# Characterizing Profiles of Polysubstance Use among High School Students in Baltimore, Maryland: A Latent Class Analysis

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## Abstract

**Background.**—Adolescent drug use has long term health consequences, like substance use disorders and psychiatric illnesses. Proximal health risks, especially for overdose, are amplified when multiple substances are combined. Existing literature on polysubstance use among adolescents has largely focused on alcohol, tobacco, and marijuana, but has largely excluded other drugs like opioids. Understanding how adolescents combine illicit drugs is essential for intervening to prevent poor health outcomes.

**Methods.**—We aimed to explore patterns of lifetime polysubstance use among adolescents in Baltimore City. We used data on 9th-12th graders recruited to participate in the 2017 local Baltimore Youth Risk Behavior Survey who reported any lifetime drug use (n=387; 60% female, 77% non-Hispanic Black). We then conducted a latent class analysis using 10 indicators of lifetime drug and alcohol use. After selecting the class model, we tested for associations between the class profiles and race, sex, school grade, and lifetime injection drug use.

**Results.**—We identified three profiles of lifetime polysubstance use in our sample: alcohol and marijuana (68.6% of sample), polysubstance (22.0%), and alcohol/pain medication/inhalant use (9.4%). Members of the polysubstance use class were more likely to be male and to report injection drug use.

**Conclusions.**—Understanding broader patterns of drug use beyond alcohol, tobacco and marijuana amongst adolescents is a crucial step towards preventing adverse drug and health-related outcomes later in life. More research is needed to characterize the full health impact of youth polysubstance use patterns and related risk behaviors like injection drug use.

**Conflicts of Interest:** None.

**Keywords**

Polysubstance use; adolescents; latent class analysis; youth risk behavior survey; drug use patterns

## 1. Introduction

Adolescent drug use is pervasive in the United States (US). In 2017, 35.6% of high school students reported lifetime marijuana use, 14.0% had misused prescription pain medications, 6.9% has used synthetic marijuana, 6.6% had used hallucinogens, and 6.2% had used inhalants (Kann et al., 2018). Other drugs, like ecstasy (4.0%), cocaine (4.8%), steroids (2.9%), methamphetamine (2.5%), and heroin (1.7%), are rarer among US youth, but represent serious health concerns for youth who consume them (Kann et al., 2018). Adolescent drug use is associated with many negative outcomes, including arrests, school dropout, and substance use and psychiatric disorders (Brook et al., 2000; Gil et al., 2004; Newcomb and Bentler, 1988; Vida et al., 2009; White et al., 1998).

Adolescent substance use in the US varies geographically, with recent studies documenting geographic differences in the prevalence of heroin and non-medical prescription opioid use (NMPO) use (Jones et al., 2019), and geographic differences in trends in adolescent heroin and injection drug use over time (Brighthaupt et al., 2019). The prevalence of other substance use (e.g., cocaine, alcohol) also varies regionally in the US (Johnston et al., 2019; Thorlton et al., 2012). Understanding patterns of adolescent substance use in places with particularly high substance use burdens is necessary to inform tailored public health programming.

Baltimore City is among the cities with high rates of adolescent drug use, warranting further investigations into youth drug use patterns in this urban context (Jones et al., 2019). As in many urban settings, adolescents in Baltimore face high levels of poverty (31% of families living below the poverty line) and significant social problems that are known contributors to adolescent drug use, like pervasive community violence and an under-funded public school system (Baltimore Neighborhood Indicators Alliance, 2019; Dashiff et al., 2009; National Center for Education Statistics, 2017; Wright et al., 2013). Because these contextual factors are shared, in varying degrees, by many other cities, identifying the nuances of adolescent substance use in Baltimore City can also form the basis for understanding youth drug use in other urban centers.

Understanding how adolescents use and combine drugs and the potential risks these behaviors confer within high drug use contexts is important for developing tailored interventions. Research among adults has demonstrated that polysubstance use increases one's risk for fatal and non-fatal overdoses, HIV, and Hepatitis C (Coffin et al., 2003; Darke et al., 2005; Degenhardt and Hall, 2012; Harrell et al., 2012; Roth et al., 2015; Sorg et al., 2016; Wu et al., 2011). The literature documenting specific patterns of polysubstance use among adolescents has important limitations. Studies have typically focused on alcohol, tobacco, and marijuana, and included few other substances (typically stimulants and/or inhalants) or combined all other drugs into single illicit drug use variables (Delk et al., 2019; Kulis et al., 2016; Morean et al., 2016; Su et al., 2018; Tomczyk et al., 2016). A systematic

