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Regression Mixture Models of Alcohol Use and Risky Sexual Behavior Among Criminally-Involved Adolescents

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Abstract Adolescents involved with the criminal justice system engage in high levels of both risky sexual behavior and alcohol use. Yet a strong relationship between the two constructs has not been consistently observed, possibly due to heterogeneity in the data. Regression mixture models were estimated in the current study to address such potential heterogeneity. Criminally-involved adolescents (n=409) were clustered into latent classes based on patterns of the regression of two measures of risky sexual behavior, condom use and frequency of intercourse, on alcohol use. A three-class solution emerged where alcohol use did not significantly predict either risky sex outcome for approximately 25% of the sample; alcohol use negatively predicted condom use and positively predicted frequency of intercourse for approximately 38% of participants; and alcohol use negatively predicted condom use but not frequency of intercourse for the remaining participants. These classes were then distinguished on the basis of five covariates previously found to influence either alcohol use, risky sexual behavior, or the relationship between the two: self-esteem, gender, participant age, relationship status, and impulsivity/sensation-seeking. High self-esteem, being female, being older, and being in a relationship predicted membership in the class with no observed relationship of alcohol use to risky sex, relative to the other classes. Implications of the present findings are discussed in terms of exploring different risky sex and alcohol use patterns within criminally involved adolescents, as well as understanding the effectiveness of interventions for subgroups of individuals.

Keywords Alcohol use · Risky sexual behavior · Condom use · Criminally-involved adolescents · HIV/AIDS · Regression mixture models

Adolescents are at high risk for sexually transmitted diseases (STDs) including the human immunodeficiency virus (HIV) (CDC 2005; Whaley 1999). Higher rates of STDs have been observed among adolescents involved with the criminal justice system in comparison to the general adolescent population (Morris et al. 1995), likely because such adolescents are younger at first intercourse, have a greater number of sexual partners, and report lower rates of condom use (cf. Barthlow et al. 1995; Romero et al. 2007; Teplin et al. 2003). Alcohol use is commonly cited as a reason for lack of condom use among adolescents (Brook et al. 1994; Lowry et al. 1994; Morris et al. 1998), and alcohol use in the context of sexual encounters appears to be increasing among adolescents (CDC 2006). A full understanding of the relationship of alcohol use to sexual risk-taking behavior among criminally-involved adolescents is critical for promoting safer sexual behavior in this at-risk population.

It may seem intuitive that greater alcohol use would be associated with risky sex, yet reviews of studies examining

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this relationship have generally yielded inconsistent findings (Cooper 2002; Halpern-Felsher et al. 1996; Leigh 2002; Leigh and Stall 1993; Weinhardt and Carey 2000), and this tends to be the case even when a variety of methodologies have been used (e.g., global correlations, event-level relationships). Positive associations between alcohol use and risky sexual behavior have certainly been observed, although non-significant associations occur just as, if not more, often. For example, among adolescents, neither a diary method/event-level study (Bailey et al. 2006) nor a global correlation-level study (Flisher and Chalton 2001) found evidence for associations between alcohol use and condom use. Furthermore, in a review by Cooper (2002), only 6 of 29 event-level analyses demonstrated the expected relationship between alcohol use and risky sexual behavior. There has been some evidence in the small number of studies conducted specifically among criminally-involved adolescents that alcohol use relates to several HIV risk behaviors, including inconsistent condom use and multiple sexual partners (Bryan et al. 2007; Castrucci and Martin 2002; Otto-Salaj et al. 2002); however, these effects might not occur consistently for all individuals (see Bryan et al. 2007).

