

# Transitions in Current Substance Use from Adolescence to Early-Adulthood

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**Abstract** Substance use behaviors do not occur in isolation of one another and are not static over time. As adolescents age into early adulthood, there may be dynamic changes in their substance use behaviors, and these changes may be influenced by family and school factors. The current study uses Latent Transition Analysis to examine these changes by measuring transitions among different substance use profiles based on past 30-day alcohol, tobacco and marijuana use, and by estimating associations with demographic, family and school factors. Data were from youth ( $n = 850$ ; 80 % African American, 17 % white, 3 % mixed race, 50 % female and 50 % male) in grade 10 (Time 1), with 24- (Time 2) and 48-month (Time 3) follow-ups. Substance use profiles included Non-users (54 %), Alcohol and Marijuana Users (20 %), and Alcohol, Tobacco and Marijuana Users (26 %). There were considerable transitions among profiles from Time 1 to Time 2, and fewer transitions from Time 2 to Time 3. At Time 1, African American race and positive school attitudes were negatively associated with being an Alcohol and Marijuana User, and being an Alcohol, Tobacco and Marijuana User. Family conflict, parental school involvement, female gender and African American race were associated with

transitions among substance use profiles. Implications are discussed for a better understanding of transitions in substance use profiles, and for promoting maintenance of non-use and transitions from substance using profiles to non-use.

**Keywords** Alcohol · Tobacco · Marijuana · Substance use · Youth · Longitudinal

## Introduction

Youth substance use remains a major public health priority. In 2012, 26, 11 and 15 % of 12–17 year olds reported past 30-day alcohol, tobacco and marijuana use, respectively (Johnston et al. 2013), with higher estimates for 18–25 year olds (U.S. DHHS 2012). These substances are implicated in many adverse health and social consequences (McGinnis and Foege 1999; Squeglia et al. 2009), and their use during adolescence has been linked with habitual use later in life (The National Center on Addiction and Substance Abuse 2012). African American youth report lower rates of alcohol and tobacco use (but not marijuana use) as compared to youth of other races/ethnicities (Johnston et al. 2013), yet experience a disproportionate burden of substance use related consequences such as incarceration (Kakade et al. 2012) and school dropout (Townsend et al. 2007). In this article, we aimed to understand factors associated with transitions in substance use over time. We analyzed data from a high-risk sample consisting primarily of African American youth to estimate transitions among different profiles of alcohol, tobacco and marijuana use. We also identified family and school factors associated with the transitions from adolescence to early-adulthood, a period

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that can bring considerable role instability and accompanying stress (Arnett 2004).

### Transitions in Profiles of Substance Use

Substance use behaviors tend to cluster dynamically over time. Adolescent populations can consist of various profiles of substance users such as Non-users, single substance users and poly-substance users (Cleveland et al. 2010; Vaughn et al. 2013). For example, when examining adolescent alcohol, tobacco and marijuana use one study found Non-users, tobacco only users, and alcohol, tobacco and marijuana users as prominent profiles (Cleveland et al. 2010). Another study found profiles that included low users, alcohol only users, tobacco only users, alcohol and marijuana users, and users of all three substances (Dierker et al. 2007). Similar findings have been reported in analyses of substance use patterns among Native American youth (Mitchell and Plunkett 2000). These findings support a profile-based approach to studying substance use during adolescence, but the types of profiles that were identified were inconsistent. In addition, youth may also transition over time from non-use to using, from one profile of use (e.g., using marijuana and alcohol) to another (e.g., avoiding marijuana but continuing to use alcohol only), from using to non-use, and the like (Steinman and Schulenberg 2003). Approaches that account for the correlation among different substance use behaviors and transitions from one substance use profile to another can allow for a more faithful representation of substance use compared to examining each behavior separately and statically (Steinman and Schulenberg 2003).

Although many studies have examined the sequencing (Howell et al. 2012; Kandel 2002) and trajectories of substance use (Chassin et al. 2004; Hix-Small et al. 2004; Jackson et al. 2002; Kandel 2002; Spoth et al. 1999), only a few have examined transitions across different substance use profiles (Lanza et al. 2010; Maldonado-Molina and Lanza 2010; Spoth et al. 1999). Lanza et al. (2010), for example, followed college freshmen and identified four profiles with notable transitions within a single year such as from being cigarette smokers to bingers with marijuana use (19 %), and from bingers with marijuana use to Non-users (6 %). Maldonado-Molina and Lanza (2010) examined a 1-year period using data from the Longitudinal Study of Adolescent Health. They also identified several substance use profiles with most notable transitions being cigarette only users at Time 1 transitioning to drunkenness and advance-stage drug users at Time 2. Research that identifies transitions in substance use profiles from adolescence to early-adulthood, and one that identifies associated risk and protective factors can inform interventions that aim to maintain non-use profiles, and promote transitions from a

substance using to a non-using profile (Steinman and Schulenberg 2003).

