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## The Role of Individual and Contextual Factors in Differentiating Substance Use Profiles among Adolescents

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### ABSTRACT

**Background:** Adolescent substance use is a significant public health concern due to its prevalence and associated negative consequences. Although many adolescents use substances, there is substantial heterogeneity in their use patterns. Identifying risk and protective factors that differentiate adolescents with different substance use profiles is important for preventing negative consequences for those at risk. **Objective:** This study identified distinct latent profiles of substance use by considering adolescents' involvement in multiple common and illicit substances as well as related problems and examined the extent to which individual and contextual factors in the family, peer, school, and neighborhood environments were related to adolescents' membership of substance use profiles. **Method:** Data came from 9,155 high school students (51% female; 74% European American) who completed electronic surveys in the 2009 Dane County Youth Assessment (DCYA). Latent class analysis (LCA) was conducted to identify profiles of adolescent substance involvement and related problems. Multinomial logistic regression was conducted to examine associations between individual and contextual factors and latent class membership. **Results:** LCA identified four distinct profiles of adolescent substance use characterized by both licit and illicit substance use and related problems: *Abstainers* (56.3%), *Alcohol-only users* (25.6%), *Alcohol-cigarette-marijuana users* (13.8%), and *Problem polysubstance users* (4.3%). Controlling for demographics, individual and contextual factors were associated with adolescents' likelihoods of membership in substance use profiles; notably, the associations varied to some extent across substance use profiles. **Conclusions:** Substance use is heterogeneous among adolescents. Effects of risk and protective factors on substance use vary depending on adolescents' substance use patterns.

### KEYWORDS

Adolescent; latent class analysis; profile; risk and protective factors; substance use

Adolescents' use of alcohol, tobacco, marijuana, and other illicit drugs is a significant public health concern due to its prevalence (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2016) and associated negative health and psychosocial consequences (Bonomo et al., 2001; McCambridge, McAlaney, & Rowe, 2011; Squeglia, Jacobus, & Tapert, 2009). Although many adolescents use substances, there is substantial heterogeneity in their use patterns. A body of work has identified distinct profiles of substance use among adolescents based on frequency and quantity of use, as well as the number/kinds of substance used, including social drinkers, heavy drinkers, alcohol, tobacco, and other drugs (ATOD) experimenters, and other subtypes (Cleveland, Collins, Lanza, Greenberg, & Feinberg, 2010; Colder & Chassin, 1999; Ludden & Eccles, 2007; Steinhausen & Metzke, 2003). Further, research has shown that these different profiles of substance use have differential implications for adolescents' psychosocial outcomes. For example, health risks are elevated among polysubstance users (Earleywine & Newcomb,

1997; Hakansson, Schlyter, & Berglund, 2011). Thus, identifying risk and protective factors that differentiate adolescents with different substance use profiles is important for characterizing adolescents who are at risk and preventing negative consequences related to substance use. In this study, our goals were to empirically identify latent classes of adolescent substance use and to examine individual and contextual correlates of the resulting latent profiles.

### Adolescent substance use profiles

Heterogeneity in adolescent substance use is well recognized in the literature (Glantz, Conway, & Collier, 2005). The vast majority of studies of characterizing heterogeneity in adolescent substance use have focused on using frequency and quantity information of a specific substance (e.g., alcohol) or a limited set of substances (e.g., alcohol, tobacco, marijuana; Cleveland et al., 2010; Ludden & Eccles, 2007) and consequences related to substance use

(Colder & Chassin, 1999; Steinhausen & Metzke, 2003). Although a person-centered approach has been useful in revealing distinct profiles of adolescent substance use for common substances, a relatively limited number of studies have considered a broad range of both licit and illicit drugs in identifying profiles of adolescent substance involvement. Given national trends for continued spread of adolescents illicit drug use (Johnston et al., 2016), it is important to also extend efforts to use information from a broad range of both licit and illicit substance use and related problems, to characterize adolescents' distinct substance use profiles. The few studies that included measures of uncommon illicit substances (e.g., cocaine, opiates) in addition to common substances (e.g., alcohol, marijuana) have tended to combine the uncommon drugs into a "other illicit drugs" category rather than considering each illicit substance separately in analysis to characterize adolescent substance use patterns (Brooks-Russell et al., 2015; Conway et al., 2013), which failed to examine the role of specific illicit substances in characterizing substance use patterns. Building on the literature, we examined the patterns of substance use involvement among adolescents by considering their use of a wide range of licit and illicit substances and related problems.

