

**Do JUUL and e-cigarette flavors change risk perceptions of adolescents? Evidence from a national survey.**

Kiersten Strombotne, PhD<sup>1</sup>, John Buckell, PhD<sup>2</sup>, and Jody Sindelar, PhD<sup>3</sup>

1. Corresponding Author: Kiersten Strombotne, Department of Health Law, Policy & Management, Boston University School of Public Health, 715 Albany St., Boston, MA 02118, USA; telephone: 617-358-3367; email: [kiersten@bu.edu](mailto:kiersten@bu.edu)
2. John Buckell, Health Economics Research Center, Nuffield Department of Population Health, University of Oxford, Oxford, UK.
3. Jody Sindelar, Department of Health Policy & Management, Yale School of Public Health, New Haven, CT, USA

**Keywords:** Electronic nicotine delivery devices; adolescents; risk perceptions; public policy

**Word Count:** 4,010

**Reference Count:** 40

## **Do JUUL and e-cigarette flavors change risk perceptions of adolescents? Evidence from a national survey.**

### **Abstract**

*Introduction.* Use of JUULs and e-cigarettes is growing rapidly, particularly among adolescents. Research suggests that flavors may increase the appeal of these products, but little is known about how flavors influence perception. We examine whether youth perceptions about the health risks of JUULs and e-cigarettes vary with flavors.

*Methods.* We conducted a national survey in 2018 of 1,610 high school students aged 14-18 who had ever heard of either JUULs or e-cigarettes. Respondents were asked to rate the lung cancer risk, the harm of secondhand vapor, potential for addiction, and healthiness of different flavored JUUL and e-cigarette products. We investigate the relationship among flavor, risk perception and socio-demographic information.

*Results.* We find that risk perceptions for both JUULs and e-cigarettes differ significantly by flavor type. Youths perceive fruit flavors to be less likely to lead to lung cancer (-0.909 [0.065]), have harmful secondhand vapor (-0.933 [0.060]), and be more addictive (1.104 [0.094]) relative to tobacco flavors. Candy, menthol/mint, and alcohol flavors show similar patterns of risk association, although the magnitude is slightly smaller than for fruit flavors.

*Conclusions.* Youths believe that flavors are related to the health risks of both JUULs and e-cigarettes despite the fact that these differences in risk by flavor have not been scientifically or systematically established. A policy concern is that misperceptions based on flavor may result in increased vaping by youths. The findings from this study support the assertion that banning fruit, menthol or mint, and sweet flavors could reduce the appeal of JUULs and e-cigarettes to youth, with concomitant health protections.

## I. Introduction

Adolescent e-cigarette use is on the rise and has recently surpassed combustible cigarette use nationwide (1,2). The increase in e-cigarette use in 2017-2018 increased substantially, and in 2019, an estimated 10.5% of middle school students and 27.5% of high school students reported current e-cigarette use (3,4). The recent and rapid rise in e-cigarette use prompted the US Surgeon General to declare a youth epidemic in 2018 (5). JUULs in particular now account for 75% of the electronic nicotine delivery system market, up from 40% market share in 2017 (6,7). JUULs and e-cigarettes may be attractive to adolescents because they are novel, trendy, and generally perceived as less harmful than combustible cigarettes (8–10).

Evidence suggests that the variety of flavors available in these products also make them more appealing (9,11). Recent research reveals that youth are more likely to initiate e-cigarette use with non-tobacco flavored products (12–14). JUULs, which are a single brand and type of e-cigarettes, come in only a handful of flavors, including Virginia Tobacco, Classic Tobacco, Fruit Medley, Mango, Crème Brûlée, Menthol, Mint, and Cool Cucumber. Content analysis of e-cigarette retail websites show that almost all e-cigarettes are flavored (including tobacco flavor) (15).

Despite the rise in sales and the prevalence of flavors, little is known about how flavors themselves influence youth perceptions of JUULs and e-cigarettes or the decision of whether and how much to use them. To our knowledge, two studies have directly examined the relationship between e-cigarette flavors and e-cigarette perceptions. In a cross-sectional study, Cooper et al. (2016) find that youth e-cigarette users viewed flavored e-cigarettes as “less harmful” than non-flavored e-cigarettes compared to youth that had never used cigarettes (16). Pepper, Ribisl & Brewer (2016) examine the impact of specific flavors on e-cigarette perceptions (17). The researchers randomized adolescents to one of five e-cigarette flavors (tobacco, alcohol, menthol, candy or fruit), and assessed perceptions of health risks with the question, ‘If you regularly used an e-cigarette or other vaping device with (flavor condition), how harmful to your health do you think it would be?’ They find that adolescents perceived fruit-flavored e-cigarettes as less harmful than tobacco-flavors but saw no differences amongst the other flavors.

While previous research has examined youth perceptions of overall harmfulness, our study builds on prior research and examines four specific e-cigarette risks: the risk of lung cancer, the potential harms of secondhand vapor, the risk of long-term addiction and the overall healthiness of vaping. We also extended the literature by distinguishing between JUUL, about which less is known and whose use is growing rapidly, and e-cigarettes. While there may be some actual differences in risk by flavors due to the use of different chemical contents used in individual flavors and brands, evidence is very limited. Furthermore, if there are some differences in risk based on the current chemical makeup of a given flavor, these risks are likely to be idiosyncratic and not pertaining to all specifications of a broad category of flavors such as ‘fruit’ or ‘candy.’ In addition, if there are differences, they are unlikely to be known by these youths. Thus, we classify evidence of variation (as opposed to the null of no difference) in perceived risks by flavor category as misperceptions of the impact on risk. We focus on adolescents because they are the critical age category for experimentation and initiation, and eventual use of combustible cigarettes.

