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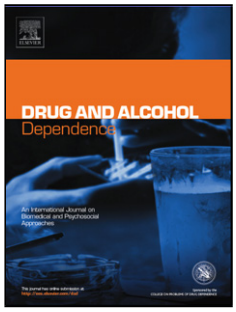

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Patterns of Substance Use among HIV-Positive Adults Over 50: Implications for Treatment and Medication Adherence

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ABSTRACT

Background: The population of older adults living with HIV is increasing in the United States. Despite an increased focus on the health of HIV-positive older adults, knowledge about their substance use, a primary risk factor for HIV medication non-adherence, and the association between use, problems associated with use, and adherence behavior, is limited. *Methods:* Data were collected from 557 HIV-positive adults aged 50 and older in the New York City area via telephone interview. Participants reported the number of days in the past month on which they missed any doses of HIV medication as well as the number of days they used alcohol, marijuana, cocaine/crack, opiates, amyl nitrite (poppers), and other drugs. The severity of substance use associated problems was assessed using the DAST-10 and AUDIT-C. *Results:* The sample included gay/bisexual (40.4%) and heterosexual (28.1%) men as well as lesbian/bisexual (4.9%) and heterosexual (26.7%) women. Latent class analyses identified four distinct patterns of substance use: Exclusive Alcohol Use; Alcohol and Marijuana; Alcohol and Cocaine/Crack; and Multiple-Substance Use. Variability in the number of missed HIV medication days and perceptions of substance use associated problems were observed across classes, with poorest adherence reported in the Alcohol and Cocaine/Crack class, followed by the Multiple-Substance Use class. These two classes also reported the greatest perceived impairment from substance use. *Conclusions:* Patterns of recent substance use were associated with varying levels of HIV medication adherence and perceived substance use impairment, indicating that substance type matters when considering the health of older adults living with HIV, and that multiple-substance use needs to be addressed by interventions aimed at improving medication adherence.

KEYWORDS: Substance Use, Older Adults, HIV and aging, Medication Adherence

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1. INTRODUCTION

In 2011, the Centers for Disease Control and Prevention (CDC) estimated that over 314,000 older adults (aged 50 or older) are living with HIV in the USA (CDC, 2013), and it is projected that, by 2015, this age group will comprise 50% of all Americans living with HIV (Greene et al., 2013). In recent years, researchers have directed increasing attention toward the health and wellbeing of this growing population of older adults living with HIV. Recent studies have focused on physical and/or psychological co-morbidities associated with aging with HIV (Balderson et al., 2013; Hardy and Vance, 2009; Havlik et al., 2011; Heckman et al., 2002; Oursler et al., 2006; Rodriguez-Penney et al., 2013), sexual activity and risky behaviors (Cooperman et al., 2007; Golub et al., 2010; Lovejoy et al., 2008), social support and coping (Johnson et al., 2009), and social stigma (Emlet, 2006; Grov et al., 2010; Shippy and Karpiak, 2005).

Despite advances in these areas, research related to alcohol and drug use in older adults living with HIV has progressed more slowly (Green et al., 2010; Skalski et al., 2013). This is of concern given that the number of older adults experiencing problems with substance use is increasing (Han et al., 2009), and that rates of substance use are particularly high in older adults with HIV-positive compared to their peers (Justice, 2010; Rabkin et al., 2004; Skalski et al., 2013). One important reason to focus on substance use among HIV-positive older adults is the association between substance use and medication non-adherence. Active substance use has generally been found to be a strong predictor of suboptimal adherence to HIV medication, as illustrated by Malta et al.'s (2008) systematic review of 41 HIV medication adherence studies on adults across age groups. Adherence difficulties have been found to be particularly pronounced in users of cocaine or amphetamines (Arnsten et al., 2002; Baum et al., 2009; Gonzalez et al.,

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2013; Ingersoll et al., 2011; Parsons et al., 2013; Reback et al., 2003), combined cocaine and methamphetamine use (Hinkin et al., 2007), combined cocaine and heroin use (Leri et al., 2003), injection drug use (IDU; Kerr et al., 2004), and hard drugs in general (Cohn et al., 2011) - see Gonzalez et al. (2011) for a review of adherence studies separated by single substances.

In the few studies examining HIV medication adherence among older adults, rates of adherence of 84.9% (Barclay et al., 2007) and 87.5% (Hinkin et al., 2004) have been reported and, in both of these studies, adherence among older adults was significantly greater than among younger persons. More recently, Johnson et al. (2009) found that 80% of HIV-positive adults over age 50 reported 95% adherence or greater. Although initially adherence of ≥95% was believed necessary to achieve virologic response (Paterson et al., 2000), more recent research has suggested that lower rates of adherence (e.g., 90%) may be effective once viral suppression is achieved (Bangsberg et al., 2001). Among the limited number of studies focused on substance use among HIV-positive older adults, only two have examined HIV medication adherence outcomes. Catz et al. (2001) focused exclusively on alcohol and found use predicted poorer adherence. Meanwhile, Cohn et al. (2011) aggregated cocaine, amphetamine, and heroin use and found that total use across all substances assessed was associated with poorer adherence.

