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Heterogeneity in the Relationship of Substance Use to Risky Sexual Behavior Among Justice-Involved Youth: A Regression Mixture Modeling Approach

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Abstract Justice-involved adolescents engage in high levels of risky sexual behavior and substance use, and understanding potential relationships among these constructs is important for effective HIV/STI prevention. A regression mixture modeling approach was used to determine whether subgroups could be identified based on the regression of two indicators of sexual risk (condom use and frequency of intercourse) on three measures of substance use (alcohol, marijuana and hard drugs). Three classes were observed among n = 596 adolescents on probation: none of the substances predicted outcomes for approximately 18 % of the sample; alcohol and marijuana use were predictive for approximately 59 % of the sample, and marijuana use and hard drug use were predictive in approximately 23 % of the sample. Demographic, individual difference, and additional sexual and substance use risk variables were examined in relation to class membership. Findings are discussed in terms of understanding profiles of risk behavior among at-risk youth.

Keywords Substance use · Risky sexual behavior · Justice-involved youth · HIV/AIDS prevention · Regression mixture modeling

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Introduction

Young people under the age of 25 are at risk of contracting sexually transmitted infections (STI), including the human immunodeficiency virus (HIV) [1]. Indeed, 50 % of all new HIV infections worldwide occur among those between the ages of 15 and 24 [2]. In comparison to the general adolescent population, adolescents involved with the juvenile justice system have a higher incidence of risky sexual behaviors (e.g., more sexual partners, lower rates of condom use) [3–6]. These increased levels of risky sexual behavior result in high rates of unintended pregnancy and STIs in this population [5]. A handful of interventions have been targeted specifically toward justice-involved youth (see [7] for a review), with evidence that strategies that are effective with mainstream youth do not necessarily apply to juvenile offenders. Developing effective HIV/STI prevention strategies that resonate with at-risk youth remains an important area of research.

One way to best inform and tailor such programs is through the identification of co-occurring HIV risk factors (i.e., behavioral and individual difference variables that are associated with higher or lower rates of risky sexual behavior), specifically among at-risk youth such as those involved with the justice system [8]. In addition to high rates of risky sexual behavior, justice-involved youth also engage in higher rates of substance use compared to their mainstream peers [4, 9, 10]. Marijuana is the most commonly abused drug in this group and alcohol is number two; other drugs of abuse are less common, though are still used more frequently among justice involved adolescents relative to adolescents not involved with the justice system [9, 11]. Substance use has been implicated as one possible cofactor for risky sexual behavior where higher levels of substance use/abuse may be associated with higher levels

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of risky sexual behavior. There is a vast literature examining the association of alcohol use to risky sexual behavior [12–15] and a smaller body of literature on the relationship between marijuana use and risky sexual behavior [16–22]. However, only a small portion of this work has been conducted specifically among justice-involved youth [10, 23–28]. Furthermore, both the alcohol and marijuana literature have shown mixed conclusions, where the expected positive associations of both alcohol use and marijuana use with risky sexual behavior have not been consistently observed (for reviews see [22, 29]). Such inconsistencies are apparent across different methods for examining the relationship (e.g., global correlation, event-level).

While much less common than alcohol and marijuana use [30], there are also a subset of adolescents who use other drugs of abuse including so-called "club drugs" [e.g., gamma hydroxybutyric acid (GHB), methylenedioxymethamphetamine (MDMA or ecstasy), ketamine (Special K)], stimulants [e.g., crack, cocaine, methamphetamine), as well as hallucinogens (e.g., LSD/acid and psilocybin/mushrooms)]. However, much of the research linking other drug use to risky sexual behavior has been conducted among specialized populations, for example, men-who-have-sex-with-men (MSM) attending party venues [31, 32], women who exchange sex for money or drugs [33], and participants identified specifically because of a substance use problem (e.g., injection drug users) [34], to name a few. Among adolescents, one study showed that higher rates of cocaine use were associated with a greater likelihood of repeated sexually transmitted infections, though this study was specific to substance-dependent adolescents [35]. Another study showed that among African American female adolescents, ecstasy use interacted with depressive symptoms to predict unprotected sex and STI incidence rate [36]. Finally, methamphetamine use and inconsistent condom use were associated with one another among incarcerated female adolescents identified specifically because of an STI diagnosis [37]. There are still comparatively little data that have examined the relationship between other drug use and sexual risk among adolescents [38], whether mainstream or justice-involved. This question is nevertheless important, given the findings in other populations, so we included an examination of the relationship of other drug use to sexual risk behavior. However, because the data in this area are comparatively sparse, we considered these analyses exploratory.

One approach to explaining the relationship of substance use to risky sexual behavior is an inductive, theory-based approach examining various potential mechanisms underlying the relationship; for example, causal relationships based on expectancy theory [12, 23] or alcohol myopia theory [39], or third variable explanations such as a general proneness for deviance that explains both behaviors [40].