Understanding how flavors affect youth perceptions of JUULs and e-cigarettes is of great policy importance. As medical and public health experts increasingly assert that banning fruit and sweet flavors could reduce the appeal of e-cigarettes and JUUL to youth, with concomitant health protections, rigorous evidence is needed to support or refute these claims (18).

## **II. Methods**

### ***Survey Procedures and Sample***

We conducted an online cross-sectional survey in 2018 of adolescents aged 14-18 who had ever tried or heard of either JUULs or e-cigarettes. Adolescents were recruited based on quotas derived from the 2015 US census for a total of 2,000 participants. Quotas were defined by age (14 to 18), region (New England, Mid Atlantic, Midwest, South, Mountain, Pacific), gender (female, male), and race (white, non-white). We were unable to collect the full sample; the final sample of completed surveys is 1,621 adolescents aged 14 to 18 years in the U.S who have ever heard of or tried e-cigarettes of any type. Thus, our sample is not nationally representative. Importantly, none of the quotas were empty; that is, at least some responses were collected from all the quotas. We provide the specific quotas in Appendix A.

Participants were recruited through Qualtrics Online Research Panels and data were collected via their online questionnaire platform. Eligible individuals provided consent prior to participation.

### ***Promoting data quality***

We used several techniques to promote data quality. The survey was piloted on 100 respondents and their feedback was used to improve the final survey. “Forced responses” were used to prevent respondents from skipping through the survey. In addition, respondents were provided with information indicating that their responses would be used only for research. A minimum time threshold was used to identify whether respondents rushed through. We also checked whether respondents appeared to be duplicates (e.g. very similar socio-demographics). In addition, we provided instructions and definitions to improve the quality of the responses. Qualtrics delivered a total of 1,621 completed surveys within the quotas. We removed 11 observations for failing to meet inclusion criteria (age or awareness of e-cigarettes). The final analytic sample was 1,610 respondents.

## ***Measures***

### ***Participant characteristics***

Survey questions collected information regarding age, gender (female or male), race (American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White), ethnicity (Hispanic, non-Hispanic), urbanicity (rural, suburban, urban) and state of residence. Respondents were also asked about school satisfaction (“How satisfied at school were you during your last year of school”) on a scale of 0 (not at all satisfied) to 10 (completely satisfied), free or reduced price lunch program participation (yes, no), and parents’ highest level of education (see [Table 1](#)).

### ***Awareness and use of JUUL and e-cigarettes***

Awareness of e-cigarettes and/or JUUL was determined by a “yes” response to two separate questions: “Have you ever heard of an e-cigarette / JUUL?” Narrative and visual information describing the products accompanied the awareness prompts. Ever use of traditional cigarettes, e-cigarettes, and/or JUUL was determined by a “yes” response to three separate questions: “Have you ever tried a traditional cigarette / e-cigarette / JUUL?” Finally, parental use was determined based on the response to the following question: “Do any of your parents or legal guardians use e-cigarettes, traditional cigarettes, or JUUL-types?”

#### *Perceptions of risk for JUUL and e-cigarettes*

We assessed perceptions of health risks separately for JUUL and all e-cigarettes using sliding scales. An example scale is shown in [Figure 1](#). In eight separate survey questions, respondents were asked to give a rating for each flavor with respect to: “How addictive do you think the following [JUUL/e-cigarette] flavors are?”; “How likely to cause lung cancer do you think the following e-cigarette flavors will be to a dedicated user of that [JUUL/e-cigarette flavor) when they get old?”; “How healthy do you think each of the following [JUUL/e-cigarette] flavors is for a dedicated user of [JUULs/e-cigarettes]?”; “How harmful do you think secondhand smoke (vapor) is to others from each of the following [JUUL/e-cigarette] flavors?” In each scale, respondents were asked to select a scale value from 0 to 10 for each of five different flavor options. While healthiness could be considered a ‘benefit,’ we use the term ‘risk’ in the remainder of the paper for ease of interpretation. Additional scales are shown in Appendix B.

While prior research has examined youth perceptions of risk via broad measures of overall “harmfulness,” this study seeks to understand the extent to which specific risk perceptions like addiction or secondhand vapor, are associated with e-cigarette flavors. In previous research we have found that specific dimensions of harm were important predictors of young adults’ preferences for e-cigarettes (19). Each risk perception question is intended to elicit perceptions of risk to a ‘dedicated user’ based on long-term use of each product (20). These measures are thus indirect (a non-specific user), conditional measures of perception (21). Indirect measures capture own and others’ risk, which may be important for youth as they could underestimate their own risk on account of optimism bias (22,23). Conditional measures are thought to be better predictors of behavior than unconditional measures (24,25).

#### *Selection of Flavors*

Flavor options for JUULs and e-cigarettes differed because they are sold in different flavors. At the time of the survey, JUULs were available in tobacco, menthol/mint, fruit medley/mango, cool cucumber and crème brûlée flavors. Broader, generic flavors categories were used for e-cigarettes as there are too many specific flavors to study individually. We chose flavor categories, menthol/mint, fruit, candy and alcohol, consistent with prior studies, which included tobacco (17). While previous studies have proposed alternative flavor classification schemes, we chose these five categories in order to: 1) facilitate the comparability of our results with prior studies, 2) enable comparison between specific JUUL flavors and broader e-cigarette categories, and 3) reduce the cognitive burden on survey respondents (26,27). These flavor categories capture most of the e-cigarette market, in the sense that they are used by up to 90% of young e-cigarette and JUUL users (28,29).

