of ENDS products with the evidence.

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

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

have *General Effects* as their most important attribute while *Flavor Variety* was more likely to be most important to middle-aged adults and significantly less likely to be most important to older adults. A systematic review of studies of consumers' preference for flavor found flavor to be likely important to young people.[7] However, as with our own qualitative study, which was included in the review, many of the included studies did not have experimental designs.[16] Interestingly, another Canadian DCE study of ENDS use found that younger smokers perceived cherry flavor as less harmful while older adults found tobacco flavor less harmful.[15] While we found *Flavor Availability* was more important to middle-aged adults, we did not find older adults favored tobacco flavoring. However, both of these studies found that attributes related to the users' health (*health effects* in our case and health warnings in the Canadian study) were more important than flavor, and thus efforts to regulate flavors may not reduce ENDS use as much as other regulations on other attributes, such as health effects.

Our study has several important limitations. First, our study examines choice behavior and not actual purchase behavior. While we drew from a national online survey panel, our respondent population is limited to a convenience sample. Additionally, best-worst scaling can be subject to attribute non-attendance, where participants either fail to pay attention to an attribute or attributes, or attribute dominance, where participants only pay attention to a single attribute. We found that only about 2% of participants did not attend to the majority of attributes, though about 16% failed to attend to at least one attribute. No participant showed dominance behavior. While there was some attribute non-attendance, best-worst scaling inclines participants to make judgements about more attributes and does not invite as much attribute non-attendance or dominance as can be seen in other standard DCEs. However, it seems more likely that socially desirable responses could bias respondents' choices within best-worst scaling than other DCEs

might.[24] Lastly, while we did extensive pre-testing, it is possible that different participants interpreted different attributes and levels differently. For example, it is possible that participants viewed the monthly cost of use in relation to their own use and thus the responses to monthly cost may need to be viewed with caution.

CONCLUSION

A variety of ENDS product attributes are important to consumers. *Health Effects* had the highest importance to consumers' choice of an ENDS product. Other than cost, the attributes with the highest importance scores hinged on consumers' perceptions of efficacy as a harm reduction strategy (*Health Effects)*, general benefit (*General Effects*), and tobacco cessation (*Cessation Aid*), respectively. Consumers differed by age group in some of the more important attributes. Though the overall importance of ENDS product attributes was similar, efforts to increase or 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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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[1]	*387 (64%)*	109 (71%)	153 (69%)*	125 (54%)*
Used flavored ENDS in last 30 days, of current ENDS users[2]	*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)[1]	*17 (6)*	16 (3)	18 (5)	18 (8)
Smokes more than 1 pack/day[3]	*54 (12%)*	3 (3%)*	12 (8%)*	39 (23%)*
First smoke within 30 minutes of waking[3]	*256 (59%)*	48 (44%)*	89 (59%)	119 (70%)*
Tobacco quit attempt in past 12 months[3]	*369 (85%)*	87 (79%)*	130 (85%)	152 (89%)

Note. * $p < .05$; Test versus total. [1] n=607, 154, 221, and 232, respectively; [2] n=420, 117, 170, and 133, respectively; [3] 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)
	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)

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%)[a]	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%)[a]	13 (5%)[a]	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%)[a]	4 (2%)[a]	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. [a] $p < .05$ versus total sample for age groups.

