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Latent classes of heroin and cocaine users predict unique HIV/HCV risk factors

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Abstract

Background—Patterns of heroin and cocaine use vary and may be associated with unique risk factors for bloodborne infections.

Methods—Latent class analysis identified sub-populations of 552 heroin and cocaine users in Baltimore, Maryland. Using latent class regression, these classes were analyzed for associations with demographic characteristics, risky behaviors, Hepatitis C, and HIV.

Results—Three classes were found: *Crack / Nasal-Heroin* users (43.5%), *Polysubstance* users (34.8%), and *Heroin Injectors* (21.8%). Compared to *Polysubstance* users, *Crack* / *Nasal-Heroin* users were almost 7 times more likely to identify as Black (OR = 6.97, 95% CI = 4.35-11.2). Sharing needles was over 2.5 times more likely among *Polysubstance* users than among *Heroin Injectors* (OR = 2.66, 95% CI = 1.49-4.75). *Crack/Nasal-Heroin* users were 2.5 times more likely than *Polysubstance* users to exchange drugs for sex (OR = 2.50, 95% CI = 1.22-5.13). *Crack/Nasal-Heroin* users were less likely than *Heroin Injectors* to have Hepatitis C (OR = 0.10, 95% CI = 0.06-0.18), but no significant differences were found for HIV.

Conclusions—Subpopulations of cocaine and heroin users differed in demographic classifications, HIV-risk behaviors, and Hepatitis C infection. All subpopulations included substantial numbers of HIV-positive individuals. Findings provide further evidence that non-injection drug users face significant infectious disease risk.

Keywords

Cocaine; heroin; polydrug; injection; sex trade; HIV/AIDS

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1. Introduction

Heroin and cocaine use costs society billions due to healthcare, lost productivity, and crime (Cartwright, 2000; Mark et al., 2001). Heroin and cocaine users are overlapping populations; i.e., many individuals who use heroin also use cocaine. Rates of cocaine use range from 30-80% among opioid-dependent substance users not currently in treatment and from 50-73% among patients in methadone treatment (Leri et al., 2003). Either substance can be injected, leading to a greater potential for harm. Injection drug use (IDU) alone is attributable to over 2.5 billion dollars of healthcare costs due to Acquired Immunodeficiency Disease Syndrome (AIDS) and over half a billion dollars due to Hepatitis C (Mark et al., 2001). The link between non-injection drug use (NIDU) and infectious disease is also strong, but an understanding of the mechanism driving this association is more nebulous (Drumright and Colfax, 2009). IDU is believed to be associated with infectious diseases due to sharing of needles, but multiple pathways have been suggested for how NIDU may influence disease status. There is a paucity of research investigating patterns of drug use among heavy drug users, including NIDU, and how these patterns relate to infectious disease. The current study seeks to fill this gap by exploring patterns of drug use among a sample of heroin and/or cocaine users from Baltimore, Maryland using Latent Class Analysis. These latent classes are examined in depth for relationships with risky behaviors and infectious diseases.

1.1. Patterns of drug use

Patterns of heroin and cocaine use vary dramatically among different populations. For example, in the United States (US), the simultaneous injection of heroin and cocaine, referred to as a “speedball,” is relatively common. Over 18% of illicit drug users in Miami, Florida used speedball in the last 30 days (McCoy et al., 2004) in comparison to less than 4% in Canada (Leri et al., 2004). On the other hand, crack cocaine is typically smoked in the US and rarely injected (Substance Abuse and Mental Health Services Administration, 2009), but in the United Kingdom, crack cocaine injection is a primary form of drug administration (Hickman et al., 2007). Patterns of heroin and cocaine use also vary in different historical contexts. Present-day diverse patterns of opioid and cocaine polydrug use are in stark contrast with mid-20th Century conceptions of heroin addicts focused nearly exclusively on illegal heroin use (Courtwright, 1982; Lindesmith, 1947; Monga et al., 2007).

The various patterns of drug use and routes of administration (ROAs) are associated with unique health consequences (Gossop et al., 1992; Strang et al., 1998). Smoking of cigarettes and other substances by drug users is associated with substantial adverse outcomes including medical complaints and higher mortality rates (Hser et al., 1994; Hurt et al., 1996; Patkar et al., 2005; Patkar et al., 2002; Strang et al., 1999). Smoking crack cocaine, as opposed to nasal use, is associated with increased risk of dependence (Chen and Anthony, 2004). IDU is associated with increased risk for drug dependence (Gossop et al., 1994; Strang et al., 1999) and overdose (Gossop et al., 1996).

