

Original investigation

# E-cigarette Use Among High School and Middle School Adolescents in Connecticut

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## Abstract

**Introduction:** There is limited evidence on electronic cigarette (e-cigarette) use among U.S. adolescents.

**Methods:** Cross-sectional, anonymous surveys conducted in 4 high schools (HS;  $n = 3,614$ ) and 2 middle schools (MS;  $n = 1,166$ ) in Connecticut in November 2013 examined e-cigarette awareness, use patterns, susceptibility to future use, preferences, product components used (battery type, nicotine content, flavors), and sources of marketing and access.

**Results:** High rates of awareness (MS: 84.3%; HS: 92.0%) and of lifetime (3.5% MS, 25.2% HS) and current (1.5% MS, 12% HS) use of e-cigarettes was observed. Among those who had not tried e-cigarettes, 26.4% of MS and 31.7% of HS students reported being susceptible to future use. Males ( $OR = 1.70, p < .01$ ), older students ( $OR = 1.39, p < .05$ ), Caucasians ( $OR = 2.01, p < .001$ ), ever cigarette smokers ( $OR = 13.04, p < .001$ ), and current cigarette smokers ( $OR = 65.11, p < .001$ ) were more likely to be lifetime e-cigarette users and to report greater future susceptibility (males:  $OR = 1.30$ ; Caucasians:  $OR = 1.14$ ; ever cigarette smokers;  $OR = 3.85$ ; current cigarette smokers;  $OR = 9.81$ ;  $ps < .01-.001$ ). Among MS students who were lifetime e-cigarette users, 51.2% reported that e-cigarette was the first tobacco product they had tried. E-cigarettes that were rechargeable and had sweet flavors were most popular. Smokers preferred e-cigarettes to cigarettes. Current cigarette smokers were more likely to initiate with nicotine-containing e-cigarettes, and ever and never cigarette smokers to initiate with e-cigarettes without nicotine. Primary sources for e-cigarette advertisements were televisions and gas stations and, for acquiring e-cigarettes, were peers.

**Conclusions:** Longitudinal monitoring of e-cigarette use among adolescents and establishment of policies to limit access are imperatively needed.

## Introduction

Electronic cigarettes (e-cigarettes) are marketed widely in the United States and worldwide and are rapidly gaining popularity. Recent reviews suggest exponential increases in both awareness and use rates of e-cigarettes.<sup>1-3</sup> While many adults appear to be using these devices to quit smoking tobacco cigarettes<sup>4</sup> there is also significant concern that the availability of these devices could lead to circumvention of existing smoke-free laws and maintenance of cigarette smoking among adults, as well as increased initiation and use of tobacco

products among youth. The Family Smoking Prevention and Tobacco Control Act granted the U.S. Food and Drug Administration (FDA) the authority to regulate all tobacco products and the agency has recently announced its intention to regulate e-cigarettes. However, empirical evidence on use rates, perceptions and toxicities is urgently needed to inform these regulatory decisions.

Given that most tobacco use is initiated during adolescence,<sup>5</sup> and that exposure to nicotine during adolescence is associated with many behavioral and neurochemical changes in the developing brain,<sup>6-9</sup>

there is significant concern that the appeal and availability of e-cigarettes may undermine current social norms regarding the unacceptability of tobacco use among youth and prompt engagement in a continuum of tobacco use behaviors, progressing to nicotine dependence and cigarette use. However, there is limited empirical evidence on use behaviors among adolescents to either support or refute these concerns.<sup>1,10</sup> Data collected in 2010–2011 in two northeast U.S. high schools documented increases in e-cigarette use rates from 0.9% to 2.3%.<sup>11</sup> The Centers for Disease Control reported that, during 2011–2012, use of e-cigarettes increased from 3.3% to 6.8% among students in grades 6–12.<sup>12</sup> Similar increases<sup>13</sup> and high levels of ever use<sup>14</sup> have also been observed in other countries where e-cigarettes are being marketed (e.g., in Korea and Finland). In light of the rapid growth of the e-cigarette industry, the lack of consistent local and federal policies around the use and marketing of these products, and the potential for e-cigarette use to promote the uptake of traditional tobacco products and nicotine addiction, it is imperative to monitor and understand e-cigarette use behaviors among adolescents.

In the current study, our goal was to better understand e-cigarette use behaviors among youth, and, in turn, to meaningfully contribute to the evidence base needed by FDA to regulate e-cigarettes. Specifically, we surveyed students in high schools and middle schools in southeast Connecticut in Fall 2013. We examined the following issues related to e-cigarettes among adolescents, based on cigarette smoking status: (a) awareness, (b) use rates, (c) initiation behaviors, (d) susceptibility to use, and (e) preferences for e-cigarettes versus cigarettes. We examined predictors of e-cigarette use including cigarette smoking status, and other factors known to be related to cigarette use behaviors (gender, race, age). Based on earlier evidence<sup>11</sup> we hypothesized that cigarette smoking would be associated with greater e-cigarette use. The high rates of e-cigarette uptake among youth may be driven by the appeal of the ability to manipulate various product components (e.g., battery type, nicotine content, flavors). Therefore, we also examined use of e-cigarette components including battery type (rechargeable vs. disposable), flavors and nicotine, and examined if these preferences differed by cigarette smoking status. While we did not have a specific hypothesis about the relationship of battery type to smoking status, we were interested in exploring if adolescents who had a history of cigarette smoking differed from those who had never smoked (i.e., nonsmokers) in the type of battery type that they preferred. Considering the concern that e-cigarettes may serve as a pathway to nicotine addiction,<sup>10</sup> we also explored if use of e-cigarettes with and without nicotine differed by cigarette smoking status, and whether these patterns changed from initial to regular use. Similarly, although we did not have a specific hypothesis about flavors, we were interested in exploring if use of menthol and sweet flavors differed among smokers, who presumably may have had more experience with flavors in tobacco products, when compared with nonsmokers. Finally, considering the unrestricted vigorous marketing of these devices in ways that are prohibited for cigarettes<sup>15</sup> and the established strong influences of both advertising<sup>16</sup> and exposure to other smokers like parents<sup>17</sup> and peers<sup>18</sup> on adolescent cigarette use behaviors, we also explored where adolescents had observed e-cigarette marketing and where they acquired their e-cigarettes.

