

Dynamic Patterns of Adolescent Substance Use: Results From a Nationally Representative Sample of High School Students

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ABSTRACT. Objective: Use of tobacco, alcohol, marijuana, and other drugs increases during the high school years, yet little is known about individual patterns over time, particularly patterns of contemporaneous multiple-substance use. This study examined trajectories of contemporaneous substance use and how individual and social factors differentially predict patterns of substance use. **Method:** Longitudinal trajectories of substance use were examined in a nationally representative sample of students ($N = 2,512$) over a 3-year period (10th through 12th grades) using latent class analysis. Individual, parental, and peer risk factors in 10th grade were examined in relation to membership in trajectory classes. **Result:** A five-class model was identified: nonusers (45.5%); tobacco, alcohol, and other drug users (9.2%); alcohol and other drug users (9.2%); increasing multiple-substance users (16.7%); and decreasing multiple-substance users (19.4%). Depressive symptoms at baseline were associated with a higher likelihood of membership in all classes

except the increasing multiple-substance-user class, but the association becomes insignificant when social influence factors were adjusted. Parental-monitoring knowledge was associated with a lower likelihood of membership in all classes except increasing multiple-substance-user class, whereas perceived parental disapproval was associated with a lower likelihood of membership in the tobacco, alcohol, and other drug user class. Peer substance use was associated with a higher likelihood of membership in each of the substance use classes. **Conclusions:** The identified longitudinal profiles highlight the pervasiveness and dynamic patterns of contemporaneous multiple-substance use during 10th through 12th grades. Negative peer influence increased risk, whereas positive parenting behaviors decreased risk. The findings are consistent with the need to foster social influences and protective factors against adolescent substance use. (*J. Stud. Alcohol Drugs*, 76, 962–970, 2015)

RISK FACTORS AND CONSEQUENCES OF substance use have long been studied in relation to individual substances (e.g., tobacco, alcohol, marijuana, and other illicit drugs). However, many adolescents use multiple substances (Connell et al., 2009, 2010; Conway et al., 2013; Dierker et al., 2007; Whitesell et al., 2006). Measuring contemporaneous multiple-substance use is important because it accurately represents the experiences of many substance users and may be an important focus for risk factor identification and programmatic attention. Multiple-substance use is linked to

frequent substance use (Conway et al., 2013; Dierker et al., 2007), substance dependence (Whitesell et al., 2006), mental and physical health problems (Conway et al., 2013; Kandel et al., 1986), and many high-risk behaviors, including sexual risk taking (Connell et al., 2009), weapon carrying, assault, and unsafe driving behaviors (e.g., nonuse of seatbelts and speeding) (Baskin-Sommers & Sommers, 2006). The following analysis addresses gaps in the existing literature by identifying trajectories of substance use over time and their associated risk factors on adolescent substance use.

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Patterns of substance use

Prior cross-sectional studies have consistently identified four to five distinct patterns of substance use among high school students. In previous analyses of the baseline of the longitudinal data analyzed in the current study, Conway and colleagues (2013) used a nationally representative sample of 10th-grade students and found four patterns (“classes”) of users: majority nonusers, alcohol users, marijuana users, and polysubstance users (e.g., alcohol, tobacco, marijuana, and other illicit drug use). Four other studies using national and local samples found four or five classes of substance users, with a consistent finding of a polysubstance-user class using alcohol, tobacco, marijuana, and/or other drugs (Connell et al., 2010; Cranford et al., 2013; Dierker et al., 2007; Lamont et al., 2014; Whitesell et al., 2006). These studies were limited to cross-sectional analysis. Previous studies examining longitudinal changes in adolescent substance use have considered one substance at a time (e.g., Dauber et al., 2011; Dierker et al., 2007; Donovan & Molina, 2013; Huang et al., 2012), an index of substance use (e.g., Chassin et al., 2004; Donovan & Molina, 2013), or the combination of tobacco and alcohol concurrent with symptoms of psychiatric distress (Green et al., 2013). Thus, the extent, stability, and risk factors remain unclear for contemporaneous multiple-substance use.