1.2. Relationships with infectious diseases

Infectious diseases such as Human Immunodeficiency Virus (HIV) are potential consequences of drug use. In particular, IDU is known to be associated with HIV and hepatitis C infection (Chitwood et al., 2003; Nelson et al., 2002). NIDU can also be a risk factor for HIV. For example, alcohol (Hutton et al., 2008) and marijuana (Boyer et al., 2000; Boyer et al., 1999) use are both associated with increased risk for sexually transmitted diseases (STD’s). A recent comprehensive chapter on HIV risk and prevention for NIDU noted that most published studies on HIV and opioids fail to distinguish non-injection from injection opioid use (Drumright and Colfax, 2009). The relatively few studies demonstrate high rates of infectious disease among non-injection heroin users (Ferreira et al., 2009; Rich et al., 2006; Vallejo et al., 2008). Further investigation is warranted to understand the nature of the association between NIDU and infectious disease.

One difficulty in understanding this association is the wide range of substance use patterns. Since substance users often use a variety of drugs by different ROAs, focusing on individual drugs may be difficult or lack real-world generalizability. Examinations of patterns of drug use may be a more productive approach. In contrast to an approach focusing on variables of interest, such as particular drugs or ROAs, Latent Class Analysis (LCA) is an effective person-centered approach for identifying subpopulations empirically. Effective use of LCA has allowed for furthering our understanding of the development of cocaine dependence (Reboussin and Anthony, 2006), drug abuse and dependence in the US general population (Agrawal et al., 2007), ecstasy use problems (Martins et al., 2011; Scheier et al, 2008), and patterns of drug use among cocaine and heroin users in Canada (Monga et al., 2007; Patra et al., 2009). However, until quite recently (Kuramoto et al., 2011), there appeared to be no published LCA identifying classes of heroin and cocaine use patterns in the US. Patterns of drug use in the US differ in important ways from those in Canada. For example, prior LCA research did not investigate speedball use due to the low prevalence rates in Canada (Monga et al., 2007; Patra et al., 2009). Further, prior research in the United States did not specifically investigate risky sexual behaviors (Kuramoto et al., 2011). This study addresses these critical gaps in the literature by using LCA to identify specific polydrug use patterns in heroin and cocaine users and examine how these classes relate to risky behaviors and infectious diseases, specifically Hepatitis C and HIV. We expected that, although infectious disease would be relatively high in all classes, classes using more substances, particularly via injection routes, would also engage in more risky behaviors, resulting in higher rates of Hepatitis C and HIV.

2. Methods

2.1. Participants and design

The present study sample consisted of 552 self-identified Black and White adult drug users in Baltimore, Maryland, United States, from the NEURO-HIV Epidemiologic study, a longitudinal investigation funded by the National Institute on Drug Abuse to evaluate neuropsychological and social-behavioral risk factors of contracting infectious diseases among injection and non-injection drug users (Severtson et al., 2010a). Recruitment involved advertisements in local newspapers, referrals, and street outreach. To be eligible for the study, participants needed to report using cocaine or heroin in the past 6 months and be between 18 and 50 years old. Upon arrival, participants provided informed consent, received blood tests, gave urine samples, and completed the HIV-Risk Behavior Interview, a semi-structured interview about drug use and sexual practices. This interview was adapted from a similar interview used for the REACH study and included questions on demographic variables in addition to medical, education, and neurodevelopment histories (Strathdee and Sherman, 2003). The study was approved and monitored by the Institutional Review Board at the Johns Hopkins Bloomberg School of Public Health. Demographic characteristics are presented in Table 1. The sample included 321 men (58%) and 231 women (42%). Half self-identified as Black (n=276) and the other half self-identified as White (n=276).

2.2. Measures

2.2.1. Latent class indicators—Table 1 notes all routes of administration (ROAs) and substances used in the past month by 20% or more of the sample. Past month substance use is often used as a variable of interest in substance abuse research (Monga et al., 2007) including national surveys, such as Monitoring the Future (Johnston et al., 2002). Although not without limitations, this measure avoids being over too long a length of time to result in unreliable memory as well as including a long enough time span to avoid incorrect categorizations due to random, recent events (e.g., short periods of abstinence coinciding with research interview despite typical patterns of use). Prior research used 20% as a cut-off (Monga et al., 2007). Over a quarter (28.4%) of the sample used speedball in the past month. However, the next most prevalent category, “Downers,” a composite group including barbiturates and sedatives, was only used by 14.5% of the sample. Notably, less than 1% of this Baltimore sample used stimulant drugs more common in other geographical areas, such as amphetamines. Thus, we chose to use the methodology from the prior published study. The eight indicators chosen based on 20% or higher prevalence were as follows: alcohol, cigarettes, injecting speedball, injecting heroin, snorting heroin, injecting cocaine, smoking crack, and smoking marijuana.