## Methods

### Participants

Participants were adolescents attending four high schools (HS) and two middle schools (MS) in four different district reference groups (DRGs; school groupings based on indicators of socioeconomic status,

financial need, and school enrollment) in Southeast Connecticut in November 2013. The total sample comprised 3,614 HS students (school 1:  $n = 877$ ; school 2:  $n = 1,210$ ; school 3:  $n = 527$  and school 4:  $n = 1,000$ ) and 1,166 MS students (school 1:  $n = 430$ ; school 2:  $n = 736$ ). Response rates calculated based on attendance on the day of the survey were high (87.1% HS; 94.1% MS). The final sample was 47.7% male in HS and 50.5% male in MS and consisted of Caucasians (66.4% HS; 81.1% MS), Hispanics (13.2% HS; 6.2% MS), Black (8.4% HS; 2.1% MS), Asians (4.1% HS; 3.5% MS), mixed race (5.3% HS; 4.0% MS) and others (1.6% HS; 1.5% MS). The HS sample had an average age of 15.63 ( $SD = 1.20$ ; range = 13–21), the MS sample had an average age of 12.18 ( $SD = 0.90$ ; range = 11–14), and students were evenly distributed across grades within each school.

### Procedures

This study was approved by the Institutional Review Board of Yale University and the local school boards and schools. We selected six schools from different DRG's in Connecticut and invited them to participate; of these, four HS agreed to participate. We then sent out invitations to four MS from two of the DRG's where the HS's had agreed to participate and two agreed to participate.

All-school surveys were conducted in each of the participating schools. Approximately two weeks prior to the survey, information sheets were mailed home to all parents informing them that Yale staff would be administering a school-wide survey on tobacco use behaviors, and, that if they did not want their child to participate, they needed to inform the research team by a specified date; 12 adolescents whose parents called in were privately told that they could not participate but were allowed to stay in the classroom and complete other work during the survey. Surveys were completed in advisories/homerooms and were distributed by teachers who informed the students that participation was voluntary and surveys were anonymous. These instructions also were repeated on the cover sheets of the survey. Research personnel were available in the school at the time of the surveys to answer questions.

### Measures

#### Demographic Characteristics

Students reported on gender (What is your gender?: Male/Female), race/ethnicity (How would you describe yourself? Select all that apply: White or Caucasian, Black or Africa American, Hispanic/Latino, Asian, Other) and age (How old are you? Open-ended response). Each school provided student attendance rates on the day of the survey administration.

#### Cigarette Smoking Status

Cigarette smoking status was measured using responses to (a) "How old were you when you first tried a cigarette, even one or two puffs" and (b) "During the past 30 days how many days did you smoke a cigarette?" "Never-smokers" were defined as adolescents who indicated that they had never smoked a cigarette, in response to question 1. "Current smokers" were defined as adolescents who reported smoking cigarettes on 1 or more days during the past 30 days, in response to question 2. "Ever-smokers" were adolescents who reported that they had tried cigarettes in response to question 1, but reported not smoking cigarettes during the past 30 days in response to question 2.

#### E-cigarette Awareness

E-cigarette awareness was measured using dichotomous (Yes/No) responses to "Have you heard of e-cigarettes?" Students were told

that e-cigarettes were “Electronic devices that are shaped like cigarettes and contain a liquid, which is vaporized and inhaled.”

#### E-cigarette Use

E-cigarette use was measured using dichotomous (Yes/No) responses to “Have you tried e-cigarettes?” and open-ended, quantitative responses to “How many days out of the past 30 did you use an e-cigarette?” “Lifetime e-cigarette users” were defined as adolescents who had tried an e-cigarette. “Never e-cigarette users” were defined as adolescents who reported that they had never tried an e-cigarette. “Current e-cigarette users” were defined as adolescents who indicated use in the past 30 days. Current e-cigarette users were a subset of lifetime e-cigarette users.

#### E-cigarette Preference

E-cigarette preference was measured using responses to “Given a choice, would you rather smoke an e-cigarette, a regular cigarette, or neither?”

#### E-cigarette Initiation

E-cigarette initiation was assessed among those who reported any e-cigarette use (i.e., lifetime e-cigarette users) using “What is the first tobacco product you have ever tried?” (response options included: e-cigarettes, cigarettes, blunts, hookah, smokeless tobacco) and age of onset was determined using the open-ended question “How old were you when you first tried an e-cigarette?”

