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Electronic Cigarette Use by Youth: Prevalence, Correlates, and Use Trajectories from Middle to High School

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Abstract

Purpose—The aim of this study was to examine the use of electronic cigarettes (e-cigarettes) among adolescents over time, including correlates of lifetime use by 8th grade and trajectories of current use across 9th grade.

Methods—Participants (N=1,091) from seven school districts in Oregon, USA completed four self-report surveys on substance use, from the spring of 8th grade (M age = 14.4 years old; SD = 0.50) through the spring of 9th grade.

Results—Overall, 27.7% of 8th graders had used e-cigarettes and 16.8% were current e-cigarette users (used in the past 30 days); use did not significantly differ by gender or ethnicity. Correlates of e-cigarette lifetime use by 8th grade included lifetime and current use of marijuana, alcohol, cigarettes, and chewing tobacco. Five percent of students were “Accelerators,” on average using e-cigarettes 14 of the last 30 days in 8th grade, increasing to daily use (30/30 days) by the end of 9th grade. Across all substances, those in the Accelerator group were more likely to have reported lifetime substance use by 8th grade and current substance use in 9th grade, compared to the “Infrequent/No Use” group.

Conclusions—A sizeable proportion of young adolescents are using e-cigarettes, and e-cigarette use is highly correlated with use of other substances, including marijuana. Adolescents who progress to daily e-cigarette use in high school are more likely to use other substances compared to low or non-users. E-cigarettes may be a relatively new addition to a constellation of substances being actively used by a segment of the youth population.

Keywords

E-cigarettes; adolescents; substance use

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Conflicts of Interest: The authors have no conflicts of interest or financial relationships with any organizations that might have an interest in the submitted work. We have followed all ethical and professional codes and standards of research for this study.

Implications and Contribution: Prevalence rates for e-cigarettes are high among youth, and 5% of students reported daily use by the end of 9th grade. E-cigarette users were more likely to use other substances as well, including marijuana, indicating that e-cigarettes may be a new addition to at-risk youths' constellation of substances.

Electronic cigarettes (e-cigarettes) are increasingly popular, and are being widely marketed to [1,2] and utilized by adults and youth alike [3]. Battery-powered e-cigarettes typically deliver nicotine and likely other harmful substances via heating a liquid solution into inhalable vapor [4]. Often this liquid is flavored to taste fruity or sweet and may be appealing to youth for this reason [5], but these flavorings may also pose respiratory health risks [6,7]. E-cigarettes have just become regulated by the Food and Drug Administration (FDA) but thus far are considered to have minimal health risks by adolescents. Only a quarter of high school students know that they may contain nicotine, and a majority is not aware of what is in them at all [8]. In fact, e-cigarettes do pose a health risk and typically contain nicotine as well as inhalation toxins that children and adolescents should not be consuming [4,6,7].

As tobacco use is commonly initiated during adolescence, the appeal and widespread availability of e-cigarettes to youth is a major public health concern [9,10]. Adolescent use of e-cigarettes is rapidly increasing [11–13], and although the sale of tobacco products is prohibited for those under 18, minors appear to have easy access to e-cigarettes [14]. From 2011 to 2015, current (last 30 days) use of e-cigarettes increased dramatically in a nationally representative United States survey for both middle (0.6% to 5.3%) and high school students (1.5% to 16.0%) [11]. Other nationwide data from the Youth Risk Behavior Surveillance (YRBS) of high school students found that 44.9% had used electronic vaping devices, and 24.1% reported current use [12]. Finally, in the 2015 national Monitoring the Future (MTF) survey, current use was 9.5% for 8th graders and 14.0% for 10th graders, more than twice the prevalence rate of conventional cigarettes [13].

While nationally representative samples are important for tracking trends in tobacco use, state samples are important to provide insight into geographical variations in population norms, such as ethnic and cultural differences. Small cross-sectional studies of California, Florida, and Hawaii youth indicate varying prevalence rates in different regions. In a 2013 survey of 410 Southern Californian 7th graders, lifetime use was 11.0% (they did not ask current use) [15]. In Florida, current use among 6th–8th graders increased from 1.5% in 2011 to 4.0% in 2014 [16]. In Hawai'i, a 2013 survey of 9th and 10th graders found higher prevalence rates; lifetime use was 29% and current use was 18% [17]. Although these studies demonstrate differing rates of use across a variety of geographical areas, longitudinal research is needed to track trajectories across time, as well as co-use or progression to use of other substances, as there may be some geographical variations in these patterns. The current study adds to this knowledge by examining another geographic area, the Pacific Northwest; by including longitudinal data; and by following adolescents during a risky period, from middle school into high school.