### **The role of individual and contextual factors**

Social ecological models suggest that individuals are embedded in multiple social ecological systems and that human development and behaviors are influenced by individuals' personal characteristics and the social contexts surround them (e.g., Bronfenbrenner, 1979). Indeed, numerous studies have identified an array of risk and protective factors of adolescent substance use across multiple domains, ranging from individual characteristics to influences from the family, peer, school, and neighborhood contexts (Cleveland, Feinberg, Bontempo, & Greenberg, 2008; Connell, Gilreath, Aklin, & Brex, 2010; Patrick & Schulenberg, 2014). At the individual level, adolescents' attitude toward substance use is consistently associated with their substance use. Adolescents who disapprove of and view substance use as risky are less likely to use substances (Lipperman-Kreda, & Grube, 2009). In the family context, parental monitoring, support, and warmth are protective factors related to lower adolescent substance use, and adolescents' perception of parental disapproval of substance use is linked to lower use (Bahr, Hoffmann, & Yang, 2005; Barnes, Reifman, Farrell, & Dintcheff, 2000; Mayberry, Espelage, & Koenig, 2009; Sargent & Dalton, 2001; Su & Supple, 2014). Family dysfunction as indicated by intense family conflicts (including violence), parental drug and alcohol misuse, and unstable home environments, has been shown as a risk factor

for greater substance use (McKay, Murphy, Rivinus, & Maisto, 1991).

Peer context also contributes to adolescents' substance use, and peer substance use is one of the most consistent and robust predictors of adolescent substance use. Adolescents who affiliate with substance using peers or perceive that their peers/friends use substances are also more likely to use substances themselves (Henry, 2008; Prinstein, Boergers, & Spirito, 2001; Su & Supple, 2014). Schools represent an additional key context that influences adolescent substance use. In particular, feeling connected to school (resulting from supportive relationships with peers and teachers) is associated with lower substance use (Bond, Butler, & Thomas, 2007; Catalano, Oesterle, Fleming, & Hawkins, 2004; Henry, 2008; Su & Supple, 2014). At the neighborhood level, a sense of cohesion, safety, and support in one's neighborhood has been associated with lower adolescent substance use (Mayberry, Espelage, & Koenig, 2009), even after controlling for individual and family-level factors (Winstanley et al., 2008).

Notably, the vast majority of the prior research examining the risk and protective factors associated with adolescent substance use has focused on predicting adolescents' initiation, frequency, and/or quantity of substance use. These studies, using variable-centered approaches, assumed that associations between risk and protective factors and substance use are linear and homogeneous for all adolescents, without taking into account the heterogeneity in the patterns of their substance use behaviors. Using a person-centered approach, a few studies, however, have shown that the effects of individual and contextual factors may vary across different substance use profiles. For example, Colder and Chassin (1999) found that family dysfunction differentiated heavy alcohol users from moderate and light alcohol users, but did not differentiate moderate users from light users. Connell et al. (2010) showed that adolescents' perceived parental disapproval of use predicted lower likelihood of being classified as frequent polysubstance users but was not associated with adolescents' risk of being alcohol experimenters or occasional polysubstance users. Taken together, these studies underscore the need for further research to examine the roles of various factors in distinguishing different profiles of adolescent substance use.

### **The current study**

The purpose of the current study was two-fold. First, we aimed to identify distinct profiles of substance use by considering adolescents' use of multiple licit and illicit substances as well as problems related to substance use. Second, guided by social ecological model, we

examined the extent to which individual (i.e., adolescents' disapproval of substance use) and contextual factors in the family (i.e., parental involvement, parental disapproval of substance use, family dysfunction), peer (i.e., peer substance use), school (i.e., school connection), and neighborhood (i.e., neighborhood cohesion) were related to adolescents' membership of substance use profiles. We expected to identify distinct profiles of adolescent substance involvement; a large group of adolescents would be classified as abstainers/non-users, along with other groups characterized by different kind(s) of substances used and related problems. We also hypothesized that individual and contextual factors would be associated with adolescents' probabilities of membership in different substance use profiles and that these associations would differ across different profiles.

## Method

### Sample

Data for this study were drawn from the 2009 Dane County (Wisconsin) Youth Assessment (DCYA), a county-wide survey of students in grades 7 through 12. A total of 17,366 students participated in the survey. For the current study, only high school students (grades 9–12) were included given the relatively low prevalence of substance use among middle school (grades 7 and 8) students. Students who self-identified as Native American or mixed race or of "other" race/ethnicity were also excluded due to low overall sample sizes in these groups ( $n = 811$ ). The final analytic sample for this study included 9,155 high school students from 35 schools in 14 school districts (age ranged between 13 and 17;  $M_{\text{age}} = 15.6$  years,  $SD = 1.08$ ; 51% female), 84.0% of whom were European American, 7.0% were African American, 4.2% were Hispanic American, 2.2% were Southeast Asian, and 2.6% were Asian American.