### *Data analysis*

We test whether and how youths' perceptions of the four main risk dimensions varied across flavors and JUUL and e-cigarette. Our outcome variables are the respondents' recorded perception of each risk dimension (0 to 10). Perceptions are pooled over flavors and products for each individual; that is, respondents' recorded perceptions for each flavor is treated as a single observation of the same dimension. We collected 5 flavor observations for each product type (e-cigarettes and JUUL). Perception data were collected separately by product because the flavor categories are not identical between e-cigarettes and JUUL. Therefore, with 2 products and 5 flavors for each product, we have 10 observations of each risk dimension per individual. In regressions, perceptions are pooled over flavors within each product for each of the 1,610 individuals yielding 8,050 (5\*1610) observations for JUUL products and 8,050 observations for e-cigarettes.

Our primary independent variables of interest are dummy/indicator variables for flavor type. The coefficients on flavor dummy variables capture youths' perceptions of each flavor, relative to tobacco (omitted category), for each risk dimension. For example, the coefficient on fruit in the addiction regression indicates the difference in youths' perception of the addictiveness of fruit vs tobacco for that particular product.

We adjust for confounding by specifying a rich set of control variables in our models (see [Table 1](#)). These include gender, race, ethnicity, measures of socioeconomic status (parents' education and whether the respondent received free lunches at school), school satisfaction, product awareness, product use, and parent product use (cigarettes, e-cigarettes, JUUL). In addition, we included full sets of age and state indicators (fixed effects).

We specify eight regressions of these risk dimensions (one for each flavor for each of the four products) and regress risk perceptions on flavor variables and the other control variables. We estimate separate regressions for perceptions of e-cigarettes and JUUL both because of the possibility of separate impacts of flavors and due to the different flavors for each product. We estimate the following ordinary least squares regression model:

$$Perception_i = \beta_{flav}FLAV + \delta'Z_i + \varepsilon_i \quad (1)$$

Where  $Perception_i$  is each individual's ( $i$ ) perception of each of the four main risks (likelihood of lung cancer, harm caused by secondhand vapor, addictiveness, or healthiness).  $FLAV$  is a dummy variable for each flavor and  $\beta_{flav}$  indicates how perceptions vary by each flavor relative to tobacco.  $\delta Z_i$  is a set of individual characteristics ( $Z$ ), including age and state fixed effects, and how each is associated with overall perceptions ( $\delta$ ).  $\varepsilon_i$  is the error term assumed to be normally distributed. Since we have multiple observations per individual, we cluster the standard errors at the individual level.

The software STATA (version 14) is used for estimation. The Yale Human Subjects Committee approved this study.

### III. Results

#### *Participant characteristics*

**Table 1** presents descriptive characteristics of the respondents. Respondents had a mean age of 16.06 (SD = 1.39) and were 49% female; the majority were white/Caucasian (75%). Many respondents were from suburban areas (54%), participated in free or reduced-price lunch programs (48%) and had parents that had completed “some college or more” (67%). On a scale of 0 to 10, respondents reported a 6.4 (SD = 2.74) point average school satisfaction rating.

#### *JUUL and e-cigarette use patterns*

Ninety-three per cent of respondents indicated that they had heard of e-cigarettes and 89% had heard of JUUL products like those shown in the visual prompt. Conditional on product awareness, use of these products was moderate: 38% of the sample had ever tried e-cigarettes while 37% had ever tried a JUUL product. In comparison, only 30% had ever tried combustible cigarettes. Combustible cigarettes were the most commonly reported product for parental tobacco use (26%).

#### *Average Perceptions of Risk*

We present mean risk perception scale values for each of the four risk dimensions for both JUUL and e-cigarettes in **Table 1**. These means indicate the average scale value (0 to 10) across all five flavors for a given risk dimension. Overall, respondents do not perceive JUULs ( $2.11 \pm 2.78$ ) or e-cigarettes ( $1.87 \pm 2.70$ ) to be healthy. Respondents reported average risks of lung cancer, second hand vapor harm, and addictiveness to be greater than 5 for both JUUL and e-cigarette products.

#### *Perceptions of JUUL and E-Cigarette Risks*

**Table 2** presents results of ordinary least squared regression models examining whether flavor and demographic characteristic predict the perception of risks of JUULs: likelihood of lung cancer, potential harms of secondhand vapor, potential for addiction, and healthiness. Perceptions of risk differed significantly by flavor type, as we detail below. All coefficients are significant at the .05 level or higher, and most are significant at the .001 level as indicated in the table.

Perhaps most strikingly, youths perceive fruit flavors to be less likely to lead to lung cancer ( $-0.909[0.065]$ ), less likely to have harmful secondhand vapor ( $-0.933[0.060]$ ), healthier ( $0.820[0.056]$ ), and more addictive ( $1.104[0.094]$ ) relative to tobacco flavors. Crème brûlée and mint/menthol flavors show similar patterns of risk association, although the magnitude is slightly smaller than fruit flavors. In all regressions, tobacco flavoring (the base category) is perceived as more likely to lead to lung cancer and produce harmful secondhand vapor. Youth perceive cucumber flavors to be least addictive relative to tobacco flavor ( $-0.219[0.092]$ ), and also healthier ( $0.776[0.056]$ ). We discuss this finding in detail Section IV below.

