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Preferences, use, and perceived access to flavored e-cigarettes among United States adolescents and young adults

Benjamin W. Chaffee^{a,*},

Bonnie Halpern-Felsher^b,

James Alton Croker^a,

Miranda Werts^a,

Elizabeth T. Couch^a,

Jing Cheng^a

^aUniversity of California San Francisco, San Francisco, CA, United States

^bResearch Lab, Stanford University, Stanford, CA, United States

Abstract

Background: Citing concern over youth use, the Food and Drug Administration announced a prioritized enforcement policy against cartridge-based (reusable pod) e-cigarettes in non-menthol, non-tobacco flavors, effective February 2020. Data are needed regarding youth e-cigarette access and use behaviors following this policy.

Methods: This cross-sectional national (USA) online panel survey, conducted March/April 2021, included 2253 participants ages 14–20 who ever used e-cigarettes 3 times (73% past 30-day users). Participants reported their flavor preferences, use reasons, and perceived ease of access. Latent class analysis categorized participants according to their preferred e-cigarette flavors, and multinomial logistic regression identified sociodemographic and behavioral correlates of class membership.

Results: Most past 30-day e-cigarette users used reusable pod (77%) or modern disposable (68%) devices, 1 non-tobacco (92%), sweet (76%), and/or menthol flavors including fruit-ice (70%) (flavor and device categories not mutually exclusive). Most past 30-day users (70%) and non-users (63%) perceived it would be somewhat or very easy to acquire e-cigarettes in flavors they like. Latent class analysis identified four e-cigarette flavor preference classes: mint (34% of

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*Corresponding author: 707 Parnassus Ave. Room D3214, Box 0758, San Francisco, CA, 94143 United States. benjamin.chaffee@ucsf.edu (B.W. Chaffee).

Credit authorship contribution statement

BWC: Conceptualization, Methodology, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Visualization, Supervision, Funding acquisition. **BHF:** Conceptualization, Investigation, Writing - Review & Editing, Supervision, Funding acquisition. **JAC:** Writing - Review & Editing. **MW:** Investigation. **ETC:** Writing - Review & Editing, Project administration. **JC:** Methodology, Formal analysis, Investigation, Writing - Review & Editing, Funding acquisition. All authors have approved the final article.

Declaration of competing interest

Dr. Halpern-Felsher is a paid expert scientist in some litigation against some e-cigarette companies and an unpaid scientific advisor and expert witness regarding some tobacco-related policies. The remaining authors declare no conflicts of interest related to this research.

sample), no preference (29%), fruit/sweet (28%), and dislikes 1 flavor (10%). Relative to no preference, membership in fruit/sweet (RRR: 1.87; 95% CI: 1.37, 2.57) and mint (RRR: 3.85; 95% CI: 2.77, 5.36) classes was associated with using e-cigarettes 50 times. Fruit/sweet membership was inversely associated with combustible tobacco use (RRR: 0.50; 95% CI: 0.38, 0.66).

Conclusion: Young e-cigarette users maintained ample access to flavored and cartridge-based products. Stronger access restrictions and enforcement are required to reduce youth e-cigarette use.

Keywords

Electronic cigarette; Tobacco; Tobacco control; Adolescent health; Young adult health; Population-based study

1. Introduction

In January 2020, the United States Food and Drug Administration (FDA) finalized a policy to prioritize enforcement against cartridge-based e-cigarettes in flavors other than tobacco and menthol, effective February 1, 2020 (Food and Drug Administration, 2020). At the time, no e-cigarette product was authorized for sale in the United States, meaning that no e-cigarette was being sold with legal authorization. However, the FDA had exercised enforcement discretion to defer authorization requirements, effectively allowing all e-cigarettes into the marketplace. The FDA announcement cited “epidemic levels” of youth e-cigarette use (Cullen et al., 2019; Food and Drug Administration, 2020), particularly use of mint and fruit flavors and cartridge-based systems (Leventhal et al., 2019b), such as those sold under the JUUL brand, in which single-use cartridges, or pods, are swapped in and out of a reusable device. The policy goal was to focus on products most attractive to youth. Companies that did not cease manufacture, distribution and sale of prioritized products within 30 days “risked FDA enforcement actions (Food and Drug Administration, 2020),” but those enforcement actions were not delineated. The policy was criticized for vague product definitions and for excepting menthol, refillable, and disposable e-cigarette products increasingly popular among youth (Gee, 2020; Hemmerich et al., 2020). The policy was defended as providing flexibility to pursue action against any e-cigarette company selling products that target youth (Zeller, 2020).

E-cigarettes are the most commonly consumed tobacco product among adolescents (Cullen et al., 2019; Rose et al., 2020). Flavors in e-cigarettes and other tobacco products and a cooling sensation from added menthol may increase product appeal and mask harshness, motivating youth experimentation and continued use (Carpenter et al., 2005; Goldenson et al., 2019; Kostygina et al., 2016; Kreslake et al., 2008). Fruit flavors and sweet/dessert flavors are considered particularly popular among young e-cigarette users; however, combination fruit-ice flavors (i.e., fruit with a cooling, presumably mentholated sensation) and mint flavors (with and without menthol) are also used commonly (Gaiha et al., 2021; Harrell et al., 2017; Schneller et al., 2019). While recent surveillance indicates a possible decline in e-cigarette use prevalence among adolescents, 80% of e-cigarette users report using flavored products (Park-Lee et al., 2021).

Emerging data also suggest that flavored and pod-based product use continued to be normative among young e-cigarette users in the months following the FDA enforcement prioritization policy. The 2020 National Youth Tobacco Survey (NYTS), conducted from January to March (partly before and after the FDA policy took effect), demonstrated that high school e-cigarette users most commonly used pod devices and fruit (73%), mint (56%), menthol (37%), or sweet (36%) flavors (Wang et al., 2020). In a May 2020 national online survey of adolescents and young adults, reusable pod/cartridge e-cigarettes (e.g., JUUL) and disposable e-cigarettes, such as those sold under the Puff Bar brand, were the most used devices, and mint, menthol, or ice was the most used class of flavors among both reusable and disposable users (Gaiha et al., 2021). Bar-shaped “fifth-generation” disposable devices, sometimes called “podmods” (Delnevo et al., 2020; Williams, 2020), do not actually contain pods, are not modifiable, and differ from first-generation “cigalike” disposable devices. This manuscript uses “modern disposable” to refer to these disposables (e.g., Puff Bar) and “reusable pod” to refer to reusable systems with single-use cartridges (e.g., JUUL).

