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## Prospective Predictors of Flavored E-cigarette Use: A One-Year Longitudinal Study of Young Adults in the U.S.

Julia Cen Chen, PhD<sup>a</sup>, Kerry M. Green, PhD<sup>a</sup>, Amelia M. Arria, PhD<sup>b</sup>, and Dina L.G. Borzekowski, EdD<sup>a</sup>

<sup>a</sup>Department of Behavioral and Community Health, University of Maryland School of Public Health, College Park, MD, 20742

<sup>b</sup>Center on Young Adult Health and Development, University of Maryland School of Public Health, Department of Behavioral and Community Health, College Park, MD, 20742

### Abstract

**Introduction**—E-cigarettes with fruit and candy flavors are particularly appealing among young adults. This study examined the prospective predictors of young adults' flavored e-cigarette use to inform regulation and prevention efforts.

**Methods**—We used the wave 1 (2013–2014) and wave 2 (2014–2015) data of the Population Assessment of Tobacco and Health (PATH) Study, a nationally representative cohort study of U.S. youth and adults. We analyzed a sample of young adults aged 18–34 ( $n=12,383$ ) to identify wave 1 prospective predictors (i.e., socio-demographic characteristics, mental health symptoms, marijuana use, tobacco use, and e-cigarette harm perceptions) of wave 2 flavored e-cigarette use.

**Results**—At wave 2, 8.0% of young adults used e-cigarettes, and 2.5% and 5.5% used tobacco and menthol (TM) and non-tobacco and non-menthol flavors (NTM) flavors, respectively. In the multivariable model, significant prospective predictors (wave 1) of NTM flavored e-cigarette use compared to TM flavored e-cigarette use (wave 2) were younger age (18–24 years) (AOR=1.82,  $p<0.001$ ), female gender (AOR=1.81,  $p<0.001$ ), education attainment of high school graduate and higher (AOR=1.60,  $p=0.024$ ), marijuana use (AOR=1.96,  $p<0.001$ ), ever but non-past-month cigarette smoking (AOR=2.75,  $p<0.001$ ), never cigarette smoking (AOR=5.08,  $p=0.016$ ), and lower harm perception of e-cigarettes (AOR=1.59,  $p=0.005$ ).

**Conclusion**—This study highlights high rates of NTM flavor use and specific predictors of NTM flavored e-cigarettes use among young adults in the U.S. Regulation and prevention efforts for curbing flavored e-cigarette use among young adults should particularly focus on these risk factors and high risk groups (e.g., 18–24 years, female, and never cigarette smokers).

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**Corresponding Author:** Julia Cen Chen, PhD, Department of Behavioral and Community Health, University of Maryland School of Public Health, College Park, MD, 20742, Tel: 443-310-7665, jchen8@umd.edu.

#### Contributors

All authors contributed to the study's concept and design. JCC conducted literature searches and provided summaries of previous research studies. JCC also conducted the statistical analysis and wrote the manuscript. All authors contributed to the writing of the manuscript and have approved the final manuscript.

#### Conflict of Interests

No conflict declared.

## Keywords

Electronic Cigarettes; Vaping; Young Adults; Flavored E-cigarettes; The PATH Study; Nicotine; Tobacco Use; Substance Use

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## 1. Introduction

In recent years, electronic cigarettes, or e-cigarettes, have increased in popularity among young adults in the U.S. In 2013, 21.6% of 12–24 year-olds had experimented with e-cigarettes and 5.1% were current users (Schoenborn and Gindi, 2015). Flavored e-cigarettes, enhanced to taste like fruit, candy, chocolate, and other sweet flavors, are particularly appealing to young adults (Bonhomme et al., 2016; Choi et al., 2012) and might be a primary reason for this age group to initiate e-cigarette use (Shiplo et al., 2015). During 2013–2014, among 18–24 and 25–29 year-old current e-cigarette users in the U.S., 85% and 73% used flavored e-cigarettes, respectively (Bonhomme et al., 2016).

Despite their popularity, flavored e-cigarette use might lead to adverse health consequences. First, e-cigarette flavoring ingredients might be toxic to inhale (Leigh et al., 2016) and result in harm to the respiratory system (Allen et al., 2016; Behar et al., 2013; Callahan-Lyon, 2014). Second, e-cigarettes with attractive flavors could potentially increase nicotine addiction by enhancing the rewarding and reinforcing properties associated with vaping (Audrain-McGovern et al., 2016) as well as promote regular and more frequent e-cigarette use (Chen, 2018; Huang et al., 2016; Morean et al., 2018). Third, flavored e-cigarette use among young, non-cigarette smokers might escalate cigarette smoking intentions (Chen et al., 2017), leading to increased cigarette initiation in the future. Finally, young adult users of flavored tobacco generally may be more likely to develop persistent tobacco use patterns compared to non-using peers (Villanti et al., 2013).

