

Research Paper

Differential patterns of e-cigarette and tobacco marketing exposures among youth: Associations with substance use and tobacco prevention strategies

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ABSTRACT

Background: This study identified patterns of tobacco marketing exposures among youth and examined their associations with substance use and tobacco prevention strategies.

Methods: In Fall 2018, 2,058 middle and high school students (ages 11–18) in an Appalachian county completed a substance use and behavioral health surveillance survey. We conducted latent class analysis (LCA) to identify exposure classes based on responses to 14 tobacco marketing exposures. Multinomial logistic regression was then performed to determine associations between the latent classes with past 30-day substance use and tobacco prevention strategies (e.g., school policies, parental rules, prevention messages).

Results: Four latent classes of marketing exposure were identified among middle school students: low exposure, television, social media, and high exposure. Multinomial logistic regression found significant associations between e-cigarette use with the social media and high exposure classes, while prescription drug use was associated with the social media class and alcohol use with the high exposure class. For high school students, five classes were identified: low exposure, social media, environmental, cigarettes, and high exposure. E-cigarette and prescription drug use were associated with the social media and high exposure classes. Cigarette use was associated with the social media class. School rules prohibiting e-cigarettes were associated with the television class for middle school students. Self-reported exposure to prevention messages about the harms of tobacco were associated with multiple exposure classes for both middle (television and social media) and high school (social media and cigarettes) students, suggesting that both pro- and anti-tobacco communications have become ubiquitous and may be saturating youth.

Conclusion: This study demonstrates the need for stricter tobacco marketing regulations and multi-level interventions beginning in early adolescence that focus on increasing media-based literacy for youth to better discern tobacco prevention messages from pro-tobacco communications.

Introduction

E-cigarette use among youth continues to be a public health concern in the United States. Between 2014 and 2018, middle and high school students reported using e-cigarettes more than any other tobacco product (Gentzke et al., 2019). From 2017 to 2019, the 30-day prevalence of e-cigarette use more than doubled for 8th graders (1.6% to 3.9%), 10th graders (4.3% to 12.6%), and 12th graders (5.0% to 14.0%) (Miech, Johnston, O'Malley, Bachman, & Patrick, 2019). Due to the rapid rise and sustained popularity of e-cigarettes, youth are at heightened risk of adverse health outcomes like nicotine dependence and vaping associated pulmonary injury (Case et al., 2018; Krishnasamy et al., 2020; Morean, Krishnan-Sarin, & O'Malley, 2018; Richter, Pugh, Smith, & Ball, 2017). Additionally, youth who use e-cigarettes may be

at greater risk of transitioning to cigarette smoking and using other substances, including cannabis, alcohol, and prescription drugs (Berry et al., 2019; Dai, Catley, Richter, Goggin, & Ellerbeck, 2018; Gilbert, Kava, & Afifi, 2020; Leventhal et al., 2015; Park et al., 2020; Richter et al., 2017).

Considerable research suggests that a key reason for the uptake and continued use of e-cigarettes among youth is pervasive and targeted marketing towards youth (Auf et al., 2018; Grana & Ling, 2014; Hammig, Daniel-Dobbs, & Blunt-Vinti, 2017; Kwon, Seo, Lin, & Chen, 2018; Mantey, Cooper, Clendennen, Pasch, & Perry, 2016; Marynak, Gentzke, Wang, Neff, & King, 2018; Padon, Maloney, & Cappella, 2017; Singh et al., 2016). From 2011 to 2013, youth exposure to e-cigarette television advertisements increased by 256% (Duke et al., 2014). Data from the National Youth Tobacco Surveys (NYTS) showed

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that youth exposure to e-cigarette advertising from at least one source (e.g., the Internet, retail stores, newspapers and magazines, and television) increased from 2014 (69%) to 2016 (78%) (Marynak, Gentzke, Wang, Neff, & King, 2018). Youth reported highest exposure to e-cigarette marketing in retail stores (68%), followed by the Internet (40.6%), television (37.7%), and newspapers and magazines (23.9%) in 2016 (Marynak et al., 2018). Moreover, nearly 30% of middle and high school students reported exposure to three or more sources in 2016 (Marynak et al., 2018).

Heightening this concern is evidence demonstrating that exposure to multiple sources of marketing is associated with increased use of e-cigarettes and other substances (Gilbert, Kava, & Afifi, 2020; Lee, Lin, Seo, & Lohrmann, 2017; Mantey et al., 2016). Such findings have called for stricter regulations of e-cigarette marketing across social media platforms (Clark et al., 2016; Pokhrel et al., 2018), television (Duke et al., 2014), and retail settings near schools and neighborhoods (Giovenco et al., 2016; Pasch et al., 2018). Other efforts have examined how tobacco prevention strategies may reduce marketing exposures and risk of use, including parental rules and family-based strategies on reducing e-cigarette use and attitudes (McMillen et al., 2018), school policies that prohibit e-cigarette use on campus (Adams, Jason, Pokorny, & Hunt, 2009; Milicic, DeCicca, Pierard, & Leatherdale, 2018; Nicksic, Harrell, Pérez, Pasch, & Perry, 2018), and prevention interventions highlighting the harms and psychosocial determinants of tobacco use (Kelder et al., 2020). Yet, less is known about differential patterns of tobacco marketing exposure and how use of e-cigarettes and other substances may be associated with certain patterns. Similarly, there is a dearth of research examining the association between tobacco marketing exposures and prevention strategies. Because existing research has predominantly employed generalized measures of tobacco marketing exposures (e.g., at least one source, two sources), important information about differential patterns of exposure that can inform targeted marketing regulations and tailored interventions for youth may be masked.