**Table 3** presents similar regression results for e-cigarette flavors however, the e-cigarette regressions included alcohol and candy flavors (but not cucumber or crème brûlée). All the flavor coefficients are significant at the .01 level or higher, and most are significant at the .001 level as indicated in the table. Risk perceptions across all four dimensions present a similar pattern for e-cigarettes as they do for JUUL with two notable differences. First, the magnitude of differences between tobacco flavors and the remaining flavors were higher in e-cigarettes than in

JUULs. Second, in these regressions, risk perceptions of fruit, menthol/mint, alcohol and candy display a similar relationship to tobacco flavor. The magnitude of the findings is greatest for fruit and candy flavors.

Each regression model in tables 2A and 2B includes socio-demographic controls. We find that, holding flavor constant, females are more *pessimistic* than their male counterparts about the risks of both JUULs and e-cigarettes: they are more likely to believe these products can cause lung cancer, emit harmful secondhand vapor, and lead to addiction. They are also less likely to believe these products are healthy. Youths who had tried JUUL and those who had never heard of JUUL were more *optimistic* about the benefits and risks of JUUL compared to people who had heard of them but not tried. The complete set of control variable estimates for tables 2 and 3 can be found in Appendix C.

## **IV. Discussion**

### ***Summary***

Overall we find that risk perceptions for both JUULs and e-cigarettes differ significantly by flavor type. Our findings for JUUL are novel, while our findings for e-cigarettes are consistent with prior research (16,17). Perhaps not surprisingly, tobacco is considered to provide the greatest risk for lung cancer and secondhand vape and is considered to be the least healthy. Thus, it would appear that youths are generalizing from their knowledge of tobacco in cigarettes to the artificial flavor of tobacco in vaping products. In general, the magnitude of risk perceptions between tobacco flavors and the remaining flavors were higher in e-cigarettes than in JUULs. We hypothesize that these differences could arise for many reasons, including that youth may have greater familiarity with e-cigarettes, and thus have stronger priors. Differential perceptions across these products is valuable information for policymakers seeking to impose regulations on flavors.

Across both products, youths perceive fruit flavors to be less likely to lead to lung cancer and less likely to produce harmful secondhand vapor and to be healthier. As with tobacco, these results might not be that surprising as youths may be generalizing their perceptions of the healthiness of fruit to vaping. However, a somewhat perplexing result, is that youths consider fruit to be more addictive relative to tobacco flavors. Based on answers to our survey question about youths' favorite flavors, we find that fruit is by far the most preferred flavor of e-cigarettes. Thus, youths may be conflating their fondness for the fruit flavor with addictiveness, that is, the more that they like the flavor, the harder that it would be to cut back or quit. Similarly, in all regressions, youth perceive tobacco flavoring as more likely to lead to lung cancer and produce harmful secondhand vapor. In general, these patterns replicate the real-life healthiness of the actual products that the flavors represent.

Menthol or mint in JUULs is perceived to be the least likely to lead to lung cancer and to produce harmful secondhand vaping. It is considered in the midrange of addictiveness and tied for the least addictive. In combustible cigarettes, evidence shows that menthol is considered to be cooling, less harsh and easier for youths to smoke (30). It appears that this perception with respect to combustibles may be generalized to e-cigarettes and JUULs. For e-cigarettes, the impacts of menthol are somewhat different, perhaps due to comparison to different flavors



available in e-cigarettes.

Candy flavors show a similar pattern of risk associations to that of fruit, with the exception that candy is considered to be less healthy. This latter finding is consistent with the idea that youths consider actual candy to be less healthy than fruit in the real-world products. The risk perception coefficients for alcohol e-cigarette flavors are similar in sign to those of fruit and candy, but the magnitudes are smaller. This finding is also consistent with youths considering alcohol to be less healthy than candy.

### *Contributions of this paper*

This paper contributes to the findings of the impact of flavors and has implications for vaping trends and policies to deter use. To our knowledge, this is the first study to examine the relationship between flavors and JUUL risk perceptions. JUUL use is growing so rapidly that it is important to understand the drivers of the growth, which in turn adds to an understanding of policies that could mitigate related problems. This study also adds to the limited evidence on possible reasons for the rapidly expanding demand by adolescents for JUULs (6,31). Further, by examining both JUULs and e-cigarettes within a single study, we can compare the impact of flavors in e-cigarettes to that of JUUL. Previous evidence suggested that youth believe that flavors—especially candy, menthol and fruit—are less “harmful” than unflavored e-cigarettes, or tobacco or alcohol flavored e-cigarettes (16,17). We extend the existing literature by examining multiple dimensions of risk, including lung cancer, secondhand vaping, addictiveness and perceived healthiness. By collecting and using a large, recent, national sample we provide detailed and generalizable findings that are current. By conducting the sample online and to our specifications, we address potential data quality concerns (cf. methods section). Also, we selected only those youth who had heard of e-cigarettes; thus, our sample is more informative of youths most likely to be at risk of future vaping and who might be most at risk of transiting to smoking, which is even more dangerous.