Individual and social risk factors

Key predictors of substance use among adolescents and emerging adults include individual-, peer-, and parent-related factors (Stone et al., 2012). Although prior findings are not always consistent, and bidirectional in nature, studies have shown that teens who have depressive symptoms are at higher risk for substance use, dependence, and multiple-substance use (Conway et al., 2013; Costello et al., 1999; Fleming et al., 2008; Hussong et al., 1998; King et al., 2004; Loeber et al., 1998; Marmorstein et al., 2010; Sihvola et al., 2008; Stice et al. 1998). Associating with peers who use substances has also been related to initiation, greater use (D’Amico & McCarthy, 2006), and multiple-substance use (Lamont et al., 2014). Finally, positive parenting practices (e.g., responsiveness, monitoring, setting expectations for nonuse) and family relationships have all been associated with delayed or reduced substance use (Avenevoli et al., 2005; Ryan et al., 2010). The association among such predictors and longitudinal trajectories characterized by multiple-substance use is largely unknown.

Current study

The first aim of the current study was to extend previous research by examining trajectories of contemporaneous substance use over a 3-year period (10th to 12th grades) in a

nationally representative sample of U.S. youth. Our second aim was to examine how individual and social factors differentially predict membership in each substance use–trajectory class.

Method

Sample

The NEXT Generation Health Study is a longitudinal study of a cohort of 10th-grade U.S. students beginning in spring 2010. The Institutional Review Board of the Eunice Kennedy Shriver National Institute of Child Health and Human Development approved the study protocol. Further details about school and student recruitment have been reported previously (Conway et al., 2013). We recruited a nationally representative cohort of U.S. students in 10th grade using a multistage stratified design and oversample of African American students. A total of 80 schools of 137 (58%) agreed to participate. Students completed questionnaires in spring 2010 (10th grade), 2011 (11th grade), and 2012 (12th grade). The retention rate from Wave 1 to Wave 3 was 86%.

Measures

Substance use. Substance use was measured at each of the three waves of the study. Past-month substance use was reported for cigarette smoking and alcohol use utilizing a 7-point scale (1 = *never*, 2 = *once or twice*, 3 = *3–5 times*, 4 = *6–9 times*, 5 = *10–19 times*, 6 = *20–39 times*, 7 = *≥40 times*). Past-month heavy episodic drinking (HED), or “binge” drinking, was assessed by asking how many times in the past month the participant had four or more (females) drinks or five or more (males) drinks in a row on an occasion. HED was reported using a 6-point scale (1 = *none*, 2 = *once*, 3 = *twice*, 4 = *3–5 times*, 5 = *6–9 times*, 6 = *≥10 times*). For other drug use, participants reported past-year use of marijuana, medication to get high, and other illicit drugs (Ecstasy [3,4-methylenedioxymethamphetamine; MDMA], amphetamines, opiates, cocaine, glue or solvents, LSD [lysergic acid diethylamide], and anabolic steroids) on a 7-point scale (1 = *never*, 2 = *once or twice*, 3 = *3–5 times*, 4 = *6–9 times*, 5 = *10–19 times*, 6 = *20–39 times*, 7 = *≥40 times*).

Responses for substance use (smoking, drinking, and other drug use) were coded into three ordinal variables (representing “no use,” “infrequent use,” and “frequent use”) at each of the three waves, resulting in nine outcome variables in total. Smoking was coded as *never*, *once or twice*, or *more than three times*. Alcohol and HED were combined into one drinking outcome because they are highly correlated ($\alpha = .81, .79, \text{ and } .84$ for the 3 years). Drinking was coded *none* if both alcohol and HED were *never/none*, *frequent* if either alcohol was used more than three times or HED occurred

more than two times, and *infrequent* otherwise. Marijuana, medication, and other drug use were combined into one drug-use variable because of their low prevalence (ranging from 0.9% for glue or solvents to 5.6% for medication to get high in the 10th grade). Drug use was coded *none* if no marijuana/medication/other drug use was reported; *frequent* if any marijuana, medication, or other drugs were used more than three times; and *infrequent* otherwise. The decision to reduce the substance use variables to a trichotomy (no use, infrequent use, and frequent use) was a balance of preserving the higher end of the distribution while managing variables with skewed distributions.

Individual risk factors. Individual predictors assessed at baseline (10th grade, or 11th grade if they missed the whole survey in 10th grade) include self-perceptions of health, depressive symptoms, and somatic symptoms. Self-perception of health was assessed with one item: asking participants to rate their health as excellent, good, fair, or poor (1 = *excellent*, 4 = *poor*). Responses of *fair* and *poor* were combined into one level because of the low prevalence of those reporting poor health (Table 1). On a 5-point scale (1 = *never*, 2 = *seldom*, 3 = *sometimes*, 4 = *often*, 5 = *always*), respondents reported how often they experienced the following six items over the past 30 days: feeling very sad, feeling grouchy/irritable or in a bad mood, feeling hopeless about the future, feeling like not eating or eating more than usual, sleeping a lot more or a lot less than usual, and difficulty concentrating on schoolwork. Responses were averaged to indicate depressive symptoms (Dahlberg et al., 2005) ($\alpha = .82$). For somatic symptoms (Hetland et al., 2002), respondents reported how often they endorsed the following four items over the past 6 months: having a headache, having a stomachache, having a backache, and feeling dizzy (1 = *rarely or never*, 2 = *about every month*, 3 = *about every week*, 4 = *more than once a week*, 5 = *about every day*). Responses were averaged to measure somatic symptoms ($\alpha = .81$).