### Family and School Factors, and Transitions in Substance Use

In the analysis to identify risk and protective factors associated with substance use profiles and transitions several theoretical perspectives guided the current study. Socio-ecological (Bandura 1991; Bronfenbrenner 1979) and eco-developmental perspectives (Szapocznik and Coatsworth 1999) broadly guided the study. They emphasize the role of context and developmental transitions over time including the family and school contexts in health behaviors during youth and adolescence. Additionally, the current study was informed by Social Bond (Hirschi 1969) and Self-Control Theories (Gottfredson and Hirschi 1990), which postulate that the strength of bonds adolescents have with their family and school can influence substance use behaviors (Durkin et al. 1999; Hay 2001; Hirschi 2004). With regard to family factors for example, studies have shown that low family conflict (Loke and Mak 2013; Ryan et al. 2010), high parental support (Branstetter et al. 2011), and high parent school involvement (Cordova et al. 2013) protect adolescents from initiating substance use and promote non-use (Vakalahi 2001). Equally important are school protective factors such as school connectedness (Bond et al. 2007), prominence of school in an adolescent's life (Bryant et al. 2003), perceived self-efficacy to do well in school, and positive attitudes towards school and teachers (Brooks et al. 2012). However, it is unclear how these family and school factors are associated with *transitions* among different profiles of substance use from adolescence to early-adulthood. For example, it is not well understood how these factors influence transitions from substance using profiles to non-use, transitions into using more substances, and maintenance of substance use during this developmental period, which can often involve significant social and role change, vulnerability and stress.

### Latent Transition Analysis

We used Latent Transition Analysis, a longitudinal extension of Latent Class Analysis that is relatively underused in research on youth substance use (Collins and Lanza 2013; Hyatt and Collins 2000; Lanza et al. 2010). Latent Transition Analysis longitudinally extends the measurement model of Latent Class Analysis, which assumes that a set of variables (e.g., measuring different substance use behaviors) can be represented by an underlying grouping structure in which members of a latent class (i.e., profile) have common patterns of behaviors. In Latent Transition Analysis, changes in latent class (called latent *status* in

Latent Transition Analysis) membership over time are modeled via estimating transition probabilities. In addition, Latent Transition Analysis can estimate associations between individual characteristics and latent status membership, as well as factors associated with transition probabilities. This statistical approach offers powerful tools to estimate transitions in substance use profiles over time and identify factors associated with the transitions.

## The Current Study

The current study focused on how family and school factors influence changes in substance use profiles based on alcohol, tobacco and marijuana use from adolescence to early-adulthood. As outlined above, substance use behaviors do not occur in isolation of one another and are not static over time. In addition, given that there are substantial developmental and social changes related to family and school contexts during the period covering adolescence and early-adulthood, we examined how family and school factors (known to be associated with youth substance use) were associated with longitudinal transitions among substance use profiles. We, therefore, sought to answer the following questions: How do adolescents transition among different substance use profiles (i.e., latent statuses) as they age into early-adulthood; and do transitions among the profiles become less frequent over time; does family conflict, which is characteristic of weak family bonds, increase the risk of transitioning from a non-using profile or a profile characterized by using one or more substances; does family conflict reduce the likelihood of transitioning from a substance using profile to a non-using one; do parental support and parental school involvement, which are characteristic of strong family bonds, decrease the risk of transitioning into a substance using profiles, and do they increase the risk of transitioning from a substance using profile to a non-using one? We sought to answer similar questions with regard to the association between transition in substance use profiles and school factors that measure the degree of connectedness individuals have with and the level of importance they place on school.

To answer these questions, we used Latent Transition Analysis. We characterized profiles of current substance use (i.e., latent statuses) based on past 30-day alcohol, tobacco and marijuana use during adolescence and early-adulthood. We then estimated probabilities of transitioning among profiles of substance use from adolescence to early-adulthood. Finally, we estimated associations of demographic, family and school factors with profiles of substance use and transitions over time. This allowed us to create a longitudinal model of how substance use behaviors

clustered from adolescence to early-adulthood, and identify associated factors.

## Methods

### Participants

Data were from a longitudinal study of adolescents at risk for high school dropout conducted in four urban public high schools in the Midwest United States. Inclusion criteria were having a grade point average of 3.0 or lower at the end of grade 8, no current diagnosis of emotional or developmental impairments, and self-identification as African American, white, or mixed race (Zimmerman et al. 2002). We used data from participants ( $n = 850$ ) in grade 10 (Time 1 in 1995), who were again surveyed 24 (Time 2 in 1997) and 48 months later (Time 3 in 2000). The retention rates for Time 2 and Time 3 were 90.6, and 67.3 %, respectively. The mean age at Time 1 was 15.9 years (SD 0.7). The sample was 80 % African American, 17 % white, and 3 % mixed race, and was evenly distributed by gender.

### Data Collection

Trained interviewers conducted structured face-to-face interviews with participants during school hours at Time 1 and Time 2, and at respondents' homes or a community setting at Time 3. Participants who dropped out of school or moved were interviewed in their homes or a community setting. Each interview lasted 50–60 min. After the interview, each participant completed a self-administered questionnaire about substance use and other sensitive information. This study received approval from the University of Michigan Institutional Review Board and participating schools.

