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Adolescent Tobacco Uptake and Other Substance Use: A Latent Class Analysis

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Abstract

Objective: The purpose of this study was to identify patterns of tobacco uptake and other substance use, from early to late adolescence.

Methods: We used weighted latent class analysis, conducted separately for 7th, 9th, and 11th graders, to assess patterns of susceptibility, ever and current use of combustible tobacco and e-cigarettes, and other substance use (ie, current alcohol, binge drinking, and marijuana). Data were from Wave 3 of the Texas Adolescent Tobacco and Marketing Surveillance System (n = 2733; N = 461,069), collected in fall 2015. Multinomial regression was used to examine differences in class membership by demographic factors.

Results: Two latent classes were identified in 7th grade, 3 classes in 9th grade, and 4 classes in 11th grade models. In each grade, classes included both a “no risk” and a “tobacco susceptible” class. For 9th grade, there was an additional “tobacco ever use” class, and 11th grade had the same additional class as well as an “all products use” class.

Conclusion: Distinct patterns of polysubstance use emerged as grade level increased, supporting a stage-sequential model of onset and progression across developmental age groups. Future research can examine other factors affecting transitions across these stages.

Keywords

tobacco; adolescents; latent class analysis; stage-sequential model

Because the initiation of tobacco use is likely to occur during adolescence,¹ more research is needed to explore the uptake of tobacco products during this critical developmental period. Experimentation with tobacco between the ages of 12 and 18 years significantly increases the odds of dependence on alcohol, tobacco, and marijuana in young adulthood.² the uptake

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Human Subjects Approval Statement

The University of Texas Health Science Center’s Institutional Review Board approved this study (reference number HSC-SPH-13-0377).

Conflict of Interest Disclosure Statement

All authors of this article declare they have no conflicts of interest.

of tobacco use among youth is often described as proceeding in stages, from no use, to susceptible to use, to initiation, and onto experimentation and higher frequency of use.^{1,3,4}

To date, most studies of stage-sequential models of the onset and progression of tobacco use have focused exclusively on cigarettes,^{5,6} leaving much to be studied about the diversity of tobacco products that are available and increasingly used by youth. In 2016, electronic cigarettes (e-cigarettes) were the most used tobacco product among high school students, with 11.3% reporting past 30-day use, followed by cigarettes (8.0%), cigar products (7.7%), and hookah (4.8%).⁷ The same patterns of use were seen among middle school students, with past 30-day use being highest for e-cigarettes (4.2%), followed by cigarettes (2.2%), cigar products (2.2%), and hookah (2.0%). Additionally, use of multiple tobacco products was high, with 9.6% of high school and 3.1% of middle school students reporting use of more than one tobacco product in the past 30 days.⁷

Alcohol, marijuana, and tobacco are the 3 most commonly used substances, and in youth, polyuse is common.⁸ In 2013, among US high school students who reported currently using one or more tobacco products, 85.8% also reported current alcohol use, and 64.5% reported current marijuana use.⁹ One potential explanation for the high co-occurrence of tobacco, alcohol, and marijuana use is the common liability model, which posits that there are shared or “common” underlying factors (eg, environmental, behavioral, genetic, etc) that may influence the use of multiple types of substances.^{10,11} Previous research has shown that adolescents who use alcohol, marijuana, and cigarettes before the age of 16 are at higher risk for dependence and abuse of all 3 substance in young adulthood.¹² Lastly, it is important to identify patterns of polysubstance use to determine which products are used simultaneously; such information will aid in the development of targeted interventions preventing substance/tobacco use.