Of course, there are limitations as well. Participation in the survey was limited to youths ages 14-18. Therefore, our findings may not be generalizable outside this age group. The internet sample requires a computer or a smart-phone to participate and may be subject to selection bias. However, now that internet access is nearly universal among youths, it is not as much of a concern as before the widespread access to the internet. Internet surveys may be subject to limitations in clarity in language and terminology. Although we pilot tested our study prior to implementation, it is possible that respondents may have had differing interpretations of terms like “addictiveness” or “dedicated user” when terms were not explicitly defined. Because the data is cross-sectional, we are unable to determine causation: namely, if the reported perceptions directly affect future product uptake or use. In addition, we did not include an exhaustive list of flavor categories and thus are unable to evaluate how risk perceptions may differ for less popular flavors among youths like spice or coffee (28,29) or differ between mint and menthol. While having a non-exhaustive list of flavor categories reduces the cognitive burden of respondents, less popular flavors may exhibit different patterns of risk associations among youths (32).

In sum, we find that youths believe that the artificial flavors available in both JUULs and e-cigarettes are related to the actual health risks of these vaping products in systematic ways. This

is a misperception if health risks do not in fact vary across flavors in systematic ways. At present there is a lack of evidence that show systematic health harms vary across flavor categories.

### ***Policy Implications***

Our findings have several important policy implications. One policy concern is that misperceptions based on the sets of flavors available in all e-cigarettes but most specifically in JUUL may result in increased vaping and more specifically ‘JUULing’ by youths. Youths may falsely believe that non-tobacco flavors convey protection relative to tobacco flavor. Thus, non-tobacco flavors overall may make vaping more appealing, and give a false sense of protection relative to tobacco flavor. Due to flavor availability, youths may begin to vape thinking that they will be less likely to be addicted to nicotine and less likely to harm their health and that of others. This would be especially important if using non-tobacco flavored e-cigarettes is a gateway to smoking combustible cigarettes, although evidence to support the gateway hypothesis is mixed (33–35).

The FDA has banned all flavors in combustible cigarettes, except for menthol. And they had previously indicated that they were considering restricting sales of non-tobacco flavors (except mint and menthol) in vaping products to youths under some scenarios (36). However, such bans have not yet been implemented by the FDA (37). In part perhaps because of the slow response by the FDA, states and cities are considering, and beginning to, implement flavor bans. Several states including Michigan, Washington, Oregon have banned flavors in e-cigarettes, at least on a short-term basis (38,39). Philadelphia’s bill to ban flavors in e-cigarettes in places where adolescents can buy them will likely be signed by the Mayor by the end of 2019 (40).

The FDA and local governments will need empirical evidence to enact such regulations and importantly, to select the best policies. Our finding that adolescents consider menthol or mint e-cigarettes in e-cigarettes to be the least likely flavor to lead to lung cancer and to produce harmful secondhand vaping may be helpful for governmental bodies considering which flavors to ban as menthol is of key policy concern. Notably, the impact of these flavor perceptions will also depend on other laws that governments may pass. However, generally findings from this study support the assertion that banning fruit, sweet, and menthol/mint flavors could reduce the appeal of e-cigarettes and JUULs to youth, with the likely concomitant health protections of fewer youths vaping.

**Acknowledgements**

Research reported in this publication was supported in part by grant number P50DA036151 to Yale from the National Institute on Drug Abuse (NIDA) and FDA Center for Tobacco Products (CTP). The content is solely the responsibility of the author(s) and does not necessarily represent the official views of the National Institutes of Health or the Food and Drug Administration. All authors made equal contributions to the design, analysis, and write-up of this research. No financial disclosures were reported by the authors of this paper. We thank Kurt Petschke for his valuable help and feedback, and we thank Grace Kong for collaborations on an earlier, related survey. The research presented in this paper is that of the authors and does not reflect the official policy of the NIH.

## References

1. Arrazola RA, Singh T, Corey CG, Husten CG, Neff LJ, Apelberg BJ, et al. Tobacco Use Among Middle and High School Students — United States, 2011–2014. *MMWR Morb Mortal Wkly Rep*. 2015 Apr 17;64(14):381–5.
2. Johnston LD, O’Malley PM, Miech RA, Bachman JG, Schulenberg JE. Monitoring the Future National Survey Results on Drug Use, 1975-2015: Overview, Key Findings on Adolescent Drug Use [Internet]. Institute for Social Research; 2016 [cited 2019 Sep 17]. Available from: <https://eric.ed.gov/?id=ED578539>
3. Cullen KA, Gentzke AS, Sawdey MD, Chang JT, Anic GM, Wang TW, et al. e-Cigarette Use Among Youth in the United States, 2019. *JAMA*. 2019 Dec 3;322(21):2095–103.
4. Gentzke AS, Creamer M, Cullen KA, Ambrose BK, Willis G, Jamal A, et al. Vital Signs: Tobacco Product Use Among Middle and High School Students — United States, 2011–2018. *Morb Mortal Wkly Rep*. 2019 Feb 15;68(6):157–64.
5. US Department of Health and Human Services. Surgeon General’s Advisory on E-cigarette Use Among Youth [Internet]. [cited 2019 Dec 10] p. 4. Available from: <https://e-cigarettes.surgeongeneral.gov/documents/surgeon-generals-advisory-on-e-cigarette-use-among-youth-2018.pdf>
6. Huang J, Duan Z, Kwok J, Binns S, Vera LE, Kim Y, et al. Vaping versus JUULing: how the extraordinary growth and marketing of JUUL transformed the US retail e-cigarette market. *Tob Control*. 2019 Mar 1;28(2):146–51.
7. Herzog B, Kanada P. Nielsen: Tobacco “All Channel Data” Through 12/29. San Francisco, CA: Wells Fargo Securities; 2019.
8. Ambrose BK, Rostron BL, Johnson SE, Portnoy DB, Apelberg BJ, Kaufman AR, et al. Perceptions of the Relative Harm of Cigarettes and E-cigarettes Among U.S. Youth. *Am J Prev Med*. 2014 Aug 1;47(2, Supplement 1):S53–60.
9. Choi K, Forster J. Characteristics Associated With Awareness, Perceptions, and Use of Electronic Nicotine Delivery Systems Among Young US Midwestern Adults. *Am J Public Health*. 2013 Jan 17;103(3):556–61.
10. Camenga DR, Cavallo DA, Kong G, Morean ME, Connell CM, Simon P, et al. Adolescents’ and Young Adults’ Perceptions of Electronic Cigarettes for Smoking Cessation: A Focus Group Study. *Nicotine Tob Res Off J Soc Res Nicotine Tob*. 2015 Oct;17(10):1235–41.
11. Kong G, Morean ME, Cavallo DA, Camenga DR, Krishnan-Sarin S. Reasons for Electronic Cigarette Experimentation and Discontinuation Among Adolescents and Young Adults. *Nicotine Tob Res*. 2015 Jul 1;17(7):847–54.

