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Patterns and Social Determinants of Substance Use among Arizona Youth:

A Latent Class Analysis Approach

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# Patterns and Correlates of Substance Use among Arizona Youth: A Latent Class

## Analysis Approach

### Introduction

Substance use (e.g., alcohol, illicit drug, and prescription drug use) has become one of America's central problems and has resulted in massive economic, health, and social costs. In 2017, there were more than 70,000 cases of drug overdose death (an average of 192 per day), and the number of nonfatal overdose incidents was even higher (National Institute on Drug Abuse, 2019b). Out of all substance use issues, the prevalence among youth is especially concerning. In 2017, 5,455 youth—or nearly 15 per day—died from drug overdose (National Institute on Drug Abuse, 2019a). In 2017, approximately 2 million youth (7.5% of youth aged 12 to 17) reported themselves as current illicit drug users, and 2.5 million (10%) self-reported as alcohol users (Substance Abuse and Mental Health Services Administration, 2018a). Previous studies pointed out that the misuse of substances was highly associated with poor academic performance, aggravated physical and mental health problems, disruptions in family functioning, unhealthy peer relationships, and accidental deaths (Bahr, Hoffmann, & Yang, 2005; Beyers, Toumbourou, Catalano, Arthur, & Hawkins, 2004; Hawkins & Weis, 2017).

Substance use at an early age also increases the risk of future substance abuse and addiction (Hawkins & Weis, 2017; Spooner & Hetherington, 2004).

Despite the use of the term “substance use” is often collective, there is a considerable variation in the prevalence and harm among the substances. Some types of substances, such as alcohol and cigarette (and marijuana at some places), are legal and culturally acceptable (Elek, Miller-Day, & Hecht, 2006; White, Johnson, & Buyske, 2000). Other types of substances, such as methamphetamine, are illegal and have known drastic detrimental health effects. Among the substance types, opioid is gaining increased policy and academic attention, given its rise recently. The category includes a variety of drugs, some of which were legal (often as prescription pain relievers) and others illegal (heroin). In 2016, opioids resulted in nearly 43,000 deaths and incurred a \$95.8 billion societal cost (Normile, Hanlon, & Eichner, 2018).

While the dichotomy between substance users and non-users is often crucial for public health and policy reasons, the categorization among substance users bears at least the same level of significance—if not higher. Different levels (and combinations) of substance use warrant different plans of treatment and prevention. For example, youth who report occasional usage of tobacco and

alcohol usually warrant education and consultation (World Health Organization, 2014), whereas those who report regular usage of heroin or fentanyl may need immediate medical attention (Somerville et al., 2017).

Empirical research has shown that youth substance use tends to involve multiple substance types (Choi, Lu, Schulte, & Temple, 2018; Ritchwood, Ford, DeCoster, Sutton, & Lochman, 2015; Snyder & Medeiros, 2013). For example, data in 2017 suggested that 52.3% of youth engaged in heavy drinking also used at least one illicit drug during the meantime (Substance Abuse and Mental Health Services Administration, 2018b). A body of research also suggested a “gateway effect,” claiming that the use of some substances (often those more prevalent and less damaging, e.g., alcohol, cigarettes, and marijuana) precedes and predicts the subsequent use of more addictive and detrimental substances (Fairman, Furr- Holden, & Johnson, 2019; Maldonado-Molina & Lanza, 2010; Morral, McCaffrey, & Paddock, 2002). Therefore, researchers on substance use must take a holistic and systematic scope. The examination of the use and polyuse patterns across a broad spectrum of substance types will lead to additional insights from studies examining a single type of substance.

The Social Determinants of Health (SDoH) Framework

Emerged and refined from the ecological systems theory (Bronfenbrenner, 1992), the SDoH framework has received considerable recent attention in behavioral health-related research (Bambra et al., 2010; Evans, Barer, & Marmor, 1994; Marmot, Friel, Bell, Houweling, & Taylor, 2008; Viner et al., 2012). The SDoH framework indicates that people's health outcome is not only determined by genetic factors but also depends on social factors. In the context of substance use among a youth population, the SDoH framework encompasses intrapersonal factors (e.g., attitudes towards substance use), interpersonal factors (e.g., interaction with family and peers), and social and environmental factors (e.g., experience at school and education attainment).

Previous studies found strong relationships between substance use among youth and social factors at a variety of levels (Petraitis, Flay, Miller, Torpy, & Greiner, 1998). The perceived disapproval or negative perception of substance use, an intrapersonal factor, was one of the primary protective factors against actual substance use (Hohman, Crano, Siegel, & Alvaro, 2014; Miech, Johnston, & O'Malley, 2017; Stanley, Swaim, & Dieterich, 2017). Studies have confirmed the role of a variety of variables at the parental and peer levels, such as parental neglect (Gilliard-Matthews, Stevens, Nilsen, & Dunaev, 2015), peer pressure

(Wambeam, Canen, Linkenbach, & Otto, 2014), gang involvement (Walker-Barnes & Mason, 2004), insecure family attachment (Schindler & Bröning, 2015), and welfare participation (Wu, de Saxe Zerden, & Wu, 2016). Previous studies also found that both cyberbullying and physical bullying victimizations (Litwiller & Brausch, 2013), low school commitment and academic failure (Chan, Kelly, Carroll, & Williams, 2017), community disorganization, availability of substances, and community culture and norms were all associated with a higher risk of substance use (Hawkins, van Horn, & Arthur, 2004; Jackson, Denny, & Ameratunga, 2014).

In the present study, we continue to investigate how social factors at these different levels explain substance among the youths (Bambra et al., 2010; Hawkins & Weis, 2017; Spooner & Hetherington, 2004). Following the SDoH framework and the findings of previous studies, we hypothesize that variables at the individual, peer, family, school, and community levels will work together in shaping the pattern of substance use.