2.2.2. Demographics, HIV-risk behaviors, and disease status—Demographic and drug use variables were used to examine characteristics of individuals within classes and to elucidate the general meaning of the classes. Dichotomous variables were used for ease of interpretation. Based on a median age of 33, substance users were divided into those over 33 years old and those 33 years old or younger. Behaviors and environments associated with infectious disease risk, and thus examined in analysis, include drug use (Drumright and Colfax, 2009), jail (Jurgens et al., 2009), needle sharing (Chitwood et al., 2003; Nelson et al., 2002) and sexual risk behaviors (Jenness et al., 2011). Cigarette smoking was included as well, primarily due to its association with increased mortality (Pines et al., 2011), but also due to the remote possibility that it may be a risk factor for HIV (Marshall et al., 2009). Casual sex was defined as having sex with someone for less than 3 months, including one-night stands, but not transactional sex. For drug use, separate questions were asked for each substance based on ROA. Questions regarding injection of heroin, for example, were asked separately from questions regarding snorting of heroin. There were a total of 63 substance-ROA pairs. The median number of substances used in an individual’s lifetime was 8. Thus, individuals who used over 8 substances in their lifetime were labeled “Lifetime Polydrug Use.” Urinalysis results included cocaine and opioid use. In addition, we included items from the interview regarding lifetime history of incarceration, any diagnosis of a psychiatric disorder, injection drug use, needle sharing, and exchanging drugs for sex. Disease status for Hepatitis C or HIV was determined via blood samples.

2.3. Statistical analysis

Latent class analysis (LCA) was used to examine profiles of substance use. LCA is a statistical method in which several items (or indicators) are used to determine subgroups or classes of individuals who exhibit a similar pattern of responses (McCutcheon, 1987; Whitesell et al., 2006). LCA assumes that the class structure accounts for the similar reporting by individuals on the indicator variables within each class (Reboussin et al., 2006). Responses to the indicator variables are statistically independent conditional on class membership (Lazarsfeld and Henry, 1968; McCutcheon, 1987; Reboussin et al., 2006), i.e., the class membership explains any association between the reported indicators (Lazarsfeld and Henry, 1968; McCutcheon, 1987; Reboussin et al., 2006). The resulting assumption permits that classes are interpreted as homogenous and distinct from each other and that within any class the item reporting patterns differ only by random error (McCutcheon, 1987; Reboussin et al., 2006).

The eight drug use indicator variables were entered into the LCA model. Starting with a one class model and incrementally increasing the number of classes, a series of LCA models were fit to the data. In order to ensure that global, rather than local, maxima were reached, we used a minimum of 500 random starts. If necessary, the number of starts was increased until the log likelihood was replicated a minimum of five times. Multiple fit statistics were used to determine the best-fitting, most parsimonious model, including the Bayesian Information Criteria (BIC; Schwartz, 1978), the parametric bootstrap likelihood ratio test (BLRT; McLachlan and Peel, 2000), and the Lo-Mendell-Rubin adjusted likelihood ratio test (LMR; Lo et al., 2001).

The value and utility of the resultant classes was assessed using entropy (Ramaswamy et al., 1993). Entropy uses individual estimated posterior probabilities to summarize the degree to which the latent classes are distinguishable and the precision of assignment of individuals into classes. It ranges from 0 to 1 with higher values indicating better class separation. Entropy is not a measure of fit, nor was it originally intended for model selection; however, low values of entropy may indicate that the model is failing to find homogeneous groupings of individuals with distinct profiles. Finally, the choice of latent class solution presented was also informed by substantive criteria, such as meaningfulness in terms of the current epidemiology of drug use. The *n* reported in each class is a total based on individual probabilities of class membership, i.e., a number ranging from 0.0, or no chance of membership in that specific class for that specific individual, and 1.0, or 100% certainty of class membership. Thus, these numbers are decimals, rather than whole numbers. Mplus version six was used for the LCA modeling (Muthén and Muthén, 2010).