One method that has proven useful for examining patterns of polysubstance use among adolescent populations is latent class analysis (LCA), a statistical technique comparable to factor analysis that categorizes people into classes of behavior based on the structural relationships among multiple categorical indicators of these behaviors.^{13,14} The benefit of LCA is it is a data-driven method to identify person and group level patterns of polyuse in a systematic way as opposed to relying on *a priori* assumptions of the researchers to define groups.¹³ Previous studies have used LCA to identify youth substance abuse profiles. These studies typically include indicators of tobacco, alcohol and/or marijuana use, with a majority of studies noting distinct classes of none or low substance users, alcohol users, and polysubstance users.¹⁵ However, variations in the types of products examined and methods of measuring product use make comparisons across studies difficult. Additionally, as it is a newer product, only a few studies include e-cigarettes in these models.^{16–18}

Existing LCA studies also differ in how they operationalize product use, such as ever and/or past 30-day use. Some studies include indicators for both ever and past 30-day use of the product.^{17–20} Other studies only have indicators for ever use²¹ or past 30-day use.^{16,22–24} The way in which tobacco use is measured is important as it also reflects the stage of tobacco uptake. For example, a youth reporting ever use of a product, but not past 30-day use, is often considered to be in the initiation or experimentation stage; on the other hand, a

past 30-day user of a product is often considered to be a current user of the product and considered to be at higher risk (more advanced on the spectrum of product use).³ Importantly, all of the prior models failed to assess whether a non-user of a product was susceptible to future product use. To date, only one study has included measures of susceptibility into latent class analyses assessing patterns of tobacco use, and this study was conducted in India.²⁵

Susceptibility is a construct that identifies adolescents who are predisposed to using tobacco products based on their curiosity, future intentions, and the influence of friends.^{4,26} In a nationally representative sample of adolescents in the US between 2013 and 2014, 15.2% to 28.6% of never users were susceptible to some form of combustible tobacco products, and 27.4% of never users were susceptible to e-cigarettes.²⁷ Thus, susceptibility is a prevalent risk factor in adolescent populations. Susceptibility is also a strong predictor of subsequent cigarette smoking initiation and experimentation with other tobacco products.^{4,26,28–36}

The aim of this study was to build a latent class model that included multiple tobacco products and had indicators representing 4 stages of tobacco uptake: non-use, susceptible to use, ever use, and past 30-day use. Current (past 30-day) use of alcohol and marijuana also were included in the model, as along with tobacco, these are the 3 most commonly used substances and previous research indicates that use of all 3 substances in youth increases risk of dependence on tobacco products in young adulthood.¹² Therefore, adding alcohol and marijuana use indicators to the model will allow for the possible identification of a class that uses all products that may be at greater risk of tobacco dependence. Lastly, we ran separate models for the 3 grade levels (7th, 9th and 11th), as we anticipated that patterns of use would differ by age.

METHODS

Study Sample

The present study examines data from the Texas Adolescent Tobacco and Marketing Surveillance System (TATAMS). TATAMS is an on-going longitudinal study that measures use of tobacco products. Participants included 3907 adolescents, who at Wave 1 (October 2014 to May 2015), were in the 6th, 8th, and 10th grade. These participants represented 461,069 students in the sampling frame and were drawn from a representative sample of schools (N = 79) in 5 counties containing the 4 largest cities in Texas: Austin, San Antonio, Houston, and Dallas/Fort Worth. A description of the sampling design and school recruitment is provided elsewhere.³⁷

This study is a cross-sectional analysis of the Wave 3 survey, collected from November 2015 to January 2016. The Wave 3 survey was completed by 2733 participants for a weighted response rate of 66.9%. Wave 3 data were weighted so that the 2733 respondents would be representative of the original sampling frame population of 461,069. Parental consent and student assent were obtained for all participants.

Measures

Latent class indicator variables.—Participants were asked about their ever use of e-cigarettes and 4 combustible products – cigarettes, little filtered cigars, cigars/cigarillos, and hookah, with dichotomous yes/no response options for each individual item. Susceptibility to each tobacco product was measured among participants who reported never using the product with the following 3 questions: (1) “Have you ever been curious about using [product type]?” (2) “Do you think you will use/smoke [product type] in the next 12 months?” and (3) “If one of your close friends were to offer you [product type], would you use it?” The response options for all questions were “Definitely not,” “Probably not,” “Probably yes,” and “Definitely yes.” If participants answered “Definitely not” to all 3 questions, they were coded non-susceptible; all others were coded as susceptible. Two 3-category indicator variables (one for e-cigarettes and one for combustible products), based on ever use and susceptibility items, were created with response categories of ever use, susceptible to use, and not susceptible to use. For the combustible product variable, participants who reported ever use of any combustible product were coded as combustible product ever users; never users of combustible products were coded as susceptible to use if they were susceptible to any of the combustible products, or not susceptible to use if they were not susceptible to any combustible product. The e-cigarette product variable was coded similarly, based on responses to e-cigarette ever use and e-cigarette susceptibility items.