Compounding the challenge of exploring differential associations between the use of specific substances and medication adherence is the fact that the use of multiple substances is known to be commonplace (Kedia et al., 2007) and persistent in many older adults (Midanik et al., 2007). Evidence that different drugs may impact adherence differently (Gonzalez et al., 2013) underscores Leri et al.'s (2003) call for the "need for systematic studies of the patterns of co-use" (p.16). Hence, it is critical that an awareness of multiple-substance use informs

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investigations of associations between individual substances and outcomes such as medication adherence.

We sought to identify patterns in the types and frequency of substance use among older adults living with HIV, and to determine whether patterns of use are differentially associated with HIV medication adherence. A more accurate picture of substance use patterns will help researchers and clinicians in the development of more tailored interventions addressing substance use in order to improve HIV medication adherence and overall health in this growing population.

2. METHODS

2.1. Participants

In total, 651 individuals in the New York City area were either contacted by research staff after preliminary screening in person or online, or called the research center directly in response to passive recruitment materials, and 625 (96.0%) of these consented to complete the telephone survey. Data were collected from the 557 (89.1%) individuals who met criteria for inclusion, meaning they reported an HIV-positive serostatus, an age of at least 50 years, and were currently prescribed at least one HIV medication. Participant ages ranged from 50 to 72, with an average of 55 (SD = 4.4). Demographic data are provided in Table 1. The majority of participants (68.5%) identified as male, described their race/ethnicity as Black/African American (68.6%), and were not in a relationship (58.0%).

2.2. Procedures

Data were collected between November, 2011 and March, 2013, using a telephone-administered structured interview designed to determine eligibility for participation in a randomized clinical trial of a behavioral intervention, the Wisdom in Spirituality Education

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(WISE) study. Telephone interviews were administered by a trained research assistant who entered participant responses directly into an electronic database using a common survey interface, Questionnaire Development Software (QDS). While enrollment in the full WISE study was contingent upon meeting specific substance use and medication non-adherence criteria, prospective participants were allowed to complete the full telephone interview regardless of reported substance use and medication adherence. No participants were excluded from screening on the basis of substance use, mode of administration, or HIV medication adherence. Information about HIV status and age enrollment criteria, but not substance use, was made explicit on study recruitment materials.

The WISE study utilized both active and passive approaches to recruitment, conducted online and in person. Active recruitment activities included attendance by study staff at community and social events targeted towards the HIV-positive community and/or individuals who use substances. At these events, study information was provided and interested individuals completed a brief preliminary screener using an iPad. Subsequently, individuals who met preliminary screening eligibility (e.g., age 50 or older, HIV-positive, on HIV medication, and with substance use and/or substance use related problems) were invited to provide contact information to be called for completing the full telephone interview. Passive recruitment included distribution of flyers and printed project materials, as well as internet distribution (via listservs and websites targeting the HIV-positive community and/or service providers) of study information. These passive materials contained a telephone number to call directly for the telephone-administered structured interview, as well as an internet-based link that provided additional study information and the brief preliminary screener. Potential participants had the option of completing this preliminary screener and providing contact information, in which case

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they were called to complete the full telephone interview. As a result of multiple pathways for eligibility screening, the full telephone interview was only completed by individuals abstinent from substance use in cases where those individuals called the research center directly in response to passive recruitment materials. All recruitment materials and procedures were approved by the IRB of the research team.

2.3. Measures

Participants provided information on basic demographic and other characteristics, including gender, sexual identity, race, age, relationship status, and most recent viral load. With respect to viral load, participants were asked "What was your most recent viral load?" Participants could then either report being detectable/undetectable or provide a report of their viral load in terms of viral copies per ml. Where the latter information was provided, participant responses were recoded such that ≥ 200 copies was detectable and < 200 copies was undetectable.

2.3.1 HIV medication non-adherence. Participants responded to questions related to their HIV medication regimen. Information included whether the participant was currently prescribed medication and the number of years they had been prescribed any medication. Non-adherence was assessed using a single item, "How many days, in the last 30 days, have you missed taking any doses of your HIV medication?". It was been shown that self-report measures of HIV medication adherence with 30 day recall periods are significantly associated with viral load and other indicators of adherence (Simoni et al., 2006).