#### The Use of Latent Class Analysis (LCA) in Substance Use Research

Over the years, a set of finite mixture modeling techniques, featured by latent class analysis (LCA), has garnered increasing attention in the research on

risk and protective factors for child and youth development. The use of LCA per se is no longer neoteric to the field of substance use research—a recent systematic review identified 23 different studies adopting this technique (Tomczyk, Isensee, & Hanewinkel, 2016). Out of those 23 studies reviewed, 17 were published in or after 2010. Through a crude Google Scholar search, we found over 20 additional substance use studies that adopted the method published in peer-reviewed journals in 2018 and 2019 (e.g., Choi, Lu, et al., 2018; Choi, Yu, & Sacco, 2018; Merrin & Leadbeater, 2018). The popularity of the method is clearly on the rise.

One key advantage of LCA is that it allows for the identification of clusters or groups of youth that share a similar holistic pattern in a large number of observed variables. Many areas on child and youth development, such as criminal behaviors (Yan, 2019), family management (Lanza & Rhoades, 2013), and school experiences (Gage, Prykanowski, & Larson, 2014). In the context of substance use, LCA is strongly preferable when the number of substances is large (Lanza, Patrick, & Maggs, 2010). It starts with a set of variables indicating the usage of a list of substances, then groups the youth into multiple “types” of users or non-users (see Methods and Results below for details). Most studies identified multiple

groups through LCA—often consisting of a non-user or low-risk user group and a variety of groups indicating different levels and combinations of substance use.

Despite all the progress, two critical gaps remain in the literature. First, to date most studies adopting the LCA model only examined a small number of substance types, often little beyond alcohol, tobacco/cigarettes, and marijuana (e.g., Chung, Kim, Hipwell, & Stepp, 2013; Dierker, Vesel, Sledjeski, Costello, & Perrine, 2007; Gilreath, Astor, Estrada, Johnson, et al., 2014; Gilreath, Astor, Estrada, Benbenishty, & Unger, 2014; Lamont, Woodlief, & Malone, 2014; Lanza et al., 2010). Researchers have paid relatively less attention to the less common and more detrimental and epidemic types of substances (e.g., opioid, cocaine, methamphetamine). These studies afforded a plethora of knowledge on the intersection of the more common substance types (i.e., alcohol, cigarettes, and marijuana). However, much less is known about the overall pattern between them and the more risky substances. Second, there has also been an insufficient amount of attention to the explanation of substance use under the SDoH theoretical framework. Most studies that used LCA included a minimal number of explanatory variables, often little beyond the youth's demographic characteristics (Tomczyk et al., 2016). The SDoH framework suggests that the risk and protective

factors for substance use exist at multiple levels—the youth themselves, their family, their neighborhood and others. Within the LCA context, there has been an insufficient amount of attention to the association between the group membership and variables at these different levels.

The present study addresses both gaps in the literature of LCA studies on youth substance use with a unique and comprehensive dataset. Our study included a total of 15 types of substances, both those well-studied (e.g., marijuana and alcohol) and less-well-studied (e.g., opioids and steroids) in existing research. We also incorporated the insights of the SDoH theory and adopted a much comprehensive set of risk and protective factor variables to explain the group membership. Our study utilized a unique but relatively less-studied group—school youth in Arizona. Compared with the U.S. average, the proportion of Hispanic and Native American students is much higher (Arizona Criminal Justice Commission, 2016). Recent data also suggested that youth in Arizona had a higher level of prevalence in substance use (Centers for Disease Control and Prevention, 2018). With these unique characteristics, there has been little attention to this population's overall pattern and grouping of substance use (Meier, Docherty, Leischow, Grimm, & Pardini, 2019; Tomczyk et al., 2016). By analyzing the sample

of youth in Arizona, our paper addresses this research gap and sheds light on the knowledge of substance use.

## Method

### Data and Sample

The current study used data from the Arizona Youth Survey (AYS), administered by the Arizona Criminal Justice Commission (Arizona Criminal Justice Commission, 2016). The AYS builds on the Communities That Care approach (Hawkins et al., 2008) and aims to examine the frequency and prevalence of risky behaviors (e.g., substance use, gang involvement, and delinquency behaviors) by Arizona youth. The AYS utilized a multi-wave cross-sectional design, and we used only the 2016 wave.

Data collection was completed in the spring of 2016. The survey aimed at students at the 8<sup>th</sup>, 10<sup>th</sup>, and 12<sup>th</sup> grades, and all public, private, and charter schools in the state were eligible to participate. A total of 57,170 youth from 249 schools (which covered all of the 15 counties in Arizona) participated in the survey, and both paper and online surveys were offered. Although the sampling was not stratified or simple random, it yielded a sample that had comparable demographic composition to the population of Arizonan students. ACJC concluded the dataset

as “valid and representative” (for more details, see Arizona Criminal Justice Commission, 2016).

Our analytic sample consisted of all subjects who had complete and reasonable information on all variables used (i.e., substance use and risk and protective factors,  $n = 30,187$ ). We had to drop over 40% of cases because of missing data, which reflects the tradeoff between the comprehensiveness of the models and the completeness of information. A series of sensitivity checks suggest that this did not appear to be a problematic issue. First, the demographic composition of our sample was still very similar to the student population of Arizona (see Results section below and Arizona Criminal Justice Commission, 2016). Second, between individuals who remained in the analytic sample and those who were excluded, there did not appear to be a statistically significant difference in the levels of most substance use variables. The LCA results with the analytic sample were nearly identical to those with the full set of individuals with no missing substance use information ( $n = 44,807$ ). Third, to increase the sample size, we also estimated a set of robustness check models with subsets of the predictors (so that youth with partially missing predictor variables may be included), and the main story did not change. An alternative approach to address

this issue is multiple imputation. However, recent studies suggest that multiple imputation also has its shortcomings and is not necessarily the best option for any missing data situation (Cismondi et al., 2013; Sterne et al., 2009).

