

Characteristics of Daily E-Cigarette Use and Acquisition Means Among a National Sample of Adolescents

American Journal of Health Promotion
1-8
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DOI: 10.1177/0890117119854051
journals.sagepub.com/home/ahp


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Abstract

Purpose: To examine the relationship between several e-cigarette-related characteristics and daily e-cigarette use among adolescent current users.

Design: Secondary analysis of 2016 National Youth Tobacco Survey data.

Setting: United States middle schools and high schools.

Sample: One thousand five hundred seventy-nine current e-cigarette users.

Measures: Daily e-cigarette use and e-cigarette flavors, brands, device type, and acquisition were measured.

Analysis: Logistic regression and Poisson regression models were built.

Results: A total of 13.6% of current users reported daily use. Results indicated that daily users were at increased odds of using all flavor types (all $P < .001$), with the exception of menthol/mint, and using a higher number of flavors than nondaily users ($P < .001$). Daily users were more likely to use Blu, eGo, Logic, Halo, NJOY, and another unlisted brand but less likely to report they did not know the brand used (all $P \leq .01$). Daily users also reported using a higher number of brands than nondaily users ($P < .001$). Daily users were at increased odds of using marijuana/tetrahydrocannabinol (THC) oil wax as device ingredients ($P < .001$) and less likely to use only nicotine ($P < .001$) or unknown ingredients ($P = .004$). Daily users were more likely to acquire e-cigarettes from a vape shop, gas station/convenience store, Internet, mall/shopping center kiosk, drug store, grocery store, or other place (all $P \leq .01$).

Conclusion: Comprehensive efforts are needed to reduce e-cigarette use and nicotine addiction among adolescents.

Keywords

tobacco control, e-cigarettes, health policy

Purpose

Electronic cigarettes (e-cigarettes) are the most commonly used tobacco product among middle school and high school students nationwide.¹ E-cigarette use has grown exponentially from 2011 to 2018, with a total of 4.9% (0.57 million) middle school students and 20.8% (3.05 million) high school students reporting e-cigarette use in the past 30 days (current use).¹ Current use rates increased significantly from 2017 to 2018 with a 48% increase in e-cigarette use among middle school students and a 78% increase among high school students, overturning the decreasing trends observed in recent years.¹ Additionally, rates of frequent e-cigarette use increased among high school students between 2017 and 2018.¹

Concerning evidence exists on e-cigarette use. Prior research suggests that these products may reverse the recent progress made in tobacco control by renormalizing smoking

and increasing adolescent initiation.^{2,3} Emerging evidence suggests e-cigarette use may lead to future cigarette smoking among this population.⁴⁻⁷ Additionally, adolescent tobacco product use patterns have remained stable over time due to the rise in nontraditional products, especially e-cigarettes.⁸ This is

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concerning as adolescent use may lead to nicotine dependence, and approximately 9 of 10 adult daily smokers start before 18 years old.⁹ Long-term consequences of nicotine exposure during adolescence include negatively affecting the developing adolescent brain leading to cognitive and behavioral impairments.^{9,10} Yet other, other studies suggest that e-cigarette use may be a safer alternative to cigarette use.^{11,12} Despite the ongoing public health debate, more research is needed to identify adolescents at risk for nicotine addiction to inform prevention efforts.

A main reason cited for initiation and popularity among adolescents is flavoring/taste appeal.¹³ Current users report the most common substance last vaped was “just flavoring”.¹⁴ E-cigarette companies heavily market flavors to youth, as this increases rates of use and nicotine addiction.¹³ Other research reports high rates of adolescents not knowing how much nicotine concentration is in the e-liquid they used.¹⁵ Additionally, adolescents use e-cigarette devices to vaporize marijuana.¹⁶ Examining characteristics of daily users may help inform regulatory actions addressing adolescent initiation, use, and cessation of e-cigarette products.¹⁷

