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Latent class analysis of current e-cigarette and other substance use in high school students

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Abstract

Objective—There is limited research on adolescents' use of e-cigarettes and other substances.

Materials and Methods—2,241 Connecticut high school students completed anonymous, cross-sectional surveys assessing e-cigarette and other substance use. We used latent class analysis (LCA) to: 1) classify students based on their past-month use of e-cigarettes, cigarettes, cigars, smokeless tobacco, hookah, blunts, marijuana, and alcohol, and 2) determine if age, sex, or race predicted class membership.

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Contributors

Dr. Morean contributed to conceptualization of the study and the development of the self-report survey, developed and tested the hypotheses reported in the manuscript, ran all statistical analyses, and wrote the primary manuscript draft.

Dr. Kong contributed to conceptualization of the study and the development of the self-report survey and critically reviewed drafts of the manuscript.

Dr. Camenga contributed to conceptualization of the study and the development of the self-report survey and critically reviewed drafts of the manuscript.

Dr. Cavallo contributed to conceptualization of the study and the development of the self-report survey and critically reviewed drafts of the manuscript.

Dr. Simon contributed to conceptualization of the study and the development of the self-report survey, provided consultation on the statistical analyses, and critically reviewed drafts of the manuscript.

Dr. Krishnan-Sarin secured study funding, headed the conceptualization of the study and the development of the self-report survey, and critically reviewed drafts of the manuscript.

All authors have approved the final version of the manuscript.

Conflict of Interest

None

Results—Past-month e-cigarette use was 11.6%, and use rates for the remaining substances ranged from 2.8% (smokeless tobacco) to 20.7% (alcohol). The optimal latent class solution comprised four classes: 1) primarily abstainers (81.6%; Abstainers), 2) primarily e-cigarette and alcohol users (4.6%; E-cigarette-Alcohol), 3) primarily marijuana and alcohol users (6.9%; Marijuana-Alcohol), and 4) primarily users of all products (6.9%; All Products). Compared to Abstainers, 1) all substance-using classes comprised older students, 2) the All Products and E-cigarette-Alcohol classes were more likely to comprise males and less likely to comprise Blacks, and 3) the Marijuana-Alcohol class was more likely to comprise Blacks and Latinos. Relative to the All Products and E-cigarette-Alcohol classes, the Marijuana-Alcohol class was more likely to comprise females, Blacks, and Latinos.

Conclusions—LCA identified four substance use classes, two of which included elevated e-cigarette use. Class membership differed by age, sex, and race. Additional research should evaluate characteristics that may explain the different product use profiles identified in the current study including cultural differences, peer group norms, and differing perceptions of the harmfulness of each substance.

Keywords

Adolescent; electronic cigarettes; alcohol; marijuana; cigarettes; tobacco

1. INTRODUCTION

E-cigarettes are gaining popularity among all age groups in the U.S. despite limited research on their safety. Of particular concern, rates of e-cigarette use are growing exponentially among youth. With regard to past-month use, the 2014 National Youth Tobacco Survey indicated that e-cigarette use tripled among high school (HS) students from 4.5% in 2013 to 13.4% in 2014, surpassing all other tobacco use, including traditional cigarettes (9.2%; Arrazola et al., 2015). Similarly, results from a recent, large survey study conducted in Connecticut found that 12.0% of HS students reported past-month e-cigarette use (Krishnan-Sarin et al., 2014).