A broader developmental account might assume that alcohol use and risky sexual behavior ought to be strongly correlated for all adolescents, because both are determined by the confluence of biological, social, and contextual factors related to an underlying "proneness for deviance" (e.g., Jessor et al. 1998). Further, there are rationales for why the association of some risk behaviors may be stronger for younger adolescents than for older adolescents and adults (e.g., Guilamo-Ramos et al. 2005). Several narrower theoretical frameworks, such as alcohol myopia theory (Steele and Josephs 1990) and expectancy theory (Cooper 2006; Hull and Bond 1986), have been proposed to explain why the association of alcohol with risky sexual behavior may actually be causal, rather than simply two behavioral manifestations of deviance. We certainly acknowledge that there a variety of perspectives on why alcohol use and risky sex co-occur for adolescents. However, rather than focusing on *why* these effects may occur, an alternative, yet related, question is to explore *for whom* they are occurring. The inconsistent results from past studies suggest some level of heterogeneity in the data such that some individuals may demonstrate the expected positive association between alcohol use and risky sexual behavior whereas others may not. Given the myriad of developmental, situational and individual-level explanations underlying the association of alcohol use to risky sexual behavior, one approach to understanding this relationship may thus be to identify subgroups for which there is a positive association between the two constructs, rather than to expect a strong overall relationship across all individuals (Cooper 2006). The present study is an attempt to capture individual-level heterogeneity in the alcohol use/risky sex relationship by identifying and characterizing subgroups within the broader population of interest that differ in their level of association between these two variables.

Past research has often relied on standard regression or correlational analyses to explore the relationship between alcohol use and risky sexual behavior (cf. Cooper 2006), where moderators can be included as a potential means to test for differing sub-groups (e.g., Bryan et al. 2007). However, given the number of different theoretical accounts and the broad range of findings in the literature, a more exploratory approach may be beneficial. Regression mixture (RM) modeling represents one such alternative, providing a means to detect latent subgroups of individuals demonstrating differing relationships between alcohol and risky sexual behavior with limited *a priori* assumptions regarding what may exist in the data. Standard regression analysis assumes a homogenous population, characterizing the relationship between dependent and independent variables using a single regression function (although *observed* group membership, such as gender, may certainly be taken into account as a moderating or control variable). In contrast, RM analysis tests for multiple regression functions related to *unobserved* heterogeneity within the population. In this approach, participants are clustered into latent classes based on similarity in the degree of relationship between the variables of interest, as determined by both theoretical and empirical criteria (Ding 2006; McLachlan and Peel 2000). Covariates that are likely to predict class membership may also be included to better characterize the resulting latent classes.

For the current study, latent classes were defined based on the relationship of alcohol use to two indicators of risky sexual behavior, lifetime condom use and frequency of intercourse. Several demographic and personality variables were included as potential covariates based on prior literature demonstrating their role in clarifying the link between risky sexual behavior and alcohol use. Gender was included because some studies have found a positive relationship between alcohol and risky sex for females only (e.g., Bryan et al. 2007; Huba et al. 2003; Rees et al. 2001), whereas others have found this relationship only among males (e.g., Cooper and Orcutt 1997). Age was included as it provides a general means for examining the developmental context in which risky sex and alcohol use occurs, as the relationship between these risk behaviors may differ over time due to factors such as shifting peer group norms (e.g., Guilamo-Ramos et al. 2005). Specifically, previous research has found that the relationship between substance

use and risky sexual behavior is stronger for younger adolescents than older adolescents (Cooper 2002; Kingree and Phan 2001). We assessed current relationship status because the association between risky sex and alcohol use may be more likely for casual sex partners (Fortenberry et al. 1997; Gold et al. 1992; LaBrie et al. 2005; Leigh 2002). Personality factors such as impulsivity/sensation-seeking and self-esteem may also play a role in characterizing the alcohol use/risky sex relationship and thus were included as covariates. Impulsivity/sensation-seeking has previously been shown to account for the apparent association between risky sexual behavior and alcohol use; i.e., once impulsivity is accounted for the relationship of alcohol use to risky sex is reduced (Cooper et al. 2003; Justus et al. 2000; Kalichman et al. 1996, 2003; Kalichman and Cain 2004). A number of studies have suggested that self-esteem may relate to risky sex (e.g., Ethier et al. 2006; Holmbeck et al. 1994) and substance use (e.g., Unger et al. 1997); however, because findings have been somewhat inconsistent across studies, the inclusion of this factor as a covariate was considered to be of a more exploratory nature.