2.4. Missing data

Mplus uses a full information maximum likelihood estimation with the assumption the data is missing at random (MAR; Hogan et al., 2004). This approach is widely accepted (Schafer and Graham, 2002). No participants needed to be removed due to missing data on latent class indicators. Covariance coverage ranged from 0.993-1.0, well over minimum thresholds for adequate coverage (e.g., .10, Muthén and Muthén, 2010).

2.5. Class associations

After deciding on the appropriate number of classes that best fit the data, we examined the association between class membership and several demographic and predictor variables as well as outcomes utilizing the auxiliary option (Bandeen-Roche et al., 1997; Muthén and Asparouhov, 2007; Wang et al., 2005). This option was used to study the association of classes with demographics, hiv-risk behaviors, and disease status without changing the unconditional latent class model (Muthén and Muthén, 2010). The AUXILIARY (r) option was used to examine which covariates are important predictors of latent classes. This is done using posterior-probability based multinomial logistic regression of a categorical latent variable on a set of covariates. For disease status, we adjusted results for age, sex, and race. The AUXILIARY (e) option was used to examine the extent to which HIV status varied as a function of latent class membership by testing the equality of means across latent classes using posterior probability-based multiple imputations. Percentages obtained are reported with standard errors based on probabilities of class membership.

In summary, the use of auxiliary information, potentially derived from substantive theory, is highly relevant to determine the concurrent and prognostic validity of specific latent class profiles. The inclusion of auxiliary information in mixture analysis is a necessary step in understanding as well as evaluating the fidelity and utility of the resultant profiles (Petras and Masyn, 2010).

3. Results

3.1. Class Membership

A latent class model consisting of three classes was selected as it had the lowest Bayesian Information Criteria (BIC) score, 5029.94 (see Table 2). The Lo-Mendell-Rubin (LMR) adjusted likelihood ratio test and Bootstrap Likelihood Ratio Test (BLRT) also supported a 3-class solution, although the ideal solutions for the LMR and BLRT were 4-class and 5-class, respectively. Thus, out of the three main fit indices, a 3-class model was supported by all 3 indices. Although Monte Carlo simulations suggest that a BLRT fares best overall in LCA, simulations also favor the BIC over the AIC and, in certain situations, over the Adjusted BIC (Nylund et al., 2007). Further, the relative frequency was lower for the 4-class and 5-class solutions, which indicates concern about wide confidence intervals for the regression coefficients (Petras and Masyn, 2010). Thus, based on concerns of parsimony, practical utility, and theoretical concerns, we chose the 3-class model presented. For reference, the four class model included a separate class with high probabilities for injection drug use, but a 0% probability for snorting of heroin. In addition, there was a 0% probability for smoking crack among a class with high probabilities for injecting heroin. In the five class model, a class with a 100% probability of injecting heroin, but 0 % probability for injecting cocaine was found. In addition, there was a class with about a 50% probability of injecting heroin, but a 0 % probability for snorting heroin or smoking crack.

Class 1, consisting of 43.5% (n = 240.1) of the sample, was composed of individuals with high (over 50 %) probabilities of cigarette smoking, drinking alcohol, snorting heroin, and smoking crack. Probabilities for any type of injection use in this sample did not exceed 14%. Snorting heroin and crack smoking is higher in this group than any other group, so we refer to this group as *Crack/Nasal-Heroin* users. In contrast, class 2, over a third of the sample (34.8%), n = 191.8, had relatively high probabilities (> 45%) for every indicator except nasal heroin. This class is thus referred to as *Polysubstance*. The final class, representing a little over a fifth (21.8%) of the sample, n = 120.1, had high probabilities of cigarette smoking and heroin injection, but relatively low (less than 25%) probabilities of all other indicators. This third class is referred to as *Heroin Injectors*. See Figure 1.

3.2. Characteristics of classes

3.2.1. Demographics—Table 3 provides odds ratios and 95% confidence intervals comparing latent classes on demographics, HIV-risk behaviors, and disease status. Analyses of demographic variables found significant class-level differences for all demographic variables examined (see Table 3). Individuals in the *Crack/Nasal-Heroin* group were almost two times more likely to be in the over 33 years old age group as compared to *Heroin Injectors* and 2.5 times more likely as compared to *Polysubstance* users. These individuals with high probabilities of crack smoking and heroin snorting were over 5.5 times as likely to identify themselves as Black compared to both *Heroin Injectors* and *Polysubstance* users .