However, another approach to asking this question is a more deductive, data-driven approach of seeking to understand whether there are particular subgroups in a population for whom a relationship exists. At least in the existing literature on alcohol and marijuana, there is clearly individual-level heterogeneity in the data, where the expected positive association of substance use to risky sexual behavior emerges for some youth but not for others [23, 41]. Our focus was thus to identify these subgroups of individuals for whom there was a relationship of substance use to risky sexual behavior, rather than to expect significant relationships across all individuals.

Regression mixture modeling (RMM) is one approach to subgroup identification, where the goal is to take a "person-centered" data-driven approach to determine whether latent classes of individuals demonstrating differing relationships (e.g. between alcohol use, marijuana use, other drug use, and risky sexual behavior) exist in the data [42, 43]. Standard regression analysis assumes a homogeneous population and thus characterizes the relationship between predictors and outcomes using a single regression function (although observed group membership, such as age, may be taken into account as a moderating or control variable). In contrast, RMM tests—within the context of a single overall model—for the presence of several (or at least more than one) regression equations that may reflect heterogeneity in the population in terms of the regression coefficients. In RMMs, latent groups are identified that group participants in terms of differential effects of the predictor(s) on the outcome(s). In this approach, multiple multivariate normal distributions are modeled simultaneously, with each based on a latent class in which individuals within each class demonstrate a homogeneous relationship of the predictor(s) to the outcome(s). Participants are clustered into latent classes based on similarity in the degree of relationship of the predictor(s) to the outcome(s), as determined by both theoretical and empirical criteria [44, 45]. Explanatory variables that may be expected to relate to class membership (either as predictors or as outcomes of the observed class membership) may also be included to better characterize the resulting latent classes.

Schmiege et al. [41] applied RMM to assess whether latent classes could be identified based on the regression of risky sexual behavior on alcohol use in a sample of youth in juvenile detention centers. A three-class solution was observed: alcohol use was not significantly associated with risky sexual behavior for approximately a quarter of the sample; alcohol use was negatively associated with condom use and positively associated with frequency of intercourse for almost 40 % of participants; and alcohol use was negatively associated with condom use but not frequency of intercourse for the remaining participants. These classes were then distinguished on the basis of five

explanatory variables: self-esteem, gender, participant age, relationship status, and impulsivity/sensation-seeking. Lower self-esteem, being male, being younger, and not being in a relationship were associated with membership in the classes where a relationship of alcohol use to risky sex was observed relative to the class where no relationship was observed.

There were several goals of the present study. First, given the importance of replication in the context of data-driven mixture modeling techniques, we attempted to replicate the results of the Schmiege et al. [41] study in a completely new sample with regard to the association of alcohol and risky sexual behavior. Second, the prior study was limited to alcohol use and did not include a measure of marijuana use nor a measure of other drug use. Given both rapidly changing public opinion and public policy with regard to the legalization of marijuana, and the prevalence of marijuana use among young people generally and juvenile-justice youth in particular, we extended our prior work by including marijuana use as a focus. Further, based on the scarcity of existing data on the role of other drug use in the sexual risk behavior of adolescents, we included other drug use as an additional focus. For the current study, latent classes were defined based on the effects of alcohol use, marijuana use, and other drug use as predictors of two indicators of risky sexual behavior: condom use and frequency of intercourse. Finally, based on the importance of identifying co-occurring demographic/behavioral variables for understanding constellations of risk, we extended the previous work by examining additional explanatory variables expected to relate to substance use, risky sexual behavior, or both. The explanatory variables were examined in relationship to class membership once the class structure was determined based on the regression relationships between substance use and risky sexual behavior. The same five demographic and personality variables examined in Schmiege et al. [41] were still included here, both for consistency between studies and for theoretical reasons (e.g., [23, 24, 29, 46–49]). Additional variables examined in the present study included demographic variables (race/ethnicity and sexual orientation), personality/individual difference variables (externalizing behaviors; [50, 51]) and sexual history and risk variables (relationship seriousness, use of other birth control, pregnancy history, number of sexual partners, and substance use during intercourse; [52, 53]).

To summarize, developing effective HIV prevention strategies among at-risk youth, such as those involved with the juvenile justice system, is critical and may depend on identifying situational and contextual variables that best inform the tailoring of intervention techniques. A substantial amount of research has examined the putative relationship of alcohol use to risky sexual behavior, and more recent literature has focused on the relationship of marijuana use to risky sexual behavior [54]. However, the majority of research has been conducted among mainstream adolescents or college students, who are at objectively lower risk for HIV and STI. Studies drawn from low risk or specialized populations may not be directly applicable to justice-involved adolescents for whom both substance use and risky sexual behavior are both relatively more normative and especially likely, and/or who have unique developmental and social circumstances, placing them at relatively higher risk of negative consequences including HIV/STI. In addition, there is very little research on the role of other drugs of abuse and sexual risk behavior among either mainstream or justice-involved adolescents. The present study aimed to determine the existence of, as well as characterize potential heterogeneity in, the relationship of alcohol use, marijuana use, and other drug use to risky sexual behavior by (a) classifying a sample of probated adolescents into latent subgroups based on their observed global relationship between alcohol use, marijuana use, and other drug use with two indicators of risky sexual behavior and (b) examining the differences between the observed subgroups on demographic and personality variables. We expected to replicate prior results [41] by showing that the regression of risky sexual behavior on substance use would not be consistent across individuals and could instead best be represented by latent classes. Further, we sought to extend the previous study by examining the relative contribution of alcohol use compared to marijuana use and other drug use in terms of their association to risky sexual behavior and by examining the role of additional predictor/contextual variables to better characterize the subgroups.