To summarize, a substantial amount of research has sought to determine the relationship of alcohol use to risky sexual behavior. However, the majority of research has been conducted in non-criminal populations, which may not be particularly applicable to criminally-involved adolescents for whom such risky behaviors may be both relatively more normative and especially likely. By their involvement in the criminal justice system, our participants have likely exceeded the typical threshold for proneness for deviance that results in the co-occurrence of multiple risk behaviors; we are thus left with less variance in risk behavior, resulting in potentially less covariance among constructs that can be explained by underlying deviance proneness. The present study aimed to determine the existence of, as well as characterize, potential heterogeneity in the relationship between alcohol use and risky sexual behavior by: (1) classifying a very risky sample of incarcerated adolescents into subgroups based on their observed relationship between these two constructs, and (2) examining the differences between the observed subgroups on demographic and personality variables. Based on the available data from past studies with criminally-involved and more normative populations, we expected to observe groups who demonstrated the positive relationship between alcohol and risky sex. However, given high levels of risk behavior among criminally-involved adolescents, as well as prior inconsistencies in the literature, the RM modeling approach allowed us to explore the presence of and characterize other patterns (e.g., non-significant associations) between the constructs under study.

Method

Participants

Participants were 484 adolescents (83% male, 17% female) recruited from three detention facilities located in Denver, Colorado. Gender proportions were consistent with the distribution of males and females in Denver Youth Corrections facilities as well as the broader population of criminally-involved adolescents. The present sample was taken from a larger, ongoing randomized controlled trial examining the efficacy of an alcohol and sexual risk reduction intervention. However, only pre-intervention assessment data was included to ensure that results were not influenced by intervention conditions. Analyses were conducted using baseline data collected prior to administration of the intervention, and all participants were measured under identical conditions, regardless of eventual assignment to intervention condition. Most participants (92.65%) reported having sex at least once, and nearly 91% reported having consumed alcohol in the past year. Participants who did not report engaging in both behaviors were not included in the analyses. Analyses were thus limited to the 409 participants who were sexually active and had experience with alcohol in the past year.[1]

The sample was ethnically diverse, consisting of approximately 38.5% Caucasian, 28.4% Hispanic, 11.5% African American, 3.4% Asian or Pacific Islander, 4.2% Native American, 2.2% other ethnicity, and 11.8% multiracial participants. Participant age ranged from 14 to 17 (M= 15.82; SD=1.04), and 68.2% of the participants reported still being in school. When not in detention, approximately 28.8% reported living with their mother and father, 42.7% with their mother only, 9.4% with their father only, 8.1%

[1] These exclusionary criteria are consistent with other research in this domain (e.g., Bryan et al. 2007; Kingree and Phan 2002; Tubman and Langer 1995) and are based on the match to the research question of the present study. Specifically, the study is exploring whether there is unidentified heterogeneity in the data with different subgroups of individuals who both drink alcohol and have sexual intercourse who do or do not show the positive relationship between alcohol use and risky sex. We acknowledge that this approach necessarily overestimates the proportion of individuals for whom alcohol use predicts risky sexual behavior, as individuals lacking experience with both alcohol and sexual behavior would not be expected to demonstrate a relationship between the two. Including these double-abstainers certainly would have increased the number who emerged in the "no relationship" class; however, the later characterization of this class based on the covariates would not be as meaningful because it would be impossible to distinguish those who did not exhibit a relationship between the two due to zero scores on both constructs from those who truly did not demonstrate a relationship between the two constructs based on the theoretical rationale suggested by the covariates that emerged as significant.

with a guardian, and 10.7% other (e.g., by themselves, with their grandmother, in a foster home). The mean age of first intercourse was 12.99 (SD=1.69) and the median number of sexual partners was 6 (with a mode of 4).