2.3.2 Substance use behavior. Recent substance use was assessed in a manner consistent with the organizational framework utilized in the Computerized Diagnostic Interview Schedule's substance dependence module (Blouin et al., 1988). Participants reported whether or not they

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used alcohol, marijuana, cocaine/crack, amphetamines, sedatives, opiates (e.g., heroin, codeine or synthetic opiates), PCP, psychedelics (e.g., LSD, mushrooms, Special K), solvents, or other drugs. When substance use in the past 30 days was reported, participants were asked to indicate the number of days each substance was used. Fewer than 10% of respondents endorsed any use of sedatives, amphetamines, PCP, psychedelics, or solvents. In order to reduce convergence problems associated with the inclusion of variables with very low frequency, these substances were aggregated into a single "other drug" variable, which represented the number of days each substance was used added up.

2.3.4 Injection Drug Use. Participants who reported the use of any drug other than alcohol were asked to indicate all of the ways in which they had ever taken or used the substance/s. Options included injection, orally, smoking, snorting, booty/vaginal bump, and other. Responses were condensed into a single variable indicating whether the participant had ever engaged in IDU.

2.3.5 Alcohol related problems. Among participants reporting alcohol use in the past 30 days, perceptions of problematic drinking were assessed using the three-item Alcohol Use Disorders Identification Test – Consumption (AUDIT-C) scale (Bush et al., 1998). Scores ranged from 0 to 12. Scores of four and three indicate a high risk of problem drinking for men and women respectively. The scale demonstrated adequate reliability (Cronbach's α = .70).

2.3.6 Drug use related problems. Among participants reporting drug use in the past 30 days, perceptions of substance use related problems were assessed using the 10-item Drug Abuse Screening Test (DAST-10) (Skinner, 1982). Scores ranged from 0 to 10. Scores of three indicate intermediate severity of problem use. The scale demonstrated adequate reliability (Cronbach's α = .77).

2.4. Analytic Plan

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Latent class analysis (LCA) assumes that a latent categorical variable underlies responses to a set of predictors or 'indicators'. The purpose of the LCA is to determine the number of categories needed to accurately model indicator variable responses (Jung and Wickrama, 2008; Nylund et al., 2007). For the current analysis, five substance use variables were specified as class indicators (the number of days in the past 30 when the participant used alcohol, marijuana, cocaine/crack, opiates, or other drugs). Outcome variables, predicted by latent class membership, can be incorporated into the model as distal outcomes. Doing so results in the distal outcome serving as an additional indicator of latent class membership (Asparouhov and Muthèn, 2012). In the current analysis, the number of missed medication days was modeled as a distal outcome and therefore constituted a 6th indicator of class membership. Consistent with the treatment of count variables, a negative binomial distribution was specified for all observed variables and a dispersion parameter was calculated for each.

Latent class models, from one to five classes, were estimated and the fit of each model was compared to the others using MPlus version 7.0. Model fit was evaluated using four standard criteria: 1) the adjusted Lo-Mendel-Ruben Likelihood Ratio Test (LMR-LRT) provides a test of whether a model with *k* categories represents a statistically significant improvement in fit over a model with *k*-1 categories. A significant *p*-value for the LMR-LRT is support for rejecting a given model in favor of a model with one additional class; 2) the Bayesian information criterion (BIC; Raferty, 1995) and Akaike's information criterion (AIC; Akaike, 1973) represent the amount of information lost by imposing a model on the observed data. Low BIC and AIC values are preferred because they indicate that less information is lost (Muthèn and Muthèn, 2000); 3) entropy values which represent the clarity of classification, ranging from 0 to 1, with 0 corresponding to random assignment to category and 1 representing perfect

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classification. Higher values of entropy are preferred, although there is a generally accepted threshold (Muthèn and Muthèn, 2000; Ramaswamy et al., 1993), and; 4) finally, we considered class size when making final model selections, as classes with extremely small *n*'s are of limited utility.

After determining the appropriate number of latent classes, we examined between-class differences in indicator variable responses to identify the salient characteristics of each class and formulate class labels. Because indicator variables followed a negative binomial distribution, these analyses were conducted using the generalized linear module in SPSS to calculate a negative binomial regression model. Separate models were calculated for each in each. Group-by-group differences were evaluated using Least Significant Difference (LSD) post hoc comparison tests. Finally, we conducted secondary analyses to evaluate the statistical significance of between-class differences in demographic characteristics and perceived substance use severity (AUDIT-C and DAST-10 scores). These analyses utilized analysis of variance (ANOVA; for continuous outcome variables) and χ^2 tests of independence (for categorical outcome variables).

3. RESULTS

3.1. Latent class analysis of substance use and HIV medication adherence patterns

In order to identify patterns of substance use among individuals currently using, we excluded 88 individuals who reported no days of substance use during the assessment period from the latent class analyses. For subsequent analyses, these individuals were placed, a priori, into a "No Use" category on the basis of the complete absence of any variability in use across all substances.