Due to the numerous negative health impacts of flavored e-cigarette use among young adults, efforts are much needed to further understand the sub-groups at risks of using flavored e-cigarettes to design prevention and intervention strategies for this group. Many studies have explored the demographic and psychosocial correlates of using flavored tobacco products including cigarettes, little cigars, and cigarillos. These studies found that correlates and predictors of flavored tobacco use include: young age (King et al., 2013; Kostygina et al., 2016; Rath et al., 2016; Smith et al., 2016; Villanti et al., 2013), female gender (Delnevo et al., 2015; King et al., 2013; Kostygina et al., 2016; Smith et al., 2016; Villanti et al., 2013), African American race (Delnevo et al., 2015; Kostygina et al., 2016; Smith et al., 2016; Sterling et al., 2016; Villanti et al., 2013), sexual identity (Rath et al., 2016), anxiety symptoms (Rath et al., 2016), and low income (King et al., 2013; Sterling et al., 2016). Evidence for education levels as a predictor of flavored tobacco use is mixed; one study found that lower levels of education predicted flavored tobacco products (Smith et al., 2016), whereas another study identified higher education as a predictor (Villanti et al., 2013). One study also identified marijuana use as a correlate of using flavored, non-cigarette tobacco products among young adults (Rath et al., 2016). Additionally, tobacco harm perceptions influence consumers' choice towards tobacco flavors; individuals who consider

tobacco use less harmful or with more beneficial outcomes are more likely to use non-tobacco flavored products compared to those who perceive tobacco use more negatively (Ashare et al., 2007; Czoli et al., 2015; Thrasher et al., 2015).

Studies that examined the correlates and predictors of flavored e-cigarette use in specific have mostly focused on tobacco use as risk factors. Combustible tobacco use was found to be associated with flavored e-cigarette use (Chen, 2018; Farsalinos et al., 2013; Harrell et al., 2017; Tackett et al., 2015). This could be because e-cigarettes have been marketed and frequently used as a smoking cessation aid by adult cigarette smokers (Giovenco et al., 2014). Pertaining to e-cigarette flavors, never and former adult cigarette smokers are more likely to use fruity and candy flavored e-cigarettes than current smokers; while current smokers tend to use tobacco and menthol flavored e-cigarettes (Farsalinos et al., 2013; Harrell et al., 2017) potentially due to taste similarities between tobacco and menthol flavored e-cigarettes and cigarettes. Additionally, studies found e-cigarette use history to be an important risk factor for using flavored e-cigarettes; long-time e-cigarette users, as opposed to novice users, appear to be more likely to use fruity and candy flavored e-cigarettes (Chen, 2018; Tackett et al., 2015). These studies, however, were limited by their use of convenience samples and cross-sectional study designs.

No research has been conducted to investigate multiple predictors of U.S. young adults' flavored e-cigarette use, encompassing both risk factors previously shown to influence flavored tobacco use in general and flavored e-cigarette use in specific. Thus, this study was designed to fill this critical knowledge gap and used the wave 1 and wave 2 data of the Population Assessment of Tobacco and Health (PATH) Study, a nationally representative longitudinal study of U.S. adults and youth. Unlike previous research that categorized tobacco flavors as "flavored" versus "non-flavored", this study categorized e-cigarette flavors as tobacco and menthol (TM) flavors and non-tobacco and non-menthol (NTM) flavors. The distinction was important predominantly because of the sensory similarities between TM flavored e-cigarettes and regular and menthol cigarettes. Previous research has shown that TM flavored e-cigarette users might be different from users of NTM flavors in regards to their tobacco use history and socio-demographic characteristics (Farsalinos et al., 2013; Tackett et al., 2015; Yingst et al., 2015). Moreover, most of the U.S. localities that have restricted the sale of flavored e-cigarettes only banned NTM flavors and exempted TM flavors (Tobacco Control Legal Consortium, 2017). Thus, studies that distinguish users of TM versus NTM flavors hold great potential to inform the advancement and evaluation of regulations related to flavored e-cigarette products. The aim of this study was to identify prospective predictors of TM and NTM flavored e-cigarette use among young adults to identify those who would be most affected by tobacco flavor regulations and to inform prevention efforts in terms of who should be targeted for programming and what potential risk factors should be addressed by these efforts.

## 2. Methods

### 2.1 Sample

The PATH Study is a nationally representative, longitudinal cohort study of civilian, non-institutionalized adults and youth in the U.S. The PATH study used audio computer-assisted

self-administered interviews in English and Spanish to collect information on tobacco use and health status and more information on the study design can be found elsewhere (Hyland et al., 2017). Waves 1 and 2 of the adult surveys of the PATH Study were collected between 2013–2014 and 2014–2015, respectively. For this prospective analysis, the sample was restricted to the 12,383 18–34-year-old respondents who completed both waves (retention rate=81.8%). The subsample of past-month e-cigarette users at wave 2 (n=1,421) was used to identify the predictors of e-cigarette use with TM versus NTM flavors.