Research suggests that e-cigarette use among adolescents is associated with cigarette smoking, and there is evidence that e-cigarette use may maintain nicotine addiction among current tobacco users or promote dual use of e-cigarettes and other tobacco products (Krishnan-Sarin et al., 2014; Camenga et al., 2014; Dutra and Glantz, 2013). There also is concern that e-cigarette use among never-smokers may lead to nicotine addiction and/or serve as gateway to the use of other tobacco products including cigarettes. For instance, in a large, recent survey study, 24.8% of e-cigarette users who had never smoked a cigarette reported initiating e-cigarette use with e-cigarettes that did not contain nicotine and subsequently switching to using e-cigarettes containing nicotine (Krishnan-Sarin et al., 2015). Furthermore, a recent study indicated that e-cigarette use among youth prospectively predicts the initiation of cigarette smoking one year later (Primack et al., 2015). Finally, there is emerging evidence that adolescent e-cigarette users are more likely than non-users to engage in polysubstance use (e.g., Camenga et al., 2014; Miech et al., 2015; Morean et al., 2015), perhaps reflecting a broader, underlying profile of substance-related risk. Results of a recent study that analyzed data from Monitoring the Future indicated that e-cigarette users

are more likely than non-users to smoke cigarettes, binge drink, smoke marijuana, and take prescription medications that were not prescribed to them by a doctor (i.e., amphetamines, sedatives including barbiturates, tranquilizers, and/or narcotics; Miech et al., 2015). Adolescent e-cigarette users also have been shown to be more likely than adolescents who smoke cigarettes exclusively to smoke hookah and blunts (Camenga et al., 2014). Finally, a recent study indicated that adolescent e-cigarette users are using e-cigarettes to vaporize marijuana at concerning rates (Morean et al., 2015). As e-cigarettes continue to gain popularity, developing a better understanding of the link between adolescent e-cigarette use and the use of a wide range of other commonly used substances is critical to identifying the role e-cigarettes may play in substance use among youth.

Prior research indicates that latent class analysis (LCA), which empirically identifies subgroups of participants based on similar patterns of responses, is a valuable statistical tool for identifying youth substance use profiles (e.g., Bohnert et al., 2014; Lanza and Rhoades, 2013; Miech et al., 2015; Tomczyk et al., 2015). However, only one study of which we are aware has used LCA to identify adolescent substance use profiles that include e-cigarettes; Miech and colleagues (2015) used LCA to identify substance use profiles based on past-month e-cigarette use, cigarette use, marijuana use, binge drinking, and prescription medication misuse. Among 10th grade students and 12th grade students, classes were identified that largely comprised abstainers (probability of substance use ranged from 0.01 for cigarettes to 0.07 for e-cigarettes in 10th grade and from 0.02 for cigarettes to 0.08 for marijuana in 12th grade) and that comprised polysubstance users (probability of substance use ranged from 0.26 for prescription medications to 0.70 for marijuana in 10th grade and from 0.30 for prescription medications to 0.83 for marijuana in 12th grade). Among 12th grade students, a second class of polysubstance users was identified that comprised predominantly e-cigarette users (probability of substance use ranged from 0.01 for prescription medications to 0.93 for e-cigarettes). The study conducted by Miech and colleagues (2015) makes an important contribution to the literature. However, the study did not examine the use of other tobacco products that previously have been linked to cigarette and/or e-cigarette use like cigars, hookah, and blunts (e.g., Camenga et al., 2014). Thus, it remains important to evaluate how the use of a wide range of tobacco products contributes to adolescent substance use profiles across the full range of high school students.

In the current study, we examined HS students' current use of e-cigarettes, cigarettes, cigars, smokeless tobacco, hookah, blunts, marijuana, and alcohol. We first examined past-month use rates of each product within the analytic sample (i.e., the sample of adolescents who had non-missing past-month substance use data for all substances). Latent class analysis was then used to determine profiles of past-month product use. Within the same model, multinomial logistic regression was used to evaluate the extent to which demographic characteristics (i.e., age, sex, race) were associated with class membership. Consistent with prior research, we hypothesized that one of the identified latent classes would represent students who engaged in little or no past month substance use (i.e., abstainers) and that one group would represent users of multiple substances. However, given the relative novelty of the current study, we did not outline any additional hypotheses regarding what substance use profiles may be identified via LCA or how the demographic variables would relate to the identified classes.