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

Figure 2. Importance of ENDS characteristics, n=660

Appendix Table 1. ENDS Characteristics and Definitions

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

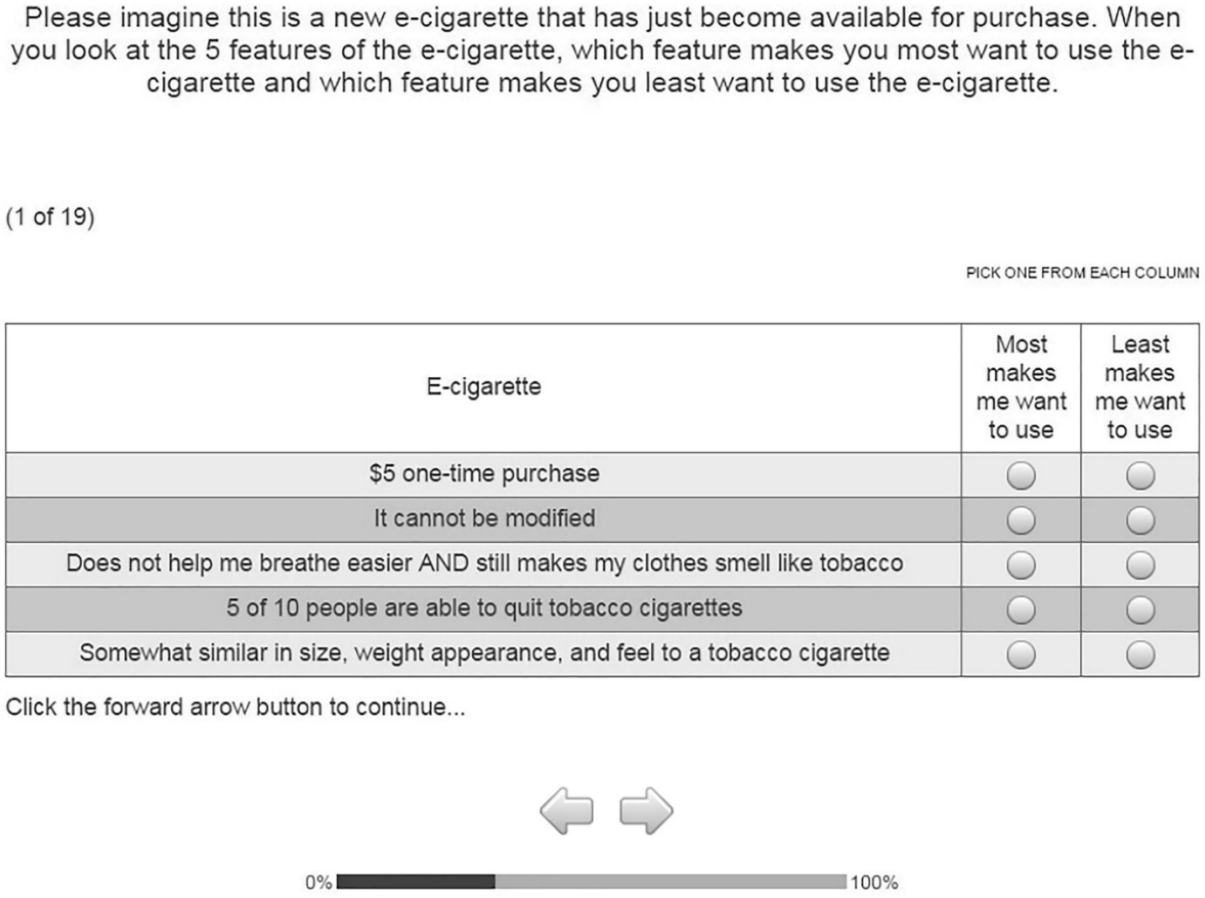
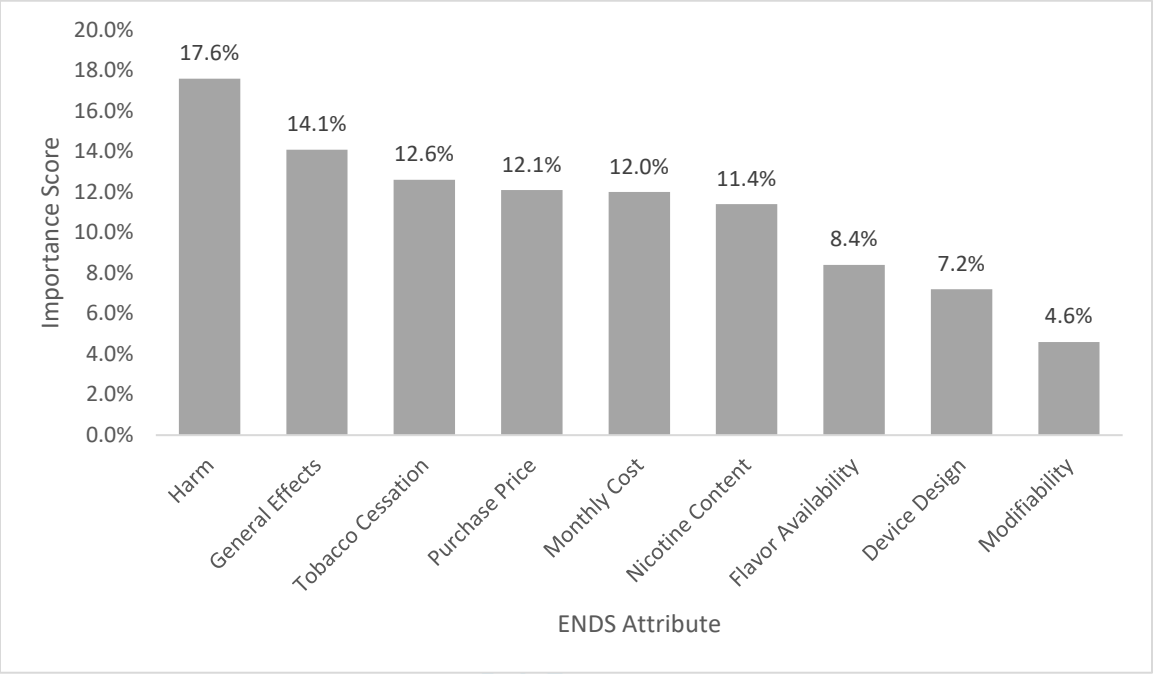


Figure 2. Importance of ENDS characteristics, n=660



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.

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

	Item No	Location
Title and abstract	1	(*a*) We included Discrete Choice Experiment in our title
		(*b*) We included the overarching results in the abstract
Introduction		
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
Methods		
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
Results		
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
Discussion		
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.
Other information		
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.