## Measures

Measures of substance use. The original AYS instrument included self-reported lifetime usage of 17 substances. One of the 17, phenoxydine, was a non-existing drug. This variable served as a quality check for the responses. If a subject reported usage of phenoxydine, there was reasonable suspicion on the truthfulness of the subject's entire response. We followed ACJC's (2016) recommendation and excluded these individuals from all subsequent analyses ( $n = 1,542$ ). We also combined cigarettes and e-cigarettes into one variable for the ease of model interpretation. Although the users of cigarettes and e-cigarettes did not necessarily overlap (Choi, Yu, et al., 2018), our robustness check found no difference when we coded the two variables separately. We then used the lifetime usage history of the remaining 15 substances for the LCA, all coded dichotomously (see Results section below for the complete list).

Our selection of substance types was much broader than most studies adopting the LCA approach (Tomczyk et al., 2016). Most previous studies only

examined the most common substance types—alcohol, tobacco/cigarettes, and marijuana. Some studies did include an “other drugs” category, which was less specific and informative than our list of substances. Other than information on lifetime use, the AYS also contained information on the use of substances in the 30 days before the survey. A robustness check suggests those variables led to similar findings.

Measures of risk and protective factors. Based on previous literature of social determinants of substance use (Galea & Vlahov, 2002; Resnick et al., 1997; Spooner & Hetherington, 2004) and social developmental theory (Hawkins & Weis, 2017), we included a set of possible risk and protective factors at the individual, peer, parental/household, school, and community levels for all analytic models. The variables we used were either direct measures of the youth’s personal and home characteristics or scales developed from the Communities That Care approach. Many studies have confirmed the reliability and validity of these commonly-used risk and protective factor scales (Arthur et al., 2007; Arthur, Hawkins, Pollard, Catalano, & Baglioni, 2002; Feinberg, Ridenour, & Greenberg, 2007).

At the individual level, we included the youth's demographic characteristics: age, gender, grade, and race (coded as White, Latinx, African American, Native American, Asian and Pacific Islander, and multi-racial). We also used two scales to measure the youth's adverse childhood experience (ACE) and self-reported negative perception of substance use (for details on all scales, see Table 1). At the peer level, we examined the youth's number of best friends, the number of best friends staying drug-free (both numerically from 0 to 4, where 4 represented four or more), and gang membership. There was also a scale on their best friends' negative perception of substance use.

[Table 1 approximately here.]

At the parental/household level, we examined the youth's free or reduced-cost lunch status, the maternal education level (measured as whether their mother had some college education or higher), whether the youth's biological parents were currently living together, and whether their siblings have ever used marijuana. We also included two scales: family attachment and parental negative perception of substance use. At the school level, we included whether the youth experienced academic difficulties (measured as receiving mostly Ds and Fs in classes) and whether they experienced physical bullies or e-bullies. We also

included a scale on the youth's school commitment. At the community and societal level, we examined whether the use had any exposure to substance use prevention advertisements. There were also three scale variables: the community's negative perception of substance use, ease of access to substances, and community attachment.

#### Latent Class Analysis (LCA) and Regression Analysis

LCA starts with a group of observed categorical variables (i.e., the 15 substance types listed above), then divides individuals in the sample into meaningful groups based on the overall pattern (Choi, Lu, et al., 2018; Choi, Yu, et al., 2018; Kremer, Vaughn, & Loux, 2018; Ritchwood et al., 2015; Tomczyk et al., 2016). The common practice is to decide on the total number of groups by fitting statistics (e.g., the Bayesian Information Criterion, BIC), and then interpret the groups by the conditional probabilities (i.e., the probability of each response variable given the group). We assigned each youth to the group that he or she was most likely to belong to, then investigated the role of the risk and protective factors. Since the group membership was a nominal measure, we estimated a multinomial logistical regression model, with controlling for the clustering effects at the school level.

## Results

### Descriptive Statistics

Substance use variables. We first present the descriptive statistics of the lifetime substance use variables in Table 2. Overall, alcohol (42.1%), cigarettes (31.4%), and marijuana (23.9%) were the most frequently used substances among the respondents. Out of the 12 remaining substance types, only prescription pain relievers (7.1%) and over-the-counter (OTC) drugs (5.7%) had prevalence rates over 5%. With 15 types of substances, there were  $2^{15} = 32,768$  different combinations in theory. Of these possible patterns, we observed over 1,000 in our sample. This highlights the necessity of LCA since it is barely possible to make sense of a dependent variable with over 1,000 categories.

[Table 2 approximately here.]

Demographics and predictors. We present the descriptive statistics of our predictors in Table 3. The largest race group in the sample was White (47.5%), followed by Latinx (37.5%) and multi-racial. The average age was 15.4 years, and 46.9% of the sample were male. The overall racial and gender composition of the analytic sample was similar to that of the full AYS sample (Arizona Criminal Justice

Commission, 2016, p. 12). The proportion of 8<sup>th</sup> graders was the largest (37.3%), followed by 10<sup>th</sup> graders (33.9%).

[Table 3 approximately here.]

There was some variation in the youth's risk and protective factors. Overall, the sample had a low to moderate level of adverse childhood experiences. On average, the youth reported having slightly fewer than three best friends, but only had 1.6 best friends drug-free. The level of gang involvement was low, as only 3.2% of the sample reported being a gang member. Approximately 42.3% of the subjects received free or reduced-cost lunch, and 39.6% came from families in which the biological parents did not live together. For both physical bully and e-bully, around 30% of youth reported having experience. The overall level of commitment to school was moderate (3.1 on a 5-point scale), but only 5.4% of the subjects were having academic difficulties. At the community level, exposure to drug prevention advertisement was prevalent (74.7%). However, the youth also reported having moderately easy access to substances (2.3 on a 4-point scale). Despite the variation in the level of substance use and accessibility, there was an overall strong negative perception of substance use at all levels.