### Measures

#### *Current Substance Use*

Substance use questions were drawn from the *Monitoring the Future* study (Johnston et al. 2003). Because our aim was to examine the presence and absence of past 30-day substance use, we dichotomized each substance use variable. It was not our aim to assess the magnitude of substance use. Ours was a more conservative approach because dichotomizing variables yields overall reduced statistical power (Ragland 1992).

*Alcohol Use* Alcohol use was measured by asking how many times participants had an alcoholic beverage in the past 30 days. Response options ranged from 1 (no use) to 7

(40 or more times). Drinking one or more times in the past 30 days was defined as current alcohol use.

**Tobacco Use** Tobacco use was measured by asking how often participants smoked cigarettes during the past 30 days. Response options ranged from 1 (not at all) to 7 (two or more packs a day). Current tobacco use was defined as smoking one or more cigarettes during the past 30 days.

**Marijuana Use** Marijuana use was measured by asking two questions: how often participants used marijuana in the past 30 days, and how often they used hashish in the past 30 days. Response options ranged from 1 (no use) to 7 (40 or more times). Using marijuana or hashish on one or more occasions in the past 30 days was defined as current marijuana use.

## Family Factors

### *Family Conflict*

Family conflict was measured with the 5-items Family Environment Scale (Moos and Moos 1981) (Cronbach's  $\alpha_{\text{Time 1}} = 0.79$ ) which assessed levels of fighting and acting out in family such as “we fight in our family” and “family members get so angry they throw things”. Response options ranged from 1 (hardly ever) to 4 (often).

### *Parental Support*

Parental support was measured using the 5-items Parental Support Scale (Procidano and Heller 1983) (Cronbach's  $\alpha_{\text{Time 1}} = 0.88$ ) to assess emotional support, problem solving and moral support from parents. For example, items asked about whether “my mother (or father) enjoys hearing about what I think,” “my mother (or father) is good at helping me solve problems,” and “I rely on my mother (or father) for moral support”. Response options ranged from 1 (not true) to 5 (very true). If scale scores were available from both parents, the average was used.

### *Parent-School Involvement*

Parent-school involvement was measured using seven items (Cronbach's  $\alpha_{\text{Time 1}} = 0.77$ ) such as “if you started to get D's or F's, how likely is it that your parent(s) would: “yell at you,” (reverse coded) and “help you with your homework.” Response options ranged from 1 (not at all) to 4 (very).

## School Factors

### *School Positive Attitudes*

School positive attitudes was measured with seven items (Cronbach's  $\alpha_{\text{Time 1}} = 0.76$ ) about the participant's general attitude toward school (Hawkins et al. 1992) such as “I do extra work on my own in class,” and “I like my teachers”. Response options ranged from 1 (strongly disagree) to 4 (strongly agree).

### *School Importance*

School importance was measured with four items (Cronbach's  $\alpha_{\text{Time 1}} = 0.80$ ) about how important school is (Roeser et al. 1994) such as “I think being successful in school is important”. Response options ranged from 1 (not true) to 5 (very true).

### *School Efficacy*

School efficacy was measured with five items (Cronbach's  $\alpha_{\text{Time 1}} = 0.80$ ) about the participant's perceived ability of do well in school (Midgley et al. 1993) such as “I can do even the hardest school work if I try”. Response options ranged from 1 (not true) to 5 (very true).

All school and family factors were measured at Time 1 and Time 2.

## Covariates

We included as covariates the participant's gender (male or female), race (white, African American or mixed race), family socioeconomic status (SES), parental substance use and peer substance use at Time 1.

### *Family Socioeconomic Status*

SES was measured using prestige scores of parents' occupation (Nakao and Treas 1990). If scores were available from both parents, the higher score was used. SES scores ranged from 29.28 (household worker) to 64.38 (professional), with mean = 39.90 (SD 10.42) indicating a blue-collar occupation.

### *Parental Substance Use*

The parental substance use scale (Xue et al. 2007) consisted of 13 items such as how often the parent/guardian

drinks beer, wine and hard liquor; gets drunk; gets high or stoned; and has been treated for a drug problem (Cronbach's  $\alpha_{\text{Time 1}} = 0.72$ ). Response options ranged from 1 (never) to 5 (very often). Summary scores were calculated by averaging numeric responses.

### *Peer Substance Use*

The peer substance use scale (Xue et al. 2007) included 13 items about friends' substance use of alcohol, tobacco, marijuana and other drug use (Cronbach's  $\alpha_{\text{Time 1}} = 0.85$ ). Response options ranged from 1 (none) to 5 (all). Summary scores were calculated by averaging numeric responses.