review of latent class analyses of adolescent polysubstance use identified that the classes typically found in existing studies are no/low use, polysubstance use, and single substance classes (i.e. alcohol only, marijuana only) (Tomczyk et al., 2016). Of studies that include a broader range of drugs, most typically find similar classes, and a few identify NMPO-related classes in addition to overall polysubstance classes (Choi et al., 2018; Kulis et al., 2016; Tomczyk et al., 2016; Wu et al., 2020). This is due, in part, to the inclusion of adolescents who do not use drugs in study samples, which decreases latent class models' ability to detect nuance within polysubstance use if there is a large portion of the study sample that does not endorse model indicators. Expanding the type of substances included in latent analyses and focusing specifically on adolescents who do endorse drug use will enable characterization of more specific profiles that may be associated with poor health outcomes and can be targeted by future interventions.

Presently, we aim to characterize profiles of lifetime polysubstance use among adolescents in Baltimore City, Maryland who report lifetime use of a wide range of substances, including several drugs unexplored to date (e.g., opioids), to increase understanding of the intersection between opioid and other drug use among these youth.

## 2. Methods

### 2.1. Data Source.

Data for this study come from the Youth Risk Behavior Survey (YRBS) datasets for Baltimore City from 2017 (N=805). The YRBS is conducted biennially in public high schools. Students complete an anonymous self-administered survey. The overall response rate for Baltimore City was 69%. We restricted the sample to individuals who reported using ≥ 1 non-alcohol drug (listed below) in their lifetime (n=389). We further excluded 2 ungraded students in the sample, yielding a final analytic sample of 387. We did not apply survey weights to the analysis, because weighted estimates would likely be non-representative within this restricted sample.

### 2.2. Measures.

Participants reported any lifetime use of alcohol or any of the following 9 drugs : marijuana, synthetic marijuana, cocaine, methamphetamine, heroin, pain medications (not as prescribed by a doctor), inhalants, ecstasy, and steroids. We included sex (male, female), race/ethnicity (Non-Hispanic Black, Other), grade ($9^{th}$-$12^{th}$), and any lifetime injection drug use (IDU) as covariates. More than 10% had missing data on marijuana use (13.7%), alcohol use (20.7%), and IDU (11.6%).

### 2.3. Analysis.

We conducted a latent class analysis (LCA) of the 10 substance use measures to identify subgroups with similar polysubstance use profiles (Goodman, 1974; Lazarsfeld and Henry, 1968). Here, LCA allows for the identification of homogenous subgroups with respect to the substance use indicators to identify distinct profiles of drugs use that may confer unique health risks. We used model fit statistics to determine the preferred number of classes: Akaike Information Criteria, Bayesian Information Criteria, and Lo-Mendell-Rubin

Likelihood Ratio Tests (Nylund et al., 2007). We used a Full Information Maximum Likelihood estimator, which addresses missingness as effectively as multiple imputation (Collins et al., 2001). We then used a manual three-step approach to test for associations between class membership and our covariates of interest, where logits for the classifications probabilities were used to account for individuals' likelihood of membership in classes other than their most likely class (Vermunt, 2010). Analyses were conducted using Mplus 8.3 (Muthén and Muthén, 1998–2017).

## 3.  Results

With the exception of 9th graders, our sample was fairly evenly distributed across grades (9th: 17.8%, 10th: 28.3%, 11th: 23.3%, 12th: 30.6%). There were more female (59.6%) than male (40.4%) students in our sample. Most students were Black (77.5%). Marijuana was the most commonly used drug (89.2%), followed by alcohol (80.1%), prescription pain medications (26.0%), synthetic marijuana (21.5%), and inhalants (22.8%). Heroin (15.0%), steroids (15.5%), methamphetamine (14.0%), ecstasy (13.3%), cocaine (13.9%), were the least prevalent drugs used. In our sample, 13.2% reported lifetime injection.

We selected a three class LCA model for polysubstance use based on the fit statistics in Table 1. The three-class model was preferred according to the BIC and Lo-Mendell-Rubin Likelihood Ratio Test, had good entropy, and was the largest model that retained a sufficiently sized smallest class. The conditional probabilities of endorsing each drug use indicator by class are displayed in Figure 1. The largest class represented 68.6% of the sample and was characterized by alcohol and marijuana use. The second largest class contained 22.0% of the sample and was characterized by high probabilities of using all drugs and alcohol (hereafter referred to as polysubstance use). The smallest class represented 9.4% of the sample and was primarily characterized by alcohol, inhalant, and pain medication use, with some marijuana use.