Procedure

All study procedures were approved by an institutional review board at the University of Colorado at Boulder, and a federal certificate of confidentiality was also obtained for this research. Participants were given the opportunity to participate by the detention center intake staff. Adolescent assent and parent/guardian consent were required prior to participation, and participants completed the questionnaire in a closed conference room at their detention facility. All survey administration procedures were supervised by research personnel, not by detention center personnel. Participants completed the questionnaire in small, same-sex groups ranging in size from 1 to 10. Participants completed all measures on a laptop computer using ACASI (audio-computer-assisted-self-interview) procedures (Williams et al. 2000). ACASI was utilized in order to prevent confusion due to complicated skip patterns in the survey, and to allow each question to be read aloud to participants over the computer, thus assisting those who have difficulty reading. Participants were given the option to opt out of any question they did not feel comfortable answering and were compensated $25 for this initial session.

Measures

Risky Sexual Behavior Lifetime condom use was measured with the question "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, 7.6% reported never using condoms, 66.8% reported inconsistent use and 25.6% reported always using condoms (M=3.55, SD=1.21). 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=3.32, SD=1.61).

Alcohol Problems/Dependence Alcohol use, related problems and dependence were measured using the Alcohol Use Disorders Identification Test (AUDIT; Saunders et al. 1993). The AUDIT is a ten-item scale that measures both frequency of alcohol consumption and problems related to alcohol use. Responses to all items range on a scale from 0 to 4. Questions include "How often do you have 6 or more drinks on one occasion?" and "How often during the last year have you had a feeling of guilt or remorse after drinking?" The AUDIT score was calculated as the sum of the ten items with higher scores reflecting higher consumption and alcohol dependence. Scores potentially range from 0–40 with an average score of 11.37 (SD=7.47, α=0.85) in the current sample. Using a cut-off score of 8 or above on the AUDIT, which has been suggested in past research (Conigrave et al. 1995), 64.79% of the participants were in the range of hazardous or harmful drinking.

Covariate Measures Current relationship status was assessed with a dichotomous yes/no question "Are you in a relationship right now?" (yes=64.06%). *Impulsivity/sensation-seeking* was measured with Zuckerman's (1994) Impulsivity and Sensation Seeking scale. Participants rated 19 statements in a true/false format. Statements include "I like doing things just for the thrill of it" and "I prefer friends who are exciting and unpredictable." Scores were calculated as the sum of the responses for the 19 statements (M=11.43; SD=3.94; α=0.77) such that higher scores indicate higher impulsivity/sensation-seeking. The self-esteem measure (Rosenberg 1965) was calculated as the mean of eight statements (e.g., "In general, I am satisfied with myself"), each measured on a four-point scale ranging from 1=*disagree a lot* to 4=*agree a lot* (M=3.23, SD=0.51, α=0.79). Two items from the original ten-item measure were excluded ("I certainly feel useless at times" and "I feel I do not have much to be proud of") as these items have not loaded significantly on a self-esteem latent factor in our prior work with this population. This 8-item version has demonstrated high reliability in our previous work with criminally involved adolescents (e.g., Bryan et al. 2004, 2005).

Results

Analysis Plan

RM models were estimated in Mplus Version 5.1 (Muthén and Muthén 1998–2008) to examine whether distinct classes could best represent all or some of the regression parameters estimating the effect of AUDIT scores on condom use behavior and frequency of intercourse (Vermunt and Magidson 2002). In this approach, classes of individuals are expected to be similar to one another in regard to relationships among the variables of interest, but different from individuals in other classes. The usefulness of including covariates in mixture models has been widely recognized as a means to more accurately describe and predict latent class membership (see Muthén 2002; Vermunt and Magidson 2002). Covariates were examined directly within the RM models, such that the prediction of most likely latent class

membership was obtained in Mplus by the multinomial regression of latent class membership on each of the covariates.