Additionally, 2 indicators were created assessing participants’ past 30-day use of the 5 tobacco products. Participants reporting e-cigarette use one or more times in the past 30 days were categorized as past 30-day e-cigarette users; those reporting the use of any combustible product one or more times in the past 30 days were categorized as past 30-day combustible users. three additional dichotomous indicators assessed past 30-day use of alcohol, past 30-day use of marijuana, and past 14-day binge drinking, defined as 5 or more alcoholic drinks in a row on any one occasion in the past 14 days.

Covariates.—Participants reported sex, age, race/ ethnicity (coded as Hispanic, non-Hispanic (NH) white/other and NH black) and their subjective economic status (SES). SES was assessed with the question: “In terms of income, what best describes your family’s standard of living in the home where you live most of the time? Would you say your family is: (very well off, living comfortably, just getting by, nearly poor, or poor)?” The SES measure was recoded into a 3-point scale, with the categories of “just getting by,” “nearly poor,” and “poor” collapsed due to the low prevalence of “nearly poor” and “poor” categories.

Data Analysis

Descriptive statistics were generated for all variables in SAS 9.4 (SAS Institute, Cary NC). All other analyses were conducted in Mplus Version 7.3.³⁸ LCA was performed to identify profiles of substance use. Analyses were run separately for each grade level, 7th, 9th and 11th, to account for potential differences in patterns of use based on developmental stage. To determine the optimal number of classes, models were run starting with a one class solution, and increasing the number of class by one, until the Bayesian Information Criterion (BIC), adjusted BIC, and Akaike Information Criterion (AIC) began to increase between

consecutive models. The following criteria were used to select the optimal number of classes: (1) the model could not have a class that represented less than 5% of the population in order to have a large enough sample size to conduct subsequent regression analysis; (2) the entropy, or the likelihood that participants are classified correctly, had to be greater than 75%;³⁹ and (3) the BIC, adjusted BIC, and AIC had to be smaller than all the models with fewer classes.⁴⁰

To examine how demographics relate to class membership likelihood, the 3-step approach was used.³⁹ First, the optimal class solution was determined as described above. Second, using latent class posterior probabilities, each participant's likely class was determined, as well as a logit, based on the classification uncertainty rate. In the third step, a multinomial regression analysis was performed with the most likely class variable as the dependent variable and the demographic variables as the independent variables, while using the logit from step 2 to account for error in classification. All analyses used sampling weights to account for the complex design, clustering of participants within schools, and non-response bias, as well as to generalize to the study population.³⁷ In the LCA models, full-information maximum likelihood was used to handle missing data. In the regression model, any missing data on the dependent variables were handled with listwise deletion, resulting in 5 cases being removed from analysis.

RESULTS

Descriptive Statistics

Table 1 presents participants' demographics, and Table 2 presents the latent class indicator prevalence stratified by grade. The weighted mean age for 7th grade participants was 12.3 years (SE = 0.03), 14.3 years (SE = 0.03) for 9th grade participants, and 16.0 years (SE = 0.07) for 11th grade participants.

Latent Class Analysis Results

For the 7th grade cohort, a 2-class model was the best solution as it had the lowest AIC, BIC, and adjusted BIC with an entropy of 0.98. For the 9th grade cohort, the ideal solution based on AIC, BIC, and adjusted BIC was a 4-class model. However, as one of the class's membership probabilities was only 2.5% of the population, the 3-class model was chosen and had an entropy of 0.79. Similarly, for 11th graders, the fit statistics indicated the 5-class model was the optimal solution, but one class had a membership probability of 2.8%; therefore, the 4-class model was chosen and had an entropy of 0.85.