While both adults and youth use e-cigarettes at relatively high rates, youth patterns of use appear to be distinctly different from those of adults. While adult e-cigarette users are typically current or former conventional cigarette users [18], a significant number of adolescents who initiate and continue to use e-cigarettes have never tried any other type of tobacco product [13,19,20] and are using them out of curiosity, attractive flavoring, or for pleasure [21]. One of the first published longitudinal studies of high school students indicates that 9th grade e-cigarette-only users were more likely to use other combustible

tobacco products in 10th grade compared to e-cigarette never-users [22]; other studies tracking adolescents over time have found similar results [23–25]. Similarly, the 2015 Monitoring the Future survey found that teen e-cigarette users were more likely than non-users (30.7% vs. 8.1%) to use cigarettes, cigars, or hookahs within 6 months [13]. Another cross-sectional study of Icelandic 10th graders found that adolescent e-cigarette users were more likely than nonusers to report using alcohol, chewing tobacco, and marijuana [26]. Thus, initial studies indicate that e-cigarettes may be a gateway to use of other tobacco products for adolescents, and may be a newer addition to an adolescent user's repertoire of substances. If e-cigarettes are leading to or accompanying use of other substances, and have health risks and e-liquid contents that adolescents are not aware of [8], additional longitudinal studies are needed to identify students at risk of becoming regular e-cigarette users, and to track associations between e-cigarette use and use of other (tobacco and non-tobacco) substances. The current study examines trajectories of e-cigarette use patterns and investigates associations between using e-cigarettes and other substances in adolescence.

There are also some indications of differences in e-cigarette use by gender and ethnicity. In the MTF nationwide sample, males were significantly more likely to be e-cigarette users, especially in later high school grades [13]. The Florida Youth Tobacco Survey of middle and high school students collected in 2014 found no significant gender difference in current e-cigarette use by middle school students, but in high school, males were significantly more likely to be current e-cigarette users [16]. The YRBS showed that 10th grade males were significantly more likely to have used e-cigarettes compared to 10th grade females (45.3% vs. 41.2%), and Hispanics used at significantly higher rates than white non-Hispanics (51.9% vs. 43.2%) [12]. Further studies examining demographic characteristics of youth who use e-cigarettes are needed to design policies and counter-marketing strategies that will reach at-risk youth. By examining gender and ethnicity as predictors of e-cigarette use in our sample, we are adding to this literature. We hypothesized that Hispanics and males would be more likely to report e-cigarette use, and that regular e-cigarette users would be more likely to use cigarettes, chewing tobacco, alcohol, and marijuana compared to low or non-users of e-cigarettes.

The purpose of this study is to examine prevalence rates of e-cigarette use in 8th graders, to investigate correlates (gender, ethnicity, use of other substances) of e-cigarette use, and to examine classes of early usage patterns from the year prior to the transition into high school (8th grade) through the first year of high school (9th grade). This is a critical period for many youth, as the transition from middle to high school is an especially risky period of exposure and use of substances, and identification of adolescents who are using and increasing their use of e-cigarettes over time is needed to determine predictors and correlates of regular use [27]. Therefore, we also examine whether gender and ethnicity predict membership of e-cigarette classes, as well as odds ratios by class of use of cigarettes, chewing tobacco, alcohol, and marijuana.

METHODS

Data were collected via web-based computer surveys at 11 middle schools in seven school districts in Oregon. Schools were selected based on having above-average rates of students

receiving free and reduced lunch, a proxy for serving lower income households. Schools were also selected to provide both rural and suburban locations. Parents of all 1409 8th grade students in participating districts were mailed a description of the study along with an opt-out card to return if they did not want their child to participate in the study; 107 (7.6%) opted out. An additional 40 students (2.8%) were ineligible for participation due to being a ward of the state, not able to read English/Spanish, or seldom attending school, and 74 students (5.3%) were no longer attending participating schools at the time of the assessment. Out of the final sample of 1188 eligible 8th graders, we obtained data on 1130 (95%), collected from 2014–16. Project staff administered the surveys during regular classes.