### Procedure

Data were collected by the Dane County Youth Commission, an organization that partners with schools and community agencies to address youth health. Sampling procedures included a census strategy (surveying all students in a school) in most school districts that were relatively small, and random sampling in one large school district in a metropolitan area. Post-survey weights were constructed that adjust for unequal probabilities of participation in the surveys across schools. The weighted sample data provided estimates representative of the student population in the county. Electronic surveys were administered in schools between November 2008 and February 2009, allowing students who were absent during the initial

survey administration to complete at a later date. The data were provided to the authors in a de-identified format and were approved by their institutional IRB. A passive consent procedure was used with parents who were informed about the survey weeks in advance and could decline their child's participation (adolescents also could refuse participation). More detailed information about the sample and procedures can be found in Dane County Department of Human Services (2009).

## Measures

### Adolescent substance use

Adolescents reported on nine items regarding their frequency of substance use ranging from cigarette smoking to using inhalants during the past year, and another four items indicating risky substance use and/or problems related to substance use such as getting into trouble while using substances and having been told to cut down on use (0 = *no*, 1 = *yes*; see all items in Table 3). Response options to items related to frequency of substance use ranged from 1 (*not at all*) to 6 (*daily*). These items were recoded to 0 (*not at all*) or 1 (*past-year use*) as binary indicators to be included in the LCA.

### Adolescent's disapproval of substance use

Participants responded to four items on their attitudes toward substance use by teenagers (e.g., *How do you feel about someone your age smoking cigarette?*) on a 4-point scale (0 = *strongly approve* to 4 = *strongly disapprove*). Items were averaged. ( $\alpha = .89$ )

### Parental involvement

A six-item scale was used to assess adolescents' perceptions that their parents monitor their free-time behaviors and are supportive and caring (e.g., *my parents usually know where I am when I go out*). Students rated on a 4-point scale (0 = *strongly agree* to 3 = *strongly disagree*). Items were reversed coded and averaged, with higher scores indicating higher involvement. ( $\alpha = .83$ )

### Parental disapproval of substance use

Three items were used to measure adolescents' perceptions of their parents' attitude toward adolescents' use of cigarette, alcohol and marijuana (e.g., *How wrong do your parents feel it would be for you to smoke marijuana?*). Response options ranged from 0 (*not wrong*) to 3 (*very wrong*). Items were averaged. ( $\alpha = .79$ )

### Family dysfunction

Participants responded to six items on stressors and adverse experiences in adolescents' home life including exposure to parental drug use, violence, and daily

stressors (e.g., “My parents physically fight with each other”). Response options ranged from 0 (*strongly agree*) to 3 (*strongly disagree*). Items were reversed coded and averaged; higher scores indicated higher dysfunction. ( $\alpha = .76$ )

### Peer substance use

Adolescents rated their perceived level of peer substance use using two items (“Most of my friends do not drink or do drugs”, and “Most of my friends do not smoke cigarettes or chew tobacco”), using a 4-point scale (0 = *strongly agree* to 3 = *strongly disagree*). Items were averaged. ( $\alpha = .83$ )

### School connectedness

Six items were used to assess adolescents’ positive connection to and perceived support from adults at school (e.g., “I feel like I belong at this school”). Response options ranged from 0 (*strongly agree*) to 3 (*strongly disagree*). Items were reversed coded and averaged, with higher scores indicating higher school connectedness. ( $\alpha = .81$ )

### Neighborhood cohesion

Adolescents responded to five items assessing the extent to which they perceive their neighborhoods as a cohesive and safe environment (e.g., “People in my community know and care about each other”) using a 4-point scale (0 = *strongly agree* to 3 = *strongly disagree*). Items were reverse coded and averaged, with higher scores indicating greater neighborhood cohesion. ( $\alpha = .70$ )