## 2.2 Measures

**2.2.1 E-cigarette use status (wave 2).**—E-cigarette use status was categorized as: Non-E-cigarette Use, E-cigarette Use with TM Flavors, and E-cigarette use with NTM Flavors. The respondents who did not report using e-cigarettes in the past 30 days were considered non-e-cigarette users. The respondents who used e-cigarettes that are “flavored to taste like menthol, mint, clove, chocolate, alcoholic drinks, candy or other sweets” were then asked which specific flavors they used. Response options included: (1) “Menthol/mint,” (2) “Clove/spice,” (3) “Fruit,” (4) “Chocolate,” (5) “An alcoholic drink,” (6) “Candy/other sweets,” and (7) “Some other flavor.” Since tobacco flavors were not listed as one of the flavor options in the PATH Study but were one of the popular flavors used by young adult e-cigarette users (Harrell et al., 2017), those who did not select any of the flavor options were considered as using tobacco flavors. Respondents who considered as using tobacco flavors and respondents who only selected “Menthol/mint” flavors were categorized as “E-cigarette Use with TM Flavors.” Respondents who selected one flavor other than “Menthol/mint” and more than one flavor including or not including “Menthol/mint” were categorized as “E-cigarette Use with NTM Flavors.”

**2.2.2 Sociodemographic characteristics (wave 1).**—The following sociodemographic characteristics were included as potential predictors of flavored e-cigarette use at wave 2: age, sex, race, household income, education, and sexual identity (see Table 1 for variable categories).

**2.2.3 Past-month mental health symptoms (wave 1).**—A mental health symptom variable was constructed by using four questions from the Global Appraisal of Individual Needs—Short Screener (GAIN-SS) (Conway et al., 2017; Dennis et al., 2008). These questions have shown moderate to high reliability among youth and adult samples (Titus et al., 2008). Specifically, respondents were asked to identify the time period when they last experienced: (1) “Feeling very trapped, lonely, sad, blue, depressed, or hopeless about the future?” (2) “Sleep trouble, such as bad dreams, sleeping restlessly, or falling asleep during the day?” (3) “Feeling very anxious, nervous, tense, scared, panicked, or like something bad was going to happen?” and (4) “Becoming very distressed and upset when something reminded you of the past?” Response categories were: “Past month,” “2 to 12 months ago,” “Over a year ago,” and “Never.” Respondents who experienced at least one of the four symptoms during the past month were coded as having mental health symptoms (yes/no).

**2.2.4 Past-month marijuana use (wave 1).**—For individuals answering affirmatively to using “marijuana, hash, THC, grass, pot or weed” during their lifetime, they were further

asked whether or not they used these substances in the past month. Past-month use of marijuana was therefore coded as a binary variable (yes/no).

**2.2.5 Past-month e-cigarette use (wave 1).**—Respondents were asked about their use of e-cigarettes in the past 30 days, which was used to construct two separate variables for past month e-cigarette use (yes/no).

**2.2.6 Cigarette smoking status (wave 1).**—Respondents were asked whether they had ever smoked cigarettes in the past. Those who had smoked before were further asked whether they had smoked in the past 30 days. These two questions were used to construct cigarette smoking status variable with three categories: (1) past-month smokers, (2) ever but non-past-month smokers, and (3) never smokers.

**2.2.7 E-cigarette harm perception (wave 1).**—Perceived harm of e-cigarettes compared to cigarettes was measured by the question “Is using e-cigarettes less harmful, about the same, or more harmful than smoking cigarettes?” The response categories were: “Less harmful,” “About the same,” and “More harmful.” The latter two categories were collapsed to create a binary variable (e-cigarettes less harmful vs. e-cigarettes same or more harmful than smoking cigarettes).

## 2.3 Statistical analyses

The following statistical analyses were conducted to achieve the research aims. First, chi-square tests were employed to identify the associations between wave 1 predictors and wave 2 flavored e-cigarette use. Second, pair-wise bivariate logistic regression models were developed to examine the individual effects of predictors on: (1) TM flavored e-cigarette use compared to non-e-cigarette use, (2) NTM flavored e-cigarette use compared to non-e-cigarette use, and (3) NTM flavored e-cigarette use compared to TM flavor use. Third, using the sample of past-month e-cigarette users at wave 2, multivariable logistic regression models assessed the combined effect of the predictors on NTM flavor use compared to TM flavor use. Wave 1 and 2 adult surveys (public data file) of the PATH Study were used for this study. Wave 2 complex sampling weights were applied and the nonresponse from wave 1 to wave 2 was accounted for by wave 2 longitudinal weights (U.S. Food and Drug Administration, 2017). All socioeconomic predictors used the PATH public data file were already imputed, and other predictors and e-cigarette use outcomes had low levels of missingness (<5%). Therefore, no additional imputation was applied. Using Stata 12.0 software, the observations that missed values in particular variables were excluded from the statistical procedure using these variables (i.e., listwise deletion of missing data) (Hamilton, 2012).