1.1. Objectives

The present study characterizes device type and flavor behaviors among young e-cigarette users approximately one year after the FDA policy announcement, allowing time for regulators, sellers, and users to adjust to the new policy. As the main goal of this study was descriptive, no numerical hypothesis was defined. Data are from a national online panel of e-cigarette repeated ever-users (3 times) ages 14–20 years, conducted from March to April 2021. The investigation also examines participants’ e-cigarette flavor preferences and perceived access to flavors that they like. Finally, using latent class analysis (LCA), we classify participants according to their flavor preferences and examine how flavor preferences relate to sociodemographic characteristics, e-cigarette and other tobacco use behaviors, and reasons for e-cigarette use. Examining e-cigarette flavor preferences, rather than use behaviors alone, may help inform assumptions about how youth may respond to potential policies.

2. Methods

2.1. Participants

Results are based on a national cross-sectional online survey of adolescents and young adults who reported e-cigarette ever use (3 times). Participants were recruited from existing, actively managed market research panels aggregated by a third-party vendor (Qualtrics). Online research panels have gained wide use in behavioral health sciences research, including tobacco control research (Noar et al., 2018) and with youth specifically (Gaiha et al., 2021; Schleicher et al., 2016). While panel members may not represent the general population, participants reflect a range of geography, age, income levels, and racial/ethnic groups.

For this investigation, panel members residing in the United States whose demographic profiles potentially matched study eligibility criteria were invited to complete a screener questionnaire to confirm their age (eligible: 14–20 years) and lifetime e-cigarettes use (eligible: 3 times). A threshold of 3 times was set as an inclusion criterion to help assure

that the study population included participants familiar with e-cigarettes from repeated use. Of 8860 completed screener questionnaires, 2712 participants met eligibility criteria and 2253 of these completed the survey. Surveys were administered from March 18 to April 25, 2021. Median completion time was 9 min. Participant incentives varied by panel but typically consisted of points redeemable toward merchandise, travel, or other awards. Before beginning the survey, potential participants were provided information stating that the survey was a research study and were informed of the study goals, its voluntary nature, and were asked to complete two items to confirm their comprehension. Signed informed consent was not collected to preserve anonymity. The University of California San Francisco Institutional Review Board approved all study procedures.

2.2. E-Cigarette and tobacco use

All participants were provided with a list of 9 different tobacco products (cigarettes; cigars; chewing tobacco; moist snuff; snus pouches; nicotine pouches; heated tobacco; hookah; and nicotine tablets or lozenges), 6 types of e-cigarette devices (modern disposables; reusable pods; cigalikes; refillable pens; box mods; rebuildable; and other), marijuana, and alcohol and asked to endorse all of the products listed that they had ever used (never; 1–10 times; 11–99 times; 100 times or more). The list included photographs and example brands. For each product ever used, participants reported how many days in the past 30 days they used that product (0 to 30).

2.3. E-Cigarette flavor access and preferences

Past 30-day e-cigarette users (using any e-cigarette device 1 day in the past 30 days) were asked to endorse which e-cigarette flavors they had used in the past 30 days from a list (unflavored; tobacco flavor; mint or menthol that is frost, cooling, or ice; mint or wintergreen [not frost cooling, or ice]; fruit [like apple or berry]; fruit-ice combination [like lush-ice, banana-ice]; dessert [like ice cream, cookie, or chocolate]; alcohol [like bourbon or wine]; don't know; other flavor). All participants, including e-cigarette non-users were asked, "Right now, how difficult or easy is it to find e-cigarettes or vapes in flavors that you like?" with 4 options (very easy to find flavors I like; somewhat easy to find flavors I like; somewhat difficult to find flavors I like; very difficult to find flavors I like). Participants were then asked how it is (very easy; somewhat easy; somewhat difficult; very difficult) to find each of 8 specific e-cigarette flavors (fruit; candy or dessert; mint; icy, frost, or menthol; fruit-ice combination; alcohol; tobacco; unflavored) and how it is (very easy; somewhat easy; somewhat difficult; very difficult) to find fruit, candy, fruit-ice, and/or dessert e-cigarette flavors from 5 specific sources (vape shops; convenience store or gas station; online; from family; from friends; some other way).

2.4. Latent class analysis

All participants were asked to respond to the prompt, "How much do you like the following flavors for e-cigarettes or vapes?" (strongly dislike; somewhat dislike; neither like or dislike; somewhat like; strongly like) for 8 flavors (fruit; candy or dessert; mint; icy, frost, or menthol; fruit-ice combination; alcohol; tobacco; unflavored). Participants missing flavor preference data were excluded from the LCA analysis ($n = 16$, 0.7% of total sample).

Given the small number of missing observations, we do not expect their exclusion to impact results.

The latent class model is a finite mixture model to identify and characterize clusters of similar participants. To identify distinct subgroups (classes) based on participants' discrete responses to the 8 flavors, where each flavor question included 5 options, we started with fitting marginal latent class models for multiple polytomous outcomes (Bandeem-roche et al., 1997). Starting with a one-class model, we fitted models with increasing numbers of classes up to 10 classes. Each model was run multiple times in the R package poLCA to have relatively good certainty in obtaining global maximum log-likelihood (Linzer and Lewis, 2011). Models from 2-class to 10-class were compared based on considerations statistically (maximum log likelihood, Akaike information criterion, Bayesian information criterion) and for ease of interpretation (class size and class distinctness). A five-class model was considered most adequate to describe the data based on statistical and interpretability considerations.

2.5. Flavor preference associations

Participant sociodemographic characteristics and e-cigarette and/or other tobacco use behaviors were compared between the retained latent classes using pair-wise hypothesis tests and then a multivariable multinomial logistic regression model. Additionally, past 30-day e-cigarette users were asked to endorse their reasons for using e-cigarettes from a list of 21 potential reasons compiled from literature (Evans-Polce et al., 2018; Wang et al., 2019). Reasons were examined across flavor preference classes. Responses were unweighted. Results were considered statistically significant if $P < 0.05$, unless otherwise noted (see Tables).

3. Results

3.1. Participant characteristics

Seventy-three percent of survey participants were past 30-day e-cigarette users (Table 1). As a group, past 30-day e-cigarette users were older and more likely than past 30-day non-users to identify as nonHispanic White, have a parent with a college degree, and report past 30-day use of other tobacco, cannabis, or alcohol (Table 1).