### **Analytic Strategy**

We used Latent Transition Analysis to examine profiles of current alcohol, tobacco and marijuana use. The advantage of Latent Transition Analysis and other finite mixture models is their ability to uncover unobserved heterogeneity in a given population, leading to the identification of meaningful response patterns (Muthén 2004). In the case of our example, a given individual could have any of up to 512 unique substance use patterns across the three time points of data collection. Our analysis plan allowed us to succinctly summarize this large number of patterns into a small set of distinct substance use profiles. Following recommendations by Collins and Lanza (2013), we determined the optimal number of latent statuses to describe profiles of substance use across the three time points. Once identified, we introduced parameter constraints on item-response probabilities (i.e., the probability that a response option is endorsed for each latent status category) to determine whether a more parsimonious model had equivalent fit. Next, we introduced family and school factors, as well as covariates to assess associations with latent status membership. We then included family and school factors to assess associations with transitions in status membership from Time 1 to Time 2, and Time 2 to Time 3. Model fit indices included the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). We used procedures described by Collins and Lanza (2013) to compare the fit of nested models to test the significance of transition predictors. The analyses were conducted using Proc LTA in SAS ("PROC LCA & PROC LTA (Version 1.3.0) [Software]" 2013).

### **Missing Data**

To maximize the sample size, missing data for covariates were imputed assuming randomness in missing data using the Markov chain Monte Carlo method in SAS to generate

pseudo-random draws from a simulated joint posterior distribution via Markov chains. This method constructs a Markov chain long enough for the distribution of the elements to stabilize to a stationary distribution, which is the distribution of interest. By repeatedly simulating steps of the chain, the method imputes values from the stabilized distribution of interest (Schafer 2010).

For the study variables with missing data, the percentage of missing data ranged from 4.6 % for the family conflict measure at Time 1 to 20.0 % for the school positive attitudes measure at Time 2. Descriptive statistics showed that means and standard deviations roughly equaled those in the original data, and contained no extreme values. We also compared those who completed all three waves of data collection ( $n = 571$ ) with the analytic sample ( $n = 850$ ); we found that there were no differences in substance use rates at Time 1 and Time 2, and that item-response probabilities in the unconditional model were nearly identical for substance use behaviors at baseline across latent status categories.

### **Results**

To determine the optimal number of substance use latent statuses (i.e., profiles), we began with a two-status model, and incrementally added an additional status until the fit did not improve. Our decision about the number of statuses to use was made based on a combination of both empirical evidence, and theoretical interpretability of class structure (Collins and Lanza 2013). Our selection process began with a focus on model fit statistics. We estimated two- [log-likelihood (LL) =  $-3299.63$ ; AIC =  $659.73$ ; BIC =  $768.89$ ], three- (LL =  $-3227.97$ ; AIC =  $552.40$ ; BIC =  $747.00$ ), four- (LL =  $-3167.01$ ; AIC =  $474.48$ ; BIC =  $773.50$ ) and five-status (LL =  $-3155.29$ ; AIC =  $503.04$ ; BIC =  $925.47$ ) models, at which point both AIC and BIC values showed increasingly worse fit. We did not use the negative log likelihood statistic, as this measure is sensitive to the number of parameters in the model. Although both AIC and BIC are both penalized-likelihood information criteria statistics, there are subtle differences in both that led us to prefer the BIC values. Most notably, AIC is more likely to indicate too many classes, whereas BIC is more likely to indicate too few (Dziak and Coffman 2012). Overall, the four-status model produced the lowest AIC value ( $474.48$ ), and the three-status model produced the lowest BIC value ( $747.00$ ). The three-status model was more conceptually meaningful and interpretable when comparing the item-response and transition probabilities. The four-status model included a latent status that was difficult to classify across the three substance use behaviors. We therefore used a three-status model moving forward.

We then compared the fit of the three-status model constraining item-response probabilities to be equivalent across time with an unconstrained model. The unconstrained model provided superior fit [ $\chi^2(18) = 59.04$ ;  $p < 0.001$ ], albeit estimating more parameters. When considering the number of parameters estimated, the constrained model offered a better balance of parsimony and model fit ( $BIC_{\text{unconstrained}} = 747.00$ ;  $BIC_{\text{constrained}} = 684.60$ ). The constrained model had the added benefit of ensuring the meaning of each status was invariant over time (Collins and Lanza 2013). We thus opted for the constrained model moving forward.

Latent Status 1 contained the largest percentage of respondents (54.2 %), followed by Latent Status 3 (26.0 %) and Latent Status 2 (19.8 %). Item-response probabilities for each status at Time 1 are reported in Table 1. Respondents in Latent Status 1 (“Non-users”) were unlikely to endorse any form of substance use at baseline. In Latent Status 2 (“Alcohol and Marijuana Users”), the probability of endorsing alcohol use was 0.58 and marijuana use was 0.57. Respondents classified into Latent Status 3 (“Alcohol, Marijuana and Tobacco Users”) had high probabilities of endorsing alcohol use (0.71), tobacco use (1.00) and marijuana use (0.69).

