UCLA
UCLA Electronic Theses and Dissertations

Title

Motivation for Substance Use, Venue of Sexual Encounter, and Sexual Risk Behavior among Men who Have Sex with Men (MSM) in the Multicenter AIDS Cohort Study (MACS): Factor Analysis, and Global vs. Event-Level Generalized Linear Mixed Model (GLMM) Ass...

Permalink

https://escholarship.org/uc/item/7r52511f

Author

Burrell, Earl Ryan

Publication Date

2014

Peer reviewed|Thesis/dissertation

eScholarship.org Powered by the California Digital Library
University of California

UNIVERSITY OF CALIFORNIA
Los Angeles

Motivation for Substance Use, Venue of Sexual Encounter, and Sexual Risk Behavior among Men who Have Sex with Men (MSM) in the Multicenter AIDS Cohort Study (MACS):

Factor Analysis, and Global vs. Event-Level Generalized Linear Mixed Model (GLMM) Assessment Approach

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Epidemiology by

Earl Ryan Burrell

2014

© Copyright by

Earl Ryan Burrell

2014

ABSTRACT OF THE DISSERTATION

Motivation for Substance Use, Venue of Sexual Encounter, and Sexual Risk Behavior among Men who Have Sex with Men (MSM) in the Multicenter AIDS Cohort Study (MACS):

Factor Analysis, and Global vs. Event-Level Generalized Linear Mixed Model (GLMM) Assessment Approach

by

Earl Ryan Burrell
Doctor of Philosophy in Epidemiology
University of California, Los Angeles, 2014
Professor Roger Detels, Chair

We use factor analysis to explore motivations for substance use before and/or during sexual activity in order to identify underlying structure in response types. The sample included 1º, 2º, and 3º motivation responses of 1,012 seropositive and 1,084 seronegative participants enrolled in the Multicenter AIDS Cohort Study (MACS) seen between 2006 and 2010. We found a single common factor for all alcohol and substance use combinations that combines the social and sexual domains. We also identified a second factor with four distinct loading patterns conditional on the alcohol or substance combination used. While there are strong sexual components for each, the underlying structure is complex, and also includes aspects of the social and personal domains. These underlying motivational structures are important in understanding why men engage in substance use in the context of sex, and may help identify men who participate in high-risk sexual behavior.

We simultaneously modeled between-subject and within-subject variability using Generalized Mixed Linear Models (GLMMs) to explore the role of key “person variables” (HIV serostatus, sexual sensation seeking, and partner type) specific to the venue of sexual encounter in the association between substance use and sexual risk in the Multicenter AIDS Cohort Study

(MACS). GLMMs were fit for each of three venues (Internet, bars, and bathhouses) using data from 1,012 seropositive and 1,084 seronegative participants seen between 2006 and 2010. We were able to show that venue-specific measurements of HIV serostatus, partner type, and sexual sensation seeking (SSS) are important in understanding the relationship between substance use and sexual risk, and may help explain the absence of consistent main effects seen in correlational or experimental studies. These person variables may aid the development of multivariate theoretical models that better fit substance use and sexual risk behavior associational data.

We utilize the multiple measurement approaches available in the Multicenter AIDS Cohort Study (MACS) to build Generalized Linear Mixed Models (GLMMs) describing the association of substance use and sexual risk measured at the global level, and compare results to our previously published work using a venue-specific assessment approach. GLMMs were used to simultaneously model between-subject and within-subject variability in sexual risk behaviors (HIV serostatus, sexual sensation seeking, partner type, and venue of sexual encounter) among 1,012 seropositive and 1,084 seronegative participants seen between 2006 and 2010. All alcohol and drug use combinations were associated with having a higher numbers of unprotected anal intercourse (UAI) partners since last visit, regardless of venue of sexual encounter, when measured at the global level. These results reflect those from a venue-specific analyses of substance use and sexual risk conducted in the same cohort. While the global assessment approach used here does not permits causal interpretation of findings, we argue that establishing causality may not be a necessary condition for identifying the underlying person variables that confound the association between substance use and sexual risk, nor the utility of these variables in designing and implementing more tailored interventions.

The dissertation of Earl Ryan Burrell is approved.

Marjan Javanbakht
Steve Shoptaw
Ron Brookmeyer
Robert J. Kim-Farley
Roger Detels, Committee Chair

University of California, Los Angeles

2014

TABLE OF CONTENTS

LIST OF TABLES AND APPENDICES

Motivation for substance use while engaging in sexual behavior: Factor analysis among men who have sex with men (MSM) in the Multicenter AIDS Cohort Study (MACS)

Substance use, venue of sexual encounter, and sexual risk behavior among men who have sex with men (MSM) in the Multicenter AIDS Cohort Study (MACS): A Generalized Linear Mixed Model (GLMM) approach

Substance use and sexual risk behavior among men who have sex with men (MSM) in the Multicenter AIDS Cohort Study (MACS): Comparison of global versus venue-specific assessment approaches

VITA/BIOGRAPHICAL SKETCH

Earl Ryan Burrell earned his Bachelor of Arts in molecular and cell biology with an emphasis in biochemistry and molecular biology, and his minor in lesbian, gay, bisexual, and transgender (LGBT) studies from the University of California, Berkeley. He completed his post-baccalaureate training in molecular inflammation research at the National Institutes of Health where he studied the signaling cascades involved in the activation of immune response cells. Earl went on to obtain his Masters in Public Health in infectious disease epidemiology at Columbia University, Mailman School of Public Health. He completed his thesis research with the New York City Blood Center assessing patters of HIV-serostatus disclosure and serosorting among men who have sex with men (MSM) in New York City.

After working with MSM in the California Bay Area, MSM and traditional *hijras* in the slums of Mumbai, India, LGBT transient youth in New York City, and male inmates at Sing Sing New York State prison, Earl developed a strong interest in public health infectious disease research, particularly HIV/AIDS prevention among sexual minorities in developing countries. After his master's program, Earl worked for Desmond Tutu HIV Foundation in Cape Town, South Africa as Programmes Manager of the men's health research arm where conducted several HIV prevention research projects among high-risk urban and township MSM.

Earl then came to UCLA's Field School of Public Health where he was a PhD candidate in the department of Epidemiology under Dr. Roger Detels. While at UCLA, Earl worked with MACS data to evaluate the association between substance use and sexual risk behaviors among men who have sex with men (MSM) as part of doctoral dissertation. He assessed the mediating effects of specific environmental and psychosocial modifiers measured at the event-level using longitudinal within-subject analysis, and compare event-level analysis to results obtained from general assessment measures to better understand the strengths and limitations of each.

Motivation for substance use while engaging in sexual behavior: Factor analysis among men who have sex with men (MSM) in the Multicenter AIDS Cohort Study (MACS)

Earl Ryan Burrell, MPH; Michael W. Plankey, PhD; Marjan Javanbakht, MPH, PhD; Steve Shoptaw, PhD; Ron Brookmeyer, MS, PhD; Robert J. Kim-Farley, MPH, MD; Roger Detels, MS, MD

Abstract

We use factor analysis to explore motivations for substance use before and/or during sexual activity in order to identify underlying structure in response types. The sample included 1º, 2º, and 3º motivation responses of 1,012 seropositive and 1,084 seronegative participants enrolled in the Multicenter AIDS Cohort Study (MACS) seen between 2006 and 2010. We found a single common factor for all alcohol and substance use combinations that combines the social and sexual domains. We also identified a second factor with four distinct loading patterns conditional on the alcohol or substance combination used. While there are strong sexual components for each, the underlying structure is complex, and also includes aspects of the social and personal domains. These underlying motivational structures are important in understanding why men engage in substance use in the context of sex, and may help identify men who participate in high-risk sexual behavior.

Background

The HIV epidemic continues to disproportionality affect gay and bisexual men (hereafter “men who have sex with men” or MSM) [1-3]. One strategy to reduce the transmission of HIV among MSM is the identification and prevention of the potential modifiable behaviors that may contribute to sexual risk taking behaviors. Alcohol and drug use is known to be associated with sexual risk taking [4]. Alcohol use is associated with unprotected anal intercourse (UAI) and higher numbers of sexual partners [5,6]. In addition, the use of stimulants, such as methamphetamine, has been associated with higher rates of UAI, multiple sexual partners, and casual partners among MSM [7-13]. Stimulant use has been shown to be behaviorally disinhibiting, especially among MSM at high risk of HIV seroconversion [14-23]. Although originally developed as a medical aid to combat erectile dysfunction (ED), recreational use of erectile dysfunction drugs (EDDs) such as sildenafil (Viagra) are not uncommon [24,25]. Erectile dysfunction and the use of drugs to treat ED are associated with increased sexual risk behaviors [26,27], including illicit drug use [28-30] and decreased condom use among MSM [31-34]. And, like methamphetamine use, the recreational use of EDDs is strongly associated with high-risk sexual behavior and HIV transmission [35-37]. Amyl nitrite inhalants (aka “Poppers”) are peripheral vasodilators used by MSM to facilitate and enhance sexual intercourse [38]. Studies have associated use of amyl nitrites by MSM with prevalent HIV infection, high-risk sexual behaviors, and increased risk of HIV seroconversion [38-43]. The combined use of stimulants with poppers or EDDs has been shown to be especially behaviorally disinhibiting among MSM, enhancing sexual activity by heightening intensity, prolonging sexual activity without orgasm, and decreasing inhibitions [14-20,23]. Evidence suggest that this drug combination in particular has significant sexual meanings for MSM [44], and are hence termed “sex drugs”. It has also been shown that the use of “sex drugs” increase the risk for HIV seroconversion in the Multi-center AIDS Cohort Study (MACS) [45].

Various etiological theories of substance use have been developed to understand the psychosocial factors that influence MSM's decision to use alcohol and drugs in the context of sex, such as the influence of the user’s psychological state and surrounding social norms on substance use behavior [46,47]. It has been hypothesized that MSM use alcohol and drugs to facilitate the meeting of sexual partners, to escape stress and relax [48], and to enhance the sexual experience [49,50] by increasing and prolonging states of sexual arousal and the capacity for multiple partners. [12] Díaz et al. [51] report in a recent study of Latino MSM that motivations for stimulant use clustered by five main factors, including energy, sexual enhancement, social connection, coping with stressors, and focused work productivity. Methamphetamine users reported motivations more frequently related to sexual enhancement, whereas cocaine users reported motivations more often related to social connections [51].

Because of the social and health consequences of substance use among MSM, it is important to understand individual’s specific motivations for alcohol and substance use in the context of sex, specifically “sex drug” combinations which pose particular risk for HIV transmission in this population. This knowledge may prove useful in the identification of individuals prone to engage

in both substance use and sexual behavior, and help tailor targeted interventions. The MACS includes questions designed to ascertain motivations to engage in alcohol and drug use behavior before and/or during sexual activity. We use factor analysis to describe the underlying structure of the 1º, 2º, and 3º motivation responses.

Methodology

Population and Study Design

We use self-report data collected from the MACS to explore motivations for alcohol and substance use before and/or during sex. The MACS is an ongoing prospective study of the natural and treated histories of HIV infection among MSM in the United States. The study design and history of recruitment have been described in detail previously [52-54]. Briefly, a total of 6,972 MSM were recruited in three separate waves between 1984 and 2003 at four centers located in Baltimore-Washington, DC; Chicago; Los Angeles; and Pittsburgh. In all four of the geographic areas, collaborating institutions launched aggressive campaigns to enroll volunteers with specific characteristics (age and clinical HIV status) in the metropolitan areas they served. Recruitment was accomplished through combinations of media publicity (e.g., notices placed in gay bars, newspapers, community centers, and the gay press), promotional events or offerings (e.g., raffles and free medical screening), personal connections of both community leaders and men already enrolled in the study, and previous clinical contacts with largely gay medical practices or through research of other conditions in gay men [52]. Men who reported sex with other men in the 12 months previous to study screening, and without a diagnosis of AIDS or cancer were asked to voluntarily enroll, and one center initially restricted enrollment to persons aged 18-50 years. All participants return every 6 months for detailed interviews, physical examinations, and collection of blood for laboratory testing and storage in a central repository. Additionally, participants answer questions about medical conditions, medical treatments, sexual behavior, alcohol consumption, and drug use (medicinal and recreational) assessed using audio computer-assisted self-interviewing (ACASI), a methodology shown to yield more accurate assessments of 'sensitive behaviors', such as substance use and sexual activity, than interviewer-administered questionnaires [55]. The sample analyzed here includes 1,012 seropositive and 1,084 seronegative participants seen and alive between 2006 and 2010 (visits 46-54) [56]. All MACS questionnaires are available at http://www.statepi.jhsph.edu/macs/forms.html.

Variables of Interest

The data set used here contains variables collected during each semi-annual MACS visits 46 through 54 (2006-2010), including basic demographics self-reported at enrollment (age, race/ethnicity, highest level of education attained, and study center), HIV serostatus, and self-reported behavior questionnaire data [56]. The behavior questionnaire included data on alcohol and drug use (EEDs, poppers, cocaine, crack, methamphetamine, and ecstasy), sexual risk behaviors (protected vs. unprotected anal sex), partner type (main vs. casual), and motivation

for substance use. Behavior questionnaire data were collected for each participant referencing all sex partners since their last visit.

Age for these analyses was calculated using self-reported date of birth at study enrollment and was treated as both a continuous and categorical covariate divided into five strata (18-25, 26-35, 36-45, 46-55, 56+). Race/ethnicity was self-reported at the first MACS study visit (initial baseline) and was categorized as White non-Hispanic (reference group), White Hispanic, Black non-Hispanic, Black Hispanic, and “other” (predominantly mixed race). Self-reported highest level of education completed at baseline was categorized as grade 12 or less, college, and post-college graduate (reference group). HIV serostatus was determined by ELISAs with confirmatory Western blot tests performed on all participants initially at baseline and every six months thereafter if initially seronegative. The date of seroconversion was defined as the midpoint between the dates of the last HIV seronegative visit and the first HIV seropositive visit. Partners were categorized as either main or casual partners. Main partners are defined as partners with whom participants have a longstanding relationship with, live with, or are partnered with. Causal partners are those whom participants consider to be a one-time partner, or someone with whom they have not developed a longstanding, close relationship.

MACS participants were asked to choose their top three (1º, 2º, and 3º) motivations for engaging in substance use that occurred before and/or during each sexual encounter from a list of 18 reasons:

- To have better sex?
- To forget problems?
- To relax?
- To be more sociable?
- To increase your energy level?
- To focus and get things done?
- To feel better emotionally?
- To feel better physically?
- To have more sex?
- To work better?
- To take a break from a difficult situation?
- To feel more connected to others?
- To fit in better with other gay men?
- To have a spiritual experience?
- To perform sexual acts that I don't normally do?
- I just like the feeling of getting high
- Other reason not listed above
- NO second/third reason

The answer choices attempted to capture some of the contextual/situational factors that can affect an individual's choice to use alcohol or drugs before and/or during sex, including sexual (e.g., To have better sex, To perform sexual acts that I don't normally do), personal (e.g., To work better, To relax), and social (e.g., To fit in better with other gay men, To feel more connected to others).

Alcohol use was classified using both reported average number of drinks the participant drank per day and reported frequency of drinking since the last visit. Alcohol use was defined as binge drinking (having 5 or more drinks per occasion at least monthly), or heavy drinking (having 3-4 drinks at least weekly since last visit). Participants who reported low to moderate or no drinking comprise the reference group of alcohol use in this analysis. Recreational drug use of interest in this analysis were those commonly used by MSM during sex, specifically stimulants (defined here as methamphetamine and/or crack and/or cocaine), poppers, and EDDs. We defined seven different combinations of drug use reported at the current or previous visit: (1) EDD alone, (2) poppers alone, (3) EDD + poppers, (4) stimulants alone, (5) stimulants + EDD, (6) stimulants + poppers, and (7) stimulants + EDD + poppers. The use of these drug combinations was defined as "yes" if a participant reported using them at any time between the current and previous visit. Variable categorization was adopted from previous research in the MACS in order to facilitate comparability of results [45].

The number of sexual partners since the prior study visit was categorized as none (reference), one, 2–4, and 5 or more UAI (receptive or insertive) partners. These categories were derived from findings that the unadjusted risk of HIV seroconversion increased linearly from 1–5 partners but plateaued after ≥6 partners [45].

Descriptive Statistical Analyses

Univariate analyses includes two-sample t-tests for mean differences and χ^2 tests of independence to characterize age, race/ethnicity, highest level of education attained, employment, study center, partner type, and frequency of UAI by HIV serostatus.

Factor Analysis

In order to examine the 1º, 2º, and 3º motivations for substance use, we employed principal factor analysis to detect the underlying structure in their relationships. This approach has previously been used to identify underlying structure in answer patters [51], and allows us to utilize information available in all three response from a single participant. Principal factor analysis makes a distinction between common and unique parts of the variation present in a variable. The estimate for the communality of a variable is the proportion of the variance of the variable that is both error free and shared with other variables in the correlation matrix. The factor analysis model chosen for the analysis presented here accounts only for the variability in an answer choice that it has in common with any other answer choice, and assumes that each answer is a function of the underlying factors. We set the prior communality estimate for each answer to its maximum absolute correlation with any other answer choice given.

Eigenvalues were retained based on the proportion criterion whereby the cumulative proportion of common variance explained by successive factors was set to 1.0. This method was confirmed by the graphical scree test method first proposed by Cattell [57], in which eigenvalues are plotted as a function of the number of factors (Appendix 2). The number of factors retained coincides with the tangent of the curve. In order to extract principal factors we rotate the reference axes of the original factor solution to simplify the factor structure and achieve a more meaningful and interpretable solution.

The 18 answer choices available in the motivations for substance use question set are not mutually exclusive, and the observed association between substance use and sexual risk behaviors can result from a combination of several answer choices. For this reason we choose an orthogonal rotation in which the angle between the reference axes of factors were maintained at 90º and the rotation maximizes the variance of the original variable space. This type of rotation, called varimax, maximizes the variance of the factor, while minimizing the variance around the variable to obtain orthogonal, independent factors underlying the 18 possible motivations for substance use responses [58]. To our knowledge, the “Main reasons to engage in substance use during sexual encounters” question set of the MACS has not been analyzed as we describe here, and presents a unique opportunity to explore the role of self-reported motivations to engage in substance use before and/or during sexual activity

Missing data was considered to be missing completely at random. As our sample size was adequate for the analysis proposed, complete case analysis was performed using listwise deletion. This approach has the important advantage of leading to unbiased parameter estimates. All data analysis was performed using SAS software (SAS/STAT 9.4, SAS Institute Inc., Cary, NC, USA).

Results

The mean age of participants overall was 49.5 years (SD 10.12) with HIV seronegative men being statistically significantly older compared to HIV seropositive men (p<.0001) (Table 1). The plurality of men in this cohort was aged 46-55 years (41.06%). There were more HIV seronegative men aged 18-35 years and >56 years, and more HIV seropositive men aged 36-55 years (p<.0001). The majority of participants identified as White, non-Hispanic (64.45%) and of these, the majority were HIV seronegative (57.63%). In all other racial categories the majority of men were HIV seropositive (p<.0001). A large majority of participants had attained some college education or higher (80.72%). The majority of those with a grade 12 or less education were HIV seropositive (59.13%), while in all other education categories the majority of men were HIV seronegative (p<.0001). The largest group of participants was recruited from Los Angeles (33.87%) and the smallest group from Chicago (18.35%). In all centers except Chicago, the majority of participants were HIV seronegative (p<.0001). The plurality of participants had >5 male partners in the previous six months (34.86%), and the majority of men were HIV seronegative across all strata of UAI partner numbers (p=0.0028). There was no statistically significant difference in HIV serostatus among men who reported a main partner in the previous six months compared to those who reported only casual partners (p=0.0892).

The top three motivations to engage in substance use before and/or during sex are presented in Table 2. Among men who reported alcohol use, 44% responded with “To relax” as their 1º motivation, 26% responded with “To fit in better with gay men” as their 2º motivation, and 43% responded with “To have more sex” as their 3º motivation. Among users of EDDs, poppers, stimulants, and any combination thereof, men reported “To have better sex” as their 1º motivation, “To fit in better with gay men” as their 2º motivation, and “To have more sex” as their 3º motivation. No statistically significant differences were seen in motivations for alcohol and substance use by categorical age, HIV serostatus, partner type (main vs. causal), number of male partners in the previous six months, or UAI with causal partners (Appendix 1).

Table 3a presents the eigenvalues along with the cumulative variance explained by each. The first two positive eigenvalues accounted for >100% of the common variance because the reduced correlation matrix was not positive definite (non-zero column vectors are not required to be real and positive) and negative eigenvalues were possible. This pattern suggests that only two common factors were present, this conclusion was supported by scree and variance explained plots (Appendix 2).

Both the principal factor patterns and varimax rotated factor patterns are displayed in Table 3b. The variance explained by the factors was more evenly distributed in the varimax rotated solution as compared to the unrotated solution, however the total variance accounted for by both factor patterns remained unchanged. This invariance property was also observed for the final communality estimates of the variables. For orthogonal factor solutions, the values of the factor pattern matrices can be interpreted as correlations.

For the first alcohol use factor, there was strong loading of the 2º and 3º motivations, “To fit in better with other gay men” and “To have more sex” respectively, with a weak loading of the 1º motivation “To relax”. For the second alcohol use factor, the 1º and 2º motivations “To relax” and “To fit in better with other gay men” respectively had strong loadings, while the 3º motivation “To have more sex” had a weak loading.

For the first factor of EDDs alone, poppers alone, and their combined use, there was strong loadings of the 2º and 3º motivations, “To fit in better with other gay men” and “To have more sex” respectively. The second factor for these substance use combinations was a contrast of the 1º and 2º motivations, “To have better sex” and “To fit in better with other gay men” respectively.

The first factor for stimulant use alone had strong loadings of the 2º and 3º motivations, “To fit in better with other gay men” and “To have more sex” respectively, with a weak loading of the 1º motivation “To have better sex”. The second factor had strong loadings of the 1º and 2º motivations, “To have better sex” and “To fit in better with other gay men” respectively, with a weak loading of the 3º motivation “To have more sex”.

The first factor for stimulants + EDDs, stimulants + poppers, and stimulants + EDDs + poppers, had strong loadings of the 2º and 3º motivations, “To fit in better with other gay men” and “To have more sex” respectively. The second factor for had a strong loading of the 1º motivation “To have better sex” with a weak loading of the 3º motivation “To have more sex”.

Discussion

There was marked consistency of motivations across the eight substance use combinations examined in this sample, with the majority of men choosing only four response types among the 18 possible responses. Using factor analysis, we found these four motivations to vary uniquely in type and strength by alcohol and substance use combination, and cluster around sexual ("To have more sex", and "To have better sex"), personal ("To relax"), and social ("To fit in better with gay men") domains. This supports previous work by Jerome et al. [59] who showed that motivations for club-drugs, including stimulant use, fell into three larger domains, namely a physical, an emotional/mental, and a social domain.

We found a single factor with a common loading pattern for alcohol and all substance use combinations corresponding to "To fit in better with other gay men" and "To have more sex". This loading pattern suggests a link between the social and sexual aspects of alcohol and substance use among MSM. These results confirm what several studies have reported, high lifetime prevalence of recreational drug use in the gay community, especially in the context of clubs and parties [25,60,61], and that drugs are used as a mechanism to feel like part of the mainstream gay community, cope with their sexual identity, and to reduce sexual inhibitions [62].

The second factor had four distinct loading patterns conditional on four substance use combinations: alcohol, EDDs + poppers, stimulants, stimulants + EDDs + poppers. For alcohol use, the motivations "To relax" and "To fit in better with other gay men" both loaded strongly, suggesting an underlying non-sexual motivation for alcohol use that may be better understood in the context of social norms and external stressors. This pattern is in-line with recent work showing that the association of alcohol use with sexual behavior is best understood as a function of social circumstances and personal variables, including to escape stress and relax [5,48,63].

EDDs and poppers, used alone or in combination, all loaded "To have more sex" on the second factor, contrasting with "To fit in better with other gay men". This result suggests an underlying sexual motivation for the use of these substance combinations. There is agreement in the literature showing that the recreational use of EDDs and poppers by MSM facilitate and enhance sexual intercourse [25,45,64]. We additionally found that this drug combination is negatively correlated with the social norm "To fit in better with other gay men", indicating that the impact of EDDs and poppers on sexual activity may be driven by the mechanism of disinhibition [65,66]. Disinhibition is defined as a disregard for social norms, moral obligations, and behavioral restraint [67,68].

For stimulant use alone, there was a strong loading of both "To have better sex" and "To fit in better with other gay men", suggesting a complex interaction that includes positive correlations with both sexual and social components. Stimulants such as cocaine and methamphetamine are sympathomimetic and can acutely influence numerous psychological and physiological

effects, including heightening of the senses, enhanced and prolonged states of sexual arousal, feelings of euphoria, giving the user increased energy and confidence, and alleviating feelings of loneliness and isolation [49,51,69-72]. We found that motivations to engage in stimulant use among MACS participants was positively correlated with enhanced sexual sensation and sexual behavior, followed by increased socialization with gay men. This result complements previous research among stimulant using MSM in Los Angeles describing the perception of one's own use of methamphetamine in comparison to that of other gay or bisexual users to facilitate gay sexual experiences and access gay culture [44].

When stimulants were combined with EDDs and/or poppers (aka “sex drugs”), “To have better sex” and “To have more sex” strongly loaded onto the second factor indicating that this drug combination is highly positively correlated with purely sexual motivations. This association provides a proxy indicator of the “sex drug” connection that has been documented extensively. The combined use of methamphetamine and other stimulants (cocaine, crack and ecstasy) with poppers or EDDs has been shown to be behaviorally disinhibiting, especially among MSM at high risk of HIV seroconversion and transmission [17-20,22]. Ostrow et al. [45] has shown that MSM in the MACS who use all three “sex-drugs” are at greater risk of HIV seroconversion. This evidence suggests that men who use methamphetamine combined with EDDs and poppers intend to engage in sexual behavior, and that this behavior may put them at increased risk for HIV transmission.