Concerning acquisition means, in May 2016, the US Food and Drug Administration (FDA) issued a federal rule to exercise regulatory authority over e-cigarettes, including banning sales of these products to individuals under 18 years of age.¹⁸ Prior to the implementation of the FDA’s rule, local and state regulations varied on e-cigarette sales to minors and use of these products.¹⁹ Despite this legislation, current e-cigarette use and frequency of use continue to rise at disproportionate rates among adolescents,¹ highlighting the critical need to assess e-cigarette acquisition means. Limited research has assessed the relationship between acquisition means and daily e-cigarette use in a nationally representative sample of adolescents. However, prior research on a small adolescent sample with limited generalizability found that top sources of e-cigarettes were friends, tobacco shops, and online shops.²⁰ Assessing this relationship at the national level is important to inform widespread prevention intervention and regulatory efforts that may reduce adolescent e-cigarette access and use.

With rapid uptake of e-cigarettes among adolescents in recent years,¹ it is important to identify risks associated with daily use. Our study objective was to examine the relationship between several e-cigarette-related characteristics (ie, e-cigarette flavors, brands, device types, and ingredients) and daily e-cigarette use among adolescent current users.

Methods

Design

We analyzed 2016 National Youth Tobacco Survey (NYTS) data,²¹ the most recent version available during analyses. The NYTS is a cross-sectional survey that uses a stratified, 3-stage cluster sample of 202 regular US public and private schools (81.5% participation) and 20 675 middle and high school

students (87.9% participation) to collect information on tobacco-related indicators and e-cigarette use and related characteristics such as device type. The overall NYTS participation rate at the school- and student-levels was 71.6%. All school participation was voluntary. Parents had the opportunity to opt their child out of participating in the survey, and students voluntarily completed the anonymous paper-based survey during regular school hours. More detailed methodology is described elsewhere.²¹

Sample

We limited our analyses to 1579 middle school and high school students who reported past 30-day e-cigarette use (8.5%; current use). The study was exempt by our institutional review board due to using publicly available, deidentified secondary data.

Measures

Daily e-cigarette use. Daily e-cigarette use was assessed using the following question: “During the past 30 days, on how many days did you use e-cigarettes?” For the purpose of the present study, participants who used e-cigarettes on all 30 days were defined as daily e-cigarette users.

E-cigarette-related characteristics. Several e-cigarette-related characteristics were assessed in the present study: flavor type, brand type, device type, and device ingredients. E-cigarette flavor type was assessed using the following question, “What flavor of tobacco products have you used in the past 30 days (Select one or more).” Response options included: (1) menthol or mint, (2) clove or spice, (3) fruit, (4) chocolate, (5) alcohol drink (such as wine, cognac, margarita, or other cocktails), (6) candy, desserts or other sweets, and (7) some other flavor not listed. Due to participants being able to select more than one response option, we also assessed e-cigarette flavor type as a count variable based on number of flavors. Additionally, since the question on flavor type asked about nonspecific tobacco products, we delimited this particular analysis to adolescents ($n = 847$) who indicated they used e-cigarettes in the past 30 days that were flavored.

We assessed e-cigarette brand type by using the following question, “What brands of e-cigarettes have you ever tried? (Select one or more).” Response options included: (1) Blu, (2) NJOY, (3) MarkTen, (4) Logic, (5) VUSE, (6) Vaping Plus, (7) eGo, (8) Halo, (9) some other brand not listed, and (10) do not know the brand name. Similarly, we assessed e-cigarette brand type as a count variable based on number of brands.

E-cigarette device type was evaluated by using the following question, “Thinking about all types of e-cigarettes, have you used the disposable kind or rechargeable/refillable/tank kind?” Response options included: (1) only the disposable kind, (2) only the rechargeable/refillable/tank kind, and (3) both the disposable kind and rechargeable/refillable tank kind.

Table 1. Personal Characteristics of Adolescent E-Cigarette Users, NYTS 2016.