In the 7th grade model, 77.5% of the population belonged to a "no risk" class and were characterized by low probabilities of susceptibility to or use of products. The remaining 22.4% belonged to a "tobacco susceptible" class, having a high probability of being susceptible to combustible tobacco (80.5%) and e-cigarettes (75.5%). Similarly, the 9th graders had a class for "no risk" (48.3%) and "tobacco susceptible" (37.8%), and an additional class, "tobacco ever use," characterized by a high probability of ever use of combustible tobacco (87.6%) and e-cigarettes (88.6%). The 11th grade cohort also had a "no risk" class (39.5%), a "tobacco susceptible" class (26.1%), and a "tobacco ever use" class

(24.4%). Finally, the 11th grade cohort had an additional fourth class, “all product use,” defined by high probabilities of ever use of combustible tobacco (85.8%) and e-cigarettes (91.4%), and high probabilities of past 30-day alcohol use (100.0%) and marijuana use (67.1%), as well as past 14-day binge drinking (59.8%) (Table 3).

Multinomial Regression Results

For each grade level, Tables 4 and 5 present the multinomial regression results based on differences between the latent classes by sex, race/ethnicity and SES. Table 4 uses the “no risk” class as the reference group, and Table 5 uses the “tobacco susceptible” class as the reference group. The comparison between the “tobacco ever use” class and the “all product use” class in 11th grade is not shown, as there were no significant differences by demographic factors.

When compared to the “no risk” class, girls compared to boys had lower odds of being in the “tobacco susceptible” class for all grades (Table 4). Girls also had lower odds of belonging to the “tobacco ever use” class when compared to the ‘no risk’ class for 11th grade, but there was not a statistically significant relationship for sex in 9th grade (Table 4). There was also no relationship by sex when comparing the “no risk” to the “all product use” class. When comparing the “tobacco susceptible” class to the “tobacco ever use” class, there were no significant relationships by sex for 9th or 11th grade (Table 5). However, 11th grade girls had 2 times the odds compared to boys belonging to the all product class versus the “tobacco susceptible” class (Table 5).

For 7th and 9th grade cohorts, Hispanic students as compared to NH white/other students had higher odds of belonging to the “tobacco susceptible” class compared to the ‘no risk’ class (Table 4). There were no other significant differences between Hispanic students and NH white/other students between latent classes (Table 4 and 5). When comparing NH black students to NH white/other students, no significant differences were found except in the 11th grade cohort, where NH black students had lower odds of being in the “all product use” class versus both the “no risk” class (Table 4) and the “tobacco susceptible” class (Table 5).

In the 7th and 11th grade cohorts, there were no significant differences in class membership by SES. However, in the 9th grade cohort, students in the low-SES group had 3 times the odds as compared to the high-SES group of being in the “tobacco susceptible” class versus the “no risk” class (Table 4). Conversely, in 9th grade, students in the low-SES and medium-SES group had lower odds of being in the “tobacco ever use” class compared to the “tobacco susceptible” class (Table 5).

DISCUSSION

In this study, we examined patterns of tobacco uptake and other substance use among 7th, 9th, and 11th grade students, using latent class analyses. It is one of the first to be inclusive of e-cigarettes as well as other alternative tobacco products^{17–19,26,42} and uniquely represents tobacco product uptake stages by grade level. Most LCA studies that include participants over multiple grade levels use grade or age as a covariate.^{15–18,42,43} Few studies examine grade levels separately.²⁴ This study found differences in the relationship between

demographic groups and the odds of class membership by grade level, indicating it is necessary to stratify by grade, as there are distinct differences across the adolescent development period. Additionally, it is only the second study that includes susceptibility to tobacco use as an indicator in the LCA model,²⁵ dividing tobacco never users into those that are not susceptible versus susceptible to future use. Ultimately, our results describe the profiles of tobacco use across 3 grade levels, providing support for a stage-sequential model of onset and progression in tobacco use, from early to late adolescence. By identifying progressing stages of tobacco use and patterns of co-use with alcohol and marijuana, this study can inform the development of future programs intervening early in the trajectory of tobacco use and preventing further escalation of use.