Race/ethnicity was not a statistically significant correlate of class membership. More than three-quarters of those in each group were Black (alcohol/marijuana: 76.9%; polysubstance: 75.3%; alcohol/inhalants/pain medication: 90.5%). The classes had the following estimated proportions in each grade level: alcohol/marijuana – 16.2% in 9th, 27.0% in 10th, 24.5% in 11th, and 32.3% in 12th; polysubstance – 14.5% in 9th, 31.9% in 10th, 21.7% in 11th, and 31.9% in 12th; alcohol/pain medication/inhalants – 29.2% in 9th, 32.3% in 10th, 22.5% in 11th, and 16.0% in 12th. The only statistically significant differences between classes in terms of grade was that twelfth graders were more likely than ninth graders to be in the alcohol/marijuana class (ß=1.36, p=0.031) and the polysubstance class (ß=1.45, p=0.039) than the alcohol/pain medication/inhalants class. The polysubstance use class had a lower probability of members being female (38.9%) than the alcohol/marijuana (65.2%; ß=−1.09, p<0.001) and alcohol/pain medication/inhalants (64.5%; ß=−1.03, p=0.024) classes. The low prevalence of injection drug use in the sample precluded from testing for differences by latent class, as tests produced standard errors too large to be reasonably considered reliable. Instead, we calculated the prevalence of lifetime IDU for each class, accounting for misclassification: 0.0% in the alcohol/pain medication/inhalants class, 2.0% in the alcohol/marijuana class, and 66.0% in the polysubstance class.

## 4. Discussion

In this study, we used latent class analysis to characterize patterns of polysubstance use among Baltimore City high school students who reported lifetime drug use. We identified three primary patterns of substance use: marijuana and alcohol use, polysubstance use, and alcohol, pain medication, and inhalant use. The polysubstance use class was more likely to be male, and report lifetime cigarette use, and injecting drugs.

There are two distinct groups of youth who are using opioids in Baltimore, who may be at very different risks for overdose and infectious disease outcomes. The polysubstance class had a high estimated prevalence of injection drug use, putting them at higher risk for injection-related HIV and Hepatitis C infection. Youth in the polysubstance class may also be at increased risk for severe drug use patterns and substance use disorders. The alcohol/pain medication/inhalants class may be at heightened risk for overdoses, if these lifetime measures reflect concurrent use. Alcohol is a central nervous system depressant, as are most inhalants with the exception of nitrates(Evans and Balster, 1991; Williams et al., 2007). When depressants are combined with opioids, the risk of experiencing a fatal overdose increases substantially (Warner- Smith et al., 2001; White and Irvine, 1999). More research is needed to directly test the health consequences associated with the adolescent substance use profiles we have identified and their similarities and differences from adult outcomes.

This study indicates that polysubstance use is common among adolescents who use drugs in Baltimore City. Understanding the ways in which adolescents combine multiple substances is essential for both research and public health practice in this population. In this study, we began to highlight different patterns of polysubstance use that exist among adolescents in Baltimore, which points to groups with divergent health risks. These results suggest that distinct harm reduction programs related to preventing these outcomes would be most appropriate for different groups of adolescents, based on their polysubstance use profiles.

This study has some limitations to consider. Most importantly, the Baltimore YRBS only measures lifetime illicit drug use, except for marijuana. We were unable to determine if the use of multiple drugs occurred simultaneously, and future studies are needed to clarify this. However, studies of simultaneous polysubstance use are relatively rare even among adults. Frequency and recency of use are important characteristics of polysubstance use that we were not able to address in this study. Future studies are needed to explore these characteristics of substance use among adolescents within the context of polysubstance use to fully understand the risks of overdose and other adverse health outcomes. Regardless, endorsing lifetime use of a variety of substances still represents some level of risk for adverse health outcomes among adolescents. The YRBS data only reflects high school attending adolescents, thus adolescents who are not attending school and may be at high risk for substance use and related harms are not included in this study. Furthermore, we could not evaluate the health impact of adolescent drug use profiles in this study because YRBS does not measure key substance use-related health outcomes, like overdose, HIV, and Hepatitis C infection. Finally, the results of this study may only generalize to other demographically similar adolescent populations living in urban environments. Socio-environmental risk factors, like poverty and violence, are common in Baltimore City, and these factors should

be considered when comparing the present findings to those in other settings. Nonetheless, this study expands our understanding of polysubstance use among youth in notably high-risk urban contexts, by including a range of drugs and focusing on adolescents who endorse drug use.