3.2.2. HIV-risk behaviors—As expected, *Polysubstance* users were more likely to report “Lifetime Polydrug Use” than *Heroin Injectors*. Urinalysis results supported the class structures. As compared to *Heroin Injectors*, *Crack/Nasal-Heroin* users were more likely to test positive for cocaine, but less likely to be positive for opioids. *Polysubstance* users were over 2.5 times more likely to share needles as compared to *Heroin Injectors*. *Crack/Nasal-Heroin* users were much less likely to share needles compared to both *Heroin Injectors* and *Polysubstance* users, but 2.5 times *more* likely to have sold drugs for sex as compared to *Polysubstance* users and nearly 3 times more likely than *Heroin Injectors*. To more fully understand the lifetime, as opposed to past 30 day, histories of the *Crack/Nasal-Heroin* users, we used most likely class membership to examine lifetime history of injection drug use. Only 36.6% of members of this class injected any drugs in their lifetime.

3.2.3. Disease Status—There were no differences in the significant relationships reported here whether or not we adjusted for demographic differences. *Crack/Nasal-Heroin* users were less likely to have Hepatitis C as compared to both *Heroin Injectors* and *Polysubstance* users. There were no significant associations between latent class membership and HIV status. Since this was unexpected, we investigated the equality of means across classes. Although the differences were not significant, χ^2 (degrees of freedom=2) = 0.20, p = 0.86, the percentage of HIV-positive individuals was higher in the *Crack/Nasal-Heroin* class (9.3%, *Standard Error* = 2.0) than in either the *Polysubstance* class (7.8%, *SE* = 2.2) or the *Heroin Injectors* class (7.7%, *SE* = 2.9).

4. Discussion

4.1 Review of Major Findings

Overall, our findings are consistent with research demonstrating high rates of infectious diseases among cocaine and heroin users (Buchacz et al., 2000; Chitwood et al., 2003; Drumright and Colfax, 2009; Ferreira et al., 2009; Kuo et al., 2004; Rich et al., 2006; Vallejo et al., 2008). Due to differing recruitment strategies, indicator variables, and other issues, it is difficult - if not impossible - to compare results of prior latent class analyses. Nonetheless, some patterns can be noted. The three classes identified in the analysis are in some ways consistent with prior research (Kuramoto et al, 2011; Monga et al., 2007; Patra et al., 2009), although some notable differences emerged. The largest class included participants with relatively high probabilities of smoking crack and snorting heroin, but low probabilities of injection drug use (IDU). This differs from Canadian samples of opioid users wherein, although classes with low probabilities of IDU were identified, the majority of participants used via IDU (Monga et al., 2007; Patra et al., 2009). It resembles more closely a sample from Baltimore in finding classes with low probabilities of injection drug use (Kuramoto et al., 2011). The existence of these classes provide further evidence of an aversion to injection drug use among certain segments of the cocaine and heroin-using population who prefer other routes of administration (ROAs). The next largest class included participants with high probabilities of every substance and ROA except for nasal heroin. Injection heroin leads to a larger subjective “high” than nasal heroin (Comer et al., 1999), so individuals who are not resistant to injection are likely to prefer the injection route.

The smallest class, though still substantial at over one fifth of the sample, included individuals that almost exclusively used injection heroin. Although historically this pattern was considered a norm (Courtwright, 1982; Lindesmith, 1947), prior research suggested that this type of drug use may be rarer in this century (Monga et al., 2007). Indeed, recent Canadian samples demonstrated widespread cannabis, alcohol, and other drug use among heroin injectors (Monga et al., 2007; Patra et al., 2009). However, certain individuals may use heroin to self-medicate an underlying issue with aggression or rage (Khantzian, 1985, 1997) and thus prefer sedative effects over stimulative effects of drugs. This “self-medicating” type of individual may be in contrast to those who are more euphoria-seeking, as is likely the case with the *Polysubstance* or *Crack/Nasal-Heroin* users. Nevertheless, all classes likely have some euphoria-seeking qualities and all classes have some probability of using cocaine. Further research is needed to understand the underlying mechanisms for these patterns of use.

The classes in the current study showed distinct demographic differences. *Crack/Nasal-Heroin* users were more likely to self-report Black race, compared to the other 2 classes. This is consistent with findings that in the past decade, young White drug users in Baltimore were more likely than African-American substance users to inject drugs (Broz and Ouellet, 2008). *Crack/Nasal-Heroin* users were also more likely to be older than the other 2 classes. Research shows that African-American substance users often start illicit drug use later in their life than their White counterparts, which may partially explain this age effect (Green et al., 2010). Polysubstance users were less likely to be female than the other two classes. This supports research showing that, among individuals with opioid disorders in the US, men are more likely than women to have additional substance use disorders, although women appear more likely to have additional mental disorders (Grella et al., 2009). Given the demographic characteristics of the classes, it is perhaps not surprising that the *Crack/Nasal-Heroin* class smoked fewer cigarettes, as heavy smokers were previously found to be more likely to be White in this sample (Harrell et al., 2011) and among other illicit drug-using samples (Haas et al., 2008).