3.2. Flavored e-cigarette use

Flavored product use predominated among past 30-day e-cigarette users. Ninety-two percent of users reported using flavored e-cigarettes in the past 30-days (Table 2). Past 30-day e-cigarette users most often endorsed fruit (61%), fruit-ice (47%) and menthol (45%) as flavors used in the past 30 days (Table 2). The majority (58%) endorsed 2 flavors; 32% endorsed 3 flavors. Combined, 76% endorsed a sweet flavor, and 70% endorsed a menthol flavor (Table 2).

Flavored use was near universal regardless of device type or use frequency (Table 3). The most used device types were modern disposables, like Puff Bar, and reusable pods, like JUUL (Table 3). Among all past 30-day e-cigarette users, 77% reported using a reusable

pod at least once in the past month and 68% reported using a modern disposable. However, modern disposables were more likely than reusable pods to be participants' single most used device (Table 3). Individuals who used modern disposables the most were more likely than reusable pod users to report using sweet (85% vs. 65%) or fruit (84% vs. 63%) flavors, although menthol flavor use was similar (72% vs. 69%). Participants who used e-cigarettes more frequently endorsed more different flavors used (Table 3).

3.3. Perceived e-cigarette access

Most participants perceived it to be easy to find e-cigarettes in flavors they like (Table 4). Past 30-day e-cigarette users reported it would be very easy (40%) or somewhat easy (30%) to find such flavors. Non-users similarly reported very easy (34%) or somewhat easy access (29%), despite additionally being offered a "don't know" response option (Table 4). Only 17% of non-users indicated not knowing how easy it would be to find e-cigarettes in flavors they like.

When asked how current ease of access to flavored e-cigarettes differed from early 2020, "about the same" was the most common response among users (40%) and non-users (41%). Among the minority of participants who perceived somewhat or much more difficulty (24% of users; 21% of non-users), the most endorsed reasons were less availability of e-cigarettes in all flavors (42%), the COVID-19 pandemic (35%), less availability of e-cigarettes in preferred flavors (32%), and in-store age verification (31%).

Mint, menthol, and fruit flavors were viewed as the easiest e-cigarette flavors to access, and vape shops were seen as the easiest location to find fruit or sweet e-cigarettes (Table 5). In contrast, unflavored and alcohol flavored e-cigarettes were viewed as more difficult to find.

3.4. Latent class analysis

A five-class LCA solution was chosen based on model fit and interpretability (Fig. 1). One class of "straight line" responses (5% of total sample) was considered potentially indicative of inattentive survey taking and not included in association analyses. The remaining four classes were subjectively labeled as mint (34% of remaining sample: strong preference for mint, menthol, and fruit-ice); no preference (29%: favorable toward all flavors, including tobacco and unflavored, few strong preferences); fruit/sweet (28%: strong preference for fruit, sweet, and fruit-ice, strong dislike for tobacco, alcohol, and unflavored); and dislikes one or more (10%: strong dislike for 1 flavor with few strong favorable preferences).

Consistent with preferences, past 30-day e-cigarette users who were members of the fruit/sweet class were most likely to report using any fruit (86%) and any sweet (88%) flavored e-cigarette. However, the mint and no preference classes also reported substantial use of fruit (mint class: 74%, no preference class: 70%) and sweet (mint class: 75%, no preference class: 74%) flavors. Past 30-day e-cigarette users who were members of the mint class were most likely to report use of mint (69%) and menthol (85%) e-cigarettes. Mint use was less common in the fruit/sweet class (35%) and no preference class (39%), but due to use of fruit-ice flavors, menthol use was common (fruit/sweet class: 70%, no preference class: 56%).

Participant characteristics and behaviors differed by e-cigarette flavor preference (Table 6). Of the four retained LCA classes, members of the mint class were most likely to identify as non-Hispanic White, have a parent with a college degree, and used e-cigarettes more frequently in the past 30 days and more times overall (Table 6). Members of the no preference class were least likely to be female, non-Hispanic White, or have used e-cigarettes 50 times. Members of the fruit/sweet class were younger, most likely to be female, and least likely to use other tobacco, cannabis, or alcohol. Finally, members of the dislikes one or more class were least likely to be past 30-day e-cigarette users (Table 6).

Reasons for e-cigarette use were similar across three of the four LCA classes (Table 7). Past 30-day e-cigarette users in the mint, no preference, and fruit/sweet class were most likely to endorse getting a buzz/high, availability of flavors, use by friends, and ability to use unnoticed, in that order. In the dislikes one or more flavor class, the most endorsed reason for e-cigarette use was “I think I’m addicted”; the third-most endorsed reasons was “it’s hard to stop” (Table 7). Quitting other tobacco and resembling a regular cigarette were among the least endorsed reasons in all classes.

Associations between participant characteristics and e-cigarette flavor preferences persisted in multivariable models (Table 8). Using e-cigarettes 50 times was associated with membership in fruit/sweet (RRR: 1.87; 95% CI: 1.37, 2.57) and mint (RRR: 3.85; 95% CI: 2.77, 5.36) classes, relative to the no preference class. Combustible tobacco use (RRR: 0.50; 95% CI: 0.38, 0.66), as well as use of smokeless tobacco and cannabis, was inversely associated with fruit/sweet membership (Table 8). Female and Hispanic/Latinx participants were more likely to be members of the mint and fruit/sweet classes. Setting mint as the reference class (not shown in table), female (RRR: 1.32; 95% CI: 1.02, 1.72) and Black (RRR: 1.75; 95% CI: 1.10, 2.79) participants were more likely to be members of the fruit/sweet class, while e-cigarette use 50 times (RRR: 0.49; 95% CI: 0.35, 0.68), past 30-day combustible tobacco use (RRR: 0.58; 95% CI: 0.45, 0.76), and smokeless tobacco use (RRR: 0.41; 95% CI: 0.28, 0.60) were inversely associated with fruit/sweet class membership.

4. Discussion

More than one year following FDA enforcement prioritization against certain flavors and types of e-cigarettes (Food and Drug Administration, 2020), adolescent and young adult e-cigarette users in the present study near universally reported use of flavored products, most often sweet, fruit, or menthol. Use of cartridge/pod systems and disposable e-cigarettes was widespread. It was uncommon to report difficulty finding e-cigarettes in desirable flavors or to report more difficulty finding sweet/fruit flavors compared with prior to enforcement prioritization. Together, the results suggest ample access to and prevalent use of flavored and pod-based e-cigarettes, despite recent policy.