The Five-Group LCA Model of Substance Use

Model selection. Table 4 presents the fitting statistics for the LCA models. The common practice in the literature is to select the model with the lowest Bayesian Information Criterion (BIC) value or the adjusted BIC. However, it is noteworthy that most previous studies had a sample size of some hundreds or a few thousand. On the contrary, we had a sample size of over 30,000. The massive amount of variation resulted in all fitting statistics to be improving throughout our analysis (see Table 4). Despite the continued improvement of model fit, some of the larger models have already emitted signals of overfitting—tiny groups with little substantive value for prevention and intervention. We noticed that the improvement of BIC was substantial up to the 5-group model, then became much less after the number of groups reached five. Therefore, we decided to adopt a five-group model to represent the data.

[Table 4 approximately here.]

The distribution of the groups was uneven in the sample. The largest group accounted for over 60% of the sample, and the smallest group accounted for less than 2%. Two of the groups appeared small (< 5% of the population each), but one of the two groups was close to 5%, and the other group was also found in the more parsimonious (4-group) model. Moreover, as to be detailed below, both

groups had their unique theoretical and practical importance, and are expected to be small given their characteristics. In the literature, it was also typical for studies adopting LCA to identify one or two small groups (Tomczyk et al., 2016). We do not view the variation in the group size as a warning sign of the model.

Group characteristics. Figure 1 presents the characteristics of the five groups. The first group, which accounted for 1.8% of the sample, had a high conditional probability of use on all types of substances. Within the sample, this group had the highest probability of usage for all substance types and had over 80% probabilities for the use of alcohol, marijuana, and prescription pain relievers—the most common form of opioids. For the simplicity of presentation, we refer to this group as Serious Users. The second group, Moderate Users, accounted for 5.9% of the sample. This group had probabilities near 100% for the use of alcohol, marijuana, and cigarette, and the second-highest probability of nearly all other types of substances. The third group, Non-progressive Users, accounted for 4.3% of the sample. Similar to Moderate Users, this group also had relatively high probabilities for the use of prescription pain relievers and OTC drugs. However, this group had much lower probabilities for marijuana and cigarette, as well as a lower probability for alcohol than three of the four remaining

groups. For this group, it did not appear that the use of marijuana and cigarette preceded the use of OTC drugs and prescription pain relievers (because both were reports of lifetime usage), hence the name.

[Figure 1 approximately here.]

The fourth group, Common Substance Users, was the second-largest group at 24.7% of the sample. This group reported relatively high probabilities of alcohol, marijuana, and cigarette usage (the three most common), but little usage of all other substances. Essentially, this group represented the exclusive use of the three most common substances in the sample. The fifth group, Abstainers, was the largest (63.3% of the sample). As the name suggests, this group had low conditional probabilities for all substances. These groups depict the variation in the involvement and degree of substance usage. There was one high-risk group (Serious Users) and one low-risk group (Abstainers), and the level of substance use for the three other groups fell in between.

Risk and Protective Factors of Substance Use.

To investigate the role of individual and societal variables in predicting substance use, we estimated a multinomial logistic regression model with our five groups as the dependent variable. We used the group with the lowest risk of

substance use, the Abstainers, as the reference group, and calculated the Relative Risk Ratio (RRR) for each group. The RRR represents the likelihood of belonging to a particular group instead of the reference group. We present our findings in Table 5.

[Table 5 approximately here.]

Overall model fit and anomaly detection. The multinomial logistic regression model had a pseudo- $R^2$  value of 0.28. The value is similar to or higher than those reported in studies on substance use using similar types of data (Bachman, Johnson, & O'Malley, 1998; Hohman et al., 2014). There did not appear to be a major lack of model fit. We also examined our regression models and did not find influential outliers in the predictor variables. Although our model contained a large number of predictor variables, the variance inflation factor (VIF) values ranged between 1.05 and 7.5, suggesting no multicollinearity problems.

Demographic variables. At the individual level, we found that race, age, and gender provided a few demographic predictors for membership of certain groups. Specifically, Latinx youth were more likely to be Moderate Users, Non-progressive Users, and Common Substance Users (RRRs between 1.20 and 1.48). Black youth, to the contrary, were less likely to be Serious Users, Moderate Users, and

Common Substance Users (RRRs between 0.23 and 0.82). Native American youth were more likely to be Common Substance Users, and multi-racial youth were less likely to be Serious Users. The age of youth was associated with higher risks of being Moderate Users and Common Substance Users (RRRs between 1.23 and 1.37). Males had a lower risk of being Moderate Poly Users, Non-progressive Users, and Common Substance Users (RRRs between 0.62 and 0.85).

Individual-level risk and protective factors. At the individual level, all risk and protective factors included in the model appeared to be significant predictors of a group membership. Specifically, a higher number of ACE was associated with higher risks for all groups (RRRs between 1.16 and 1.45) relative to Abstainers. Negative individual perception of substance use was associated with lower risks for all groups (RRRs between 0.09 and 0.36).

Peer level variables. Negative peer perception of substance use (RRRs between 0.46 and 0.75) appeared to be a protective factor against substance use, whereas gang involvement appeared to be a risk factor for all classes relative to Abstainers (RRRs between 1.69 and 4.90). The number of best friends appeared to be a risk factor for substance use (RRRs between 1.09 and 1.13), whereas the number of friends drug-free acted as a protective factor (RRRs between 0.81 and

0.88). However, neither variable was predictive of the Non-progressive User group.