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Model fit data for latent class models containing one through five classes are provided in Table 2. All indicators suggested that a two-class solution was superior to a solution with only one class. While entropy declined with the inclusion of a 3rd class, all other indicators improved. Similarly, all indicators suggested model improvement with the inclusion of a 4th class, while entropy was unchanged. The inclusion of a 5th class, while supported by some indicators of model fit, was contra-indicated by the emergence of a very small class (which contained approximately 6% of the total sample). As a result, the four-class solution represented the best overall fit to the data.

3.2. Latent class substance use characteristics

Between-class differences in substance use were evaluated using a negative-binomial regression and LSD post hoc pairwise comparison tests. Results of these analyses are presented in Table 3. These results informed the creation of latent class category labels.

3.2.1 Class 1: Exclusive Alcohol Use. This category was characterized by the nearly exclusive use of alcohol. Members of this class reported alcohol consumption on 7.5 days in the previous 30 (approximately twice per week) on average. No members of this category reported any cocaine/crack, or opiate use, and only two members reported one day each of marijuana use. The occurrence of poppers and other drug use was very rare (less than one day in the previous month on average).

3.2.2 Class 2: Alcohol and Marijuana Use. This category was characterized by regular use of alcohol and marijuana (significantly more than members of Classes 1 and 3). Members of this class reported alcohol use on approximately 11 days and marijuana use on approximately half of the days (M = 15.6; SD = 10.5) during the assessment period. No members of this class reported

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any days of cocaine/crack or opiate use, and the occurrence of poppers and other drugs was relatively rare (less than one day in the previous month on average).

3.2.3 Class 3: Alcohol and Cocaine/Crack Use. This category was characterized by the regular use of alcohol and cocaine/crack. Members of this class reported alcohol and cocaine/crack use an average of 8.6 (*SD* = 9.7) and 7.7 (*SD* = 7.9) days, respectively. The occurrence of marijuana use among this class was very rare, occurring on average less than one day in the previous 30.

3.2.4 Class 4: Multiple-Substance Use. This category was characterized by the greatest number of use days for almost all substances, with the exception of marijuana (where Class 4 did not differ from Class 2) and poppers (which did not differ significantly between classes). Members of this class reported the use of alcohol (*M* = 14.2, *SD* = 10.3), marijuana (*M* = 15.6, *SD* = 12.3), and cocaine/crack (*M* = 11.7, *SD* = 11.6) on approximately three to four days per week in the previous 30 days. In addition, they reported approximately weekly use of opiates (*M* = 4.7, *SD* = 14.5) and other drugs (*M* = 3.6, *SD* = 16.2).

3.3. Latent class and indicators of substance use impairment

Self-reported scores of alcohol-related impairment and drug-related impairment (as measured by the AUDIT-C and DAST-10, respectively) differed across the four classes but not directly in accordance with severity of use. AUDIT-C scores were significantly higher for the Multiple-Substance Use class, compared to all other classes. However, no significant differences emerged between the Alcohol and Cocaine/Crack Use class and the Alcohol and Marijuana Use class, despite the latter reporting significantly more days using alcohol. Mean DAST-10 scores in the Exclusive Alcohol Use class were significantly lower than all other classes. While significantly higher than the mean among Exclusive Alcohol Use class members, the mean DAST-10 score within the Alcohol and Marijuana class was significantly below that observed in

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the Multiple-Substance Use class and the Alcohol and Cocaine/Crack Use class; mean DAST-10 scores in these latter two classes did not differ significantly from one another.

The likelihood of IDU also varied significantly across substance use pattern. Individuals in the Alcohol and Cocaine/Crack class as well as the Multiple-Substance Use class were more likely to engage in IDU than those in the Exclusive Alcohol Use or Alcohol and Marijuana Use classes. The odds of IDU did not differ between individuals in the Alcohol and Cocaine/Crack and Multiple-Substance Use classes. This finding is consistent with the fact that the likelihood of injecting any substances (cocaine/crack, opiates, and amphetamines) was extremely low among those in the Exclusive Alcohol Use and Alcohol and Marijuana Use classes.

3.4 Latent class demographic characteristics

Table 1 displays demographic characteristics for each substance use class. There was significant variability in the gender and sexual orientation composition of substance use groups. Gay/bisexual men were disproportionally over-represented in the Multiple-Substance Use class while heterosexual men were disproportionally over-represented in the Alcohol and Cocaine/Crack class. In contrast, heterosexual women were disproportionally over-represented in the No Use and Exclusive Alcohol Use classes and under-represented in the Multiple-Substance Use class. The proportion of lesbian woman did not differ across classes, but this may be the result of the low number of lesbian women in the sample. These groups did not differ significantly in age, race, or the likelihood of being partnered.