Menthol and disposable e-cigarettes were not prioritized for enforcement, citing evidence at the time that youth preference for menthol was “much lower” than for mint and fruit (Food and Drug Administration, 2020; Leventhal et al., 2019b). In a national online survey of adolescents and young adults conducted three months after the policy took effect, a

combined category of mint, wintergreen, or menthol flavors was the most used flavor, matching or exceeding use of fruit flavors in all age groups and device types (Gaiha et al., 2021). Disposable devices, which offer convenience and concealability at a lower initial cost than reusable devices with interchangeable cartridges/pods, gained substantial market share in the year before the enforcement prioritization policy (Delnevo et al., 2020; Williams, 2020). Use of disposable devices was widespread in the present work, the other national online study (Gaiha et al., 2021), and 2020 NYTS findings (Wang et al., 2020). These results suggest that flavors (i.e., menthol) and device types (i.e., disposables) not prioritized for enforcement had already or would soon rank among those most used by young people. However, not only were non-prioritized flavors and devices popular with youth, but flavors (i.e., fruit and mint) and devices (i.e., cartridge-based) that were prioritized also persisted as readily accessible and commonly used in the present data and other recent work (Gaiha et al., 2021).

The emergence of fruit-ice combination flavors potentially contributes to increasing youth use of mentholated e-cigarettes. Fruit-ice e-cigarette flavors gained substantial popularity around the time of the 2020 FDA enforcement prioritization announcement (Gaiha et al., 2021; Leventhal et al., 2021) and, among young adults, have been associated with more frequent vaping and dual- use of combustible tobacco (Leventhal et al., 2021). Participants in our study, when asked to endorse e-cigarette flavors they used from a list, selected menthol less often than fruit (45% vs. 61%); however, considering fruit-ice flavors as a form of both menthol and fruit greatly narrowed the popularity gap (any menthol: 70%, any fruit: 74%). A survey of high school students in Connecticut emphasized the cooling sensation produced by freeze, ice, or chill vape flavors over the word “menthol” and found 52% prevalence of cooling flavor use among e-cigarette users (Davis et al., 2021). Rather than rely on respondents to recognize menthol as a flavor, survey instruments should include ice, fruit-ice, and cooling terminology to capture menthol product use fully.

“Ice” flavors not explicitly characterized as menthol in their marketing also have implications for tobacco control and regulation. In April 2021, the FDA announced a commitment to work toward a proposed product standard to eliminate menthol as a characterizing flavor in cigarettes and to ban all characterizing flavors in cigars, aimed in part at reducing youth initiation (Food and Drug Administration, 2021a). Restricting the additives that produce the cooling sensation rather than relying on a characterizing flavor definition would be a more direct and enforceable approach to eliminate cooling flavors (Davis et al., 2021).

In the present study, strong preference for mint or menthol comprised the largest class and was associated with more lifetime and past 30-day e-cigarette use. While greater lifetime use was also associated with fruit/sweet preference (compared to no strong preference), unlike mint/menthol, fruit/sweet preference was associated with less dual-use of other tobacco. The cross-sectional nature of the present study requires cautious interpretation, but it is possible that sweet/fruit flavors are more attractive than mint/menthol flavors to youth at lower risk for combustible tobacco use. Notably, female participants were more likely than males to prefer sweet/fruit flavors, reminiscent of tobacco industry research showing that flavored cigarettes would appeal to women and younger smokers (Carpenter et al., 2005).

A previous latent class analysis of young adult e-cigarette users found that participants who used multiple devices and flavors tended to vape more (Lanza et al., 2020). Similarly, a study of high school students reported an association between greater e-cigarette use and liking a larger number of flavors (Morean et al., 2018). Likewise, among middle school students in Mexico, liking fruit flavors was associated with greater lifetime e-cigarette use (Zavala-Arciniega et al., 2019). Together, these results suggest that young people with more experience using e-cigarettes tend also to have stronger flavor opinions. Prospective findings have shown that youth who use sweet, fruit, or buttery e-cigarette flavors are more likely than users of mint/menthol, unflavored, or tobacco flavors to sustain their e-cigarette use over time (Leventhal et al., 2019a).

While prior research has focused on the most appealing e-cigarette flavors, our study revealed a novel class of individuals who strongly disliked certain flavors. Most participants in this class had weak affinity for some flavors, strongly disliked one or two flavors, and were not unified in which flavor(s) they disliked. Notably, participants in this class differed from all other e-cigarette users in their endorsed reasons for vaping: addiction-related reasons were much more prominent. For youth in this class, for whom nicotine dependence is a potentially stronger driver than flavors of e-cigarette use, flavor restriction policies alone may be insufficient to reduce their use. This suggests a need for multipronged policies, including effective youth e-cigarette cessation treatments.

In August 2021, the FDA began announcing e-cigarette authorization decisions under the Premarket Tobacco Product Application (PMTA) pathway (Food and Drug Administration, 2021b). The FDA denied marketing orders to many flavored products, granted authorization to a single tobacco-flavored product, Vuse Solo, but as of this writing, had yet to decide on some of the largest e-cigarette brands, including JUUL. In announcing its decision, the FDA cited relatively low youth use of the Vuse brand and tobacco flavors in the 2021 NYTS (Park-Lee et al., 2021). In the present study, use of tobacco flavor was indeed relatively uncommon. However, the no preference latent class was the second largest and the group most amendable to tobacco and unflavored e-cigarettes. In its pending PMTA decisions, the FDA should consider both youth affinity for menthol e-cigarettes and the potential for authorized tobacco flavored or unflavored e-cigarettes to become viable alternatives for the many youth without strong flavor preferences.

Several study limitations should be considered. While this sample was diverse in its sociodemographic characteristics, commercially administered panel survey respondents are not necessarily representative of the general population (Miller et al., 2020). Online survey panels may differ from the general population in their demographic and attitudinal composition. This study was cross-sectional. It was not possible to track longitudinal changes before and after enforcement prioritization. Only included were e-cigarette repeated ever-users; thus, perceptions of e-cigarette never-users and overall population e-cigarette use prevalence could not be estimated. It is possible that the FDA enforcement prioritization policy deterred some youth from ever initiating e-cigarette use, and these individuals would not be eligible for this study. Included e-cigarette non-users (i.e., former users) largely did not perceive difficulty accessing flavored e-cigarettes.