Family level variables. Parental negative perception of substance use appeared to be the primary protective factor against substance use (RRRs between 0.69 and 0.82), while sibling's marijuana use was associated with higher risks for all groups relative to Abstainers (RRRs between 1.47 and 3.70). The role of other variables appeared to be mixed. For example, the mother's education level as well as reduced-cost lunch status did not appear to be related to the group membership, which was also mostly the case for free lunch status (positively related to Common Substance User group only). The role of family attachment depended on the class—youth with higher parental attachment had a lower risk to be Serious Users, but a higher risk to be Common Substance Users.

School level variables. At the school level, e-bully victimization was associated with higher risks for all groups relative to Abstainers (RRRs between 1.39 and 2.14) and had a much stronger predictive power than physical bully victimization. Academic difficulties were associated with higher risks for all groups except Non-progressive Users (RRRs between 1.28 and 1.91), and school commitment appeared to be unrelated to group membership.

Community level variables. To the contrary of all other levels, negative perception of substance use at the community level was not a significant predictor of the group membership. The primary predictor at this level was the ease of access to substances, which predicted a higher risk for all groups relative to Abstainers (RRRs between 1.36 and 3.44). Exposure to substance use prevention advertisement was also related to a higher risk for all groups other than Common Substance Users (RRRs between and 1.38 and 1.68). Community attachment did not appear to be a significant predictor of substance use membership except for a lower risk for Non-progressive Users.

Interaction effects. In Table 6, we present the interaction effects between the youth's race and the negative perceptions of substance use at all levels, controlling for all predictors used in the main model (Table 5 above). Overall, very few interaction effects were significant, suggesting that the role of negative perceptions did not vary much among races. The youth's own negative perception of substance use had a stronger effect for African Americans than for Whites (RRRs between 2.43 and 5.46), and had a weaker effect for Native Americans and Asians and Pacific Islanders than for Whites (RRRs between 0.36 and 0.65). Friends' negative perception of substance use had a weaker effect on Latinx than

on Whites (RRRs between 0.66 and 0.86). The inclusion of interaction terms did not change the main findings of the regression model.

[Table 6 approximately here.]

## Discussion

This study investigated the pattern and predictive factors of substance use with recent data from a sample of youth in Arizona. We found visible heterogeneity within our sample—five different groups regarding substance use behaviors among the youth, each associated with a set of demographic and social predictors. Both findings furthered our understanding of youth substance use as detailed below.

According to the LCA model, the majority of the youth (Abstainers)—nearly 65%—were mostly able to stay drug-free. Another 25% of the sample (Common Substance Users) did report substance use but were limited to the most common types of substances—alcohol, cigarettes, and marijuana. The pattern and size of both groups were consistent with the previous literature on substance use (Tomczyk et al., 2016) as well as recent national statistics (Substance Abuse and Mental Health Services Administration, 2018a, 2018b). Despite the difference in names and the documentation of the harm of these common substances (Berg et al., 2015; Resnick et al., 1997), researchers largely agreed that both groups

represented the lower-risk end among the population (Connell, Gilreath, Aclin, & Brex, 2010; Snyder & Smith, 2015). We also found two groups representing the higher-risk individuals in the population, Serious Users and Moderate Users. These groups were also present in many previous studies adopting the LCA approach, often labeled as “polyusers” (Tomczyk et al., 2016). The groups were small and accounted for a total of less than 8% of the population. Nevertheless, both warrant a high level of social and medical service and support.

A unique finding of the current study is the group of Non-progressive Users (4.3%), who reported relatively high probabilities of lifetime usage of prescription pain relievers (a common form of opioids) and OTC drugs, but low probabilities of usage of the common substances. This group is relatively novel to the studies using LCA (Tomczyk et al., 2016) and stands in sheer contrast with the hypothesis of the “gateway effect”—that the use of conventional substances precedes the less common and more damaging substances. In other words, our study suggests that the resistance of alcohol, marijuana, and cigarettes does not necessarily guarantee the resistance of other (and perhaps more detrimental) substance types. This finding is particularly alerting and resonates with the recent attention to the opioid crisis (Normile et al., 2018; Substance Abuse and Mental Health

Services Administration, 2018b). It is necessary for treatment, prevention, and education programs to target a more comprehensive list of substances rather than the common substances exclusively.

On and above the identification of the five groups, our study further examined the role of risk and protective factors in the light of the SDoH perspective (Evans et al., 1994; Galea & Vlahov, 2002; Spooner & Hetherington, 2004). At each level, at least one variable was significantly predicting the youth's group membership, which suggests that substance use is socially determined. ACE, gang involvement, siblings' use of marijuana, e-bully victimization, and ease of access to substances were related to higher risks for groups other than Abstainers. All these variables were well-established negative factors for the development of children and youth (Hawkins, Catalano, & Miller, 1992; Resnick et al., 1997). The primary protective factors against substance use were the negative perceptions of substance use at the individual, peer, and parental levels, which is also consistent with the literature (Bachman et al., 1998; Hawkins et al., 1992). However, it is worth attention that the perception of substance use at the community level did not appear to have a significant relationship with substance use.