#### E-cigarette Susceptibility

E-cigarette susceptibility was measured using an adaptation of the susceptibility to cigarette smoking questions;<sup>19</sup> specifically, students were asked to respond to the questions “If one of your best friends offered you an e-cigarette, would you smoke it?” and “Do you think that in the future you might experiment with e-cigarettes?” on a scale ranging from “definitely not” to “definitely yes” with anything other than “definitely not” being noted as susceptible to future e-cigarette use.

#### E-cigarette Product Components Used (First and Current Use)

Product (Battery) type, nicotine content, and flavors associated with first use and current use were assessed among lifetime e-cigarette users. Product type was assessed using responses to “When you first tried an e-cigarette, what type did you use?” and among current e-cigarette users to “What type of e-cigarettes do you usually use?” (response options to both questions included “disposable e-cigarettes,” “rechargeable e-cigarettes,” and “I don’t know”).

#### Nicotine Content

Nicotine content was assessed with the following question: “When you first tried an e-cigarette, did it have nicotine? (response options included “Yes,” “No” or “I don’t know”), and among current e-cigarette users with responses to “Do you usually use e-cigarettes with nicotine?” (response options included “Yes,” “No,” “Both with and without nicotine”, and “I don’t know”). We also assessed preferences for flavors using “Which of the following flavors of e-cigarettes have you tried?” and “Which flavors do you prefer when you smoke e-cigarettes?” among lifetime and current e-cigarette users. Adolescents were instructed to select as many of the following options as were applicable: “Menthol”, “Tobacco”, “Sweet flavors”, “Combinations of more than one flavor”, and “Other.”

#### Sources of E-cigarette Marketing and Acquisition

Sources of e-cigarette marketing and acquisition were assessed using the questions “Where have you recently seen advertisements or e-cigarettes being sold?” and “Where have you recently seen advertisements on social media for e-cigarettes?” We also assessed sources from which lifetime e-cigarette users acquire e-cigarettes using the questions “Where do you usually get e-cigarettes?” (see [Figure 1](#) for the complete listing of sources of marketing and of e-cigarette acquisition; adolescents were asked to pick all options that applied).

#### Statistical Analyses

All analyses (unless specified) compared students by cigarette smoking status (never-smokers, ever-smokers and current smokers) within HS and MS separately. Descriptive statistics on e-cigarette (a) awareness, (b) use rates, (c) preference, (d) age of onset and (e) susceptibility to use, were generated separately for MS and HS samples to account for age and school environment differences. Similar statistics were also generated on the type of tobacco product first used to examine initiation of e-cigarette use. Comparisons were conducted using chi-square tests for categorical variables and *t* tests or analysis of variance (ANOVA) for continuous variables. Significant chi-square tests were followed up with Bonferroni-corrected *z* tests to identify cells with proportions that differed significantly from one another. Significant ANOVAs were followed up with Bonferroni-corrected multiple comparisons to identify groups that differed significantly from one another.

Predictor analyses were run using MPLUS 7 to determine the extent to which lifetime and current e-cigarette use, respectively, were influenced by age and the following categorical variables: gender, race (i.e., Caucasian vs. non-Caucasian), and cigarette smoking status (i.e., ever and current smokers vs. never-smokers). Analyses accounted for the clustered nature of the data by school. Among never e-cigarette users we ran a third model to evaluate the extent to which the aforementioned variables influenced susceptibility to using e-cigarettes in the future.

For the analyses examining characteristics of e-cigarettes among “lifetime-users” or “current-users” of e-cigarettes, we combined the MS and HS samples since the number of MS students reporting ever or current use of e-cigarettes was small. Chi-square analyses were used to evaluate whether cigarette smoking status (i.e., never-smokers, ever-smokers, current smokers) was associated with the type of product used (i.e., rechargeable vs. disposable) and the nicotine contents of the (a) the first e-cigarette ever used among lifetime e-cigarette users and (b) the typical e-cigarette used by current e-cigarette users. Given a concern that some adolescent e-cigarette users (especially nonsmokers) may initiate with non-nicotine-containing e-cigarettes and switch to nicotine-containing e-cigarettes, we conducted exploratory analyses to evaluate the extent to which e-cigarette nicotine content was consistent over time (i.e., first e-cigarette used to typical e-cigarette used) based on cigarette smoking status. Analyses were conducted within the total sample of current e-cigarette users who provided responses to the questions assessing the nicotine content of their first e-cigarette and typical e-cigarette ( $n = 275$ ). To this end, we first created a categorical variable reflecting four possible combinations of nicotine status (i.e., first/typical no nicotine; first/typical nicotine; first nicotine/typical no nicotine; and first no nicotine/typical nicotine). We then conducted a chi-square analysis to evaluate whether consistency varied over time based on cigarette smoking status (never, ever, current). Bonferroni-corrected *z* tests

were run to identify cells with proportions that differed significantly from one another.

Finally, descriptive analyses explored flavors of e-cigarettes that had been tried, as well as sources of e-cigarette marketing (among all students) and e-cigarette acquisition (among lifetime e-cigarette users); we could not run statistical comparisons on any of these variables since adolescents selected multiple options.

## Results

### E-cigarette Knowledge Among All Students

Almost all adolescents had heard of e-cigarettes (92.0% HS; 84.3% MS; see Table 1).

### E-cigarette Use Rates Among All Students

Among all HS students, 25.2% were lifetime e-cigarette users and 12% were current e-cigarette users. Among all MS students, 3.5% were lifetime e-cigarette users and 1.5% were current e-cigarette users (Table 1).