In preliminary analysis (data not shown), we tested models to identify factors associated with latent status membership with family and school factors entered individually. Family conflict, positive school attitudes, and school importance were significantly associated with status membership ( $ps < 0.01$ ), but when we added demographic factors school importance was no longer significant, and when we further added peer and parental substance use, only positive school attitudes remained significant ( $p < 0.05$ ). The multivariate analysis of latent status membership (Table 2) showed that relative to Non-users, the Alcohol and Marijuana User and Alcohol, Tobacco and Marijuana User latent statuses were less likely to be African American than white, more likely to have parents and peers who use alcohol or other drugs, and were less likely to have positive attitudes toward school. No other variables were associated with latent status membership.

Table 3 presents the latent status transition probabilities after accounting for predictors of latent status membership. When comparing Time 1 to Time 2 with Time 2 to Time 3 transition periods, there was a greater probability that Non-users transitioned to a substance user latent status during Time 2 to Time 3. More specifically, during Time 1 to Time 2 there was roughly equal probabilities of Non-users transitioning into the Alcohol and Marijuana User (0.10) and the Alcohol, Tobacco and Marijuana User (0.09) latent statuses, while during Time 2 to Time 3 there was a greater probability that Non-users transitioned to the Alcohol and Marijuana User latent status (0.19) than to the Alcohol,

Tobacco and Marijuana User latent status (0.05). Probabilities of transitioning from a substance user latent status to the Non-user latent status were about equal when comparing Time 1 to Time 2 with Time 2 to Time 3 transitions periods. However, during Time 1 to Time 2 there was a greater probability that the Alcohol and Marijuana User latent status (0.16) compared to the Alcohol, Tobacco and Marijuana User latent status (0.07) transitioned to the Non-user latent status. The reverse was observed during Time 2 to Time 3 transitions when there was a lower probability that the Alcohol and Marijuana Users (0.08) compared to Alcohol, Tobacco and Marijuana Users (0.15) transitioned to the Non-users status.

For the substance user latent statuses, there was less stability in status membership during the Time 1 to Time 2 than during the Time 2 to Time 3 transition period. For example, during Time 1 to Time 2 there was a 0.47 probability that Alcohol and Marijuana Users and 0.78 probability that Alcohol, Tobacco and Marijuana Users did not transition to a different latent status. In comparison, during Time 2 to Time 3 there was a 0.62 probability that Alcohol and Marijuana Users and 0.82 probability that Alcohol, Tobacco and Marijuana Users did not transition to a different latent status.

When individually testing factors associated with transitions, we found that family, school and demographic factors were significant (Table 4). Family conflict was associated with both the Time 1 to Time 2 and the Time 2 to Time 3 transitions. Respondents reporting higher levels of family conflict at Time 1 were at lower odds of transitioning from the Alcohol and Marijuana User (OR 0.41) or the Alcohol, Tobacco and Marijuana User (OR 0.43) statuses at Time 1 to the Non-user status at Time 2. Interestingly, the pattern appeared to reverse for the second transition, with higher levels of family conflict at Time 2 associated with higher odds of transitioning from the Alcohol and Marijuana User (OR 1.13) or the Alcohol, Tobacco and Marijuana User (OR 1.17) statuses at Time 2 to the Non-user status at Time 3. School importance was associated with Time 1 to Time 2 transitions, and parental school involvement was associated with Time 2 to Time 3 transitions.

With regard to the covariates, we found that female compared to male Alcohol and Marijuana Users at Time 1 were at over fifteen times higher odds of becoming Non-users at Time 2 (OR 15.63), and female compared to male Alcohol, Tobacco and Marijuana Users at Time 2 were at almost 5 times higher odds of becoming Non-users at Time 3 (OR 4.84). African American compared to white Alcohol and Marijuana Users at Time 1 were at over 10 times higher odds of becoming Non-users at Time 2 (OR 10.53), and African American compared to white Alcohol, Tobacco and Marijuana Users at Time 1 were at over 4

**Table 1** Substance use behaviors, profiles (i.e., latent statuses) and item-response probabilities at baseline (n = 850)

Past 30-day substance use	Latent status (i.e., substance use profile)		
	Non-user (54.3 %)	Alcohol and Marijuana User (19.8 %)	Alcohol, Tobacco and Marijuana User (26.0 %)
Alcohol (32.36 %)	0.08	0.58	0.71
Tobacco (28.04 %)	0.05	0.00	1.00
Marijuana (33.16 %)	0.02	0.57	0.69

The Latent Status columns show the probabilities of responding “Yes” to each substance use item

**Table 2** Factors associated with baseline latent status membership (n = 850)

	Odds ratios (referent: Non-user)		
	Non-user	Alcohol and Marijuana User	Alcohol, Tobacco and Marijuana User
Gender	–	1.00	0.97
Black**	–	0.80	0.62
Mixed race	–	1.04	0.69
Family Socioeconomic status	–	0.99	0.99
Peer substance use***	–	1.36	1.86
Parental substance use***	–	1.47	1.87
Parental support	–	1.27	1.19
Parent-school involvement	–	0.83	0.76
Family conflict	–	0.98	0.98
School positive attitude*	–	0.51	0.61
School importance	–	1.09	0.72
School efficacy	–	1.29	1.05