RM analyses may be considered exploratory in the sense that one determines the number of classes that exist in the data by estimating multiple mixture models, each with an increasing number of classes. 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 the theoretical meaningfulness and conceptual interpretability of the class structure (Muthén 2002; Muthén and Muthén 2000). The statistical measures of fit were the Bayesian Information Criterion Index (BIC), the Lo–Mendell–Rubin likelihood ratio test (LMR-LRT; Lo et al. 2001), and a bootstrap likelihood ratio test (BLRT; Nylund et al. 2007). Lower 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.

Estimation of the Regression Mixture Models

Table 1 depicts the BIC, LMR-LRT, and BLRT values for the two, three, and four class solutions. The BIC value was lowest for the three class solution, indicating support for a three class model. Furthermore, the LMR-LRT was highly significant ($p<0.001$) for the three class model, but was only on the cusp of significance ($p=0.05$) for the four class model. Finally, even though the BLRT value could be considered significant for the four class solution, this value might not be stable because of trouble replicating the best log likelihood value, even with an extremely large number (400) of bootstrap samples. Based on the lowest BIC, the highly significant LMR-LRT, and the stability and significance of the BLRT, the three class solution was retained as the final model.

There were approximately 25%, 37%, and 38% of participants distributed across the three classes, respectively, as estimated from the model posterior probabilities. There was good distinction among the three classes in this final model, based on an overall entropy value of .86 and that approximately 94%, 97%, and 92% of participants were estimated to have been correctly classified into the three respective classes. As shown from the regression slopes in Table 1, AUDIT scores did not predict either condom use or frequency of intercourse for those in Class 1. Class 1 can thus be characterized as the "no relationship" class of individuals where alcohol use does not relate to risky sexual behavior. In contrast, AUDIT negatively predicted condom use and positively predicted frequency of intercourse for those in Class 2. Class 2 can thus be characterized as the "alcohol relationship to risky sex" class where alcohol use plays a role in both greater frequency of intercourse and lower condom use. In Class 3, AUDIT scores negatively predicted condom use, but did not significantly relate to frequency of intercourse, and is referred to as the "alcohol relationship to condom use" class. As shown in Table 2, AUDIT scores and frequency of intercourse were highest and condom use lowest in the "no relationship" class. In contrast, AUDIT scores and frequency of intercourse were lowest and condom use highest in the "alcohol relationship to risky sex" class. To examine whether the differences in the regression coefficients across latent classes were significant, we estimated a model where the regression coefficients were constrained to equality across classes and compared it to a model where the

Table 1 BIC, Lo–Mendell–Rubin (LRM) LRT, and BLRT values and regression slopes for two-, three-, and four-class solutions

Class	BIC	LRM LRT	BLRT	Class 1 regression slopes	Class 2 regression slopes	Class 3 regression slopes	Class 4 regression slopes
2 class solution	2,806	116.48, $p<0.001$	118.24, $p<0.001$	β_{CU}: −0.108 (0.072), n.s. β_{FOI}: 0.188 (0.087), $p<0.05$	β_{CU}: −0.118 (0.063), $p<0.01$ β_{FOI}: 0.277 (0.084), $p<0.01$		
3 class solution	2,799	71.64, $p<0.001$	72.73, $p<0.001$	β_{CU}: −0.059 (0.097), n.s. β_{FOI}: −0.038 (0.104), n.s.	β_{CU}: −0.166 (0.079), $p<0.05$ β_{FOI}: 0.245 (0.147), $p=0.05$	β_{CU}: −0.146 (0.075), $p=0.05$ β_{FOI}: 0.015 (0.123), n.s.	
4 class solution	2,812	52.40, $p=0.05$	53.19, $P<0.001$[a]	β_{CU}: −0.062 (0.113), n.s. β_{FOI}: −0.032 (0.105), n.s.	β_{CU}: −0.128 (0.065), $p<0.05$ β_{FOI}: 0.043 (0.011), $p<0.001$	β_{CU}: −0.191 (0.09), $p<0.05$ β_{FOI}: 0.075 (0.123), n.s.	β_{CU}: 0.012 (0.213), n.s. β_{FOI}: −0.339 (0.129), $p<0.01$