### E-cigarette Use Rates Among Ever Cigarette Smokers

Among adolescents who reported that they had tried cigarettes in the past but were not current smokers (i.e., ever cigarette smokers; combined  $n$  [MS and HS] = 423), 59.8% reported having tried e-cigarettes and 22.9% reported using an e-cigarette during the past month on an average of 9.77 ( $SD = 10.41$ ) days (separate MS and HS data in Table 1; combined data not in Table 1).

### E-cigarette Versus Cigarette Preference Among All Students

Preference for e-cigarettes (when compared with cigarettes or neither) also was significantly greater among ever and current cigarette smokers, when compared with never cigarette smokers (Table 1;  $ps < .001$ ).

### E-cigarette Initiation Among Lifetime Users of E-cigarettes

MS ( $n = 41$ ) and HS ( $n = 912$ ) lifetime e-cigarette users reported initiating tobacco use with a wide variety of products: (MS: 51.2% e-cigarettes, 17.1% cigarettes, 12.3% blunts, 12.2% hookah, 2.4% cigars, 0% smokeless tobacco; HS: 18.5% e-cigarettes, 28.7% cigarettes, 23.2% blunts, 7.5% hookah, 8% cigars, 5.3% smokeless tobacco). E-cigarettes, cigarettes, and blunts were the top three products endorsed by both MS and HS students. Importantly, among lifetime users of e-cigarettes, MS students were more likely than HS students to report that e-cigarettes was the first tobacco product they had tried [ $\chi^2(7) = 29.70, p < .001$ ].

No differences were observed in age of onset of e-cigarette use, by smoking status, among HS or MS students. Among HS students reporting use of e-cigarettes in the past 30 days (i.e., current e-cigarette users), current cigarette smokers used e-cigarettes on a greater number of days in the past month (12.04 [ $SD = 7.0$ ]) when compared with never-smokers (5.40 [ $SD = 6.51$ ]; Table 1;  $p < .001$ ).

### E-cigarette Susceptibility Among Never-Users of E-cigarettes

While many never-users of e-cigarettes reported being susceptible to e-cigarette use in the future (Table 1: HS [31.7%]; MS [26.4%]),

**Table 1.** Electronic Cigarette (E-Cigarette) Knowledge, Use Rates, Age of Onset, Susceptibility and Preference Among Middle and High School Students, Stratified by Cigarette Smoking Status

	Total sample	Samples stratified by cigarette smoking status			$\chi^2$	F
		Never-smokers	Ever-smokers	Current smokers		
<b>Middle school</b>	$N = 1,166$	$n = 1,134$	$n = 19$	$n = 13$		
Heard of e-cigarettes (% yes)	84.3	84.0	94.7	100.0	3.82	NA
Ever tried e-cigarettes (% yes)	3.5	2.1	52.6	53.8	238.27*	NA
Age of onset (e-cigarettes; $M, SD$ )	12.24, .82	12.23, .75	12.56, .73	11.86, 1.07	NA	1.47
Past 30 day use of e-cigarettes (% yes)	1.5	0.9	10.5	38.5	148.21*	NA
Days used e-cigarettes in the past 30 days ( $M, SD$ ) <sup>a</sup>	5.82, 7.36	4.40, 4.22	15.50, 20.51	4.80, 4.27	NA	2.28
E-cigarettes susceptibility <sup>b</sup> (% yes, never e-cigarette users only)	26.4	25.5	100.0	83.3	75.59*	NA
Preference for e-cigarette (vs. cigarette or neither)	9.1	7.7	63.2	53.8	159.20*	NA
<b>High school</b>	$N = 3,614$	$n = 2,890$	$n = 404$	$n = 320$		
Heard of e-cigarettes (% yes)	92.0	90.0	95.3	97.2	20.44*	NA
Ever tried e-cigarettes (% yes)	25.2	13.2	60.1	90.0	1197.20*	NA
Age of onset (e-cigarettes; $M, SD$ )	15.18, 1.32	15.30, 1.17	15.19, 1.28	15.01, 1.52	NA	3.85
Past 30 day use of e-cigarettes (% yes)	12.0	4.6	23.5	64.1	1223.55*	NA
Days used e-cigarettes in the past 30 days ( $M, SD$ ) <sup>a</sup>	9.49, 10.03	5.40, 6.51	9.77, 10.41	12.04, 7.00	NA	19.32*
E-cigarettes susceptibility <sup>b</sup> (% yes, never e-cigarettes users only)	31.7	29.6	57.0	73.3	35.48*	NA
Preference for e-cigarette (vs. cigarette or neither)	25.2	18.9	49.5	48.9	1202.43*	NA

Note. Never-smokers reported never trying a cigarette; ever-smokers had tried cigarettes but had not smoked in the past 30 days; current smokers reported smoking at least one cigarette in the past 30 days.

<sup>a</sup>Days of e-cigarette use in the past 30 days were determined only among those who reported past 30-day use of e-cigarettes.

<sup>b</sup>Susceptibility to e-cigarettes was determined based on responses to two questions adapted from the Pierce susceptibility to cigarette scale.

\* $p < .001$ .

these rates were significantly higher in both ever-smokers and current smokers in MS and HS (Table 1).