  

	Odds ratios (referent: Alcohol, Tobacco and Marijuana User)		
	Non-user	Alcohol and Marijuana User	Alcohol, Tobacco and Marijuana User
Gender	1.04	1.04	–
Black**	1.62	1.30	–
Mixed race	1.46	1.51	–
Family Socioeconomic status	1.01	1.00	–
Peer substance use***	0.54	0.73	–
Parental substance use***	0.53	0.79	–
Parental support	0.84	1.07	–
Parent-school involvement	1.31	1.08	–
Family conflict	1.02	1.00	–
School positive attitude*	1.64	0.84	–
School importance	1.40	1.52	–
School efficacy	0.95	1.23	–

“Non-user” is the reference category

\*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

times higher odds of becoming Non-users at Time 2 (OR 4.56). Peer substance use was associated with transitioning from the Non-user latent status at Time 1 to the Alcohol and Marijuana User (OR 1.34) or Alcohol, Tobacco and Marijuana User (OR 1.30) latent statuses at Time 2.

Lastly, we estimated a final Latent Transition Analysis model that included all family, school and control variables (i.e., gender, race, socioeconomic status, peer drug use and parent drug use) as predictors of Time 1 status membership as well as status transition probabilities. Overall, the full

**Table 3** Latent status transition probabilities from Time 1 to 2, and Time 2 to 3 (n = 850)

Latent Status	Latent Status			Total n
	Non-user	Alcohol and Marijuana User	Alcohol, Tobacco and Marijuana User	
Time 1 to Time 2 Transition				
Non-user	0.81	0.10	0.09	459
Alcohol and Marijuana User	0.16	0.47	0.37	168
Alcohol, Tobacco and Marijuana User	0.07	0.15	0.78	223
Total n	413	160	277	850
Time 2 to Time 3 transition				
Non-user	0.76	0.19	0.05	413
Alcohol and Marijuana User	0.08	0.62	0.30	160
Alcohol, Tobacco and Marijuana User	0.15	0.03	0.82	277
Total n	366	188	296	850

model did not significantly improve fit compared to the unconditional transition model. The results for predicting Time 1 status membership reported above did not change.

## Discussion

The existing literature suggests that because alcohol, tobacco and marijuana use tend to be correlated during adolescence and early-adulthood, these substance use behaviors can be examined using a profile-based approach (Steinman and Schulenberg 2003). However, the research is inconsistent with regard to the composition of substance use profiles. In addition, though studies have examined the sequencing (Howell et al. 2012) and trajectories of substance use (Kandel 2002), little is known about transitions among different substance use profiles as adolescents mature into early-adulthood, and how known family and school risk and protective factors for youth substance use (Stone et al. 2012) are associated with transitions among substance use profiles over this developmentally important period. Therefore, our study sought to characterize longitudinal transitions among substance use profiles (i.e., latent statuses) from adolescence to early-adulthood, and identify associated family, school and demographic factors.

### Substance Use Latent Statuses

Our results confirm past studies about the presence of underlying grouping structures to substance use behaviors in youth populations; however, there were some notable differences. We found that nearly half of the sample belonged to substance user latent statuses characterized by using multiple substances, and in contrast to other studies (Cleveland et al. 2010; Dierker et al. 2007) none belonged

to single substance user groups. For example, in addition to the Non-user latent status, Alcohol and Marijuana Users were identified as a substance use latent status as were Alcohol, Tobacco and Marijuana Users with about one-fifth of the sample in the Alcohol and Marijuana User and one-fourth in the Alcohol, Tobacco and Marijuana User latent statuses. These differences may be attributable to the composition of our sample, which consisted of youth at high-risk for school dropout. Other studies included samples from the general student population (Cleveland et al. 2010; Dierker et al. 2007).

The findings about factors associated with latent status membership partially support prior research and our conceptual framework, which was guided by eco-developmental perspectives, Social Bond Theory and Social Control Theory, and focused on family and school factors. Consistent with the existing literature reporting lower rates of alcohol and tobacco use by African Americans compared to whites (Johnston et al. 2013), our finding showed that African Americans were at lower odds than whites to be in the Alcohol and Marijuana User and Alcohol, Tobacco and Marijuana User latent statuses. The results partly corroborated research indicating that strong bonds with schools are protective against substance use. As in previous research (Brooks et al. 2012), we found that positive school attitudes was a protective factor; youth with positive school attitudes were at lower odds of being in the substance user latent statuses. However, our findings were not consistent with theory and existing research about other school and family risk and protective factors, which show that school importance (Bond et al. 2007; Brooks et al. 2012; Bryant et al. 2003), parental support (Branstetter et al. 2011) and parental school involvement (Cordova et al. 2013) are protective factors, and family conflict is a risk factor (Loke and Mak 2013; Ryan et al. 2010) for