### Analytic plan

We started with descriptive and correlation analyses with the risk and protective factors. We then conducted a latent class analysis (LCA) in Mplus 7.31 (Muthén & Muthén, 1998–2010) to identify distinct profiles of substance use based on past-year use of 9 substances and 4 related problems. LCA is an appropriate statistical method for identifying unobservable subgroups within a population based on individuals’ patterns of behaviors and characteristics (Collins & Lanza, 2010). We estimated a series of LCA models that specified different number of latent classes (from 2 to 6). The most well-fitting model was determined via the likelihood-ratio  $G^2$  statistics, Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Lo-Mendell-Rubin Likelihood Ratio Test (LMR LRT), and model entropy. A model with lower  $G^2$ , AIC, BIC, and higher entropy is preferable. The LRT tests whether a model with  $k$  number of classes fits better than a  $k-1$  number of classes. These tests are used to evaluate if, for example, a 4-class model fits significantly better than a 3-class model. In addition, latent class separation (i.e.,

whether classes can clearly be distinguished from each other based on item-response probabilities) and model interpretability (e.g., class size and meaningfulness of each class) were taken into account to determine the optimal model (Collins & Lanza, 2010).

After identifying profiles of adolescent substance use using LCA, we conducted multinomial logistic regression to examine how individual and contextual factors were associated with adolescents’ likelihoods of membership in each profile using the R3STEP command in Mplus. We included all individual and contextual factors, along with covariates (i.e., age, gender, race/ethnicity), in the same model. Given that students were nested within schools in our sample, we used TYPE = COMPLEX and the CLUSTER command in Mplus to take into account the nesting nature of the data in all analyses in order to yield unbiased estimates.

## Results

### Descriptive statistics

Table 1 presents means and standard deviations of the risk and protective factors, along with bivariate correlations. Prevalence of adolescent use of each substance and problems is presented in Table 3.

### Adolescent substance use profiles

Model fit statistics for 2–6 latent class solutions are presented in Table 2. Results indicated that the four-class model had significantly better model fit than 2- or 3-class models when examining the LMR LRT. That is, there was a statistically better fit when comparing a 4-class model to a 3-class model, but that adding a 5<sup>th</sup> and 6<sup>th</sup> class, did not result in significant improvements in model fit. In addition, the 4, 5, and 6 class models had lower AIC and BIC values. Although the AIC and BIC values were lower for these latter two models, when examined as a scree plot (not shown), these values tended to “bottom

**Table 1.** Descriptive statistics and bivariate correlations for individual and contextual factors.

	1	2	3	4	5	6	7
1. Adolescent disapproval	—						
2. Parental involvement	.35	—					
3. Parental disapproval	.46	.37	—				
4. Family dysfunction	-.32	-.44	-.35	—			
5. Peer substance use	-.46	-.28	-.32	.22	—		
6. School connectedness	.24	.42	.24	-.29	-.29	—	
7. Neighborhood cohesion	.19	.36	.22	-.32	-.25	.46	—
Mean	2.88	2.39	2.44	.50	.91	2.18	2.24
SD	1.11	.53	.68	.52	.88	.55	.67

Note. All correlations were statistically significant at  $p < .01$ .

**Table 2.** Comparison of LCA models: Fit statistics.

Number of classes	Likelihood Ratio G2	df	AIC	BIC	LMR LRT p-value	Entropy
2	4895.80	8103	92975.02	93188.81	< .001	.91
3	4164.87	8097	87451.61	87772.30	< .001	.93
<b>4</b>	<b>3678.51</b>	<b>8077</b>	<b>86039.35</b>	<b>86466.94</b>	<b>&lt; .001</b>	<b>.87</b>
5	3471.09	8070	85567.90	86102.38	.76	.86
6	3314.05	8061	85323.56	85964.94	.16	.86

out” or reach near minimum values when specifying a 4-class model. Furthermore, the four-class model revealed distinguishable and meaningful classes when compared to the other models and had relatively higher model entropy compared to the 5- and 6-class models. In consideration of the balance of model fit, parsimony, and interpretability of the classes, we adopted the four-class solution as the final model.

Table 3 presents the assigned label, prevalence estimates, and item-response probabilities for each class. 56.3% of adolescents were classified as *abstainers*. Adolescents in this class were non-users in the past year and reported no related problems. 25.6% of adolescents were classified as *alcohol-only (ALC) users*. This class was characterized by high probability of alcohol use in the past year but low probability of other substance use and associated problems. 13.8% of adolescents were classified as *alcohol-cigarette-marijuana (ACM) users*. Members of this class had high probabilities of using common substances such as alcohol, cigarettes, and marijuana but were not likely to use other illegal substances or inappropriate use of prescriptions or non-prescription drugs. They also had

moderately high probability of having substance-related problems. 4.3% of adolescents were classified as *problem polysubstance (POLY) users*, characterized by high probabilities of a variety of use of both licit and illicit substances in the past year and having problems (see Table 3). The probabilities to endorse use of other illegal drugs, non-prescription/prescription drugs to get high, and inhalants were uniquely elevated in the *POLY* users group.