Conclusions

This research is the first to specifically look at self-reported motivations for alcohol and substance use before and/or during sexual activity in the MACS. We found one factor with a common loading pattern for all alcohol and substance use combinations that combines the social and sexual domains. In addition, we identified a second factor with four distinct loading patterns conditional on the alcohol or substance combination used. While there are strong sexual components for each, the underlying structure is complex, and includes aspects of both the social and personal domains. We confirm that the underlying structure for the motivations to use “sex drugs” lies in the sexual domain, suggesting varying levels of risk for each substance combination used. Our findings in the MACS support what other research has shown, that while motivations for substance use are multifaceted, the sexual, personal, and social domains drive substance use in the context of sexual activity [59,73,74]. These underlying motivational structures are important in understanding why men engage in substance use before and/or during sexual activity, and may help identify men who participate in often risky sexual activity. Behavioral interventions that aim to identify and modify substance use behaviors among MSM should consider the complex roles of the sexual, social, and personal domains in substance use in the context of sex.

Limitations

Data meet the Kaiser's Measures of Sampling Adequacy (MSAs) of ≥0.5, indicating that the partial correlations (controlling all other variables) are smaller than the original correlations, and that the data are appropriate for common factor modeling (Appendix 3). While the overall MSAs were sufficient, additional motivation rankings would have been desirable to include in the analysis to better define common factors. The measurements for both alcohol/drug use and sexual behavior in the MACS rely on self-report data collection, with several limitations including recall bias, telescoping, and social-desirability bias [75]. Questions about both alcohol/drug use and sexual behavior are highly personal and are assumed to result in under-, rather than over-reporting [76,77]. Although the MACS participants were diverse in terms of age, highest level of education attained, race/ethnicity, geographic region, and baseline levels of HIV risk, they may not be nationally representative of MSM.

Table 1: Demographics by HIV status among MACS participants 2006-2010

	HIV- (n=1296)	HIV+ (n=1205)	Overall (n=2501)	T-Test P-Value
Age in Years (SD)	50.8 (10.90)	48.1 (8.99)	49.5 (10.12)	<.0001
	HIV- (n=1296)	**HIV+ (n=1205)**	**Overall (n=2501)**	**Chi-Square P-Value**
Age Categories				
18-25	27 (71.05%)	11 (28.95%)	38 (1.52%)	
26-35	100 (52.63%)	90 (47.37%)	190 (7.60%)	
36-45	226 (40.21%)	336 (59.79%)	562 (22.47%)	
46-55	496 (48.30%)	531 (51.70%)	1027 (41.06%)	
>56	447 65.35%)	237 (34.65%)	684 (27.35%)	<.0001
Race/Ethnicity				
White, non-Hispanic	929 (57.63%)	683 (42.37%)	1612 (64.45%)	
White, Hispanic	59 (42.14%)	81 (57.86%)	140 (5.60%)	
Black, non-Hispanic	248 (42.32%)	338 (57.68%)	586 (23.43%)	
Black, Hispanic	5 (33.33%)	10 (66.67%)	15 (0.60%)	
Other	55 (37.16%)	93 (62.84%)	148 (5.92%)	<.0001
Education				
Grade 12 or less				
Some college or college graduate	197 (40.87%)	285 (59.13%)	482 (19.28%)	
Some graduate work or graduate	638 (50.32%)	630 (49.68%)	1268 (50.72%)	
degree	460 (61.33%)	290 (38.67%)	750 (30.00%)	<.0001
Center				
Baltimore	313 (53.87%)	268 (46.13%)	581 (23.23%)	
Chicago	176 (38.34%)	283 (61.66%)	459 (18.35%)	
Pittsburgh	353 (57.49%)	261 (42.51%)	614 (24.55%)	
Los Angeles	454 (53.60%)	393 (46.40%)	847 (33.87%)	<.0001
Number of Male Partners in Previous 6 Months				
0	176 (60.27%)	116 (39.73%)	292 (2.49%)	
1	2162 (55.49%)	1734 (44.51%)	3896 (33.19%)	
2-4	1796 (51.94%)	1662 (48.06%)	3458 (29.46%)	
>5	2202 (53.83%)	1889 (46.17%)	4091 (34.86%)	0.0028
Main Partner in Previous 6 Months				
No	2285 (51.50%)	2152 (48.50%)	4437 (51.83%)	
Yes	2199 (53.33%)	1924 (46.67%)	4123 (48.17%)	0.0892

Table 2: Top three motivations to engage in substance use combinations during sexual intercourse among MACS participants 2006-2010

	First	Second	Third
Alcohol	To relax 44% (2227)	To fit in better with other gay men 26% (1287)	To have more sex 43% (2007)
EDDs	To have better sex 75% (912)	To fit in better with other gay men 26% (317)	To have more sex 47% (551)
Poppers	To have better sex 62% (1671)	To fit in better with other gay men 25% (664)	To have more sex 49% (1213)
EDDs + Poppers	To have better sex 63% (2107)	To fit in better with other gay men 27% (900)	To have more sex 50% (1551)
Stimulants	To have better sex 36% (411)	To fit in better with other gay men 16% (177)	To have more sex 31% (344)
Stimulants + EDDs	To have better sex 54% (1129)	To fit in better with other gay men 22% (471)	To have more sex 41% (819)
Stimulants + Poppers	To have better sex 53% (1804)	To fit in better with other gay men 24% (812)	To have more sex 45% (1424)
Stimulants + EDDs + Poppers	To have better sex 55% (2164)	To fit in better with other gay men 26% (1033)	To have more sex 47% (1720)

Table 3a: Eigenvalues with cumulative variance for alcohol and substance use combinations among MACS participants 2006-2010

	Eigenvalues	Cumulative Variance Explained
Alcohol	0.66906406	0.9209
	0.08749087	1.0414
	-0.03006129	1.0000
EDDs	0.48211400	0.7826
	0.22473491	1.1473
	-0.09076835	1.0000
Poppers	0.30315075	0.8362
	0.09120766	1.0878
	-0.03184198	1.0000
EDDs + Poppers	0.31574642	0.8005
	0.12534568	1.1183
	-0.04666012	1.0000
Stimulants	0.65762438	0.8752
	0.11723524	1.0312
	-0.02346965	1.0000
Stimulants + EDDs	0.54647237	0.8977
	0.06668667	1.0073
	-0.00443654	1.0000
Stimulants + Poppers	0.39093288	0.8845
	0.06337400	1.0279
	-0.01233900	1.0000
Stimulants + EDDs + Poppers	0.45120372	0.8737
	0.08050936	1.0296
	-0.01529771	1.0000

Table 3b: Factor patterns with final communality estimates for motivations for alcohol and substance use by alcohol and substance use combinations among MACS participants 2006-2010

Motivations for Use		Factor Pattern		Varimax Rotated Factor Pattern		Final Communality Estimate
		Factor 1	Factor 2	Factor 1	Factor 2	
Alcohol	**1°**	0.44679	0.21170	0.17112	0.46385	0.24444
	2°	0.51201	-0.00104	0.36656	0.35748	0.26217
	3°	0.45529	-0.20658	0.46983	0.17094	0.24996
Total		0.66906	0.08749	0.38439	0.37217	0.75656
EDDs	**1°**	-0.37177	0.31505	0.00957	0.48722	0.23747
	2°	0.50483	0.02307	0.33664	-0.37690	0.25538
	3°	0.29841	0.35348	0.46252	-0.00821	0.21399
Total		0.48211	0.22473	0.32735	0.37950	0.70685
Poppers	**1°**	-0.30900	0.19836	-0.04275	0.36469	0.13483
	2°	0.37869	0.00955	0.24766	-0.28664	0.14350
	3°	0.25350	0.22753	0.33671	-0.05156	0.11603
Total		0.30315	0.09121	0.17654	0.21782	0.39436
EDDs + Poppers	**1°**	-0.13678	0.29177	-0.01616	0.32184	0.10384
	2°	0.40856	-0.06867	0.35217	-0.21821	0.17164
	3°	0.36072	0.18841	0.40520	0.03786	0.16562
Total		0.31575	0.12535	0.28847	0.15263	0.44109
Stimulants	**1°**	0.33302	0.28394	0.12289	0.42002	0.19152
	2°	0.54274	0.00280	0.45240	0.29985	0.29458
	3°	0.50215	-0.19133	0.52487	0.11523	0.28876
Total		0.65762	0.11724	0.49525	0.27961	0.774860
Stimulants + EDDs	**1°**	0.16147	0.24397	0.07102	0.28381	0.08559
	2°	0.50641	-0.08441	0.50562	0.08903	0.26358
	3°	0.51376	0.00653	0.48227	0.17722	0.26399
Total		0.54647	0.06669	0.49328	0.11988	0.61316
Stimulants + Poppers	**1°**	0.11042	0.22658	0.04239	0.24846	0.06353
	2°	0.42947	-0.10135	0.44065	0.02326	0.19472
	3°	0.44079	0.04199	0.41129	0.16401	0.19606
Total		0.39093	0.06337	0.36513	0.08918	0.45431
Stimulants + EDDs + Poppers	**1°**	0.14988	0.25332	0.05589	0.28899	0.08664
	2°	0.45450	-0.12225	0.46913	0.03784	0.22152
	3°	0.47135	0.03733	0.43129	0.19378	0.22356
Total		0.45120	0.08051	0.40922	0.12249	0.53171

Appendix 1: Top three motivations to engage in substance use during sexual intercourse by select variables among MACS participants 2006-2010

	Age Category															HIV Status					
	18-25			26-35			36-45			46-55			>56			+			-		
Alcohol	3 31.9% (47)	13 19.2% (47)	9 33.3% (39)	3 38.2% (476)	13 24.0% (475)	9 39.3% (433)	3 40.3% (1107)	13 20.8% (1108)	9 34.8% (1017)	3 44.6% (2077)	13 27.1% (2078)	9 43.8% (1925)	3 50.0% (1317)	13 28.0% (1319)	9 50.2% (1250)	3 40.6% (2276)	13 26.5% (2279)	9 42.7% (2113)	3 47.4% (2748)	13 24.9% (2748)	9 43.3% (2551)
EDDs	3 100.0% (3)	13 33.3% (3)	9 66.7% (3)	1 70.2% (47)	13 29.8% (47)	9 46.2% (39)	1 64.8% (193)	13 22.7% (194)	9 49.1% (175)	1 76.0% (558)	13 26.3% (556)	9 51.8% (504)	1 79.6% (411)	13 27.3% (411)	9 48.0% (383)	1 73.9% (608)	13 26.5% (608)	9 50.2% (546)	1 76.7% (604)	13 25.9% (603)	9 49.6% (558)
Poppers	1 40.0% (10)	3 30.0% (10)	9 44.4% (9)	1 53.5% (142)	13 16.2% (142)	9 40.3% (129)	1 57.1% (475)	13 18.1% (475)	9 41.4% (435)	1 62.2% (1220)	13 26.2% (1221)	9 51.1% (1112)	1 66.9% (839)	13 27.8% (838)	9 51.5% (794)	1 61.2% (1450)	13 22.1% (1450)	9 46.8% (1342)	1 63.4% (1236)	13 27.8% (1236)	9 51.5% (1137)
EDDs + Poppers	1 45.5% (11)	13 27.3% (11)	9 60.0% (10)	1 54.0% (163)	13 22.1% (163)	9 41.5% (147)	1 56.1% (586)	13 21.2% (586)	9 44.3% (540)	1 62.7% (1507)	13 28.2% (1506)	9 51.6% (1377)	1 68.4% (1082)	13 28.8% (1082)	9 52.2% (1023)	1 61.6% (1756)	13 24.9% (1756)	9 48.5% (1626)	1 64.4% (1593)	13 29.0% (1592)	9 51.8% (1471)
Stimulants	1 35.7% (14)	2 21.4% (14)	9 36.4% (11)	1 31.0% (100)	13 19.0% (100)	9 32.3% (93)	1 38.6% (355)	8 13.5% (356)	9 27.7% (340)	1 36.5% (479)	13 15.6% (480)	9 32.3% (464)	1 33.2% (190)	13 18.4% (190)	9 35.3% (187)	1 39.2% (743)	13 13.6% (744)	9 30.3% (719)	1 30.4% (395)	13 19.2% (396)	9 33.5% (376)
Stimulants + EDDs	1 40.0% (15)	2 20.0% (15)	9 33.3% (12)	1 40.4% (136)	13 22.8% (136)	9 36.5% (126)	1 45.2% (498)	13 16.8% (499)	9 35.8% (472)	1 55.5% (931)	13 23.2% (930)	9 43.3% (870)	1 61.3% (532)	13 25.9% (532)	9 44.4% (502)	1 51.0% (1188)	13 20.5% (1187)	9 38.9% (1117)	1 56.6% (924)	13 24.7% (925)	9 44.5% (865)
Stimulants + Poppers	1 40.0% (20)	13 20.0% (20)	9 47.1% (17)	1 41.4% (203)	13 20.2% (203)	9 38.8% (188)	1 46.1 (724)	13 17.5% (725)	9 36.2% (675)	1 53.5% (1535)	13 25.1% (1536)	9 46.6% (1422)	1 60.4% (923)	13 27.7% (922)	9 49.7% (878)	1 51.5% (1869)	13 21.4% (1869)	9 42.0% (1758)	1 54.8% (1536)	13 26.8% (1537)	9 48.2% (1422)
Stimulants + EDDs + Poppers	1 40.0% (20)	13 20.0% (20)	9 47.1% (17)	1 42.5% (221)	13 24.0% (221)	9 39.7% (204)	1 46.7% (812)	13 19.7% (813)	9 39.2% (760)	1 55.1% (1775)	13 27.4% (1775)	9 48.0% (1641)	1 62.3% (1132)	13 29.2% (1132)	9 50.9% (1073)	1 52.5% (2106)	13 24.0% (2106)	9 44.1% (1975)	1 57.1% (1854)	13 28.4% (1855)	9 49.4% (1720)

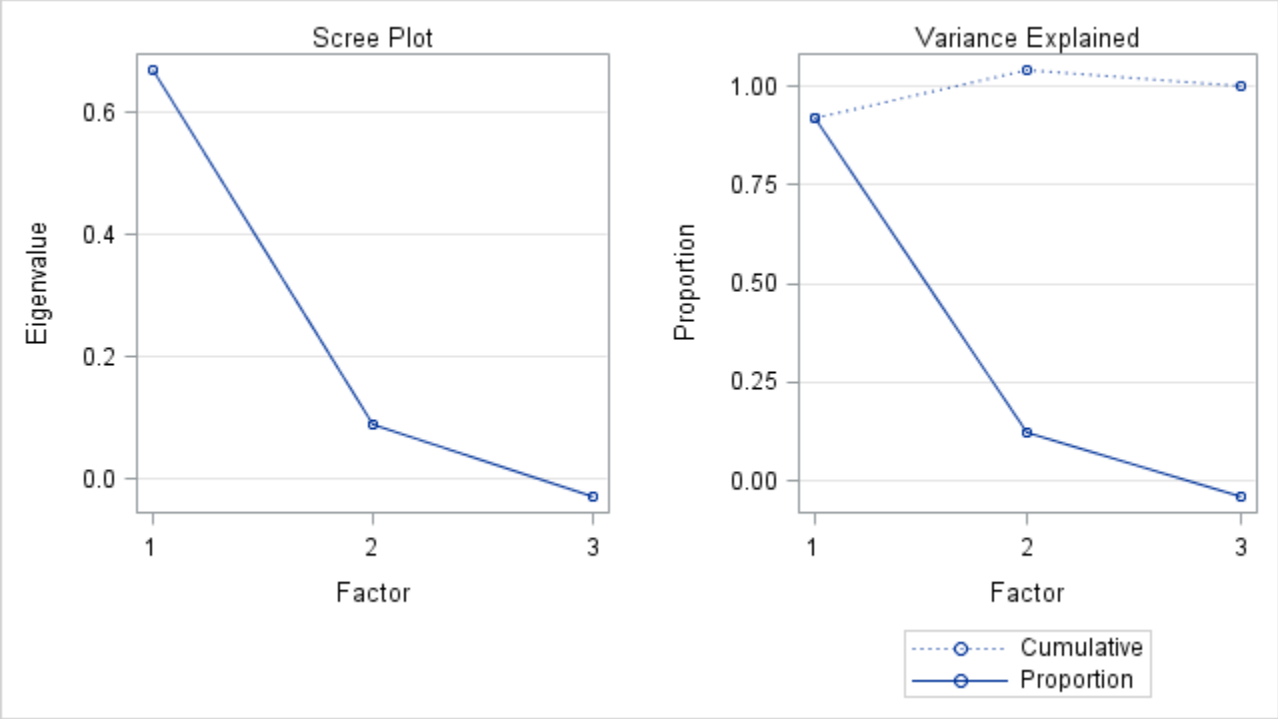
	Main Partner					
	Yes			No		
Alcohol	3 46.5% (1954)	13 24.2% (1956)	9 42.1% (1807)	3 42.3% (1810)	4 21.5% (1811)	9 38.4% (1697)
EDDs	1 77.4% (491)	8 25.9% (490)	9 48.7% (446)	1 74.9% (557)	13 27.6% (558)	9 50.7% (505)
Poppers	1 59.7% (1100)	13 24.1% (1100)	9 47.3% (1019)	1 64.1% (1290)	13 23.6% (1290)	9 49.5% (1187)
EDDs + Poppers	1 61.7% (1361)	13 25.9% (1362)	9 48.7% (1265)	1 63.7% (1562)	13 26.3% (1561)	9 50.6% (1437)
Stimulants	1 32.8% (393)	13 15.0% (393)	9 29.7% (377)	1 38.5% (499)	13 13.8% (500)	9 30.8% (484)
Stimulants + EDDs	1 54.4% (791)	13 21.3% (790)	9 40.1% (743)	1 54.8% (935)	13 22.6% (935)	9 42.2% (875)
Stimulants + Poppers	1 51.3% (1315)	13 23.8% (1315)	9 44.1% (1230)	1 55.2% (1573)	13 22.8% (1573)	9 45.2% (1465)
Stimulants + EDDs + Poppers	1 54.1% (1539)	13 25.7% (1540)	9 45.6% (1442)	1 55.8% (1793)	13 25.6% (1792)	9 47.2% (1665)

	Number of Partners												Casual Partner UAI											
	0			1			2-4			>5			0			1			2-4			>5		
Alcohol	3 39.3% (61)	13 26.2% (61)	9 53.9% (52)	3 49.1% (1224)	13 35.5% (1224)	9 53.6% (1105)	3 46.2% (1482)	13 22.3% (1484)	9 40.4% (1388)	3 43.3% (1883)	13 21.5% (1883)	9 39.7% (1767)	3 44.1% (1900)	13 23.1% (1902)	9 41.6% (1781)	3 44.6% (531)	13 21.5% (531)	9 36.3% (491)	3 41.6% (656)	13 21.2% (656)	9 39.7% (619)	3 40.3% (585)	13 20.3% (585)	9 36.3% (543)
EDDs	1 50.0% (6)	5 33.3% (6)	7 40.0% (5)	1 72.3% (159)	13 27.7% (159)	9 51.8% (143)	1 77.4% (288)	13 33.8% (287)	9 52.3% (258)	1 76.8% (703)	8 25.3% (704)	9 49.6% (643)	1 73.7% (434)	13 31.0% (435)	9 52.7% (395)	1 74.5% (137)	8 34.1% (135)	9 43.8% (121)	1 74.1% (197)	13 23.4% (197)	9 44.8% (181)	1 78.1% (247)	8 32.8% (247)	9 45.9% (231)
Poppers	1 86.7% (15)	13 26.7% (15)	9 63.6% (11)	1 62.6% (396)	13 27.5% (396)	9 49.5% (368)	1 60.6% (680)	13 24.1% (680)	9 47.3% (628)	1 62.5% (1590)	13 24.3% (1590)	9 49.6% (1467)	1 66.4% (1005)	13 29.7% (1005)	9 52.7% (919)	1 58.9% (331)	13 25.1% (331)	9 47.4% (304)	1 56.1% (426)	13 17.7% (425)	9 45.7% (403)	1 62.4% (505)	3 19.0% (506)	9 42.9% (478)
EDDs + Poppers	1 76.2% (21)	13 23.8% (21)	9 50.0% (16)	1 63.0% (505)	13 28.9% (505)	9 51.1% (468)	1 63.3% (864)	13 27.8% (863)	9 49.3% (800)	1 62.7% (1900)	13 26.0% (1901)	9 50.6% (1755)	1 66.2% (1252)	13 32.0% (1253)	9 52.9% (1147)	1 61.0% (408)	13 26.4% (406)	9 48.3% (377)	1 58.1% (522)	13 19.8% (521)	9 47.5% (493)	1 60.8% (643)	13 18.2% (644)	9 44.2% (607)
Stimulants	1 35.7% (14)	3 21.4% (14)	9 42.9% (14)	1 37.5% (160)	13 19.4% (160)	9 35.3% (150)	1 33.7% (341)	13 13.8% (341)	9 29.9% (328)	1 37.3% (474)	13 13.7% (475)	9 29.5% (461)	1 29.1% (313)	13 18.2% (313)	9 32.8% (299)	1 39.6% (164)	13 16.5% (164)	9 39.5% (157)	1 38.4% (255)	8 16.1% (255)	9 27.4% (245)	1 41.0% (249)	8 15.6% (250)	9 28.7% (244)
Stimulants + EDDs	1 42.1% (19)	3 15.8% (19)	9 36.8% (19)	1 53.2% (301)	13 23.9% (301)	9 41.9% (277)	1 51.7% (592)	13 23.9% (591)	9 40.5% (555)	1 57.3% (1007)	13 21.0% (1007)	9 42.3% (946)	1 54.4% (695)	13 27.1% (695)	9 44.8% (649)	1 54.1% (268)	8 21.0% (267)	9 39.7% (247)	1 49.6% (401)	13 19.0% (401)	9 35.5% (380)	1 52.7% (433)	8 23.3% (433)	9 37.8% (415)
Stimulants + Poppers	1 61.5% (26)	6 23.1% (26)	9 50.0% (22)	1 54.9% (526)	13 26.2% (526)	9 46.0% (491)	1 50.3% (913)	13 22.6% (913)	9 43.0% (854)	1 55.0% (1789)	13 24.0% (1789)	9 46.1% (1669)	1 57.2% (1206)	13 28.4% (1206)	9 48.6% (1110)	1 50.1% (437)	13 24.0% (437)	9 46.1% (406)	1 48.7% (577)	13 18.1% (576)	9 40.1% (551)	1 49.5% (667)	13 16.2% (668)	9 39.0% (639)
Stimulants + EDDs + Poppers	1 61.3% (31)	13 19.4% (31)	9 44.4% (27)	1 56.0% (623)	13 27.6% (623)	9 47.1% (580)	1 53.6% (1076)	13 26.1% (1075)	9 45.6% (1006)	1 56.0% (2036)	13 25.9% (2037)	9 47.7% (1896)	1 58.7% (1430)	13 31.0% (1431)	9 49.8% (1318)	1 52.5% (495)	13 25.5% (494)	9 46.0% (461)	1 50.5% (657)	13 19.7% (656)	9 42.4% (625)	1 49.6% (773)	13 18.5% (774)	9 40.7% (737)

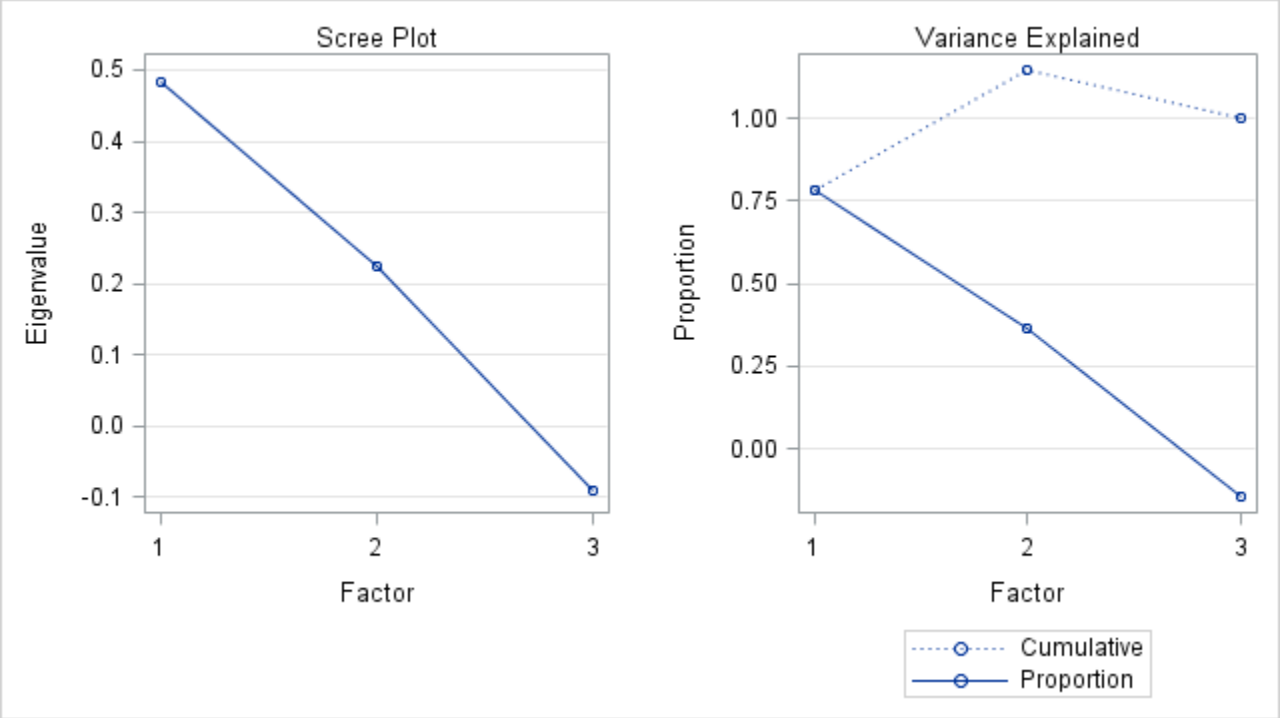
1. To have better sex?
2. To forget problems?
3. To relax?
4. To be more sociable?
5. To increase your energy level?
6. To focus and get things done?
7. To feel better emotionally?
8. To feel better physically?
9. To have more sex?
10. To work better?
11. To take a break from a difficult situation?
12. To feel more connected to others?
13. To fit in better with other gay men?
15. To have a spiritual experience?
16. To perform sexual acts that I don't normally do?
17. I just like the feeling of getting high
18. Other reason not listed above
19. NO second/third reason