Methods

Participants

Data for these analyses were baseline assessments from a longitudinal study assessing substance-use and sexual risk among youth ($n = 728$) recruited from juvenile probation offices in the Denver metropolitan area [24]. Participants answered questions about their substance use and sexual-risk behavior every 6 months over a 2-year period. Participants (n = 485 male and n = 243 female) had a mean age of 15.71 years ($SD = 1.05$; range 14–18, interquartile range (IQR) = 2). The sample was ethnically diverse: 40.9 % were Hispanic, followed by African-American (24.5 %), White (15.7 %), multi-racial (11.6 %), American-Indian/Alaskan Native (3.4 %), an unidentified ethnicity (2.9 %) and Asian/Pacific islander (1.1 %). The majority of participants reported attraction to the opposite

sex (85.5 %), while a small number reported attraction to the same sex (4.0 %) or to both sexes (10.5 %). Most participants (596/681, 87.52 %) reported having sex at least once; 89.46 % reported ever having used marijuana; 61.31 % reported marijuana use in the past 6 months; 68.87 % reported alcohol use in the past 6 months; and 34.44 % reported use of at least one hard drug (of eight measured) in the past 6 months. These secondary analyses were conducted among the n = 596 sexually experienced participants, as limiting the analyses to those who were sexually active provides the best match to the research question. Only the baseline data from the larger longitudinal study were used due to lack of availability of specific key measures at follow-up assessments.

Procedure

Posters advertising the opportunity to be involved in research were displayed in the waiting rooms of youth probation offices. Research staff approached young people waiting for appointments during peak hours and asked if they were interested in information about a research study concerning health and risk behaviors in which young people on probation may engage. A brief description of the study was provided to interested adolescents. To be eligible to participate, individuals had to be (a) 14–18 years old, (b) currently on probation, (c) able to speak and read english, (d) cognitively capable of understanding the assent information, and (e) if under 18 have fully informed consent of a parent or legal guardian. Written assent was obtained from each participant (or informed consent in the case of 18-year-old participants), and recorded verbal consent via tape-recorded phone calls was obtained from each parent/guardian for youth under the age of 18. Probation and juvenile-justice staff were not involved in recruitment, and participation decisions had no impact on the young person's probation status or treatment. Participants received $20 for completing the baseline assessment. All procedures were reviewed and approved by the local IRB, and a federal certificate of confidentiality was obtained from NIH/NIDA to protect participants involved in this research.

Questionnaire data were collected using audio computer-assisted self-interviewing (ACASI) technology on individual laptop computers. Questions were displayed on the computer screen while respondents heard the recorded questions over headphones. Previous experience with this population indicates that literacy can be a problem, and the ACASI technology eliminates many issues with understanding the questions being asked and navigating the skip patterns within the questionnaire [55, 56]. The technology has also been shown to encourage honest responding [57].

Measures

Risky sexual behavior

Condom use was measured with the question, "In the past 6 months, how much of the time have you used condoms when you've had sexual intercourse?" Response options were 1 = never, 2 = almost never, 3 = sometimes, 4 = almost always, and 5 = always. Overall, 11.4 % reported never using condoms, 55.2 % reported inconsistent use and 33.4 % reported always using condoms ($M = 3.60$, $SD = 1.34$, IQR = 2). Frequency of intercourse was measured with the question, "On average, how often do you have sexual intercourse?" Response options were 1 = a few times a year, 2 = once a month, 3 = once a week, 4 = 2–3 times a week, 5 = 4–5 times a week, and 6 = almost every day ($M = 2.97$, $SD = 1.50$, IQR = 2).

Substance use

Frequency of marijuana use was assessed with the item "In the last 6 months, how often did you use marijuana?" with response options of 0 = never, 1 = occasionally, 2 = once a month, 3 = 2–3 times a month, 4 = 4–5 times a month, 5 = once a week, 6 = 2–3 times a week, 7 = 4–5 times a week, and 8 = every day ($M = 3.80$, $SD = 3.57$, IQR = 8). Alcohol use was assessed as a composite of three items from White and Labouvie [58] that assessed *frequency of alcohol use* ("In the last 6 months, how often did you consume at least one alcoholic drink" with response options from 0 = never to 8 = every day), *quantity of use* ("In the last 6 months, how many drinks did you usually have at one time" with response options from 0 = none to 9 = more than 20), and *frequency of getting drunk* ("In the last 6 months, when you drank how often did you get drunk?" with response options from 1 = never to 5 = always). Response options were on different scales across the three items, so items were standardized (mean = 0, standard deviation = 1) and the alcohol use composite was calculated as the mean of these standardized items ($M = 0.07$, $SD = 0.91$, IQR = 1.84, $\alpha = 0.88$). Participants were asked their frequency of use of several other drugs in the prior 6 months: crack/cocaine, LSD/acid, mushrooms, ecstasy, GHB, heroin, ketamine, or methamphetamines. Response options were 0 = never, 1 = occasionally, 2 = once a month, 3 = 2–3 times a month, 4 = 4–5 times a month, 5 = once a week, 6 = 2–3 times a week, 7 = 4–5 times a week, and 8 = every day. Hard drug use was assessed as the mean frequency of use across these eight drugs of abuse ($M = 0.23$, $SD = 0.66$, IQR = 0.22).