β_{CU} the slope for the regression of condom use on AUDIT scores, β_{FOI} the slope for the regression of frequency of intercourse on AUDIT scores

[a] The best likelihood value not replicated in majority of bootstrap draws for the 4-class solution and this value may not be interpretable

regression coefficients were unconstrained across classes. Models were compared using two times the change in the log likelihood (LL) value. There was significantly better fit in the model that allowed the regression coefficients to differ across classes (Δ-2LL=190.96, $p<0.001$), supporting the conclusions drawn from the tests of overall model fit that more than one class is necessary to represent the regression parameters.

Effects of Covariates on Latent Class Membership

The next step was to further explore distinctions among all three classes by examining the effects of the five covariates as simultaneous predictors of class membership. Table 2 depicts the *estimated* mean/percentage scores of each of the covariates within each class based on likely class membership and demonstrates the significance of contrasts testing the prediction of class membership from each of the covariates using multinomial logistic regression.

As shown by the letters following each mean (in which common letters denote no significant difference between classes), the "no relationship" and "alcohol relationship to risky sex" classes were distinguishable in terms of current relationship status, participant age, and self-esteem. Specifically, those currently in a relationship ($B=2.26$, $p<0.001$; odds ratio=9.58), older participants ($B=0.34$, $p=0.06$; odds ratio=1.40), and those with higher self-esteem ($B=1.16$, $p<0.001$; odds ratio=3.19) were more likely to be in the "no relationship" class relative to the "alcohol relationship to risky sex" class. Women ($B=1.46$, $p<0.01$; odds ratio=4.31), older participants ($B=0.37$, $p<0.05$; odds ratio=1.45), and those with higher self-esteem ($B=0.82$, $p<0.05$; odds ratio=2.27) were more likely to be in the "no relationship" class versus the "alcohol relationship to condom use" class. Finally, women ($B=1.34$, $p<0.01$; odds ratio=3.28) and those *not* currently in a relationship ($B=1.65$, $p<0.001$; odds ratio=5.21) were more likely to be in the "alcohol relationship to risky sex" class than the "alcohol relationship to condom use" class. Taken together, these covariate analyses demonstrate that the three classes that emerged can be distinguished in terms of several personality and demographic variables that help to explain the patterns of alcohol dependence/problems and risky sexual behavior among participants.

Discussion

The purpose of this study was to examine patterns of risky sexual behavior and alcohol use among high-risk, criminally-involved adolescents. RM models identified classes that demonstrated distinct relationships of alcohol use to risky sexual behavior. The expected positive relationship between alcohol use and condom use emerged in both the "alcohol relationship to risky sex" and "alcohol relationship to condom use" groups. However, a full 25% of the sample was classified into the "no relationship" class that did not match the expected association between the alcohol use and risky sex constructs. The emergence of this class supports the hypothesis of heterogeneity in the data and, although these models would need to be replicated in non-criminal populations, these results suggest a potential explanation for the inconsistent findings from past studies (cf. Cooper 2002; Leigh and Stall 1993). If there are adolescents whose risky sex is unassociated with high levels of alcohol use, this may reduce the possibility of observing the expected overall positive relationship between these constructs.