Rates of medication non-adherence (medication adherence on ≤ 90% of days) did not vary significant among Alcohol and Marijuana, Alcohol and Cocaine/Crack, and Multiple-Substance Use classes; however, these groups reported higher rates of non-adherence compared to the No Use and Exclusive Alcohol classes. These latter groups did not differ significantly

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from one another. Similar results were observed for self-reported viral load detectability. Individuals in the Alcohol and Cocaine/Crack class did not differ significantly from the Multiple-Substance Use class; however, rates of reported viral load detectability were higher than that reported by individuals in the No Use, Exclusive Alcohol Use, and Alcohol and Marijuana classes. These latter classes did not differ significantly from one another. Reported length of time since HIV diagnosis was longer in the No Use class compared to the Alcohol and Cocaine/Crack and the Multiple-Substance Use class. These latter two classes did not differ significantly from each other. Individuals in the Exclusive Alcohol and the Alcohol and Marijuana classes did not differ significantly from any other class. Results of a Mann-Whitney non-parametric test of between-group differences suggested that the number of missed medication days was significantly greater ($p < .05$) among participants who reported a detectable viral load ($M = 2.1$, $SD = 3.9$) compared to those who reported an undetectable viral load ($M = 4.9$, $SD = 7.8$), supporting the validity of these two self-report measures.

3.5. Latent class HIV medication non-adherence characteristics

Table 1 displays the mean number of missed medication days reported by members of each class and for individuals who reported complete abstinence from alcohol and drug use during the assessment period. Results of a negative binomial regression and LSD post hoc pairwise comparisons suggested that missed medication days varied significantly among the groups. The Exclusive Alcohol Use class and the No Use class did not differ significantly in number of missed medication days ($M = 1.3$, $SD = 4.4$, and $M = 1.3$, SD = 1.9, respectively; $p = .88$). Alcohol and Marijuana use was associated with a significantly greater number of missed medication days ($M = 2.9$, $SD = 4.2$) compared to both the No Use and Exclusive Alcohol Use patterns ($p = .01$ and $p = .002$, respectively). Alcohol and Cocaine/Crack use was associated with

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the highest number of missed medication days (M = 4.3, SD = 7.7), significantly more than the No Use and Exclusive Alcohol Use ($p < .001$ and $p < .001$ respectively). Similarly, members of the Multiple-Substance Use class reported significantly more missed medication days on average (M = 3.5, SD = 4.9) compared to the No Use and Exclusive Alcohol Use classes (both $p < .001$). No significant differences were observed between the Multiple-substance use class and the Alcohol and Marijuana ($p = .28$) or Alcohol and Cocaine/Crack classes ($p = .29$). The difference between the Alcohol and Cocaine/Crack and Alcohol and Marijuana class was also not significant ($p = .06$)

4. DISCUSSION

This study utilized LCA to identify distinct patterns of substance use and medication non-adherence in a sample of HIV-positive older adults. Among active substance users, four latent classes were characterized by different patterns of use: exclusive alcohol use, alcohol and marijuana, alcohol and cocaine/crack, and multiple-substance use. Significant differences in HIV medication non-adherence, viral load, and substance use associated problems emerged among these classes and a comparison group of HIV-positive older adults who reported no drug or alcohol use, which illustrates the importance of considering the types and combinations of substances used by HIV-positive older adults when designing interventions and planning treatments. The pronounced role of substance use in this sample of HIV-positive older adults highlights the need for ongoing screening for substance use as a vital part of improving HIV medication adherence and maintaining overall health, as well as strengthening prevention efforts more widely.

In the total sample, 70.7% of participants were more than 90% adherent. This is somewhat lower than rates found in community samples recruited from HIV service providers

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(e.g., Barclay et al., 2007; Johnson et al., 2009). These differences may be due, in part, to different thresholds used to classify individuals as adherent or non-adherent. Findings from the current study were similar to the results of Hinkin et al. (2007), who found that 71% of older adults attained a rate of adherence of 90% or greater. In the present study, medication adherence of >90% was observed among 92% of the No Use class, 83.7% of the Exclusive Alcohol Use class, 65.5% for the Alcohol and Marijuana class, 64.4% for the Alcohol and Cocaine/Crack class, and 56.8% for the Multiple-Substance Use class. Consistent with previous research (Gonzalez et al., 2011), classes characterized by the use of substances other than alcohol showed greater odds of medication adherence problems.

Findings from the current study bear both similarities and differences with existing research that has focused on single substance use and results from other LCA studies of substance use patterns. The current findings concur with previous research regarding the association between cocaine/crack use and poorer medication adherence (Arnsten et al., 2002; Baum et al., 2009; Ingersoll et al., 2011), but a more complete picture is offered by identifying that, in this sample, cocaine/crack use does not generally occur in individuals without alcohol use as well (almost 90% of cocaine/crack users reported recent alcohol use). The current findings also offer insight into the adherence difficulties of a group rarely described in the literature – those who report use of multiple substances, not solely cocaine/crack or solely opiates.