### Predictors of E-cigarette Use and Susceptibility Among All Students

Results from the logistic regression models are presented in Table 2. The first model accounted for significant 41.7% of the variance in lifetime e-cigarette use. Older students ( $OR = 1.39$ ), males ( $OR = 1.70$ ), Caucasians ( $OR = 2.01$ ), ever cigarette smokers ( $OR = 13.04$ ), and current cigarette smokers ( $OR = 65.11$ ) were more likely to have tried e-cigarettes than their respective counterparts. The second model accounted for 36.6% of the variance in current e-cigarette use. Older students ( $OR = 1.26$ ), males ( $OR = 1.72$ ), Caucasians ( $OR = 2.25$ ), ever cigarette smokers ( $OR = 10.24$ ), and current cigarette smokers ( $OR = 74.44$ ) were more likely to currently use e-cigarettes than their respective counterparts. Among students who had never tried e-cigarettes, the third model accounted for 3.9% of the variance in e-cigarette susceptibility. Males ( $OR = 1.30$ ), Caucasians ( $OR = 1.14$ ), ever cigarette smokers ( $OR = 3.85$ ), and current cigarette smokers ( $OR = 9.81$ ) were more susceptible to using e-cigarettes in the future than their respective counterparts.

### E-cigarette Product Components Used Among Lifetime and Current E-cigarette Users

As indicated earlier, for these analyses only we combined the MS and HS samples since the number of MS students reporting e-cigarette use was small ( $n = 41$ ).

#### Product Battery Type

With respect to the type of e-cigarettes first used by lifetime e-cigarette users, greater use of rechargeable versus disposable e-cigarettes [ $\chi^2(4) = 32.09, p < .001$ ] was observed. Similar findings were also observed with regard to typical use among current e-cigarette users reporting use in the past month [ $\chi^2(6) = 20.80, p = .002$ ]. When examined by cigarette smoking status, lifetime e-cigarette users who were also current cigarette smokers reported using rechargeable e-cigarettes more frequently than never-smokers who did not differ from ever-smokers (Table 3); no smoking status related differences were observed with disposable e-cigarette use at first use. Similarly, among current e-cigarette users, ever and current cigarette smokers were more likely to use rechargeable cigarettes when compared with never-smokers (Table 3).

**Table 2.** Characteristics Predicting Electronic Cigarette (E-Cigarette) Use (Lifetime and Current) and Susceptibility in Logistic Regression Analysis

	<i>E-cigarette lifetime use (n = 953)</i>			<i>E-cigarette current use (n = 451)</i>			<i>E-cigarette susceptibility (n = 2,013)</i>		
	<i>B</i>	<i>SE</i>	<i>OR</i>	<i>B</i>	<i>SE</i>	<i>OR</i>	<i>B</i>	<i>SE</i>	<i>OR</i>
<b>Age</b>	0.26	0.07	1.39**	0.19	0.08	1.26*	-0.01	0.06	0.99
<b>Gender</b> (female <sup>a</sup> vs. male)	0.11	0.02	1.70***	0.12	0.04	1.72**	0.07	0.04	1.30**
<b>Race</b> (non-White <sup>a</sup> vs. White)	0.13	0.04	2.01**	0.16	0.04	2.25***	0.03	0.01	1.14**
<i>Cigarette smoking status</i>									
Never-smokers <sup>a</sup>	–			–			–		
Ever-smokers	0.31	0.02	13.04***	0.27	0.02	10.24***	0.15	0.36	3.85***
Current smokers	0.45	0.01	65.11***	0.45	0.02	74.44***	0.12	0.02	9.81***

*Note.* For the multilevel categorical variable (i.e., smoking status), – denotes the reference group (i.e., never-smokers). Never-smokers reported never trying a cigarette; ever-smokers had tried cigarettes but had not smoked in the past 30 days; current smokers reported smoking at least one cigarette in the past 30 days.

<sup>a</sup>Reference group for the 2-level categorical variables (i.e., gender, non-White participants). Analyses for e-cigarette lifetime and current e-cigarette use were conducted using the full sample. Analyses for e-cigarette susceptibility were run using data only from those adolescents who reported never trying an e-cigarette.

\* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

**Table 3.** Percentage of Students Using Various Electronic Cigarette (E-Cigarette) Battery Types and E-Cigarettes With Nicotine by Cigarette Smoking Status

	First e-cigarette use				Typical e-cigarette use			
	Total ( <i>n</i> = 953)	Never-smoker ( <i>n</i> = 405)	Ever-smoker ( <i>n</i> = 253)	Current smoker ( <i>n</i> = 295)	Total ( <i>n</i> = 451)	Never-smoker ( <i>n</i> = 144)	Ever-smoker ( <i>n</i> = 97)	Current smoker ( <i>n</i> = 210)
<b>Battery type</b>		$\chi^2(4) = 32.09, p < .001$				$\chi^2(6) = 20.80, p = .002$		
Disposable	20.8	17.8 <sup>a</sup>	21.3 <sup>a</sup>	24.4 <sup>a</sup>	11.3	15.3 <sup>a</sup>	13.4 <sup>a,b</sup>	7.6 <sup>b</sup>
Rechargeable	61.6	57.0 <sup>a</sup>	62.9 <sup>a,b</sup>	66.8 <sup>b</sup>	60.1	45.8 <sup>a</sup>	61.9 <sup>b</sup>	69.1 <sup>b</sup>
Uncertain	17.2	24.4 <sup>a</sup>	15.8 <sup>b</sup>	8.5 <sup>c</sup>	10.6	16.7 <sup>a</sup>	6.2 <sup>b</sup>	8.6 <sup>b</sup>
Both	–	–	–	–	6.0	6.9 <sup>a</sup>	4.1 <sup>a</sup>	6.2 <sup>a</sup>
<b>Nicotine content</b>		$\chi^2(4) = 154.47, p < .001$				$\chi^2(6) = 67.45, p < .001$		
Nicotine	38.6	19.3 <sup>a</sup>	38.3 <sup>b</sup>	65.4 <sup>c</sup>	22.4	4.2 <sup>a</sup>	16.5 <sup>b</sup>	37.6 <sup>c</sup>
No nicotine	40.6	55.6 <sup>a</sup>	39.1 <sup>b</sup>	21.4 <sup>c</sup>	22.0	27.8 <sup>a</sup>	30.1 <sup>a</sup>	13.8 <sup>b</sup>
Uncertain	20.4	24.4 <sup>a</sup>	22.1 <sup>a</sup>	13.2 <sup>b</sup>	12.0	18.1 <sup>a</sup>	10.3 <sup>a,b</sup>	8.6 <sup>b</sup>
Both	–	–	–	–	17.1	22.9 <sup>a</sup>	13.4 <sup>a</sup>	14.8 <sup>a</sup>