The inclusion of covariates further identified a number of variables that predicted membership in each cluster. Being in a current relationship predicted membership in the "no relationship" class relative to the "alcohol relationship

Table 2 Estimated risky sexual behavior, AUDIT, and covariate means as a function of class membership and significance of prediction of class membership from the covariates

Covariate	Class 1 "No relationship"	Class 2 "Alcohol relationship to risky sex"	Class 3 "Alcohol relationship to condom use"
Lifetime condom use	3.23 (1.13) a	3.82 (1.28) b	3.50 (1.13) c
Frequency of intercourse	5.53 (.50) a	1.61 (.54) b	3.57 (.51) c
AUDIT	12.82 (8.25) a	10.48 (6.95) b	11.05 (7.28) b
% female	25% a	22% a	9% b
Participant age	16.18 (.98) a	15.64 (1.02) b	15.72 (1.05) b
% in relationship	83% a	41% b	75% a
Impulsivity/sensation seeking	11.37 (4.07) a	11.27 (3.83) a	11.63 (3.98) a
Self-esteem	3.37 (.43) a	3.14 (.49) b	3.21 (.54) b

Common letters (e.g., ab) indicate no significant differences among classes

to risky sex" class, and this is consistent with studies in non-criminal populations showing a stronger association of alcohol consumption with low condom use among casual partners than serious partners (Fortenberry et al. 1997; Gold et al. 1992; LaBrie et al. 2005; Leigh 2002), as well as with evidence that those in long-term relationships are often less likely to use condoms (e.g., Ku et al. 1993; Macaluso et al. 2000; Reisen and Poppen 1995). Interestingly, the "no relationship" class appears to be the riskiest at first glance, although both the higher frequency of intercourse and lower condom use observed in this class might be explained by the notion that this class also likely captures those adolescents who have consistent sexual partners. The higher rate of alcohol use in this class suggests that alcohol may be part of the social culture for these adolescents, but, due to their relationship status, alcohol might not be used as a "social lubricant" to facilitate sexual activity. In addition, participants tended to be older in the "no relationship" group relative to the two other groups, suggesting the possible role of developmental factors in influencing the co-occurrence of alcohol use and risky sex. For example, it may be that adolescents drink and engage in risky sex at younger ages as a more general deviant behavior pattern, but as one grows older and both risky sex and alcohol use become less deviant, these behaviors are less likely to co-occur as a general pattern of norm-violating behavior.

In contrast, both alcohol use and frequency of intercourse were lowest for those in the "alcohol relationship to risky sex" group relative to the other classes suggesting that both behaviors may be characterized as opportunistic for these adolescents. This class may indeed represent those for whom alcohol use leads to risky sex, although causal explanations cannot be directly tested in the present study, and it is just as likely that broader developmental accounts of the relationship of risk behaviors to an underlying proneness for deviance might explain this association. The primary difference between this class and the "alcohol relationship to condom use" class is whether alcohol use predicted frequency of intercourse. This difference might be best understood in terms of the observed gender differences where being male strongly predicted membership in the "alcohol relationship to condom use" class. Alcohol use may not impact frequency of intercourse to the same extent that it impacts condom use among males because males have been shown to have a much greater interest in casual sex as compared to females (Clark and Hatfield 1989) and may thus not need to achieve the same level of disinhibition from alcohol to have an interest in engaging in intercourse. We stress that we cannot test causal hypotheses with these data; however, the distinct pattern of associations between alcohol and condom use in one cluster versus alcohol and sexual intercourse in another cluster does to some degree argue against the perspective that if all risk behaviors are a manifestation of an underlying proneness for deviance they ought to all be related positively.