Parenting practices. Baseline parenting practices include parental-monitoring knowledge and disapproval for substance use, both assessed at baseline. Parental-monitoring knowledge was assessed using questions adapted from a validated five-item scale (Brown et al., 1993). Adolescents reported their perceptions of their mother's and (on separate items) father's monitoring knowledge about their activities including who their friends were, how they spent their money, where they were after school, where they went at night, and what they did with their free time. Response options included the following: 1 = *don't have/see father or mother/guardian*; 2 = *he/she doesn't know anything*; 3 = *he/she knows a little*; 4 = *he/she knows a lot*. Higher scores reflect higher levels of parental-monitoring knowledge. Scores were averaged for each parent across the five items and then averaged across parents ($\alpha = .83$ for mothers, $\alpha = .95$ for fathers).

Perceived parental disapproval of substance use was measured using items adapted from prior studies (Hartos

TABLE 1. Description of the sample and baseline covariates ($N = 2,512$)

Variable	Percentage (SE)
Gender ($n = 2,512$)	
Male	45.5 (1.7)
Female	54.5 (1.7)
Race ($n = 2,512$)	
White	57.1 (5.4)
African American	19.2 (3.9)
Hispanic	18.6 (3.5)
Other	5.0 (1.0)
Parental education ($n = 2,512$)	
Low	33.0 (2.8)
Medium	27.2 (1.6)
High	39.8 (3.2)
Family structure ($n = 2,356$)	
Both parents	52.2 (2.3)
Other	47.8 (2.3)
Self-perception of health ($n = 2,509$)	
Excellent	17.5 (1.7)
Good	53.3 (2.2)
Fair/poor	29.2 (2.0)
	Weighted mean (SE)
Depressive symptoms ($n = 2,508$)	2.33 (0.03)
Somatic symptoms ($n = 2,508$)	2.11 (0.06)
Parental-monitoring knowledge ($n = 2,509$)	3.23 (0.03)
Parental disapproval ($n = 2,509$)	6.02 (0.06)
Peer substance use ($n = 2,452$)	1.64 (0.05)

et al., 2000; Hetherington, 1992). Participants were asked how important it is to his/her parents/guardians that you do not use alcohol, do not smoke cigarettes, and do not use marijuana (with response options from 1 = *not at all* to 7 = *extremely*). The three items were averaged to create a measure of perceived parental disapproval, with higher scores reflecting higher levels of parental disapproval ($\alpha = .93$).

Peer substance use. At baseline, teens were asked to think of their five closest friends and report the frequency that their five closest friends drink alcohol, get drunk, smoke cigarettes, smoke/use marijuana, and take other drugs. On a 5-point scale, response options ranged from *never* to *almost always*. Responses to the five items were averaged to create a measure of peer substance use ($\alpha = .85$).

Demographic covariates. Baseline demographic variables included the following: gender; race/ethnicity (White, African American, Latino, other); parental education as reported by the parent during the consent process (lower than high school, some college or technical school, bachelor's or graduate degree); and family structure (living with both biological parents; living with others, such as a step-parent).

Analysis

Latent class analyses (LCA) were performed to examine the patterns of the substance use outcomes (smoking, drinking, and other drug use) over time. The LCA was adjusted for gender, race/ethnicity, and parental education. Maximum

likelihood estimates of the item response probabilities of each outcome were calculated, characterizing the profile of the latent classes. To determine a reasonable number of latent classes, we fit separate LCA models with and without covariates specifying different number of classes. The model fit indexes were examined including Akaike Information Criterion (AIC; Akaike, 1987), Bayesian Information Criterion (BIC; Schwarz, 1978), and sample-size-adjusted BIC (Sclove, 1987). Smaller AIC and BIC values suggest a better model fit. When the model fit indexes disagreed, preference was given to more parsimonious models and models with clearer interpretation. We then computed the posterior membership probabilities for each adolescent and assigned them to the latent class with the highest probability.