There were notable differences in behaviors relevant to increased risk of infectious diseases. *Polysubstance* users were more likely to share needles and engage in casual sex than *Heroin Injectors*, i.e., those with a high probability of heroin injection, but low probabilities of drinking alcohol or using cocaine. This suggests that polysubstance use is associated with an increased likelihood of risky behaviors. In contrast, *Crack/Nasal-Heroin* users were more likely to give someone drugs in exchange for sex. Given the severe substance use profiles of *Polysubstance* users and *Heroin Injectors*, this may be surprising, but consistent with research showing that transactional sex is associated with cocaine use to a greater extent than alcohol or injection heroin use (Jenness et al., 2011; Raj et al., 2007; Ross et al., 2003; Windle, 1997). Further research is needed to explain the mechanism driving this difference.

As expected, those who primarily used injection routes for drug administration were more likely to have Hepatitis C. Injection drug use is associated with increased risk of Hepatitis C and evidence suggests it is more transmissible via blood than HIV (Mehta et al., 2011; Sulkowski et al., 2002). The rates of HIV were not significantly different across the classes. The point estimates were actually lower among those who used via injection routes than those with low probabilities of injection use. A variety of possibilities exist for this negative finding. Slightly over a third (37%) of the class with low probabilities of IDU reported injecting drugs at some prior point in their lifetime, so it is possible this prior IDU resulted in HIV transmission. On the other hand, the increased rates of HIV among this class may be due to the increased rates of Black individuals. In 2007, the Center for Disease Control (CDC) estimated that over 65% of new HIV/AIDS cases between 2001 and 2005 were attributed to high-risk heterosexual contact for African-Americans, compared to less than 15% for Whites in the same time frame (CDC, 2008). Social network structure (Latkin et al., 2010) is a potential source of these disparities, particularly among African-American non-injection drug users (Kuo et al., 2011; Miller et al., 2007; Miller and Neaigus, 2002; Neblett et al., 2011; Pilowsky et al., 2007). In addition, novel harm minimization strategies aimed at reducing needle sharing and other risky injection practices (e.g., Tobin et al., 2011) may have reduced the risk of infection for IDU. Further research is needed.

The mechanism of infectious disease transmission among non-injection drug users is currently unclear. One possible explanation is that intoxication through the use of various substances may lead to a lack of attention to engaging in the practice of safe sex or a propensity toward engaging in high-risk sex (Castor et al., 2010; Strathdee and Sherman, 2003). Crack use, in particular, is associated with more risky sexual activities (Kuo et al., 2011; Miller et al., 2007). Although there is supportive evidence that illicit drug use leads directly to increased risky sexual behavior (Neaigus et al., 2001; Strathdee and Sherman, 2003), there is also contradictory evidence (for a review, see Drumright and Colfax, 2009). Thus, another possibility is that both the higher presence of sexually transmitted diseases and illicit drug use are explained by a third causal variable, such as desire for disengagement from risk awareness (McKirnan et al., 1996), impulsivity (Lejuez et al., 2005), personality disorder (Kokkevi et al., 1998), and/or cognitive factors (Mitchell et al., 2006). Heroin and cocaine users with cognitive deficits are more likely to have a history of Hepatitis B and/or C infection, supporting the idea that cognitive factors may lead to increased risky behaviors and thus transmission of infections (Severtson et al., 2010a; Severtson et al., 2010b). Further research, whether at a biochemical, behavioral, or sociological level, is needed to determine if cognitive factors or another mechanism are behind the association between illicit drug use, particularly crack, and risky sexual behaviors.

4.2 Limitations and strengths

There are some limitations to this study. The classic form of the latent class model assumes observed variables within each class to be independent. This assumption is questionable in many cases and the current study is no exception. For example, there may be some level of continuity of severity among the indicator variables, such that someone who injects heroin is more likely to also inject cocaine. Factor Mixture Models can be useful in addressing these concerns in future research (Lubke and Muthen, 2005). Nonetheless, LCA is a useful approach and helpful complement to other methods of classification across the Dimensional-Categorical spectrum (Masyn et al., 2010). In addition, if the classes truly represented only a ranking in severity, we would not expect profile classes to intersect, but yet we found the classes do intersect. As with all cross-sectional studies, no causal relationships can be established from the cross-sectional data presented. Associations noted may be due to confounding factors within the classes rather than directly due to the patterns of drug use observed. Longitudinal and experimental research may provide better answers to causal questions such as how drugs impact sexual activity. As the longitudinal data for this dataset recently became available, future research may explore this issue in more detail, including models to examine transition between classes.