Apart from the general risk and protective factors, the roles of three sets of variables are especially worth mentioning. First, the relationship between race and substance use was somewhat inconsistent across the groups, as no race had significantly higher or lower risks for all groups other than Abstainers. Generally, Latinx youth had a higher risk for most substance user groups than White youth, and African American youth had a lower risk than White youth. We found no visible disparities in the patterns of substance use between White youth and Asian and Pacific Islander, Native American, and multi-racial youth. The findings are generally consistent with the literature, which suggested that the racial differences in substance use may be due to socioeconomic and cultural factors associated with race (Choi, Yu, et al., 2018; Shih, Miles, Tucker, Zhou, & D'Amico, 2010). Second, the number of friends appeared to be a risk factor of substance use, but the number of friends staying drug-free was a protective factor. The role of friends is mixed—while peer pressure can be a cause of substance use (Allen, Chango, Szvedo, Schad, & Marston, 2012), peers with a strong commitment to staying drug-free help the youth's resistance of substances. Third, a stronger family attachment was related to a lower risk for Serious Users, but a higher risk for Common Substance Users. A possible reason for the latter finding is that the

use of common substances (especially alcohol and cigarettes) among youth may reflect a higher level of safety at home, and may also be explicitly allowed by the parents at home (Elek et al., 2006; Nash, McQueen, & Bray, 2005).

Put together, our findings suggest that the prevention of substance use needs to root in all the different levels simultaneously. There are many school-level and community-level substance use prevention programs, such as the Drug Resistance Strategies Project and Keepin' it REAL (Hecht et al., 2003; Tobler & Stratton, 1997). Our findings suggest that other than targeting substance use directly, future efforts at these levels need to also aim at the reduction of e-bullying and the availability of substances, as well as the improvement of academic performance. More importantly, our findings suggest that prevention efforts at the community level per se will not help unless the youth, their friends, and their families internalize the negative perceptions of substance use. Any effort capable of fulfilling these goals should be encouraged.

The study has several limitations. First, the respondents were limited to children who attended school on the day of the survey administration. However, students who experiment with substances were more likely to drop out of school (Townsend, Flisher, & King, 2007). This may result in an underrepresentation of

substance users in the sample and may limit the generalizability of our findings within youth who regularly attend school in Arizona. Second, the groups found by LCA may or may not overlap with the perceptions of the youth and the schools. This is an inherent limitation of the methodology (Tomczyk et al., 2016), and we caution readers to keep it in mind while going over the findings. Third, the cross-sectional nature of the data did not allow us to make any causal inference, or to estimate the developmental trajectories of substance use (Yoon, Yoon, Yoon, & Snyder, 2019). Fourth, all substance use variables were based on self-reports, and some youth may not be able to differentiate between all substance types (Meier et al., 2019). Although we tried our best to ensure the quality of responses by excluding youth who reported the use of the fake drug, our substance use statistics may still be subject to over- or under-reporting. Fifth, our findings may or may not be replicable on youth outside of Arizona. As summarized above, although many of our findings are consistent with findings on youth at other places, there is no guarantee that the groups will replicate on other research sites (Tomczyk et al., 2016). The difference in the composition of the student population may also lead to disagreements between our study and future studies taking a similar approach (Arizona Criminal Justice Commission, 2016).

Despite its limitations, the findings of our study still had some crucial implications. First, substance use is much more complicated than a simple dichotomy between users and non-users. The five groups reflect different levels of risk and need, and the Non-progressive group suggests that the use of prescription pain relievers does not necessarily build on the use of common substances. Second, the regression analysis provides evidence for the social determination of the substance use groups. Prevention and intervention efforts need to emerge from all levels—individual, peer, family, school, and community. Third, the main protective factors against substance use are the negative perceptions of substance use and friends' commitment to stay drug-free. Policymakers will need to ensure the establishment of norms against substance use at the individual, peer, and family levels.

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Table 1. Scales Used in the Present Study

Scales	Items
Adverse childhood experience (ACE, 0-6)	Sum of six dichotomous variables on experiences between born and time of survey: a) living with anyone who was a problem drinker or an alcoholic; b) living with anyone who used illegal street drugs or who abused prescription medications; c) living with anyone who served time or was sentenced to serve time in a prison, jail, or other correctional facility; d) parents separated or divorced; e) having adults at home who ever slapped, hit, kicked, punched, or beat each other up; and f) having adults at home who ever swore at you, insult you, or put you down.
Youth's negative perceptions of substance use (1-4)	Average of five 4-point Likert scales measuring the attitude of the youth themselves towards alcohol, cigarettes, marijuana, LSD, and prescription drugs, 1 = not wrong at all, 4 = very wrong.
Best friends' negative perceptions of substance use (1-4)	Average of four 4-point Likert scales measuring the youth's best friends' attitude towards alcohol, cigarettes, marijuana, and prescription drugs, 1 = not wrong at all, 4 = very wrong.
Family attachment (1-4)	Average of six 4-point Likert scales measuring the youth's closeness to mother and father (three for each parent): a) feeling very close; b) sharing thoughts and feelings, and c) enjoying spending time with their parents, 1 = strongly disagree, 4 = strongly agree).
Parents' negative perceptions of substance use (1-4)	Average of four 4-point Likert scales measuring the youth's parents' attitude towards alcohol, cigarettes, marijuana, and prescription drugs, 1 = not wrong at all, 4 = very wrong.
School commitment (1-5)	Average of three 5-point Likert scale questions measuring the youth's commitment to the school: a) "How interesting are most of your courses to you?" (1 = not at all interesting, 5 = very interesting); b) "How important do you think the things you are learning in school are going to be for you later in life?" (1 = not at all important, 5 = very important); and c) "How often did you feel that the school work you were assigned was meaningful and important? (1 = never, 5 = almost always).
Community's negative perceptions of substance use (1-4)	Average of three 4-point Likert scales measuring the attitude of adults in the youth's neighborhood towards alcohol, cigarettes, marijuana, 1 = not wrong at all, 4 = very wrong.

Community attachment  
(1-4)

Average of three 4-point Likert scales measuring the youth's attachment to the community: a) "If I had to move, I would miss the neighborhood I now live in"; b) "I like my neighborhood" (for both a and b, 1 = strongly disagree, 4 = strongly agree); and (c) "I'd like to get out of my neighborhood" (1 = strongly agree, 4 = strongly disagree).