The LCA models aligned well with the stage-sequential model of tobacco uptake.³ The emergence of a class including polyuse of tobacco, alcohol, and marijuana is important, as adolescent polysubstance use is associated with a wide range physical and mental health issues.¹² Additionally, a study of adolescents found that polyuse of alcohol, marijuana, and cigarettes before the age of 16 predicted dependence on and abuse of these substances and other illegal drugs in young adulthood.¹² The identification of these polysubstance users suggests that future interventions, aimed at curbing the use of tobacco products among adolescents, should also include discussion of other substance use.

The LCA models identified in this paper do not include a class defined by a high probability of current use of tobacco products, which would represent the more advanced stages of tobacco uptake. This result is supported by previous findings showing that whereas high school students experiment with tobacco, sustained use of the products does not occur until young adulthood.¹

Regarding sex, our study found that 11th grade girls, compared to boys, were more likely to be in the “all product use” class and the “no risk” class, when compared to the “tobacco susceptible” class. These contradictory findings warrant future research. Specifically, our study found that 11th grade girls, when compared to 11th grade boys, had 2 times the odds of being in the “all product use” class compared to the “tobacco susceptible” class. Other studies have similar findings, with girls having higher odds than boys of being in the occasional polysubstance use class (participants who only use the products 1 or 2 times in the past 30 days) when compared to the nonuser class, but the data are inconsistent for frequent polysubstance use classes.^{44,45} Data from Monitoring the Future suggests that high school girls have a higher prevalence of past 30-day alcohol use as compared to boys. This higher rate of alcohol use may explain our findings that girls are more likely to be in the “all product use” class as compared to boys.⁸ In addition, we found that 11th grade girls, compared to boys, had higher odds of being in the “no risk” (ie, committed non-users) class compared to the “tobacco susceptible” class and compared to the “tobacco ever use” class. This could be an indicator that susceptibility to tobacco use plays a less important role for girls in the onset of tobacco and other drug use. However, as LCA is a cross-sectional method, it is not possible to determine how participants are transitioning between classes. Future studies employing a latent transition analysis would be able to examine this progression directly.

The Population Assessment of Tobacco and Health (PATH) study reported that Hispanic youth, ages 12–17 years old, were significantly more likely to be susceptible to tobacco use compared to NH Whites; however, in young adulthood, ages 18–24 years old, the risk of being a tobacco user did not vary by race/ethnic groups.²⁷ This is similar to the current study's finding that in grades 7th and 9th, Hispanic youth, compared to NH white/other students, were at increased risk of being in the susceptible class compared to the “no risk” class; however, there was no statistically significant difference by race/ethnicity in the oldest cohort. Additional research is required to illuminate why Hispanics may be at a higher risk at an earlier age for the onset of tobacco and other drug use. The current study also found that NH black adolescents in 11th grade had reduced odds, when compared to NH white/other students, of being in the “all product use” class when compared to the “no risk” and “tobacco susceptible” classes. This finding is in line with current research indicating that NH black youth, compared to NH white youth, use cigarettes²⁷ and alcohol⁴⁶ at lower rates.