The current study investigated differential patterns of e-cigarette and tobacco marketing exposures and associations with substance use and tobacco prevention strategies among a sample of school-aged youth from a rural, Appalachian community in the United States. Our primary objective was to utilize latent class analysis (LCA) to identify distinguishable patterns of 14 types of e-cigarette and tobacco marketing exposures among youth over the past 30 days. We hypothesized that more than two classes of youth with discernible patterns of exposure would be identified and that the classes would differ with regard to both the type and level of exposure. The second objective of this study was to examine associations between exposure classes with e-cigarette use, tobacco use, and other substance use, as well as with school e-cigarette policies, parental rules about e-cigarettes and tobacco, prevention messages about e-cigarettes and tobacco, and demographics. Based on previous research studies (Adams et al., 2009; McMillen et al., 2018; Milicic et al., 2018; Nicksic et al., 2018), we hypothesized that e-cigarette, cigarette, and other substance use would be associated with higher exposure classes, while parental rules, school policies, and prevention messages would be associated with lower tobacco marketing exposure.

Methods

Background and procedures

A cross-sectional substance use and behavioral health surveillance survey was administered to students in grades 6, 8, 10, and 12 in Fall 2018. The purpose of the survey was to anonymously measure substance use and related risk and protective factors among students using established measures from ongoing federal surveillance systems in the United States (Kann et al., 2018; Substance Abuse and Mental Health Services Administration, 2018). The e-cigarette and tobacco marketing exposure measures were adapted from validated items from the

National Youth Tobacco Survey and Population Assessment of Tobacco and Health Study (Agaku, King, & Dube, 2014; Hyland et al., 2017). Additional marketing exposure items were developed by the research team as items focusing on social media exposure specific to friends and celebrities did not exist at the time this survey was designed.

A paper-pencil version of the survey was administered to six middle and high schools from a rural county in Tennessee. Trained survey administrators followed standardized protocols approved by the Pacific Institute of Research and Evaluation's Institutional Review Board. Administrators informed students of the survey's content and purpose, that participation was voluntary, and that they could end participation at any time. The survey took 30-45 minutes to complete.

Study measures

A total of 14 items measured youth exposure to tobacco-related advertisements and media content in the past 30 days (never, 1-2 times, 3-4 times, several times a week, every day or almost every day). Two environmental exposure items asked how often students saw any ads for tobacco cigarettes, cigars, or other tobacco products inside or outside of a store or a billboard near their neighborhood; and inside or outside of a store or a billboard near their school. An identical pair of environmental exposure items were asked with reference to e-cigarettes or vape devices. Two items asked about exposure to tobacco cigarettes, cigars, or other tobacco products online or on social media and in a magazine. An identical set of online and magazine items were asked with reference to e-cigarettes or vape devices. Two items asked about exposure to cigarette and e-cigarette imagery on television. Four items captured how often students saw social media posts about smoking cigarettes or cigars, social media posts about vaping or using e-cigarettes, celebrities smoking cigarettes or cigars, and celebrities vaping or using e-cigarettes. We dichotomized the 14 items into high (i.e., several times a week and every day or almost every day) and low (never, 1-2 times, 3-4 times) exposure categories.

Five items assessed whether students used the following substances in the past 30 days (yes/no): cigarettes, e-cigarettes, alcohol, cannabis, and prescription drugs (e.g., sedatives/tranquilizers, opioids, stimulants). Tobacco prevention strategies included whether students' parents/guardians have clear rules about the use of cigarettes, tobacco, and e-cigarettes (yes/no); students' schools have a rule against using e-cigarettes or vape devices on school property (yes/no); and students' exposure to prevention messages and advertisements about the harms of cigarettes, tobacco, e-cigarettes, or vape devices in the past 12 months (several times or at least once a month vs. never or a few times). Demographics included grade (6, 8, 10, 12), biological sex (male, female), and race (non-Hispanic [NH] White and non-White).

Analyses

Latent class analysis (LCA) was performed to empirically identify classes of youth based on combinations of responses to the 14 tobacco marketing exposure items. Preliminary analyses revealed significant grade differences in the distribution of the 14 items, so we conducted LCA for middle (grades 6 and 8) and high school students (grades 10 and 12) separately. LCA assumes that the association between the 14 tobacco marketing exposure items may be explained by a common, unobservable (i.e., latent) structure that, based on probability, can be used to classify youth into two or more mutually exclusive subgroups. Because analysis of tobacco marketing exposure using standard methodological approaches (e.g., pairwise comparisons) can make evaluation of item overlap difficult, LCA represents an effective strategy for reducing the number of possible combinations into a more manageable and interpretable set of classes exhibiting the key patterns of marketing exposure in the study population.