Of the 1130 students who completed the 8th grade baseline survey, 1091 (97%) answered items on e-cigarette use and were included in analyses. Participants completed three more surveys in the fall, winter, and spring of their 9th grade year, for a total of four timepoints. Surveys were done every three months during the school year based on a recent study showing seasonal variation in substance use onset [28], highlighting the importance to assess patterns of e-cigarette initiation and escalation in adolescents that may be missed by annual surveys. We did not assess students if they moved away from participating school districts. Growth Mixture Modeling (GMM) was used to explore trajectories of current usage of e-cigarettes; GMM is a person-centered technique that can identify differences in longitudinal change among unobserved groups (i.e., classes).

Measures

Demographic factors—Students reported their date of birth, gender (1 = male; 0 = female), and ethnicity (1 = Hispanic, 0 = non-Hispanic), and race.

Lifetime and current substance use—At each time point, students reported whether they had ever used e-cigarettes, cigarettes, chewing tobacco, alcohol, or marijuana (e.g., “In your whole life, how many different times have you ever smoked an e-cigarette [“vape pen”] or an e-hookah, even a puff?”). If prior lifetime use was reported, students were then asked how many days out of the last 30 they had used each substance to assess current use (e.g., “In the last 30 days, on how many days would you say you have smoked an e-cigarette [“vape pen”] or an e-hookah, even a puff?”). For participants with no prior lifetime use, current use was coded to zero days. When reporting prevalence rates, lifetime and current use items were dichotomized into 0 (no use) or 1 (any use).

Statistical Analysis

We provide a descriptive report of sample characteristics, participation rates, and lifetime and current prevalence rates of e-cigarettes and other substances in 8th grade. A set of bivariate analyses were used to identify sample characteristics associated with survey participation and rates of substance use. GMM was used to identify trajectory-based subgroups of e-cigarette usage from 8th through 9th grade. We employed a maximum likelihood estimator with robust standard errors using a sandwich estimator that performs well with non-normal distributions [29]. Prior to identifying the appropriate number of classes for e-cigarette use, single-class models were used to identify a suitable functional form to describe change in usage over time (e.g., quadratic), using a model comparison

approach. After identifying the form, a second set of models identified potential unobserved trajectory classes. Applying recommended criteria [30], these models were evaluated on fit criteria (Akaike Information Criterion [AIC], Bayesian Information Criterion [BIC], and adjusted BIC), entropy (ranges from 0 to 1 with higher values indicating improved accuracy of individuals being classified into groups and adequate separation between latent classes), probability diagnostics of class membership, sample size per class, and the amount of heterogeneity within the specified classes as identified by the variance of the growth parameters. All GMM analyses were conducted in MPLUS v7.3 [31]. Final models were evaluated to describe how the trajectory classes differ in terms of gender, ethnicity, and use of other substances.

Ethics statement—This study was approved by the Oregon Research Institute Institutional Review Board. An implicit (opt out) consent procedure was utilized before data collection commenced in schools; all students were under age 18.

RESULTS

Demographics

In the spring of their 8th grade year, students' mean age was 14.4 years (SD = 0.50 years); 47% were male, 53% were non-Hispanic white, 37% were Hispanic, 4% were Native American, 2% were African American, 1% were Asian or Pacific Islander, 12% were more than one race, and the remainder were of unknown race/ethnicity.

Participation Rates

Of the 1091 participants who provided a report of e-cigarette use in the spring of 8th grade, 80% ($n = 871$) provided a report in the fall of 9th grade, 73% ($n = 796$) in the winter of 9th grade, and 71% ($n = 775$) in the spring of 9th grade. Participants with reported substance use in 8th grade were less likely to continue participation across all 9th grade assessments compared to those with no reported substance use ($p < .05$), and in the spring of 9th grade, males were less likely to participate than females (males = 68%, females = 74%, $p = .03$).

Prevalence of Substance Use in 8th grade

Overall, 27.7% of 8th grade students reported lifetime use of e-cigarettes and 16.8% were current users (last 30 days). Of 8th grade lifetime e-cigarette users, 41.3% had not previously used cigarettes or chewing tobacco. Table 1 shows lifetime and current prevalence rates of substance use among 8th graders by ethnicity and gender. Interestingly, there were no significant gender or ethnic differences detected for e-cigarette users, but there were differences for other reported substances (see Table 1).