**Table 4** Odds ratios measuring associations of family and school factors with transitions in latent status membership from Time 1 to 2, and Time 2 to 3 (n = 850)

Family and school factors (likelihood ratio test: Time 1 to 2; Time 2 to 3)	Time 1 to Time 2 transitions			Time 2 to Time 3 transitions		
	Non-user	Alcohol and Marijuana User	Alcohol, Tobacco and Marijuana User	Non-user	Alcohol and Marijuana User	Alcohol, Tobacco and Marijuana User
<b>Family conflict (<math>p &lt; 0.01</math>; <math>p &lt; 0.05</math>)</b>						
Non-user	Reference	1.54	2.16	Reference	1.13	0.99
Alcohol and Marijuana User	0.41	Reference	0.72	1.13	Reference	0.86
Alcohol, Tobacco and Marijuana User	0.43	0.85	Reference	1.17	0.72	Reference
<b>Parent support (<math>p = 0.07</math>; <math>p = 0.48</math>)</b>						
Non-user	Reference	1.22	0.83	Reference	0.68	0.31
Alcohol and Marijuana User	0.59	Reference	2.63	0.81	Reference	0.77
Alcohol, Tobacco and Marijuana User	0.98	0.42	Reference	0.68	1.69	Reference
<b>Parent school involvement (<math>p = 0.45</math>; <math>p &lt; 0.01</math>)</b>						
Non-user	Reference	0.38	1.20	Reference	0.72	0.88
Alcohol and Marijuana User	1.17	Reference	1.44	0.75	Reference	0.43
Alcohol, Tobacco and Marijuana User	0.61	0.38	Reference	0.76	2.54	Reference
<b>School importance (<math>p &lt; 0.01</math>; <math>p = 0.79</math>)</b>						
Non-user	Reference	0.29	0.25	Reference	0.88	0.50
Alcohol and Marijuana User	1.51	Reference	1.02	1.06	Reference	0.93
Alcohol, Tobacco and Marijuana User	2.27	2.26	Reference	1.17	0.25	Reference
<b>School attitude (<math>p = 0.33</math>; <math>p = 0.59</math>)</b>						
Non-user	Reference	0.33	0.27	Reference	0.73	0.31
Alcohol and Marijuana User	1.31	Reference	0.88	1.04	Reference	1.41
Alcohol, Tobacco and Marijuana User	1.23	1.01	Reference	0.94	0.62	Reference
<b>School efficacy (<math>p = .77</math>; <math>p = 0.66</math>)</b>						
Non-user	Reference	0.41	0.53	Reference	0.99	0.34
Alcohol and Marijuana User	1.60	Reference	1.58	1.68	Reference	1.36
Alcohol, Tobacco and Marijuana User	2.39	2.40	Reference	1.46	0.21	Reference

Models include gender, race, socioeconomic status, peer drug use, parent drug use, parental support, parent-school involvement, family conflict, school positive attitude, school importance and school efficacy as baseline status membership predictors. Transition models do not include control for other independent variables. The likelihood ratio test was used to compare Time 1 to Time 2 and Time 2 to Time 3 transition models separately with the baseline model

adolescent substance use. These factors were not associated with membership in substance use latent statuses. The divergent findings may partially be due to the strong effects of peer and parent substance use in our baseline statistical models, which may have suppressed the effect of other factors.

The findings regarding the composition of and factors associated with latent status membership have some implications for intervention. Programs for substance use prevention and control that are single substance specific may not be as relevant as ones that use poly-substance

approaches. None of the latent statuses we identified included a single substance user group, and the more common substance user latent status was the Alcohol, Tobacco and Marijuana User status. In addition, our findings suggest that interventions that increase positive school attitudes in youth may be beneficial.

**Transitions in Substance Use Latent Statuses**

There was a high probability that status membership did not change over the two transition periods; however, there

were still notable transitions. For example, transitions were observed both from the Non-user to the substance user latent statuses and from the substance user to the Non-user latent statuses. The latter findings reinforce the evidence reported elsewhere (Moffitt 1993) indicating that substance use may be adolescent-limited for some individuals, who mature out of regular use as they age into adulthood (Schulenberg et al. 2014). Transitions to and among the two substance user latent statuses indicate life course-persistent patterns (Moffitt 1993) of substance use particularly in light of findings that the probability of these transitions was high during both transitions periods, and that once participants transitioned to the substance user statuses, transitions to the Non-user status appeared intractable. For the substance user latent statuses, transitions became more static over time; there was a lower probability of change in status membership during the second than the first transition period. Finally, there was evidence of escalation in substance use with over 30 % probability that Alcohol and Marijuana Users during each of the transition periods transitioning to the Alcohol, Marijuana and Tobacco User latent status. This pattern of transitions is congruent with previous research reporting the sequencing (Howell et al. 2012) and increase in types of substances used (Lanza et al. 2010; Maldonado-Molina and Lanza 2010; Marti et al. 2010).