Between-class differences in viral load in the current study were consistent with the findings of Green et al. (2010). Both studies found a significant association between multiple substance use patterns and poor HIV-associated health, and that the use of marijuana without other illicit drugs was associated with comparatively fewer negative health consequences. Class profiles identified in Green et al.'s sample were somewhat different and rates of use varied

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across the two studies. These differences may arise from methodological differences, in terms of assessing substance use in the past year compared to the past three months, the inclusion of alcohol use, using categorical indicators of use rather than frequency of use, and differences in sample characteristics.

The work of Monga et al. (2007), which focused on opioid users in Canada, provides an example of the application of LCA to examine patterns of use at a more substance-specific level. The latent class indicators included 12 different substances, and specific types of prescription and non-prescription opioids, as well as injection status, were assessed. Among the sample of opiod users (not limited by age or HIV status), rates of IDU were much higher than in both Green et al. (2010) and the current study (7.4% and 5.9%, respectively). Monga et al.'s (2007) sample was almost entirely made up of users of multiple substances, most closely resembling the Multiple-Substance Use pattern in the current study, and notably high co-use of alcohol and marijuana were observed in both.

Analysis of demographic differences in class composition extend the work of previous LCA studies by examining gender and sexual orientation differences between substance use groups. These results suggest that, in general, women are more likely to be represented in lower risk use patterns. Among men, meaningful distinctions exist with regard to sexual orientation, with gay and bisexual men over-represented among multiple-substance users and heterosexual men over-represented among alcohol and cocaine/crack users.

Patterns of substance use were also associated with varying levels of perceived impairment from alcohol and drug use (measured by AUDIT-C and DAST-10). While mean AUDIT-C scores in all use classes neared the cutoff for hazardous drinking (Bush et al., 1998), scores were significantly elevated for the Multiple-Substance Use class relative to all other use

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patterns. Similarly, elevated DAST-10 scores were observed among individuals in both the Alcohol and Cocaine/Crack Use as well as Multiple-Substance Use classes; however, mean DAST-10 scores among members of the Alcohol and Marijuana Use class were near the clinical cutoff (Skinner, 1982).

These results demonstrate the degree to which the combined use of substances contextualizes perceptions of impairment. The number of marijuana use days did not differ significantly between the Alcohol and Marijuana and the Multiple-Substance Use classes; however, DAST-10 scores differed across these classes, with the latter reporting increased impairment. Meanwhile, individuals in the Alcohol and Cocaine/Crack class reported a more restricted range of substance use than those in the Multiple-Substance Use class; however, the DAST-10 scores for these two classes were both elevated and did not differ significantly from one another. Similarly with respect to alcohol, individuals in the Alcohol and Marijuana class reported significantly more days of alcohol use than those in the Alcohol and Cocaine/Crack class; however, AUDIT-C scores across the two classes did not differ significantly from one another.

The investigation of multiple substances can be used to better inform intervention efforts to minimize substance use in older adults (Briggs et al., 2011), by tailoring treatments according to substance types rather than either focusing solely on a single substance (Sorocco and Ferrell, 2006), or aiming for total elimination of all substance use. The current findings may serve as the basis for innovative intervention approaches that conform to Gonzalez et al.'s (2011) call for "the development of efficacious and effective ART adherence interventions that specifically address co-occurring substance use and varying levels of substance use–related impairment" (p. 230). For example, relative elevations of AUDIT-C and DAST-10 scores suggested that

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individuals in the Alcohol and Cocaine/Crack Use class perceived more problems associated with their drug use compared to alcohol use. Substance use intervention for such individuals may benefit from matching treatment priorities to such perceptions of impairment, focusing at least initially on cocaine/crack use. In contrast, targeting alcohol use only among the Alcohol and Marijuana Use class may be sufficient to improve medication adherence as, on average, those users did not report significant impairment from their marijuana use, and may not be easily engaged in a program that expects reduced marijuana use. The Alcohol and Cocaine/Crack Use and the Multiple-Substance Use patterns may present the greatest challenge for substance reduction interventions but this appears particularly pressing given their associations with adherence difficulties and impairment, both of which pose serious health risks. Tailored intervention approaches will need to navigate differing constellations of use and may need to prioritize reductions of certain substances over others.

This study has several limitations. First, associations between substance use patterns and variables of interest (demographic characteristics, substance use frequency, medication adherence, DAST and AUDIT scores) were calculated at the bivariate level. While useful at the descriptive level, future studies may benefit from testing multivariate models. In addition, the use of LCA to identify patterns of use involves the process of naming derived classes based upon their salient characteristics. These class labels are best viewed as general or heuristic descriptors. They may not always fully capture important profile dimensions in their entirety - for example, while opioid use was not a predominant feature in the Alcohol and Crack/Cocaine class, it was endorsed by a number of class members.