2. MATERIAL AND METHODS

2.1 Participants

In November 2013, adolescents attending 4 HSs (N = 3614) in Southeastern CT completed an anonymous survey assessing attitudes toward and use of e-cigarettes and other tobacco products. Due to a request from the administration of one HS that questions explicitly assessing the quantity and frequency of alcohol and marijuana use be omitted from the survey, 2737 students received questions assessing tobacco, e-cigarette, marijuana, and alcohol use. Given the aims of the current study, the analytic sample comprised data from 2241 students who had non-missing past-month data for all products assessed. The analytic sample was 54.4% female and 65.1% White with a mean age of 15.60 (SD=1.19) years¹. Students were distributed evenly across grades 9–12.

2.2 Procedures

The Institutional Review Boards of Yale University and the local school administrators and superintendents approved the study. Passive parental permission was obtained prior to survey administration. For students, completing the survey indicated consent/assent. Prior to completing the survey, students were informed that the survey was anonymous and that their responses would be kept confidential. Students completed the survey during their homeroom periods.

2.3 Measures

2.3.1—Students reported demographic information on age, sex, and race/ethnicity

2.3.2—*Current e-cigarette, cigar, smokeless tobacco, hookah, and blunt use* was determined via the following question: “During the past 30 days, on how many days did you [use the respective product]?” (open-ended response). Those who reported using a product at least once in the past 30 days were classified as current users.

2.3.3—Current cigarette smoking was determined based on the following question, “During the past 30 days, on how many days did you smoke cigarettes?” Answer choices included 0, 1, 2, 3–5, 6–10, 11–20, 21–28, and everyday. Students who reported smoking cigarettes on at least 1 day in the past month were classified as current smokers.

2.3.4—Current alcohol and marijuana use status, respectively, were determined based on the following question: “During the past 30 days, on how many days did you use alcohol / marijuana?” Answer choices included, “I have never tried alcohol / marijuana, I have tried alcohol / marijuana but did not use it in the past 30 days, 1, 2, 3–5, 6–10, 11–20, 21–28, and everyday.” Students who reported using alcohol/marijuana on at least 1 day in the past month were classified as current users.

¹The analytic sample differed significantly from the sample of 496 students who had missing past-month substance use data. Specifically, the analytic sample included more females (54.4% vs. 44.2%), more White students (65.1% vs. 54.4%), fewer Black students (9.1% vs. 14.8%), fewer Latino students (14.3% vs. 18.9%), fewer cigarette smokers (7.2% vs. 14.5%), fewer marijuana users (14.5% vs. 26.4%), and fewer alcohol users (20.7% versus 38.1%). However, the full set of analyses described in the manuscript also was run within the total sample (N = 2737). The pattern of findings regarding latent class structure and demographic differences observed between latent classes directly mirrored that reported in the paper.