*Note.* This table depicts percentages for the total samples as well as the results of chi-square analyses conducted to evaluate the extent to which cigarette smoking status influenced students' use of different e-cigarette battery types and different e-cigarette nicotine contents (first product ever tried and product typically used). Data are presented as percentages of the total samples of never-smokers, ever-smokers, and current smokers, respectively. Within rows, superscript letters reflect the results of Bonferroni-corrected  $z$  tests used to compare smoking categories. Cell values with *different* superscript letters assigned to them differ significantly from one another at  $p < .05$ . Cell values with matching superscript letters denote categories with proportions that do not differ significantly from one another at  $p < .05$ .

### Nicotine Content

Lifetime e-cigarette users initiated mostly with e-cigarettes containing no nicotine (Table 3), although rates differed based on cigarette smoking status. Smokers were more likely to report initiating use with e-cigarettes containing nicotine followed by ever-smokers and never-smokers. Never-smokers were more likely to report initiating use with e-cigarettes not containing nicotine, followed by ever-smokers, and current smokers. Similar findings were also observed in current e-cigarette users.

With respect to the consistency of the nicotine content of e-cigarettes between initial use and current typical use among current e-cigarette users differences were observed based on cigarette smoking status [ $\chi^2(6) = 65.98, p < .001$ ]. Follow up Bonferroni-corrected  $z$  tests revealed that current cigarette smokers were most likely to consistently use nicotine e-cigarettes (current smokers 59.2%; ever-smokers 31.9%; never-smokers 11.4%;  $p$  values  $< .05$ ). Never and ever cigarette smokers were more likely than current smokers to consistently use e-cigarettes without nicotine, but were comparable to one another (current smokers 8.9%; ever-smokers 26.1%; never-smokers 27.6%). Percentages of students switching from using nicotine to no nicotine e-cigarettes did not differ based on smoking status (current smokers 7.0%; ever-smokers 13.0%; never-smokers 7.6%). Of great concern, never cigarette smokers were more likely to report moving from using e-cigarettes without nicotine to using e-cigarettes with nicotine than were either ever-smokers or current smokers (never-smokers 24.8%; ever-smokers 7.2%; current smokers 6.4%).

### Flavors

With respect to flavors, most lifetime e-cigarette users reported that they had tried and preferred sweet flavors (Table 4). Menthol and tobacco flavors appeared to be used mostly by e-cigarette users who were also cigarette smokers, although at considerably lower rates than sweet flavors.

### E-cigarette Marketing Sources Among All Students

MS and HS adolescents reported seeing advertisements for e-cigarettes in a wide variety of locations (Figure 1A) with television and gas stations being the primary spots.

### E-cigarette Acquisition Sources Among Ever E-cigarette Users

MS and HS adolescents reported a variety of sources of obtaining e-cigarettes, with peers being the primary source (Figure 1B).

## Discussion

We observed that awareness and use rates of e-cigarettes among high school and middle school adolescents in Connecticut were high in Fall 2013. Specifically, 25.2% of HS and 3.5% of MS adolescents reported trying e-cigarettes and 12% of HS and 1.5% of MS adolescents reported using e-cigarettes in the past month. Earlier evidence in 2010–2012 from our group and others indicated high awareness of e-cigarettes, and increased rates of e-cigarette use over the years.<sup>11,20</sup> Although the current study was not longitudinal, use rates of e-cigarettes among Connecticut high school students seem to have increased within a short time frame, with rates of past month use being at 2.3% in June 2011<sup>11</sup> and 12% in November 2013.