To examine the association between class membership and individual and social factors, we first tabulated the summary statistics of risk factors within each class. Then the association was estimated by multinomial logistic regressions of class membership on the risk factors, adjusting for demographic covariates. Sequential models were tested. Individual factors were included first, and then parenting practices and perceptions of peer substance use were added incrementally. This allowed us to examine and compare the independent effects of different risk factors. Exponentiated regression coefficients were interpreted as the increase in the odds of being in one class relative to the reference class per unit increase in a risk factor while other variables were held fixed.

The LCA was performed in Mplus (Version 7; Muthén & Muthén, 2011), and the multinomial logistic regression was fitted in SAS SURVEYLOGISTIC procedure Version 9.3 (SAS Institute Inc., Cary, NC). Analyses accounted for the complex survey sampling design, including a longitudinal sampling weight to account for nonresponse. LCA can handle missing responses by specifying a missing-at-random assumption (Bollen & Curran, 2006), meaning that the missingness of substance use information was explained by the observed variables only. Subjects with missing covariates were excluded, and the size of analysis sample in LCA was $n = 2,512$. Subjects with missing covariates were excluded in the multinomial logit model, resulting in the analysis sample of $n = 2,316$ in the model that adjusts for all the risk factors.

Results

Model fitting and description of trajectory classes

Summary statistics of the sample and baseline covariates are reported in Table 1. To determine the best model, we examined model fit statistics for different numbers of latent classes. The information criteria indices were discrepant; models with five to nine classes were all feasible candidates. We further examined each of the models and found that models with more than five classes all identified latent class-

es with relatively rare prevalence (about 5%), which would not add substantial interpretive value. Therefore, we chose a five-class model based on its interpretability. With the exception of the nonusers, all of the classes demonstrated contemporaneous multiple-substance use. Thus, the class labels are designed to emphasize the predominant substances or pattern of substance use over time. The five classes, which are described in Table 2 and Figure 1, were labeled as follows: tobacco, alcohol and other drug users ("Class 1-TAD"), predominantly alcohol and other drug users ("Class 2-AD"), increasing multiple-substance users ("Class 3-TAD+"), decreasing multiple-substance users ("Class 4-TAD-"), and nonusers ("Class 5-nonusers"). Figure 1 shows the level of smoking, drinking, and other drug use at each grade for each of the five classes. The first panel shows the proportion of youth using frequency, infrequency, or not at all for each grade and type of substance for Class 1-TAD. Comparing Class 1-TAD and Class 2-AD illustrates that a much higher proportion of adolescents in Class 1-TAD used tobacco at all three grades (nearly all by the 12th grade), whereas in Class 2-AD, approximately half or fewer used tobacco at each of the three grades.

Class 1-TAD (9.2% of the sample) had high and increasing rates of smoking, as well as moderate to high drinking and drug use at all three waves, with a peak in 11th grade (Figure 1). Class 2-AD (9.2%) had moderate levels of smoking and high levels of alcohol use at all three waves, and a decline in drug use from 10th to 12th grades. Class 3-TAD+ (16.7%) had relatively low levels of smoking and drug use, moderate levels of alcohol use, and increasing rates of use for all three types of substances across the three waves, especially from 11th to 12th grades. Class 4-TAD- (19.4%) had relatively low levels of smoking, moderate levels of alcohol and other drug use, and decreasing rates of use for all three types of substances, with a notable decrease in alcohol and other drug use from 10th to 11th grades. Class 5-nonusers (45.5%) had consistently very low rates of smoking, drinking, and other drug use at all three waves, with a slight increase in moderate alcohol use by the third wave.

Table 2 reports the distribution of demographic characteristics and other covariates by class. Females were less likely than males to be in Classes 1-TAD, 2-AD, and 4-TAD-. Compared with White students, African Americans were less likely to be in Class 1-TAD and Class 3-TAD+ but were more likely to be represented in Class 4-TAD-. All the covariates have significant unadjusted association with the class membership at the .05 significance level.