Among the middle school students (6th and 8th grade), 21 of the 1,155 youth ages 10 and 15 years old were removed from the sample due to developmental purposes (e.g., younger and older students skipping or repeating grades), yielding an analytical subsample of 1,134 students 11-

14 years old. For the high school students (10th and 12th grade), a total of 924 students 15-18 years old were included. We entered the 14 tobacco marketing exposure items into the LCAs and proceeded iteratively to examine a maximum of seven classes. To determine the most parsimonious number of classes for middle and high school students, we used the following fit statistics (Nylund, Asparouhov, & Muthén, 2007): the Akaike information criterion (AIC), Bayesian information criteria (BIC), adjusted BIC (aBIC), model entropy, and Lo-Mendell-Rubin likelihood ratio test (LMR-LRT). Lower values of AIC, BIC, and aBIC better model fit, while entropy values closer to 1 indicate higher classification precision. The LMR-LRT yields *p*-values to determine whether a model with *k*-classes provides better fit than a model with *k*-1 classes.

After identifying the best fitting solutions, we determined multivariate associations between class membership with substance use, tobacco prevention strategies, and demographics through multinomial logistic regression models. We used a three-step approach to fit the multinomial logistic regression models, which treated substance use, tobacco prevention strategies, and demographics as auxiliary variables and controlled for uncertainty in class assignment while maintaining the original class structure (Asparouhov & Muthén, 2014). This produced adjusted odds ratios (aORs) and 95% confidence intervals (95% CIs) for the associations between class membership with substance use, tobacco prevention strategies, and demographics.

Full-information maximum likelihood was used in all statistical models to account for missing data (Enders, 2001), as item-level missingness was low (<3.8%). Multiple imputation was performed with 20 imputed datasets as a sensitivity analysis to assess the stability of the associations between class membership with substance use, tobacco prevention strategies, and demographics. A two-sided *p*-value less than or equal to 0.05 was considered statistically significant. All statistical analyses were conducted using Stata Version 15 (StataCorp, 2017) and Mplus Version 8 (Muthén & Muthén, 2017).

Results

Sample demographics and characteristics are shown in Table 1. Of the 2,058 students who completed the survey, 29.1% were in grade 6, 26.0% in grade 8, 24.7% in grade 10, and 20.2% in grade 12. Slightly over half of the sample was female (51.2%). The majority of students (73.5%) were White. The most common type of substance use in the past 30 days was e-cigarettes (27.8%), followed by alcohol (14.8%), cannabis (12.3%), prescription drugs (11.5%), and cigarettes (9.0%). For the tobacco prevention strategies, 72.1% of students reported that their parents have clear rules about e-cigarette and tobacco use, 82.6% reported they attend a school with a rule against e-cigarette use on campus, and 80.6% reported that they had been exposed to messages and advertisements about the harms of cigarettes, tobacco, e-cigarettes, and vape devices several times or at least once a month in the past 12 months.

Table 2 shows the distribution of the 14 tobacco marketing exposure items stratified by middle and high school. The most common exposure reported was the internet and social media domain (range 10.6-18.5% for middle school and 25.3-39.3% for high school). Youth were also commonly exposed to the environmental and television domains, while the print domain exposure was least prevalent. High school students were more likely than middle school students to report exposure to all 14 marketing items (*p*-values < 0.0001).

A comparison of model fit indicated that a four-class solution was most optimal for middle school, with the AIC, BIC, and aBIC values demonstrating marginal improvement in the five-class solutions (Supplemental Table 1). Additionally, the LMR-LRT indicated that the five-class model did not provide a better solution (*p*<0.13). For high school students, the fit statistics were also suggestive of four classes, although the five-class solution provided an additional meaningful class that was large enough for further analysis. Entropy was high across all solutions for both middle and high school students (>0.90), indicating excellent delineation of classes (Asparouhov & Muthén, 2014).

Table 1

Distribution of demographics, substance use, and tobacco prevention strategies among students in 2018.

Characteristics		Total Students (N=2,058)	
		N	(%)
Grade	6	599	(29.1)
	8	535	(26.0)
	10	509	(24.7)
	12	415	(20.2)
Biological Sex	Male	1,000	(48.8)
	Female	1,051	(51.2)
Race	NH White	1,489	(73.5)
	Non-White	536	(26.5)
Substance use (30-day)	Cigarette	184	(9.0)
	E-cigarette	567	(27.8)
	Alcohol	302	(14.8)
	Cannabis	250	(12.3)
	Prescription drug	232	(11.5)
Tobacco prevention strategies	Family rules ^a	1,408	(72.1)
	School rule ^b	1,675	(82.6)
	Prevention messages ^c	1,603	(80.6)

Note: Differences in column totals and percentages are due to missing data.