## 3. Results

### 3.1 Descriptive Findings

This study found that during 2014–2015 (wave 2), about 8.0% of U.S. young adults aged 18–34 used e-cigarettes in the past month, and the use of NTM flavors was more prevalent than TM flavors (5.5% vs. 2.5%). Among TM flavored e-cigarette users, about 57.0% used

tobacco flavors and 43.0% used menthol/mint flavors. Among NTM e-cigarette users, the most popular flavors included fruit (71.2%) and candy (52.5%) flavors. Close to half (47.4%) of NTM flavor users used one flavor, 27.3% used two flavors, and 25.8% used more than two flavors.

### 3.2 Predictors of E-cigarette Use Compared to Non-E-cigarette Use

All wave 1 predictors were significantly associated with e-cigarette use status at wave 2 except for education attainment (Table 1). Compared to non-e-cigarette users, male, white, and LGBT individuals were more likely to be past-month TM and NTM flavored e-cigarette users ( $p<0.001$ ). Additionally, those who had lower household incomes, had mental health symptoms in the past month, and/or used substances including marijuana, e-cigarettes, and cigarettes in the past month were more likely to be past-month TM and NTM flavored e-cigarette users ( $p<0.01$ ). Lastly, those who perceived e-cigarettes as less harmful than cigarettes were more likely to have used TM and NTM flavored e-cigarettes in the past month ( $p<0.001$ ).

Table 2 presents the unadjusted logistic regression model results and shows the predictors of TM and NTM flavored e-cigarette use compared to non-e-cigarette use. When compared to non-e-cigarette use, the predictors of TM and NTM flavored e-cigarette use were similar. For examples, females were less likely to use TM (OR=0.49, CI=0.27–0.50,  $p<0.001$ ) and NTM (OR=0.70, CI=0.62–0.78,  $p<0.001$ ) flavored e-cigarettes compared to males. Respondents who had smoked cigarettes before but did not smoked in the past month at wave 1 were less likely to use TM (OR=0.02, CI=0.01–0.04,  $p<0.001$ ) and NTM (OR=0.09, CI=0.12–0.23,  $p<0.001$ ) flavored e-cigarettes compared to those who smoked cigarettes in the past-month; and respondents who had never smoked cigarettes before were less likely to use TM (OR=0.14, CI=0.09–0.20,  $p<0.001$ ) and NTM (OR=0.38, CI=0.34–0.44,  $p<0.001$ ) flavored e-cigarettes compared to those who smoked cigarettes in the past-month.

### 3.3 Predictors of NTM Flavor Use Compared to TM Flavor Use

When comparing NTM and TM flavored e-cigarette use, bivariate (Table 2) and multivariable (Table 3) logistic regression models yielded very similar results. Table 3 highlights the multivariable regression results for assessing the prospective predictors of NTM flavored e-cigarette use compared to TM flavor use among past-month e-cigarette users. Younger age (AOR=1.28, CI=1.37–2.41,  $p<0.001$ ), being female (AOR=1.81, CI=1.33–2.46,  $p<0.001$ ), having a high school/GED degree and higher (AOR=1.60, CI=1.07–2.42,  $p=0.024$ ), using marijuana in the past month (AOR=1.96, CI=1.37–2.81,  $p<0.001$ ), ever but non-past-month cigarette smoking (AOR=2.75, CI=1.83–4.13,  $p<0.001$ ), never cigarette smoking (AOR=5.08, CI=1.36–18.97,  $p=0.016$ ), and perceiving e-cigarettes as less harmful than cigarettes (AOR=1.59, CI=1.15–2.19,  $p=0.005$ ) were more likely to be associated with NTM flavor use compared to TM flavor use. Additionally, black respondents were less likely to use NTM flavored e-cigarettes than white respondents (AOR=0.64, CI=0.42–0.99,  $p=0.043$ ).

## 4. Discussion

This study extends prior research regarding population-based prospective predictors of flavored e-cigarette use among young adults. Among e-cigarette users, younger age, female gender, education attainment of high school graduate/GED and higher, marijuana use, ever but non-past-month cigarette smoking, never cigarette smoking, and diminished harm perceptions of e-cigarettes predicted NTM flavor use. Results also showed that about 8% of young adults ages 18 and 34 years old in the U.S. used e-cigarettes in the past month and about 69% of these users adopted NTM flavors. Consistent with previous research (Bonhomme et al., 2016; Choi et al., 2012), fruit and candy flavors are highly popular NTM flavors used by this group. More than half of the NTM flavor users had used more than one NTM flavor in the past month. We suspect that multiple flavor use might be influenced by users' pro-e-cigarette social environment or driven by the desire of sustaining e-cigarette use.