Appendix 2: Scree and Variance Explained plots for top three motivations for alcohol and substance use combinations among MACS participants 2006-2010

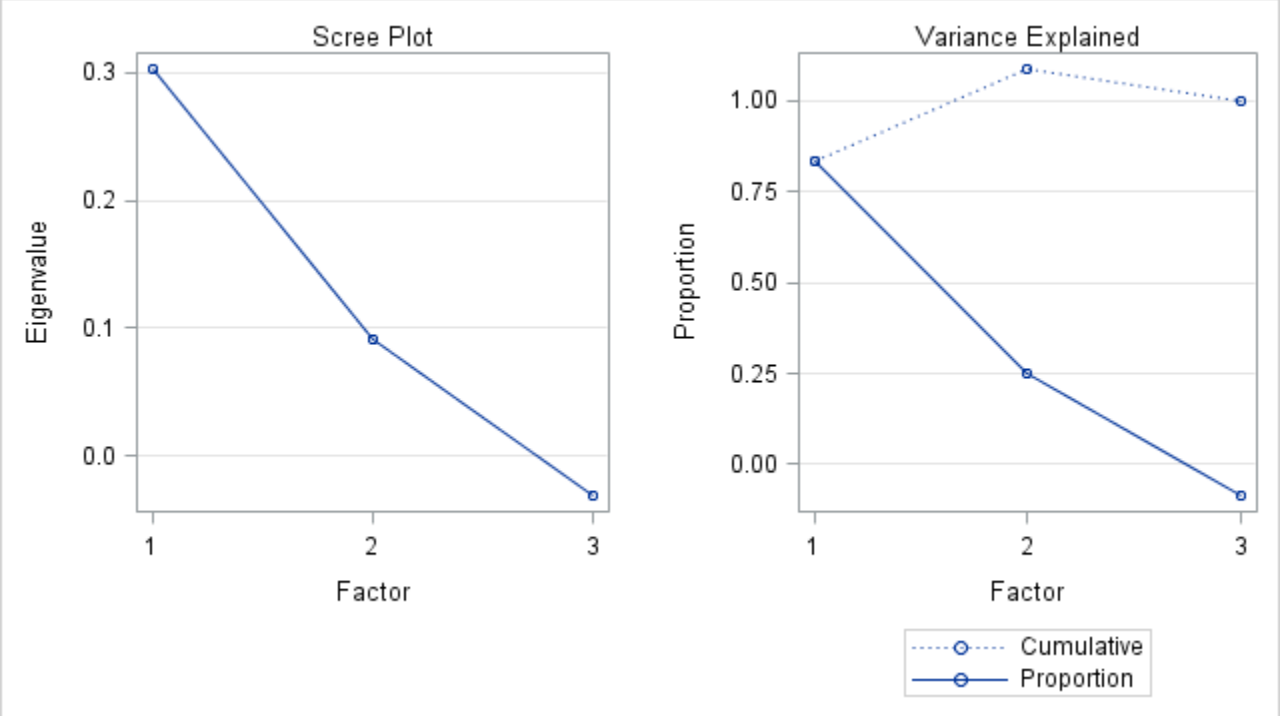
Alcohol



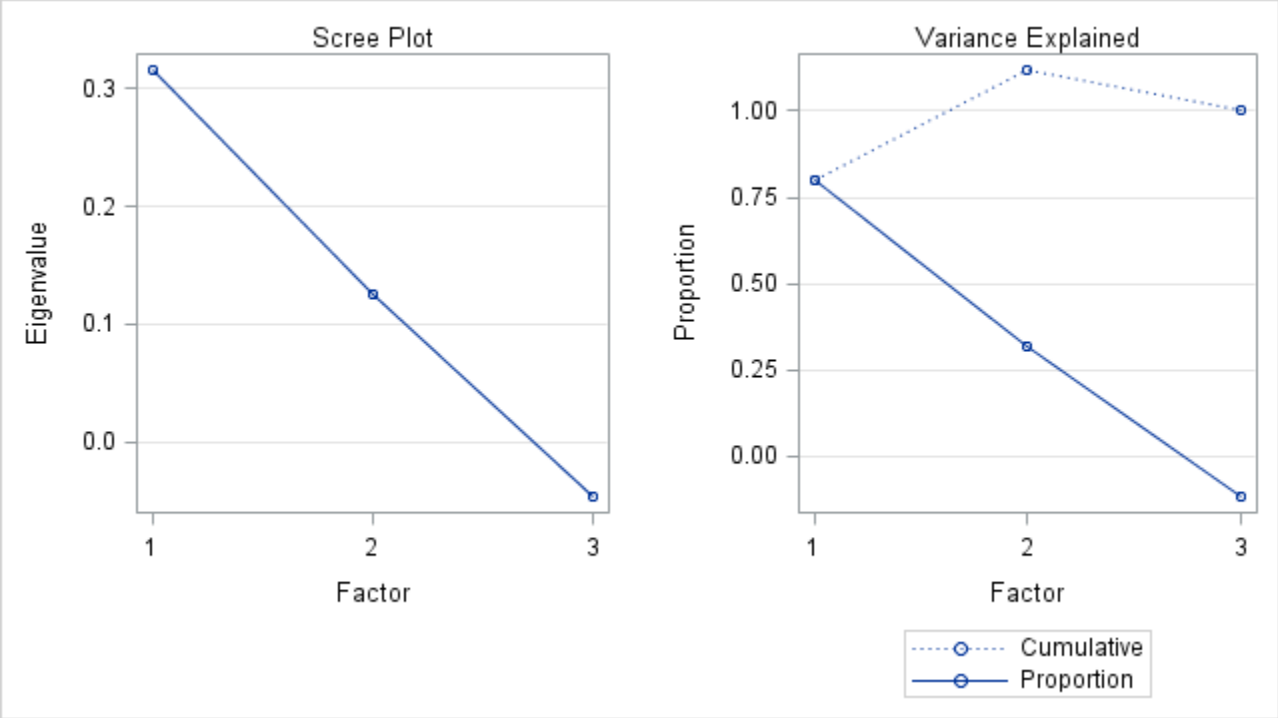
EDDs



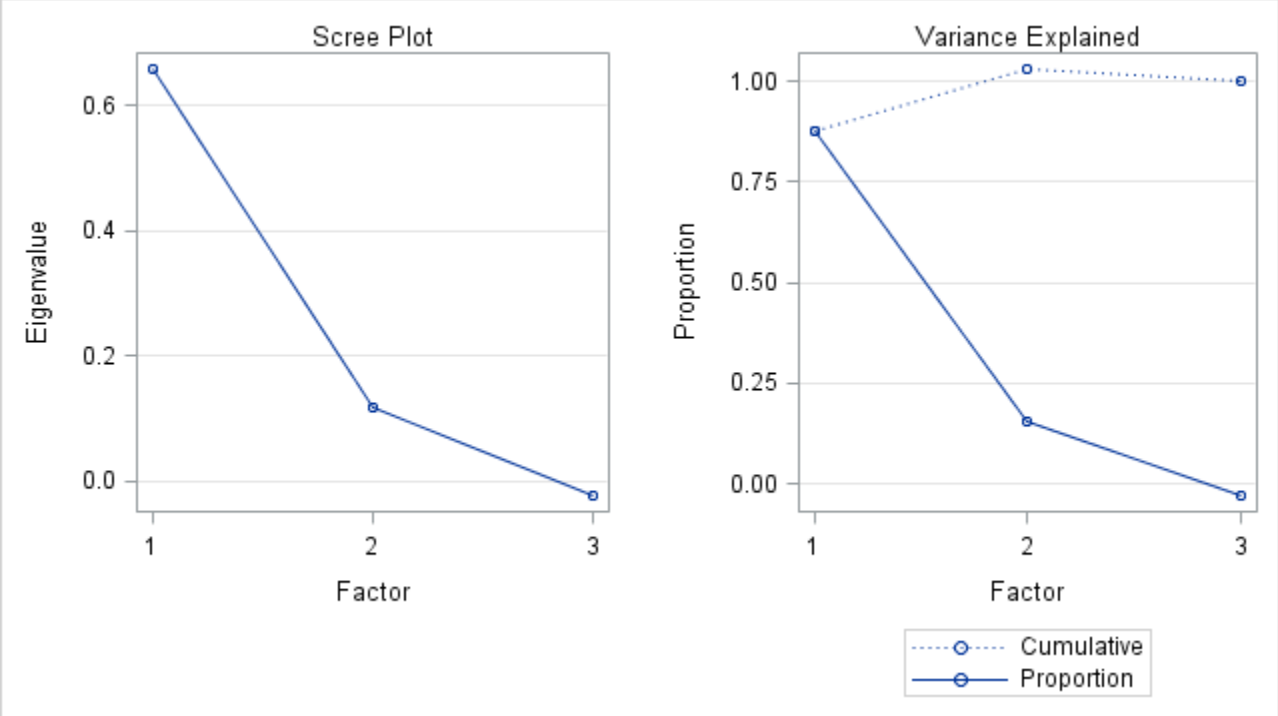
Poppers



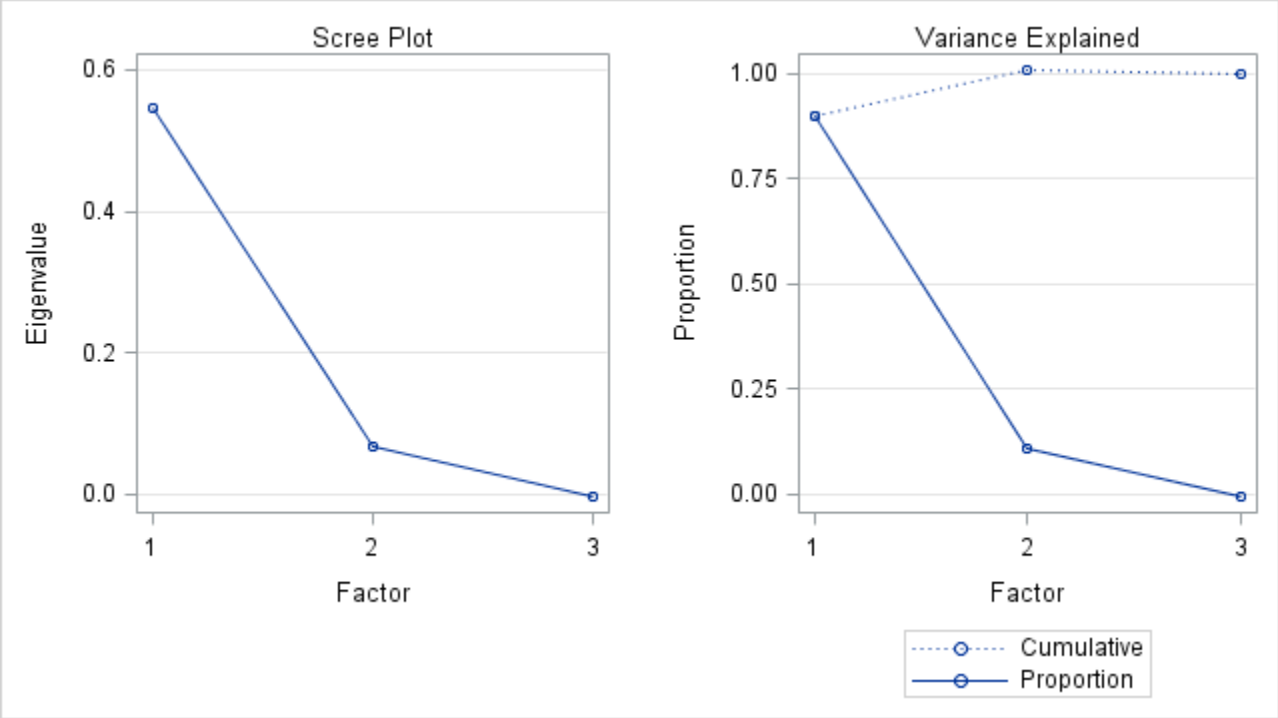
EDDs + Poppers



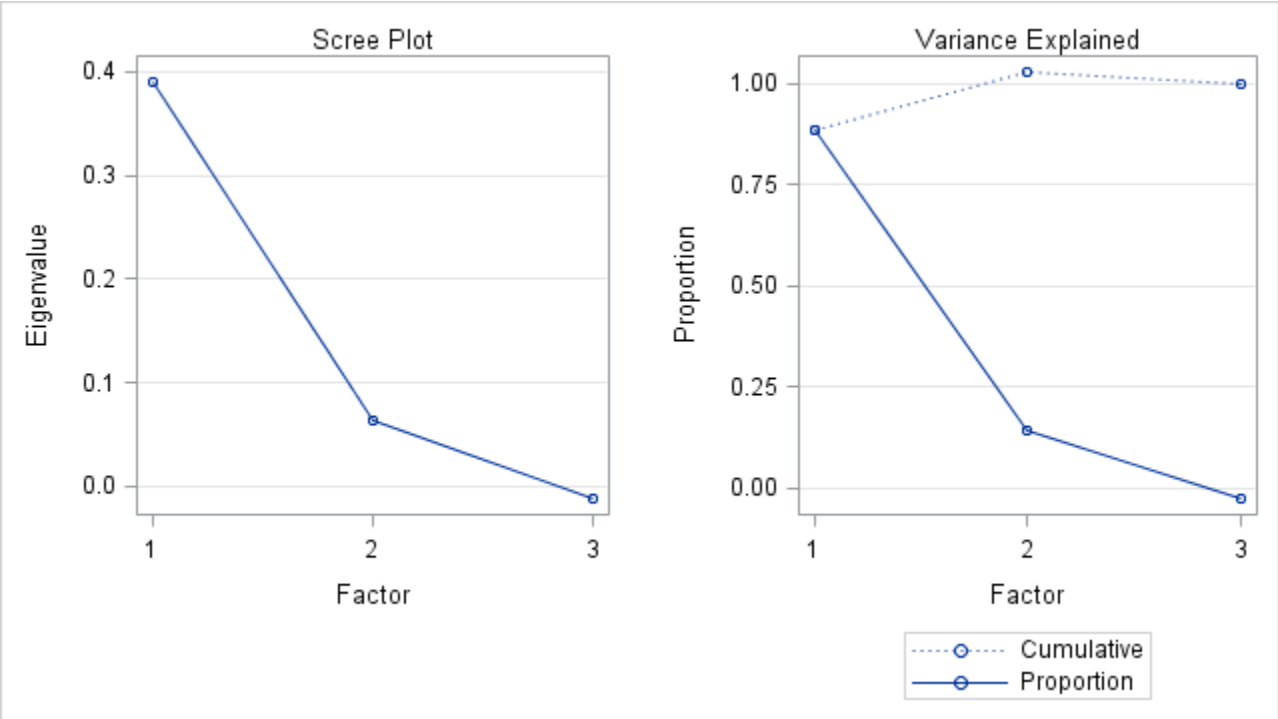
Stimulants



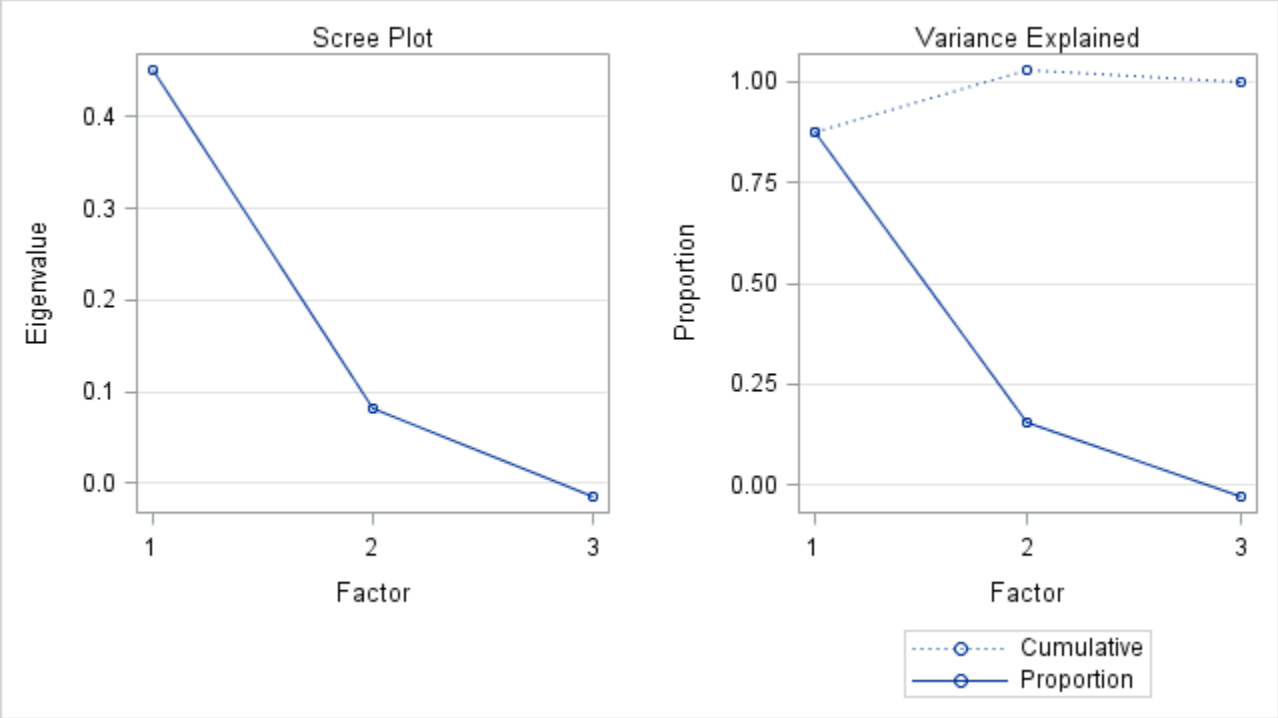
Stimulants + EDDs



Stimulants + Poppers



Stimulants + EEDs + Poppers



Appendix 3: Kaiser's Measures of Sampling Adequacy (MSAs) for top three motivations for alcohol and substance use combinations among MACS participants 2006-2010

Kaiser's Measure of Sampling Adequacy:
Overall MSA = 0.58111269

Alc 1º	Alc 2º	Alc 3º
0.59719769	0.56217609	0.59361656

Kaiser's Measure of Sampling Adequacy:
Overall MSA = 0.46684289

EDD 1º	EDD 2º	EDD 3º
0.56076005	0.57753600	0.55188548

Kaiser's Measure of Sampling Adequacy:
Overall MSA = 0.51373368

Popp 1º	Popp 2º	Popp 3º
0.51574102	0.50924817	0.52125958

Kaiser's Measure of Sampling Adequacy:
Overall MSA = 0.48304778

EDD +Popp 1º	EDD +Popp 2º	EDD +Popp 3º
0.56073996	0.58850143	0.58458922

Kaiser's Measure of Sampling Adequacy:
Overall MSA = 0.55246691

Stim 1º	Stim 2º	Stim 3º
0.60482089	0.53684929	0.54802921

Kaiser's Measure of Sampling Adequacy:
Overall MSA = 0.51999317

Stim + EDD 1º	Stim + EDD 2º	Stim + EDD 3º
0.61740179	0.51437218	0.51363960

Kaiser's Measure of Sampling Adequacy:
Overall MSA = 0.50671807

Stim + Popp 1º	Stim + Popp 2º	Stim + Popp 3º
0.54644274	0.50490028	0.50448067

Kaiser's Measure of Sampling Adequacy:
Overall MSA = 0.51207049

Stim + EDD + Popp 1º	Stim + EDD + Popp 2º	Stim + EDD + Popp 3º
0.55949369	0.50913755	0.50808034

References

1. Hariri S, McKenna MT. Epidemiology of human immunodeficiency virus in the United States. Clin Microbiol Rev 2007;20:478–488.
2. Jaffe HW, Valdiserri RO, De Cock KM. The reemerging HIV/AIDS epidemic in men who have sex with men. J Am Med Assoc 2007;298:2412–2414.
3. Sullivan PS, Hamouda O, Delpech V, Geduld JE, Prejean J, Semaille C, Kaldor J, Folch C, Op de Coul E, Marcus U, Hughes G, Archibald CP, Cazein F, McDonald A, Casabona J, van Sighem A, Fenton KA. Reemergence of the HIV epidemic among men who have sex with men in North America, Western Europe, and Australia, 1996–2005. Ann Epidemiol 2009;19:423–431.
4. Leigh BC. Alcohol and condom use; A Meta-analysis of event-level studies. Sexually Transmitted Diseases 2002;29:476–482
5. Vanable PA, McKirnan DJ, Buchbinder SP, Bartholow BN, Douglas JM, Judson FN, MacQueen KM. Alcohol use and high-risk sexual behavior among men who have sex with men: The effects of consumption level and partner type. Health Psychol 2004;23:525–532.
6. Irwin TW, Morgenstern J, Parsons JT, Wainberg M, Labouvie E. Alcohol and sexual HIV risk behavior among problem drinking men who have sex with men: An event level analysis of timeline followback data. AIDS Behav 2006;10:299–307.
7. Purcell DW, Parsons JT, Halkitis PN, Mizuno Y, Woods WJ. Substance use and sexual transmission risk behavior of HIV-positive men who have sex with men. Journal of Substance Abuse 2001;13:185–200
8. Thiede H, Valleroy LA, MacKellar DA, et al. Regional patterns and correlates of substance use among young men who have sex with men in 7 US urban areas. Am J Public Health 2003;93:1915–1921
9. Garofalo R, Mustanski BS, McKirnan DJ, Herrick A, Donenberg GR. Methamphetamine and young men who have sex with men: Understanding patterns and correlates of use and the association with HIV related sexual risk. Arch Pediatr Adolesc Med 2007;161:591–596
10. Colfax G, Vittinghoff E, Husnik MJ, McKirnan D, Buchbinder S, Koblin B, Celum C, Chesney M, Huang YJ, Mayer K, Bozeman S, Judson FN, Bryant KJ, Coates TJ. Substance use and sexual risk: A participant- and episode-level analysis among a cohort of men who have sex with men. Am J Epidemiol 2004;159:1002–1012
11. Shoptaw S, Reback CJ. Methamphetamine use and infectious disease-related behaviors in men who have sex with men: Implications for interventions. Addiction 2007;102:130–135
12. Stall R, Purcell DW. Intertwining epidemics: A review of research on substance use among men who have sex with men and its connection to the AIDS epidemic. AIDS Behav 2000;4:181–192
13. Stueve A, O'Donnell L, Duran R, San Doval A, Geier J. Being high and taking sexual risks: findings from a multisite survey of urban young men who have sex with men. AIDS Educ Prev 2002;14:482–495
14. Colfax GN, Mansergh G, Guzman R, et al. Drug use and sexual risk behavior among gay and bisexual men who attend circuit parties: a venue-based comparison. J Acquir Immune Defic Syndr. 2001; 28(4):373–379
15. Crosby R, Metty A. A descriptive analysis of HIV risk behavior among men having sex with men attending a large sex resort. J Acquir Immune Defic Syndr. 2004; 37(4):1496–1499
16. Hirshfield S, Remien RH, Humberstone M, Walavalkar I, Chiasson MA. Substance use and high-risk sex among men who have sex with men: a national online study in the USA. AIDS Care. 2004;16(8):1036–1047
17. Mansergh G, Shouse RL, Marks G, et al. Methamphetamine and sildenafil (Viagra) use are linked to unprotected receptive and insertive anal sex, respectively, in a sample of men who have sex with men. Sex Transm Infect. 2006; 82(2):131–134
18. Sanchez TH, Gallagher KM. Factors associated with recent sildenafil (Viagra) use among men who have sex with men in the United States. J Acquir Immune Defic Syndr. 2006; 42(1):95–100
19. Halkitis PN, Palamar JJ, Mukherjee PP. Poly-club-drug use among gay and bisexual men: a longitudinal analysis. Drug Alcohol Depend. 2007; 89(2–3):153–160
20. Schwarcz S, Scheer S, McFarland W, et al. Prevalence of HIV infection and predictors of hightransmission sexual risk behaviors among men who have sex with men. Am J Public Health. 2007;97(6):1067–1075
21. Semple S, Zians J, Strathdee S, Patterson TL. Sexual marathons and methamphetamine use among HIV-positive men who have sex with men. Arch Sex Behav. 2007
22. Spindler HH, Scheer S, Chen SY, et al. Viagra, Methamphetamine, and HIV Risk: Results From a Probability Sample of MSM, San Francisco. Sex Transm Dis. 2007
23. Drumright LN, Strathdee SA, Little SJ, et al. Unprotected Anal Intercourse and Substance Use Before and After HIV Diagnosis Among Recently HIV-Infected Men Who Have Sex With Men. Sex Transm Dis. 2007; 34(6):401–407
24. Halkitis PN, Mukherjee PP, Palamar JJ. Multi-level modeling to explain methamphetamine use among gay and bisexual men. Addiction 2007;102(Suppl. 1):76–83
25. Mansergh G, Colfax GN, Marks G, Rader M, Guzman R, Buchbinder S. The Circuit Party Men's Health Survey: Findings and implications for gay and bisexual men. American Journal of Public Health 2001;91:953–958
26. Hirshfield S, Chiasson MA, Wagmiller RL, et al. Sexual dysfunction in an internet sample of U.S. men who have sex with men. J Sex Med. 2010;7:3104–14