Additionally, further research in other areas of the country is needed to see if our study results are generalizable outside of Baltimore, MD. It is possible, for example, that substance users with an exclusive focus on heroin injection may be a cultural factor specific to Baltimore. Also, data were obtained by self-report, which may be limited by memory biases or trust issues. The urinalysis data, however, is consistent with the findings presented, and self-report is generally recognized as relatively valid (Darke, 1998). The use of past 30 day substance use helps to reduce memory bias, but may miss important individual characteristics if patterns in the past month were atypical for the individual. Nonetheless, this is a commonly used method (Monga et al., 2007, Johnston et al., 2002).

Despite these limitations, there are several notable strengths to the current study. Prior latent class analyses based on drug administration patterns of heroin and cocaine were in Canada rather than the US, and did not include speedball injection in the model (Monga et al., 2007; Patra et al., 2009). Further, unlike the recent study from Baltimore (Kuramoto et al., 2011), the LCA in the present study was used to investigate needle sharing and risky sexual behaviors, which are important HIV-risk variables. This allows for a deeper understanding of how these variables may play a role in the HIV epidemic.

4.3 Implications

LCA and other epidemiological research techniques can help understand at-risk populations for purposes of intervention. All of the classes identified demonstrate substantial risk for contracting infectious diseases, but risk profiles varied by group. The existence of these subgroups suggests a need for targeted prevention and intervention efforts. For example, among polysubstance users, the clearest need is for reductions in needle-sharing behaviors, as may be accomplished via needle exchange programs (Clark and Fadus, 2010).

Despite notable reduction in infectious disease risk among non-injection drug users, substantial risks still exist, most notably from unsafe sexual behaviors. Further effort is needed to address these concerns. Fortunately, substance abuse treatment, and similar types of treatment, are associated with reductions in sexual risk behavior (Drumright and Colfax, 2009; Magura et al., 1994; St Lawrence et al., 2002; Wechsberg et al., 2008). Interventions focusing on sexual behaviors associated with drug use – regardless of ROA, but perhaps especially for non-injection cocaine and heroin users – are needed to reduce the risk of STD transmission among vulnerable populations. Prevention and treatment outcomes can be improved by a more thorough understanding of the interrelations between different substances of abuse.

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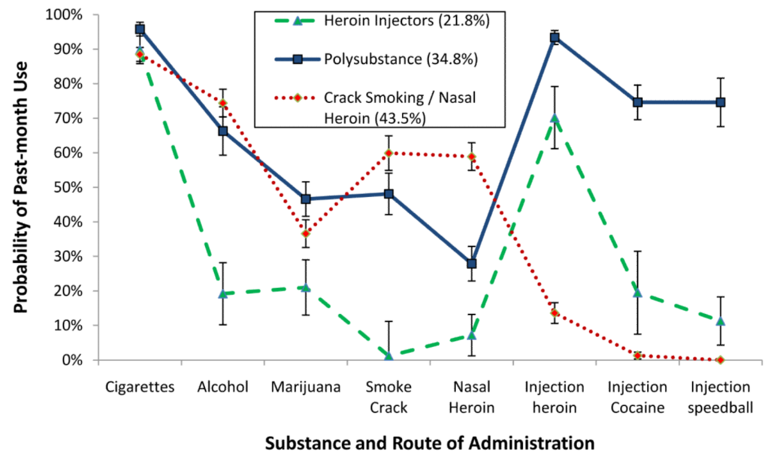

Figure 1.

Three class solution of a latent class analysis of 552 users of cocaine and/or heroin in Baltimore, MD. Estimated probabilities for past-month drug use are graphed based on latent class membership. Error bars indicate standard errors of estimated probabilities.