Second, data on medication adherence, substance use, and viral load, were gathered through self-report. While some research has indicated that self-report overestimates actual

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medication adherence (Burney et al., 1996; Liu et al., 2001; Wagner and Rabkin, 2000), a recent meta-analysis of 41 empirical studies noted that self-report measures of adherence showed moderate to high correlations with more sensitive methods (Shi et al., 2010). The validity of self-reported substance use has been debated at length – however, outside of correctional and criminal justice settings, many studies support the validity of self-report regarding substance use from participants in treatment and research settings, having found moderate to strong concordance with electronic measures (Harrison et al., 2007). Relatedly, the use of aggregate data imposed additional limitations. First, it prevented an analysis of whether medication non-adherence occurred on the same day(s) as substance use. Second, while the occurrence of IDU was assessed, the aggregated nature of data collection prevented an analysis of which substances were administered via this route.

Finally, the sampling methods utilized in this study, based in the New York metro area, also limit generalizability. Recruitment venues included community-based organizations, and this may have over-represented individuals engaged with service providers. In addition, recruitment procedures under-represented individuals who were completely abstinent from alcohol and drug use, and may have also under-represented IDU individuals. The sample of non-using individuals here serves as a comparison group; however, the sample is not necessarily representative of the prevalence of substance use within this population.

Despite these limitations, the use of LCA to identify patterns of substance use and medication non-adherence has enabled a more nuanced interpretation of substance use data, advancing research into lifestyle factors impacting medication adherence among older adults living with HIV. Findings relating to perceived impairment suggest potential differences in people's motivation to engage in care and treatment. Such findings may serve as the basis for

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tailoring substance use interventions to match profiles of impairment and motivations to change among substance users.

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Table 1. Demographic characteristics by class membership

Demographics	Total n = 557	No Use n = 88	Class 1 Exclusive Alcohol Use n = 106	Class 2 Alcohol and Marijuana n = 85	Class 3 Alcohol and Cocaine/Crack n = 146	Class 4 Multiple-Substance Use n = 132	Test Statistic
	n (%)	*n (%)*	*n (%)*	*n (%)*	*n (%)*	*n (%)*	
Gender/Sexual Identity							$\chi^2(12) = 22.1$*
Gay/Bisexual Men	224 (40.4)	30 (34.1)[a]	43 (40.6)[ab]	37 (43.5)[ab]	46 (31.5)[a]	68 (51.5)[b]	
Straight Men	156 (28.1)	25 (28.4)[ab]	24 (22.6)[a]	23 (27.1)[ab]	54 (37.0)[b]	30 (22.7)[a]	
Lesbian/Bisexual Women	27 (4.9)	3 (3.4)	5 (4.7)	5 (5.9)	5 (3.4)	9 (6.8)	
Straight Women	148 (26.7)	29 (33.0)[a]	33 (31.1)[a]	20 (23.5)[ab]	41 (28.1)[ab]	25 (18.9)[b]	
Race and Ethnicity							†
Black/African American	382 (68.6)	60 (68.2)	64 (60.4)	54 (63.5)	103 (70.5)	101 (76.5)	
White/European	63 (11.3)	8 (9.1)	16 (15.1)	14 (16.5)	11 (7.5)	14 (10.6)	
Latino	97 (17.4)	16 (18.2)	25 (23.6)	15 (17.6)	27 (18.5)	14 (10.6)	
Other	15 (2.7)	4 (4.5)	1 (0.9)	2 (2.4)	5 (3.4)	3 (2.3)	
Partner Status							$\chi^2(4) = 3.8$
Single	322 (58.0)	46 (52.3)	68 (64.2)	51 (60.0)	84 (57.5)	73 (55.3)	
Partnered	233 (42.0)	42 (47.7)	36 (34.0)	34 (40.0)	62 (42.5)	59 (44.7)	
Medication non-adherence							$\chi^2(4) = 44.5$**
≤ 90% adherent	163 (29.3)	7 (8.0)[a]	17 (16)[a]	30 (35.3)[b]	52 (35.6)[b]	57 (43.2)[b]	
> 90% adherent	393 (70.7)	80 (90.9)	89 (84)	55 (64.7)	94 (64.4)	75 (56.8)	
Viral Load							$\chi^2(4) = 22.7$**
Undetectable (VL <200)	398 (76.1)	66 (82.5)[a]	82 (84.5)[a]	71 (87.7)[a]	93 (65.5)[b]	86 (69.9)[b]	
Detectable	125 (23.9)	14 (17.5)	15 (15.5)	10 (12.3)	49 (34.5)	37 (30.1)	
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	
Age (years)	55.0 (4.4)	55.5 (4.3)	55.1 (4.6)	55.5 (4.8)	54.7 (4.1)	54.6 (4.4)	F (4, 552) = 1.2
Number of Missed Medication Days	2.4 (5.2)	1.3 (4.4)[a]	1.3 (1.9)[a]	2.9 (4.2)[b]	4.3 (7.7)[b]	3.5 (4.9)[b]	$\chi^2(4) = 45.2$**
Medication Duration (years)	12.1 (7.0)	13.8 (7.2)[a]	12.7 (6.6)[ab]	12.6 (6.4)[ab]	11.2 (7.2)[b]	11.2 (6.9)[b]	$F(4, 551) = 2.7$*

* $p < .05$

** $p \leq .01$

† An overall χ^2 value is not reported because 5 (25%) cells were associated with expected values less than 5. Row-by-row comparisons found no significant differences at $p < .05$.