### The role of individual and contextual factors

We conducted multinomial logistic regressions to examine how individual and contextual factors were associated with adolescents’ substance use profiles. Results are presented in Table 4. As expected, adolescents’ disapproval of substance use was associated with lower likelihoods of being in “higher-risk” substance use profiles relative to “lower-risk” substance use profiles. Specifically, adolescents’ disapproval of substance use was associated with lower likelihoods of being classified as *ALC*, *ACM*, or *POLY* users, relative to *abstainers*; lower likelihoods of being classified as *ACM* or *POLY* users relative to *ALC*

**Table 3.** Prevalence of adolescent substance use and item-response probabilities for latent class model.

	Sample Prevalence	Item-Response Probabilities by Latent Class			
		Abstainers (n = 5,174; 56.3%)	ALC Users (n = 2,350; 25.6%)	ACM Users (n = 1,272; 13.8%)	POLY Users (n = 398; 4.3%)
In the last 12 months, how many times did you smoke cigarettes or cigars?	19.9%	.008	<b>.219</b>	<b>.712</b>	<b>.969</b>
In the last 12 months, how many times did you use snuff or chewing tobacco?	6.1%	.001	.043	.181	<b>.595</b>
In the last 12 months, how many times did drink beer or wine?	39.0%	.056	<b>.738</b>	<b>.925</b>	<b>.970</b>
In the last 12 months, how many times did you drink hard liquor?	35.5%	.004	<b>.703</b>	<b>.949</b>	<b>.991</b>
In the last 12 months, how many times did you use marijuana?	23.4%	.011	.288	<b>.816</b>	<b>.987</b>
In the last 12 months, how many times did you use other illegal drugs?	6.1%	.000	.003	<b>.152</b>	<b>.927</b>
In the last 12 months, how many times did you use non-prescription drugs to get high?	5.2%	.001	.007	.072	<b>.954</b>
In the last 12 months, how many times did you use prescription drugs to get high?	5.9%	.000	.018	.106	<b>.948</b>
In the last 12 months, how many times did you use inhalants?	3.2%	.001	.016	.031	<b>.558</b>
Have you ever used alcohol or drugs while you are by yourself, alone?	16.0%	.005	.205	<b>.513</b>	<b>.839</b>
Have you ever forgotten things you did while using alcohol or drugs?	21.4%	.001	.277	<b>.765</b>	<b>.907</b>
Has your family or friends ever told you that you should cut down on your drinking or drug use?	9.3%	.002	.055	<b>.379</b>	<b>.628</b>
Have you ever gotten into trouble while you were using alcohol or drugs?	12.5%	.000	.109	<b>.514</b>	<b>.639</b>

Note. All items were recoded to 1 = involvement or problem, 0 = no involvement or problem. *ALC* = alcohol-only. *ACM* = alcohol-cigarette-marijuana. *POLY* = problem polysubstance.