Characteristic	Overall (N = 1579), n (%) ^a	Nondaily User (n = 1370), n (%) ^b	Daily User (n = 209), n (%) ^b	P Value ^c
Sex				
Male	938 (58.8)	782 (83.4)	156 (16.6)	<.001
Female	629 (41.2)	579 (90.8)	50 (9.2)	
Race/ethnicity				
White	731 (58.0)	638 (86.0)	93 (14.0)	.71
Black	148 (8.0)	135 (90.2)	13 (9.8)	
Asian	22 (1.1)	16 (80.6)	6 (19.4)	
Other ^d	145 (7.3)	125 (86.0)	20 (14.0)	
Hispanic	474 (25.6)	405 (86.1)	69 (13.9)	
Grade level				
6th-8th grade	411 (23.1)	364 (88.8)	47 (11.2)	.21
9th-12th grade	1154 (76.9)	1001 (86.3)	153 (13.7)	
E-cigarette initiation age				
≤13 years old	561 (36.0)	470 (83.4)	91 (16.6)	<.001
>13 years old	921 (64.0)	833 (89.7)	88 (10.3)	
Current flavored e-cigarette use				
No	817 (50.1)	721 (88.6)	96 (11.4)	.01
Yes	762 (49.9)	649 (84.2)	113 (15.8)	

Abbreviations: e-cigarette, electronic cigarette; NYTS, National Youth Tobacco Survey

^an refers to raw scores and column percentages are weighted. Missing values excluded.

^bn refers to raw scores and row percentages are weighted. Missing values excluded.

^cP values derived from χ^2 tests.

^dOther race includes non-Hispanic American Indian or Alaska Native, non-Hispanic Native Hawaiian or Pacific Islander, and multiple races.

E-cigarette device ingredients were assessed via the following question, “Have you ever used an e-cigarette device with a substance besides nicotine? (Select one or more).” Response options included: (1) yes, have used an e-cigarette device with marijuana, tetrahydrocannabinol (THC) or hash oil, or THC wax; (2) yes, have used an e-cigarette device with another substance that is not marijuana, THC or hash oil, or THC wax; (3) no, have only used an e-cigarette device with nicotine; and (4) do not know or not sure.

E-cigarette acquisition means. E-cigarette acquisition means were assessed with the following question, “During the past 30 days, where did you get or buy the e-cigarettes that you have used?” Response options included: (1) gas station or convenience store, (2) grocery store, (3) drug store, (4) mall or shopping center/kiosk stand, (5) on the Internet, (6) vape shop or other store that only sells e-cigarettes, (7) some other place not listed, (8) family member, (9) friend, and (10) some other person who is not a family member or a friend.

Covariates. Participants reported their sex, race/ethnicity (white, black, Asian, other, Hispanic), grade level (6th to 8th grade, 9th to 12th grade), age of first e-cigarette use (ie, initiation; ≤13 years old, >13 years old), and current flavored e-cigarette use (no, yes). Current flavored e-cigarette use was derived from a question asking participants whether they used flavored e-cigarettes in the past 30 days.

Analysis

We used frequencies and χ^2 analyses to examine characteristics of current users and the relationships between daily versus

nondaily use and covariates: sex, race/ethnicity (white, black, Asian, Hispanic, other), grade level (6th to 8th, 9th to 12th), age of e-cigarette initiation (≤13, >13 years old), and current flavored use. We used adjusted logistic regression models for categorical exposure variables (eg, flavor type) and Poisson regression models for integer exposure variables (eg, number of flavors). The NYTS sampling weights were applied to account for survey non-response and the complex survey design. R version 3.3.0 was used for all analyses, with a $P < .05$ indicating statistical significance. Missing values were removed prior to analyses.

Results

Of the 1579 current users, 58.8% were male, 76.9% were in high school, 58.0% were white, 25.6% Hispanic, 8.0% black, 1.1% Asian, and 7.3% other races (Table 1). Nearly two-thirds (64.0%) initiated e-cigarette use >13 years old, 50% engaged in flavored e-cigarette use, and 13.6% were daily users.

There were differences in daily use based on sex, initiation age, and flavored use (see Table 1). Specifically, males ($P < .001$), those who first used e-cigarettes ≤13 years old ($P < .001$), and those who reported current flavored e-cigarette use ($P = .01$) had higher rates of daily e-cigarette use compared to females, those who first used e-cigarettes >13 years old, and those who did not report current flavored e-cigarette use.