A broader implication of the regression mixture modeling approach is the potential for these types of analyses to facilitate the tailoring of intervention design and analysis. The latent subgroups of individuals who tend to be similar to one another regarding the pattern of risk behaviors in question could act as moderators for intervention effects. As an example, we are presently evaluating a randomized controlled trial comparing a sexual risk reduction intervention that includes a theoretically-based alcohol risk reduction component relative to a sexual risk reduction only condition and relative to a control condition (Schmiege et al. 2009). Findings support the superiority of the combined sexual and alcohol risk reduction intervention over both other conditions in reducing sexual risk behavior, although the present data suggest that the inclusion of alcohol-related content might not be as influential in reducing sexual risk behavior for those in the "no relationship" subgroup. Adolescents in the "no relationship" subgroup may instead benefit most from intervention content focused on the behaviors and contextual factors that emerged as relevant in the present analyses; for example, negotiation of safer sex behavior within the context of one's romantic relationship. Alternatively, lower self-esteem significantly predicted membership in the "alcohol relationship to risky sex" and "alcohol relationship to condom use" groups, relative to the "no relationship" group. These preliminary findings suggest that interventions might target a broader risk profile, for example, by combining sexual and alcohol risk reduction content with content related to the development of self-esteem. Indeed, incorporation of personality variables is consistent with prior theoretical work in this domain (Bryan et al. 2004; Noar et al. 2006; Robbins and Bryan 2004). We caution, however, that the ideas presented here provide just one direction for intervention design; there are likely other situational and individual difference variables, such as adolescents' motivation for change, which may influence intervention effectiveness.

RM modeling represents only one approach to exploring regression models among subgroups of individuals and is exploratory in the sense that it involves identifying the type and number of classes that are the best fit for a given data set. Future studies should attempt to replicate these classes, perhaps supplementing the analyses with additional observed variables. For example, it would be useful to further examine the "no relationship" group, if it replicates, as a means to better determine additional variables that *do* relate to risky sexual behavior within this subgroup. In addition, the relationship of alcohol use to sexual behavior among those in Classes 2 and 3 could be studied at multiple levels (e.g., global, situational, and episodic) to best understand the link between these two constructs among those who are

most likely to demonstrate the relationship, and to shed light on whether the association is causal or not.

As already mentioned, a limitation of this study is that it does not provide the means to make causal statements regarding the relationship between the variables of interest. The correlational nature of these data is shared by most research in this domain, given the practical and ethical difficulties associated with experimental manipulations of intoxication in non-laboratory settings, particularly with minors. The study is also limited by the self-report nature of the data and the single-item nature of some of our assessments. Another limitation is that the majority of participants were male, making it difficult to provide an in-depth examination of potential gender differences. However, the sample is representative of the population of criminally-involved adolescents from which it was drawn, and the study findings can be generalized to that group.

Examining the relationship of alcohol use and risky sexual behavior within a criminally-involved population does raise important methodological issues. Although the focus on an understudied and at-risk population of adolescents can be considered a strength of this study, our criminally-involved sample may differ significantly from other groups such as college students and less deviant adolescents. It will be important to replicate these analyses with non-criminal populations in order to explore whether there are similar patterns of heterogeneity in the relationship of alcohol use to risky sexual behavior in these groups as well. Furthermore, as the study was conducted with incarcerated adolescents, there is the potential that time incarcerated could have confounded results, such as reductions in alcohol use due to being in detention. Nonetheless, incarceration time is unlikely to have had a significant impact on results as the study purposefully sampled from adolescents who had been recently incarcerated (participants were generally assessed within 2 weeks of incarceration) and measures of alcohol and risky sex variables were framed within the past year or longer. In addition, participants reported fairly high rates of both alcohol and risky sex, suggesting access to both was readily available within the time frames assessed. Future directions for this research could include examining these variables in adolescents on parole to further limit the effects of incarceration on behavioral outcomes.

In summary, the relationship of alcohol use to risky sexual behavior is indeed quite complex. The present study attempted to more effectively characterize individual differences in this relationship by classifying subgroups of individuals based on their relationship of alcohol use to risky sexual behavior and then by linking the observed subgroups to a variety of personality/demographic factors. This study provides one potential explanation for the lack of consistent findings regarding the relationship between alcohol use and risky sex and provides further characterization of subgroups of individuals who do demonstrate the anticipated positive relationship. A more complete understanding of the etiology of risk behaviors generally defined, as well as the specific role of alcohol use in accounting for risky sexual behavior, has broad implications for intervention development and evaluation.

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