Associations of E-cigarette Use with Other Substances

Table 2 shows the associations between e-cigarette use and other substances at all timepoints. Prevalence of lifetime e-cigarette usage in the spring 8th grade was significantly related to the lifetime report of other examined substances, the highest of which was marijuana ($\phi = .63$), followed by cigarettes ($\phi = .55$), alcohol ($\phi = .50$), and chewing tobacco ($\phi = .36$). The significant relationships between lifetime e-cigarette usage and

reports of current substance use, listed in order of magnitude, are: marijuana ($\phi=.51$), alcohol ($\phi=.46$), cigarettes ($\phi=.39$), and chewing tobacco ($\phi=.25$).

Prevalence of Substance Use in 9th grade

By the spring of 9th grade, 31.4% of students had used e-cigarettes and 17.4% were current users. These are conservative prevalence estimates, as 8th grade e-cigarette users discontinued participation in 9th grade surveys in disproportionate numbers. Of the 8th graders who reported no lifetime use of e-cigarettes by the spring survey, 16% reported lifetime use by the spring of 9th grade. Prevalence of other tobacco products had also increased, as 23.1% had used cigarettes and 11.2% were current cigarette users, and 9.4% had used chewing tobacco and 4.1% were current chewing tobacco users. Increases were also found in alcohol and marijuana use; close to half (46.4%) had tried alcohol, with 25.1% reporting current use, and over a quarter (27.3%) had tried marijuana and 18.2% were current marijuana users. Of the 9th graders who reported lifetime use of e-cigarettes by the spring survey, 37.9% had not tried cigarettes or chewing tobacco; of 9th grade never-users of e-cigarettes, 92.1% had not tried conventional tobacco products.

The GMM specified the growth as a second-order (quadratic) polynomial and identified two e-cigarette trajectory classes. Class 1 is composed of 1035 (94.9%) non- or low-users of e-cigarettes (Infrequent/No Use), and Class 2 contains 56 (5.1%) current, accelerating users of e-cigarettes (Accelerators). Model fit for the two class solution was as follows: Entropy of .981, indicating high probabilities of correct classification, and the average latent class probability for likely class membership was .997 for Class 1 and .976 for Class 2, with correspondingly low probabilities of being in a different class, indicating independence of classes. The two class solution achieved an improved AIC, BIC, and sample size adjusted BIC over the one class solution while also outperforming the three class solution with higher entropy, improved classification of participants into classes, larger class sizes, and meaningful groups. In the two class model, the Infrequent/No Use class had a significant latent intercept growth parameter (intercept Mean=0.68, SD 0.18, $p<.05$; slope Mean=0.03, SD=0.08, $p=.726$; and quadratic Mean=-0.00, SD=0.01, $p=.957$) and the Accelerator class had significant intercept, slope, and quadratic growth parameters (intercept Mean=13.9, SD=1.59, $p<.001$, slope Mean=-2.2, SD=0.98, $p=.025$, quadratic Mean=1.6, SD=0.25, $p<.001$). Nonsignificant latent growth factors variances were obtained for both classes (see Figure 1 for a graphical depiction of the means for the two classes at each timepoint).

The average student in the Accelerator class was using e-cigarettes 14 out of 30 days in the spring of 8th grade, and increased to 30 out of 30 days a year later (i.e., they became daily users). Though gender and ethnicity were not predictive of class membership, members of the Accelerator class were more likely to have reported lifetime substance use by 8th grade and current use of substances in the spring of 9th grade. See Table 3 for odds ratios of lifetime substance use by spring of 8th grade and current use in the spring of 9th grade for each reported substance for those in the Accelerator class versus those in the Infrequent/No Use class. Students in the Accelerator class had significantly higher odds of using all other

substances by the spring of 8th grade, and also had significantly higher odds of using other substances in addition to e-cigarettes in the spring of 9th grade.

DISCUSSION

This study contributes to a growing body of evidence indicating that adolescents are using e-cigarettes at high rates, and that many are using e-cigarettes before trying cigarettes or chewing tobacco. In addition, e-cigarette users were more likely to have used and be using other substances, and in fact the highest correlated substance for both lifetime and current use was marijuana. This indicates that adolescents may be adding e-cigarettes to their repertoire of various substances. Our longitudinal data shows that 5% of the sample were using e-cigarettes daily by the end of 9th grade, at about 15 years old. This group of “Accelerators” appears to be composed of students at high risk of using other substances early, by 8th grade, and of continuing use of other substances in addition to e-cigarettes in 9th grade.