### 4.1.  Conclusions.

Adolescents who use drugs in Baltimore City have a variety of substance use profiles, each of which may have distinct health impacts. Specific patterns of substance use may heighten risks for overdose, and infections related to injection drug use. More research is needed to fully characterize the health consequences of polysubstance use profiles in adolescence, and their relationships to overdose and infectious disease outcomes.

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## Highlights

- Polysubstance use was common among adolescents who used drugs in Baltimore City.

- Three profiles emerged: alcohol/marijuana, polysubstance, and alcohol/inhalants/pain medication.

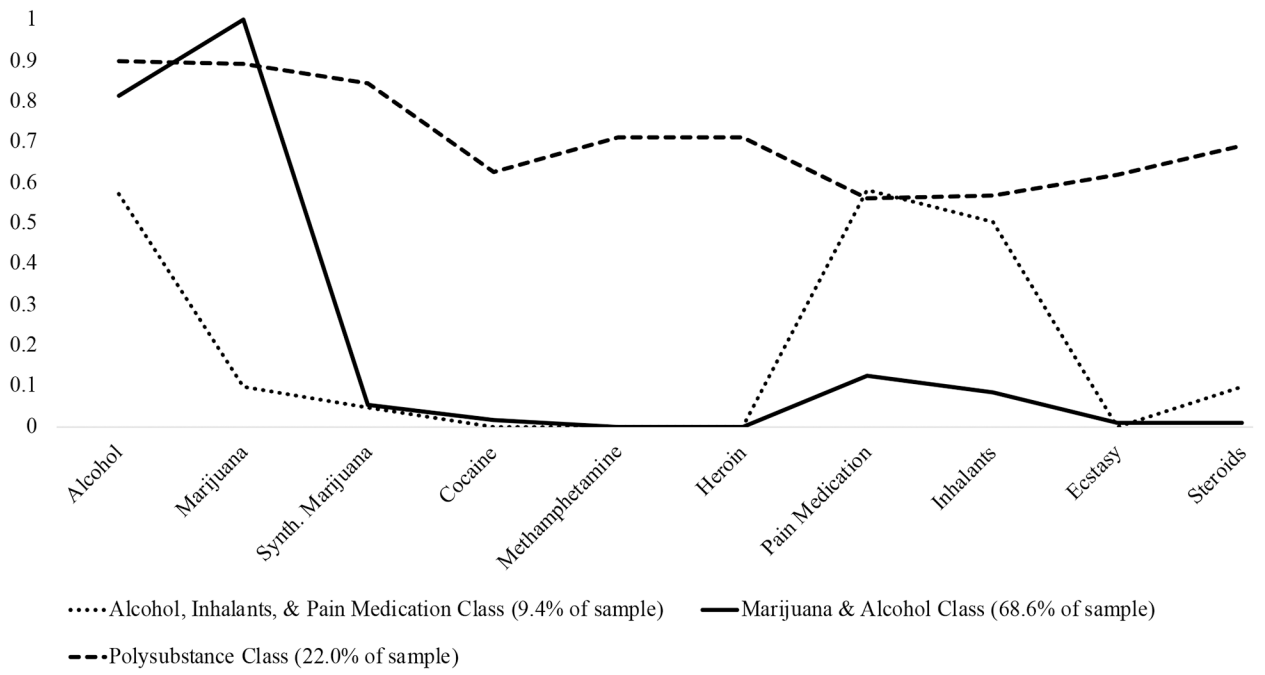- The polysubstance use class was more commonly male and 66% had injected drugs.

**Figure 1.**
Probabilities of Use of Each Drug by Latent Class.

**Table 1.**

Latent Class Analysis Fit Statistics

| Classes | Smallest Class | Log Likelihood | AIC | BIC | Entropy | LMR p-value |
|---------|----------------|----------------|-----|-----|---------|-------------|
| 1 | -- | −1603.843 | 3227.687 | 3267.271 | -- | -- |
| 2 | 21.9% | −1198.862 | 2439.724 | 2522.851 | 0.957 | 0.000 |
| 3 | 9.4% | −1161.761 | 2387.521 | 2514.191 | 0.936 | 0.012 |
| 4 | 6.3% | −1140.884 | 2367.767 | 2537.979 | 0.879 | 0.191 |
| 5 | 4.7% | −1122.532 | 2353.064 | 2566.819 | 0.949 | 0.001 |
| 6 | 4.7% | −1109.256 | 2348.513 | 2605.81 | 0.813 | 0.000 |