**Table 4.** Individual and contextual correlates of adolescent substance use subtypes.

	ALC users vs. abstainers	ACM users vs. abstainers	POLY users vs. abstainers	ACM users vs. ALC users	POLY users vs. ALC users	POLY users vs. ACM users
Age	.29 (1.34) <sup>***</sup>	.66 (1.93) <sup>***</sup>	.62 (1.86) <sup>***</sup>	.37 (1.45) <sup>***</sup>	.34 (1.40) <sup>**</sup>	-.03 (.97)
Gender	.40 (1.49) <sup>***</sup>	.26 (1.30)	.04 (1.04)	-.14 (.87)	-.36 (.70)	-.22 (.80)
African American	-.31 (.73)	-1.36 (.26) <sup>**</sup>	-2.02 (.13) <sup>**</sup>	-1.05 (.35) <sup>**</sup>	-1.72 (.18) <sup>**</sup>	-.66 (.52)
Hispanic American	-.35 (.70)	-.70 (.50)	-2.56 (.08) <sup>***</sup>	-.35 (.70)	-2.21 (.11) <sup>***</sup>	-1.86(.16) <sup>***</sup>
SE Asian American	-1.42 (.24) <sup>*</sup>	-8.71 (.00)	-4.45 (.01) <sup>**</sup>	-7.29 (.00)	-3.03 (.05) <sup>**</sup>	4.26 (70.81)
Asian American	-1.04 (.35) <sup>*</sup>	-2.15 (.12) <sup>***</sup>	-1.71 (.18) <sup>*</sup>	-1.11 (.33) <sup>*</sup>	-.68 (.51)	.44 (1.55)
Adolescent disapproval	-.91 (.40) <sup>***</sup>	-1.60 (.20) <sup>***</sup>	-2.16 (.12) <sup>***</sup>	-.69 (.50) <sup>***</sup>	-1.25 (.29) <sup>***</sup>	-.55 (.58) <sup>***</sup>
Parental involvement	-.15 (.86)	-.40 (.67) <sup>**</sup>	-1.19 (.30) <sup>***</sup>	-.25 (.78)	-1.03 (.36) <sup>***</sup>	-.78 (.46) <sup>***</sup>
Parental disapproval	-.12 (.89)	-.22 (.80)	-.43 (.65) <sup>*</sup>	-.09 (.91)	-.31 (.73) <sup>*</sup>	-.22 (.80)
Family dysfunction	.27 (1.31)	.52 (1.68) <sup>*</sup>	1.12 (3.06) <sup>***</sup>	.25 (1.28)	.86 (2.36) <sup>***</sup>	.61 (1.84) <sup>***</sup>
Peer substance use	.78 (2.18) <sup>***</sup>	1.62 (5.05) <sup>***</sup>	1.65 (5.21) <sup>***</sup>	.84 (2.32) <sup>***</sup>	.86 (2.36) <sup>***</sup>	.03 (1.03)
School connectedness	-.08 (.92)	.26 (1.30)	.16 (1.17)	.35 (1.42) <sup>*</sup>	.24 (1.27)	-.11 (.90)
Neighborhood cohesion	.002 (1.00)	-.52 (.59) <sup>**</sup>	-.80 (.45) <sup>***</sup>	-.52 (.59) <sup>***</sup>	-.81 (.44) <sup>***</sup>	-.28 (.76)

Note. Unstandardized coefficients are presented; odds ratios are presented in parenthesis. \* $p < .05$  \*\* $p < .01$  \*\*\* $p < .001$ . ALC = alcohol-only. ACM = alcohol-cigarette-marijuana. POLY = problem polysubstance. SE = Southeast. Gender was coded as 1 = male, 0 = female. Dummy variables were created for race/ethnicity, and European Americans were considered as the reference group.

users; and lower likelihoods of being classified as *POLY* users relative to *ACM* users.

At the family level, parental involvement was associated with adolescents' lower likelihoods of being in the *ACM* or *POLY* profiles relative to *abstainers*, as well as lower likelihoods of being in the *POLY* users profile relative to *ALC* and *ACM* profiles. Parental disapproval or adolescent substance use was also associated with lower likelihoods of being classified as *POLY* users relative to *abstainers* and *ALC* users. On the other hand, family dysfunction was associated with higher likelihoods of being in the *ACM* or *POLY* users profile relative to *abstainers*, as well as higher likelihoods of being in the *POLY* users profile relative to the *ALC* and *ACM* users profile. None of the family contextual factors differentiated *ALC* users from *abstainers*, nor did they differentiate *ACM* users from *ALC* users.

Peer substance use was associated with higher likelihoods of being classified in the *ALC*, *ACM*, and *POLY* users classes, relative to *abstainers*. Peer substance use was also associated with higher risk of being in the *POLY* or *ACM* users class relative to the *ALC* users class. However, peer substance use did not differentiate *POLY* users from *ACM* users.

At the school level, adolescents' sense of connectedness was largely not associated with profiles of adolescent substance use, except that it was associated with adolescents' lower likelihood of being classified as *ACM* users relative to *ALC* users. At the neighborhood level, neighborhood cohesion was associated with adolescents' lower risk of being in the *ACM* or *POLY* users classes relative to the *abstainers* and the *ALC* users classes. However, neighborhood cohesion did not differentiate *ALC* users from *abstainers*, nor did it differentiate *POLY* users from *ACM* users.

## Discussion

This study used a person-centered approach to examine the heterogeneous profiles of substance involvement (both licit and illicit substances) and the correlates of those profiles in a large community sample of adolescents. Results from LCA analyses revealed four distinct profiles of substance use characterized by both common and illicit substance use and related problems: *abstainers*, *alcohol-only users*, *alcohol-tobacco-marijuana users*, and *problem polysubstance users*. Controlling for demographics, individual and contextual factors were associated with adolescents' likelihoods of membership in substance use profiles; notably, the associations varied to some extent across substance use profiles.