Abbreviations: NH, non-Hispanic

^a Parents/guardians have clear rules about the use of cigarettes, tobacco, and e-cigarettes.

^b Schools have a rule against using e-cigarettes or vape devices on school property.

^c Exposure to prevention messages and advertisements about the harms of cigarettes, tobacco, e-cigarettes, or vape devices several times or at least once a month in the past 12 months.

Fig. 1 illustrates the conditional probabilities for the final four-class solution among middle school students. The largest class comprised 64.7% of the sample and had low probabilities for all tobacco exposure items. The predominantly television class (17.1%) had a modestly increased probability of reporting exposure to cigarette imagery on television (0.52). The social media class (13.2%) had moderately high probabilities for the four internet and social media items (range 0.53-0.72) as well as being exposed to depictions of celebrities using e-cigarettes (0.53). The high exposure class was the smallest group (5.1%) and was characterized by high probabilities of exposure to all 14 items.

For the high school students (Fig. 2), the low exposure class comprised slightly over half the sample (54.7%). The social media class (10.0%) had high probabilities of exposure to the four internet and social media items (0.54-0.92) as well as celebrity depictions of cigarette (0.93) and e-cigarette (0.99) use. The environmental class (6.9%) had high probabilities for the four environmental exposures (0.67-1.00) along with high probabilities of the two internet and social media items for e-cigarettes. The tobacco cigarettes class (19.5%) had moderately high probabilities for the internet and social media item for tobacco cigarettes (0.65) and cigarette imagery on television (0.53). The high exposure class (8.6%) had high probabilities of exposure to all 14 items (0.71-0.99).

Tables 3 and 4 show the results from the multinomial logistic regression models with the low exposure classes serving as the base outcomes. For middle school students (Table 3), no associations were found for grade, sex, and race, except students in grade 8 having increased odds of being in the social media class (aOR = 2.81, 95% CI = 1.62-4.86) compared to grade 6. E-cigarette use was associated with the social media (aOR = 3.48, 95% CI = 1.69-7.15) and high exposure (aOR = 3.06, 95% CI = 1.16-8.06) classes. Prescription drug use was associated with the social media class (aOR = 4.44, 95% CI = 1.99-9.90), while alcohol use was associated with the high exposure class (aOR = 17.10, 95% CI = 1.35-217.27). Students reporting that their school has a rule against

Table 2
Distribution of 14 e-cigarette and tobacco marketing exposure items among 2058 middle and high school students in 2018.

Exposures (30-day) ^a	Middle School (n=1,134)		High School (n= 924)	
	n	(%)	n	(%)
Environmental				
Cigarettes in stores/billboards near home (cigenv1)	162	(14.7)	251	(27.7)
E-cigarettes in stores/billboards near home (cigenv1)	109	(9.8)	187	(20.7)
Cigarettes in stores/billboards near school (cigenv2)	96	(8.8)	173	(19.2)
E-cigarettes in stores/billboards near school (cigenv2)	68	(6.2)	159	(17.7)
Internet and social media				
Cigarettes online or social media (cigint1)	203	(18.5)	293	(32.6)
E-cigarettes online or social media (cigint1)	188	(17.1)	273	(30.4)
Social media posts about cigarettes (cigint2)	117	(10.6)	228	(25.3)
Social media posts about e-cigarettes (cigint2)	169	(15.3)	355	(39.3)
Television				
Cigarettes on television (cigtv)	218	(19.7)	249	(27.6)
E-cigarettes on television (cigtv)	149	(13.5)	174	(19.4)
Print				
Cigarettes in a magazine (cigmag)	62	(5.7)	98	(11.0)
E-cigarettes in a magazine (cigmag)	63	(5.8)	102	(11.5)
Celebrities				
Cigarette smoking (cigceleb)	88	(8.0)	162	(18.0)
E-cigarette vaping (cigceleb)	120	(10.9)	183	(20.3)

Note: Differences in column percentages are due to missing data.

^a Exposure several times a week and every day or almost every day.

using e-cigarettes on campus were more likely to be in the television class (aOR=1.94, 95% CI=1.13-3.34). In a sensitivity analysis utilizing multiple imputation, the parameter estimates for the demographic, substance use, and prevention strategy variables were virtually unchanged (<1% difference between raw and imputed).

For high school students (Table 4), students in grade 12 were less likely to be in the tobacco cigarettes class (aOR=0.65, 95% CI=0.42-0.99), while females were more likely than males to be in the social media (aOR=1.74, 95% CI=1.01-3.05), tobacco cigarettes (aOR=1.95, 95% CI=1.29-2.93), and high exposure (aOR=1.80, 95% CI=1.06-3.07) classes. Use of cigarettes (aOR=2.74, 95% CI=1.30-5.77), e-cigarettes (aOR=2.26, 95% CI=1.17-4.39), and prescription drugs (aOR=3.58, 95% CI=1.83-7.01) were associated with the social

media class. E-cigarettes (aOR=4.41, 95% CI=2.17-8.94) and prescription drugs (aOR=2.99, 95% CI=1.42-6.29) were also associated with the high exposure class. Among the prevention strategies, exposure to prevention messages about the harms of cigarettes, tobacco, e-cigarettes, or vape devices was associated with the social media (aOR=2.79, 95% CI=1.02-7.62) and cigarettes (aOR=3.14, 95% CI=1.42-6.92) classes. The parameter estimates for the demographic, substance use, and prevention strategy variables were highly comparable in the sensitivity analysis with multiple imputation.