Among young adult e-cigarette users, those who were younger (18–24 years) and female were more likely to use NTM flavors than their older and male counterparts. Historically, tobacco companies used sweetened tobacco products as a way to attract young, female consumers (Carpenter et al., 2005; Samet and Yoon, 2010). Research is needed to determine how the taste of attractive NTM flavors can be modified or the specific types of NTM flavors can be regulated to reduce NTM flavors' appeal to younger females who in the absence of flavors might not vape. We found a negative relationship between educational level and e-cigarette use, which is consistent with some prior research (Regan et al., 2011). Our study further showed that NTM flavored e-cigarette use is more prevalent among young adults with higher education attainment than TM flavor use. This finding might indicate that the motivations of using e-cigarette products vary between higher and lower educated young adults, and these differences drive their choices for e-cigarette flavors. Perhaps more highly educated users are using e-cigarettes for non-nicotine purposes such as recreational and social reasons, and these motivations might, in turn, encourage them to choose popular NTM flavors with an appealing taste and smell. More studies are needed to help understand the reasons why young adults with various educational backgrounds use e-cigarette flavors differently.

Our research also comports with previous studies showing that white young adults are more likely to use e-cigarettes, regardless of flavors, than other race and ethnic groups (Saddleson et al., 2015; Sutfin et al., 2013), presumably because the majority of e-cigarette marketing strategies were heavily tailored to the white population (Richardson et al., 2013). We suspect that this might be related to the fact that the retail availability of e-cigarettes was more likely in neighborhoods with lower percentages of racial and ethnic minority residents (Rose et al., 2014). Our findings, however, contracted with previous research that found African American adults are more likely to use flavored tobacco products compared to their white peers (Delnevo et al., 2015; Kostygina et al., 2016; Smith et al., 2016; Sterling et al., 2016; Villanti et al., 2013). We suspect that this discrepancy is partially due to grouping menthol/mint flavors with tobacco flavors, thereby attenuating the effect of African American's disproportionately higher use of menthol tobacco flavors (Gardiner, 2004). Nevertheless, more research is warranted to investigate whether and how flavored e-cigarettes are

marketed and promoted differently between white and racial and ethnic minority young adults and whether these discrepancies lead to disparities in flavored e-cigarette use.

This research also discovered that cigarette smoking status at wave 1 is the most influential predictor of NTM flavored e-cigarette use at wave 2. For the ever smokers who did not smoke cigarettes in the past month at wave 1, vaping might reintroduce the harm of nicotine and cancer-causing chemicals or lead to cigarette smoking relapse to this group. As for never smokers, our finding is particularly worrisome since NTM flavored e-cigarettes might serve as this group's starter tobacco product and thereby facilitate their development of regular tobacco use and nicotine addiction (Stanton et al., 2016). Evidence suggests that non-smoking youth who use non-tobacco flavored e-cigarettes have a higher cigarette smoking susceptibility than those who use tobacco flavored e-cigarettes (Chen et al., 2017). The existence of a similar pattern among young adults is highly likely given that e-cigarette use is associated with cigarette smoking openness among non-smoking young adults (Coleman et al., 2014). Nevertheless, considering the potential harm associated with the use of NTM flavored e-cigarettes, prevention efforts should ideally focus on non-past-month smokers (including ever and never smokers) to reduce their curiosity and positive perceptions of NTM flavored e-cigarettes.

Our results demonstrated a positive relationship between marijuana use at wave 1 and e-cigarette use at wave 2. Young adults might engage in vaping as a method for administering marijuana (Budney et al., 2015), especially since marijuana users perceive vaping marijuana to be safer or less harmful compared to combustible smoking methods (Malouff et al., 2014). We also found that past-month marijuana use at wave 1 is associated with respondents' adoption of e-cigarettes with NTM flavors at wave 2. We suspect that young adults might purposely mix marijuana with NTM flavorings to enhance the vaping experience. This relationship could also be explained, again, by high sensation seeking shared among NTM flavor users and marijuana users. Previous research found a linkage between sensation seeking, e-cigarette use, and marijuana use among college students (Sutfin et al., 2013) and that the appeal of sweet flavored tobacco products is greater among young people who are highly sensation-seeking (Manning et al., 2009). Due to the lack of data for measuring sensation seeking in the PATH adult survey, we were unable to further investigate this possibility.

The study results also revealed that the respondents who had lower harm perception about e-cigarettes were more likely to use NTM flavors compared to TM flavors. We suspect that those who considered e-cigarettes less harmful were less likely to be aware of the potential negative health consequences of using NTM flavors as compared to those who considered e-cigarettes more harmful. It is also likely that those with lower harm perceptions have higher sensation seeking tendencies than those with higher harm perceptions, and in turn, are more likely to use NTM flavors. Future research is warranted to explore the mechanisms behind this relationship. Informing young adults with lower e-cigarette harm perception about the known health risks associated with vaping, especially as it relates to vaping NTM flavors, might deter their interest in using these flavors.