Ease of access to  
substances (1-4)

Average of five 4-point Likert scale questions regarding how easy it was for the youth to get the following substances on their neighborhood: cigarettes, alcohol, prescription drugs, marijuana, and other illegal drugs, 1 = very hard, 4 = very easy.

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**Table 2.** Substance Use Rates

<b>Substance</b>	<b>Proportion Used</b>	<b><i>SD</i></b>
Alcohol	0.421	0.494
Marijuana	0.239	0.426
Cigarettes and e-cigarettes	0.314	0.464
Inhalant	0.049	0.215
Steroids/Anabolic Steroids	0.012	0.109
OTC Drugs	0.057	0.231
Synthetic Drugs	0.019	0.136
Prescription Pain Relievers	0.071	0.258
Prescription Sedatives	0.045	0.207
Prescription Stimulants	0.034	0.181
LSD/Hallucinogens	0.031	0.174
Cocaine/Crack	0.023	0.149
Ecstasy	0.021	0.144
Methamphetamines	0.005	0.072
Heroin	0.005	0.067
<i>n</i>	30,187	

**Table 3.** Sample Descriptive Statistics (*n* = 30,187)

<b>Variable</b>	<b>Mean</b>	<b>SD</b>	<b>Min</b>	<b>Max</b>
<b><i>Individual level</i></b>				
Age	15.404	1.703	12	19
Male	0.469	0.499	0	1
<b><i>Race</i></b>				
White	0.475	0.499	0	1
Latinx	0.375	0.484	0	1
African American	0.029	0.167	0	1
Native American	0.033	0.178	0	1
Asian and Pacific Islander	0.032	0.176	0	1
Multi-racial	0.056	0.230	0	1
<b><i>Grade</i></b>				
8 <sup>th</sup>	0.373	0.484	0	1
10 <sup>th</sup>	0.339	0.473	0	1
12 <sup>th</sup>	0.288	0.453	0	1
Adverse childhood events	1.768	1.630	0	6
Youth's negative perceptions of substances use	3.530	0.617	1	4
<b><i>Peer level</i></b>				
Number of best friends	2.838	1.161	0	4
Best friends' negative perceptions of substances use	3.278	0.843	1	4
Number of best friends drug-free	1.580	1.657	0	4
Gang involvement	0.032	0.175	0	1
<b><i>Family level</i></b>				
Parents living together	0.604	0.489	0	1
Maternal education	0.518	0.500	0	1
Parents' negative perception on substances use	3.760	0.457	1	4
<b><i>Free lunch participation</i></b>				
Received free lunch	0.342	0.474	0	1
Received reduced cost lunch	0.081	0.272	0	1
Neither free or reduced cost lunch	0.577	0.494	0	1
Family attachment	2.938	0.806	1	4
Sibling marijuana use	0.287	0.452	0	1
<b><i>School level</i></b>				
Academic difficulties	0.054	0.227	0	1
Physically bullied	0.317	0.465	0	1
E-bullied	0.276	0.447	0	1
School commitment	3.057	0.899	1	5
<b><i>Community &amp; Societal level</i></b>				
Community's negative perception on substances use	3.407	0.762	1	4
Community attachment	2.894	0.815	1	4
Ease of access to substances	2.239	0.974	1	4
Exposure to substance use prevention advertisements	0.747	0.435	0	1

Table 4. Model Selection Statistics

	<b>AIC</b>	<b>BIC</b>	<b>Difference in BIC</b>	<b>Adjusted BIC</b>	<b>Log likelihood</b>	<b>Entropy</b>
1	49726.86	49851.59		49803.92	-103410.91	
2	15130.59	15388.36	34463.22	15289.84	-86096.78	3429.22
3	6297.56	6688.37	8699.99	6539.01	-81664.26	5468.64
4	4989.25	5513.11	1175.27	5312.89	-80994.11	6838.01
5	4196.73	4853.63	659.47	4602.57	-80581.85	8571.71
6	3849.75	4639.69	213.94	4337.78	-80392.35	9564.12
7	3694.06	4617.05	22.64	4264.29	-80298.51	10568.95
8	3551.13	4607.16	9.89	4203.55	-80211.05	11186.31

**Table 5.** Multinomial Logistic Model Explaining Class Membership

Variables	(1) Serious Users	(2) Moderate Users	(3) Non-progressive Users	(4) Common Subst. Users
<b><i>Individual Level</i></b>				
Age	1.02 (0.08)	1.37*** (0.06)	1.02 (0.04)	1.23*** (0.05)
Male	0.90 (0.12)	0.85* (0.06)	0.62*** (0.04)	0.85*** (0.04)
<b><i>Race</i></b>				
Latinx	1.15 (0.13)	1.20* (0.11)	1.28** (0.11)	1.48*** (0.09)
African American	0.23** (0.12)	0.65* (0.14)	0.70 (0.15)	0.82* (0.07)
Native American	1.48 (0.45)	1.06 (0.18)	1.05 (0.19)	1.34** (0.14)
Asian and Pacific Islander	0.54 (0.24)	0.71 (0.19)	0.84 (0.16)	0.82 (0.13)
Multi-racial	0.63* (0.15)	0.94 (0.13)	1.03 (0.14)	0.89 (0.07)
<b><i>Grade</i></b>				
10th Grade	2.06*** (0.43)	0.80 (0.10)	0.68** (0.08)	1.03 (0.10)
12th Grade	2.43** (0.83)	0.59** (0.11)	0.53*** (0.10)	0.89 (0.14)
Adverse childhood events	1.45*** (0.06)	1.37*** (0.03)	1.24*** (0.03)	1.16*** (0.01)
Youth's negative perceptions of substances use	0.09*** (0.01)	0.16*** (0.01)	0.36*** (0.02)	0.34*** (0.01)
<b><i>Peer Level</i></b>				
Number of best friends	1.13** (0.05)	1.11*** (0.03)	1.00 (0.03)	1.09*** (0.02)
Best friends' negative perceptions of substances use	0.46*** (0.03)	0.57*** (0.02)	0.75*** (0.04)	0.72*** (0.02)
Number of best friends drug-free	0.81*** (0.03)	0.84*** (0.02)	0.99 (0.02)	0.88*** (0.01)
Gang Involvement	4.90*** (0.96)	2.83*** (0.40)	1.69** (0.31)	1.78*** (0.18)
<b><i>Family Level</i></b>				
Parents living together	0.91 (0.11)	0.92 (0.06)	1.23** (0.09)	0.84*** (0.04)
Maternal education	1.09 (0.13)	1.10 (0.07)	1.10 (0.07)	1.02 (0.04)
Parents' negative perceptions of substances use	0.69*** (0.06)	0.77*** (0.05)	0.70*** (0.05)	0.82*** (0.04)
Received free lunch	0.96 (0.15)	1.13 (0.09)	1.10 (0.10)	1.16** (0.06)
Received reduced cost lunch	0.96 (0.20)	1.09 (0.13)	0.83 (0.11)	1.10 (0.07)
Family attachment	0.85* (0.07)	1.00 (0.05)	0.99 (0.05)	1.09*** (0.03)
Sibling marijuana use	3.70***	3.43***	1.47***	2.63***