Our analysis using a fully controlled model predicting transitions in status membership did not support our conceptual framework. The results showed that the fully controlled model, which included family, school and demographic factors, did not improve fit over the unconditional transition model suggesting that the factors we examined were not associated with transitions among latent statuses. The uncontrolled models, however, indicated that family conflict, school importance and parent school involvement were associated with latent status transitions. In addition, females compared to males, and African Americans compared to whites were more likely to transition from the substance using latent statuses to non-use.

These findings have some implications for theory and measurement. As noted above, the finding support the dual taxonomy of adolescent-limited and life course-persistent substance use (Moffitt 1993), at least up to age 21. However, there is a need for theoretical development that conceptualizes longitudinal determinants of transitions in substance use behaviors. There may be changes in the nature of social bonds between individuals and their families with respect to the type of parental support with educational and work-related aspirations. The relevance of these bonds may change in relation to the developmental features of emerging adulthood such as the move away from a focus on the parental family and high school to the self. These changes have been described in existing

substance use developmental theory (Arnett 2004; Bronfenbrenner 1979) but require proper operational definitions. For example, to capture changes over time the family and school factors included in the current study could be measured as trajectories (Cordova et al. 2014) to estimate their relation to transition in substance use during this developmental period.

The results also have implications for interventions. There remains a need for early intervention when substance use behaviors may be more malleable. Starting early with substance use prevention efforts may put youth on a trajectory of lower risk in later adolescence and young adulthood (Tarter 2002). Additionally, the results also indicate the need for secondary prevention efforts during this developmental period. More interventions are needed to promote transitions from the substance user latent statuses to non-use during adolescence and early adulthood. These interventions would have to mitigate biological (Steinman and Schulenberg 2003) and bolster resiliency factors (Fergus and Zimmerman 2005), particularly in individuals at risk for life-course persistent patterns of use. From our results and contrary to prior studies (Stone et al. 2012), it is not clear whether focusing primary and secondary prevention efforts on the family and school factors we measured would be beneficial in maintenance of and transitions to non-use. Due to the higher risk of persistent substance use in males and whites, interventions to increase transitions from substance use to non-use may benefit by targeting and tailoring programs to these groups. In sum, targeted primary and secondary prevention interventions starting in early adolescence are indicated.

### Strengths

This study used a rich longitudinal data set about youth alcohol, tobacco and marijuana use. The sample consisted of lower SES youth who were followed from adolescence (age 16) to early-adulthood (age 21). This allowed for a thorough examination of transitions in substance use profiles and association with individual, family and school level factors. The sample included a population that is not typically studied especially with longitudinal data over so many years.

### Limitations

There were several notable limitations to this study. First, the sample may limit the generalizability of the findings. Participants were at high risk for high school drop out, were mostly African Americans (80 %) and white (17 %) and from a Mid-Western urban environment. Second, the substance use measures were based on self-reports, and likely suffer from underreporting bias, but such data have

been shown to have adequate validity and reliability for research using longitudinal designs to assess risk and protective factors for substance use and misuse. Third, although it would have been ideal to include information about amount of use, particularly heavy use, in our dependent measures of substance use, the data were sparse in this regard. For example, at Time 1, 0.25 % reported using alcohol more than 40 times during the past 30-days, 1.5 % reported using marijuana more than 40 times during the past 30-days, and 1.3 % reported smoking a pack or more a day during the past 30-days. Fourth, we limited our analysis to three substances due to low reports of using other substances. Longitudinal research on substance use needs to include analysis of other substances such as prescription drugs and heroin, which are growing in popularity. Finally, an important limitation is the lack of available statistical significance tests and standard errors within Latent Transition Analysis for item-response probabilities, transition probabilities and odds ratios measuring the associations of factors with specific transition probabilities. Despite these limitations, the study offers important insights about longitudinal changes in substance use profiles and contributing factors.

## Conclusions

Our findings reinforce the value of profile-based approaches to studying substances use. Many adolescents in our sample exhibited co-occurring patterns of substance use behaviors. In addition to Non-users, we found two substance user profiles: the Alcohol and Marijuana User and the Alcohol, Tobacco and Marijuana User latent statuses. There were substantial transitions among the three substance use profiles during adolescence. Transitions from substance user profiles to non-use became less probable as adolescents entered early-adulthood. Although the factors we examined did not explain transitions among profiles from adolescence to early-adulthood, we found that race, peer and parent substance use, and positive school attitudes were associated with substance use profile membership. Our results indicate that in addition to early interventions to prevent substance use, there is a need for secondary prevention efforts that target regular youth substance users particularly programs that address the use of multiple substances.

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**Authors' contributions** RM conceptualized the paper and wrote significant portions of the paper. JH conducted the data analysis,

drafted the analysis and results sections, and reviewed drafts of paper. DC reviewed drafts of the paper. HH and SA helped draft the methods section and reviewed drafts of the paper. JG critically reviewed the statistical approach and drafts of the paper. MZ oversaw the scientific integrity of the paper and critically reviewed drafts of the paper. All authors read and approved the final manuscript.

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