Past research has shown that low SES is associated with cigarette smoking initiation in youth;^{47,48} yet, there is less evidence for alternative tobacco products, and what does exist is contradictory.¹⁷ The relationship between SES and susceptibility is also understudied; however, the PATH study found that 12–17-year-old students whose parents had higher levels of education had higher odds of being susceptible to tobacco products compared to students whose parents had not completed high school.²⁷ The current study found no associations between class membership and SES, except in the 9th grade model. Contradictory to the findings from the PATH study, 9th grade students reporting low SES compared to high SES were at increased odds of being in the “tobacco susceptible” class relative to the “no risk” class. Additionally, in the 9th grade model, students reporting low- and medium SES compared to high-SES were at decreased odds of being in the “tobacco ever use” class relative to the “tobacco susceptible” class. These results may suggest that youth in the high-SES class initiate tobacco use at a younger age compared to lower SES peers, but susceptibility to use in the future is still high for the low-SES group. Longitudinal analysis, including latent transition analyses, would be able to examine these relationships.

Strengths and Limitations

The current study utilizes a large, ethnically diverse population-based sample, which is about 50% Hispanic. Although representative of the sampling frame of Texas adolescents, it has limited generalizability beyond the study's urban Texas counties; however, TATAMS tobacco use rates are comparable to nationwide numbers.²⁷ As this is a cross-sectional analysis, we cannot make causal inferences, nor does this method demonstrate how participants transition between classes; future research should examine this. The use of the LCA method allows for participants to be grouped into classes of substance use based on structural relationships among the indicators variables as opposed to relying on *a priori* assumptions of how behaviors may cluster. LCA is not without its limitations though. Whereas the researcher should assess the optimal number of classes to have in the model based on fit statistics (eg, BIC, AIC), the researcher is provided some latitude to keep in mind a theoretical framework when choosing the best fit, which may introduce some subjectivity. Also, it ultimately relies on the researcher to interpret the meaning of the classes appropriately.¹³ The LCA model may have benefited from also including indicators

of alcohol and marijuana susceptibility and/or ever use; however, the TATAMS survey does not assess this. Lastly, the survey did not inquire about the nicotine content of the e-cigarettes used. It is possible some youth were using nicotine-free versions, which eliminates the addictive nature that may lead to sustained e-cigarette use and experimentation with other tobacco products, but not the exposure to other harmful and toxic constituents found in e-cigarettes.

Conclusions

This study is one of the first to identify profiles of polysubstance use across 3 grade levels, providing support for a stage-sequential model of onset and progression in tobacco and other drug use. Through these profiles, targets for intervention can be identified to prevent or reduce substance use. Future research should examine factors that influence transitions across these stages.

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Table 1

Demographics of Sample by Grade Level

	7 th grade (n = 765, N = 148,465)		9 th grade (n = 913, N = 160,080)		11 th grade (n = 1055, N = 152,524)	
	<i>a</i> n	Weighted Prevalence (%) (95% CI)	<i>a</i> n	Weighted Prevalence (%) (95% CI)	<i>a</i> n	Weighted Prevalence (%) (95% CI)
Sex						
Girls	448	48.8% (36.1–61.5)	499	48.9% (42.8–54.9)	609	49.0% (43.1–54.9)
Boys	317	51.2% (38.5–63.9)	414	51.1% (45.1–57.2)	446	51.0% (45.1–56.9)
Race/Ethnicity						
NH ^b Black	85	13.2% (8.8–17.6)	117	17.1% (10.3–24.0)	207	18.0% (11.8–24.1)
Hispanic	288	53.8% (44.8–62.8)	303	55.7% (44.0–67.4)	412	52.8% (43.7%–61.4)
NH ^b White/Other	392	33.0% (23.2–42.7)	493	27.2% (16.6–37.7)	436	29.5% (22.2–36.7)
Socio-economic status						
Very well off	166	22.7% (18.6–26.8)	176	14.0% (9.7–18.2)	120	9.0% (6.2–11.8)
Living comfortably	486	61.0% (55.6–66.4)	585	64.2% (56.2–72.1)	685	67.8% (62.9–72.7)
Just getting by/nearly poor/ poor	112	16.3% (13.7–19.0)	150	21.8% (15.0–28.7)	248	23.2% (19.3–27.1)

Note.