Discussion

To our knowledge, this study is the first to empirically identify

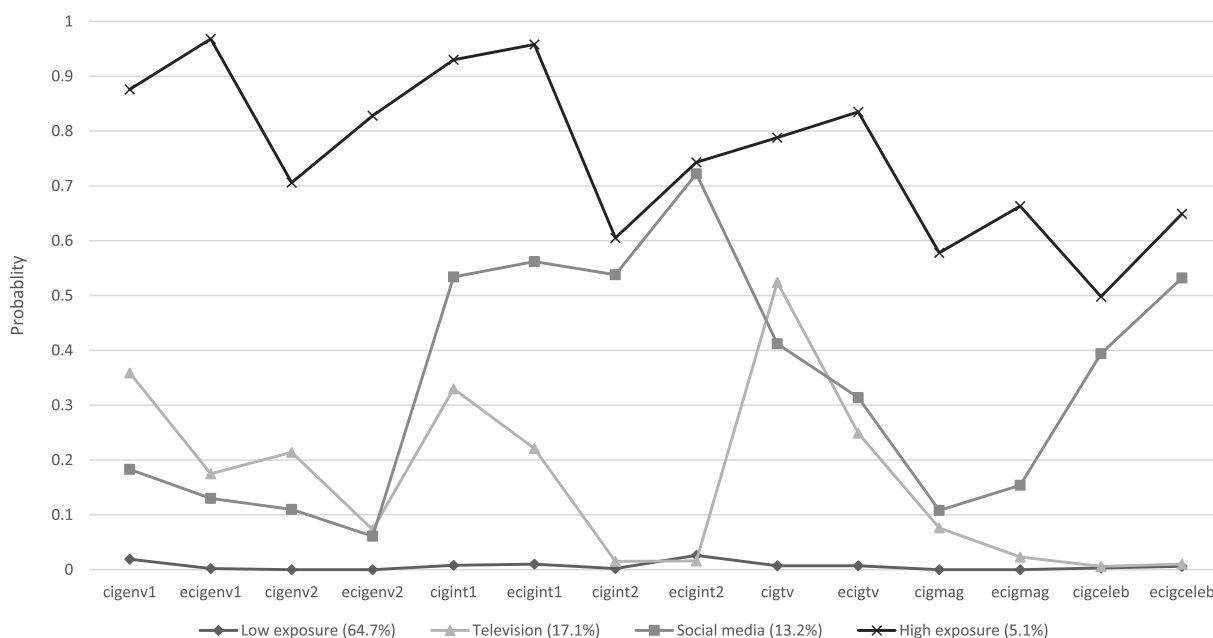


Fig. 1. Probability plot from latent class analysis of 14 e-cigarette and tobacco marketing exposures in the past 30 days among middle school students in 2018 (n = 1,134). Abbreviations: cigenv1 = cigarettes in stores/billboards near home; cigenv1 = e-cigarettes in stores/billboards near home; cigenv2 = cigarettes in stores/billboards near school; cigenv2 = e-cigarettes in stores/billboards near school; cigint1 = cigarettes online or social media; cigint1 = e-cigarettes online or social media; cigint2 = social media posts about cigarettes; cigint2 = social media posts about e-cigarettes; cigtv = cigarettes on television; cigtv = e-cigarettes on television; cigmag = cigarettes in a magazine; cigmag = e-cigarettes in a magazine; cigceleb = cigarette smoking among celebrities; cigceleb = e-cigarette vaping among celebrities