Explanatory variables

Race/ethnicity was categorized into four groups for analytic purposes: non-Hispanic White, non-Hispanic Black, Hispanic, and other/multiracial. Due to limited variability, s*exual orientation* was assessed by comparing those who exclusively reported opposite sex attraction to those who reported attraction to either the same sex or both sexes. *Relationship seriousness* was assessed by first asking participants (yes/no) if they were in a relationship (yes = 61.5 %); those in a relationship further characterized their relationship as "casually dating," "steadily dating," or "seriously committed"). Relationship seriousness was therefore assessed on a 4-point scale from 0 = not in a relationship to 3 = seriously committed ($M = 1.51$, $SD = 1.25$, IQR = 3.0). Participants were also asked to describe their *relationship with last intercourse partner,* with response options of "someone I just met," "a casual sex partner," and "my boyfriend or girlfriend." *Impulsivity/sensation seeking* [59] was calculated using the mean of a 20-item scale, with 12 items [60] assessing impulsive decision-making (e.g., "I act on the spur of the moment"; "I do the first thing that comes into my mind") and 8 items [61] taken from the Brief Sensation Seeking Scale (e.g., "I prefer friends who are excitingly unpredictable"; "I would like to explore strange places"). All items were rated on a 5-point scale from 1 = disagree a lot to 5 = agree a lot or from 1 = never to 5 = always (M = 3.02, SD = 0.60, IQR = 0.85, α = 0.86). *Externalizing behavior* was measured using the mean of 31 items from the aggression and delinquent behavior subscales of the child behavior checklist youth self report (e.g., "I lie or cheat"; "I get in many fights" [62]). Items were measured on a 3-point scale from 0 = not true to 2 = very true/often true (M = 1.65, SD = 0.30, IQR = 0.42, α = 0.88). *Self-esteem* was calculated as the mean of eight items (e.g., "In general, I am satisfied with myself"), each measured on a 4-point scale ranging from 1 = disagree a lot to 4 = agree a lot (M = 3.36, SD = 0.48, IQR = 0.75, α = 0.75). Two items from the original 10-item measure [63] were excluded ("I certainly feel useless at times" and "I feel I do not have much to be proud of"), as these items did not load significantly on a self-esteem latent factor in our prior work with this population and because this 8-item version has demonstrated high reliability in our previous work with justice-involved adolescents [55, 64, 65]. Use of *birth control other than condoms* was assessed with the item "In the last 6 months, how much of the time have you used some other kind of birth control when you've had sexual intercourse?" This item was asked immediately following the condom-use item and included response options of 1 = never to 5 = always (M = 2.33, SD = 1.51, IQR = 3.0). *Number of sexual partners* was assessed with

the open-ended item "In your lifetime, how many people have you had sexual intercourse with?" ($M = 6.58$; $SD = 4.69$, IQR = 7.0). Given the large upper bound associated with this item, participants answering more than 15 partners were capped at 15 for conceptual reasons (though results were consistent when this variable was not capped). *Age at first intercourse* was assessed with the open-ended item "How old were you the first time you had sexual intercourse?" ($M = 13.29$; $SD = 1.54$, IQR = 1.0). *Pregnancy history* was assessed with the item "Have you ever been pregnant or gotten someone pregnant?" where 22.30 % responded "yes." *Frequency of alcohol use during sex* was assessed with the item "In the past 6 months, how much of the time did you use alcohol when you had sexual intercourse?" and *frequency of marijuana use during sex* was assessed with the item "In the past 6 months, how often were you using marijuana when you were having sex?" Both items were assessed on a 5-point scale from 1 = never to 5 = always ($M = 2.04$; $SD = 1.05$, IQR = 2.0 for alcohol and $M = 2.27$; $SD = 1.29$, IQR = 2.0 for marijuana).

Analysis Plan

The goal of the analyses was to examine potential heterogeneity in the regression of risky sexual behavior on substance use. Regression mixture models were estimated in Mplus Version 7.1 [66] to examine whether distinct classes could best represent the regression parameters estimating the effect of marijuana use, alcohol use, and other drug use on condom use behavior and frequency of intercourse [67]. In this approach, the six regression parameters (beta coefficients) representing the effects of three predictors on two outcomes were estimated simultaneously across classes. Individuals within a class were expected to be similar to one another in regard to the regression of risky sexual behavior on substance use, but different from individuals in other classes. One-, two-, three-, and four-class models were estimated, and confidence in the final solution was based on several statistical indices of fit as well as on the theoretical meaningfulness and conceptual interpretability of the class structure [68, 69]. The statistical indices of fit used were Akaike's information criterion index (AIC), the Bayesian information criterion index (BIC), the Lo-Mendell-Rubin likelihood ratio test [70], and a bootstrap likelihood ratio test [71]. Lower AIC and BIC numbers indicate a better fitting model; for both the LMR-LRT and the BLRT, fit is determined by a significance test comparing the estimated model to a model with one fewer class where a significant value indicates that the estimated model fits the data significantly better than a model with one fewer class. Although RMMs relax the assumption that the effects of the predictors on outcomes are the same across