In this Oregon sample, we found higher rates of lifetime and current e-cigarette use compared to those seen in some nationally representative studies [e.g., MTF, 13], although rates were similar to those seen in a sample of Hawai’ian adolescents [17], indicating that regional differences may place some adolescents at a higher risk of using e-cigarettes. Similar to other recent data [13], we found that 8th graders were using e-cigarettes at higher rates than other conventional tobacco products. The state of Oregon recently restricted the sale of e-cigarettes devices to minors under age 18; the data presented here was largely collected before this regulation was enacted at the end of May 2015, so it remains to be seen if this restriction lessens e-cigarette use by minors in Oregon.

Although few studies of middle and high school students have examined gender and ethnic differences in use of e-cigarettes, some cross-sectional studies have found that white males were most likely to use e-cigarettes [32], especially in high school [16], while others find that Hispanic high school students report the highest use [e.g., 12]. In this sample of primarily white and Hispanic students, contrary to our hypotheses, we found no significant gender or ethnicity differences in prevalence of e-cigarette use in 8th grade, or in accelerated rates of use across 9th grade. Thus, we found that males, females, Hispanics, and non-Hispanics are at relatively equal risk for using e-cigarettes. This finding reveals the broad appeal, access, and popularity of e-cigarettes in this young adolescent population, and indicates that anti e-cigarette marketing strategies should target all of these groups. After these data were collected, the FDA moved to regulate e-cigarettes, so at the time participants completed these surveys there were no limits on advertising, flavorings, or content of the e-liquid, and e-cigarettes were heavily marketed to youth [1,33].

When examining the subsample of regular e-cigarette users who progressed to daily use by 9th grade (Figure 1), rates of use are fairly consistent over the first three timepoints, followed by a marked increase in the spring of 9th grade. Possibly students were monitored by adults less in the spring as they get older [34], and as the weather improved they may have spent more time outside and unsupervised, providing more opportunities for use. Additional longitudinal research with intensive measurement and information about adult supervision

and exposure to e-cigarettes via peers and parents could address variations in rates, as well as identifying and predicting critical timepoints for preventing initiation and escalation of use.

Similar to this study, others have found that adolescents who use e-cigarettes are more likely to use other substances [26]; we found that marijuana use was particularly high among e-cigarette users. The state of Oregon recently legalized recreational marijuana, so attitudes towards marijuana are likely becoming increasingly positive in this geographic area. Adolescent e-cigarette users may be vaping marijuana, as was found to be the case for 27.9% of high school e-cigarette users in another study [35]. Further work is needed to examine substance use growth trajectories for non-users, cigarette users, and dual users and how these groups may differ in substance use risk over time.

Strengths and Limitations

This study has several strengths. First, it is one of the first studies examining longitudinal data on e-cigarette use by students from middle school into high school. Second, our data included frequent assessments, three times per school year. This kind of intensive measurement is needed to understand patterns of e-cigarette initiation and escalation that may be missed by annual surveys. A third strength is the terminology used to describe e-cigarette use in survey items; we included “vape pen” and “e-hookah” in our description of “e-cigarette,” thus capturing use by adolescents who may not think of a “vape pen” or “e-hookah” as being in the same category as an e-cigarette. Fourth, we had high rates of follow-up from 8th grade through 9th grade, tracking students as they went from middle school into high schools.

This study also had some limitations. First, our longitudinal data was collected for a relatively short time, across one year, and 8th grade reports of substance use predicted attrition, with substance users less likely to complete 9th grade surveys. Thus, the 9th grade substance use figures presented here are likely conservative estimates. However, our use of GMM utilized all available data, lessening the impact of attrition. A second limitation is that we did not ask about use of all tobacco-based products, such as hookahs and little cigars, which are often flavored and are commonly used by adolescents [36]. A third limitation is that we relied on self-report of substance use, including e-cigarette use. However, self-reported data on conventional tobacco products has been found to be valid for adolescents [37], and we have no reason to think this would differ for e-cigarettes. A fourth limitation is that we did not ask participants what the e-cigarettes they used contained. Other studies have indicated that more than 60% of adolescents do not know what is in e-cigarettes, including nicotine [8]; thus asking this question may not have accurately indicated e-cigarette contents, but would have been informative regarding adolescent knowledge. Finally, this study was conducted in one geographic area with primarily white and Hispanic students; thus, these findings may not be generalizable to other populations.