E-Cigarette-Related Characteristics and Daily E-Cigarette Use

Among adolescents who used e-cigarettes that were flavored in the past 30 days (n = 847), daily e-cigarette users were at

Table 2. E-Cigarette-Related Characteristics Among Adolescent Daily Users, NYTS 2016.

Characteristic	Overall (N = 1579) n (%) ^a	Nondaily User (n = 1370) n (%) ^b	Daily User (n = 209) n (%) ^b	aOR (95% CI) ^c	P Value
Flavor type^{d,e}					
Fruit	505 (62.3)	420 (59.7)	85 (76.3)	4.05 (2.16, 7.60)	<.001
Candy/desserts/sweets	388 (49.1)	309 (45.7)	79 (67.5)	2.92 (1.83, 4.67)	<.001
Menthol/mint	290 (35.1)	229 (33.1)	61 (46.0)	1.41 (0.93, 2.14)	.10
Other	226 (26.3)	170 (23.0)	56 (44.2)	2.68 (1.75, 4.1)	<.001
Alcohol drink	116 (14.5)	75 (11.2)	41 (32.6)	3.84 (2.33, 6.32)	<.001
Chocolate	112 (12.3)	83 (10.5)	29 (22.1)	2.79 (1.61, 4.84)	<.001
Clove or spice	48 (5.8)	25 (3.5)	23 (18.4)	6.11 (3.01, 12.39)	<.001
Number of flavors, M (SE) ^{e,f}	2.05 (0.05)	1.87 (0.05)	3.07 (0.19)	1.76 (1.52, 2.03) ^g	<.001
E-cigarette brands ever tried^d					
Don't know	513 (33.8)	491 (94.9)	22 (5.1)	0.22 (0.13, 0.36)	<.001
Other	503 (33.0)	406 (80.9)	97 (19.1)	1.92 (1.36, 2.73)	<.001
Blu	425 (26.4)	359 (82.8)	66 (17.2)	1.60 (1.11, 2.29)	.01
VUSE	272 (16.2)	231 (84.7)	41 (15.3)	1.11 (0.72, 1.72)	.64
Vapin Plus	219 (14.6)	185 (86.3)	34 (13.7)	1.16 (0.73, 1.86)	.53
eGo	179 (11.9)	130 (72.3)	49 (27.7)	3.36 (2.22, 5.09)	<.001
Logic	98 (6.1)	64 (65.7)	34 (34.3)	4.74 (2.79, 8.05)	<.001
Halo	91 (5.2)	61 (65.3)	30 (34.7)	4.34 (2.45, 7.70)	<.001
NJOY	88 (6.2)	65 (74.2)	23 (25.8)	2.34 (1.39, 3.94)	.001
MarkTen	70 (4.6)	52 (77.4)	18 (22.6)	1.67 (0.83, 3.36)	.15
Number of brands ever tried, M (SE) ^b	1.58 (0.03)	1.52 (0.03)	1.98 (0.14)	1.25 (1.13, 1.38) ^g	<.001
E-cigarette type					
Disposable kind	112 (5.9)	102 (92.6)	10 (7.4)	Ref	
Rechargeable/refillable/tank kind	563 (38.3)	745 (90.3)	78 (9.7)	2.42 (0.71, 8.21)	.16
Both disposable and rechargeable	823 (55.9)	460 (80.5)	103 (19.5)	1.15 (0.33, 3.93)	.83
E-cigarette device ingredients ever used^d					
Only nicotine	564 (36.9)	525 (92.0)	39 (8.0)	0.48 (0.33, 0.70)	<.001
Marijuana, THC or hash oil, THC wax	598 (38.0)	473 (78.2)	125 (21.8)	2.65 (1.87, 3.74)	<.001
Other substance that is not marijuana	171 (10.0)	139 (82.0)	32 (18.0)	1.52 (0.88, 2.60)	.10
Don't know	260 (15.0)	237 (92.5)	23 (7.5)	0.34 (0.16, 0.71)	.004

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; e-cigarette, electronic cigarette; NYTS, National Youth Tobacco Survey; THC, tetrahydrocannabinol.

^an is raw sample size and percent is weighted valid column percent unless noted otherwise. Missing values excluded.