2.4 Data Analytic Plan

Using SPSS 22 (IBM, 2013), we calculated descriptive statistics within the total analytic sample ($n = 2241$) to determine current use rates of each product, including past-month use (yes/no) and the frequency of use in days. Several of the answer choices for cigarette smoking, marijuana use, and alcohol use represented ranges (e.g., 3–5 days). To facilitate presentation of the results, we substituted the mean for each of the ranges when reporting on the frequency of use (e.g., 4 days for 3–5 days). Using Mplus 7.0 (Muthen and Muthen, 1998–2012), we then conducted LCA to identify profiles of substance use based on past month use of each of the 8 products. Previous research (Miech et al., 2015) examined latent classes separately for 8th, 10th, and 12th grade students, due, in part, to the sampling procedures used in Monitoring the Future. However, given that the current study assessed substance use in high school students in grades 9–12 and that social boundaries between grades are often permeable (i.e., students often affiliate with older and/or younger students), we ran a single LCA model to identify substance use profiles among high school students, broadly defined. As described below, age was included as a predictor of latent class to explore potential differences in substance use profiles among younger and older students. To determine class membership, criterion-endorsement probabilities were calculated which determined the likelihood that past month use of a given product was endorsed by each identified class. Each participant subsequently was assigned to whichever class had the largest posterior probability. To determine the optimal number of classes, we ran models evaluating the relative fit of 1, 2, 3, 4, and 5 class solutions. To determine the best fitting model, each model was compared to the previous model (e.g., a 2 class solution versus a 1 class solution), and the superior model was chosen on the basis of a smaller Bayesian Information Criteria (BIC) value, a smaller sample size-adjusted BIC value, a smaller Akaike Information Criterion value, a higher entropy value, and significant Lo-Mendell-Rubin (LMR) and bootstrapped likelihood ratio (LR) tests. Within the same Mplus framework, we ran multinomial logistic regression to determine the extent to which demographic variables (i.e., age, sex, race) were associated with the latent classes. This approach provides the benefit of simultaneously estimating the effect of each level of a covariate on the probability of class membership relative to a referent class (e.g., each substance-using class versus abstainers). We also requested alternative parameterization solutions for the model, which allowed for comparisons of the effects of each covariate using different reference classes (e.g., one substance-using class versus another substance-using class). Given the priority we placed on having valid past-month substance use data, there were no missing data on these variables. However, full information maximum likelihood was specified to handle missing data on the remaining study variables (i.e., age [% missing = 0.3], sex [% missing = 0.8], race [% missing 0.8]). The school in which each student was enrolled was included in the model to control for clustering by school. However, it was not possible to comment on exactly how the schools differed in relation to the current study aims, so we did not interpret observed differences by school. For the analyses, the largest school was chosen as the reference group.

3. RESULTS

3.1 Prevalence of current product use

Product use rates ranged from 2.8% (smokeless tobacco) to 20.7% (alcohol), with 11.6% reporting e-cigarette use. Participant demographics and product use rates are presented in Table 1.

3.2 Latent Class Analysis

A 4 latent class solution was deemed optimal for several reasons. First, it had the lowest associated BIC value (which is one of the most reliable criterion) and was the largest class solution to have both significant LMR and bootstrapped LR tests (p -values $< .001$; See Table 2; Collins and Lanza, 2010). Second, the three-class model had little differentiation between two of its classes; one class represented abstainers and the others represented polysubstance users. The only difference between the polysubstance using classes was that one group used marijuana whereas the other did not. Finally, the probabilities for most likely latent class membership were better for the four-class model than for the three-class model, indicating low classification error for each of the four classes (Four Class Model: Abstainers 0.99; E-cigarette-Alcohol 0.96; Marijuana-Alcohol 0.92; All Products 0.92; Three Class Model: Class 1 0.99; Class 2 0.97; Class 3 0.72). In sum, the four classes comprised students who abstained from all substances with the exception of a small amount of alcohol use (i.e., “Abstainers;” 81.6%;), students who primarily used e-cigarettes and alcohol (i.e., “E-cigarette-Alcohol;” 4.6%), students who primarily used marijuana, blunts, and alcohol (i.e., “Marijuana-Alcohol;” 6.9%), and students who used all products at an elevated rate (i.e., “All Products;” 6.9%). Of note, cigar and smokeless tobacco use were relatively low across all classes. See Figure 1 for a graphical depiction of the latent classes and Table 3 for participant demographics and conditional probabilities of substance use within each latent class.

3.3 Multinomial Logistic Regression

Compared to Abstainers, 1) each of the other classes were more likely contain older students, 2) the E-cigarette-Alcohol class and the All Products class were more likely to contain males and less likely to contain Blacks, and 3) the Marijuana-Alcohol class was more likely to contain Blacks and Latinos (See Table 4). Relative to the All Products class, 1) the Marijuana-Alcohol class was more likely to contain females, Blacks, and Latinos. There were no significant differences between the All Products class and the E-cigarette-Alcohol class. Finally, relative to the E-cigarette-Alcohol class, the Marijuana-Alcohol class was more likely to contain older students, females, Blacks, and Latinos.