a: Unweighted sample size*b*: NH = Non-Hispanic

Table 2

Indicator Frequencies of Sample by Grade Level

	7 th grade (n = 765, N = 148,465)		9 th grade (n = 913, N = 160,080)		11 th grade (n = 1055, N = 152,524)	
	^a n	Weighted Prevalence (%) (95% CI)	^a n	Weighted Prevalence (%) (95% CI)	^a n	Weighted Prevalence (%) (95% CI)
Susceptible to combustible Tobacco	209	31.3% (27.8–34.8)	331	39.0% (33.5–44.5)	373	33.9% (29.8–37.9)
Susceptible to e-cigarettes	136	18.6% (15.2–22.0)	253	26.7% (22.0–31.3)	275	23.3% (19.6–27.1)
Ever tried combustible Tobacco	34	5.7% (1.8%–9.5)	118	16.8% (12.4–21.1)	299	29.3% (24.7–34.0)
Ever tried e-cigarettes	31	5.9% (2.3–9.5)	159	20.4% (15.0–25.7)	386	39.6% (33.8–45.3)
Past 30 day combustible Users	1	0.2% (0.0–0.7)	16	1.9% (0.7–3.1)	58	5.1% (3.2–7.0)
Past 30 day e-cigarettes	1	0.1% (0.0–0.2)	27	2.8% (1.1–4.5)	67	5.5% (3.8–7.1)
Past 30 day alcohol use	33	4.1% (1.9–6.4)	94	10.3% (7.1–13.5)	212	21.6% (17.7–25.5)
Past 14 day binge drinking	3	1.3% (0.0–3.1)	26	3.0% (0.5–5.5)	76	7.4% (5.6–9.3)
Past 30 day marijuana use	8	2.0% (0.0–4.3)	38	4.2% (1.9–6.4)	124	11.7% (8.7–14.7)

Note.

^a: Unweighted sample size

Table 3

Class Membership and Item-response Probabilities for 7th, 9th, and 11th Grade Models

7th grade	Class membership probabilities	No Risk	Tobacco Susceptible	Tobacco ever use	Tobacco ever use
	<i>Item response probabilities</i>				N/A
	Susceptible to combustible tobacco	16.9%	80.5%	--	--
	Susceptible to e-cigarettes	2.1%	75.5%	--	--
	Ever tried combustible tobacco	1.6%	19.5%	--	--
	Ever tried e-cigarettes	1.2%	22.3%	--	--
	Past 30 day combustible users	0.0%	1.0%	--	--
	Past 30 day e-cigarettes	0.0%	0.3%	--	--
	Past 30 day alcohol use	1.0%	14.8%	--	--
	Past 30 day binge drinking	0.0%	5.8%	--	--
	Past 30 day marijuana use	0.0%	9.0%	--	--
9th grade	Class membership probabilities	48.3%	37.8%	13.9%	N/A
	<i>Item response probabilities</i>				
	Susceptible to combustible tobacco	9.4%	86.9%	11.2%	--
	Susceptible to e-cigarettes	4.8%	60.3%	11.1%	--
	Ever tried combustible tobacco	2.6%	8.7%	87.6%	--
	Ever tried e-cigarettes	4.1%	16.1%	88.6%	--
	Past 30 day combustible users	0.0%	0.0%	13.5%	--
	Past 30 day e-cigarettes	0.0%	0.0%	20.0%	--
	Past 30 day alcohol use	1.2%	16.9%	24.2%	--
	Past 30 day binge drinking	0.0%	5.7%	6.3%	--
	Past 30 day marijuana use	0.0%	0.8%	27.7%	--
11th grade	Class membership probabilities	39.5%	26.1%	24.4%	9.9%
	<i>Item response probabilities</i>				
	Susceptible to combustible tobacco	12.1%	86.5%	22.3%	10.7%
	Susceptible to e-cigarettes	6.8%	71.2%	7.1%	2.9%
	Ever tried combustible tobacco	0.0%	8.1%	76.5%	85.8%
	Ever tried e-cigarettes	8.8%	19.3%	90.0%	91.4%

	No Risk	Tobacco Susceptible	Tobacco ever use	Tobacco ever use
Past 30 day combustible users	0.0%	0.0%	10.3%	25.8%
Past 30 day e-cigarettes	0.0%	0.0%	9.1%	32.4%
Past 30 day alcohol use	6.7%	19.8%	15.6%	100.0%
Past 30 day binge drinking	1.4%	3.6%	0.0%	59.8%
Past 30 day marijuana use	0.9%	1.4%	17.7%	67.1%

Note.