Individual and social risk factors

Table 3 presents individual and social risk factors predicting membership in each of the four substance-user classes in comparison with the nonuser class. In Model 1, with individual risk factors only, depressive symptoms

TABLE 2. Weighted percentage (*SE*) of five substance use–trajectory classes by each categorical covariate, and weighted mean (*SE*) for continuous covariates in five substance use–trajectory classes

Variable	Class 1 Tobacco, alcohol, and other drug users, 9.2% (<i>n</i> = 230)	Class 2 Alcohol and other drug users, 9.2% (<i>n</i> = 230)	Class 3 Increasing multiple-substance users, 16.7% (<i>n</i> = 420)	Class 4 Decreasing multiple-substance users, 19.4% (<i>n</i> = 488)	Class 5 Nonusers, 45.5% (<i>n</i> = 1,144)
Gender, % ^a					
Male	10.4 (3.3)	11.7 (2.6)	16.5 (2.3)	20.8 (2.4)	40.6 (2.8)
Female	8.1 (1.1)	7.0 (1.3)	16.9 (1.5)	18.3 (1.7)	49.7 (2.6)
Race, %					
White	12.2 (1.4)	10.7 (2.6)	24.5 (2.2)	9.3 (1.1)	43.3 (2.5)
African American	0.0 (–)	8.0 (2.2)	6.0 (1.3)	32.2 (3.5)	53.9 (3.9)
Hispanic	5.7 (2.5)	6.7 (1.4)	4.3 (1.2)	38.0 (3.7)	45.3 (6.0)
Other	23 (12.8)	5.4 (3.2)	15.2 (2.8)	16.3 (5.0)	40.2 (13.3)
Parental education, %					
Low	14.3 (3.2)	4.5 (1.3)	13.4 (2.2)	27.6 (3.2)	40.2 (4.6)
Medium	10.9 (2.4)	5.4 (1.5)	14.1 (2.1)	20.2 (2.5)	49.4 (3.8)
High	3.7 (1.0)	15.6 (3.5)	21.2 (1.9)	12.1 (1.5)	47.3 (3.4)
Family structure, %					
Both biological parents	6.5 (1.0)	8.9 (2.0)	19.5 (1.8)	15.2 (2.0)	49.9 (2.6)
Other	12.6 (3.7)	9.5 (1.9)	14.2 (1.8)	22.5 (1.4)	41.2 (3.4)
Self-perception of health, %					
Excellent	3.6 (0.9)	10.8 (2.4)	19.0 (2.3)	18.1 (4.0)	48.4 (3.4)
Good	8.5 (1.9)	8.5 (2.5)	18.6 (2.1)	17.0 (1.8)	47.5 (2.8)
Fair/poor	13.8 (3.7)	9.4 (2.3)	11.9 (2.2)	24.7 (2.4)	40.1 (3.9)
Depressive symptoms, <i>M</i>	2.74 (0.12)	2.46 (0.08)	2.29 (0.07)	2.48 (0.07)	2.18 (0.04)
Somatic symptoms, <i>M</i>	2.65 (0.11)	2.31 (0.13)	2.12 (0.07)	2.14 (0.09)	1.94 (0.04)
Parental-monitoring knowledge, <i>M</i>	2.99 (0.12)	3.05 (0.07)	3.32 (0.05)	3.03 (0.05)	3.37 (0.04)
Parental disapproval, <i>M</i>	4.80 (0.24)	5.44 (0.28)	6.22 (0.11)	5.90 (0.07)	6.37 (0.10)
Peer substance use, <i>M</i>	2.90 (0.11)	2.45 (0.09)	1.53 (0.04)	1.77 (0.06)	1.21 (0.02)

^aRow percentages by class.

were associated with membership in Classes 1-TAD, 2-AD, and 4-TAD-. The association with membership in Class 3-TAD+ was also positive but marginally significant. Somatic symptoms were significantly associated with Classes 1-TAD and 2-AD. After we adjusted for parental risk factors (Model 2), depressive and somatic symptoms remained significant for some latent classes, but effect sizes were slightly reduced. Parental-monitoring knowledge and perceived parental disapproval were protective for substance use. After we adjusted for peer risk factors (Model 3), depressive and somatic symptoms became nonsignificant, although the direction of association remained the same. The protective effect of parental factors was reduced. Parental-monitoring knowledge was associated with lower likelihood of membership in all substance-user classes except Class 3-TAD+, whereas parental disapproval was associated with lower likelihood of membership in Class 1-TAD. Peer substance use was strongly associated with a higher likelihood of membership in any of the substance-user classes (odds ratios ranging from 2.96 to 11.20; Table 3).

We refit Models 1–3 with Class 1-TAD as the reference class (data not shown). In the fully adjusted Model 3, Classes 2-AD, 4-TAD-, and 5-nonusers all reported higher levels of perceived parental disapproval at baseline compared with Class 1-TAD. All classes, except Class 3-TAD+, reported less peer substance use in comparison with Class 1-TAD.