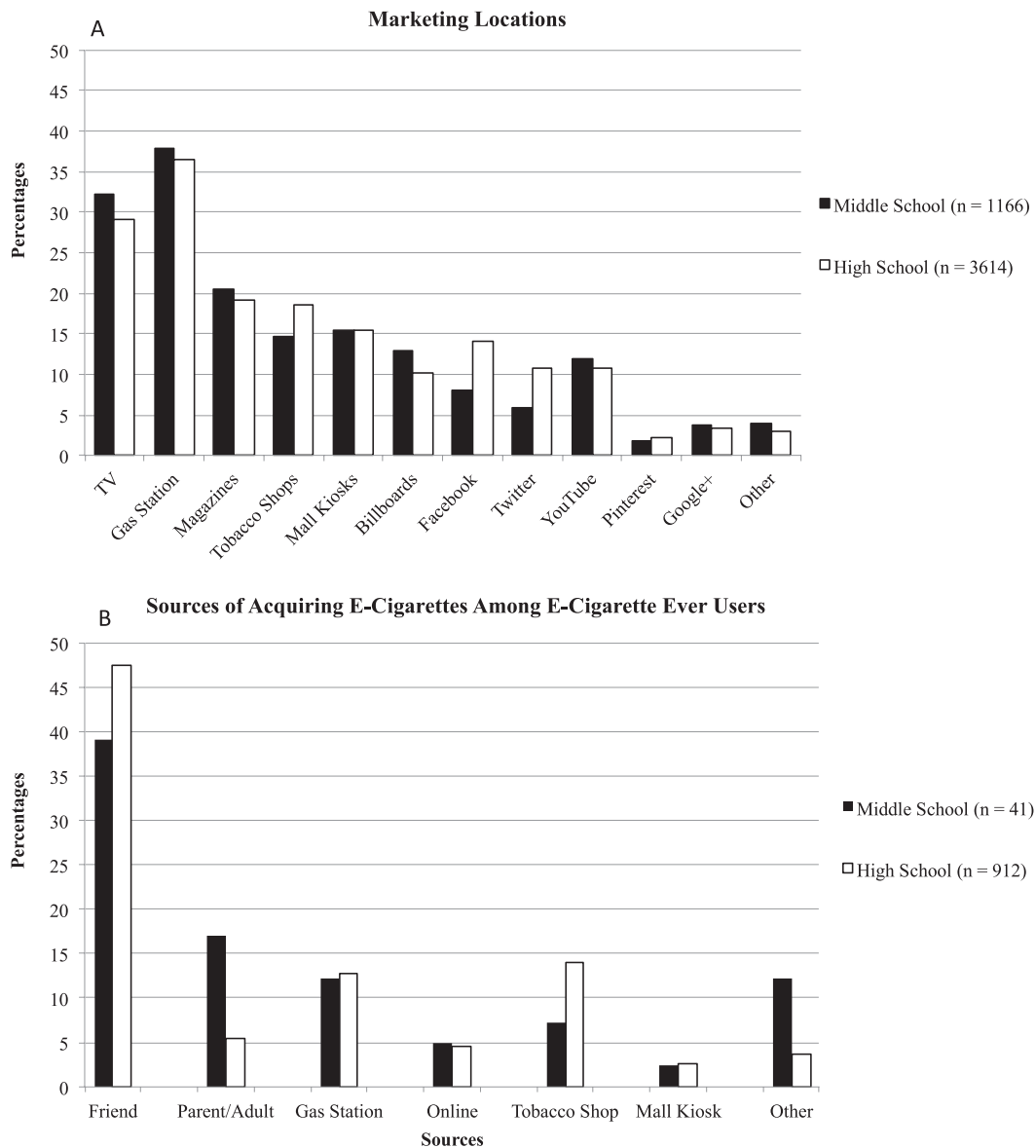
Rates of e-cigarette use (lifetime and current) were higher in adolescents who were older, male, Caucasian, and who reported cigarette smoking (ever and current). We also observed e-cigarette use among adolescents who reported that they had never smoked cigarettes (MS: 2.1%; HS: 13.2%). Moreover, rates of susceptibility to future e-cigarette also were high (MS: 26.4%; HS: 31.7%), with males, Caucasians, and cigarette smokers (ever and current) being more susceptible to future use. This is particularly concerning since initiation of e-cigarette use could serve as a “gateway” for future use of other tobacco products. In fact, a high percentage (59.8%) of MS and HS adolescents who reported that they had tried cigarettes in the past but were not current smokers (i.e., ever cigarette smokers) indicated that they had tried e-cigarettes, and 22.9% reported using an e-cigarette during the past month. A central concern is that e-cigarette use among this potentially vulnerable population, who had tried cigarettes but decided not to continue, may lead to re-initiation of cigarette use and/or progression to regular use of various tobacco products. Alternatively, it also is possible that students who tried cigarettes in the past used e-cigarettes to quit smoking; further research to explore this issue is imperatively needed.

E-cigarette use also could initiate a pathway to nicotine dependence. It was particularly concerning that 20.4% of adolescents who had tried e-cigarettes reported not knowing whether the first e-cigarette they had used contained nicotine; in fact, this lack of knowledge was greater among never and ever cigarette smokers when compared with current cigarette smokers (24.2% never-smokers, 22.1% ever-smokers and 13.2% smokers). We observed that among the adolescents who reported initiating with e-cigarettes containing nicotine (38.6% of lifetime e-cigarette users), 19.3% were never cigarette smokers, 38.3% were ever cigarette smokers and 65.4% current smokers. Particularly concerning, we also found that many adolescents who had tried e-cigarettes but were not cigarette smokers

**Table 4.** Electronic Cigarette (E-Cigarette) Flavors Tried and Preferred by Lifetime E-Cigarette Users, by Cigarette Smoking Status

	Flavors tried			Flavors preferred				
	Total ( $n = 953$ )	Never-smoker ( $n = 405$ )	Ever-smoker ( $n = 253$ )	Current smoker ( $n = 295$ )	Total ( $n = 953$ )	Never-smoker ( $n = 405$ )	Ever-smoker ( $n = 253$ )	Current smoker ( $n = 295$ )
Flavors								
Menthol	22.1	10.9	21.7	38.0	8.7	3.5	5.5	18.6
Sweet flavors	70.7	68.6	73.1	71.5	56.8	52.1	58.1	62.0
Tobacco	13.9	3.7	15.8	26.1	3.0	0.5	2.4	7.1
Combos	18.7	9.4	19.0	31.2	7.7	4.7	7.1	12.2
Other	3.7	4.0	4.3	2.7	2.8	2.5	3.6	2.7

*Note.* Never-smokers reported never trying a cigarette; ever-smokers had tried cigarettes but had not smoked in the past 30 days; current smokers reported smoking at least one cigarette in the past 30 days. Data are presented as percentages of the total samples of never-smokers, ever-smokers, and current smokers, respectively.