27. Mao L, Newman CE, Kidd MR, Saltman DC, Rogers GD, Kippax SC. Self-reported sexual difficulties and their association with depression and other factors among gay men attending high HIV-caseload general practices in Australia. J Sex Med. 2009;6:1378–85
28. Grov C, Parsons JT, Bimbi DS. Sexual compulsivity and sexual risk in gay and bisexual men. Arch Sex Behav. 2010;39:940–9.
29. O'Leary A, Wolitski RJ, Remien RH, et al. Psychosocial correlates of transmission risk behavior among HIV-seropositive gay and bisexual men. AIDS. 2005;19:S67–75
30. Smolenski DJ, Ross MW, Risser JMH, Rosser BRS. Sexual compulsivity and high-risk sex among Latino men: the role of internalized homonegativity and gay organizations. AIDS Care. 2009;21:42–9
31. Purcell DW, Wolitski RJ, Hoff CC, Parsons JT, Woods WJ, Halkitis PN. Predictors of the use of Viagra, testosterone, and antidepressants among HIV-seropositive gay and bisexual men. AIDS. 2005;19:S57–66
32. Rosen RC, Catania JA, Ehrnhardt AA, et al. The Bolger conference on PDE-5 inhibition and HIV risk: implications for health policy and prevention. J Sex Med. 2006;3:960–75
33. Marks G, Richardson JL, Milam J, Bolan R, Stoyanoff S, McCutchan A. Use of erectile dysfunction medication and unsafe sex among HIV+ men who have sex with men in care. Int J STD AIDS. 2005;16:271–2
34. Cove J, Petrak J. Factors associated with sexual problems in HIV-positive gay men. Int J STD AIDS. 2004;15:732–6
35. Crosby R, DiClemente RJ. Use of recreational Viagra among men having sex with men. Sexually Transmitted Infections 2004;80:466–468
36. Fisher DG, Marlow R, Rosenberg R, Reynolds GL, Ferell N, Jaffe A. Recreational Viagra use and sexual risk among drug abusing men. American Journal of Infectious Diseases 2006;2:107–114
37. Swearingen SG, Klausner JD. Sildenafil use, sexual risk behavior, and risk for sexually transmitted diseases, including HIV infection. American Journal of Medicine 2005;118:571–577
38. Romanelli F, Smith KM, Thornton AC, Pomeroy C: Poppers: Epidemiology and clinical management of inhaled nitrite abuse. Pharmacotherapy 2004,24(1):69-78
39. Brewer DD, Golden MR, Handsfield HH: Unsafe sexual behavior and correlates of risk in a probability sample of men who have sex with men in the era of highly active antiretroviral therapy. Sex Transm Dis 2006,33(4):250-5
40. Rusch M, Lampinen TM, Schilder A, Hogg RS: Unprotected anal intercourse associated with recreational drug use among men who have sex with men depends on partner type and intercourse role. Sex Transm Dis 2004;31(8):492-8
41. Buchbinder SP, Vittinghoff E, Heagerty PJ, Celum CL, Seage GR 3rd, Judson FN, McKirnan D, Mayer KH, Koblin BA: Sexual risk, nitrite inhalant use, and lack of circumcision associated with HIV seroconversion in men who have sex with men in the United States. J Acquir Immune Defic Syndr 2005,39(1):82-9
42. Weber AE, Craib KJ, Chan K, Martindale S, Miller ML, Cook DA, Schechter MT, Hogg RS: Determinants of HIV serconversion in an era of increasing HIV infection among young gay and bisexual men. AIDS 2003;17:774-7
43. Colfax G, Coates TJ, Husnik MJ, Huang Y, Buchbinder S, Koblin B, Chesney M, Vittinghoff E, the EXPLORE Study Team: Longitudinal patterns of methamphetamine, popper (amyl nitrite), and cocaine use and high-risk sexual behavior among a cohort of San Francisco men who have sex with men. J Urban Health 2005;82(1 Suppl 1):i62-70
44. Reback CJ. The Social Construction of a Gay Drug. Methamphetamine Use Among Gay and Bisexual Males in Los Angeles. City of Los Angeles Report. 1997. Available at: http://www.uclaisap.org/documents/final-report_cjr_1-15-04.pdf (accessed January 3, 2013)
45. Ostrow DG, Plankey MW, Cox C, Li X, Shoptaw S, Jacobson LP, Stall RC. Specific sex drug combinations contribute to the majority of recent HIV seroconversions among MSM in the MACS. J Acquir Immune Defic Syndr. 2009 Jul 1;51(3):349-55
46. Elliot, DS.; Huizinga, D.; Ageton, SS. Explaining delinquency and drug use. Beverly Hills: Sage; 1985
47. Zinberg, NE. Drug, set and setting: The basis for controlled intoxicant use. New Haven: Yale University Press; 1984
48. Clatts M, Goldsamt L, Yi H. Drug and sexual risk in four men who have sex with men populations: evidence for a sustained HIV epidemic in New York City. J Urban Health 2005;82(1 suppl 1):i9–i17
49. Semple SJ, Patterson TL, Grant I. Motivations associated with methamphetamine use among HIV+ men who have sex with men. Journal of Substance Abuse Treatment 2002;22 (3):149–156
50. Clatts MC, Welle DL, Goldsamt LA. Reconceptualizing the interaction of drug and sexual risk among MSM speed users: notes toward an ethno-epidemiology. AIDS and Behavior 2001;5(2):115–130
51. Díaz RM, Heckert AL, Sánchez J. Reasons for stimulant use among Latino gay men in San Francisco: a comparison between methamphetamine and cocaine users. J Urban Health. 2005 Mar;82(1 Suppl 1):i71-8. Epub 2005 Feb 28
52. Kaslow RA, Ostrow DG, Detels R, et al. The Multicenter AIDS Cohort Study: rationale, organization, and selected characteristics of the participants. Am J Epidemiol. 1987;126(2):310–318
53. Dudley J, Jin S, Hoover D, Metz S, et al. The Multicenter AIDS Cohort Study: retention after 9 ½ years. Am J Epidemiol. 1995;142(3):323–330
54. MACS Public Data Set. http://www.statepi.jhsph.edu/macs/pdt.html [Accessed January 3, 2013]
55. Gribble JN, Miller HG, Cooley PC, et al. The impact of T-ACASI interviewing on reported drug use among men who have sex with men. Subst Use Misuse. 2000; 35(6–8):869–890
56. Multicenter AIDS Cohort Study Data Working Group Meeting. CAMACS Report October 2011
57. Cattell, R.H. The Scree Test For The Number Of Factors. Multivariate Behavioral Research, Vol. 1, Iss. 2, 1966
58. Walkey FH, McCormick IA. Multiple replication of factor structure: a logical solution for a number of factors problem. Multivariate Behaviour Research 1985;20: 57–67

59. Jerome RC, Halkitis PN, Siconolfi DE. Club drug use, sexual behavior, and HIV seroconversion: a qualitative study of motivations. Subst Use Misuse. 2009;44(3):431-47
60. Kipke M, Weiss G, Ramirez M et al. Club Drug use in Los Angeles among young men who have sex with men. Subst Use Misuse 2007;42:1723–1743
61. Halkitis P, Palamar J. Multivariate modeling of Club Drug use initiation among gay and bisexual men. Subst Use Misuse 2008;43:871–879
62. Bauermeister JA. It's all about "connecting": reasons for drug use among Latino gay men living in the San Francisco Bay Area. J Ethn Subst Abuse. 2007;6(1):109-29
63. Barta WD, Portnoy DB, Kiene SM, Tennen H, Abu-Hasaballah KS, Ferrer R. A daily process investigation of alcohol involved sexual risk behavior among economically disadvantaged problem drinkers living with HIV/AIDS. AIDS and Behavior 2008;12:729–740
64. Plankey MW, Ostrow DG, Stall R, et al. The relationship between methamphetamine and popper use and risk of HIV seroconversion in the multicenter AIDS cohort study. J AIDS. 2007;45:85–92
65. Ostrow DG. Barriers to the recognition of links between drug and alcohol abuse and AIDS. In Acquired immune deficiency syndrome and chemical dependency. National Institute on Alcohol Abuse and Alcoholism. DHHS Publication No. (ADM) 87-1513. U.S. Government Printing Office, Washington, DC, 1987, pp. 15-20
66. Smith T. Counseling gay men about substance abuse and AIDS. In Acquired immune deficiency syndrome and chemical dependency. National Institute on Alcohol Abuse and Alcoholism: DHHS Publication No. (ADM) 87-1513. U.S. Government Printing Office, Washington, DC 1987:53-59
67. McKirnan DJ, Vanable PA, Ostrow DG, Hope B. Expectancies of sexual “escape” and sexual risk among drug and alcohol-involved gay and bisexual men. J. Subst. Abuse 2001;13:137–154
68. Ostrow DG. The role of drugs in the sexual lives of men who have sex with men: continuing barriers to researching this question. AIDS Behav. 2000;4:205–219
69. Halkitis PN, Green KA, Mourgues P. Longitudinal investigation of methamphetamine use among gay and bisexual men in New York City: findings from Project BUMPS. J Urban Health. 2005;82(1 Suppl 1):i18–i25
70. Shrem MT, Halkitis PN. Methamphetamine abuse in the United States: contextual, psychological and sociological considerations. J Health Psychol. 2008;13(5):669–679
71. Colfax G, Shoptaw S. The methamphetamine epidemic: implications for HIV prevention and treatment. Current HIV/AIDS Reports 2005;2:194–199
72. Shoptaw S. Methamphetamine use in urban gay and bisexual populations. Topics in HIV medicine 2006;14:84–7
73. Koblin BA, Torian LV, Guilin VA, Ren LA, MacKellar DA, Valleroy LA. High prevalence of HIV infection among young men who have sex with men in New York City. AIDS 2000;14:1793–1800
74. Stall R, Mills TC, Williamson J, Hart T, Greenwood G, Paul J, et al. Association of co-occurring psychosocial health problems and increased vulnerability to HIV/AIDS among urban men who have sex with men. American Journal of Public Health 2003;93(6)939–942
75. Feinberg SE, Tanur JM. Large-scale social surveys: Perspectives, problems, and prospects. Behavioral Science 1983;28:135–153
76. Blair E, Sudman S, Bradburn NM, Stocking C. How to ask questions about drinking and sex: Response effects in measuring consumer behavior. Journal of Marketing Research 1977;14:316–321
77. Bradburn N, Sudman S; Blair, E. Improving interview method and questionnaire design. San Francisco: Jossey-Bass; 197

Substance use, venue of sexual encounter, and sexual risk behavior among men who have sex with men (MSM) in the Multicenter AIDS Cohort Study (MACS):

A Generalized Linear Mixed Model (GLMM) approach

Earl Ryan Burrell, MPH; Michael W. Plankey, PhD; Marjan Javanbakht, MPH, PhD; Steve Shoptaw, PhD; Ron Brookmeyer, MS, PhD; Robert J. Kim-Farley, MPH, MD; Roger Detels, MS, MD

Abstract

We simultaneously modeled between-subject and within-subject variability using Generalized Mixed Linear Models (GLMMs) to explore the role of key “person variables” (HIV serostatus, sexual sensation seeking, and partner type) specific to the venue of sexual encounter in the association between substance use and sexual risk in the Multicenter AIDS Cohort Study (MACS). GLMMs were fit for each of three venues (Internet, bars, and bathhouses) using data from 1,012 seropositive and 1,084 seronegative participants seen between 2006 and 2010. We were able to show that venue-specific measurements of HIV serostatus, partner type, and sexual sensation seeking (SSS) are important in understanding the relationship between substance use and sexual risk, and may help explain the absence of consistent main effects seen in correlational or experimental studies. These person variables may aid the development of multivariate theoretical models that better fit substance use and sexual risk behavior associational data.

Background

Despite theoretical support for the association of alcohol and drug use with high-risk sexual behavior, situational association studies in both general populations and in gay and bisexual men (hereafter “men who have sex with men” or MSM) have been inconsistent. Situational assessments measure stimulant use and sexual risk behavior occurring together at multiple discrete sexual events in the same person over time, and can be conducted on data that include either a single event or multiple events for each participant. This technique ensures that substance use and sexual activities are temporally paired, accounting for within-person variability in both. Weinhardt [1] suggests the analyses of multiple event data provides a mechanism for participants to serve as their own controls, at least for those who engage in sex while both using and abstaining from substances.

This type of analysis has been conducted using retrospective accounts of behavior and prospective daily diaries. Both of these approaches have yielded mixed results in adult MSM, with some reporting positive associations between alcohol use and sexual risk [2-4] and others finding no association [5,6]. In a review of situational association studies evaluating the alcohol and sexual risk link, Weinhardt & Carey [7] find that individuals who practice safer sex do so when both sober and when drinking, while individuals who fail to use condoms when drinking also fail to use them when sober. Colfax et al. [3] find that alcohol and drug use are independent predictors of serodiscordant unprotected anal intercourse (UAI), while Irwin et al. [4] show that drinking increases risk taking when engaging in receptive anal intercourse but not for insertive anal intercourse. In a meta-analysis, Leigh [8] show that individuals who drink alcohol during their first sexual encounter are less likely to use condoms; however this finding is not supported when data were restricted to most recent sexual encounter.

Although studies have examined the situation-specific relationship between substance use and high-risk sexual behavior [3,9], there is less known about which variables may be important in better understanding the situational association between substance use and sexual risk taking. MSM vary in their use of alcohol and drugs prior to sex, and this within-person variability may be associated with certain situational or contextual variables associated with the specific sexual encounter, and play an important role in the association between substance use and sexual risk [2,10]. Models of sexual risk behavior tend to focus on the rational decision-making processes of the individual, such as knowledge of the risk for HIV transmission and global patterns of alcohol and drug use [11-13] with insufficient attention paid to sexual behavior as a complex process influenced by personal characteristics such as HIV serostatus and sexual impulsivity, and environmental factors such as the type of sexual partner and the venue of sexual encounter. Leigh and Stall [14] point out that there may be many “person variables”, such partner type, HIV status, venue of sexual encounter, and sexual sensation seeking (SSS) that influence both substance use and sexual risk behavior, and may help explain the absence of consistent main effects in correlational or experimental studies on substance use and sexual risk [7,15,16].

Partner Type and HIV serostatus

A growing literature suggests that partner type influences the sexual risk behaviors of MSM [17-21], as well as substance use. Vanable [6] found that for encounters involving a main partner, rates of UAI did not vary as a function of alcohol use. However, heavy alcohol use (consumption of 4 or more drinks) tripled the likelihood of UAI for episodes involving a casual partner. There is some evidence that drug use prior to sex may vary within-persons depending on various characteristics associated with the sexual encounter or sexual partner. For example, both young and adult MSM appear to be more likely to engage in UAI while under the influence of drugs when having sex with casual partners as opposed to main partners [9,22]. This study is consistent with previous investigations that have found that alcohol and stimulant drug use may influence the likelihood of UAI depending on the type of sexual partner [23]. HIV seronegative MSM tend to engage in higher levels of UAI with their main partners as compared with casual partners [19,20,24,25]. However, among the relatively few investigations of the effects of partner type on the sexual behaviors of HIV seropositive MSM, results are mixed. Semple et al [26] suggest that HIV seropositive MSM engage in more unprotected sex with main compared to casual partners, whereas other researchers have found no differences [27-30]. Thus, the effect of HIV serostatus and partner type on the sexual behaviors of MSM remains unclear [31].

Venue of Sexual Encounter

Various etiological theories have been developed for the effects of alcohol and drug use on sexual risk behaviors, such as the influence of venue, environmental, and social circumstances [32,33]. Several studies have showed that sexual risk behaviors of HIV seronegative MSM vary according to venue. It is known that venues of sexual encounter such as parks, adult book stores, beaches, alleys, restrooms, sex parties, and gyms [34,35] along with commercial sex environments such as bathhouses [36], and the Internet [37,38] can impact the sexual risk behaviors of MSM. In addition to sexual risk behaviors, venue of sexual encounter is also associated with substance use and other social-behavioral factors corresponding to sexual behavior [36,39,40].

Sexual Sensation Seeking (SSS)

It has been suggested that individual personality traits that might influence risk taking, such as sexual impulsivity and sexual sensation seeking (SSS), are associated with sexual risk behaviors [41-43]. SSS is defined as a personality characteristic that is associated with a desire to engage in varied and novel sensations and experiences, and has received empirical support as a correlate of multiple risk-taking behaviors, including both alcohol and drug use [44-46]. A recent review showed that SSS may help identify risk-prone individuals who are more likely to engage in a number of risk behaviors, including alcohol use, drug use, and sexual risk behavior [47]. In MSM, evidence suggests that SSS may account for some of the association between both alcohol and drug use and sexual risk [48], but it has not been found to do so in all groups of MSM [49].

We use data from the Multicenter AIDS Cohort Study (MACS) to simultaneously model venue-specific environmental factors (partner type and substance use) that vary within-person over

time, as well as between-person variability (HIV serostatus and SSS), to better understand the various inconsistencies in the association between substance use and sexual risk among MSM.

Methodology

Population and Study Design

The MACS is an ongoing prospective study of the natural and treated histories of HIV infection among MSM in the United States. A total of 6,972 men were recruited in three separate waves between 1984 and 2003 at four centers located in Baltimore-Washington, DC; Chicago; Los Angeles; and Pittsburgh. The study design and history of recruitment have been described in detail elsewhere [50-52]. Briefly, in all four of the geographic areas, collaborating institutions launched aggressive campaigns to enroll volunteers with specific characteristics (e.g., age and clinical HIV status) in the metropolitan areas they served. Recruitment was accomplished through combinations of media publicity (e.g., notices placed in gay bars, newspapers, community centers, and the gay press), promotional events or offerings (e.g., raffles, free medical screening), personal connections of both community leaders and men already enrolled in the study, and previous clinical contacts with largely gay medical practices and research studies on other conditions in gay men [50]. Men who reported sex with other men in the 12 months previous to study screening, and without a diagnosis of AIDS or cancer were asked to voluntarily enroll, and one center initially restricted enrollment to persons aged 18-50 years. All participants return every 6 months for detailed interviews, physical examinations, and collection of blood for laboratory testing and storage in a central repository. Additionally, participants answer questions about medical conditions, medical treatments, sexual behavior, alcohol consumption, and drug use (medicinal and recreational) assessed using audio computer-assisted self-interviewing (ACASI), a methodology shown to yield more accurate assessments of 'sensitive behaviors', such as substance use sexual behaviors, than interviewer-administered questionnaires [53]. The sample used here includes 1,012 seropositive and 1,084 seronegative participants seen and alive between 2006 and 2010 (visits 46-54) [55,56]. All MACS questionnaires are available at http://www.statepi.jhsph.edu/macs/forms.html.

Variables of Interest

We looked at several variables collected during semi-annual MACS visits 46 through 54 (2006-2010), including basic demographics reported at enrollment (age, race/ethnicity, education, and study center), health status (HIV serostatus and SSS), and behavior questionnaire data [54]. The behavior questionnaire includes data on alcohol and drug (methamphetamine, cocaine, crack-cocaine, MDMA, poppers, and EDDs) use, sexual risk behaviors (protected vs. unprotected anal sex), partner type (main vs. casual), and venue of sexual encounter (Internet, bar, and bathhouse), and was collected for each participant referencing all sex partners since their last visit.

Demographics (age, race/ethnicity, education, and study center) and other behaviors were self-reported. Age at baseline for these analyses was calculated using self-reported date of birth and was treated as a categorical covariate divided into five strata (18-25, 26-35, 36-45, 46-55, 56+). Race/ethnicity was self-reported at the first MACS study visit (initial baseline) and is categorized as White non-Hispanic (reference group), White Hispanic, Black non-Hispanic, Black Hispanic, and “other” (predominantly mixed race). Self-reported highest level of education completed at baseline was categorized as grade 12 or less, college, and post-college graduate (reference group).

HIV serostatus was determined through ELISAs with confirmatory Western blot tests performed on all participants initially at baseline, and every six months thereafter if initially seronegative. The date of seroconversion was defined as the midpoint between the dates of the last HIV seronegative visit and the first HIV seropositive visit. Personal attitudes on SSS were measured in the MACS Men’s Attitude Survey (MAS) every two years [55] and consisted of 20 statements to which participants responded on a 5-point Likert scale, with scores ranging from 1 (strong disagreement) to 5 (strong agreement). Cross-sectional studies in community-based samples [56-58] and in the MACS [55] have demonstrated that the attitudinal scales have robust psychometric properties and are able to predict risky sexual behavior [59]. A per item average score was calculated for each attitude subscale and then stratified as follows: 1.0–2.5 for disagree (reference group), 2.6–3.5 for neutral; and 3.6– 5.0 for agree. Partners were categorized as either main or casual partners. Main partners were defined as someone with whom participants have a longstanding relationship, live with, or are partnered with. Causal partners are those whom participants consider to be a one-time partner, or someone with whom they have not developed a longstanding, close relationship with. Using data from MACS visit 47-51 Darilay and Jacobson [60] showed that 39% - 61% of men reported meeting new sexual partners through the Internet, bars, and/or bathhouses, depending on the visit. We categorize venues of sexual encounter into (1) Internet, (2) bar, and (3) bathhouse.

The exposure variable alcohol was classified using both average number of drinks the participant drank per day and frequency of drinking since the last visit. Alcohol use was defined as binge drinking (having 5 or more drinks per occasion at least monthly), or heavy drinking (having 3-4 drinks at least weekly since last visit). Participants who reported low to moderate or no drinking comprise the reference group of alcohol use in this analysis. Recreational drug exposures of interest in this analysis were those commonly used by MSM during sexual episodes, specifically stimulants (defined here as methamphetamine and/or crack and/or cocaine and/or MDMA), poppers, and EDDs. We used eight different combinations of drug use reported at the current or previous visit: (1) EDD alone, (2) poppers alone, (3) EDD + poppers, (4) stimulants alone, (5) stimulants + EDD, (6) stimulants + poppers, and (7) stimulants + EDD + poppers. The use of these drug combinations was defined as “yes” if a participant reported using them at any time between the previous and current visit. We adopted variable categorization based on previous research in the MACS in order to facilitate comparability of results [61,62].

The outcome of interest was the number of self-reported sexual partners with whom the participant engaged in UAI (respective or insertive) since the previous visit, and was treated as non-normal (Poisson distribution) count data.

Venue-Specific Question Set

We examined the relationship between substance use and sexual risk behaviors using the venue-specific variables available in the MACS measured as follows:

"Since your last visit, how many new partners with whom you had unprotected anal intercourse did you meet through (*Internet/bathhouse/bar*)?"

"Thinking about the same new partners you met through the (*Internet/bathhouse/bar*), did you use any of the following substances (*eight drug use combinations*) prior to and/or during your sexual encounters?"

This venue-specific question approach ensures that both the exposure of interest (substance use combination, and venue of sexual encounter) and the outcome (number of UAI partners since last visit) are temporally paired.

Descriptive Statistical Analyses

Univariate analyses included two-sample t-tests for mean differences and χ^2 tests of independence to characterize demographic variables (age, race/ethnicity, education, and study center), SSS, alcohol and drug use, partner type, and venue of sexual encounter by HIV serostatus.

Generalized Linear Mixed Model (GLMM)

Except for demographic characteristics, site of recruitment, and SSS, all other variables, including alcohol and drug use, sexual risk behaviors, partner type, and venue of sexual encounter were time varying (i.e., they were updated at each visit). We therefore modeled within-subject correlated variances resulting from multiple data points repeatedly measured from the same individual (i.e., the residuals from the same individual are likely to be correlated, or dependent). Because individuals differ systematically from each other from visit to visit, we also modeled separate error terms for between-subject variation. In order to accomplish this, we used a Generalized Linear Mixed Model (GLMM), a statistical model that extends the class of generalized linear models (GLMs) by incorporating normally distributed random effects. GLMMs are designed to account for the dependency in nested or multilevel structure observational data, allowing us to conduct both within-subject and between-subject analysis. We fit GLMMs to hold relevant between-person (demographic variables, HIV serostatus, and SSS) differences constant, while treating environmental influences as within-person effects (alcohol and drug use prior/during sex and partner type), allowing them to vary longitudinally across the 9 visits of data collection.

The GLMM procedure fits statistical models to data where the response is not necessarily normally distributed, conditional on normally distributed (Gaussian) random effects. A non-normal Poisson distribution was used to estimate frequency of UAI, as this approach helps to account for deviations from normality in our count data outcome variable. This distribution also accounts for over-dispersion in the outcome variable resulting from the presence of outliers and an over-preponderance of cases with values of zero. This distribution resulted in a ratio between the Pearson statistic and its degrees of freedom that was closest to 1.0 (Appendix 1). The default link function for the Poisson distribution in the GLMM procedure is log.

As well as non-normal distribution, our repeat measures data display correlations among some or all of the observations. The correlations in our data arise from repeated observation of the same individual at each visit, and can be analyzed as random effects. Suppose **Y** represents the (n x 1) vector of observed data and **γ** is a (r x 1) vector of random effects. The GLMM procedure assumes that $\mathbf{E}[\mathbf{Y}|\boldsymbol{\gamma}] = g^{-1}(\mathbf{X}\boldsymbol{\beta} + \mathbf{Z}\boldsymbol{\gamma} + \mathbf{e})$ where g is a differentiable monotonic link function, in this case log, and g^{-1} is its inverse. The GLMM contains a linear mixed model inside the inverse link function. This model component is referred to as the linear predictor, $\boldsymbol{\eta} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}\boldsymbol{\gamma} + \mathbf{e}$. The matrix **X** is an (n x p) matrix of rank k, and **Z** is an (n x r) design matrix for the random effects. The random effects are assumed to be normally distributed with mean 0 and variance matrix **G**. The distribution of the errors **e** is assumed to be normal with mean 0 and variance **R**. The models fit by the GLMM procedure extend the GLM by incorporating correlations among the responses. This is accomplished by including random effects on the linear predictors and/or by modeling the correlations among the data directly. The GLMM procedure distinguishes between the two types of random effects depending on whether the parameters of the covariance structure for random components are contained in **G** or in **R**. The associated covariance structures of **G** and **R** are termed the G-side and R-side covariance structure, respectively. Both the **G**-side random effects and **R**-side covariances parameters are estimated by likelihood-based techniques.

Between-person random effects are represented as elements of **γ**, and are contained in **G**. The G-side random effects are constructed by adding random effects to the linear predictor. Within-person "residual" effects arising from repeat measure data are contained in **R** and model the R-side covariance structure. Because our data arise from random sampling with repeated measures over time, our GLMMs contain each type of effect. We assume that each participant's baseline number of UAI partners was independent of any other participant's number of UAI partners, regardless of the venue of sexual encounter. This between-person variation is captured in **γ** by specifying each participant's intercept as a random effect, and included in the random effects matrix **G**, with G-side covariance structure. In order to model within-person correlations over time with an R-side covariance structure, we directly specified the covariance structure of the **R** matrix to be unstructured. This results in a completely general covariance pattern parameterized directly in terms of variances and covariances. This covariance pattern had the smallest AIC (Akaike's information criteria), AICC (small sample bias corrected version of AIC), BIC (Bayesian inference criterion), CAIC (consistent Akaike's information criterion), and HQIC (Hannan Quinn information criteria) fit statistics, and -2 Log Likelihood score was statistically significantly smaller than that of the Compound Symmetry covariance structure,

which has constant variance and constant covariance (Appendix 2). The variances are constrained to be nonnegative, and the covariances are unconstrained in order to avoid nonlinear constraints.