Table 1

Characteristics of 552 users of cocaine and/or heroin in the past 6 months.

	n	%
Latent Class Indicators[1]		
Cigarettes	504	91.3
Alcohol	329	59.6
Heroin – injection	292	52.9
Crack cocaine – smoking	237	43.0
Marijuana – smoking	202	36.7
Heroin – nasal	203	36.9
Cocaine – injection	168	30.5
Heroin and cocaine together (“Speedball”) – injection	157	28.4
Demographics		
Over 33 years old	288	52.2
Female gender	231	41.8
Black race	276	50.0
HIV/HCV Risk Behaviors		
Lifetime polydrug use	306	55.8
Smokes 20+ cigs per day	269	48.8
Positive for opioids	323	66.9
Positive for cocaine	268	55.5
Shared needle in lifetime	188	35.4
Sold drugs for sex	57	10.6
Disease Status		
Hepatitis C	248	50.9
HIV	43	8.5

[1]These variables refer to substances used in the past month.

Table 2

Fit statistics and entropy for a latent class analysis of 8 substances used in the past month among 552 users of cocaine and heroin in the past 6 months.

Classes	LL[a]	parameters	BIC[b]	LMR[c]	BLRT[d]	Entropy	s.c. r.f. (f)[e]
1	−2685.88	8	5422.27	NA[f]	NA[f]	NA[f]	NA[f]
2	−2486.57	17	5080.47	$p < .001$	$p < 0.001$	0.769	.49 (268.2)
3	−2432.89	26	**5029.94**	$p = .002$	$p < 0.001$	0.742	.22 (120.1)
4	−2417.04	35	5055.06	**$p = .028$**	$p < 0.001$	0.744	.13 (70.3)
5	−2402.25	44	5082.29	$p = .147$	**$p < 0.001$**	0.784	.08 (44.1)
6	−2395.05	53	5124.71	$p = .591$	$p = 0.600$	0.796	.05 (26.4)

[a] Log Likelihood;

[b] Bayesian Information Criteria;

[c] Lo-Mendell-Rubin adjusted likelihood ratio test;

[d] parametric Bootstrap Likelihood Ratio Test;

[e] smallest class relative frequency (frequency);

[f] Not Applicable

Ideal number of classes based on fit statistic shown in bold.

Table 3

Association between latent class membership and characteristics of heroin and cocaine users in Baltimore, MD.[1]

	Polysubstance vs. Heroin Injectors	Crack/Nasal-H. vs. Heroin Injectors	Crack/Nasal-H. vs. Polysubstance
Demographics			
Over 33 years old	0.78 (0.46-1.33)	1.93 (1.17-3.19)*	2.48 (1.62-3.81)***
Female gender	0.68 (0.40-1.16)	1.14 (0.69-1.90)	1.68 (1.11-2.54)*
Black race	0.80 (0.45-1.43)	5.60 (3.18-9.84)***	6.97 (4.35-11.2)***
HIV/HCV Risk Behaviors			
Lifetime polydrug use	4.01 (2.23-7.23)***	0.74 (0.45-1.24)	0.19 (0.11-0.30)***
Smokes 20+ cigs per day	1.36 (0.80-2.31)	0.48 (0.29-0.79)**	0.35 (0.23-0.53)***
Positive for opioids	1.70 (0.85-3.40)	0.43 (0.24-0.80)**	0.25 (0.15-0.42)***
Positive for cocaine	3.25 (1.74-6.08)***	1.78 (1.00-3.18)*	0.55 (0.35-0.86)*
Psychiatric disorder	1.02 (0.59-1.77)	0.95 (0.63-1.43)	0.93 (0.56-1.55)
Jail	0.70 (0.40-1.24)	0.76 (0.48-1.19)	1.07 (0.61-1.89)
Shared needle in lifetime	2.66 (1.49-4.75)**	0.15 (0.07-0.30)***	0.06 (0.03-0.10)***
Casual sex	1.97 (1.01-3.83)*	1.09 (0.56-2.10)	0.55 (0.33-0.91)*
Sold sex	1.00 (0.54-1.86)	0.96 (0.53-1.75)	0.96 (0.59-1.56)
Paid for sex	1.50 (0.63-3.55)	2.22 (0.98-5.06)†	1.48 (0.85-2.58)
Drugs for sex	1.19 (0.38-3.65)	2.97 (1.07-8.21)*	2.50 (1.22-5.13)*
Disease Status[2]			
Hepatitis C	0.72 (0.38-1.34)	0.10 (0.06-0.18)***	0.14 (0.07-0.29)***
HIV	0.94 (0.32-2.73)	0.57 (0.25-1.31)	0.61 (0.22-1.69)

† $p=0.057$

* $p \leq .05$

** $p < .01$

*** $p < .001$

[1] Associations are given as odds ratios with 95% confidence intervals in parentheses.

[2] Adjusted for Demographics