^bn is raw sample size and percent is weighted valid row percent unless noted otherwise. Missing values excluded.

^cAdjusted odds ratios resulting from multivariable logistic regression models controlling for sex, race/ethnicity, grade level, e-cigarette initiation age, and current flavored e-cigarette use.

^dReference category did not select the option since these were "check all that apply" questions.

^eFlavor type analyses were delimited to only adolescents who indicated they used e-cigarettes in the past 30 days that were flavored (n = 847).

^fData are presented as mean (SE).

^gAdjusted relative risk ratios resulting from Poisson regression models controlling for sex, race/ethnicity, grade level, e-cigarette initiation age, and current flavored e-cigarette use.

significantly increased odds of using all flavors independent of the covariates, with the exception of menthol/mint flavoring (Table 2). Specifically, daily e-cigarette users were significantly more likely to report clove or spice flavoring (adjusted odds ratio [aOR] = 6.11; 95% confidence interval [CI] = 3.01-12.39), fruit flavoring (aOR = 4.05; 95% CI = 2.16-7.60), alcohol drink flavoring (aOR = 3.84; 95% CI = 2.33-6.32), candy, desserts, or other sweets flavoring (aOR = 2.92; 95% CI = 1.83-4.67), chocolate flavoring (aOR = 2.79; 95% CI = 1.61-4.84), and some other flavoring (aOR = 2.68; 95% CI = 1.75-4.10) compared to nondaily e-cigarette users.

Adjusted Poisson regression results (adjusted relative risk [aRR] = 1.76; 95% CI = 1.52-2.03) indicated that of adolescents who used e-cigarettes that were flavored in the past 30 days (n =

847), daily e-cigarette users reported a higher number of flavors ever used (mean [M] = 3.07; standard deviation [SD] = 0.19) than nondaily e-cigarette users (M = 1.87; SD = 0.05).

Multivariable logistic regression results indicated daily e-cigarette users were more likely to have ever used the brand Logic (aOR = 4.74; 95% CI = 2.79-8.05), Halo (aOR = 4.34; 95% CI = 2.45-7.70), eGo (aOR = 3.36; 95% CI = 2.22-5.09), NJOY (aOR = 2.34; 95% CI = 1.39-3.94), Blu (aOR = 1.60; 95% CI = 1.11-2.29), and some other brand not listed (aOR = 1.90; 95% CI = 1.36-2.73) than nondaily e-cigarette users (see Table 2). However, daily e-cigarette users were significantly less likely to report they did not know the brand used (aOR = 0.22; 95% CI = 0.13-0.36) compared to nondaily e-cigarette users.

Table 3. E-Cigarette Acquisition Means Among Adolescent Daily Users, NYTS 2016.

Current E-Cigarette Use Acquisition ^a	Overall (N = 1579), n (%) ^b	Nondaily User (n = 1370), n (%) ^c	Daily User (n = 209) n (%) ^c	aOR (95% CI) ^d	P Value
Friend	743 (48.9)	684 (92.7)	59 (7.3)	0.27 (0.19, 0.39)	<.001
Vape shop/store only sells e-cigarettes	404 (25.5)	301 (72.9)	103 (27.1)	4.38 (3.09, 6.21)	<.001
Family member	244 (14.5)	214 (88.3)	30 (11.7)	0.70 (0.41, 1.20)	.20
Gas station/convenience store	207 (12.3)	165 (76.2)	42 (23.8)	2.73 (1.79, 4.17)	<.001
Other person	163 (11.1)	129 (79.9)	34 (20.1)	1.31 (0.81, 2.12)	.27
Internet	148 (9.7)	109 (74.1)	39 (25.9)	2.50 (1.59, 3.94)	<.001
Mall/shopping center kiosk/stand	83 (4.6)	64 (73.5)	19 (26.5)	3.27 (1.69, 6.30)	<.001
Drug store	82 (4.5)	53 (61.6)	29 (38.4)	5.24 (2.60, 10.56)	<.001
Other place	81 (5.1)	57 (70.4)	24 (29.6)	3.24 (1.80, 5.83)	<.001
Grocery store	54 (3.2)	36 (71.6)	18 (28.4)	2.69 (1.23, 5.91)	.01

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; e-cigarette, electronic cigarette; NYTS, National Youth Tobacco Survey.