As part of our model building exercise, we first fit venue specific GLMMs with demographic variables (age, race/ethnicity, education, and study center) independently in order to conduct hypothesis testing for the significance of each as a fixed effect in modeling number of UAI partners met through the Internet, at bars, or at bathhouses. A GLMM was then fitted with HIV serostatus independently for all three venues of sexual encounter. Final GLMMs were then built for each of the eight substance use combinations modeling number of UAI partners met through all three venues of sexual encounter. Missing data was considered to be missing completely at random. As our sample size was adequate for the analysis proposed, complete case analysis was performed using listwise deletion. This approach has the important advantage of leading to unbiased parameter estimates. All data analysis was performed using SAS software (SAS/STAT 9.4, SAS Institute Inc., Cary, NC, USA).

Results

The mean age of participants overall was 49.5 years (SD 10.12) with HIV seronegative men being statistically significantly older compared to HIV seropositive men ($p<0.0001$) (Table 1a). The plurality of men in this cohort was aged 46-55 years. Categorically, there are more HIV seronegative men aged 18-35 years and >56 years, with more HIV seropositive men ages 36-55 years ($p<0.0001$). The majority of participants identified as White, non-Hispanic (64.45%), and of these more men were HIV seronegative - (57.63%), while in all other racial categories the majority of men were HIV seropositive ($p<0.0001$). Half of participants had attained some college education or were college graduates (50.72%). The majority of those with a grade 12 or less education were HIV seropositive (59.13%), while higher education categories were more likely to be HIV seronegative ($p<0.0001$). The largest group of participants was recruited from Los Angeles (33.87%), the smallest group (18.35%) from Chicago. In all centers except Chicago, the majority of participants were HIV seronegative ($p<0.0001$). Most men (40.84%) scored 1.0-2.5 (disagree) on the SSS 5-point Likert scale, with no statistically significant difference in scores between HIV seronegative and HIV seropositive men ($p=0.7366$). The majority of men in this study (56.47%) reported that they did have a main partner in the previous six months, with no statistically significant difference between HIV seronegative and HIV seropositive men ($p=0.4365$).

Men who were HIV seropositive in this study had a statistically significant higher number of UAI partners across all three venues of sexual encounter, with 7.07 Internet ($p=0.0092$), 2.83 bar ($p=0.0361$), and 8.10 bathhouse ($p=0.0173$) UAI partners (Table 1b). Among men who met partners though the Internet, 37.54% used alcohol before and/or during sex with no statistically significant difference by HIV serostatus ($p=0.4503$). Among men who met partners at bars and used alcohol before and/or during sex, 52.69% were HIV seropositive, statistically significantly more than HIV seronegative men ($p=0.0043$). Among men who met partners at bathhouses and used alcohol before and/or during sex, 59.57% were HIV seropositive, statistically significantly more than HIV seronegative men ($p=0.0464$). HIV seropositive men were more likely to use poppers with both partners met through the Internet ($p<0.0001$) and bathhouses ($p=0.0239$), with no statistically significant difference seen for popper use with partners met through bars. No difference in EDDs use was seen by HIV serostatus for partners met through the Internet or bathhouse, however HIV seropositive men were more likely to use EDDs with partners met through bars ($p=0.0233$). For partners met through the Internet, HIV seropositive men were more likely to use Stimulants ($p<0.0001$), Poppers + EDDs ($p<0.0001$), Simulants + Poppers ($p<0.0001$), Stimulants + EEDs ($p=0.0023$), and Stimulants + Poppers + EDDs ($p<0.0001$) than their HIV seronegative counterparts. HIV seropositive men were also more likely to use Poppers + EDDs ($p=0.0257$) with partners met at bars, and Stimulants ($p<0.0001$) and Simulants + Poppers ($p=0.0008$) with partners met at bathhouses. No other statistically significant differences in substance use with partners was seen by HIV serostatus at any of the venues of sexual encounter.

In all cases, no demographic variable was statistically significant by the Type III tests of fixed effects (Appendix 3). Study center was dropped from the analysis, while age, race/ethnicity, and education were forced into all final models. When GLMMs were fitted with SSS and partner type independently, both were statistically significant when modeling number of UAI partners met through the Internet and bathhouses, but not number of UAI partners met through bars (Appendix 4). Our GLMMs reflect these results with age, race/ethnicity, education, HIV serostatus, SSS, and partner type controlled for when modeling number of UAI partners met through the Internet and at bathhouses. Only age, race/ethnicity, education, and HIV serostatus are controlled for when modeling number of UAI partners met at bars.

When modeling the number of UAI partners met through the Internet (Table 2a), being HIV seropositive ($p \leq 0.0083$), having a neutral ($p \leq 0.0003$) and agree ($p \leq 0.0002$) SSS score, and not having a main partner ($p < 0.0001$) were statistically significantly different from reference levels (HIV seronegative, disagree SSS score, and having a main partner respectively) in the final model after controlling for demographics, and across all substance use combinations. When looking at substance use before and/or during sex, alcohol use ($p < 0.0001$) and all substance use combinations ($p < 0.0001$) except for popper use alone ($p = 0.1133$) were statistically significantly different from reference levels (no substance use) in modeling number of UAI partners met through the Internet.

For the number of UAI partners met at bars (Table 2b), being HIV seropositive ($p \leq 0.0052$) was statistically significantly different from reference level (HIV seronegative) after controlling for demographics, and across all substance use combinations. When looking at alcohol and drug use before and/or during sex, all substance use combinations ($p \leq 0.0403$), except for alcohol use alone ($p = 0.4717$), were statistically significantly different from reference levels (no substance use) in modeling number of UAI partners met at bars.

For the number of UAI partners met at bathhouses (Table 2c), being HIV seropositive was statistically significantly different from reference level (HIV seronegative) after controlling for demographics only when alcohol was used before/during sex ($p = 0.0461$). In all other substance use combinations, there was no statistically significant difference in HIV serostatus when modeling number on UAI partners met at bathhouses ($p \geq 0.0551$). Both neutral ($p < 0.0001$) and agree ($p < 0.0001$) SSS scores were statistically significantly different from the reference level (disagree) after controlling for demographics, and across all substance use combinations. Partner type did not remain statistically significant in the final model, regardless of substance use combination ($p \geq 0.0893$). All substance use combinations were statistically significantly different from reference levels (no substance use) after controlling for demographics ($p \leq 0.0029$), except for those that included poppers ($p \geq 0.2345$) (Poppers, Poppers + EDDs, Simulants + Poppers, Stimulants + Poppers + EDDs).

Among men who met partners through the Internet, being HIV seropositive ($p \leq 0.0083$), neutral ($p \leq 0.0003$) and agree ($p \leq 0.0002$) SSS score, not having a main partner ($p < 0.0001$), alcohol use ($p < 0.0001$), and all substance use combinations ($p < 0.0001$) except for popper use alone ($p = 0.1133$) remained statistically significant risk factors for higher numbers of UAI partners after

controlling for demographics. For men who met partners at bars, being HIV seropositive ($p \leq 0.0052$) and all substance use combinations ($p \leq 0.0403$), except for alcohol use alone ($p=0.4717$) remained statistically significant risk factors for higher numbers of UAI partners after controlling for demographics. And for men who met partners at bathhouses, being HIV seropositive when alcohol was used before/during sex ($p=0.0461$), having, neutral ($p<0.0001$) and agree ($p<0.0001$) SSS scores, and all substance use combinations ($p \leq 0.0029$) except for those that included poppers ($p \geq 0.2345$) (Poppers, Poppers + EDDs, Simulants + Poppers, Stimulants + Poppers + EDDs) remained statistically significant risk factors for higher numbers of UAI partners after controlling for demographics.

Discussion

No demographic variables (age, race/ethnicity, education, or study center) were statistically significantly associated with number of UAI partners, regardless of venue of sexual encounter. While there has been much ambiguity in the use of person variables in situational association studies of substance use and risky sexual behaviors [63], we show that HIV serostatus, partner type, SSS, and venue of sexual encounter are important person variables, and may help explain the absence of consistent main effects described by Leigh and Stall [14].

SSS score was statistically significant across all eight substance use combinations for men who met partners through the Internet or at bathhouses. These results suggest that baseline tolerance for sexual risk is strongly associated with higher numbers of UAI partners met at these venues, and in the case of partners met at a bathhouse, more so than HIV serostatus or partner type. This supports findings by Parsons and Halkitis [36] who compare sexual risk behaviors, drug use behaviors, and psychosocial characteristics of HIV seropositive MSM who attended commercial and public sex environments with those who did not. MSM who frequented non-commercial, public sex environments were more "sexually compulsive" and engaged in more sexual risk-behavior as compared to men who did not. In a large-scale study of MSM, Binson et al. [34] reported significant associations between demographic characteristics, attendance at sexual venues, and risky sexual behaviors.

While including SSS scores allowed us to control for an individual's baseline sexual risk tolerance in our final models, substance use combinations remained strongly associated with sexual risk dependent on venue of sexual encounter, suggesting a complex relationship. For men who met partners through the Internet, all substance use combinations except popper use alone were significantly associated with higher numbers of UAI partners. For men who met partners at bathhouses, all substance combinations except popper use alone, and combinations that included popper use were significantly associated with higher numbers of UAI partners. These findings are supported be research showing that specific social environments frequented by MSM provide opportunities for substance use and other social-behavioral factors corresponding to sexual behavior [36,39,40], as well as sexual risk taking [36,39,64]. Our data highlight the importance of venue of sexual encounter in sexual risk taking, particularly substance use while meeting sexual partners through the Internet. These findings could be used to develop venue-specific interventions, such as targeted on-line prevention messaging for gay dating websites and mobile phone applications.

Not having a main partner was significantly associated with higher numbers of UAI partners met through the Internet but not at bars or bathhouses, regardless of substance combination used. Our findings are consistent with previous investigations showing that alcohol and drug use prior to sex may influence the likelihood of UAI depending on the type of sexual partner [23]. We were able to show that venue of sexual encounter may also influence the likelihood of UAI depending on the type of sexual partner.

While SSS and partner type were dropped during the model building exercise when modeling number of UAI partners met at a bar, all substance use combinations expect alcohol use alone were significantly associated with higher numbers of UAI partners met at this venue. This finding indicates that alcohol use at bars may too common to distinguish differences in sexual risk, and highlights the importance of venue of sexual encounter in our risk behavior models. This is contrast to a number of studies of both HIV seropositive and HIV seronegative MSM that confirm the association between alcohol and sexual behavior that is known to place an individual at higher risk for HIV infection [64-67]. While these studies do not include venue-specific data, they do show that alcohol use is associated with UAI. For example, in an online survey of 2,916 mixed HIV serostatus gay and bisexual men, alcohol was associated with UAI [68]. Among HIV seropositive MSM, drinking before sex has been associated with UAI with unknown serostatus partners [66]. Similarly, data from the EXPLORE study of 4,295 HIV seronegative men found that the use of six or more alcoholic drinks before or during sex predicted serodiscordant UAI [3]. While alcohol use is associated with sexual risk among MSM in general, interventions targeting men who meet sexual partners at bars should focus on drug use rather than alcohol consumption in order to reduce the risk associated with higher numbers of UAI partners.

Conclusion

Using an venue-specific approach to simultaneously model between-subject and within-subject variability, we found HIV serostatus, SSS, and partner type to be important person variables when explaining the association between substance use and sexual risk among MSM. These venue-specific person variables could be used to better understand the factors underlying existing temporal associations of substance use and sexual risk [63], and aid the development of multivariate theoretical models that better fit substance use and sexual risk behavior associational data.

Limitations

While the person variables we included in our models explain between-person variation in number of UAI partners met through the Internet and at bathhouses, the random intercepts for number of UAI partners met at bars were significant across all substance use combinations (Table 2b). This indicates unexplained between-person variation in our GLMM that could be explained by including additional variables, such as the measurement of stress and/or depression, which could better model number of UAI partners met at bars. Future research should include additional parameters in GLMMs to better fit the data and account for this unexplained between-person variation.

The MACS relies on self-report data collection for both alcohol/drug use and sexual behavior. This approach has several issues including recall bias, telescoping, and social-desirability bias

[69]. Substance use and sexual activity are common enough in this population to cause individual instances of each to become indistinguishable in memory and temporal order, and may be forgotten completely. Not only are retrospective measures of both substance use and sexual behavior subject to memory errors such as forgetting and telescoping, but additional problems may arise in assessing memory for incidents that include both substance use and high-risk sex. Laboratory studies on the effect of alcohol on memory have demonstrated that alcohol interferes with consolidation of information into long-term memory storage [70], and state-dependent learning effects have been demonstrated for other drugs as well [71]. Substance use at the time of a sexual encounter may then interfere with the process by which information is stored, such that memory of the specifics of the events may be incomplete or biased. While ACASI was used to limit the effects of social-desirability bias, questions about both alcohol/drug use and sexual behavior are highly personal and are assumed to result in under-, rather than over-reporting [72-74]. To the extent that this bias exists in our data, we expect more conservative estimates of risk than might actually be the case.

The MACS is a diverse cohort, and includes a range of participants by of age, socioeconomic status, race/ethnicity, geographic region, and baseline levels of HIV risk. However this is not a probability-based sample and may not be nationally representative of MSM.

Table 1a: Demographic Variables by HIV status among MACS participants 2006-2010

	HIV- (n=1296)	HIV+ (n=1205)	Overall (n=2501)	T-Test P-Value
Age in Years (SD)	50.8 (10.90)	48.1 (8.99)	49.5 (10.12)	<.0001
	HIV- (n=1296)	**HIV+ (n=1205)**	**Overall (n=2501)**	**Chi-Square P-Value**
Age Categories				
18-25	27 (71.05%)	11 (28.95%)	38 (1.52%)	
26-35	100 (52.63%)	90 (47.37%)	190 (7.60%)	
36-45	226 (40.21%)	336 (59.79%)	562 (22.47%)	
46-55	496 (48.30%)	531 (51.70%)	1027 (41.06%)	
>56	447 (65.35%)	237 (34.65%)	684 (27.35%)	<.0001
Race				
White, non-Hispanic	929 (57.63%)	683 (42.37%)	1612 (64.45%)	
White, Hispanic	59 (42.14%)	81 (57.86%)	140 (5.60%)	
Black, non-Hispanic	248 (42.32%)	338 (57.68%)	586 (23.43%)	
Black, Hispanic	5 (33.33%)	10 (66.67%)	15 (0.60%)	
Other	55 (37.16%)	93 (62.84%)	148 (5.92%)	<.0001
Education				
Grade 12 or less				
Some college or college graduate	197 (40.87%)	285 (59.13%)	482 (19.28%)	
Some graduate work or graduate	638 (50.32%)	630 (49.68%)	1268 (50.72%)	
degree	460 (61.33%)	290 (38.67%)	750 (30.00%)	<.0001
Center				
Baltimore	313 (53.87%)	268 (46.13%)	581 (23.23%)	
Chicago	176 (38.34%)	283 (61.66%)	459 (18.35%)	
Pittsburgh	353 (57.49%)	261 (42.51%)	614 (24.55%)	
Los Angeles	454 (53.60%)	393 (46.40%)	847 (33.87%)	<.0001
Sexual Sensation Seeking (SSS) Score				
1.0–2.5 disagree	430 (51.19%)	410 (48.81%)	840 (40.84%)	
2.6–3.5 neutral	290 (53.31%)	254 (46.69%)	544 (26.45%)	
3.6– 5.0 agree	348 (51.71%)	325 (48.29%)	673 (32.72%)	0.7366
Main Partner in Previous 6 Months				
No	393 (52.82%)	351 (47.18%)	744 (43.53%)	
Yes	528 (54.72%)	437 (45.28%)	965 (56.47%)	0.4365

Table 1b: Outcome and Exposure Variables of Interest by HIV status among MACS participants 2006-2010

Outcome Variables of Interest

	HIV- (n=437)	HIV+ (n=685)	Overall (n=1122)	T-Test P-Value
Number of Internet UAI Partners (SD)	4.79 (8.95)	7.07 (19.91)	6.18 (16.56)	0.0092
	HIV- (n=176)	**HIV+ (n=209)**	**Overall (n=385)**	**T-Test P-Value**
Number of Bar UAI Partners (SD)	2.24 (2.23)	2.83 (3.28)	2.56 (2.86)	0.0361
	HIV- (n=215)	**HIV+ (n=411)**	**Overall (n=626)**	**T-Test P-Value**
Number of Bathhouse UAI Partners (SD)	4.56 (7.15)	8.10 (28.39)	6.89 (23.44)	0.0173

Exposure Variables of Interest

Internet	**HIV- (n=369)**	**HIV+ (n=574)**	**Overall (n=943)**	**Chi-Square P-Value**
Alcohol				
No	225 (38.20%)	364 (61.80%)	589 (589%)	0.4503
Yes	144 (40.68%)	210 (59.32%)	354 (37.54%)	
Poppers				
No	267 (48.55%)	283 (51.45%)	550 (58.32%)	<.0001
Yes	102 (25.95%)	291 (74.05%)	393 (41.68%)	
EDDs				
No	266 (40.86%)	385 (59.14%)	651 (69.03%)	0.1041
Yes	103 (35.27%)	189 (64.73%)	292 (30.97%)	
Stimulants				
No	338 (44.30%)	425 (55.70%)	763 (80.91%)	<.0001
Yes	31 (17.22%)	149 (82.78%)	180 (19.09%)	
Poppers + EDDs				
No	200 (50.76%)	194 (49.24%)	394 (41.78%)	<.0001
Yes	169 (30.78%)	380 (69.22%)	549 (58.22%)	
Simulants + Poppers				
No	247 (53.70%)	213 (46.30%)	460 (48.78%)	<.0001
Yes	122 (25.26%)	361 (74.74%)	483 (51.22%)	
Stimulants + EEDs				
No	248 (42.98%)	329 (57.02%)	577 (61.19%)	0.0023
Yes	121 (33.06%)	245 (66.94%)	366 (38.81%)	
Stimulants + Poppers + EDDs				
No	188 (52.96%)	167 (47.04%)	355 (37.65%)	<.0001
Yes	181 (30.78%)	407 (69.22%)	588 (62.35%)	

Table 2a: Generalized Linear Mixed Model for number of Internet UAI partners by substance use combination among MACS participants 2006-2010

GLMM Solutions for Fixed Effects

	Alcohol		Poppers		EDDs		Stimulants		Poppers + EDDs		Simulants + Poppers		Stimulants + EEDs		Stimulants + Poppers + EEDs	
Intercept	0.1588	p=0.3680	0.1862	p=0.2935	0.03038	p=0.8603	0.1593	p=0.3633	-0.0321	p=0.8552	0.1532	p=0.3831	0.03834	p=0.8249	-0.0114	p=0.9484
Age																
18-25	0.2734	p=0.5069	0.4117	p=0.3198	0.5955	p=0.1357	0.3829	p=0.3476	0.5822	p=0.1506	0.4015	p=0.3262	0.5361	p=0.1810	0.5067	p=0.2112
26-35	0.1669	p=0.4514	0.1717	p=0.4412	0.3212	p=0.1367	0.1660	p=0.4498	0.2714	p=0.2141	0.1659	p=0.4515	0.2872	p=0.1846	0.2533	p=0.2464
36-45	-0.0569	p=0.7535	-0.0497	p=0.7850	0.0359	p=0.8383	-0.0742	p=0.6795	-0.0083	p=0.9627	-0.0671	p=0.7096	-0.0158	p=0.9286	-0.0370	p=0.8355
46-55	-0.0623	p=0.6960	-0.0686	p=0.6692	-0.0199	p=0.8979	-0.0477	p=0.7629	-0.0562	p=0.7201	-0.0774	p=0.6253	-0.0218	p=0.8883	-0.0633	p=0.6870
56+	-		-		-		-		-		-		-		-	
Race																
White, non-Hispanic	-		-		-		-		-		-		-		-	
White, Hispanic	**-0.5583**	**p=0.0165**	-0.5364	p=0.0220	**-0.4595**	**p=0.0424**	-0.4697	p=0.0421	**-0.4980**	**p=0.0300**	-0.5156	p=0.0260	**-0.4488**	**p=0.0484**	**-0.4961**	**p=0.0308**
Black, non-Hispanic	-0.1140	p=0.4691	-0.0899	p=0.5710	0.0352	p=0.8177	-0.0762	p=0.6256	-0.0027	p=0.9859	-0.0570	p=0.7163	-0.0608	p=0.6920	-0.0166	p=0.9148
Black, Hispanic	-1.0777	p=0.4504	-1.1654	p=0.4163	-1.1125	p=0.4275	-1.1056	p=0.4363	-1.0013	p=0.4785	-1.1131	p=0.4344	-1.0750	p=0.4442	-1.0001	p=0.4793
Other	-0.2626	p=0.3088	-0.2204	p=0.3950	-0.2015	p=0.4210	-0.1882	p=0.4612	-0.1993	p=0.4319	-0.2072	p=0.4186	-0.1987	p=0.4294	-0.1806	p=0.4766
Education																
12th grade or less	0.2314	p=0.2980	0.2253	p=0.3139	0.1955	p=0.3647	0.2228	p=0.3117	0.2532	p=0.2474	0.2325	p=0.2929	0.2140	p=0.3229	0.2406	p=0.2719
College	-0.0543	p=0.6831	-0.0327	p=0.8068	-0.0331	p=0.7978	-0.0397	p=0.7635	-0.0313	p=0.8107	-0.0286	p=0.8288	-0.0416	p=0.7483	-0.0347	p=0.7908
Post-college graduate	-		-		-		-		-		-		-		-	
HIV Serostatus																
Negative	-		-		-		-		-		-		-		-	
Positive	**0.3990**	**p=0.0008**	**0.3887**	**p=0.0012**	**0.3714**	**p=0.0013**	**0.3176**	**p=0.0073**	**0.3101**	**p=0.0081**	**0.3412**	**p=0.0041**	**0.3476**	**p=0.0027**	**0.3094**	**p=0.0083**
Sexual Sensation Seeking																
1.0–2.5 disagree																
2.6–3.5 neutral	-		-		-		-		-		-		-		-	
3.6– 5.0 agree	**0.3746**	**p<0.0001**	**0.4048**	**p<0.0001**	**0.3755**	**p=0.0002**	**0.4162**	**p<0.0001**	**0.3599**	**p=0.0003**	**0.3917**	**p=0.0001**	**0.3828**	**p=0.0001**	**0.3617**	**p=0.0003**
	0.5781	**p=0.0002**	**0.6063**	**p<0.0001**	**0.5722**	**p<0.0001**	**0.5917**	**p<0.0001**	**0.5684**	**p<0.0001**	**0.5884**	**p<0.0001**	**0.5698**	**p<0.0001**	**0.5679**	**p<0.0001**
Main Partner																
No	**0.3165**	**p<0.0001**	**0.3046**	**p<0.0001**	**0.3175**	**p<.00001**	**0.3297**	**p<0.0001**	**0.3055**	**p<0.0001**	**0.2994**	**p<0.0001**	**0.3102**	**p<0.0001**	**0.3044**	**p<0.0001**
Yes	-		-		-		-		-		-		-		-	
Alcohol																
No	-															
Yes	**0.2373**	**p<0.0001**														
Poppers																
No			-													
Yes			0.0757	p=0.1133												

EDDs No Yes			- **0.5031 p<0.0001**					
Stimulants No Yes				- **0.4932 p<0.0001**				
Poppers + EDDs No Yes					- **0.4907 p<0.0001**			
Simulants + Poppers No Yes						- **0.2255 p<0.0001**		
Stimulants + EEDs No Yes							- **0.4929 p<0.0001**	
Stimulants + Poppers + EDDs No Yes								- **0.4583 p<0.0001**

Table 2b: Generalized Linear Mixed Model for number of Bar UAI partners by substance use combination among MACS participants 2006-2010

GLMM Solutions for Fixed Effects

	Alcohol		Poppers		EDDs		Stimulants		Poppers + EDDs		Simulants + Poppers		Stimulants + EEDs		Stimulants + Poppers + EEDs	
Intercept	**0.8486**	**p<0.0001**	**0.6725**	**p=0.0001**	**0.6781**	**p=0.0001**	**0.7631**	**p<0.0001**	**0.6230**	**p=0.0005**	**0.6506**	**p=0.0002**	**0.6755**	**p=0.0001**	**0.6251**	**p=0.0004**
Age																
18-25	0.3680	p=0.3033	0.4410	p=0.2149	0.4215	p=0.2363	0.3371	p=0.3378	0.4715	p=0.1831	0.4190	p=0.2362	0.3997	p=0.2572	0.4356	p=0.2165
26-35	0.0368	p=0.8823	0.1152	p=0.6420	0.1332	p=0.5937	0.1312	p=0.5937	0.1633	p=0.5119	0.1390	p=0.5742	0.1547	p=0.5351	0.1644	p=0.5089
36-45	-0.3857	p=0.0703	-0.3802	p=0.0729	-0.3275	p=0.1251	-0.3222	p=0.1269	-0.3401	p=0.1078	-0.3630	p=0.0863	-0.3140	p=0.1403	-0.3320	p=0.1164
46-55	-0.2828	p=0.1331	-0.2677	p=0.1521	-0.2531	p=0.1762	-0.3113	p=0.0948	-0.2525	p=0.1751	-0.2780	p=0.1366	-0.2630	p=0.1578	-0.2543	p=0.1711
56+	-		-		-		-		-		-		-		-	
Race																
White, non-Hispanic	-		-		-		-		-		-		-		-	
White, Hispanic	-0.4536	p=0.0756	-0.4875	p=0.0542	-0.4154	p=0.1020	-0.4409	p=0.0795	-0.4616	p=0.0664	-0.4582	p=0.0690	-0.4267	p=0.0909	-0.4399	p=0.0797
Black, non-Hispanic	0.0187	p=0.9137	0.0331	p=0.8452	0.0556	p=0.7440	0.0702	p=0.6778	0.0339	p=0.8404	0.0471	p=0.7804	0.0531	p=0.7537	0.0394	p=0.8145
Black, Hispanic	0.4099	p=0.6104	0.4989	p=0.5330	0.4426	p=0.5798	0.4409	p=0.5791	0.5195	p=0.5140	0.5429	p=0.4965	0.4351	p=0.5854	0.5235	p=0.5103
Other	0.02704	p=0.9093	0.0284	p=0.9041	0.0273	p=0.9080	0.0110	p=0.9627	0.0250	p=0.9152	0.0437	p=0.8530	0.0114	p=0.9613	0.0301	p=0.8950
Education																
12th grade or less	-0.0089	p=0.9679	0.00461	p=0.9831	-0.0318	p=0.8846	-0.1798	p=0.4213	0.0249	p=0.9085	-0.0326	p=0.8807	-0.0895	p=0.6852	-0.0476	p=0.8263
College	-0.1320	p=0.3631	-0.1499	p=0.2993	-0.1393	p=0.3340	-0.2450	p=0.0955	-0.1444	p=0.3147	-0.1844	p=0.2035	-0.1598	p=0.2671	-0.1616	p=0.2606
Post-college graduate	-		-		-		-		-		-		-		-	
HIV Serostatus																
Negative	-		-		-		-		-		-		-		-	
Positive	**0.3765**	**p=0.0048**	**0.3818**	**p=0.0039**	**0.3698**	**p=0.0052**	**0.3895**	**p=0.0031**	**0.3677**	**p=0.0051**	**0.3784**	**p=0.0041**	**0.3760**	**p=0.0043**	**0.3702**	**p=0.0048**
Alcohol																
No	-															
Yes	-0.0949	p=0.4717														
Poppers																
No			-													
Yes			**0.2648**	**p=0.0303**												
EDDs																
No					-											
Yes					**0.2492**	**p=0.0403**										
Stimulants																
No							-									
Yes							**0.5781**	**p=0.0119**								