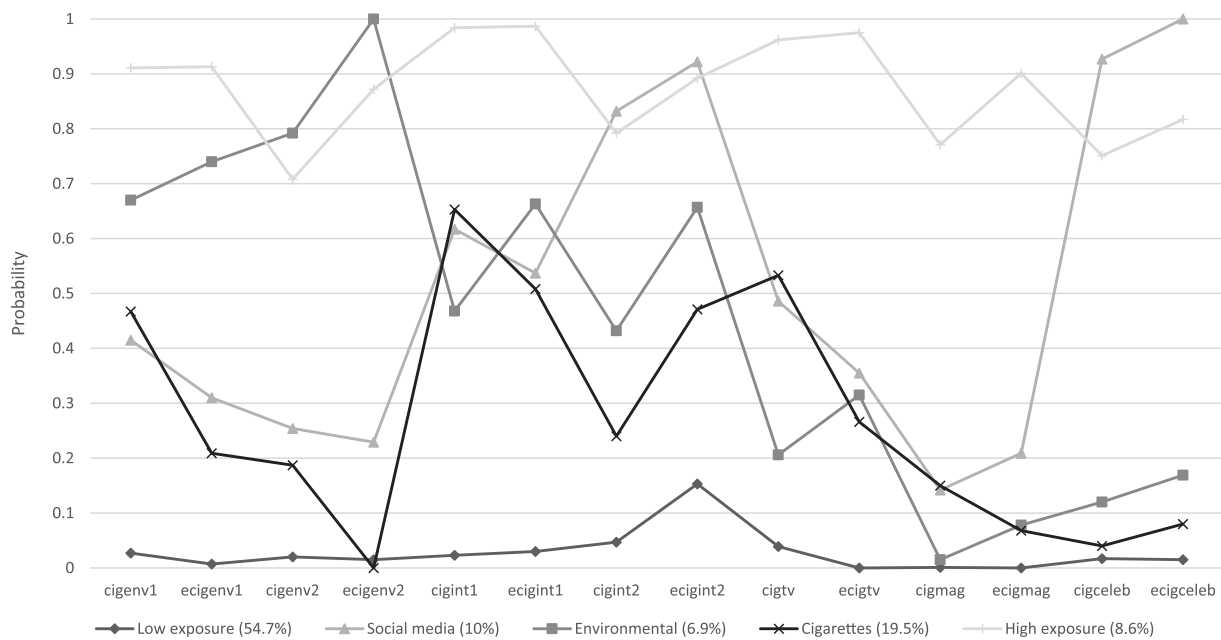


Fig. 2. Probability plot from latent class analysis of 14 e-cigarette and tobacco marketing exposures in the past 30 days among high school students in 2018 (n = 924). Abbreviations: cigenv1 = cigarettes in stores/billboards near home; ecigenv1 = e-cigarettes in stores/billboards near home; cigenv2 = e-cigarettes in stores/billboards near school; ecigenv2 = e-cigarettes in stores/billboards near school; cigint1 = cigarettes online or social media; ecigint1 = e-cigarettes online or social media; cigint2 = social media posts about cigarettes; ecigint2 = social media posts about e-cigarettes; cigtv = cigarettes on television; ecigtv = e-cigarettes on television; cigmag = cigarettes in a magazine; ecimag = e-cigarettes in a magazine; cigceleb = cigarette smoking among celebrities; ecigceleb = e-cigarette vaping among celebrities

differential patterns of e-cigarette and tobacco marketing exposures among youth and determine associations between the exposure patterns with substance use and tobacco prevention strategies. As hypothesized, our study identified more than two classes of youth with discernible patterns of exposure, although stratification by grade was necessary to address pervasive age differences across the 14 reported exposure items. Four distinct classes were identified among middle school

students (n = 1,134) and five classes were identified among high school students (n = 924). Classes characterized by predominantly internet and social media exposures were associated with higher rates of cigarette smoking and e-cigarette use. High exposure classes were also identified and demonstrated concerning patterns of polydrug use. Prevention messages about the harms of tobacco cigarettes, e-cigarettes, or vape devices were associated with the majority of the classes, which

Table 3

Multivariate associations between latent class membership with demographics, substance use, and tobacco prevention strategies among middle school students in 2018.

	Middle School Students (n = 1,134)					
	Television (17.1%)		Social Media (13.2%)		High Exposure (5.1%)	
	aOR	(95% CI)	aOR	(95% CI)	aOR	(95% CI)
Grade						
6	1.00		1.00		1.00	
8	1.15	(0.74-1.80)	2.81	(1.62-4.86)	1.10	(0.53-2.30)
Biological sex						
Male	1.00		1.00		1.00	
Female	0.92	(0.61-1.39)	1.12	(0.70-1.81)	0.93	(0.50-1.76)
Race						
NH White	1.00		1.00		1.00	
Non-White	0.82	(0.51-1.31)	1.06	(0.63-1.80)	0.91	(0.45-1.82)
Substance use (30-day)						
Cigarette	2.24	(0.40-12.58)	1.51	(0.25-9.08)	2.94	(0.55-15.75)
E-cigarette	1.70	(0.79-3.63)	3.48	(1.69-7.15)	3.06	(1.16-8.06)
Alcohol	7.67	(0.49-120.16)	13.18	(0.95-182.97)	17.10	(1.35-217.27)
Cannabis	1.61	(0.41-6.33)	2.00	(0.62-6.47)	3.32	(0.79-13.90)
Prescription drug	1.57	(0.58-4.22)	4.44	(1.99-9.90)	1.13	(0.31-4.16)
Tobacco prevention strategies						
Family rules ^a	0.77	(0.50-1.21)	1.36	(0.76-2.46)	0.67	(0.35-1.30)
School rule ^b	1.94	(1.13-3.34)	1.38	(0.75-2.55)	1.98	(0.76-5.28)
Prevention messages ^c	3.28	(1.73-6.20)	3.55	(1.51-8.35)	2.19	(0.93-5.14)

Abbreviations: aOR, adjusted odds ratio; 95% CI, 95% confidence interval; NH, non-Hispanic

^a Parents/guardians have clear rules about the use of cigarettes, tobacco, and e-cigarettes.