4. DISCUSSION

The current study adds to the research literature on adolescent substance use in the context of the increased popularity of e-cigarettes. Using LCA, we found that two classes evidenced elevated rates of e-cigarette use: the E-cigarette-Alcohol class and the All Products class. Also of note, a class emerged that comprised individuals who largely used marijuana and alcohol, but who engaged in low rates of e-cigarette and other tobacco product use.

Of interest, demographic variables were associated differently with the four identified product use classes. As anticipated, substance users generally were older than abstainers, and two of the polysubstance using classes (i.e., E-cigarette-Alcohol and All Products) were more likely to contain males. Of interest, the Marijuana-Alcohol class was more likely to contain females, although it is not clear why this finding emerged. Noteworthy differences in substance use profiles also were observed based on participant race/ethnicity. Black students were more likely than White students to be members of the Abstainers class when the Abstainers class was compared to the E-cigarette-Alcohol and All Products classes. These findings are consistent with prior research indicating that Black adolescents are more likely than their White counterparts to abstain from using substances (e.g., Clark et al., 1999; Wallace et al., 2003). These prior studies have linked higher rates of abstinence among Black adolescents to factors including religiosity (Wallace et al., 2003) and parental prohibition of substance use within the household (Clark et al., 199), although these protective factors were not assessed in the current study. In the current study, Black students were not universally more likely than White students to be abstainers; Black and Latino students were more likely than White students to be members of the Marijuana-Alcohol class. These findings are at least partially consistent with recent results from the National Youth Risk Behaviors Survey, which indicated that Black and Latino adolescents are more likely than White adolescents to use marijuana exclusively when compared to using cigarettes and/or cigars (Rolle et al., 2015). However, it is not clear the extent to which adolescents classified as “exclusive” marijuana users in the study conducted by Rolle and colleagues (2015) used other substances including alcohol, making it difficult to interpret these findings directly in relation to the current findings. However, the current findings regarding marijuana use, specifically, also are consistent with a large, nationally representative survey of Americans ages 12 years and older which found that Blacks are more likely to use marijuana than Whites and that Blacks and Latinos are more likely to have cannabis use disorder than are Whites (Wu et al., 2014).

The study findings should be considered in light of several limitations. First, our data were based on adolescent self-report, and are therefore limited by adolescents’ willingness and ability to respond honestly and accurately. However, the fact that students were informed that the survey was anonymous and that their answers would be kept confidential, should mitigate these concerns to some extent. Second, our data were collected from high schools in Connecticut, so it is unclear whether these results are generalizable to other high schools. However, it is worth noting that the substance use rates observed in the current study generally were consistent with national averages (e.g., Johnston et al., 2014). Third, the study was cross-sectional so it is not possible to draw conclusions about the temporality of the identified relationships. Finally, we placed a premium on having complete past-month substance use data from our participants rather than imputing missing past-month substance use data. Thus, we excluded adolescents who had incomplete past-month substance use data. However, the pattern of findings observed when analyses were run within the total sample directly mirrored those presented in the manuscript, mitigating concerns associated with the fact that our analytic sample differed significantly from the sample of excluded participants on a number of characteristics (e.g., sex, race, smoking status). Nevertheless, future research

is needed to evaluate the replicability of the current findings and to extend the findings to include substances not assessed in the current study.