^aReference category did not select the option since these were “check all that apply” questions.

^bn is raw sample size and percent is weighted valid column percent. Missing values excluded.

^cn is raw sample size and percent is weighted valid row percent. Missing values excluded.

^dAdjusted odds ratios resulting from multivariable logistic regression models controlling for sex, race/ethnicity, grade level, e-cigarette initiation age, and current flavored e-cigarette use.

Adjusted Poisson regression results (aRR = 1.25; 95% CI = 1.13-1.38, $P < .001$) indicated daily e-cigarette users were significantly more likely to report using a higher number of brands in their lifetime (M = 1.98; SD = 0.14) than nondaily e-cigarette users (M = 1.52; SD = 0.03).

Although no significant differences were found based on e-cigarette device type, differences were reported based on e-cigarette device ingredients (see Table 2). Daily e-cigarette users were 2.65 (95% CI = 1.87-3.74) times more likely to have ever used marijuana, THC or hash oil, or THC wax as e-cigarette device ingredients but significantly less likely to report they ever used an e-cigarette device with only nicotine (aOR = 0.48; 95% CI = 0.33-0.70) or did not know or were not sure about their e-cigarette device ingredients (aOR = 0.34; 95% CI = 0.16-0.71).

E-Cigarette Acquisition Means and Daily E-Cigarette Use

Daily e-cigarette users were at significantly increased odds to acquire e-cigarettes in the past 30 days from the following sources compared to nondaily e-cigarette users: drug store (aOR = 5.24; 95% CI = 2.60-10.56), vape shop or store that only sells e-cigarettes (aOR = 4.38; 95% CI = 3.09-6.21), grocery store (aOR = 3.74; 95% CI = 2.36-5.92), mall or shopping center kiosk/stand (aOR = 3.27; 95% CI = 1.69-6.30), gas station/convenience store (aOR = 2.73; 95% CI = 1.79-4.17), on the Internet (aOR = 2.50; 95% CI = 1.59-3.94), or another place not listed (aOR = 3.24; 95% CI = 1.80-5.83; Table 3). Daily e-cigarette users were significantly less likely to acquire e-cigarettes from a friend (aOR = 0.27; 95% CI = 0.19-0.39) compared to nondaily e-cigarette users. We replicated these analyses using a question that asked adolescents where they bought their own tobacco products, not specific to e-cigarettes, and found similar results concerning daily users being at increased risk to buy their own tobacco products in the past 30 days from a gas station/convenience store (aOR = 1.79;

95% CI = 1.25-2.56, $P = .001$), grocery store (aOR = 3.95; 95% CI = 2.33-6.68 $P < .001$), drug store (aOR = 2.76; 95% CI = 1.58-4.82 $P < .001$), on the Internet (aOR = 5.38; 95% CI = 3.36-8.60 $P < .001$), and another place not listed (aOR = 2.53; 95% CI = 1.75-3.67, $P < .001$).

Discussion

We found that 13.6% of current e-cigarette users were daily users. Daily e-cigarette users were more likely to be male and initiate e-cigarette use ≤ 13 years old. There were no differences based on grade level nor race. This contrasts with other work indicating whites have higher daily use rates and steadily increasing rates during 9th to 12th grades.²² Since e-cigarette use may lead to increased risk of cigarette smoking initiation,⁵ one potential reason for the racial/ethnic variation is that all races/ethnicities may engage in early cigarette smoking initiation at similar rates.²² Adolescent smoking initiation is becoming more prevalent among all races/ethnicities and particularly highlights the fact that nicotine addiction can impact adolescents of all ages. This could indicate that e-cigarette use may decrease the gains recently achieved in the downward trends of adolescent smoking and may partially explain the recent upward trends of adolescent e-cigarette use.¹ The US Surgeon General has concluded that adolescent e-cigarette use is a major public health concern,¹³ emphasizing the critical need for prevention intervention efforts starting during early adolescence and continuing through early adulthood.