Note: some variables have missing data. Where omnibus tests of between group differences were significant, group-by-group comparisons were evaluated using the LSD post hoc test. Groups with different superscripts differ at $p < .05$. Groups which share a common superscript do not.

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Table 2

Latent class model fit criteria

	AIC	BIC	LMR LRT	*p*	Entropy
1 class	12688.0	12701.7			
2 class	12603.8	12625.3	98.22	<.01	0.86
3 class	12569.5	12598.8	54.0	< .01	0.82
4 class	12530.2	12567.2	17.8	.03	0.82
5 class	12494.2	12539.1	57.3	0.01	0.82

AIC: Aikaike's information criterion

BIC: Sample size adjusted Bayesian information criterion

LMR LRT: adjusted Lo-Mendell-Ruben Log-likelihood Ratio Test

251658240 *p* : *p* -value associated with the Lo-Mendel-Ruben likelihood ratio test

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Table 3

Class profiles of substance use and medication adherence

	Proportion of total sample reporting use n = 557	Frequency of use among active substance users n = 469	Frequency of Use among Use Pattern (n = 469) Class 1 Exclusive Alcohol Use n = 106	Class 2 Alcohol and Marijuana n = 85	Class 3 Alcohol and Cocaine/Crack n = 146	Class 4 Multiple-Substance Use n = 132	Test Statistic
Days of use	*n (%)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	
Alcohol	414 (74.3)	10.4 (10.4)	7.5 (9.5)^{a}	11.4 (11.2)^{b}	8.6 (9.7)^{a}	14.2 (10.3)^{b}	$?^2(3) = 33.3$**
Marijuana	233 (41.8)	7.2 (10.6)	0.02 (0.1)^{a}	15.6 (10.5)^{b}	0.1 (0.24)^{a}	15.6 (12.3)^{b}	$?^2(3) = 462.1$**
Cocaine/Crack	252 (45.2)	5.7 (8.4)	†	†	7.7 (7.9)^{a}	11.7 (11.6)^{b}	$?^2(1) = 13.5$**
Opiates	86 (15.4)	2.3 (6.8)	†	†	3.4 (10.5)	4.7 (14.5)	$?^2(1) = 0.7$
Poppers	53 (9.5)	1.0 (4.2)	0.6 (2.8)	0.6 (2.7)	0.9 (4.7)	1.8 (4.1)	$?^2(3) = 5.8$
Other Drug††	65 (11.7)	1.8 (6.7)	0.1 (0.5)^{a}	1.1 (4.1)^{b}	1.8 (8.3)^{b}	3.6 (16.2)^{b}	$?^2(3) = 32.2$**
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	
AUDIT score (range 0-12)	4.3 (3.5)	5.1 (3.3)	4.3 (3.1)^{a}	4.4 (3.1)^{a}	4.8 (3.5)^{a}	6.5 (2.7)^{b}	$F(3, 465) = 12.6$**
DAST score (range 1-10)	3.9 (3.4)	4.6 (3.3)	0.5 (1.5)^{a}	4.1 (2.5)^{b}	6.0 (2.5)^{c}	6.6 (2.3)^{c}	$F(3, 465) = 174.6$*
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	
Injection Drug Use	33 (5.9%)	33 (7.0)	0 (0.0)^{a}	1 (1.2)^{a}	16 (11.0)^{b}	16 (12.1)^{b}	$?^2(3) = 21.1$**

*p =.05
**p =.01
† Empty cell not included in follow up ANOVA
†† Amphetamines, sedatives, PCP, and solvents
Note: Where omnibus tests of between group differences were significant, group-by-group comparisons were evaluated using the LSD (count variables), Games-Howell (continuous variables with unequal cell variances), or Ficher Exact (for categorical variables) pc
Groups with different superscripts differ at p < .05. Groups which share a common superscript do not.

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Contributors

Jeffrey Parsons is the primary investigator for the project which generated these data. He was responsible for data collection and project conceptualization. Tyrel Starks was primarily responsible for the creation and execution of the analytic plan. Brett Millar, Kailip Boonrai, and David Marcotte were responsible for structuring introduction and discussion sections and contributed to the writing of the entire manuscript.

Conflict of interest

The authors declare that they have no conflicts of interest.

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