^b Schools have a rule against using e-cigarettes or vape devices on school property.

^c Exposure to prevention messages and advertisements about the harms of cigarettes, tobacco, e-cigarettes, or vape devices several times or at least once a month in the past 12 months.

Table 4

Multivariate associations between latent class membership with demographics, substance use, and tobacco prevention strategies among high school students in 2018.

Characteristics	High School Students (n = 924)							
	Social media (10%)		Environmental (6.9%)		Cigarettes (19.5%)		High exposure (8.6%)	
	aOR	(95% CI)	aOR	(95% CI)	aOR	(95% CI)	aOR	(95% CI)
Grade								
10	1.00		1.00		1.00		1.00	
12	0.78	(0.44-1.42)	1.12	(0.61-2.05)	0.65	(0.42-0.99)	0.68	(0.38-1.21)
Biological sex								
Male	1.00		1.00		1.00		1.00	
Female	1.74	(1.01-3.05)	1.10	(0.61-1.99)	1.95	(1.29-2.93)	1.80	(1.06-3.07)
Race								
NH White	1.00		1.00		1.00		1.00	
Non-White	0.92	(0.44-1.92)	0.93	(0.42-2.06)	1.02	(0.61-1.70)	0.85	(0.41-1.76)
Substance use (30-day)								
Cigarette	2.74	(1.30-5.77)	1.53	(0.52-4.53)	0.82	(0.36-1.84)	1.71	(0.78-3.72)
E-cigarette	2.26	(1.17-4.39)	0.98	(0.47-2.04)	1.45	(0.90-2.32)	4.41	(2.17-8.94)
Alcohol	0.93	(0.46-1.87)	1.29	(0.51-3.25)	0.97	(0.55-1.72)	1.18	(0.60-2.30)
Cannabis	0.80	(0.42-1.53)	0.50	(0.18-1.43)	1.05	(0.54-2.04)	1.04	(0.51-2.09)
Prescription drug	3.58	(1.83-7.01)	1.76	(0.64-4.87)	1.58	(0.74-3.36)	2.99	(1.42-6.29)
Tobacco prevention strategies								
Family rules ^a	1.32	(0.63-2.75)	0.91	(0.43-1.92)	1.12	(0.64-1.95)	1.69	(0.84-3.31)
School rule ^b	0.50	(0.18-1.40)	0.69	(0.23-2.13)	0.77	(0.35-1.70)	0.59	(0.21-1.67)
Prevention messages ^c	2.79	(1.02-7.62)	3.13	(0.96-10.19)	3.14	(1.42-6.92)	2.05	(0.86-4.88)

Abbreviations: aOR, adjusted odds ratio; 95% CI, 95% confidence interval; NH, non-Hispanic

^a Parents/guardians have clear rules about the use of cigarettes, tobacco, and e-cigarettes.^b Schools have a rule against using e-cigarettes or vape devices on school property.^c Exposure to prevention messages and advertisements about the harms of cigarettes, tobacco, e-cigarettes, or vape devices several times or at least once a month in the past 12 months.

contrasts with previous studies showing an inverse relationship between prevention messages and e-cigarette and tobacco marketing exposure.

Several exposure classes were associated with multiple types of substance use, especially e-cigarette use in the past 30 days. Among middle school students, e-cigarette use was associated with the social media and high exposure classes, while a large association was found for alcohol use and the high exposure class (aOR > 15). For high school students, e-cigarette use was significantly associated with the social media and high exposure classes. Misuse of prescription drugs was also associated with both social media classes as well as the high exposure class among high school students. The range of substances associated with the high marketing exposure classes demonstrates that use of e-cigarettes, alcohol, and prescription drugs are interrelated phenomena that may require integrative interventions that focus on polydrug use rather than individual substances (McKelvey, Ramo, Delucchi, & Rubinstein, 2017; Miech, O'Malley, Johnston, & Patrick, 2016; Silveira, Green, Iannaccone, Kimmel, & Conway, 2019). In this context, prosocial marketing depictions of e-cigarettes normalize use and represent an emergent mechanism that may prime adolescents to experiment or transition to the use of other drugs (Gilbert, Kava, & Afifi, 2020; Lee et al., 2017). Moreover, our study found associations among middle school students with increased marketing exposures that strongly indicate a need to begin addressing the overlap between e-cigarettes and other substances during early adolescence, especially alcohol and prescription drugs, rather than predominantly focusing on older adolescents (Haardörfer et al., 2016; Miech et al., 2016).