This study is limited insofar as it does not include other potentially important social and environmental predictors of flavored e-cigarette use. We suspect that peer and parent use of flavored e-cigarettes as well as local regulations about the sales of flavored e-cigarettes can influence young adults' choice of e-cigarette flavors. Additionally, although the prospective design of the study removes the influence of the outcome measure on the baseline predictors, e-cigarette flavor use at the baseline, which was not captured by the wave 1 adult survey of the PATH Study, might still bias the results. Since young adult vapers may switch between various flavors (Chen, 2018), future research needs to track e-cigarette flavors used longitudinally to further understand this complex behavior. The last limitation involves the manipulation of the e-cigarette flavor variable. Our flavor classification is limited by labeling e-cigarette users who did not choose any of the flavor options as tobacco flavor users. Future research should provide "tobacco" as a flavor option to improve data accuracy. Moreover, grouping tobacco and menthol flavors together might have masked the distinct risk factors for using these two flavors. For example, racial/ethnic minority identity might be a risk factor for menthol flavored e-cigarette use due to the high prevalence of menthol cigarette smoking in minority communities (Gardiner, 2004). Future research is warranted to explore the distinct predictors of multiple NTM flavor use since multiple flavor use might post more health risks among users than single flavor use as it is associated with more frequent vaping (Chen, 2018).

This study has significant implications for developing public health initiatives for preventing and reducing flavored e-cigarette use among young adults. First, public health programs and mass media campaigns highlighting the harm and risks (e.g., respiratory health problems, nicotine addiction, and openness to cigarette smoking) associated with vaping e-cigarette flavors are greatly needed to increase this group's perceived harm of using flavored e-cigarettes. Especially, never cigarette smokers, or those having the lowest risks of substance use, need to be targeted by such initiatives since they are much more inclined to use NTM flavored e-cigarettes and thereby develop nicotine dependence and established tobacco use behavior. Second, we call for more scrutiny with respect to the tobacco industry's marketing tactics for selling flavored e-cigarettes. Since there is a long-documented history of targeting vulnerable groups including young adults and females to sell flavored tobacco products (Stanton et al., 2016), regulations to restrict or ban flavored e-cigarette advertisements and promotions are particularly needed to reduce tobacco use among these vulnerable groups. All these above-suggested preventive and regulative actions, however, need to account for the possibility that certain NTM flavors in e-cigarettes may potentially encourage adult cigarette smokers to transition off from smoking cigarettes (Audrain-McGovern et al., 2016), thereby reducing the overall harm and risks imposed to the smokers.

## 5. Conclusion

A higher proportion of young adult e-cigarette users in the U.S. adopted NTM flavored e-cigarettes compared to TM flavored e-cigarettes. Fruit and candy e-cigarette flavors are extremely popular among these users. Younger age, female gender, education attainment of high school degree graduate/GED and higher, marijuana use, ever but non-past month cigarette smoking, never cigarette smoking, and diminished harmful perceptions about using e-cigarettes prospectively predicted NTM flavor use among young adult e-cigarette users.

Future research is suggested to explore other distinctive social and environmental predictors for flavored e-cigarette use among young adults. Prevention efforts for curbing flavored e-cigarette use among young adults should particularly focus on the groups at high risks (e.g., 18–24 years, female, never cigarette smokers, and marijuana users).

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**Table 1.**

Wave 1 Sample Characteristics by Wave 2 E-cigarette Use Status Among U.S. Young Adults (Aged 18–34), 2013–2015 PATH Study Wave 1 and 2 Surveys (n=12,383)