individuals, standard assumptions of regression analysis (e.g., linearity, normality, homoscedasticity) are still assumed to hold within each class [42, 43]. This was tested in the current analyses by regression diagnostics (e.g., Q-Q plot of the residuals, plot of the residuals against the predicted values) performed within class once the final model was obtained.

Once the final class structure was determined (i.e., the best fitting model based on number of classes was chosen), the explanatory variables were examined in relationship to class membership. This was accomplished using the "auxiliary" command in Mplus whereby the prediction of most likely latent class membership was obtained by the multinomial regression of latent class membership on each of the explanatory variables [72]. The impact of the explanatory variables on class membership was examined once the final class structure was obtained such that the explanatory variables did not influence class enumeration. Latent class membership was modeled as the outcome in these analyses and the effect of each of the explanatory variables on class membership was examined holding the other covariates constant.

Results

Class Enumeration

Table 1 depicts the fit statistics for the one to three class models; the four class model did not replicate the best log likelihood value even after allowing a very large number of random start values (10,000) and was therefore not considered further. The three-class solution was chosen as the final, best fitting model based on the lower AIC and BIC values and the significant p-values for both the LMR-LRT ($p = 0.0007$) and the BLRT ($p < 0.0001$). All remaining results are reported specific to the three class solution.

There were approximately 18.1, 58.5, and 23.4 % of participants distributed across the three classes, respectively, as estimated from the model posterior probabilities. There was generally good distinction among the three classes in this final model, based on an overall entropy value of 0.76. Table 1 also shows results examining the degree of certainty of classification into specific classes for the three class model. These results indicated a high probability of correct classification (e.g., as shown in Table 1, those assigned to Class I had an average probability of 0.933 of being correctly classified, with an average probability of only 0.002 of belonging to Class II and an average probability of 0.065 of belonging to Class III).

Characteristics of the Final Three Class Model

Table 2 depicts the standardized beta coefficients of the simultaneous regression of condom use and frequency of intercourse on marijuana use, alcohol use, and other drug use for the three-class solution. As shown from these regression slopes, none of the three substances were associated with condom use or frequency of intercourse for those in Class I. Class I was therefore characterized as the "no relationship of substance use with risky sex" class of individuals, where neither marijuana use, alcohol use, nor other drug use was related to risky sexual behavior. In contrast, for those in Class II, marijuana use was negatively associated with condom use and was positively associated with frequency of intercourse, and alcohol use was negatively associated with condom use. Class II was characterized as the "marijuana and alcohol associated with risky sex" class, where marijuana and alcohol were associated with lower condom use, marijuana was associated with greater frequency of intercourse, and other drug use was not associated with either outcome. In Class III, both marijuana use and other drug use were negatively associated with condom use but did not significantly relate to

Table 1 Model fit indices of regression mixture model of increasing number of classes, and degree of classification certainty of the final three class model

Fit criteria	1-Class model	2-Class model	3-Class model
AIC	3808.43	3713.49	3656.84
BIC	3856.54	3800.95	3783.66
LMR-LRT	n/a	111.01	73.37
P value for LMR-LRT	n/a	<0.00001	0.0007
BLT	n/a	112.94	74.65
P value for BLRT	n/a	<0.0001	<0.0001
Entropy	n/a	0.74	0.76
Classification probability of 3-class model	Class I	Class II	Class III
Class I	0.933	0.002	0.065
Class II	0.02	0.867	0.113
Class III	0.013	0.081	0.906

Table 2 Beta coefficients reflecting the regression slopes of six regression parameters per each class for the three class solution

Predictor	Class 1 beta coefficients 18.1 %	Class 2 beta coefficients 58.5 %	Class 3 beta coefficients 23.4 %
Marijuana Use	β_C[a]: −0.002 (0.12), n.s.	β_C: −0.18 (0.08), p < .05	β_C: −0.35 (0.12), p < .01
	β_F[b]: −0.06 (0.12), n.s.	β_F: 0.20 (0.06), p < .001	β_F: 0.005 (0.12), n.s.
Alcohol Use	β_C: 0.14 (0.14), n.s.	β_C: −0.17 (0.07), p < .05	β_C: −0.012 (0.13), n.s.
	β_F: 0.00 (0.14), n.s.	β_F: 0.09 (0.06), n.s.	β_F: −0.08 (0.11), n.s.
Other Drug Use	β_C: −0.12 (0.13), n.s.	β_C: −0.07 (0.17), n.s.	β_C: −0.25 (0.06), p < .001
	β_F: 0.07 (0.13), n.s.	β_F: −0.002 (0.06), n.s.	β_F: 0.07 (0.10), n.s.