Associations between class membership and tobacco prevention messages were also consistently found across the exposure classes for both middle and high school students. While we originally hypothesized inverse associations between prevention strategies and increased marketing exposure, the findings in our study suggest that both pro- and anti-tobacco communications have become ubiquitous and may be saturating youth (Holton & Chyi, 2012). Experimental studies have shown that conflicting messages and counterarguments can increase ambiguous perceptions of the risks associated with e-cigarettes, potentially leading to reduced behavior intentions to avoid e-cigarette use (Katz, Erkkinen, Lindgren, & Hatsukami,

2018; Lee, Lin, Seo, & Lohrmann, 2018; Wackowski et al., 2019). Similarly, observational studies have found that cognitions and perceptions about media messages are significantly associated with social approval and estimated prevalence of e-cigarette use (Elmore, Scull, & Kupersmidt, 2017; Scull, Kupersmidt, Parker, Elmore, & Benson, 2010). As critical thinking has been shown to reduce the likelihood of positive use attitudes and expectancies and youth substance use specifically, the results from our study indicate a need for interventions focused on increasing media-based literacy (Kupersmidt, Scull, & Austin, 2010; Kupersmidt, Scull, & Benson, 2012). For example, the Elaboration Likelihood Model has been used to design interventions that teach youth how to identify a media product's message, intended audience, and any missing information about the potential harms and consequences of a product (Jeong, Cho, & Hwang, 2012; Kupersmidt et al., 2010, 2012; Vahedi, Sibalis, & Sutherland, 2018). Future studies of media literacy interventions tailored to a variety of media exposure patterns are now warranted to help youth distinguish between multiple messaging types, develop their decision-making skills, and reduce engagement in tobacco and substance use.

In addition, this study demonstrated age and sex differences in e-cigarette and tobacco marketing exposure. The differences in the number and structure of classes by grade highlight that middle and high school students have differential patterns of tobacco marketing exposure. As youth become more independent in high school, they may have increased exposure to environmental influences in stores and other settings where nicotine and tobacco products are available for purchase. In addition, the pervasive social media exposure among three of the high school classes is consistent with recent increases in mobile device ownership and thus, easier access to social media platforms (Villanti et al., 2017). These digital platforms have been shown to have increased exposure to prosocial depictions of smoking and vaping as well as online marketplaces that sell tobacco products (Soneji et al., 2018), further suggesting a need for web-based prevention interventions. Similarly, high school females were more likely than males to be in the social media, cigarettes, and high exposure classes, although no effects were found for middle school students. Research has found that the cigarette and e-cigarette industry aggressively target younger women with advertising that reflect ideas of independence, emancipation, sex appeal, slimness, glamour and beauty

(Anderson, Glantz, & Ling, 2005; Lennon, Gallois, Owen, & McDermott, 2005; Nichter et al., 2006). As such, our study provides additional evidence that gender-specific strategies focusing on media-based literacy and social norms among females are warranted.

This study has several limitations. First, the data come from a locality in rural Appalachia and are not representative of all middle and high school students in the United States. Participation was voluntary and parents could request that their child not take the survey. Moreover, findings do not include behaviors and exposures of students who were absent from school on survey administration dates due to illness, suspensions, expulsions, or truancy. Second, all schools in the county administered the survey in fall 2018 and the overall student response rate was 74 percent, although it is possible that non-response may have influenced the findings. Nonetheless, the response rate was slightly above the average response rates between 2011–2015 of the NYTS and the results from our sensitivity analyses indicated that missing data did not have a significant impact on our multivariate findings (Johnson, Collins, Villanti, Pearson, & Niaura, 2018). Another limitation of the study is that the data were self-reported. Students may have been inclined to provide more socially desirable responses to substance use items. However, our findings are consistent with substance use data from nationally representative samples of adolescents, particularly on e-cigarette use (Wang et al., 2019), cigarette use (Kann et al., 2018), and prescription drug use (Johnston et al., 2019). Similarly, the self-reported nature of the tobacco prevention strategies may not have been fully reflective of existing policies, particularly the school rules against the use of e-cigarettes and vape devices on campus. Future studies that independently confirm the presence and enforcement of tobacco prevention strategies are needed to corroborate the associations found in this investigation. Lastly, students who use e-cigarettes or tobacco products may also be more prone to recall e-cigarette and tobacco advertisements than non-users. However, the associations we found between marketing exposure and product use are congruous with prior research findings (Choi, Rose, Zhou, Rahman, & Hair, 2020; Hammig et al., 2017; Kwon et al., 2018; Mantey et al., 2016; Robertson, Cameron, McGee, Marsh, & Hoek, 2016; Singh et al., 2016).

This study provides important information about e-cigarette and tobacco marketing exposures that can inform community-based prevention and early intervention initiatives, including ongoing youth anti-drug coalition activities. Special attention should focus on tailoring efforts based on age and gender as well as designing programs focused on characteristics of the marketing exposure classes. This study highlights the need for more stringent regulations on e-cigarette and tobacco product marketing or promotion, especially on the internet and social media. Finally, additional research should focus on understanding the impact of social media influencers and celebrities endorsing the use of various substances on popular social media platforms (e.g., YouTube, TikTok, Snapchat, and Instagram), and if youth are effectively distinguishing between images of celebrity endorsements, friends' use, tobacco marketing, and tobacco prevention messages.

Declarations of Competing Interest

Differential patterns of e-cigarette and tobacco marketing exposures among youth: Associations with substance use and tobacco prevention strategies

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.drugpo.2020.102925.

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