4.1. Conclusions

In summary, the present results indicate highly prevalent use of mentholated, fruit-flavored, and both cartridge-based and disposable e-cigarettes among US adolescents and young adults, with relatively few perceived difficulties in accessing desirable flavors. Distinct classes of flavor preferences, however, demonstrate that youth are not monolithic in their flavor affinities. Flavor preference profiles were associated with current e-cigarette behaviors and reasons for use and could plausibly influence how youth respond to pending e-cigarette control policies and regulations. Given the large proportions of youth who use and like most all available flavors, policies that restrict all flavors (including menthol) across all tobacco and e-cigarette product types are needed to meaningfully impact youth use of these products.

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Abbreviations:

CI	confidence interval
FDA	United States Food and Drug Administration
LCA	latent class analysis
NYTS	National Youth Tobacco Survey
PMTA	Premarket Tobacco Product Application
RRR	relative risk ratio

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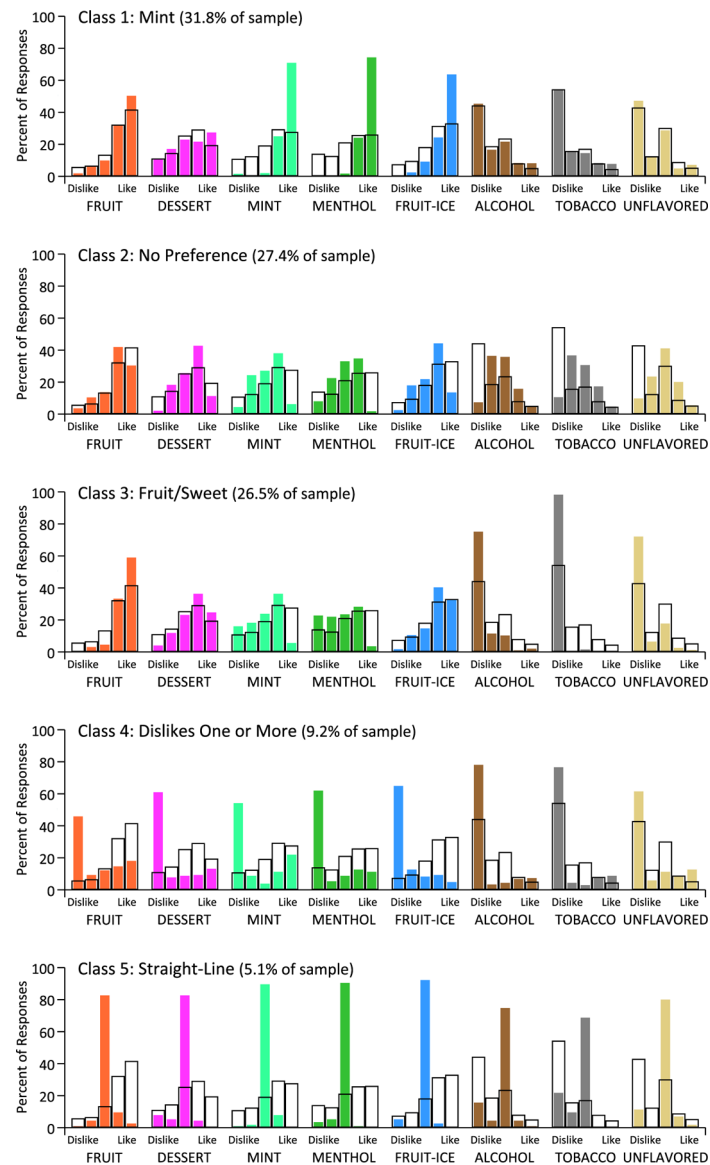


Fig. 1. E-Cigarette Flavor Preference Latent Classes.

The figure shows flavor preference response patterns in the 5-class latent class analysis solution. All participants were asked, “How much do you like the following flavors for e-cigarettes or vapes?” for eight listed flavors (Fruit flavors; Candy or dessert flavors; Mint flavors; Icy, frost, or menthol flavors; Combined icy flavors, like “icy fruit”; Alcohol flavors; Tobacco flavor; Unflavored) with response options: strongly dislike; somewhat dislike; neither like or dislike; somewhat like; strongly like. The height of the unfilled bars shows the percent of the total sample that endorsed each option for each flavor. The height of the filled bars shows the percent of the members assigned to the specific class that endorsed each option for each flavor. For example, members of Class 1 were less likely than the total sample to endorse strongly dislike, somewhat dislike, and neither like or dislike for the flavor mint, while also being more likely than the total sample to endorse strongly like for mint.

Table 1

Characteristics of the survey population.

	Total Sample N = 2253	Past 30-Day E-Cigarette Users N = 1649	Past 30-Day E-Cigarette Non-Users N = 604	p-value ¹
Age,%				0.01
14–17 years	27.5	26.0	31.5	
18–20 years	72.5	74.0	68.5	
Gender,%				0.76
Female	65.1	65.1	65.2	
Male	31.5	31.7	31.0	
Other	3.4	3.2	3.8	
Race/Ethnicity,%				<0.001
White, non-Hispanic	56.9	61.1	45.2	
Hispanic/Latinx	18.8	16.7	24.7	
Black, non-Hispanic	8.9	7.2	13.7	
Asian, ² non-Hispanic	5.3	5.1	6.0	
Other ³	10.1	9.9	10.4	
Parent Education, ⁴ %				<0.001
High School or Less	26.9	24.8	32.8	
Some College	17.0	17.5	15.7	
College Degree	53.7	55.6	46.9	
Don't Know	2.8	2.1	4.6	
Lifetime E-Cigarette Use,%				<0.001
3–10 times	21.1	14.8	38.4	
11–49 times	20.5	18.0	27.5	
50 times	58.4	67.3	34.1	
Past 30-Day Use				
E-Cigarettes,%	73.2	100	0	<0.001
Combustible Tobacco, ⁵ %	35.8	43.2	15.4	<0.001
Smokeless Tobacco, ⁶ %	15.6	20.3	2.6	<0.001

	Total Sample <i>N</i> = 2253	Past 30-Day E-Cigarette Users <i>N</i> = 1649	Past 30-Day E-Cigarette Non-Users <i>N</i> = 604	<i>f</i> p-value
Cannabis, %	61.2	71.1	34.1	<0.001
Alcohol, %	61.0	71.4	32.6	<0.001

¹ Pairwise comparison between past 30-day e-cigarette users and non-users (chi-square test).