Discussion

This study advances cross-sectional and longitudinal research by reporting patterns of stability and change of multiple-substance use over time in a nationally representative sample of high school students. In contrast to the largest class of nonusers, with largely invariable nonuse over the three study waves, Class 1 (tobacco, alcohol, and other drug users) and Class 2 (alcohol and other drug users)—distinguished mainly by tobacco use—had relatively high and stable use of alcohol and other drugs across the three waves. Given that together these two classes represent a fifth of the sample, this is a worrisome pattern of stable multiple-substance use. Class 3 (decreasing multiple-substance users) may represent a group of early experimenters who did not progress into regular users. Increasing multiple-substance users were another fifth of the sample. Both Class 3 (increasing multiple-substance users) and Class 4 (decreasing multiple-substance users) had moderate levels of substance use throughout all 3 years of the study; however, they had different patterns of change and different peak years of substance use. Future research could examine decreasing and increasing multiple-substance users to see if the trends in substance use persist after high school. Longitudinal risk factors associated with the change in substance use are worthy of future investigation.

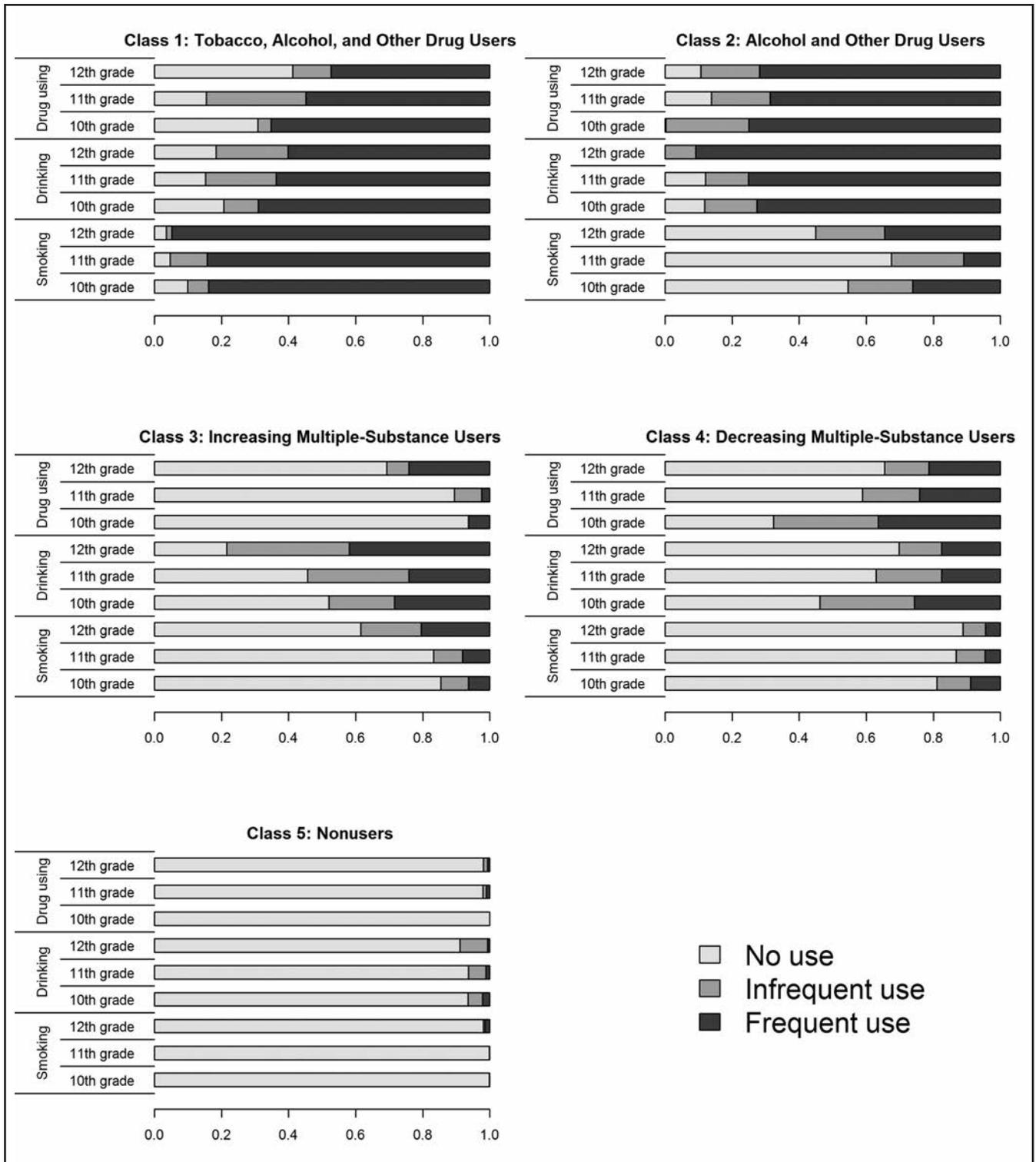


FIGURE 1. Item response probabilities of five latent classes

TABLE 3. Multinomial logistic regression of individual, parental, and peer risk factors predicting membership in substance use–trajectory classes as compared with nonusers ($n = 2,316$)