12. Shang C, Huang J, Chaloupka FJ, Emery SL. The impact of flavour, device type and warning messages on youth preferences for electronic nicotine delivery systems: evidence from an online discrete choice experiment. *Tob Control*. 2018 Oct 1;27(e2):e152–9.
13. Stanton CA, Villanti AC, Watson C, Delnevo CD. Flavoured tobacco products in the USA: synthesis of recent multidiscipline studies with implications for advancing tobacco regulatory science. *Tob Control*. 2016 Nov 1;25(Suppl 2):ii1–3.
14. Harrell MB, Weaver SR, Loukas A, Creamer M, Marti CN, Jackson CD, et al. Flavored e-cigarette use: Characterizing youth, young adult, and adult users. *Prev Med Rep*. 2017 Mar 1;5:33–40.
15. Grana RA, Ling PM. “Smoking Revolution”: A Content Analysis of Electronic Cigarette Retail Websites. *Am J Prev Med*. 2014 Apr 1;46(4):395–403.
16. Cooper M, Harrell MB, Pérez A, Delk J, Perry CL. Flavorings and Perceived Harm and Addictiveness of E-cigarettes among Youth [Internet]. 2016 [cited 2019 Sep 17]. Available from: <https://www.ingentaconnect.com/content/trsg/trs/2016/00000002/00000003/art00007>
17. Pepper JK, Ribisl KM, Brewer NT. Adolescents’ interest in trying flavoured e-cigarettes. *Tob Control*. 2016 Nov 1;25(Suppl 2):ii62–6.
18. Drazen JM, Morrissey S, Champion EW. The Dangerous Flavors of E-Cigarettes. *N Engl J Med*. 2019 Feb 14;380(7):679–80.
19. Buckell J, Sindelar JL. The impact of flavors, health risks, secondhand smoke and prices on young adults’ cigarette and e-cigarette choices: a discrete choice experiment. *Addiction*. 2019;114(8):1427–35.
20. Chaffee BW, Gansky SA, Halpern-Felsher B, Couch ET, Essex G, Walsh MM. Conditional risk assessment of adolescents’ electronic cigarette perceptions. *Am J Health Behav*. 2015 May;39(3):421–32.
21. Popova L, Halpern-Felsher BL. A Longitudinal Study of Adolescents’ Optimistic Bias about Risks and Benefits of Cigarette Smoking [Internet]. 2016 [cited 2019 Sep 17]. Available from: <https://www.ingentaconnect.com/content/png/ajhb/2016/00000040/00000003/art00006>
22. Otten W, Van Der Pligt J. Context Effects in the Measurement of Comparative Optimism in Probability Judgments. *J Soc Clin Psychol*. 1996 Mar 1;15(1):80–101.
23. Hevey D, French DP, Marteau TM, Sutton S. Assessing Unrealistic Optimism: Impact of Different Approaches to Measuring Susceptibility to Diabetes. *J Health Psychol*. 2009 Apr 1;14(3):372–7.
24. Halpern-Felsher BL, Millstein SG, Ellen JM, Adler NE, Tschann JM, Biehl M. The role of behavioral experience in judging risks. *Health Psychol*. 2001;20(2):120–6.