	(0.39)	(0.23)	(0.09)	(0.10)
<b><i>School Level</i></b>				
Academic difficulties	1.70** (0.33)	1.51*** (0.18)	0.97 (0.14)	1.28** (0.10)
Physically bullied	0.95 (0.14)	1.06 (0.08)	1.27** (0.10)	0.96 (0.04)
E-bullied	2.14*** (0.26)	1.63*** (0.12)	1.67*** (0.13)	1.39*** (0.06)
School commitment	1.11 (0.09)	1.04 (0.04)	0.94 (0.04)	0.99 (0.02)
<b><i>Community &amp; Society Level</i></b>				
Community's negative perceptions of substances use	0.98 (0.06)	0.98 (0.04)	1.03 (0.05)	0.96 (0.02)
Community attachment	0.97 (0.06)	1.01 (0.04)	0.90* (0.04)	1.03 (0.02)
Ease of access to substances	3.44*** (0.34)	2.36*** (0.10)	1.36*** (0.06)	1.59*** (0.03)
Exposure to substance use prevention Advertisements	1.68*** (0.22)	1.38*** (0.10)	1.44*** (0.12)	1.07 (0.04)
<i>n</i>	30,187	30,187	30,187	30,187

Notes. \*\*\* p<0.001, \*\* p<0.01, \* p<0.05; Robust standard errors clustered by the school and transformed in accordance with RRRs.

**Table 6.** Interaction Effects between Race and Negative Perceptions of Substance Use

Variables	(1) Serious Users	(2) Moderate Users	(3) Non-progressive Users	(4) Common Subst. Users
Latinx * youth's	0.98 (0.17)	0.88 (0.10)	0.83 (0.12)	0.94 (0.08)
Latinx * parents'	1.08 (0.23)	1.01 (0.12)	1.04 (0.15)	1.09 (0.10)
Latinx * friends'	0.66** (0.10)	0.78** (0.07)	0.90 (0.09)	0.86** (0.04)
Latinx * community's	1.08 (0.14)	1.08 (0.09)	0.96 (0.10)	0.99 (0.06)
African American * youth's	5.46* (3.80)	1.34 (0.44)	2.43* (0.96)	1.48 (0.33)
African American * parents'	0.32 (0.24)	1.09 (0.43)	1.11 (0.36)	1.07 (0.30)
African American * friends'	1.11 (0.65)	1.18 (0.23)	1.73* (0.41)	1.02 (0.14)
African American * community's	0.75 (0.39)	0.93 (0.26)	0.50* (0.16)	0.89 (0.13)
Native American * youth's	0.36* (0.15)	0.53* (0.16)	0.59 (0.20)	0.63* (0.13)
Native American * parents'	1.05 (0.33)	0.84 (0.23)	1.32 (0.38)	0.92 (0.21)
Native American * friends'	0.88 (0.33)	1.10 (0.22)	0.79 (0.23)	0.89 (0.10)
Native American * community's	1.78** (0.38)	1.05 (0.23)	1.00 (0.26)	1.14 (0.15)
Asian Pacific Islander * youth's	0.46 (0.20)	0.47* (0.18)	0.75 (0.19)	0.65* (0.12)
Asian Pacific Islander * parents'	0.72 (0.45)	1.15 (0.40)	0.94 (0.29)	1.13 (0.24)
Asian Pacific Islander * friends'	1.31 (0.52)	1.28 (0.46)	1.48 (0.37)	1.06 (0.15)
Asian Pacific Islander * community's	1.68 (0.76)	1.31 (0.31)	0.80 (0.28)	1.03 (0.15)
Multi-racial * youth's	1.14 (0.44)	0.87 (0.16)	0.90 (0.21)	0.86 (0.13)
Multi-racial * parents'	1.72 (0.70)	1.45 (0.36)	1.26 (0.28)	1.43 (0.27)
Multi-racial * friends'	1.02 (0.40)	0.96 (0.15)	1.02 (0.20)	1.00 (0.10)
Multi-racial * community's	0.79 (0.20)	0.76 (0.13)	0.92 (0.18)	0.85 (0.09)
<i>n</i>	30,187	30,187	30,187	30,187

Notes. \*\*\* p<0.001, \*\* p<0.01, \* p<0.05; Effects of all variables in main model controlled for; Robust standard errors clustered by the school and transformed in accordance with RRRs.