**Figure 1.** E-cigarette marketing and e-cigarette sources.

reported initiation with e-cigarettes that did not contain nicotine but current use with e-cigarettes that contained nicotine, suggesting that they may be on the path to nicotine dependence. Unfortunately, since our study was cross-sectional we could not examine the temporal nature of this relationship. Future longitudinal research is urgently needed to understand if the use of e-cigarettes ultimately leads to use of traditional tobacco products and/or nicotine dependence.

While the age of onset of e-cigarette use still lagged behind cigarette use among HS students, many MS adolescents who had tried e-cigarettes reported that e-cigarettes were the first tobacco product that they had used. While this evidence is limited by the small sample size of MS students ( $n = 41$ ) reporting use of e-cigarettes, this finding may be related to the more recent popularity and availability of e-cigarettes. Younger adolescents may find e-cigarettes to be less harsh than cigarettes, and also may find the autonomy provided by certain features (e.g., the ability to recharge the device and manipulate nicotine content) particularly attractive. The availability of e-cigarettes in multitudes of flavors also may increase appeal; our evidence suggests

that most adolescents have tried and prefer sweet followed by menthol flavored e-cigarettes. Use and preference for sweet flavors was high among all adolescents regardless of their cigarette smoking status. However, use of menthol and tobacco flavors was higher among adolescents who reported being current smokers or having smoked in the past; this may be related to the fact that these adolescents have been exposed to these flavors in cigarettes. Future research is imperatively needed to examine if the availability of these flavors influences e-cigarette initiation and use behaviors among adolescents.

The popularity of e-cigarettes also may be related to the aggressive marketing of these products in traditional (e.g., gas stations; tobacco shops) and newer (e.g., social media) venues; 70% of MS and 61% of HS students reported recently seeing e-cigarette advertisements in multiple physical and social media locations. It is important to note that many of the advertising venues used for e-cigarettes cannot be used to advertise cigarettes (e.g., on television). Estimates of exposure to television e-cigarette advertising obtained using Nielsen data suggest a 256% increase in youth

exposure from 2011 to 2013.<sup>21</sup> While there is limited published data on advertising of e-cigarettes in the retail environment<sup>22</sup> emerging evidence suggests that many point-of-sale locations like gas stations display e-cigarette advertisements on both the interior and exterior of the establishment, which heavily focus on the availability of flavors and are displayed at easy viewing levels for children.<sup>23</sup> Our results indicate that these marketing strategies may be troublingly effective, as many adolescents reported obtaining e-cigarettes from point-of-sale locations like gas stations and tobacco shops, as well from social media outlets. This evidence suggests that there is an urgent need to implement federal and local regulations to control e-cigarette advertising and sales to reduce children and adolescent exposure.

Our evidence also suggests that, while peers continue to be a major source of e-cigarette procurement for adolescents, many adolescents reported that they obtained their e-cigarettes from their parents. Parental and peer-related social norms have been long known to be significant factors in adolescent risk-taking and substance use behaviors. While we did not evaluate parental smoking status, adolescents who have nicotine-dependent parents are known to have earlier onset of smoking and more intense smoking patterns.<sup>17</sup> Parental permissiveness with regard to tobacco use also mediates both initiation and cessation of cigarette use.<sup>24,25</sup> With respect to e-cigarettes, many parents may not condone and may even actively endorse use.<sup>26</sup> Similarly, having peers who smoke and are supportive of smoking behaviors is an important predictor of adolescent cigarette use,<sup>18,27</sup> and this also may be true for e-cigarette use. E-cigarettes, by virtue of their design, also may be easier to use and share with friends. While these issues need to be explored in further studies, our evidence points to the critical need for appropriate and extensive public health education programs that address parental and peer permissiveness around use of e-cigarettes.

While the present study yielded crucial findings, with strengths of high response rates and inclusion of multiple middle and high schools from different district reference groups in Connecticut, several limitations merit note. First, these data were based on adolescent self-reports and were cross-sectional in nature and therefore cannot be used to draw temporal conclusions. Moreover, these data were obtained from schools in southeast Connecticut, and the generalizability of this evidence to other areas of the state, regions of the United States, and worldwide remains to be determined.

In summary, we present vital evidence on high rates of use, susceptibility to future use, and preference for e-cigarettes among middle and high school adolescents. Adolescents report greater use of and preference for e-cigarettes that are rechargeable and contain sweet and menthol flavors, and also report viewing e-cigarette advertisements in multiple locations. Federal and local policies addressing adolescent e-cigarette availability and marketing, as well as programs to prevent the exponential rise in e-cigarette use among adolescents, are urgently needed.

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## Declaration of Interests

None declared.

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