Poppers + EDDs No Yes					- **0.2695 p=0.0168**			
Simulants + Poppers No Yes						- **0.3302 p=0.0087**		
Stimulants + EEDs No Yes							- **0.2643 p=0.0228**	
Stimulants + Poppers + EDDs No Yes								- **0.2629 p=0.0202**

Table 2c: Generalized Linear Mixed Model for number of Bathhouse UAI partners by substance use combination among MACS participants 2006-2010

GLMM Solutions for Fixed Effects

	Alcohol		Poppers		EDDs		Stimulants		Poppers + EDDs		Simulants + Poppers		Stimulants + EEDs		Stimulants + Poppers + EEDs	
Intercept	0.3581	p=0.1156	0.4306	p=0.0603	0.3872	p=0.0843	0.3943	p=0.0877	0.3775	p=0.1004	0.4098	p=0.0725	0.3761	p=0.0958	0.4337	p=0.0606
Age																
18-25	-0.0849	p=0.9041	0.0450	p=0.9492	0.07812	p=0.9102	-0.1649	p=0.8179	0.0048	p=0.9945	0.0224	p=0.9747	0.0267	p=0.9694	0.0253	p=0.9714
26-35	0.5808	p=0.1227	0.6277	p=0.0964	0.6768	p=0.0676	0.5327	p=0.1633	0.6391	p=0.0879	0.6288	p=0.0940	0.6663	p=0.0738	0.6141	p=0.1028
36-45	0.0369	p=0.8849	0.0822	p=0.7475	0.1181	p=0.6375	0.0259	p=0.9201	0.0840	p=0.7401	0.0790	p=0.7561	0.1058	p=0.6749	0.0711	p=0.7800
46-55	-0.3405	p=0.1400	-0.3124	p=0.1771	-0.2932	p=0.1961	-0.3319	p=0.1566	-0.3180	p=0.1654	-0.3192	p=0.1656	-0.2848	p=0.2126	-0.3248	p=0.1588
56+	-		-		-		-		-		-		-		-	
Race																
White, non-Hispanic	-		-		-		-		-		-		-		-	
White, Hispanic	-0.5023	p=0.1084	-0.5120	p=0.1032	-0.4791	p=0.1196	-0.4870	p=0.1256	-0.5079	p=0.1027	-0.5128	p=0.1008	-0.4814	p=0.1206	-0.5170	p=0.0988
Black, non-Hispanic	-0.1620	p=0.5179	-0.1789	p=0.4771	-0.1760	p=0.4754	-0.0615	p=0.8096	-0.1662	p=0.5050	-0.1756	p=0.4835	-0.1562	p=0.5294	-0.1813	p=0.4700
Black, Hispanic	-2.0823	p=0.1731	-1.9130	p=0.2094	-1.8940	p=0.2096	-1.8323	p=0.2355	-1.8859	p=0.2139	-1.9159	p=0.2081	-1.8915	p=0.2136	-1.9364	p=0.2042
Other	-0.0048	p=0.9913	-0.0646	p=0.8835	-0.0238	p=0.9561	-0.1829	p=0.6835	-0.0585	p=0.8935	-0.0602	p=0.8909	-0.0541	p=0.9012	-0.0639	p=0.8843
Education																
12th grade or less	0.2957	p=0.4166	0.2680	p=0.4633	0.2496	p=0.4854	0.1934	p=0.6011	0.2809	p=0.4373	0.2808	p=0.4395	0.2390	p=0.5073	0.2850	p=0.4335
College	-0.2929	p=0.1346	-0.2780	p=0.1568	-0.2788	p=0.1472	-0.3302	p=0.0976	-0.2711	p=0.1631	-0.2714	p=0.1643	-0.2881	p=0.1373	-0.2693	p=0.1683
Post-college graduate	-		-		-		-		-		-		-		-	
HIV Serostatus																
Negative	-		-		-		-		-		-		-		-	
Positive	**0.3460**	**p=0.0461**	0.3341	p=0.0551	0.3260	p=0.0558	0.2456	p=0.1645	0.3196	p=0.0638	0.3278	p=0.0588	0.3082	p=0.0727	0.3312	p=0.0564
Sexual Sensation Seeking																
1.0–2.5 disagree																
2.6–3.5 neutral																
3.6– 5.0 agree	-		-		-		-		-		-		-		-	
	0.8100	**p<0.0001**	**0.8046**	**p<0.0001**	**0.7561**	**p<0.0001**	**0.8388**	**p<0.0001**	**0.7982**	**p<0.0001**	**0.8015**	**p<0.0001**	**0.7609**	**p<0.0001**	**0.8032**	**p<0.0001**
	0.8613	**p<0.0001**	**0.8746**	**p<0.0001**	**0.8134**	**p<0.0001**	**0.8982**	**p<0.0001**	**0.8705**	**p<0.0001**	**0.8732**	**p<0.0001**	**0.8091**	**p<0.0001**	**0.8758**	**p<0.0001**
Main Partner																
No	0.1088	p=0.1494	0.1185	p=0.1190	0.1102	p=0.1460	0.1302	p=0.0893	0.1168	p=0.1236	0.1176	p=0.1215	0.1097	p=0.1483	0.1174	p=0.1217
Yes	-		-		-		-		-		-		-		-	
Alcohol																
No	-															
Yes	**0.2656**	**p=0.0027**														
Poppers																
No			-													
Yes			-0.0924	p=0.2345												

EDDs No Yes			- **0.1705 p=0.0029**					
Stimulants No Yes				- **0.6027 p=0.0008**				
Poppers + EDDs No Yes					- 0.0466 p=0.5218			
Simulants + Poppers No Yes						- -0.022 p=0.7785		
Stimulants + EEDs No Yes							- **0.2089 p=0.0004**	
Stimulants + Poppers + EDDs No Yes								- -0.054 p=0.4721

Appendix 1: Unconditional Means Model (Intercept) Fit Statistics for number of UAI partners met through the Internet, at bars, and at bathhouses since last visit as Poisson distribution among MACS participants 2006-2010

Internet UAI Partners

Fit Statistics for Conditional Distribution	
-2 log L(Int UAI | r. effects)	5783.29
Pearson Chi-Square	2573.27
Pearson Chi-Square / DF	2.29

Bar UAI Partners

Fit Statistics for Conditional Distribution	
-2 log L(Bar UAI | r. effects)	1277.73
Pearson Chi-Square	316.96
Pearson Chi-Square / DF	0.82

Bathhouse UAI Partners

Fit Statistics for Conditional Distribution	
-2 log L(BTH_N | r. effects)	3320.09
Pearson Chi-Square	1457.24
Pearson Chi-Square / DF	2.33

Appendix 2: Unconditional Means Model (Intercept) AIC, AICC, BIC, HQIC fit statistics and -2 Log Likelihood score for number of UAI partners met through the Internet, at bars, and at bathhouses among MACS participants 2006-2010

Internet

Fit Statistics	
-2 Log Likelihood	1253.68
AIC (smaller is better)	1257.68
AICC (smaller is better)	1257.69
BIC (smaller is better)	1269.33
CAIC (smaller is better)	1271.33
HQIC (smaller is better)	1261.91

Bar

Fit Statistics	
-2 Log Likelihood	-4767.36
AIC (smaller is better)	-4763.36
AICC (smaller is better)	-4763.33
BIC (smaller is better)	-4751.72
CAIC (smaller is better)	-4749.72
HQIC (smaller is better)	-4759.14

Bathhouse

Fit Statistics	
-2 Log Likelihood	-2175.91
AIC (smaller is better)	-2171.91
AICC (smaller is better)	-2171.89
BIC (smaller is better)	-2160.26
CAIC (smaller is better)	-2158.26
HQIC (smaller is better)	-2167.68

Appendix 3: Solutions for Fixed Effects for basic demographics for partners met through the Internet, at bars, and at bathhouses among MACS participants 2006-2010

Internet Categorical Age

Solutions for Fixed Effects

Effect	AgeCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		1.0620	0.1270	422	8.36	<.0001	0.05	0.8123	1.3116
AgeCat	1	0.2203	0.3834	422	0.57	0.5659	0.05	-0.5333	0.9739
AgeCat	2	-0.09945	0.1986	422	-0.50	0.6168	0.05	-0.4899	0.2910
AgeCat	3	-0.1277	0.1629	422	-0.78	0.4334	0.05	-0.4478	0.1924
AgeCat	4	-0.01556	0.1519	422	-0.10	0.9184	0.05	-0.3141	0.2830
AgeCat	5	0	.	.	.	.	.	.	.

Internet Categorical Race/Ethnicity

Solutions for Fixed Effects

Effect	RaceCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		1.0759	0.06560	422	16.40	<.0001	0.05	0.9470	1.2049
RaceCat	1	-0.2679	0.2329	422	-1.15	0.2507	0.05	-0.7256	0.1899
RaceCat	2	-1.3152	0.8322	422	-1.58	0.1148	0.05	-2.9510	0.3206
RaceCat	3	-0.1063	0.1402	422	-0.76	0.4487	0.05	-0.3819	0.1693
RaceCat	4	-0.2616	0.2037	422	-1.28	0.1998	0.05	-0.6621	0.1388
RaceCat	5	0	.	.	.	.	.	.	.

Internet Categorical Education

Solutions for Fixed Effects

Effect	EducbasCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		1.1053	0.09887	424	11.18	<.0001	0.05	0.9109	1.2996
EducbasCat	1	0.1017	0.1917	424	0.53	0.5961	0.05	-0.2752	0.4786
EducbasCat	2	-0.1683	0.1199	424	-1.40	0.1611	0.05	-0.4039	0.06733
EducbasCat	3	0	.	.	.	.	.	.	.

Internet Study Center

Solutions for Fixed Effects

Effect	CENTR	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		1.1182	0.1001	423	11.18	<.0001	0.05	0.9215	1.3148
Baltimore	1	-0.2030	0.1467	423	-1.38	0.1671	0.05	-0.4914	0.08535
Chicago	2	-0.05097	0.1531	423	-0.33	0.7393	0.05	-0.3518	0.2499
Pittsburgh	3	-0.1680	0.1445	423	-1.16	0.2454	0.05	-0.4520	0.1159
Los Angeles	4	0	.	.	.	.	.	.	.

Bar Categorical Age

Solutions for Fixed Effects

Effect	AgeCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		0.9300	0.1424	200	6.53	<.0001	0.05	0.6491	1.2109
AgeCat	**1**	-0.03901	0.3011	200	-0.13	0.8971	0.05	-0.6328	0.5548
AgeCat	**2**	-0.1074	0.2115	200	-0.51	0.6122	0.05	-0.5245	0.3097
AgeCat	**3**	-0.3486	0.1716	200	-2.03	0.0535	0.05	-0.6869	-0.01029
AgeCat	**4**	-0.2951	0.1661	200	-1.78	0.0772	0.05	-0.6227	0.03248
AgeCat	**5**	0	.	.	.	.	.	.	.

Bar Categorical Race/Ethnicity

Solutions for Fixed Effects

Effect	RaceCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		0.7095	0.07024	200	10.10	<.0001	0.05	0.5710	0.8480
RaceCat	**1**	-0.05120	0.2152	200	-0.24	0.8122	0.05	-0.4756	0.3732
RaceCat	**2**	0.3091	0.8142	200	0.38	0.7046	0.05	-1.2964	1.9146
RaceCat	**3**	-0.00106	0.1520	200	-0.01	0.9944	0.05	-0.3007	0.2986
RaceCat	**4**	-0.2544	0.2227	200	-1.14	0.2546	0.05	-0.6936	0.1847
RaceCat	**5**	0	.	.	.	.	.	.	.

Bar Categorical Education

Solutions for Fixed Effects

Effect	EducbasCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		0.7920	0.1022	202	7.75	<.0001	0.05	0.5905	0.9935
EducbasCat	1	0.04433	0.1792	202	0.25	0.8049	0.05	-0.3091	0.3977
EducbasCat	2	-0.1913	0.1239	202	-1.54	0.1242	0.05	-0.4356	0.05301
EducbasCat	3	0	.	.	.	.	.	.	.

Bar Study Center

Solutions for Fixed Effects

Effect	CENTR	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		0.8301	0.1024	201	8.10	<.0001	0.05	0.6282	1.0321
Baltimore	1	-0.1555	0.1537	201	-1.01	0.3129	0.05	-0.4586	0.1476
Chicago	2	-0.1816	0.1655	201	-1.10	0.2739	0.05	-0.5078	0.1447
Pittsburgh	3	-0.2425	0.1425	201	-1.70	0.0904	0.05	-0.5235	0.03850
Los Angeles	4	0	.	.	.	.	.	.	.

Bathhouse Categorical Age

Solutions for Fixed Effects

Effect	AgeCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		1.1948	0.1659	242	7.20	<.0001	0.05	0.8681	1.5215
AgeCat	**1**	-0.4155	0.5998	242	-0.69	0.4891	0.05	-1.5971	0.7660
AgeCat	**2**	0.2143	0.2954	242	0.73	0.4688	0.05	-0.3675	0.7962
AgeCat	**3**	-0.08593	0.2094	242	-0.41	0.6819	0.05	-0.4984	0.3266
AgeCat	**4**	-0.2201	0.1986	242	-1.11	0.2688	0.05	-0.6113	0.1711
AgeCat	**5**	0	.	.	.	.	.	.	.

Bathhouse Categorical Race/Ethnicity

Solutions for Fixed Effects

Effect	RaceCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		1.1691	0.08399	242	13.92	<.0001	0.05	1.0037	1.3346
RaceCat	**1**	-0.04609	0.3288	242	-0.14	0.8886	0.05	-0.6937	0.6015
RaceCat	**2**	-1.3351	1.2474	242	-1.07	0.2855	0.05	-3.7923	1.1220
RaceCat	**3**	-0.3605	0.2136	242	-1.69	0.0928	0.05	-0.7812	0.06027
RaceCat	**4**	-0.3161	0.2589	242	-1.22	0.2234	0.05	-0.8261	0.1940
RaceCat	**5**	0	.	.	.	.	.	.	.

Bathhouse Categorical Education

Solutions for Fixed Effects

Effect	EducbasCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		1.1971	0.1288	244	9.30	<.0001	0.05	0.9435	1.4508
EducbasCat	**1**	0.2471	0.2839	244	0.87	0.3850	0.05	-0.3122	0.8063
EducbasCat	**2**	-0.2069	0.1564	244	-1.32	0.1873	0.05	-0.5150	0.1013
EducbasCat	**3**	0	.	.	.	.	.	.	.

Bathhouse Study Center

Solutions for Fixed Effects

Effect	CENTR	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		0.9779	0.1282	243	7.63	<.0001	0.05	0.7254	1.2305
CENTR	**1**	0.000450	0.2150	243	0.00	0.9983	0.05	-0.4231	0.4240
Baltimore	**2**	0.3020	0.1932	243	1.56	0.1193	0.05	-0.07850	0.6825
Chicago	**3**	0.1317	0.1860	243	0.71	0.4796	0.05	-0.2347	0.4981
Pittsburgh	**4**	0	.	.	.	.	.	.	.
Los Angeles									

Appendix 4: Solutions for Fixed Effects for SSS and partner type for partners met at bars among MACS participants 2006-2010

Solutions for Fixed Effects

Effect	SSSCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		0.7078	0.1283	195	5.52	<.0001	0.05	0.4548	0.9608
SSSCat	**1**	-0.06914	0.1461	174	-0.47	0.6366	0.05	-0.3574	0.2191
SSSCat	**2**	0.02708	0.1521	174	0.18	0.8588	0.05	-0.2730	0.3272
SSSCat	**3**	0	.	.	.	.	.	.	.

Solutions for Fixed Effects

Effect	MainPart	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		0.6344	0.08633	198	7.35	<.0001	0.05	0.4642	0.8047
MainPart	**1**	0.07538	0.09833	176	0.77	0.4443	0.05	-0.1187	0.2694
MainPart	**2**	0	.	.	.	.	.	.	.

References

1. Weinhardt LS. Effects of a detailed sexual behavior interview on perceived risk of HIV infection: Preliminary experimental analysis in a high risk sample. Journal of Behavioral Medicine 2002;25:195–203
2. Mustanski B. Moderating effects of age on the alcohol and sexual risk taking association: an online daily diary study of men who have sex with men. AIDS Behav. 2008;12(1):118–26
3. Colfax G, Vittinghoff E, Husnik MJ, McKirnan D, Buchbinder S, Koblin B, et al. Substance use and sexual risk: a participant- and episode-level analysis among a cohort of men who have sex with men. Am J Epidemiol. 2004;159(10):1002–12
4. Irwin TW, Morgenstern J, Parsons JT, Wainberg M, Labouvie E. Alcohol and sexual HIV risk behavior among problem drinking men who have sex with men: an event level analysis of timeline followback data. AIDS Behav. 2006;10(3):299–307
5. Gillmore MR, Morrison DM, Leigh BC, Hoppe MJ, Gaylord J, Rainey DT. Does ''high = high risk''? An event-based analysis of the relationship between substance use and unprotected sex among gay and bisexual men. AIDS Behav. 2002;6(4):361–70
6. Vanable PA, McKirnan DJ, Buchbinder SP, Bartholow BN, Douglas JM Jr, Judson FN, et al. Alcohol use and high-risk sexual behavior among men who have sex with men: the effects of consumption level and partner type. Health Psychol. 2004;23(5):525–32
7. Weinhardt LS, Carey MP. Does alcohol lead to sexual risk behavior? Findings from event-level research. Annual Review of Sex Research 2001;12:125–157
8. Leigh BC. Alcohol and condom use; A Meta-analysis of event-level studies. Sexually Transmitted Diseases. 2002;29:476–482
9. Drumright LN, Little SJ, Strathdee SA, Slymen DJ, Araneta MR, Malcarne VL, Daar ES, Gorbach PM. Unprotected anal intercourse and substance use among men who have sex with men with recent HIV infection. J Acquir Immune Defic Syndr. 2006;43:344–350
10. Leigh BC, Morrison DM, Hoppe MJ, Beadnell B, Gillmore MR. Retrospective assessment of the association between drinking and condom use. J Stud Alcohol Drugs. 2008;69(5):773–6
11. Mustanski B. The influence of state and trait affect on HIV risk behaviors: a daily diary study of MSM. Health Psychol. 2007;26(5):618–26
12. Bancroft J. Individual differences in sexual risk taking: a biopsychosocial theoretical approach. In: Bancroft J, editor. The role of theory in sex research. Bloomington: Indiana University Press; 2000. p. 172–212
13. Kalichman SC, Weinhardt L. Negative affect, sexual risk behavior: comment on Crepaz, Marks (2001). Health Psychol. 2001;20(4):300–1
14. Leigh BC, Stall R. Substance use and risky sexual behavior for exposure to HIV. Issues in methodology, interpretation and prevention. American Psychologist. 1993;48:1035–1045
15. McKirnan DJ, Vanable PA, Ostrow DG, Hope B. Expectancies of sexual ''escape'' and sexual risk among drug and alcohol involved gay and bisexual men. Journal of Substance Abuse. 2001;13:137–154
16. Weinhardt LS, Otto-Salaj LL, Brondino MJ, Norberg MM, Kalichman SC. Sex-related alcohol expectancies predict sexual risk behavior among severely and persistently mentally ill adults. Psychology of Addictive Behaviors. 2002;16:64–67
17. Bosga MB, de Wit JB, de Vroome EM, et al. Differences in perception of risk for HIV infection with steady and non-steady partners among homosexual men. AIDS Educ Prev. 1998;7:103–115
18. Hoff CC, Stall R, Paul J, et al. Differences in sexual behavior among HIV discordant and concordant gay men in primary relationships. J Acquir Immune Defic Syndr Hum Retrovirol. 1997;14:72–78
19. Moreau-Gruet F, Jeannin A, Dubois-Arber F, et al. Management of the risk of HIV infection in male homosexual couples. AIDS. 2001;15:1025–1035
20. Myers T, Allman D, Calzavara L, et al. Gay and bisexual men's sexual partnerships and variations in risk behaviour. Can J Hum Sex. 1999;8:115
21. Wagner GJ, Remien RH, Carballo-Dieguez A. Extramarital sex: is there an increased risk for HIV transmission? A study of male couples of mixed HIV status. AIDS Educ Prev. 1998;10:245–256
22. Stueve A, O'Donnell L, Duran R, San Doval A, Geier J. Being high and taking sexual risks: findings from a multisite survey of urban young men who have sex with men. AIDS Educ Prev. 2002;14(6):482–95
23. Seage GR, Mayer KH, Wold C, Lenderking W, Goldstein R, Cai B, Gross M, Herren T, Hingson R. The Social context of drinking, drug use, and unsafe sex in the Boston Men Study. Journal of Acquired Immune Deficiency Syndrome and Human Retrovirology. 1998;17(4):368–375
24. Dawson JM, Fitzpatrick RM, Reeves G, et al. Awareness of sexual partners' HIV status as an influence upon high-risk sexual behavior among gay men. AIDS. 1994;8:837–841
25. Hays RB, Paul J, Ekstrand M, et al. Actual versus perceived HIV status, sexual behaviors and predictors of unprotected sex among young gay and bisexual men who identify as HIV-negative, HIV-positive and untested. AIDS. 1997;11:1495–1502
26. Semple SJ, Patterson TL, Grant I. Partner type and sexual risk behavior among HIV positive gay and bisexual men: social cognitive correlates. AIDS Educ Prev. 2000;12:340–356
27. de Vroome EMM, de Wit JBF, Stroebe W, et al. Sexual behavior and depression among HIV-positive gay men. AIDS Behav. 1998;2:137–149