Conclusion

Historically, cigarettes or chewing tobacco have been initiated by youth in the 6th or 7th grade [38], and at this age adolescents are especially vulnerable to nicotine addiction as they

can experience symptoms of withdrawal after smoking as little as one cigarette a month [39]. Symptoms of nicotine dependence in adolescence predict regular smoking in emerging adulthood [40]; our study and others indicate that young adolescents may be initiating nicotine use via e-cigarettes, or adding e-cigarettes to a constellation of substance use behaviors. As the recent Surgeon General's report on e-cigarettes and youth summarizes, there are significant known deleterious health effects resulting from nicotine exposure in adolescence, including changes to the developing brain, as well as the still unknown health consequences of respiratory exposure to an array of aerosolized chemicals [10]. While the FDA issued the deeming rule in May, 2016 to regulate e-cigarettes, given high rates of use and previous marketing efforts, youth access to and willingness to use e-cigarettes may not be easily changed.

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Figure 1.
Mean days used e-cigarettes out of the past 30 days from 8th grade through 9th grade for the Accelerator class and the Infrequent/No Use class.

Table 18th Grade Rates of Lifetime and Current Use of Substances by Ethnicity and Gender

	Non-Hispanic						Hispanic						Total ^a (N = 1091)	Gender Differences OR (95% CI)	Ethnicity Differences OR (95% CI)
	Female (n = 337)			Male (n = 320)			Female (n = 222)			Male (n = 181)					
	n	%	n	%	n	%	n	%	n	%	n	%			
Lifetime															
E-Cigarette	105	31.2	85	26.6	56	25.2	46	25.4	302	27.7	0.89 (0.68, 1.16)		0.83 (0.63, 1.10)		
Cigarette	84	24.9	62	19.4	34	15.3	22	12.2	211	19.3	0.80 (0.59, 1.09)		0.56 (0.40, 0.79)		
Chewing Tobacco	25	7.4	42	13.1	10	4.5	6	3.3	88	8.1	1.78 (1.14, 2.77)		0.36 (0.21, 0.64)		
Alcohol	165	49.0	137	42.8	93	41.9	60	33.1	468	42.9	0.79 (0.61, 0.97)		0.72 (0.56, 0.93)		
Marijuana	80	23.7	56	17.5	48	21.6	24	13.3	212	19.4	0.67 (0.49, 0.91)		0.83 (0.60, 1.13)		
Current															
E-Cigarette	62	18.4	55	17.2	32	14.4	26	14.4	181	16.6	0.95 (0.69, 1.31)		0.77 (0.54, 1.08)		
Cigarette	38	11.3	20	6.3	12	5.4	9	5.0	83	7.6	0.65 (0.41, 1.04)		0.56 (0.33, 0.94)		
Chewing Tobacco	13	3.9	15	4.7	4	1.8	2	1.1	36	3.3	1.27 (0.65, 2.47)		0.34 (0.14, 0.83)		
Alcohol	88	26.1	64	20.0	57	25.7	24	13.3	239	21.9	0.63 (0.47, 0.84)		0.84 (0.62, 1.14)		
Marijuana	47	13.9	37	11.6	31	14.0	15	8.3	132	12.1	0.76 (0.52, 1.09)		0.87 (0.54, 1.28)		

Bolded values represent *p* values < .05.

OR = odds ratio; CI = confidence interval.

Gender coded as 1 = male, 0 = female; ethnicity coded as 1 = Non-Hispanic, 0 = Hispanic.

^a All students reported gender but 17 females and 14 males did not report ethnicity; these students are included in the total column.

Bivariate Relationships Between Lifetime and Current E-Cigarette Use and Use of Other Substances from 8th through 9th Grade