Variable	Class 1 Tobacco, alcohol, and other drug users OR [95% CI]	Class 2 Alcohol and other drug users OR [95% CI]	Class 3 Increasing multiple- substance users OR [95% CI]	Class 4 Decreasing multiple- substance users OR [95% CI]
Model 1: Individual risk factors ($n = 2,354$) ^a				
Self-perception of health				
Excellent	1.0 (ref.)	1.0 (ref.)	1.0 (ref.)	1.0 (ref.)
Good	1.82 [0.62, 5.36]	0.80 [0.32, 2.02]	1.00 [0.59, 1.69]	0.87 [0.50, 1.53]
Fair/poor	2.86 [0.73, 11.24]	1.19 [0.49, 2.91]	0.84 [0.44, 1.61]	1.18 [0.59, 2.33]
Depressive symptoms	1.92 [1.06, 3.47]	1.60 [1.08, 2.38]	1.27 [0.91, 1.78]	1.50 [1.12, 2.01]
Somatic symptoms	1.80 [1.18, 2.74]	1.54 [1.09, 2.18]	1.15 [0.91, 1.45]	1.25 [0.98, 1.59]
Model 2: Individual and parental risk factors ($n = 2,351$)				
Self-perception of health				
Excellent	1.0 (ref.)	1.0 (ref.)	1.0 (ref.)	1.0 (ref.)
Good	1.96 [0.63, 6.15]	0.84 [0.33, 2.14]	1.00 [0.60, 1.68]	0.88 [0.50, 1.58]
Fair/poor	2.34 [0.61, 8.98]	1.11 [0.45, 2.71]	0.81 [0.43, 1.52]	1.11 [0.56, 2.21]
Depressive symptoms	1.63 [0.86, 3.09]	1.39 [0.95, 2.04]	1.20 [0.86, 1.69]	1.37 [1.01, 1.85]
Somatic symptoms	1.68 [1.10, 2.58]	1.49 [1.02, 2.17]	1.14 [0.91, 1.44]	1.25 [0.98, 1.59]
Parental-monitoring knowledge	0.43 [0.25, 0.76]	0.38 [0.24, 0.63]	0.65 [0.40, 1.08]	0.55 [0.33, 0.90]
Parental disapproval	0.63 [0.55, 0.73]	0.74 [0.61, 0.89]	0.90 [0.79, 1.04]	0.86 [0.76, 0.97]
Model 3: Individual, parental, and peer risk factors ($n = 2,316$)				
Self-perception of health				
Excellent	1.0 (ref.)	1.0 (ref.)	1.0 (ref.)	1.0 (ref.)
Good	3.11 [0.70, 13.86]	0.94 [0.32, 2.71]	1.07 [0.64, 1.77]	0.99 [0.56, 1.73]
Fair/poor	3.30 [0.78, 13.98]	1.18 [0.44, 3.22]	0.82 [0.41, 1.63]	1.16 [0.57, 2.36]
Depressive symptoms	1.53 [0.85, 2.75]	1.36 [0.92, 2.01]	1.20 [0.84, 1.71]	1.31 [0.99, 1.74]
Somatic symptoms	1.49 [0.86, 2.59]	1.36 [0.89, 2.09]	1.09 [0.89, 1.35]	1.17 [0.93, 1.48]
Parental-monitoring knowledge	0.53 [0.37, 0.77]	0.48 [0.26, 0.89]	0.69 [0.41, 1.19]	0.57 [0.36, 0.92]
Parental disapproval	0.71 [0.59, 0.85]	0.83 [0.68, 1.00]	0.94 [0.82, 1.07]	0.90 [0.80, 1.02]
Peer substance use	11.20 [7.16, 17.52]	9.70 [6.49, 14.51]	2.96 [2.30, 3.80]	4.87 [3.23, 7.33]

Notes: OR = odds ratio; CI = confidence interval; ref. = reference. ^aAll three models controlled for gender, race, family structure, and parental education. Nonusers are the reference class. Results in **bold** are statistically significant at $p < .05$.