4.1 Conclusions

In addition to the unknown health consequences of e-cigarette use, young e-cigarette users appear to be using a wide range of substances. Additional data are needed to determine if the demographic profiles associated with elevated e-cigarette use observed in the current study are replicable. Future longitudinal research also is needed to determine whether e-cigarettes serve as a gateway product for the initiation of other forms of substance use or are taken up by adolescents who already are experimenting or using other forms of tobacco or drugs. For example, it is possible that some abstainers may experiment with e-cigarettes as their first form of substance use based on prior research suggesting that adolescents who have never smoked a cigarette are at risk of experimenting with e-cigarettes (e.g., Krishnan-Sarin et al., 2015). Similarly, as e-cigarettes continue to gain popularity, it is possible that adolescents who currently are classified as Marijuana-Alcohol users may start using e-cigarettes as a means of vaporizing cannabis (e.g., Morean et al., 2015) and subsequently transition to more regular e-cigarette use. Furthermore, additional research is needed to understand the extent to which substance use profiles are associated with a wide range of risk and protective factors (e.g., cultural differences, peer group norms, substance popularity, parental permissiveness). This information will be integral to developing effective prevention and/or intervention efforts that target specific factors (e.g., age, race/ethnicity, sex, peer norms) based on the substance use behavior they are designed to curb.

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Highlights for Review

- E-cigarette use is increasingly exponentially among youth, but little is known about adolescents' concurrent use of electronic cigarettes (e-cigarettes) and other substances.
- We evaluated past-month use of e-cigarettes, cigarettes, cigars, smokeless tobacco, hookah, blunts, marijuana, and alcohol in a sample of 2,241 Connecticut high school students.
- Using Latent Class Analysis, we empirically derived the following past-month substance use profiles: 1) primarily abstainers (81.6%), 2) primarily e-cigarette and alcohol users (4.6%), 3) primarily cannabis and alcohol users (6.9%), and 4) primarily users of all products (6.9%).
- Being older was associated with all substance use classes, but different combinations of sex and race were associated with class membership.

Figure 1.
Latent Classes

Table 1

Demographics and Observed Current Substance Use among High School Students

Demographics		Substance Use		
Age (mean [std.dev.])	15.60 (1.19)	Current Use (%)		Days Used Per Month (mean [std. dev.])
Sex (% male)	45.6	E-cigarettes	11.6	8.84 (9.95)
White (%)	65.1	Marijuana	14.5	11.64 (10.90)
African American (%)	9.1	Blunts	11.6	10.23 (10.36)
Hispanic/Latino (%)	14.3	Alcohol	20.7	4.62 (6.16)
Other Race/Ethnicity (%)	10.7	Cigarettes	7.2	11.22 (11.24)
School 1 (%)	43.5	Cigars	2.9	5.12 (7.46)
School 2 (%)	18.3	Smokeless Tobacco	2.8	9.69 (10.09)
School 3 (%)	38.2	Hookah	7.7	5.87 (7.54)

Note. Demographic data and past-month substance use rates were derived from the total analytic sample (N = 2241). The number of days each substance was used in the past month was calculated within the subset of participants who reported past month use of that substance.

Table 2

Fit Indices of Latent Class Analyses of Current Substance Use

# Classes	Log- Likelihood	AIC	BIC	Adjusted BIC	Entropy	LMR Test	Bootstrapped LR Test
1	-5445.31	10906.62	10952.34	10926.92	1.00	NA	NA
2	-3845.07	7724.14	7821.29	7767.28	0.95	$p < .001$	$p < .001$
3	-3711.15	7474.30	7622.88	7540.28	0.94	$p < .001$	$p < .001$
4	-3618.98	7307.96	7507.97	7396.77	0.94	$p < .001$	$p < .001$
5	-3600.30	7288.61	7540.05	7400.26	0.94	$p = 0.16$	$p < .001$

Note. Bolded text indicates the optimal class solution. Abbreviations are: AIC (Akaike Information Criterion); BIC (Bayesian Information Criterion); LRM (Lo-Mendell-Rubin); LR (likelihood ratio); NA (not applicable)

Table 3

Demographics and Conditional Probabilities of Current Substance Use by Latent Class