[a] β_C denotes the standardized beta coefficient for the regression of condom use on substance use

[b] β_F denotes the standardized beta coefficient for the regression of frequency of intercourse on substance use

frequency of intercourse, and alcohol was not associated with either outcome. This class was referred to as the "marijuana and other drug use associated with condom use" class.

Table 3 shows the estimated mean scores of condom use, frequency of intercourse, marijuana use, alcohol use, and other drug use scores across the three classes for the final three class model based on estimated class membership. Differences in means between the three classes are indicated by different numeric subscripts [1–3] where, within each row, the same subscript indicates no difference between classes and different subscripts indicates a significant difference. There were significant differences between classes in terms of risky sexual behavior, where condom use was lowest and frequency of intercourse was highest in the "no relationship of substance use with risky sex" class and condom use was highest and frequency of intercourse was lowest in the "marijuana and alcohol associated with risky sex" class. The three classes did not significantly differ from one another in terms of mean levels of any of the three substance use measures.

Effects of Explanatory Variables on Latent Class Membership

The next step was to further explore distinctions among the three classes by examining the relationships of each of the explanatory variables to class membership. Table 4 depicts the estimated mean/percentage scores of each of the explanatory variables within each class based on estimated class membership; it also demonstrates the significance of contrasts testing the prediction of class membership from each of the explanatory variables using multinomial logistic regression. As shown by the numeric subscripts following each mean (in which common subscripts denote no significant difference in predicting class membership), the "no relationship of substance use with risky sex" and "marijuana and alcohol associated with risky sex" classes were distinguishable in terms of participant gender, age, relationship seriousness, relationship with last intercourse partner, externalizing behaviors, and pregnancy history. Specifically, women, older participants, those in more serious relationships (overall and at last intercourse), those

Table 3 Estimated risky sexual behavior, marijuana use, alcohol use, and other drug use means by class membership for the three class solution.[a]

Behavioral variable	Class 1 "No relationship of substance use with risky sex"	Class 2 "Marijuana and alcohol associated with risky sex"	Class 3 "Marijuana and other drug use associated with condom use"
Condom use[b]	1.47 (.50)[1]	4.62 (.49)[2]	3.20 (.44)[3]
Frequency of intercourse[c]	3.80 (1.53)[1]	2.47 (1.35)[2]	3.46 (1.37)[1]
Marijuana use[d]	3.88 (3.57)[1]	3.81 (3.55)[1]	3.76 (3.59)[1]
Alcohol use[e]	0.25 (0.89)[1]	0.038 (0.88)[1]	0.043 (0.96)[1]
Other drug use[f]	0.27 (0.50)[1]	0.19 (0.59)[1]	0.31 (0.89)[1]

[a] Common numeric subscripts (e.g., [1,2]) within a row indicate no significant differences among classes

[b] Potentially ranges from 1 (never) to 5 (always)

[c] Potentially ranges from 1 (a few times a year) to 6 (almost every day)

[d] Potentially ranges from 0 (never) to 8 (every day)

[e] Measured as the mean of three standardized scores (i.e., mean = 0, standard deviation = 1)

[f] Measured as the mean frequency measured from 0 (never) to 8 (every day) for the following substances: crack/cocaine, LSD/acid, mushrooms, ecstasy, GHB, heroin, ketamine, or methamphetamines

Table 4 Estimated percentages/means of explanatory variables as a function of most likely class membership and significance of prediction of class membership from the explanatory variables.[a]

Explanatory variable	Class 1 "No relationship of substance use with risky sex"	Class 2 "Marijuana and alcohol associated with risky sex"	Class 3 "Marijuana and other drug use associated with condom use"
Female (%)	42.5_1	25.95_2	$37.23_{1,2}$
Participant age	$16.07 (1.00)_1$	$15.73 (1.01)_2$	$15.92 (1.00)_{1,2}$
Race/ethnicity			
Non-hispanic white (%)	15.24_1	15.16_1	12.41_1
Non-hispanic black (%)	20.00_1	26.24_1	21.90_1
Hispanic (%)	41.90_1	39.65_1	47.45_1
Other/multiracial (%)	22.86_1	18.95_1	18.25_1
Sexual orientation (% reporting same sex attraction)	17.48_1	11.21_1	18.05_1
Relationship seriousness[b]	$1.86 (1.31)_1$	$1.39 (1.23)_2$	$1.56 (1.24)_{1,2}$
Relationship with last person they had sex with			
Just met (%)	9.62_1	9.94_1	9.02_1
Casual (%)	15.38_1	26.51_2	33.08_2
Serious (%)	75.0_1	63.55_2	57.89_2
Impulsivity/sensation seeking[c]	$3.13 (0.61)_1$	$2.99 (0.59)_1$	$3.01 (0.63)_1$
Externalizing behaviors[d]	$1.74 (0.33)_1$	$1.62 (0.29)_2$	$1.66 (0.30)_2$
Self-esteem[e]	$3.37 (.52)_1$	$3.38 (.48)_1$	$3.32 (.46)_1$
Other birth control[f]	$2.13 (1.50)_1$	$2.28 (1.53)_1$	$2.60 (1.46)_1$
Number of sexual partners	$7.03 (5.06)_{1,2}$	$6.11 (4.47)_1$	$7.42 (4.78)_2$
Age at first intercourse	$13.20 (1.74)_1$	$13.38 (1.50)_1$	$13.15 (1.47)_1$
Ever been pregnant/gotten someone pregnant (%)	40.0_1	13.78_2	29.93_1
Frequency of alcohol use during sex[f]	$2.02 (0.99)_1$	$2.00 (1.08)_1$	$2.12 (1.02)_1$
Frequency of marijuana use during sex[f]	$2.08 (1.26)_1$	$2.27 (1.31)_{1,2}$	$2.41 (1.27)_2$