² Includes Pacific Islander/Hawaii Native.

³ Includes American Indian/Alaska Native, Middle Eastern/North African, prefer not to answer, "other," and more than one race.

⁴ Highest reported educational attainment of either father/male guardian or mother/female guardian.

⁵ Includes cigarettes, cigars, and/or hookah.

⁶ Includes moist snuff, chewing tobacco, snus, nicotine pouches, and/or nicotine tablets/lozenges.

⁷ Includes combustible, aerosolized, edible, and/or other modalities of cannabis (marijuana) consumption.

Table 2

Most used e-cigarette flavors.

Flavor Category ¹	Use in the Past 30-Days, ² %
Fruit	61.0
Fruit-Ice	47.4
Menthol	44.6
Mint (non-menthol)	15.8
Dessert or Candy	15.2
Tobacco	8.4
Alcohol	6.6
Unflavored	5.8
Don't Know	3.8
Other	1.9
Any Flavor ³	92.4
Any Sweet Flavor ⁴	75.7
Any Fruit Flavor ⁵	73.7
Any Menthol Flavor ⁶	69.6
Any Mint Flavor ⁷	49.6
Any Substance Flavor ⁸	13.9
Only ⁹ Fruit	14.6
Only Menthol	11.1
Only Fruit-Ice	6.8
Only Don't Know	2.9
Only Unflavored	2.6
Only Tobacco	1.8
Only Mint	1.2
Only Dessert or Candy	1.1
Only Other	0.6
Only Alcohol	0.4

- ¹ Categories not mutually exclusive (i.e., a respondent could endorse using both fruit flavored and unflavored e-cigarettes in the past 30 days); thus, the sum of percentages exceeds 100%.
- ² Among past 30-day e-cigarette users who endorsed 1 item from the listed flavor categories ($N = 1647$).
- ³ Includes fruit, fruit-ice, menthol, mint, dessert/candy, and/or alcohol.
- ⁴ Includes fruit, fruit-ice, and/or dessert/candy.
- ⁵ Includes fruit and/or fruit-ice.
- ⁶ Includes fruit-ice and/or menthol.
- ⁷ Includes menthol, and/or mint.
- ⁸ Includes tobacco and/or alcohol.
- ⁹ “Only” indicates respondents endorsed only one flavor option; percentage is out of the total ($N = 1647$).

Table 3

Most used e-cigarette flavors by e-cigarette device type and use frequency.

	n (%)	Past 30-Day Flavored E-Cigarette Use, ¹ %						
		Any Flavor ²	Any Sweet Flavor ³	Any Fruit Flavor ⁴	Any Menthol Flavor ⁵	Any Mint Flavor ⁶	Any Substance Flavor ⁷	
Most Used E-Cigarette Device Type ⁸								
Modern disposable ⁹	526 (31.9)	94.5	84.6	84.0	72.1	43.5	9.1	
Reusable pod ¹⁰	355 (21.6)	93.5	65.4	62.5	69.0	56.9	13.2	
Pen ¹¹	92 (5.6)	84.8	68.5	66.3	50.0	37.0	18.5	
Mod ¹²	65 (3.9)	93.8	84.6	80.0	64.6	32.3	4.6	
Cigalike ¹³	52 (3.2)	86.5	53.8	51.9	69.2	65.4	19.2	
Rebuildable ¹⁴	32 (1.9)	90.6	71.9	68.8	59.4	43.8	21.9	
Other ¹⁵	45 (2.7)	88.9	68.9	64.4	57.8	42.2	15.6	
Multiple ¹⁶	480 (29.1)	91.7	76.9	74.8	73.8	55.0	18.8	
Past 30-Day E-Cigarette Use Frequency ¹⁷								
1–5 days	384 (23.3)	83.9	68.2	64.6	50.5	32.6	11.5	
6–19 days	358 (21.7)	90.5	75.1	73.2	67.9	46.1	14.2	
20 days	905 (54.9)	96.8	79.0	77.8	78.5	58.2	14.8	

¹ Among past 30-day e-cigarette users who endorsed 1 items from the listed flavor categories (N = 1647).

² Includes fruit, fruit-ice, menthol, mint, dessert/candy, and/or alcohol.

³ Includes fruit, fruit-ice, and/or dessert/candy.

⁴ Includes fruit and/or fruit-ice.

⁵ Includes fruit-ice and/or menthol.

⁶ Includes menthol, and/or mint.

⁷ Includes tobacco and/or alcohol.

⁸ Participants reported how many days they used each type of e-cigarette device in the past 30-days and were given a photo and brief description of each device type. Their most used device type was the device type used the most days (calculated from responses).

⁹ Described in questionnaire as “Disposable pod e-cigarette/vapes (like Puff Bar, Stig, or Stix)” despite the “pod” misnomer commonly associated with these devices.

¹⁰ Described in questionnaire as “Reusable pod e-cigarette/vapes (like JUUL or Sourin)”.

¹¹ Described in questionnaire as “Pen-like refillable e-cigarette/vapes”.

¹² Described in questionnaire as “Box mod refillable e-cigarette/vapes”.

¹³ Described in questionnaire as “Disposable cigarette-shaped vapes (like Blu or NJOY)”.

¹⁴ Described in questionnaire as “Rebuildable drip e-cigarette/vapes”.

¹⁵ Described in questionnaire as “Some other kind of e-cigarette or vape (not for marijuana)”.

¹⁶ Participants categorized as “multiple” if there was tie between more than one device type for the most days used. The devices used most in this category were reusable pods (88.8%) and modern disposables (88.5%).

¹⁷ Number of days participants’ single most used device was used.

Table 4

Perceived ease of access to flavored e-cigarettes.

	Past 30-Day E-Cigarette Users N = 1659	Past 30-Day E-Cigarette Non-Users N = 595
Right now, how difficult or easy is it to find e-cigarettes or vapes in flavors that you like?, ^{1/2} %		
Very Easy	40.2	33.8
Somewhat Easy	29.6	28.7
Somewhat Difficult	21.5	13.9
Very Difficult	8.7	6.7
Don't Know ³		16.8

¹ Participants were randomized with equal probability to two different word orderings: “how difficult or easy” or “how easy or difficult” which did not yield meaningful or statistically significant differences.