Item-response probabilities >60% in bold to facilitate interpretation of latent classes.

Estimated Odds Ratios of Class Membership Based on Demographics Comparing 'No Risk' Class versus Other Classes by Grade

Table 4

	7 th grade		9 th grade		11 th grade	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
No risk vs tobacco susceptible						
Girls vs Boys ^a	0.56	(0.36–0.87)	0.46	(0.28–0.74)	0.31	(0.16–0.61)
Hispanic vs NH ^b White/Other ^a	1.68	(1.10–2.56)	2.11	(1.27–3.49)	0.99	(0.53–1.86)
NH ^b Black vs NH ^b White/Other ^a	1.50	(0.60–2.56)	1.84	(0.65–5.23)	0.62	(0.28–1.38)
SES Low vs High ^a	1.62	(0.59–4.43)	3.25	(1.08–9.81)	1.51	(0.57–4.03)
SES Medium vs High ^a	1.74	(0.78–3.89)	2.12	(0.89–5.03)	1.67	(0.76–3.67)
No risk vs tobacco ever use						
Girls vs Boys ^a	--	--	0.66	(0.41–1.09)	0.46	(0.27–0.80)
Hispanic vs NH ^b White/Other ^a	--	--	2.12	(0.97–4.60)	0.97	(0.49–1.93)
NH ^b Black vs NH ^b White/Other ^a	--	--	0.74	(0.18–3.02)	0.54	(0.28–1.04)
SES Low vs High ^a	--	--	0.76	(0.32–1.82)	0.91	(0.37–2.22)
SES Medium vs High ^a	--	--	0.43	(0.13–1.43)	0.79	(0.33–1.92)
No risk vs all product use						
Girls vs Boys ^a	--	--	--	--	0.65	(0.34–1.25)
Hispanic vs NH ^b White/Other ^a	--	--	--	--	1.06	(0.55–2.05)
NH ^b Black vs NH ^b White/Other ^a	--	--	--	--	0.16	(0.05–0.53)
SES Low vs High ^a	--	--	--	--	2.44	(0.36–16.33)
SES Medium vs High ^a	--	--	--	--	2.44	(0.41–14.45)

Note.

Boldface indicates significance.

^a: reference category^b: NH = Non-Hispanic

Table 5

Estimated Odds Ratios of Class Membership Based on Demographics Comparing Tobacco Susceptible Class Versus Other Classes By Grade^a

	9 th grade	11 th grade
	OR (95% CI)	OR (95% CI)
Tobacco susceptible vs tobacco ever use		
Girls vs Boys ^a	1.45 (0.82–2.55)	1.50 (0.90–2.49)
Hispanic vs NH ^b White/Other ^a	1.01 (0.48–2.12)	0.98 (0.41–2.34)
NH ^b Black vs NH ^b White/Other ^a	0.40 (0.07–2.20)	0.87 (0.38–2.00)
SES Low vs High ^a	0.23 (0.06–0.97)	0.60 (0.20–1.78)
SES Medium vs High ^a	0.20 (0.05–0.82)	0.47 (0.18–1.25)
Tobacco susceptible vs all products		
Girls vs Boys ^a	--	2.11 (1.11–4.02)
Hispanic vs NH ^b White/Other ^a	--	1.07 (0.55–2.07)
NH ^b Black vs NH ^b White/Other ^a	--	0.25 (0.08–0.84)
SES Low vs High ^a	--	1.61 (0.29–8.87)
SES Medium vs High ^a	--	1.46 (0.22–9.76)

Note.

Boldface indicates significance.

^a: reference category

^b: NH = Non-Hispanic