Consistent with the expectation of heterogeneity in adolescent substance use, we identified four distinct profiles of adolescent substance involvement based on nine different kinds of substances and four substance-related problems. Approximately one half of adolescents belonged to the *abstainer* class. About one-quarter of adolescents were classified into the *alcohol-only users* class, characterized as limited to alcohol use only and with low probability of experiencing substance related problems. These adolescents may be experimenters of alcohol or only drink alcohol in social events. We did not identify a smoking-only subgroup, which seems to be consistent with the national trend of decreases in cigarette smoking (NIDA, 2015) and suggests that adolescents who smoke tend to also engage in alcohol and other drug use. Despite the decline in cigarette smoking, there has been a recent increase in adolescent use of electronic cigarettes (Johnston et al., 2016). Future research is needed to examine the role of electronic cigarette use in characterizing adolescents' substance use patterns.

Interestingly, we identified two groups of adolescents who engaged in use of multiple substances: one group (*ACM* users) was characterized by a limited range of common substance use (i.e., alcohol, cigarette, marijuana), whereas the other (*POLY* users) characterized by high probabilities of endorsing a wide range of both licit and illicit drugs. Both groups also were likely to have had substance use related problems; however, the probability of experiencing problems appeared to be higher for the *problem polysubstance users* group. These results suggest that, compared to polysubstance that only involve use of relatively common substances (e.g., alcohol, marijuana), involvement of illicit drugs (other than marijuana) is particularly problematic and represents greater risk for adolescents. These results are also consistent with previous findings that alcohol, tobacco, and marijuana use tend to co-occur for some adolescents and that polysubstance use, particularly that involves other illicit drugs, is related to more negative consequences (Hakansson et al., 2011). Prior research focusing on common substances has also identified a subgroup of adolescents using a limited range of common substances (i.e., alcohol, tobacco, and marijuana; Tomczyk, Isensee, & Hanewinkel, 2016). Our findings extend the literature by identifying a unique group of polysubstance users who had strikingly high probability of using *all* of the licit *and* illicit substances considered. Although only a small proportion (4.3%) of adolescents, this is an alarming group that has significant implications for adolescent health. Our findings demonstrate the importance of accessing a broad range of substances (both common and illicit drugs) and related problems to fully understand adolescent substance use behaviors and underscore the utility of LCA in illuminating different patterns of substance involvement.

Consistent with prior research, our findings demonstrated that individual and contextual factors in the family, peer, school, and neighborhood environments are important correlates of adolescent substance use (Cleveland et al., 2008; Connell et al., 2010; Patrick & Schulenberg, 2014). We were able to examine the differential effects of these factors across substance use profiles. Only adolescents' attitudes towards substance use and their perceived peer substance use played a role in differentiating *ALC* users from *abstainers*. Interestingly, none of the family, school, and neighborhood factors were related to greater odds of being in the *ALC* group relative to *abstainers*. However, family, school, and neighborhood factors emerged as important correlates of adolescents' membership in more risky profiles (i.e., *alcohol-cigarette-marijuana users*, *polysubstance users*), above and beyond the effects of individual and peer factors. These findings suggest that alcohol involvement may be largely influenced by individual-level factors and the peer context,

whereas experiences in the family, school, and neighborhood context could differentiate adolescents' substance use subtypes when alcohol is involved. As such, while programming efforts that focus on adolescents' attitudes toward substance use and their peer affiliations may be effective in preventing underage drinking, tailoring programs to address other contextual factors in the family, school, and neighborhood (e.g., facilitating parental involvement, promoting a cohesive neighborhood environment, etc.) may better prevent adolescents' polysubstance use. It is also important for future research to examine potential differences in age of alcohol drinking onset across profiles of substance use.

Our findings also suggested that while peer substance use is a robust risk factor for adolescent substance use, its effect varied across adolescents' specific patterns of substance use. Consistent with expectation, peer substance use was associated with adolescents' greater risk of being in any of the substance using groups when compared to *abstainers*, as well as adolescents' greater likelihoods of being classified as *ACM* or *POLY* users relative to *ALC* users. However, peer substance use did not differentiate *POLY* users from *ACM* users. These findings suggest that perhaps perceiving peers as substance users largely influences adolescents' use of relatively normative/common substances (i.e., alcohol, tobacco, and marijuana), but is less influential on adolescent's problematic use of multiple illicit substances. Further, while peers play important roles in adolescents' substance involvement in general, they may be less predictive of subgroups among substance users.