25. Pligt J van der. Perceived risk and vulnerability as predictors of precautionary behaviour. *Br J Health Psychol.* 1998;3(1):1–14.
26. Yingst JM, Veldheer S, Hammett E, Hrabovsky S, Foulds J. A Method for Classifying User-Reported Electronic Cigarette Liquid Flavors. *Nicotine Tob Res.* 2017 Nov 1;19(11):1381–5.
27. Krüsemann EJZ, Boesveldt S, de Graaf K, Talhout R. An E-Liquid Flavor Wheel: A Shared Vocabulary Based on Systematically Reviewing E-Liquid Flavor Classifications in Literature. *Nicotine Tob Res.* 2019 Sep 19;21(10):1310–9.
28. Leventhal AM, Miech R, Barrington-Trimis J, Johnston LD, O’Malley PM, Patrick ME. Flavors of e-Cigarettes Used by Youths in the United States. *JAMA.* 2019 Dec 3;322(21):2132–4.
29. Schneller LM, Bansal-Travers M, Goniewicz ML, McIntosh S, Ossip D, O’Connor RJ. Use of Flavored E-Cigarettes and the Type of E-Cigarette Devices Used among Adults and Youth in the US—Results from Wave 3 of the Population Assessment of Tobacco and Health Study (2015–2016). *Int J Environ Res Public Health.* 2019 Jan;16(16):2991.
30. Hersey JC, Nonnemaker JM, Homsy G. Menthol Cigarettes Contribute to the Appeal and Addiction Potential of Smoking for Youth. *Nicotine Tob Res.* 2010 Dec 1;12(suppl\_2):S136–46.
31. Willett JG, Bennett M, Hair EC, Xiao H, Greenberg MS, Harvey E, et al. Recognition, use and perceptions of JUUL among youth and young adults. *Tob Control.* 2019 Jan 1;28(1):115–6.
32. Hoffman AC, Salgado RV, Dresler C, Faller RW, Bartlett C. Flavour preferences in youth versus adults: a review. *Tob Control.* 2016 Nov 1;25(Suppl 2):ii32–9.
33. Chen JC, Das B, Mead EL, Borzekowski DLG. Flavored E-cigarette Use and Cigarette Smoking Susceptibility among Youth [Internet]. 2017 [cited 2019 Dec 11]. Available from: <https://www.ingentaconnect.com/content/trsg/trs/2017/00000003/00000001/art00007>
34. Chen-Sankey JC, Kong G, Choi K. Perceived ease of flavored e-cigarette use and e-cigarette use progression among youth never tobacco users. *PloS One.* 2019;14(2):e0212353.
35. Friedman AS, Buckell J, Sindelar JL. Patterns of Youth Cigarette Experimentation and Onset of Habitual Smoking. *Am J Prev Med.* 2019 Jun;56(6):803–10.
36. US Food and Drug Administration. Statement from FDA Commissioner Scott Gottlieb, M.D., on efforts to reduce tobacco use, especially among youth, by exploring options to address the role of flavors – including menthol – in tobacco products [Internet]. 2019 Sep [cited 2019 Dec 17]. Available from: <http://www.fda.gov/news-events/press-announcements/statement-fda-commissioner-scott-gottlieb-md-efforts-reduce-tobacco-use-especially-among-youth>

37. Barkho G. The FDA Ban on Flavored E-Cigarettes Is Still Being Debated. Observer [Internet]. [cited 2019 Dec 17]; Available from: <https://observer.com/2019/12/fda-ban-flavored-e-cigarettes-congress-hearing/>
38. Rense S. 7 States Have Banned Vapes So Far. Is All of America Next? Esquire [Internet]. 2019 Oct 14 [cited 2019 Dec 17]; Available from: <https://www.esquire.com/lifestyle/health/a29067489/which-states-banned-flavored-e-cigarettes-vaping-juuls/>
39. Villeneuve M. New York tries to keep alive flavored e-cigarette ban. NY Daily News [Internet]. 2019 Dec 14 [cited 2019 Dec 17]; Available from: <https://www.nydailynews.com/news/sns-bc-us--vaping-flavors-20191212-story.html>
40. Gantz S. Philadelphia to restrict sales of flavored e-cigarettes. The Philadelphia Inquirer [Internet]. 2019 Dec 5 [cited 2019 Dec 17]; Available from: <https://www.inquirer.com/health/consumer/flavored-e-cigarettes-vaping-ban-philadelphia-20191205.html>

**Table 1. Baseline characteristics of study participants**

<b>Variables: Independent</b>	<b>Mean / percenta ge</b>	<b>std. dev.</b>	<b>n</b>
<b><i>Demographics</i></b>			
Age	16.06	(1.39)	1,610
14	0.18	(0.38)	1,610
15	0.20	(0.40)	1,610
16	0.20	(0.40)	1,610
17	0.22	(0.41)	1,610
18	0.20	(0.40)	1,610
Female	0.49	(0.50)	1,610
Parents Have Some College Edu	0.67	(0.47)	1,610
Free or Reduced Lunch Recipient	0.48	(0.50)	1,610
School Satisfaction Scale	6.4	(2.74)	1,610
<b><i>Race/Ethnicity</i></b>			
Amer. Indian or Alaska Native	0.02	(0.14)	1,610
Asian	0.05	(0.22)	1,610
Black	0.09	(0.29)	1,610
Multiracial	0.07	(0.26)	1,610
Native Hawaiian or Pac. Islander	0.01	(0.12)	1,610
White	0.75	(0.43)	1,610
<b><i>Hispanic</i></b>			
Hispanic	0.20	(0.40)	1,610
<b><i>Urbanicity</i></b>			
Rural	0.23	(0.42)	1,610
Suburban	0.54	(0.50)	1,610
Urban	0.23	(0.42)	1,610
<b><i>JUUL &amp; E-Cigarette Use</i></b>			
Ever heard or seen JUUL	0.89	(0.31)	1,610
Ever heard or seen e-cig	0.93	(0.26)	1,610
Never heard or seen JUUL	0.11	(0.31)	1,610
Never heard or seen e-cig	0.07	(0.26)	1,610
Ever tried combustible cig	0.30	(0.46)	1,610
Ever tried e-cig	0.38	(0.48)	1,496
Ever tried JUUL	0.37	(0.37)	1,439
Parents use combustible cig	0.26	(0.44)	1,610
Parents use e-cig	0.09	(0.28)	1,610
Parents use JUUL	0.04	(0.19)	1,610
<b>Variables: Dependent</b>	<b>mean</b>	<b>std. dev.</b>	<b>n</b>
<b><i>JUUL Risk Perception Scales*</i></b>			
Lung cancer risk	7.29	(2.84)	8,050
Secondhand vapor risk	6.48	(3.21)	8,050
Average risk of addiction	7.11	(2.85)	8,050
Healthiness	2.11	(2.78)	8,050
<b><i>E-Cigarette Risk Perception Scales*</i></b>			



Lung cancer risk	7.13	(3.02)	8,050
Secondhand vapor risk	6.49	(3.19)	8,050
Average risk of addiction	6.94	(2.87)	8,050
Healthiness	1.87	(2.70)	8,050

**Notes:** For dichotomous variables, the mean can be interpreted as the percentage of the variable in the sample. The total sample size is 1,610 respondents. Sample size for “ever tried” variables is conditional on a “yes” response to “ever heard” variables, and thus smaller than the full sample.