² For past 30-day e-cigarette non-users, the opening words “Right now” were replaced with “If you wanted to obtain an e-cigarette now” and “is it” with “would it be”.

³ “Don't Know” option presented only to past 30-day e-cigarette non-users.

Table 5

Perceived ease of access to flavored e-cigarettes, by flavor and method of acquisition.

	Very Easy,%	Somewhat Easy,%	Somewhat Difficult,%	Very Difficult,%	Mean Score ^J	p-value ²
Right now, how easy or difficult is it to find e-cigarettes or vapes in the following flavors? ^{3,4}						<0.001
Mint	60.4	25.2	9.9	4.5	1.58	a
Menthol	59.9	25.1	10.7	4.3	1.59	a
Fruit	58.7	26.9	8.5	6.0	1.62	a
Fruit-Ice	49.5	29.1	15.5	5.9	1.78	b
Tobacco	47.1	24.3	17.4	11.2	1.93	c
Dessert or Candy	31.0	32.5	26.6	9.9	2.15	d
Unflavored	31.8	18.0	23.2	26.9	2.45	e
Alcohol	12.2	13.9	34.8	39.1	3.01	f
Right now, how easy or difficult is it to find fruit, candy, fruit-ice combination, and/or dessert flavored e-cigarettes or vapes in the following locations? ^{3,4}						<0.001
Vape shop	66.5	23.6	6.6	3.2	1.47	a
Online	57.7	22.1	13.5	6.7	1.69	b
From friends	44.9	30.8	14.1	10.2	1.90	c
Convenience store	34.9	29.9	24.2	11.0	2.11	d
From family	18.8	16.8	22.0	42.4	2.88	e

¹ Category levels coded as 1 = very easy; 2 = somewhat easy; 3 = somewhat difficult; 4 = very difficult.

² Reported p-values from Friedman tests for global differences by flavor or by location; unique letters indicate statistically significant pairwise differences by Wilcoxon signed-rank tests (Bonferroni correction for multiple comparisons).

³ Participants were randomized with equal probability to two different word orderings: “how difficult or easy” or “how easy or difficult” which did not yield meaningful or statistically significant differences.

⁴ Questions only asked of past 30-day e-cigarette users who responded to all items on the list (N = 1640 flavors; N = 1641 locations).

Table 6

Participant characteristics by e-cigarette flavor preference latent class.

	Mint N = 712	No Preference N = 613	Fruiti/Sweet N = 592	Dislikes One or More N = 205	p-value ^f
Age,%					0.02
14–17 years	24.0	27.6	31.6	25.9	
18–20 years	76.0	72.4	68.4	74.2	
Gender,%					<0.0001
Female	66.0	58.9	73.0	60.5	
Male	31.0	37.7	23.0	36.1	
Other	2.9	3.4	4.1	3.4	
Race/Ethnicity,%					<0.0001
White, non-Hispanic	66.0	48.0	56.6	55.1	
Hispanic/Latinx	15.3	23.3	17.9	19.5	
Black, non-Hispanic	5.1	12.2	9.1	10.2	
Asian, ² non-Hispanic	4.9	5.1	5.7	5.9	
Other ³	8.7	11.4	10.6	9.3	
Parent Education, ⁴ %					0.05
High School or Less	25.6	26.4	28.4	26.3	
Some College	16.7	18.1	17.1	18.1	
College Degree	56.2	51.6	52.7	50.2	
Don't Know	1.5	3.9	1.9	5.4	
Lifetime E-Cigarette Use,%					<0.0001
3–10 times	10.7	26.4	20.1	27.3	
11–49 times	14.8	27.7	21.6	14.2	
50 times	74.6	45.8	58.3	58.5	
Current E-Cigarette Use,%					<0.0001
0 days in past 30 days	16.4	26.9	29.4	38.1	
1–5 days in past 30 days	12.8	24.0	14.0	19.0	
6–19 days in past 30 days	13.2	20.9	14.9	14.2	
20 days in past 30 days	57.6	28.2	41.7	28.8	

	Mint <i>N</i> = 712	No Preference <i>N</i> = 613	Fruit/Sweet <i>N</i> = 592	Dislikes One or More <i>N</i> = 205	<i>J</i> p-value
Tobacco Use After Waking, ⁵ %					<0.001
Within 30 min	35.9	53.7	45.8	39.4	
After 30 min	64.1	46.3	54.2	60.6	
Past 30-Day Use					
Combustible Tobacco, ⁶ %	40.2	45.4	23.1	38.1	<0.001
Smokeless Tobacco, ⁷ %	18.8	21.7	6.9	14.2	<0.001
Cannabis, ⁷ %	62.4	69.2	54.7	54.2	<0.001
Alcohol, ⁸ %	66.3	65.9	56.9	52.7	<0.001

¹ Chi-square test across the four latent classes ("straight-line" class excluded, *N* = 115).

² Includes Pacific Islander/Hawaii Native.

³ Includes American Indian/Alaska Native, Middle Eastern/North African, prefer not to answer, "other," and more than one race.

⁴ Highest reported educational attainment of either father/male guardian or mother/female guardian.

⁵ Includes use of any tobacco and/or nicotine product within 30 min of waking; question only asked of past 30-day tobacco and/or nicotine users (*N* = 1585).

⁶ Includes cigarettes, cigars, and/or hookah.

⁷ Includes moist snuff, chewing tobacco, snus, nicotine pouches, and/or nicotine tablets/lozenges.

⁸ Includes combustible, aerosolized, edible, and/or other modalities of cannabis (marijuana) consumption.

Table 7

Endorsed reasons for e-cigarette use by e-cigarette flavor preference latent class.