Daily users were more likely to report current flavored e-cigarette use than nondaily users in this study, and prior research indicates that flavors potentially increase smoking behavior among adolescents.^{13,23} Independent of the covariates including flavored e-cigarette use, daily users were at increased likelihood of using a higher number of and most flavors types than nondaily users. There was no difference based on menthol/mint flavoring, which is interesting given that menthol was the

only cigarette flavor not banned in the 2009 Tobacco Control Act.²⁴ In March 2018, the FDA issued an advanced notice of proposed rulemaking to examine how flavors (including menthol) play a role in nicotine addiction,¹⁷ since the 2016 rule deeming jurisdiction over e-cigarette manufacturing, distribution, and marketing excluded flavoring.¹⁸ Previous research shows that the majority (78%) of adolescent current users would not use e-cigarettes with no flavoring²⁵ and that flavored use lowers youth intentions to quit smoking.²³ This information, as well as our findings, supports the need for the FDA to eliminate e-cigarette flavorings to reduce the prevalence of adolescent daily use.

Compared to nondaily e-cigarette users, the current study's findings indicate that daily e-cigarette users reported using a significantly higher amount of brands. Specific to brand type, daily users were at increased odds of using several different e-cigarette brands including eGo, Logic, Halo, NJOY, and another unlisted brand but were at reduced odds to report they did not know the brand they used. Interestingly, the FDA implemented the leading coordinated enforcement effort in history to mitigate e-cigarette sales to minors by issuing over 1300 warning letters and fining retailers who sold e-cigarettes to those who are underage.²⁶ In detail, in September 2018, the FDA issued letters to the top 5 manufacturers, including JUUL, Vuse, MarkTen XL, blu, and Logic, asking these companies to submit a letter on how they will address youth acquisition and use of their products. We hypothesize that the unlisted brand reported by adolescents in the current study refers to the USB flash drive-shaped e-cigarettes, such as JUUL and other vape pod systems. Prior research indicates that 6% of 15- to 17-year-olds have recently used a JUUL.²⁷ Thus, the recent surge in e-cigarette use trends from 2017 to 2018 may be due to the increasing popularity of e-cigarette devices shaped like USB flash drives since they can be used subtly, contain high nicotine content, and come in flavors that appeal to adolescents.²⁸ Prior research indicates that adolescents who use e-cigarette vape pod systems have extremely high biochemically validated nicotine levels,²⁹ which raises concerns about the potential for increased adolescent nicotine addiction. The FDA is working on a Youth Tobacco Prevention Plan³⁰ that includes a series of actions to reduce youth use and access to these pod systems and other e-cigarette devices. In addition, initiatives are being implemented across the nation to increase the legal age of purchasing tobacco products to 21 years of age (commonly referred to as "Tobacco 21") in order to reduce adolescent access to e-cigarette products.¹⁸ Therefore, strengthened tobacco product sales regulation coupled with population-based prevention strategies are vital for reducing e-cigarette initiation and nicotine addiction among adolescents nationwide.

The present study's results indicated that daily e-cigarette users were at significantly increased odds to report using marijuana, THC, or hash oil products as e-cigarette device ingredients, and were at significantly decreased odds to have only used nicotine or not know their e-cigarette device ingredients. This study extends previous results that indicated lifetime users

were more likely to vape marijuana¹⁶ and demonstrates the increased likelihood of using e-cigarette devices for other hazardous reasons, such as using marijuana among daily e-cigarette users, and the necessity for related e-cigarette device regulations.