\*The data is transformed into a long format for analysis, and the dependent variables (risk dimensions) presented in this table are averaged across all five possible flavors for each respondent. Therefore, there are 8,050 observations (5 flavor values for each 1,610 respondents).

**Table 2. Results of OLS models: flavor and demographic characteristic predicting the perception of harm of JUULs**

<b>VARIABLES</b>	<b>Model 1: Lung Cancer</b>	<b>Model 2: Second Hand Vapor</b>	<b>Model 3: Addictive</b>	<b>Model 4: Healthy</b>
<b>Flavors</b>				
Menthol	-0.656*** (0.054)	-0.636*** (0.049)	0.691*** (0.076)	0.525*** (0.047)
Fruit	-0.909*** (0.065)	-0.933*** (0.060)	1.104*** (0.094)	0.820*** (0.056)
Crème Brûlée	-0.858*** (0.060)	-0.796*** (0.055)	0.266** (0.089)	0.523*** (0.044)
Cucumber	-1.126*** (0.066)	-0.992*** (0.061)	-0.219* (0.092)	0.776*** (0.056)
<b>Select Control Variables</b>				
Female	0.626*** (0.124)	0.557*** (0.145)	0.283** (0.104)	-0.659*** (0.124)
Never heard of JUUL	-0.505** (0.192)	-0.189 (0.212)	-0.410* (0.183)	0.643** (0.215)
Ever tried combustible cigarettes	-0.073 (0.191)	0.215 (0.222)	-0.050 (0.142)	0.090 (0.201)
Ever tried e-cigarettes	-0.309 (0.193)	-0.814*** (0.226)	0.079 (0.148)	0.324 (0.201)
Ever tried JUUL	-0.554** (0.169)	-0.952*** (0.189)	-0.563*** (0.132)	0.578*** (0.170)

**Notes: The number of respondents is 1,610.** The dependent variables (risk dimensions) presented in this table are averaged across all five possible flavors for each respondent. Therefore, there are 8,050 observations (5 flavor values for each 1,610 respondents. Although not shown, all models included variables for race/ethnicity, rural/urban location, parental education, free lunch status, school satisfaction, and parental cigarette, JUUL and e-cigarette use. Standard errors are clustered by individual and are reported in parentheses below each estimate. All regressions included a constant, age indicators and state fixed effects. Age was not a significant predictor of risk perception. Tobacco is the omitted (base) flavor category. \*\*\* p<0.001, \*\* p<0.01, \* p<0.05

**Table 3. Results of OLS models: flavor and demographic characteristic predicting the perception of harm of E-Cigarettes**

<b>VARIABLES</b>	<b>Model 5: Lung Cancer</b>	<b>Model 6: Second Hand Vapor</b>	<b>Model 7: Addictive</b>	<b>Model 8: Healthy</b>
<b>Flavors</b>				
Menthol	-0.945*** (0.066)	-0.888*** (0.056)	0.486*** (0.082)	0.653*** (0.048)
Fruit	-1.464*** (0.088)	-1.520*** (0.075)	1.259*** (0.105)	1.242*** (0.070)
Candy	-1.458*** (0.087)	-1.464*** (0.072)	1.220*** (0.104)	0.688*** (0.052)
Alcohol	-0.866*** (0.070)	-0.716*** (0.054)	1.115*** (0.082)	0.300*** (0.041)
<b>Select Control Variables</b>				
Female	0.565*** (0.122)	0.412** (0.137)	0.287** (0.099)	-0.596*** (0.116)
Never heard of E-cig	-0.383 (0.242)	-0.122 (0.247)	-0.217 (0.205)	0.263 (0.216)
Ever tried combustible cigarettes	0.077 (0.182)	-0.073 (0.212)	0.300* (0.134)	0.122 (0.177)
Ever tried e-cigarettes	-0.418* (0.190)	-0.824*** (0.217)	-0.184 (0.150)	0.518** (0.185)
Ever tried JUUL	-0.195 (0.158)	-0.800*** (0.180)	-0.067 (0.122)	0.143 (0.157)

**Notes: The number of respondents is 1,610.** The dependent variables (risk dimensions) presented in this table are averaged across all five possible flavors for each respondent. Therefore, there are 8,050 observations (5 flavor values for each 1,610 respondents. Although not shown, all models included variables for race/ethnicity, rural/urban location, parental education, free lunch status, school satisfaction, and parental cigarette, JUUL and e-cigarette use. Standard errors are clustered by individual and are reported in parentheses below each estimate. All regressions included a constant, age indicators and state fixed effects. Age was not a significant predictor of risk perception. Tobacco is the omitted (base) flavor category. \*\*\* p<0.001, \*\* p<0.01, \* p<0.05