[a] Common numeric subscripts (e.g., $_{1,2}$) within a row indicate no significant differences in the prediction of class membership using multinomial logistic regression

[b] Potentially ranges from 0 (not in a relationship) to 3 (seriously committed)

[c] Potentially ranges from 1 to 5, with higher scores indicating greater impulsivity/sensation seeking

[d] Potentially ranges from 0 to 2, with higher scores indicating greater externalizing behaviors

[e] Potentially ranges from 1 to 4, with higher scores indicating greater self-esteem

[f] Potentially ranges from 1 (never) to 5 (always)

with greater externalizing behaviors, and those more likely to have been/gotten someone pregnant were more likely to be in the "no relationship of substance use with risky sex" class relative to the "marijuana and alcohol associated with risky sex" class. Note that the "no relationship" class was also the class that had the lowest rate of condom use and highest frequency of intercourse and are thus at potentially highest risk for negative outcomes of risky sexual behavior.

The "no relationship of substance use with risky sex" class and "marijuana and other drug use associated with condom use" class were distinguishable in terms of relationship with last intercourse partner, externalizing

behaviors, and frequency of marijuana use during intercourse. Last intercourse with a more casual partner, lower externalizing behaviors, and greater frequency of marijuana use during intercourse predicted membership in the "marijuana use and other drug use associated with condom use" class relative to the no relationship class.

The "marijuana and alcohol associated with risky sex" and "marijuana and other drug use associated with condom use" classes were distinguished by number of sexual partners and pregnancy history. Having a greater number of sexual partners, and having had involvement with pregnancy predicted membership in the "marijuana and other

drug use associated with condom use" class relative to the "marijuana and alcohol associated with risky sex" class.

Discussion

This study aimed to examine the relative association of three different measures of substance use (alcohol use, marijuana use, and other drug use) with risky sexual behavior in a sample of at-risk adolescents on probation and to explore the hypothesis that lack of consistency in these relationships—particularly with regard to alcohol and marijuana—may be explained, in part, by individual level heterogeneity. Using a regression mixture modeling approach, three classes that demonstrated distinct relationships of substance use with risky sexual behavior were identified. Results paralleled those of Schmiege et al. [41] where the expected positive relationship between substance use and condom use emerged to some degree in both the "marijuana and alcohol associated with risky sex" and "marijuana and other drug use associated with condom use" groups. Similarly, over 18 % of the sample was classified into the "no relationship of substance use with risky sex" class, where no association was observed between substance-use and risky-sex constructs. The emergence of this class supports the hypothesis that the likelihood of observing a significant relationship of substance use to risky sexual behavior will be attenuated when there are subsets of adolescents for whom this relationship does not exist. Interestingly, there were not differences between the three classes in terms of the mean levels of substance use, but rather in the relationship of substance use to risky sexual behavior.

Of the over 80 % of the sample for whom there was a relationship between substance use and risky sex (i.e., everyone not in the "no relationship of substance use with risky sex" class), there were distinctions between the role of marijuana use versus alcohol use on risky sexual behavior. The association of marijuana use to outcomes was relatively stronger than that of either alcohol use or other drug use, given that marijuana use was associated with condom use in two classes and frequency of intercourse in one, whereas alcohol use and other drug use were each associated with condom use in only one class. This finding is consistent with other work specifically among justice-involved adolescents showing stronger relationships of marijuana use than of alcohol use to risky sexual behavior [26, 28]. Interestingly, in non-justice involved samples, there is some evidence that alcohol use may be more strongly related to risky sexual behavior than marijuana use [22, 73].

The finding that higher levels of other drug use were associated with lower condom use for nearly a quarter of the sample is notable, as this relationship has only been examined in a small amount of research specific to adolescent populations [35–37]. This finding should be considered preliminary, given the exploratory nature of these analyses, but suggests a critical direction for future research and potentially for future prevention efforts. Based on low prevalence rates for each individual drug, use was captured as an aggregate of several different substances (e.g., methamphetamines, cocaine, ecstasy), each of which may demonstrate unique relationships to risky sexual behavior. Future research should take a more targeted approach in examining relationships of individual drugs to risky sexual behavior and should aim to identify potential mechanisms underlying those relationships. It may also be that emerging data with adolescents will show a pattern of heterogeneity, much as the data on alcohol use and marijuana have shown.