	Latent Class			
	Abstainers	E-cigs, Alcohol	Marijuana, Alcohol	All Product Users
	81.60%	4.60%	6.90%	6.90%
Demographics				
Age (mean [std.dev.])	15.49 (1.18)	15.90 (1.19)	16.26 (0.95)	16.12 (1.10)
Sex (% male)	44.2	61.2	41.6	56.1
White (%)	65.5	74.8	46.8	72.3
African American (%)	9.3	2.9	15.6	4.5
Hispanic/Latino (%)	13.6	12.6	24	14.2
Other Race/Ethnicity (%)	10.8	8.7	12.3	8.4
School 1 (%)	42.4	38.8	57.1	45.2
School 2 (%)	19.1	23.3	6.5	17.4
School 3 (%)	38.5	37.9	36.4	37.4
Conditional Probability of Substance Use				
E-cigarettes	0.01 (0.01)	0.76 (0.09)	0.10 (0.06)	0.87 (0.05)
Marijuana	0.00 (0.00)	0.12 (0.06)	1.00 (0.00)	1.00 (0.00)
Blunts	0.00 (0.00)	0.00 (0.00)	0.72 (0.08)	0.97 (0.02)
Alcohol	0.11 (0.01)	0.67 (0.06)	0.63 (0.06)	0.78 (0.04)
Cigarettes	0.00 (0.00)	0.31 (0.60)	0.08 (0.05)	0.68 (0.05)
Cigars	0.00 (0.00)	0.16 (0.05)	0.00 (0.00)	0.28 (0.05)
Smokeless Tobacco	0.00 (0.00)	0.20 (0.05)	0.01 (0.02)	0.22 (0.04)
Hookah	0.01 (0.00)	0.34 (0.07)	0.16 (0.04)	0.59 (0.05)

Table 4

Demographic characteristics predict class membership

	E-cigarette-Alcohol vs. Abstainers r^2			Marijuana-Alcohol vs. Abstainers r^2			All Product Users vs. Abstainers r^2		
	OR	95% CI		OR	95% CI		OR	95% CI	
Age	1.31**	1.08	1.58	1.76**	1.52	2.03	1.55***	1.34	1.79
Sex									
Male	2.33***	1.47	3.70	1.31	0.82	2.10	1.54*	1.03	2.33
Race									
Black	0.09*	0.13	0.58	2.04*	1.05	4.35	0.28**	0.11	0.73
Hispanic	0.57	0.22	1.24	2.40*	1.26	4.51	0.58	0.29	1.19
Other	0.65	0.32	1.31	1.53	0.78	2.98	0.67	0.36	1.27
School									
2	0.92	0.51	1.67	0.25*	0.07	0.86	0.57	0.32	1.02
3	0.55	0.32	0.94	1.12	0.60	2.08	0.58	0.36	0.92
	E-cigarette-Alcohol vs. All Product Users r^2			Marijuana-Alcohol vs. All Product Users r^2			Marijuana-Alcohol vs. E-cigarette- Alcohol r^2		
	OR	95% CI		OR	95% CI		OR	95% CI	
Age	0.85	0.75	1.06	1.14	0.52	1.39	1.34*	1.07	1.69
Sex									
Male	1.52	0.83	2.78	0.49*	0.45	0.66	0.32***	0.17	0.61
Race									
Black	0.30	0.04	2.44	7.07***	2.09	23.93	23.34**	3.08	76.97
Hispanic	0.98	0.37	2.63	4.09**	1.51	11.12	4.14*	1.53	11.16
Other	0.96	0.39	2.37	2.27	0.91	5.67	2.36	0.92	6.09
School									
2	1.63	0.75	3.56	0.44	0.11	1.81	0.27	0.07	1.05
3	0.94	0.48	1.88	1.94	0.85	4.40	2.05	0.35	4.69

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Note. Reference groups for the between-class comparisons are denoted with a superscript "r." Reference groups for the demographic characteristics were females, Whites, and School 1.

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