Wave 1 Sample Characteristics	Wave 2 E-cigarette Use Status				Overall Difference p value	Difference Between TM and NTM Flavor Use p value
	Non E-cigarette Use	E-cigarette Use with TM Flavors	E-cigarette Use with NTM Flavors			
	Total N=10,962; 92.0%	N=428; 2.5%	N=993; 5.5%			
	%	% [95% CI]	% [95% CI]	% [95% CI]		
Age					<0.001	<0.001
18–24	42.5	91.0 [90.1, 91.8]	2.0 [1.8, 2.4]	7.0 [6.2, 7.7]		
25–34	57.5	92.8 [92.0, 93.5]	2.8 [2.4, 3.3]	4.4 [3.9, 5.1]		
Sex					<0.001	<0.001
Male	50.6	90.2 [89.1, 91.0]	3.4 [3.0, 4.0]	6.4 [5.8, 7.2]		
Female	49.4	94.0 [93.3, 94.5]	1.5 [1.2, 1.8]	4.5 [4.1, 5.1]		
Race					<0.001	0.246
White Alone	72.5	90.9 [90.1, 91.7]	2.8 [2.5, 3.2]	6.3 [5.7, 6.9]		
Black Alone	13.8	96.0 [94.9, 96.8]	1.5 [1.1, 2.2]	2.5 [1.9, 3.3]		
Others/Multi-racial	13.7	93.7 [93.2, 94.9]	1.7 [1.2, 2.3]	4.6 [3.5, 6.0]		
Past-Year Household Income					<0.01	0.260
<\$10,000	20.0	90.7 [89.5, 91.8]	3.3 [2.6, 4.1]	6.0 [5.2, 7.0]		
\$10,000–24,999	22.5	91.2 [89.9, 92.4]	2.5 [2.0, 3.1]	6.3 [5.4, 7.3]		
>\$24,999	57.5	92.8 [92.0, 93.6]	2.2 [1.9, 2.6]	5.0 [4.4, 5.7]		
Education					0.921	<0.01
<High School	9.9	91.4 [89.8, 92.8]	3.7 [2.8, 4.8]	4.9 [4.0, 6.1]		
High School/GED	90.1	92.1 [91.4, 92.7]	2.3 [2.1, 2.7]	5.6 [5.1, 6.1]		
Sexual Orientation					<0.001	0.159
LGBT <sup>f</sup>	8.0	87.0 [84.6, 89.1]	3.3 [2.4, 4.5]	9.7 [7.8, 11.9]		
Heterosexual/Straight	92.0	92.4 [91.7, 93.0]	2.4 [2.1, 2.8]	5.2 [4.7, 5.7]		
Past-Month Mental Health Symptoms					<0.001	0.203
Yes	38.9	89.3 [88.2, 90.4]	3.1 [2.6, 3.7]	7.6 [6.8, 8.4]		
No	61.1	93.7 [93.0, 94.3]	2.0 [1.8, 2.4]	4.3 [3.8, 4.8]		
Past-Month Marijuana Use					<0.001	<0.01
Yes	13.5	83.1 [81.3, 84.7]	4.0 [3.3, 5.1]	12.9 [11.4, 14.4]		
No	86.5	93.4 [92.8, 94.0]	2.2 [1.9, 2.5]	4.4 [3.9, 4.9]		
Past-Month E-cigarette Use					<0.001	0.085
Yes	11.4	66.2 [63.4, 68.9]	9.5 [8.3, 10.9]	24.3 [21.9, 26.8]		
No	88.6	95.3 [94.8, 95.8]	1.6 [1.3, 1.9]	3.1 [2.7, 3.5]		
Cigarette Smoking Status					<0.001	<0.001
Past-month Smokers	29.3	98.8 [98.4, 99.1]	0.1 [0.0, 0.0]	1.1 [0.8, 1.5]		

Wave 1 Sample Characteristics	Wave 2 E-cigarette Use Status					
		Non E-cigarette Use	E-cigarette Use with TM Flavors	E-cigarette Use with NTM Flavors	Overall Difference	Difference Between TM and NTM Flavor Use
	Total	N=10,962; 92.0%	N=428; 2.5%	N=993; 5.5%		
	%	% [95% CI]	% [95% CI]	% [95% CI]	p value	p value
Ever, Non-past-month Smokers	29.9	93.9 [92.8, 94.9]	1.1 [0.8, 1.6]	5.0 [4.2, 5.9]		
Never Smokers	40.7	80.6 [79.1, 82.1]	7.1 [6.3, 8.0]	12.3 [11.2, 13.4]		
Perceived Harm of E-cigarettes Compared to Cigarettes					<0.001	<0.001
E-cigs less harmful	48.2	87.5 [96.2, 88.6]	3.4 [3.0, 4.0]	9.1 [8.2, 10.1]		
E-cigs same or more harmful	51.8	94.7 [94.1, 95.3]	2.1 [1.8, 2.5]	3.2 [2.7, 3.7]		

<sup>1</sup>LGBT stands for lesbian, gay, bisexual, transgender, queer, trisexual, omnisexual and pan-sexual, etc.

**Table 2.**

Odds Ratios for Predicting Wave 2 E-cigarette Use Status Among U.S. Young Adults (Aged 18–34), 2013–2015 PATH Study Wave 1 and 2 Surveys (n=12,383)