Table 2

	E-Cigarette Use					
	8 th Grade Spring		9 th Grade Fall		9 th Grade Winter	
	Lifetime	Current	Lifetime	Current	Lifetime	Current
Lifetime Use						
8 th Grade Spring						
Cigarette	.55	.44	.39	.34	.35	.26
E-Cigarette	1.00	.74	.64	.48	.54	.32
Chewing Tobacco	.36	.32	.27	.30	.22	.18
Alcohol	.50	.37	.41	.30	.37	.24
Marijuana	.63	.53	.43	.39	.41	.31
9 th Grade Fall						
Cigarette	.46	.38	.53	.43	.46	.33
E-Cigarette	.64	.49	1.00	.72	.72	.46
Chewing Tobacco	.27	.18	.39	.36	.25	.20
Alcohol	.40	.29	.51	.39	.42	.29
Marijuana	.52	.42	.61	.51	.51	.36
9 th Grade Winter						
Cigarette	.41	.34	.43	.35	.51	.39
E-Cigarette	.54	.47	.72	.54	1.00	.68
Chewing Tobacco	.28	.22	.28	.27	.38	.26
Alcohol	.33	.24	.36	.28	.50	.33
Marijuana	.47	.39	.48	.40	.61	.42
9 th Grade Spring						
Cigarette	.42	.31	.48	.37	.47	.37
E-Cigarette	.56	.39	.73	.52	.78	.51
Chewing Tobacco	.27	.19	.32	.31	.33	.24
Alcohol	.34	.21	.39	.28	.43	.26
Marijuana	.46	.39	.48	.39	.56	.37

	E-Cigarette Use						9 th Grade Spring		9 th Grade Winter		9 th Grade Fall		9 th Grade Spring		9 th Grade Winter		9 th Grade Fall	
	8 th Grade Spring		9 th Grade Spring		9 th Grade Winter		9 th Grade Spring		9 th Grade Winter		9 th Grade Fall		9 th Grade Spring		9 th Grade Winter		9 th Grade Fall	
	Lifetime	Current	Lifetime	Current	Lifetime	Current	Lifetime	Current	Lifetime	Current	Lifetime	Current	Lifetime	Current	Lifetime	Current	Lifetime	Current
Current Use																		
8 th Grade Spring																		
Cigarette	.39	.46	.25	.29	.21	.23	.19											
E-Cigarette	.74	1.00	.49	.43	.47	.36	.39											
Chewing Tobacco	.25	.32	.18	.27	.12	.16	.13											
Alcohol	.46	.46	.31	.27	.27	.25	.24											
Marijuana	.51	.55	.33	.36	.31	.29	.29											
9 th Grade Fall																		
Cigarette	.32	.35	.39	.49	.33	.39	.33											
E-Cigarette	.48	.43	.72	1.00	.54	.48	.52											
Chewing Tobacco	.22	.15	.31	.42	.20	.23	.18											
Alcohol	.36	.28	.44	.47	.36	.32	.35											
Marijuana	.39	.33	.45	.53	.39	.38	.38											
9 th Grade Winter																		
Cigarette	.32	.33	.34	.32	.41	.52	.35											
E-Cigarette	.32	.36	.46	.48	.68	1.00	.51											
Chewing Tobacco	.14	.17	.17	.24	.25	.34	.17											
Alcohol	.28	.28	.33	.30	.46	.50	.38											
Marijuana	.34	.35	.37	.39	.49	.54	.43											
9 th Grade Spring																		
Cigarette	.29	.25	.33	.36	.35	.42	.41											
E-Cigarette	.35	.30	.47	.48	.56	.59	.70											
Chewing Tobacco	.16	.14	.23	.27	.25	.29	.28											
Alcohol	.27	.23	.33	.31	.36	.32	.41											
Marijuana	.37	.38	.36	.36	.42	.39	.50											

As both lifetime and current substance use items were dichotomized as 0 (no use) or 1 (any use), Phi Coefficients are provided.

Table 3

Odds of Reporting Substance Use Among E-Cigarette Accelerator Class in Comparison to Infrequent/No Use Class

Substance	Lifetime Use by Spring of 8 th Grade	Current Use in Spring of 9 th Grade
	OR (95% CI)	OR (95% CI)
E-cigarettes	15.97 (7.72, 33.05)	-
Cigarettes	6.88 (3.95, 12.01)	10.92 (4.38, 27.20)
Chewing Tobacco	13.56 (7.56, 24.32)	25.11 (9.07, 69.52)
Alcohol	5.87 (3.00, 11.48)	17.29 (4.98, 60.02)
Marijuana	8.71 (4.92, 15.41)	18.84 (6.15, 57.73)

OR = odds ratio; CI = confidence interval.

Two classes (Accelerators and Infrequent/No Use) were determined with Growth Mixture Modeling using four waves of data: spring of 8th grade and fall, winter, and spring of 9th grade.