By examining the relationship of various explanatory variables to observed class membership, unique profiles of each class begin to emerge. For example, the "marijuana and alcohol associated with risky sex" class reflects the largest portion of the sample (nearly 60 %) and in many ways these adolescents appear to be less experienced in terms of substance use and sexual behavior than those in the other classes. On average, the adolescents in this class were younger, were less likely to be in a serious relationship, reported having intercourse less frequently, reported fewer sexual partners, and were less likely to report having experienced involvement in a pregnancy compared to the adolescents in the other two classes. Although condom use in general is highest in this class, the association of lower condom use to higher levels of marijuana and/or alcohol may be due to lack of preparation that may come from lack of experience [74]. In contrast, those in the "no relationship of substance use with risky sex" class appear to be riskier than those in the other two classes in several ways, for example, having the highest levels of externalizing problems and a greater likelihood of reporting involvement in a pregnancy. Aspects of risk taking that are independent of substance use may simply be the most predictive of risky sexual behavior in this class. Adolescents in the no relationship class were also older and more likely to be in serious relationships. It is well known that relationship status is a strong predictor of condom use, with condom use less likely with serious partners [75, 76].

The "marijuana and other drug use associated with condom use" class is similar to the "no relationship of substance use with risky sex" class in terms of characteristics such as age, number of sexual partners, and pregnancy history; that marijuana use was associated with condom use in this class whereas it was not associated in the "no relationship" class might be explained by the greater frequency of marijuana use during sexual

intercourse observed in this class. We speculate that the relationship of other drug use to condom use may be a reflection of a greater tendency to also use other drugs of abuse in concert with sexual intercourse, though we did not collect those specific data in this study. However the lower condom use might also be associated with the frequency of sex with casual partners among those in this class. Given that overall condom use is more likely with casual partners than serious partners, it may be that their usual tendency to use condoms with casual partners is interfered with by their frequent marijuana use (and potentially other drug use) during sex. Although the explanatory variables provide some context for interpreting the observed class structures, these explanations need to be tested more fully in future research, including additional applications of latent class techniques, to better understand how constellations of risk behavior cluster in this population. These analyses also may inform intervention efforts among justice-involved youth.

Interventions with justice-involved youth have begun to include substance use content within the provision of sexual risk reduction programs to most effectively reduce sexual risk taking [56, 77, 78]. While this appears to continue to be a good strategy for the majority of adolescents, there is a proportion of adolescents that may instead benefit most from additional/alternative intervention content; for example, for those in the "no relationship of substance use with risky sex" class, content on the negotiation and necessity of safer sex behavior within the context of a stable romantic relationship may be more meaningful. The varying effects of alcohol versus marijuana versus other illicit drug use on risky sexual behavior observed here also suggests that substance use content might be most effective if tailored to the unique contextual considerations of each substance (i.e., when, where, and with whom each substance is typically used). Latent class techniques could also be applied when evaluating intervention effectiveness, whereby latent subgroups could be generated from the data and then examined as a moderator of program effectiveness.

Study findings are limited by the cross-sectional nature of the data and the inability to make causal statements regarding the relationship of substance use to risky sexual behavior. Not all constructs included in these analyses were measured longitudinally in this study precluding longitudinal assessment of these patterns; it will be important for future research to examine the stability of the class structures over time. There are strong assumptions about normality that are made for these types of models that may have implications for class enumeration and interpretation of regression relationships [42, 43, 79]. Sexual risk outcomes and substance use measures are frequently non-normally distributed; however, with the exception of other drug use, this was not true in our dataset, underscoring the level of risk of

justice-involved adolescents relative to their mainstream peers. There are several ways to examine the relationship of substance use to risky sexual behavior, and this study focused on identifying subgroups based on the global correlation among constructs and did not consider other possible configurations (e.g., event level relationships). Given that regression mixture modeling is a data driven technique, replication of study findings is critical, although it is encouraging that the pattern of results observed here paralleled those of Schmiege et al. [41]. Data were self-reported and it is unknown whether this might have led to over-reporting or under-reporting of risk behavior [80]. However, adolescent self-report has been shown to be fairly accurate [49, 81] and ACASI administration of measures was used to improve accuracy [57]. Several constructs were assessed with single-item measures, which is a limitation even though these measures have been previously used in numerous studies with high risk adolescents.

Conclusions

The potential impact of substance use on risky sexual behavior is complex and by no means consistent, but a better understanding of this relationship is useful from an HIV prevention standpoint. Regression mixture modeling was used to take a person centered approach in characterizing this relationship, whereby individuals were classified into subgroups based on the regression of risky sexual behavior on marijuana use, alcohol use, and other substance use. The fact that three distinct subgroups emerged from the data provides one potential explanation for the lack of consistent findings regarding the relationship between substance use and risky sexual behavior. Further characterization of these subgroups using a variety of additional individual difference and risk variables gives insights into potential constellations of risk behaviors among at-risk adolescents, suggests avenues of future research in this area (i.e., the influence of sexual experience, the nature of the sexual relationship, etc.) and provides direction for improved HIV preventive intervention development and evaluation.

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