28. Grulich AE, Prestage GP, Kippax SC, et al. HIV serostatus of sexual partners of HIV-positive and HIV-negative homosexual men in Sydney. AIDS. 1998;12:2508
29. Hays RB, Kegeles SM, Coates TJ. Unprotected sex and risk taking among young gay men within boyfriend relationships. AIDS Educ Prev. 1997;9:314–329
30. Marks G, Bingman CR, Duvas TS. Negative affect and unsafe sex in HIV positive men. AIDS Behav. 1998;2:89–99
31. Lightfoot M, Song J, Rotheram-Borus MJ, Newman P. The influence of partner type and risk status on the sexual behavior of young men who have sex with men living with HIV/AIDS. J Acquir Immune Defic Syndr. 2005 Jan 1;38(1):61-8
32. Elliot DS, Huizinga D, Ageton SS. Explaining delinquency and drug use. Beverly Hills: Sage; 1985
33. Zinberg, NE. Drug, set and setting: The basis for controlled intoxicant use. New Haven: Yale University Press; 1984
34. Binson D, Woods WJ, Pollack L, Paul J, Stall R, Catania JA. Differential HIV risk in bathhouses and public cruising areas. Am J Public Health. 2001 Sep;91(9):1482-6
35. Reece M, Dodge B. Exploring the physical, mental and social well-being of gay and bisexual men who cruise for sex on a college campus. J Homosex. 2003;46(1-2):111-36
36. Parsons JT, Halkitis PN. Sexual and drug-using practices of HIV-positive men who frequent public and commercial sex environments. AIDS Care. 2002 Dec;14(6):815-26
37. Chiasson MA, Parsons JT, Tesoriero JM, Carballo-Dieguez A, Hirshfield S, Remien RH. HIV behavioral research online. J Urban Health. 2006 Jan;83(1):73-85. Review
38. Bolding G, Davis M, Hart G, Sherr L, Elford J. Gay men who look for sex on the Internet: is there more HIV/STI risk with online partners? AIDS. 2005 Jun 10;19(9):961-8
39. Halkitis PN, Parsons JT. Recreational drug use and HIV risk sexual behavior among men frequenting urban gay venues. Journal of Gay and Lesbian Social Services. 2002;14:19–39
40. Grov C, Hirshfield S, Remien RH, Humberstone M, Chiasson MA. Exploring the Venue's Role in Risky Sexual Behavior Among Gay and Bisexual Men: An Event-Level Analysis from a National Online Survey in the U.S. Arch Sex Behav. 2011 Oct 20. [Epub ahead of print]
41. Hayaki J, Anderson B, Stein M. Sexual risk behaviors among substance users: Relationship to impulsivity. Psychology of Addictive Behaviors. 2006;20:328–332
42. Mccoul MD, Haslam N. Predicting high risk sexual behaviour in heterosexual and homosexual men: The roles of impulsivity and sensation seeking. Personality and Individual Differences. 2001;31:1303–1310
43. Kalichman SC, Heckman T, Kelly JA. Sensation seeking as an explanation for the association between substance use and HIV-related risky sexual behavior. Archives of Sexual Behavior. 1996;25:141–154
44. Zuckerman M. Behavioral expressions and biosocial bases of sensation seeking. Cambridge: Cambridge University Press; 1994
45. Bancroft J, Janssen E, Strong D, Carnes L, Vukadinovic Z, Long JS. Sexual risk-taking in gay men: the relevance of sexual arousability, mood, and sensation seeking. Arch Sex Behav. 2003;32(6):555–72
46. Hittner JB, Swickert R. Sensation seeking and alcohol use: a meta-analytic review. Addict Behav. 2006;31(8):1383–401
47. Woolf SE, Maisto SA. Alcohol use and risk of HIV infection among men who have sex with men. AIDS Behav. 2009;13(4):757–82
48. Kalichman SC, Tannenbaum L, Nachimson D. Personality and cognitive factors influencing substance use and sexual risk for HIV infection among gay and bisexual men. Psychol Addict Behav. 1998;12:262–71
49. Kalichman SC, Weinhardt L, DiFonzo K, Austin J, Luke W. Sensation seeking and alcohol use as markers of sexual transmission risk behavior in HIV-positive men. Ann Behav Med. 2002;24(3):229–35
50. Kaslow RA, Ostrow DG, Detels R, et al. The Multicenter AIDS Cohort Study: rationale, organization, and selected characteristics of the participants. Am J Epidemiol. 1987;126(2):310–318
51. Dudley J, Jin S, Hoover D, Metz S, et al. The Multicenter AIDS Cohort Study: retention after 9 ½ years. Am J Epidemiol. 1995;142(3):323–330
52. MACS Public Data Set. http://www.statepi.jhsph.edu/macs/pdt.html [Accessed January 3, 2013]
53. Gribble JN, Miller HG, Cooley PC, et al. The impact of T-ACASI interviewing on reported drug use among men who have sex with men. Subst Use Misuse. 2000; 35(6–8):869–890
54. Multicenter AIDS Cohort Study Data Working Group Meeting. CAMACS Report October 2011.
55. Ostrow DG, Fox KJ, Chmiel JS, Silvestre A, Visscher BR, Vanable PA, Jacobson LP, Strathdee SA. Attitudes towards highly active antiretroviral therapy are associated with sexual risk taking among HIV-infected and uninfected homosexual men. AIDS. 2002;16:775–780
56. Crawford I, Hammack PL, McKirnan DJ, Ostrow D, Zamboni BD, Robinson B, Hope B. Sexual sensation seeking, reduced concern about HIV and sexual risk behavior among gay men in primary relationships. AIDS Care. 2003;15:513–524
57. Vanable PA, Ostrow DG, McKirnan DJ, Taywaditep KJ, Hope BA. Impact of combination therapies on HIV risk perceptions and sexual risk among HIV-positive and HIVnegative gay and bisexual men. Health psychology. 2000;19:134–145
58. Vanable PA, Ostrow DG, McKirnan DJ. Viral load and HIV treatment attitudes as correlates of sexual risk behavior among HIV-positive gay men. Journal of Psychosomatic Research. 2003;54:263–269
59. Ostrow D, Fox K, Kleeberger C, Jacobson LP, Chmiel JS, Silvestre A, Visscher BR, Strathdee SA. Psychosocial correlates of incomplete adherence to HIV antiretroviral therapy (HAART): Mental health matters. 8th Conference on Retroviruses and Opportunistic Infections, Chicago, IL. 2001

60. Darilay A, Jacobson L, Behavior and Data Working Groups. Marginal vs Event Questionnaire. October 2010
61. Plankey MW, Ostrow DG, Stall R, et al. The relationship between methamphetamine and popper use and risk of HIV seroconversion in the multicenter AIDS cohort study. J Acquir Immune Defic Syndr. 2007;45(1):85–92
62. Ostrow DG, Plankey MW, Cox C, Li X, Shoptaw S, Jacobson LP, Stall RC. Specific sex drug combinations contribute to the majority of recent HIV seroconversions among MSM in the MACS. J Acquir Immune Defic Syndr. 2009 Jul 1;51(3):349-55
63. Vosburgh HW, Mansergh G, Sullivan PS, Purcell DW. A Review of the Literature on Event-Level Substance Use and Sexual Risk Behavior Among Men Who Have Sex with Men. AIDS Behav. 2012 Feb 10. [Epub ahead of print]
64. Purcell DW, Parsons JT, Halkitis PN, Mizuno Y, Woods WJ. Substance use and sexual transmission risk behavior of HIV-positive men who have sex with men. Journal of Substance Abuse. 2001;13:185–200
65. Parsons JT, Kutnick AH, Halkitis PN, Punzalan JC, Carbonari JP. Sexual risk behaviors and substance use among alcohol abusing HIVpositive men who have sex with men. Journal of Psychoactive Drugs. 2005;37:27-36
66. Purcell DW, Moss S, Remien RH, Woods WJ, Parsons JT. Illicit substance use, sexual risk, and HIV-positive gay and bisexual men: Differences by serostatus of casual partners. AIDS. 2005;19:S37-S47
67. Stall R, Paul JP, Greenwood G, Pollack LM, Bein E, Crosby GM, et al. Alcohol use, drug use and alcohol-related problems among men who have sex with men: The urban men's health study. Addiction. 2001;96:1589-1601
68. Hirschfield S, Remien RH, Humberstone M, Walavalkar I, Chiasson MA. Substance use and high-risk sex among men who have sex with men: A national online study in the USA. AIDS Care. 2004;16:1036-1047
69. Feinberg SE, Tanur JM. Large-scale social surveys: Perspectives, problems, and prospects. Behavioral Science 1983;28:135–153
70. Birnbaum IM, Parker ES. Acute effects of alcohol on storage and retrieval. In: Birnbaum, IM.; Parker, ES., editors. Alcohol and human memory. Wiley: New York; 1977. p. 99-108
71. Eich JE. State-dependent retrieval of information in human episodic memory. In: Birnbaum, IM.; Parker, ES., editors. Alcohol and human memory. New York: Wiley; 1977. p. 141-157
72. Blair E, Sudman S, Bradburn NM, Stocking C. How to ask questions about drinking and sex: Response effects in measuring consumer behavior. Journal of Marketing Research 1977;14:316–321
73. Bradburn N, Sudman S, Blair E. Improving interview method and questionnaire design. San Francisco: Jossey-Bass; 1979.
74. Miller HG, Turner CF, Moses LE. Editors. AIDS: The second decade (Ch. 6: Methodological issues in AIDS surveys). Washington, D.C.: National Academy Press; 1990.

Substance use and sexual risk behavior among men who have sex with men (MSM) in the Multicenter AIDS Cohort Study (MACS):

Comparison of global versus venue-specific assessment approaches

Earl Ryan Burrell, MPH; Michael W. Plankey, PhD; Marjan Javanbakht, MPH, PhD; Steve Shoptaw, PhD; Ron Brookmeyer, MS, PhD; Robert J. Kim-Farley, MPH, MD; Roger Detels, MS, MD

Abstract

We utilize the multiple measurement approaches available in the Multicenter AIDS Cohort Study (MACS) to build Generalized Linear Mixed Models (GLMMs) describing the association of substance use and sexual risk measured at the global level, and compare results to our previously published work using a venue-specific assessment approach. GLMMs were used to simultaneously model between-subject and within-subject variability in sexual risk behaviors (HIV serostatus, sexual sensation seeking, partner type, and venue of sexual encounter) among 1,012 seropositive and 1,084 seronegative participants seen between 2006 and 2010. All alcohol and drug use combinations were associated with having a higher numbers of unprotected anal intercourse (UAI) partners since last visit, regardless of venue of sexual encounter, when measured at the global level. These results reflect those from a venue-specific analyses of substance use and sexual risk conducted in the same cohort. While the global assessment approach used here does not permits causal interpretation of findings, we argue that establishing causality may not be a necessary condition for identifying the underlying person variables that confound the association between substance use and sexual risk, nor the utility of these variables in designing and implementing more tailored interventions.

Background

Gay and bisexual men (hereafter “men who have sex with men” or MSM) continue to be most at risk for the sexual transmission of HIV [1-3], and now account for more than half (approximately 53%) of all new HIV/AIDS diagnoses in the United States each year [4]. It is known that the use of alcohol and drugs before or during sexual episodes contributes to sexual risk-taking [5,6]. Several studies have reported higher rates of drug and alcohol abuse among MSM than among heterosexual men or the general population [7-9]. Individuals who abuse alcohol tend to put themselves at higher risk for HIV than those who do not [10], and among MSM alcohol use is associated with more sexual risk taking and higher numbers of sexual partners [11-14]. In addition, the use of recreational drugs, such as methamphetamine, has been associated with high rates of sexually transmitted infections (STIs), low rates of condom use, higher rates of unprotected anal intercourse (UAI), prolonged sexual activity, multiple partners, and casual partners among MSM [9,15-23].

Despite associations between substance use and sexual risk behavior among MSM, there is ambiguity in the literature due to the exposure (substance use) and outcome (sexual risk behavior) assessment measures often used. Results from analyses of specific sexual incidents have only sometimes shown that alcohol or drug use in a particular sexual encounter is associated with the occurrence of risky activities in that encounter. These inconsistencies may be partially due to differing methodologies that have been employed to examine this relationship. Leigh and Stall [24] describe three measurement approaches related to this methodological issue, making distinctions between global and situational assessments.

Global assessments measure overall quantity or frequency of exposure and outcome specified over broad recall periods, such as average rates of alcohol use and number of UAI partners, and examines the relationship between the two variables making comparisons. Research using this methodology has generally found positive associations between risky sexual behavior and substance use in both general populations [10,25] and MSM [9,26]. However, it is difficult to make causal inferences using this approach because it does not map a specific episode of substance use directly onto a specific episode of sexual behavior. In other words, the exposure and outcome do not necessarily occur together, and it is unknown whether people who use substances in general are also more likely to use substances while engaging in risky sexual behaviors.

Alternatively, situational association studies examine sexual risk behavior and substance use of a unique individual that occur simultaneously. This technique ensures that substance use and sexual behavior are temporally paired, accounting for within-persons variability in both, an improvement over global association studies [24]. This type of analysis has been conducted using retrospective accounts of behavior and prospective daily diaries. However, both of these approaches have yielded mixed results in adult MSM, with some reporting positive associations between alcohol use and sexual risk [14,18,27,28] and others finding no association [13,29,30].

Our group has previously published work using data from the Multicenter AIDS Cohort Study (MACS) that describes the venue-specific relationship between alcohol and drug use, and sexual risk behavior [31]. The MACS is a prospective cohort that uses a multi-assessment approach allowing for the unique opportunity to examine global and venue-specific substance use and sexual risk in the same cohort. Darilay and Jacobson [32] compare general and venue-specific question sets using indicators for UAI, number of partners with whom one had unprotected sex, and substance use developed from MACS visit 47-51 data. Responses among men who reported meeting new partners through the Internet, bars, or bathhouses are compared to general frequency responses over the same recall period. They find that only half of the sample reported the same number of unprotected partners on both the general and venue-specific question sets. Additionally, 66% of those who provide different answers for number of UAI partners have a higher number of unprotected partners in the general questionnaire. Using a Kappa statistic the authors show only moderate agreement overall between general and venue-specific responses for UAI (K= 0.57), substance use (K= 0.54), and

number of UAI partners (K= 0.44). This study suggests that outcomes may differ by type of questions set (global vs. venue-specific).

In the analysis presented here, we utilize the multiple measurement approaches available in the MACS to build Generalized Linear Mixed Models (GLMMs) describing the association of substance use and sexual risk measured at the global level, and compare results to our previously published work using a venue-specific assessment approach. GLMMs account for both with-in and between-person variation resulting from the MACS longitudinal repeat measure data, and are flexible enough to take advantage of both global and venue-specific measurements.

We fit GLMMs with HIV serostatus, partner type (main vs. casual), sexual sensation seeking (SSS) score, venue of sexual encounter (Internet, bar, or bathhouse), and substance use (one of eight alcohol or substance use combinations) to model sexual risk behavior (number of UAI partners since last visit), all measured at the global level. While longitudinal data with venue-specific detail may provide nuanced insight into sexual risk not available from a global perspective, we hypothesize that a core set of carefully measured variables will strongly predict UAI regardless of the assessment approach.

Methodology

Population and Study Design

We utilize data from the MACS prospective cohort to examine sexual risk behaviors measured at the global level. The study design and history of recruitment are described in detail elsewhere [31,33-35]. Briefly, the MACS is an ongoing prospective study of the natural and treated histories of HIV infection among 6,972 MSM recruited in three separate waves between 1984 and 2003 at four centers located in Baltimore-Washington, DC; Chicago; Los Angeles; and Pittsburgh. Men who reported sex with other men in the 12 months previous to study screening, and without a diagnosis of AIDS or cancer were asked to voluntarily enroll, and one center initially restricted enrollment to persons aged 18-50 years. As part of their participation, men return every 6 months for detailed interviews, physical examinations, and blood draws. Additionally, participants answer questions about medical conditions, medical treatments, sexual behavior, alcohol consumption, and drug use (medicinal and recreational) assessed using audio computer-assisted self-interviewing (ACASI), a methodology shown to yield more accurate assessments of ‘sensitive behaviors’, such as substance use sexual behaviors, than interviewer-administered questionnaires [36]. The sample used here includes 1,012 seropositive and 1,084 seronegative participants seen and alive between 2006 and 2010 (visits 46-54) [37]. All MACS questionnaires are available at http://www.statepi.jhsph.edu/macs/forms.html.

Variables of Interest

Variables included demographics reported at enrollment (age, race/ethnicity, education, and study center), health status (HIV serostatus and SSS), and global level data on alcohol and drug use (methamphetamine, cocaine, crack-cocaine, MDMA, poppers, and EDDs), sexual risk behaviors (number of UAI partners since last visit), partner type (main vs. casual), and venue of sexual encounter (Internet, bar, and bathhouse). Substance use and sexual behavior questionnaire data was collected at study visits occurring every six months, and references the time period since the previous visit.

Demographics (age, race/ethnicity, education, and study center) and other behaviors are self-reported. Age at baseline for these analyses was calculated using self-reported date of birth and was treated as a categorical covariate divided into five strata (18-25, 26-35, 36-45, 46-55, 56+). Race/ethnicity was self-reported at the first MACS study visit (initial baseline) and is categorized as White non-Hispanic (reference group), White Hispanic, Black non-Hispanic, Black Hispanic, and “other” (predominantly mixed race). Self-reported highest level of education completed at baseline was categorized as grade 12 or less, college, and post-college graduate (reference group). HIV serostatus was determined through ELISAs with confirmatory Western blot tests performed on all participants initially at baseline, and every six months thereafter if initially seronegative. The date of seroconversion was defined as the midpoint between the dates of the last HIV seronegative visit and the first HIV seropositive visit. Personal attitudes on SSS were measured in the MACS Men’s Attitude Survey (MAS) every two years [38] and consisted of 20 statements to which participants respond on a 5-point Likert scale, with scores ranging from 1 (strong disagreement) to 5 (strong agreement). Cross-sectional studies in community-based samples [39-41] and the MACS [31] have demonstrated that the attitudinal scales have robust psychometric properties and are able to predict risky sexual behavior [42]. A per item average score was calculated for each attitude subscale and then stratified as follows: 1.0–2.5 for disagree (reference group), 2.6–3.5 for neutral; and 3.6– 5.0 for agree. Partners were categorized as either main or casual. Main partners were defined as someone with whom participants have a longstanding relationship, live with, or are partnered with. Causal partners are those whom participants consider to be a one-time partner, or someone with whom they have not developed a longstanding, close relationship. Venues of sexual encounter, where participants report having met a sexual partner, were categorized into (1) Internet, (2) bar, and (3) bathhouse.

The exposure variable alcohol use was classified using both average number of drinks the participant drank per day and frequency of drinking since the last visit. Alcohol use was defined as binge drinking (having 5 or more drinks per occasion at least monthly), or heavy drinking (having 3-4 drinks at least weekly since last visit). Participants who reported low to moderate or no drinking comprise the reference group of alcohol use in this analysis. Recreational drug exposures of interest are those commonly used by MSM during sexual episodes, specifically stimulants (defined here as methamphetamine and/or crack and/or cocaine and/or MDMA), poppers, and EDDs. We used seven different combinations of these substances: (1) EDD alone, (2) poppers alone, (3) EDD + poppers, (4) stimulants alone, (5) stimulants + EDD, (6) stimulants + poppers, and (7) stimulants + EDD + poppers. The use of these drug combinations

was defined as “yes” if a participant reported using them at any time between the previous and current visit. We adopted variable categorization based on our previous research in the MACS in order to facilitate comparability of results [31].

Our outcome of interest was the number of self-reported sexual partners with whom the participant engaged in UAI (respective or insertive) since the previous visit, and was treated as non-normal (Poisson distribution) count data.

Global Question Set

In order to investigate the associations between substance use and sexual risk behavior measured at the global level, controlling for HIV serostatus, partner type, SSS score, and venue of sexual encounter, the following stand-alone questions were analyzed:

“Since your last visit, have you met one or more new sexual partners in any of the following settings? (Internet, bar, bathhouse)”

“Have you taken or used any (eight drug use combinations) since your last visit?”

“Since your last visit, with how many new partners did you have unprotected intercourse, even once?”

These global level questions refer to behavior that occurred since the previous visit, and are not temporally paired to each other. There is no way to know if the partners met at any of the venues of sexual encounter are the same partners with whom the participant engaged in UAI. Likewise, it is unknown if the substance use occurred while visiting these venues of sexual encounter, and/or if the substance use occurred before and/or during sexual encounters that included UAI.

Venue-Specific Question Set

Our team has previously looked at the relationship between substance use and sexual risk behaviors in the same study population using the venue-specific measurements also available in the MACS [31]. We similarly fit GLMMs with age, race/ethnicity, education, HIV serostatus, SSS score, and partner type in order to model number of UAI partners met through the Internet, at bars, or at bathhouse. However, in our previous analysis venue-specific variables were measured as follows:

"Since your last visit, how many new partners with whom you had unprotected anal intercourse did you meet through (*Internet/bathhouse/bar*)?"

"Thinking about the same new partners you met through the (*Internet/bathhouse/bar*), did you use any of the following substances (*eight drug use combinations*) prior to and/or during your sexual encounters?"

This venue-specific question approach ensures that both the exposure of interest (substance use combination, and venue of sexual encounter) and the outcome (number of UAI partners since last visit) are temporally paired. This is in contrast to the global level analysis we present here, where there is no knowledge of whether the substance using behavior took place at the venue of sexual encounter, or if substance use took place before and/or during a sexual episode. Detailed results of our venue-specific analysis have been published elsewhere [31].

Descriptive Statistical Analyses

Univariate analyses included two-sample t-tests for mean differences and χ^2 tests of independence to characterize demographic variables (age, race/ethnicity, education, and study center), SSS, alcohol and drug use, partner type, and venue of sexual encounter by HIV serostatus.

Generalized Linear Mixed Model (GLMM)

Because alcohol and drug use, sexual risk behaviors, partner type, and venue of sexual encounter are time varying (i.e. they were updated at each visit) we use GLMMs to model within-subject correlated variances resulting from repeated measurements (i.e., the residuals from the same individual are likely to be correlated, or dependent). Because individuals differ systematically from each other from visit to visit, we also model separate error terms for between-subject variation. We fit GLMMs to hold between-person (demographic variables, HIV serostatus, and SSS) differences constant, while allowing for within-person variation in globally assessed alcohol and drug use, venue of sexual encounter, and number of UAI partners since the previous visit.

The GLMM procedure fits statistical models to data where the response is not necessarily normally distributed, conditional on normally distributed (Gaussian) random effects. A non-normal Poisson distribution was used to estimate frequency of UAI, as this approach helps to account for deviations from normality in our outcome variable count data. This distribution

resulted in a ratio between the Pearson statistic and its degrees of freedom that was closest to 1.0 (Appendix 1). This distribution also accounts for over-dispersion in the outcome variable resulting from the presence of outliers and an over-preponderance of cases with values of zero. The default link function for the Poisson distribution in the GLMM procedure is log.

In building our GLMMs, we first fit demographic variables (age, race/ethnicity, education, and study center) independently in order to conduct hypothesis testing for the significance of each as a fixed effect in modeling number of UAI partners since last visit. GLMMs were then fitted independently with HIV serostatus, SSS, partner type, and the three venues of sexual encounter. Finally, we built separate GLMMs for each of the eight substance use categories, modeling number of UAI partners since last visit and controlling for demographics, HIV serostatus, partner type, SSS score, and venue of sexual encounter. Missing data was considered to be missing completely at random. As our sample size was adequate for the analysis proposed, complete case analysis was performed using listwise deletion. This approach has the important advantage of leading to unbiased parameter estimates. All data analysis was performed using SAS software (SAS/STAT 9.4, SAS Institute Inc., Cary, NC, USA).

Results

The participant demographics for this cohort have been described elsewhere [31] and are depicted in Table 1a. Men reported an average of 5.84 UAI partners since their last visit, with HIV seropositive men statistically significantly higher at 7.00 UAI partners, compared to HIV seronegative men at 4.36 UAI partners ($p=0.0002$) (Table 1b). HIV seronegative men were more likely to meet sexual partners through the Internet (58.38%) or at a bathhouse (57.56%) ($p=0.0002$), while there was no statistically significant difference in men meeting sexual partners at bars by HIV serostatus ($p=0.1206$). Over 70% of men reported abstaining from moderate or binge drinking since their last visit, with no statistically significant difference by HIV serostatus ($p=0.0886$). For popper use alone ($p<0.0001$), stimulant use alone ($p<0.0001$), stimulant + EDDs ($p<0.0001$), and stimulants + poppers +EDDs ($p<0.0001$), the majority of users were HIV seropositive. For EDDs alone ($p=0.0439$), poppers +EDDs ($p=0.0415$), stimulants + poppers ($p=0.0437$), the majority of abstainers were HIV seronegative.

All demographics (age, race/ethnicity, education, and study center) returned non-significant results, indicating that there was no difference in number of UAI partner since last visit by age, race/ethnicity, or education when compared to reference categories (56+ years old, White, non-Hispanic, Post-college graduate, and Los Angeles respectfully) (Table 2a). Study center was dropped from the analysis, while age, race/ethnicity, and education were forced into all final models.

Being HIV seropositive ($p\leq0.0060$), having a neutral ($p<0.0001$) and agree ($p\leq0.0001$) SSS score, not having a main partner ($p\leq0.0048$), and meeting a sexual partner through the Internet

($p<0.0001$), at a bar ($p<0.0001$), or at a bathhouse ($p<0.0001$) were all statistically significantly associated with higher numbers of UAI partners since last visit compared to reference levels (HIV seronegative, disagree SSS score, having a main partner, and not meeting a sexual partner through the Internet, at a bar, or at a bathhouse respectively) (Table 2a). These results held after controlling for demographics and across all substance use combinations. In addition, alcohol use ($p=0.0484$) and all seven drug use combinations ($p<0.0001$) were statistically significantly associated with higher numbers of UAI partners since last visit compared to reference levels (low to moderate or no drinking, and no drug use respectively) in our final model.

We now compare the findings between these two assessment approaches. No demographic variables (age, race/ethnicity, education, or study center) were statistically significantly associated with number of UAI partners when compared to references (56+ years old, White, non-Hispanic, Post-college graduate, and Los Angeles respectfully), regardless of substance use combination, using both venue-specific and global measurement approaches (Appendix 2) [31]. Study center was dropped in both studies while age, race/ethnicity, and education were forced into all final models where they remained non-significant across all substance use combinations and venues of sexual encounter [31].

Among men who reported meeting new sexual partners through the Internet, we were able to show that being HIV seropositive, having a neutral and agree SSS score, not having a main partner were all statistically significantly associated with higher numbers of UAI partners since last visit across all substance use combinations in both venue-specific [31] and global measurement studies. However, when we use venue-specific measurements to explore the relationship between substance use and number of UAI partners met at bars, SSS and partner type were both dropped during the model building exercise, indicating no statistically significant association with number of UAI partners met through this venue [31]. When using the same approach to explore the relationship between substance use and number of UAI partners met at bathhouses, HIV serostatus was only significantly associated with number of UAI partners when alcohol was used before and/or during sex (Table 2b) [31]. Having a neutral and agree SSS was statistically significantly associated with higher numbers of UAI partners across all eight substance use combinations, while partner type was not statistically significant across any [31]. This is in contrast to the global-level analysis, where being HIV seropositive, having a neutral and agree SSS score, not having a main partner were all statistically significantly associated with a higher number of UAI partners since last visit across all eight substance use combinations, and regardless of venue of sexual encounter.

When looking at venue-specific substance use combinations, popper use alone was not statistically significantly associated with number of UAI partners met through the Internet, alcohol use alone was not statistically significantly associated with number of UAI partners met at a bar, and popper use alone along with all substance use combinations that included poppers were not statistically significantly associated with number of UAI partners met at a bathhouse (Table 2b) [31]. When alcohol and drug use were measured at the global-level, we found all

combinations were statistically significantly associated with higher numbers of UAI partners since last visit.

Discussion

Using a global assessment approach, we found HIV serostatus, partner type, SSS score, meeting sexual partners through the Internet, bar, or bathhouse, and all eight substance use combinations were statistically significantly different from their reference categories in all final models (Table 2a). When compared to a venue-specific approach using the same cohort, we found that HIV serostatus, SSS score, and partner type, along with alcohol use alone, popper use alone, and substance use combinations that include poppers were attenuated dependent on the venue of sexual encounter (Table 2b). For men met through the Internet, popper use alone was not significantly associated with higher numbers of UAI partners since last visit, for men met at bars, alcohol use alone was not significantly associated with higher numbers of UAI partners since last visit, and for men met at bathhouses, popper use alone and all substance use combinations that include poppers were not significantly associated with higher numbers of UAI partners since last visit.

Both substance use and sexual behaviors are complex, and these results highlight the importance of HIV serostatus, SSS score, partner type, and venue of sexual encounter in describing the relationship between them. While no gold standard exists for substance use or sexual risk behavior measurement, it is important to discern the benefits and weaknesses of global versus venue-specific assessment approaches in order to better contribute to research, preventive, and education efforts to contain the spread of HIV. Leigh and Stall [24] suggest that only through situational association studies can causal inferences be made regarding the effect of alcohol and substance use on sexual risk behavior. Attributing causality even with evidence of a temporal relationship may still be difficult. While a venue-specific approach has the potential to offer detail critical to making causal inferences between substance use and sexual risk behavior for HIV transmission [24,43], global assessment approaches are often more convenient and cost effect to conduct, and mirror results found in more complex venue-specific assessments.