	Total N = 1587			Mint N = 595			No Preference N = 448			Fruit and Sweet N = 417			Dislikes One or More N = 127		
	% ¹	rank ²	% ¹	rank ²	% ¹	rank ²	% ¹	rank ²	% ¹	rank ²	% ¹	rank ²	% ¹	rank ²	
Buzz or high	50.1	1	54.8	1	44.0	1	55.6	1	31.5	8					
Flavors I like	47.3	2	53.9	2	41.7	2	49.9	2	27.6	10					
A friend uses them	41.7	3	44.4	3	37.1	3	43.9	3	37.8	2					
Can use unnoticed	38.7	4	44.4	4	30.6	5	41.2	4	32.3	7					
I think I'm addicted	35.6	5	41.0	5	26.3	10	36.7	6	39.4	1					
Do tricks with the vapor	33.5	6	36.5	7	28.3	7	37.4	5	24.4	11					
Curious	33.0	7	32.4	12	32.6	4	33.8	7	33.9	5					
Lack of smell	32.9	8	36.3	8	28.8	6	33.8	8	28.3	9					
Less harmful to me	31.6	9	34.8	10	27.9	8	30.0	11	35.4	4					
It's hard to stop	31.1	10	37.5	6	21.0	13	31.4	9	35.4	3					
Help me concentrate	29.7	11	35.3	9	24.6	11	26.4	12	33.1	6					
Something to do with friends	29.6	12	32.9	11	27.2	9	30.5	10	18.9	15					
Less harmful to people near me	25.0	13	27.6	13	21.7	12	25.4	13	22.8	12					
Affordable	22.9	14	26.2	14	19.9	14	21.6	15	22.0	13					
Use where smoking not allowed	21.0	15	24.5	15	16.3	15	21.8	14	18.9	16					
A family member uses them	16.1	16	13.8	17	15.6	16	18.7	16	20.5	14					
Easier to get than other tobacco	13.6	17	13.8	18	14.7	17	12.2	17	13.4	17					
Don't bother tobacco non-users	13.0	18	15.1	16	12.3	19	12.2	18	8.7	19					
Seen on TV, online, movies	11.0	19	11.6	19	13.2	18	8.4	19	8.7	20					
To quit other tobacco	9.4	20	10.8	20	10.0	20	6.2	20	11.0	18					
Feel like regular cigarette	7.2	21	7.7	21	8.0	21	5.5	21	7.1	21					
Number of reasons, ³ mean	5.7 (3.9)		6.4 (4.1)		5.0 (3.8)		5.8 (3.6)		5.1 (3.4)						

¹Past 30-day e-cigarette users were asked to respond to the prompt "Below are some reasons people use e-cigarettes/vapes. Please select which reasons apply to you. (Choose all that apply).".

²Percent of participants endorsing each listed reason within a given latent class (or total). Participants could endorse more than one reason; thus, the sum of percentages exceeds 100.

³Rank (1 = most endorsed; 21 = least endorsed) of each listed reason within a given latent class (or total).

³Mean (standard deviation) number of listed reasons endorsed within a given latent class (or total).

Table 8

Multivariable correlates of e-cigarette flavor preference latent classes.

	Mint		Fruit and Sweet		Dislikes One or More	
	RRR (95% CI)	No Preference RRR (95% CI)	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
Age						
14–17 years	reference	reference	reference	reference	reference	reference
18–20 years	1.15 (0.88, 1.49)	reference	0.96 (0.74, 1.25)	1.19 (0.82, 1.72)		
Gender						
Male	reference	reference	reference	reference	reference	reference
Female	1.45 (1.13, 1.86)	reference	1.92 (1.47, 2.50)	1.15 (0.81, 1.62)		
Other	1.30 (0.67, 2.51)	reference	1.96 (1.02, 3.76)	1.15 (0.46, 2.89)		
Race/Ethnicity						
White, non-Hispanic	reference	reference	reference	reference	reference	reference
Hispanic/Latinx	0.66 (0.48, 0.91)	reference	0.72 (0.52, 0.99)	0.79 (0.51, 1.23)		
Black, non-Hispanic	0.51 (0.32, 0.79)	reference	0.89 (0.59, 1.34)	0.88 (0.50, 1.55)		
Asian, ¹ non-Hispanic	0.96 (0.57, 1.63)	reference	1.11 (0.65, 1.90)	1.07 (0.52, 2.20)		
Other ²	0.64 (0.43, 0.94)	reference	0.91 (0.61, 1.35)	0.74 (0.42, 1.30)		
Parent Education ³						
High School or Less	reference	reference	reference	reference	reference	reference
Some College	0.80 (0.56, 1.13)	reference	0.73 (0.51, 1.05)	0.93 (0.57, 1.52)		
College Degree	0.96 (0.73, 1.26)	reference	0.84 (0.63, 1.12)	0.94 (0.64, 1.40)		
Don't Know	0.43 (0.20, 0.95)	reference	0.41 (0.19, 0.90)	1.28 (0.57, 2.86)		
Lifetime E-Cigarette Use						
3–10 times	reference	reference	reference	reference	reference	reference
11–49 times	1.28 (0.88, 1.86)	reference	1.02 (0.72, 1.45)	0.51 (0.31, 0.84)		
50 times	3.85 (2.77, 5.36)	reference	1.87 (1.37, 2.57)	1.40 (0.93, 2.09)		
Past 30-Day Use (reference: non-use) ⁴						
Combustible Tobacco ⁵	0.85 (0.66, 1.10)	reference	0.50 (0.38, 0.66)	0.97 (0.67, 1.40)		
Smokeless Tobacco ⁶	1.09 (0.80, 1.47)	reference	0.44 (0.30, 0.66)	0.76 (0.47, 1.21)		

	Mint	No Preference	Fruit and Sweet	Dislikes One or More
	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
Cannabis ⁷	0.66 (0.51, 0.86)	reference	0.66 (0.51, 0.87)	0.59 (0.41, 0.84)
Alcohol	0.89 (0.69, 1.16)	reference	0.82 (0.63, 1.07)	0.65 (0.45, 0.93)

Table displays results of multinomial regression analysis for latent class membership ($N = 2122$; “straight-line” class excluded, $N = 115$). Relative risk ratios reflect the multivariable adjusted relative increase in probability of being part of a given latent class (compared to “no preference” class) associated with each row characteristic (compared to the reference row).

¹Includes Pacific Islander/Hawai Native.

²Includes American Indian/Alaska Native, Middle Eastern/North African, prefer not to answer, “other,” and more than one race.

³Highest reported educational attainment of either father/male guardian or mother/female guardian.

⁴Reference category is product specific; for example, non-use of combustible tobacco (0 days in past 30 days) is the reference category for past 30-day combustible tobacco use (1 day in the past 30 days).

⁵Includes cigarettes, cigars, and/or hookah.

⁶Includes moist snuff, chewing tobacco, snus, nicotine pouches, and/or nicotine tablets/lozenges.

⁷Includes combustible, aerosolized, edible, and/or other modalities of cannabis (marijuana) consumption Abbreviations: CI = confidence interval; RRR = relative risk ratio.