Our findings also indicated that although family factors were not related to adolescents' likelihoods of being classified as *ALC* users relative to *abstainers*, family influences became increasingly relevant in differentiating use of multiple substances from alcohol use alone. Consistent with prior research on the protective role of positive parenting behaviors in adolescent substance use (Barnes et al., 2000; Sargent & Dalton, 2001), parental involvement and parental disapproval of substance use were associated with adolescents' lower likelihoods of polysubstance use. In contrast, family dysfunction was associated with adolescents' higher risk of membership in this subgroup. Interestingly, only individual and family factors differentiated the *ACM* users from *POLY* users, and peer, school, and neighborhood factors were not related. This suggests the importance of family context in adolescents' risk of polysubstance use that involves multiple illicit drugs and severe related problems.

We found very limited evidence of school connectedness in differentiating adolescents' substance use profiles when other contextual factors were considered. This contradicts previous findings from variable-centered research



that school connectedness was associated with lower adolescent substance use (Mayberry, Espelage, & Koenig, 2009; Su & Supple, 2014). Future research is needed to further understand the role of school connectedness on patterns of adolescent substance use. Consistent with expectation, neighborhood cohesion was protective in relation to adolescent substance use profiles. Specifically, neighborhood cohesion was associated with adolescents' lower risk of being in *ACM* or *POLY* users groups relative to non-polysubstance users groups (i.e., *abstainers*, *ALC* users). Adolescents' perception of neighborhood cohesion might reflect the overall quality of the neighborhood environment (e.g., levels of social controls, availability of alcohol and drugs). Thus, living in neighborhoods characterized by less cohesion is likely to increase adolescents' risk of moving into polysubstance user groups, relative to abstainers or *ALC* users groups, which may be more normative during adolescence. This suggests the need to focus on preventing polysubstance use among adolescents living in more disadvantaged neighborhoods.

Our findings need to be interpreted in light of several limitations. First, we focused on a community sample in a specific region and a specific time frame. Results of this study may not be representative of all US high school students. Replicating findings in other geographic regions and across different historical contexts will be important. Second, self-report data were used. Reliance on only adolescent reporters may inflate associations in some cases given that adolescents who use substances may more likely perceive their peers as substance users (Bauman & Ennett, 1996). Third, given the cross-sectional nature of the data, we were unable to make causal inference. For example, rather than peers influencing adolescents' substance use, it is possible that adolescents who use substances seek out similar peers (Farrell & Danish, 1993). Fourth, the item used to measure cigarette smoking in this study combined cigarettes and cigars. As many youth use cigars for smoking marijuana (i.e., blunt users), combining cigarettes and cigars in one question may confound cigarette smoking and marijuana (and perhaps other substances) use for some adolescents. Fifth, our goal was to identify profiles between users/non-users across a wide range of substances; extending to use frequency and quantity information across multiple substances to further characterize profiles of adolescent substance use will be important in future work. Sixth, guided by social ecological framework, we examined the role of several important individual and contextual factors in differentiating profiles of adolescent substance use. We focused on these factors because we considered them as malleable and could serve as promising targets for preventions and interventions. However, we recognize that there are many other important factors that may

influence adolescents' substance use profiles. For example, future studies are warranted to examine the role of mental health (e.g., conduct disorder, depression) and personality traits in differentiating substance use profiles among adolescents. Finally, although our results reveal interesting differential patterns between substance use profiles and risk factors, it is important to acknowledge that these relationships may be explained in part by underlying mechanisms and individual differences. Thus, another important direction for future research is to examine the mechanisms underlying the associations between risk/protective factors and patterns of substance involvement.

Despite these limitations, our findings extend prior research by empirically characterizing profiles of adolescent substance use with indicators of use of a broad range of common and uncommon substances and related problems, underscoring heterogeneity in adolescent substance use. Furthermore, the person-centered approach provided more nuanced insights regarding differential effects of individual and contextual factors on different patterns of adolescent substance use. Our findings suggest that intervention efforts that target at reducing adolescent substance use might be effective by addressing risk/protective factors across multiple levels such as promoting adolescents' and parental disapproval against substance use, parental involvement, and neighborhood cohesion, as well as reducing family dysfunction and association with substance using peers. Our findings also highlight that the efficacy of interventions targeting these factors may, however, vary depending on the targeting groups' substance use patterns (e.g., use of alcohol alone or in combination with other common or illicit substances). For example, efforts targeting at the family context might be more effective in reducing use for adolescents who engage in problematic, polysubstance use than for those who use alcohol only.

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