Wave 1 Sample Characteristics	Pair-wise Comparisons of E-cigarette Use Status					
	TM flavor use (Compared to Non-use)		NTM flavor use (Compared to Non-use)		NTM flavor use (Compared to TM flavor use)	
	OR [95% CI]	p value	OR [95% CI]	p value	OR [95% CI]	p value
Age						
25–34	Reference		Reference		Reference	
18–24	0.72 [0.61, 0.94]	0.007	1.63 [1.37, 1.90]	<0.001	2.06 [1.632, 2.8]	<0.001
Sex						
Male	Reference		Reference		Reference	
Female	0.49 [0.27, 0.50]	<0.001	0.70 [0.62, 0.78]	<0.001	1.73 [1.30, 2.18]	<0.001
Race						
White Alone	Reference		Reference		Reference	
Black Alone	0.54 [0.31, 0.76]	0.005	0.43 [0.31, 0.48]	<0.001	0.82 [0.53, 1.19]	0.197
Others/Multi-racial	0.72 [0.37, 0.80]	0.109	0.65 [0.52, 0.93]	0.022	1.27 [0.82, 1.94]	0.328
Past-Year Household Income						
<\$10,000	Reference		Reference		Reference	
\$10,000–24,999	0.82 [0.91, 1.76]	0.073	1.02 [0.77, 1.32]	0.754	1.42 [0.87, 2.04]	0.090
>\$24,999	0.69 [0.69, 1.12]	0.009	0.80 [0.72, 0.89]	0.025	1.23 [0.93, 1.68]	0.271
Education						
<High School	Reference		Reference		Reference	
High School/GED	0.64 [0.47, 0.87]	0.004	1.13 [0.89, 1.43]	0.314	1.76 [1.21, 2.57]	0.004
Sexual Orientation						
Heterosexual/Straight	Reference		Reference		Reference	
LGBT <sup>1</sup>	1.42 [0.91, 2.09]	0.060	2.04 [1.48, 2.62]	<0.001	1.38 [0.90, 2.22]	0.163
Past-Month Mental Symptoms						
No	Reference		Reference		Reference	
Yes	1.57 [1.21, 1.97]	<0.001	1.89 [1.60, 2.23]	<0.001	1.19 [0.87, 1.69]	0.201
Past-Month Marijuana Use						
No	Reference		Reference		Reference	
Yes	2.06 [1.61, 2.82]	<0.001	3.28 [2.82, 3.94]	<0.001	1.56 [1.23, 2.06]	0.004
Past-Month E-cigarette Use						
No	Reference		Reference		Reference	
Yes	8.75 [6.85, 11.02]	<0.001	11.31 [9.32, 13.78]	<0.001	1.30 [0.88, 1.73]	0.086
Cigarette Smoking Status						
Past-month Smokers	Reference		Reference		Reference	
Ever, Non-past-month Smokers	0.02 [0.01, 0.04]	<0.001	0.09 [0.12, 0.23]	<0.001	4.43 [1.72, 9.23]	0.002
Never Smokers	0.14 [0.09, 0.20]	<0.001	0.38 [0.34, 0.44]	<0.001	2.53 [1.77, 3.63]	<0.001
Perceived Harm of E-cigarettes Compared to Cigarettes						

Wave 1 Sample Characteristics	Pair-wise Comparisons of E-cigarette Use Status					
	TM flavor use (Compared to Non-use)		NTM flavor use (Compared to Non-use)		NTM flavor use (Compared to TM flavor use)	
	OR [95% CI]	p value	OR [95% CI]	p value	OR [95% CI]	p value
E-cigs same or more harmful	Reference		Reference		Reference	
E-cigs less harmful	1.82 [1.36, 2.24]	<0.001	3.14 [2.62, 3.87]	<0.001	1.74 [1.28, 2.37]	0.001

<sup>1</sup>LGBT stands for lesbian, gay, bisexual, transgender, queer, trisexual, omnisexual and pan-sexual, etc.

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**Table 3.**

Adjusted Odds Ratios for Predicting Wave 2 NTM Flavor Use Among U.S. Young Adult E-cigarette Users (Aged 18–34), 2013–2015 PATH Study Wave 1 and 2 Surveys (n=1,421)

Wave 1 Sample Characteristics	Wave 2 NTM Flavored E-cigarette Use (Compared to Wave 2 TM Flavored E-cigarette Use)	
	AOR [95% CI]	p value
Age		
25–34	Reference	
18–24	1.82 [1.37, 2.41]	<0.001
Sex		
Male	Reference	
Female	1.81 [1.33, 2.46]	<0.001
Race		
White Alone	Reference	
Black Alone	0.64 [0.42, 0.99]	0.043
Others/Multi-racial	1.17 [0.70, 1.93]	0.517
Past-Year Household Income		
<\$10,000	Reference	
\$10,000–24,999	1.35 [0.91, 2.01]	0.132
>\$24,999	1.20 [0.81, 1.73]	0.388
Education		
<High School	Reference	
High School/GED	1.60 [1.07, 2.42]	0.024
Sexual Orientation		
Heterosexual/Straight	Reference	
LGBT <sup>1</sup>	1.15 [0.69, 1.93]	0.589
Past-Month Mental Symptoms		
No	Reference	
Yes	1.06 [0.78, 1.43]	0.723
Past-Month Marijuana Use		
No	Reference	
Yes	1.96 [1.37, 2.81]	<0.001
Past-Month E-cigarette Use		
No	Reference	
Yes	1.23 [0.86, 1.75]	0.252
Cigarette Smoking Status		
Past-month Smokers	Reference	
Ever, Non-past-month smokers	2.75 [1.83, 4.13]	<0.001
Never Smokers	5.08 [1.36, 18.97]	0.016
Perceived Harm of E-cigs Compared to Cigarettes		
E-cigs same or more harmful	Reference	

<b>Wave 2 NTM Flavored E-cigarette Use (Compared to Wave 2 TM Flavored E-cigarette Use)</b>		
<b>Wave 1 Sample Characteristics</b>	<b>AOR [95% CI]</b>	<b>p value</b>
E-cigs less harmful	1.59 [1.15, 2.19]	0.005

<sup>1</sup>LGBT stands for lesbian, gay, bisexual, transgender, queer, trisexual, omniseual and pan-sexual, etc.

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