Daily users were more likely to acquire e-cigarettes from commercial or Internet sites but less likely to acquire e-cigarettes from a friend than nondaily users after controlling for covariates. This parallels prior research that reported heavier users obtain e-cigarettes from commercial instead of social sources such as friends.¹⁵ One potential reason for the difference between daily users and nondaily users concerning commercial acquisition means is that daily e-cigarette users may be more knowledgeable about how to get around underage sales restrictions of these products. Additionally, daily users were more likely to buy their own tobacco products, not inclusive to e-cigarettes only, from commercial and Internet sources. E-cigarette acquisition from commercial sites and Internet sites is indicative of low compliance with the federal law restricting sales to minors below 18 years of age. Local and state jurisdiction could reduce adolescent access by adopting 21 as the age of legal purchase¹⁸ and by restricting products available for purchase from commercial sources. Some cities have prohibited the sale of e-cigarette flavors or have prohibited selling flavored products within a certain distance of schools.³¹ Concerning Internet sources, prior research indicates that minors can easily obtain e-cigarettes from online sites as over 75% of purchase attempts were delivered without age verification.³² Despite the FDA's recent efforts to restrict commercial sites' e-cigarette sales to minors,²⁶ e-cigarette online vendors continue to grow globally.

Limitations

This study has many strengths including using a nationally representative sample of current e-cigarette users. However, study limitations should be noted. Due to the cross-sectional nature of the NYTS 2016 survey, causal relationships cannot be inferred. The NYTS relies on participant self-report and recall, and is limited by coverage and response biases. We were delimited to using the NYTS flavoring and brand categories, in addition to using "select one or more" responses that were not forced completion. Additionally, adolescents' self-report of e-cigarette use may have been underreported or overreported. Validation of these results by using objective measures (eg, cotinine) would provide a more accurate measure of use. Finally, residual confounding may have occurred even though we accounted for potential confounders in all analyses.

Significance

This is one of the first studies to assess the association between e-cigarette characteristics and daily use among US adolescents. Compared to nondaily users, daily users were at increased likelihood of using most flavors and brands and were more likely to vape marijuana and acquire e-cigarettes from multiple

commercial channels. Comprehensive tobacco control efforts that address the characteristics of daily users are needed to reduce e-cigarette use and nicotine addiction among adolescents.

Comprehensive tobacco control efforts that address the risks associated with daily use are needed to reduce e-cigarette use and nicotine addiction among adolescents. The dramatic decline in conventional cigarette smoking since the early 1990s provides strong evidence that policies and prevention interventions geared toward adolescents can be effective in nature. However, the growing popularity of e-cigarettes highlights the urgent need to address product use among adolescents.

The recent surge in e-cigarette use among both middle school and high school students from 2017 to 2018 underscores the need for the development and testing of innovative prevention interventions for adolescent e-cigarette use. This is highly imperative as nicotine dependence often occurs in adolescence. For instance, prevention intervention programs should include information on e-cigarettes to increase students' knowledge of these products, including information on e-cigarette device ingredients and the potential risks associated with nicotine use and addiction. This type of knowledge will assist adolescents in making informed decisions about using these products. Students should also be educated on socially acceptable refusal skills. One potential strategy is to incorporate peers in prevention programming and have them perform role-playing.

SO WHAT?

What Is Already Known on This Topic?

E-cigarettes are the most commonly used tobacco product among middle and high school students nationwide. Research is needed to identify adolescents at risk of nicotine addiction to inform prevention efforts and regulatory actions addressing initiation, use, and cessation of e-cigarettes.

What Does This Article Add?

Daily users used most flavors and brands compared to nondaily users. Daily users were more likely to have ever used marijuana as ingredients and acquire e-cigarettes from commercial sources. Efforts that address characteristics of daily users are needed.

What Are the Implications for Health Promotion Practice or Research?

The present study provides information on characteristics associated with daily e-cigarette use and highlights the need for comprehensive tobacco control efforts reducing e-cigarette use and nicotine addiction among adolescents.

Additionally, it is important to include family members and community members in prevention programming to educate them on adolescents' acquisition means. This includes educating both family and community members such as retailers about their key role in how they can act as gatekeepers to reduce youth access to e-cigarettes. Ongoing surveillance of adolescent e-cigarette use is critical to provide information on use patterns, related characteristics and acquisition means associated with use, and the effectiveness of prevention efforts to prevent and reduce adolescent e-cigarette use.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the National Institute on Drug Abuse (NIH Grant Number K01DA044313), National Institute of Environmental Health Sciences (NIH Grant Number R01ES027815), and by the Flight Attendant Medical Research Institute (FAMRI) to the AAP Julius B Richmond Center of Excellence.

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