The current study showed not only that all classes of substance users engaged in multiple-substance use, but also that a sizeable proportion consistently used multiple substances throughout the high school years. One of the distinguishing features of Class 1 (the tobacco, alcohol, and other drug user class) is the high proportion who reported smoking cigarettes, which was relatively uncommon in other classes. Not only did Class 1-TAD have high rates of using all three categories of substances, they also had relatively high frequency of use of each substance. This pattern may contribute to increased risk for the development of substance use dependence (Whitesell et al., 2006) and other problematic outcomes (Connell et al., 2009; Conway et al., 2013), to be explored in future work with this cohort.

Depressive and somatic symptoms at baseline were consistent with increased substance use risk, although not significant in every case. After we adjusted for parenting practices, depressive symptoms remained significantly related to membership in Class 4 (the decreasing multiple-substance users) but not to Class 1 (tobacco, alcohol, and other drug users) or Class 5 (increasing multiple-substance use). When we adjusted for peer influence, the association of depressive symptoms is attenuated and insignificant for all classes. This suggests a complex and heterogeneous associa-

tion among internalizing symptoms and substance use risk (e.g., Fleming et al., 2008; Hawkins et al., 1992; Hussong et al., 1998; Sihvola et al., 2008). The findings point to a need for additional research to clarify how parental and peer influences and depressive symptoms are related to adolescent substance use over time.

Parenting practices were consistently protective predictors of each of the substance use trajectories in comparison with nonusers. This is consistent with literature reviews that have found higher parental monitoring and perceived parental disapproval to be consistently related to lower substance use in adolescence and emerging adulthood (Hawkins et al., 1992; Stone et al., 2012). Through frequent and effective communication, parents can be informed about their teenage children's whereabouts, friendships, and activities, thus exerting a protective influence even when not present (Kerr & Stattin, 2000).

Not surprisingly, peer substance use was a strong predictor for every class, consistent with the substantial literature on the topic (Simons-Morton & Farhat, 2010). Peer influence can be important to the extent that peers support or discourage substance use, make substances available, and represent social norms with respect to use (Hawkins et al., 1992; Simons-Morton & Farhat, 2010). Perceived parental

disapproval and peer substance use also distinguished Class I (tobacco, alcohol, and other drug users) from most other substance-user classes. Thus, lower parental disapproval and peer substance use are not only associated with any pattern of substance use, but they are also associated with the heaviest and riskiest pattern of substance use.

Strengths and limitations

Several limitations of the current study should be noted. First, as with any LCA, there is no gold standard for the latent classes. The classes identified from a model describe the clustering pattern of the outcome variables and are subject to misclassification. The profiles of substance use patterns identified in LCA need to be confirmed with different studies and samples, but the overlap with findings from cross-sectional research is reassuring nonetheless.

Second, the substance use measures were assessed annually using either past-month or past-year time references, and more frequent assessments might be needed to clearly distinguish trajectory patterns. In addition, the measures assessed concurrent or contemporaneous use of multiple substances but do not distinguish co-ingestion or simultaneous use of multiple substances from contemporaneous use (McCabe et al., 2006, 2012). This is an important topic to be explored by future research.

Third, this study was limited to the risk factors available. For example, we were not able to include externalizing behaviors as predictors of class membership, which are consistently associated with substance use. Family history of substance use disorders and psychopathology are also well-established risk factors for substance use problems, although this analysis was unable to take these factors into account (Avenevoli et al., 2005). The peer and parental factors were self-reported by the participant rather than actual reports from those individuals, thereby introducing the potential for reporting bias. In addition, the study would benefit from more refined measures of peer influence (e.g., injunctive norms, peer pressure, exposure to peer substance use) to determine what aspect of peer substance use is particularly influential.

Despite these limitations, there are notable strengths including a relatively large, nationally representative sample of adolescents surveyed longitudinally over 3 years and a focus on multiple substances. Using these rich data, this study was able to examine trajectories of substance use over time and relate individual and social risk factors to trajectory class membership.

Conclusions

The study findings highlight the heterogeneity and variability of substance use patterns over time among high school students. Of particular concern is the pattern of per-

vasive, heavy, and consistent multiple-substance uses that is characteristic of many students in this nationally representative sample. Peer substance use and parenting behaviors were associated with membership in substance-user classes, suggesting the need for interventions that would alter peer norms and increase parental-monitoring knowledge and parental disapproval for substance use.

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