Conclusions

We were able to show a positive association between substance use and sexual risk behavior in the MACS; what is less clear is the level at which this association exists. Participants who engaged in alcohol and drug use were more likely to also engage in risky sexual behavior when measured at the global level. However, results from venue-specific analyses of sexual incidents only showed an association with particular substance use combinations at particular venues of sexual encounter. While temporality is important to deduce causality, the added burden of venue-specific questionnaires on study participants, as well as the complexities in the analysis of venue-specific data may not be necessary in the MACS when the association between

substance use and sexual risk is so well described. While the global assessment approach used here does not permit causal interpretation of findings, we argue that establishing causality may not be a necessary condition for identifying the underlying person variables that confound the association between substance use and sexual risk.

Limitations

Despite the significance of the person variables discussed here, we found that GLMMs that include alcohol use alone ($p<0.0001$) and popper use alone ($p<0.0001$) have significant random intercepts, indicating additional between-person variation that is left unexplained in our models (Table 2a). The inclusion of variables not available to us, such as the measurement of stress and/or depression, could produce GLMMs that better fit the data and account for this unexplained between-person variation. Future research may want to include these and other person variables to better model sexual risk.

Both global and venue-specific measurement approaches used in the MACS rely on self-reported data for substance use and sexual risk behaviors. Limitations with these methods include recall bias, telescoping, and social-desirability bias [44]. Because substance use and sexual activity are common enough in this population, individual instances become indistinguishable in memory and temporal order, and may be forgotten completely. Questions about both alcohol/drug use and sexual behavior are highly personal and are assumed to result in under-, rather than over-reporting [45-47]. Additional problems may arise in assessing memory of incidents that include alcohol and drug use. Substance use may then interfere with the process by which information is stored [48-49], such that memory of the specifics of the events may be incomplete or biased. This would likely result in conservative estimates of the association of substance use and sexual risk presented here, regardless of the assessment approach used.

Although MACS participants were diverse in terms of age, socioeconomic status, race/ethnicity, geographic region, and baseline levels of HIV risk, they may not be nationally representative of MSM.

Table 1a: Demographic Variables by HIV status among MACS participants 2006-2010

	HIV- (n=1296)	HIV+ (n=1205)	Overall (n=2501)	T-Test P-Value
Age in Years (SD)	50.8 (10.90)	48.1 (8.99)	49.5 (10.12)	<.0001
	HIV- (n=1296)	**HIV+ (n=1205)**	**Overall (n=2501)**	**Chi-Square P-Value**
Age Categories				
18-25	27 (71.05%)	11 (28.95%)	38 (1.52%)	
26-35	100 (52.63%)	90 (47.37%)	190 (7.60%)	
36-45	226 (40.21%)	336 (59.79%)	562 (22.47%)	
46-55	496 (48.30%)	531 (51.70%)	1027 (41.06%)	
>56	447 (65.35%)	237 (34.65%)	684 (27.35%)	<.0001
Race/Ethnicity				
White, non-Hispanic	929 (57.63%)	683 (42.37%)	1612 (64.45%)	
White, Hispanic	59 (42.14%)	81 (57.86%)	140 (5.60%)	
Black, non-Hispanic	248 (42.32%)	338 (57.68%)	586 (23.43%)	
Black, Hispanic	5 (33.33%)	10 (66.67%)	15 (0.60%)	
Other	55 (37.16%)	93 (62.84%)	148 (5.92%)	<.0001
Education				
Grade 12 or less				
Some college or college graduate	197 (40.87%)	285 (59.13%)	482 (19.28%)	
Some graduate work or graduate	638 (50.32%)	630 (49.68%)	1268 (50.72%)	
degree	460 (61.33%)	290 (38.67%)	750 (30.00%)	<.0001
Center				
Baltimore	313 (53.87%)	268 (46.13%)	581 (23.23%)	
Chicago	176 (38.34%)	283 (61.66%)	459 (18.35%)	
Pittsburgh	353 (57.49%)	261 (42.51%)	614 (24.55%)	
Los Angeles	454 (53.60%)	393 (46.40%)	847 (33.87%)	<.0001
Sexual Sensation Seeking (SSS) Score				
1.0–2.5 disagree	430 (51.19%)	410 (48.81%)	840 (40.84%)	
2.6–3.5 neutral	290 (53.31%)	254 (46.69%)	544 (26.45%)	
3.6– 5.0 agree	348 (51.71%)	325 (48.29%)	673 (32.72%)	0.7366
Main Partner in Previous 6 Months				
No	393 (52.82%)	351 (47.18%)	744 (43.53%)	
Yes	528 (54.72%)	437 (45.28%)	965 (56.47%)	0.4365

Table 1b: Outcome and Exposure Variables of Interest by HIV status among MACS participants 2006-2010

Outcome Variables of Interest

	HIV- (n=992)	HIV+ (n=1264)	Overall (n=2256)	T-Test P-Value
Number of UAI Partners Since Last Visit (SD)	4.36 (13.37)	7.00 (19.95)	5.84 (17.41)	0.0002

Exposure Variables of Interest

	HIV- (n=369)	HIV+ (n=574)	Overall (n=943)	Chi-Square P-Value
Met Partner through the Internet				0.0002
No	1539 (46.08%)	1801 (53.92%)	3340 (49.67%)	
Yes	1976 (58.38%)	1409 (41.62%)	3385 (50.33%)	
Met Partner at a Bar				0.1206
No	908 (54.53%)	757 (45.47%)	1665 (24.76%)	
Yes	2869 (56.71%)	2190 (43.29%)	5059 (75.24%)	
Met Partner at a Bathhouse				0.0002
No	966 (52.50%)	874 (47.50%)	1840 (27.36%)	
Yes	2811 (57.56%)	2073 (42.44%)	4884 (72.64%)	
Alcohol				0.0886
No	4924 (54.50%)	4111 (45.50%)	9035 (70.02%)	
Yes	2171 (56.13%)	1697 (43.87%)	3868 (29.98%)	
Poppers				<.0001
No	6240 (45.71%)	7410 (54.29%)	13650 (79.05%)	
Yes	1663 (45.96%)	1955 (54.04%)	3618 (20.95%)	
EDDs				0.0439
No	8356 (52.78%)	7475 (47.22%)	15831 (91.74%)	
Yes	713 (50.00%)	713 (50.00%)	1426 (8.26%)	
Stimulants				<.0001
No	8201 (54.29%)	6905 (45.71%)	15106 (87.50%)	
Yes	871 (40.36%)	1287 (59.64%)	2158 (12.50%)	
Poppers + EDDs				0.0415
No	8358 (52.78%)	7479 (47.22%)	15837 (91.71%)	
Yes	715 (49.97%)	716 (50.03%)	1431 (8.29%)	
Simulants + Poppers				0.0437
No	8356 (52.78%)	7476 (47.22%)	15832 (91.71%)	
Yes	716 (50.00%)	716 (50.00%)	1432 (8.29%)	
Stimulants + EEDs				<.0001
No	7410 (54.29%)	6240 (45.71%)	13650 (79.05%)	
Yes	1663 (45.96%)	1955 (54.04%)	3618 (20.95%)	

Stimulants + Poppers + EDDs				
No	8201 (54.29%)	6905 (45.71%)	15106 (87.48%)	<.0001
Yes	872 (40.33%)	1290 (59.67%)	2162 (12.52%)	

Table 2: Generalized Linear Mixed Model for number of Internet UAI partners by substance use combination among MACS participants visits 47-51

GLMM Solutions for Fixed Effects

	Alcohol		Poppers		EDDs		Stimulants		Poppers + EDDs		Simulants + Poppers		Stimulants + EEDs		Stimulants + Poppers + EEDs	
Intercept	**1.0322**	**p<0.0001**	1.0420	p=0.0524	**1.1435**	**p<0.0001**	0.0692	p=0.5311	0.0812	p=0.4572	-0.0205	p=0.8520	0.08106	p=0.4572	0.0692	p=0.5311
Age																
18-25	**0.6520**	**p=0.0360**	0.4171	p=0.1830	0.4910	p=0.1154	0.3912	p=0.2165	0.4922	p=0.1146	0.4171	p=0.1830	0.4922	p=0.1146	0.3912	p=0.2165
26-35	0.0897	p=0.5762	0.0798	p=0.6026	0.0862	p=0.5724	-0.0514	p=0.7409	0.0875	p=0.5664	0.0798	p=0.6026	0.08753	p=0.5664	-0.0514	p=0.7409
36-45	-0.1041	p=0.3998	-0.1944	p=0.1068	-0.1860	p=0.1212	**-0.2668**	**p=0.0291**	-0.1848	p=0.1238	-0.1944	p=0.1068	-0.1848	p=0.1238	**-0.2668**	**p=0.0291**
46-55	-0.1050	p=0.3361	-0.1919	p=0.0705	-0.1845	p=0.0806	-0.2079	p=0.0532	-0.1834	p=0.0825	-0.1919	p=0.0705	-0.1834	p=0.0825	-0.2079	p=0.0532
56+	-		-		-		-		-		-		-		-	
Race/Ethnicity																
White, non-Hispanic	-		-		-		-		-		-		-		-	
White, Hispanic	-0.1505	p=0.3392	-0.1944	p=0.1953	-0.2080	p=0.1641	-0.1942	p=0.2011	-0.2063	p=0.1676	-0.1944	p=0.1953	-0.2063	p=0.1676	-0.1942	p=0.2011
Black, non-Hispanic	-0.0941	p=0.3941	0.0748	p=0.4771	0.0317	p=0.7621	-0.0318	p=0.7650	0.0319	p=0.7604	0.0749	p=0.4771	0.03191	p=0.7604	-0.0318	p=0.7650
Black, Hispanic	-0.8930	p=0.0977	-0.8618	p=0.1216	-0.8806	p=0.1133	-0.9128	p=0.1045	-0.8811	p=0.1132	-0.8618	p=0.1216	-0.8811	p=0.1132	-0.9128	p=0.1045
Other	-0.2461	p=0.1716	-0.1300	p=0.4425	-0.1610	p=0.3391	-0.2463	p=0.1504	-0.1610	p=0.3392	-0.1300	p=0.4425	-0.1610	p=0.3392	-0.2463	p=0.1504
Education																
12th grade or less	-0.0820	p=0.5671	-0.0118	p=0.9298	-0.0444	p=0.7395	-0.1210	p=0.3722	-0.0462	p=0.7291	-0.0118	p=0.9298	-0.0462	p=0.7291	-0.1210	p=0.3722
College	-0.0935	p=0.3062	-0.1126	p=0.2103	-0.1459	p=0.1031	-0.1741	p=0.0561	-0.1470	p=0.1006	-0.1126	p=0.2103	-0.1470	p=0.1006	-0.1741	p=0.0561
Post-college graduate	-		-		-		-		-		-		-		-	
HIV Serostatus																
Negative	-		-		-		-		-		-		-		-	
Positive	**0.2207**	**p=0.0060**	**0.2418**	**p=0.0020**	**0.3075**	**p<0.0001**	**0.2279**	**p=0.0040**	**0.3075**	**p<0.0001**	**0.2418**	**p=0.0020**	**0.3075**	**p<0.0001**	**0.2279**	**p=0.0040**
Sexual Sensation Seeking																
1.0–2.5 disagree																
2.6–3.5 neutral																
3.6– 5.0 agree	-		-		-		-		-		-		-		-	
	0.3910	**p<0.0001**	**0.2845**	**p<0.0001**	**0.2693**	**p<0.0001**	**0.5205**	**p<0.0001**	**0.2694**	**p<0.0001**	**0.2845**	**p<0.0001**	**0.2694**	**p<0.0001**	**0.5205**	**p<0.0001**
	0.6474	**p<0.0001**	**0.5003**	**p<0.0001**	**0.4569**	**p<0.0001**	**0.3303**	**p<0.0001**	**0.4571**	**p<0.0001**	**0.5003**	**p<0.0001**	**0.4571**	**p<0.0001**	**0.3303**	**p<0.0001**
Main Partner																
No	**0.1187**	**p=0.0048**	**0.1727**	**p<0.0001**	**0.1786**	**p<0.0001**	**0.1818**	**p<0.0001**	**0.1786**	**p<0.0001**	**0.1727**	**p<0.0001**	**0.1786**	**p<0.0001**	**0.1818**	**p<0.0001**
Yes	-		-		-		-		-		-		-		-	
Met Partner through the Internet																
No																
Yes	-		-		-		-		-		-		-		-	
	0.2983	**p<0.0001**	**0.3309**	**p<0.0001**	**0.3427**	**p<0.0001**	**0.3576**	**p<0.0001**	**0.3427**	**p<0.0001**	**0.3309**	**p<0.0001**	**0.3427**	**p<0.0001**	**0.3576**	**p<0.0001**
Met Partner at a Bar																
No																
Yes	-		-		-		-		-		-		-		-	
	0.1857	**p<0.0001**	**0.2883**	**p<0.0001**	**0.2768**	**p<0.0001**	**0.2694**	**p<0.0001**	**0.2768**	**p<0.0001**	**0.2883**	**p<0.0001**	**0.2768**	**p<0.0001**	**0.2694**	**p<0.0001**

Met Partner at a Bathhouse No Yes	- **0.4330 p<0.0001**	- **0.4433 p<0.0001**	- **0.4426 p<0.0001**	- **0.4448 p<0.0001**	- **0.4426 p<0.0001**	- **0.4433 p<0.0001**	- **0.4426 p<0.0001**	- **0.4448 p<0.0001**
Alcohol No Yes	- **-0.0882 p=0.0484**							
Poppers No Yes		- **0.3647 p<0.0001**						
EDDs No Yes			- **0.3691 p<0.0001**					
Stimulants No Yes				- **0.6728 p<0.0001**				
Poppers + EDDs No Yes					- **0.3691 p<0.0001**			
Simulants + Poppers No Yes						- **0.3647 p<0.0001**		
Stimulants + EEDs No Yes							- **0.3691 p<0.0001**	
Stimulants + Poppers + EDDs No Yes								- **0.6728 p<0.0001**

Table 2b: Generalized Linear Mixed Model for number of UAI partners among MACS participants 2006-2010, global vs. venue-specific assessment comparison

GLMM Solutions for Fixed Effects

	Alcohol		Poppers		EDDs		Stimulants		Poppers + EDDs		Simulants + Poppers		Stimulants + EEDs		Stimulants + Poppers + EEDs	
Internet																
Global Poppers																
No			-													
Yes			**0.3647**	**p<0.0001**												
Venue-specific Poppers																
No			-													
Yes			0.0757	p=0.1133												
Bar																
Global Alcohol																
No	-															
Yes	**-0.0882**	**p=0.0484**														
Venue-specific Alcohol																
No	-															
Yes	-0.0949	p=0.4717														
Bathhouse																
Global HIV Serostatus																
Negative			-		-		-		-		-		-		-	
Positive			**0.2418**	**p=0.0020**	**0.3075**	**p<0.0001**	**0.2279**	**p=0.0040**	**0.3075**	**p<0.0001**	**0.2418**	**p=0.0020**	**0.3075**	**p<0.0001**	**0.2279**	**p=0.0040**
Venue-specific HIV Serostatus																
Negative			-		-		-		-		-		-		-	
Positive			0.3341	p=0.0551	0.3260	p=0.0558	0.2456	p=0.1645	0.3196	p=0.0638	0.3278	p=0.0588	0.3082	p=0.0727	0.3312	p=0.0564
Global Main Partner																
No	**0.1187**	**p=0.0048**	**0.1727**	**p<0.0001**	**0.1786**	**p<0.0001**	**0.1818**	**p<0.0001**	**0.1786**	**p<0.0001**	**0.1727**	**p<0.0001**	**0.1786**	**p<0.0001**	**0.1818**	**p<0.0001**
Yes	-		-		-		-		-		-		-		-	
Venue-specific Main Partner																
No	0.1088	p=0.1494	0.1185	p=0.1190	0.1102	p=0.1460	0.1302	p=0.0893	0.1168	p=0.1236	0.1176	p=0.1215	0.1097	p=0.1483	0.1174	p=0.1217
Yes	-		-		-		-		-		-		-		-	
Global Poppers																
No			-													
Yes			**0.3647**	**p<0.0001**												

Venue-specific Poppers No Yes		- -0.0924 p=0.2345						
Global Poppers + EDDs No Yes					- **0.3691 p<0.0001**			
Venue-specific Poppers + EDDs No Yes					- 0.0466 p=0.5218			
Global Simulants + Poppers No Yes						- **0.3647 p<0.0001**		
Venue-specific Simulants + Poppers No Yes						- -0.022 p=0.7785		
Global Stimulants + Poppers + EDDs No Yes								- **0.6728 p<0.0001**
Venue-specific Stimulants + Poppers + EDDs No Yes								- -0.054 p=0.4721

Appendix 1: Unconditional Means Model (Intercept) Fit Statistics for number of UAI partners met since last visit as Poisson distribution among MACS participants 2006-2010

Fit Statistics for Conditional Distribution	
-2 log L(NumUAI | r. effects)	12007.41
Pearson Chi-Square	5941.30
Pearson Chi-Square / DF	2.63

Appendix 2: Solutions for Fixed Effects for basic demographics among MACS participants 2006-2010

Categorical Age

Solutions for Fixed Effects

Effect	AgeCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		0.9360	0.08871	807	10.55	<.0001	0.05	0.7618	1.1101
AgeCat	**1**	0.3647	0.2985	807	1.22	0.2222	0.05	-0.2213	0.9507
AgeCat	**2**	0.009260	0.1467	807	0.06	0.9497	0.05	-0.2786	0.2971
AgeCat	**3**	-0.06182	0.1149	807	-0.54	0.5907	0.05	-0.2874	0.1637
AgeCat	**4**	-0.02445	0.1072	807	-0.23	0.8198	0.05	-0.2350	0.1861
AgeCat	**5**	0	.	.	.	.	.	.	.

Categorical Race

Solutions for Fixed Effects

Effect	RaceCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		0.9961	0.04914	807	20.27	<.0001	0.05	0.8996	1.0926
RaceCat	**1**	-0.3382	0.1661	807	-2.04	0.0521	0.05	-0.6643	-0.01217
RaceCat	**2**	-0.9122	0.5129	807	-1.78	0.0757	0.05	-1.9191	0.09456
RaceCat	**3**	-0.1589	0.09440	807	-1.68	0.0928	0.05	-0.3442	0.02644
RaceCat	**4**	-0.2150	0.1492	807	-1.44	0.1499	0.05	-0.5078	0.07780
RaceCat	**5**	0	.	.	.	.	.	.	.

Categorical Education

Solutions for Fixed Effects

Effect	EducbasCat	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		0.9806	0.07239	809	13.55	<.0001	0.05	0.8385	1.1227
EducbasCat	**1**	-0.1559	0.1204	809	-1.30	0.1957	0.05	-0.3923	0.08042
EducbasCat	**2**	-0.07098	0.08878	809	-0.80	0.4243	0.05	-0.2453	0.1033
EducbasCat	**3**	0	.	.	.	.	.	.	.

Study Center

Solutions for Fixed Effects

Effect	CENTR	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		0.9523	0.07196	808	13.23	<.0001	0.05	0.8110	1.0935
Baltimore	**1**	-0.1268	0.1071	808	-1.18	0.2370	0.05	-0.3371	0.08351
Chicago	**2**	0.01043	0.1107	808	0.09	0.9250	0.05	-0.2069	0.2278
Pittsburgh	**3**	-0.03007	0.1041	808	-0.29	0.7727	0.05	-0.2344	0.1742
Los Angeles	**4**	0	.	.	.	.	.	.	.

References

1. Hariri S, McKenna MT. Epidemiology of human immunodeficiency virus in the United States. Clin Microbiol Rev 2007;20:478–488
2. Jaffe HW, Valdiserri RO, De Cock KM. The reemerging HIV/AIDS epidemic in men who have sex with men. J Am Med Assoc 2007;298:2412–2414
3. Sullivan PS, Hamouda O, Delpech V, Geduld JE, Prejean J, Semaille C, Kaldor J, Folch C, Op de Coul E, Marcus U, Hughes G, Archibald CP, Cazein F, McDonald A, Casabona J, van Sighem A, Fenton KA. Reemergence of the HIV epidemic among men who have sex with men in North America, Western Europe, and Australia, 1996–2005. Ann Epidemiol 2009;19:423–431
4. Centers for Disease Control and Prevention. HIV and AIDS among gay and bisexual men: United States Department of Health and Human Services; 2010
5. Stall R. The prevention of HIV infection associated with drug and alcohol use during sexual activity. Advances in Alcohol and Substance Abuse 1988;7:73–88
6. Leigh BC. Alcohol and condom use; A Meta-analysis of event-level studies. Sexually Transmitted Diseases 2002;29:476–482
7. Cochran SD, Ackerman D, Mays VM, Ross MW. Prevalence of non-medical drug use and dependence among homosexually active men and women in the population. Addiction 2004;99:989-998
8. Stall R, Paul JP, Greenwood G, Pollack LM, Bein E, Crosby GM, Mills TC, Binson D, Coates TJ, Catania JA. Alcohol use, drug use and alcohol-related problems among men who have sex with men: the Urban Men's Health Study. Addiction 2001;96:1589-1601
9. Stall R, Purcell DW. Intertwining epidemics: A review of research on substance use among men who have sex with men and its connection to the AIDS epidemic. AIDS and Behavior 2000;4:181-192
10. Weinhardt LS, Carey MP. Does alcohol lead to sexual risk behavior? Findings from event-level research. Annual Review of Sex Research 2000;11:125–157
11. Leigh BC. Alcohol and unsafe sex: An overview of research and theory. In: Seminara, D.; Pawlowski, A.; Watson, R., editors. Alcohol, immunomodulation, and AIDS. New York: Alan R. Liss; 1990a. p. 35-46
12. Seage GR, Mayer KH, Wold C, Lenderking WR, Goldstein R, Cai B, Gross M, Heeren T, Hingson R. The social context of drinking, drug use, and unsafe sex in the Boston young men study. J Acquir Immune Defic Syndr Hum Retrovirol 1998;17:368–375
13. Vanable PA, McKirnan DJ, Buchbinder SP, Bartholow BN, Douglas JM, Judson FN, MacQueen KM. Alcohol use and high-risk sexual behavior among men who have sex with men: The effects of consumption level and partner type. Health Psychol 2004;23:525–532
14. Irwin TW, Morgenstern J, Parsons JT, Wainberg M, Labouvie E. Alcohol and sexual HIV risk behavior among problem drinking men who have sex with men: An event level analysis of timeline followback data. AIDS Behav 2006;10:299–307
15. Purcell DW, Parsons JT, Halkitis PN, Mizuno Y, Woods WJ. Substance use and sexual transmission risk behavior of HIV-positive men who have sex with men. Journal of Substance Abuse 2001;13:185–200
16. Thiede H, Valleroy LA, MacKellar DA, et al. Regional patterns and correlates of substance use among young men who have sex with men in 7 US urban areas. Am J Public Health 2003;93:1915–1921
17. Garofalo R, Mustanski BS, McKirnan DJ, Herrick A, Donenberg GR. Methamphetamine and young men who have sex with men: Understanding patterns and correlates of use and the association with HIV related sexual risk. Arch Pediatr Adolesc Med 2007;161:591–596
18. Colfax G, Vittinghoff E, Husnik MJ, McKirnan D, Buchbinder S, Koblin B, Celum C, Chesney M, Huang YJ, Mayer K, Bozeman S, Judson FN, Bryant KJ, Coates TJ. Substance use and sexual risk: A participant- and episode-level analysis among a cohort of men who have sex with men. Am J Epidemiol 2004;159:1002–1012
19. Shoptaw S, Reback CJ. Methamphetamine use and infectious disease-related behaviors in men who have sex with men: Implications for interventions. Addiction 2007;102:130–135
20. Stueve A, O'Donnell L, Duran R, San Doval A, Geier J. Being high and taking sexual risks: findings from a multisite survey of urban young men who have sex with men. AIDS Educ Prev 2002;14:482–495
21. Gorman M. A tale of two epidemics: HIV and stimulant use. Focus 1998, 13(4):1-3
22. Molitor F, Truax SR, Ruiz JD, Sun RK: Association of methamphetamine use during sex with risky sexual behaviors and HIV infection among non-injection drug users. West J Med 1998, 168:93-97
23. Reback CJ. The social construction of a gay drug: Methamphetamine use among gay and bisexual males in Los Angeles: City of Los Angeles AIDS Coordinator 1997
24. Leigh BC, Stall R. Substance use and risky sexual behavior for exposure to HIV: Issues in methodology, interpretation, and prevention. Am Psychol. 1993 October ; 48(10): 1035–1045
25. Cooper ML. Alcohol use and risky sexual behavior among college students and youth: evaluating the evidence. J Stud Alcohol. 2002;14:101–17
26. Hirshfield S, Remien RH, Humberstone M, Walavalkar I, Chiasson MA. Substance use and high-risk sex among men who have sex with men: a national online study in the USA. AIDS Care. 2004;16(8):1036–47

27. Mustanski B. Moderating effects of age on the alcohol and sexual risk taking association: an online daily diary study of men who have sex with men. AIDS Behav. 2008;12(1):118–26
28. Kalichman SC, Tannenbaum L, Nachimson D. Personality and cognitive factors influencing substance use and sexual risk for HIV infection among gay and bisexual men. Psychol Addict Behav. 1998;12:262–71
29. Gillmore MR, Morrison DM, Leigh BC, Hoppe MJ, Gaylord J, Rainey DT. Does ‘‘high = high risk’’? An event-based analysis of the relationship between substance use and unprotected sex among gay and bisexual men. AIDS Behav. 2002;6(4):361–70
30. Weatherburn P, Davies PM, Hickson FC, Hunt AJ, McManus TJ, Coxon AP. No connection between alcohol use and unsafe sex among gay and bisexual men. AIDS. 1993;7(1):115–9
31. Burrell E. Substance use, venue of sexual encounter, and sexual risk behavior among men who have sex with men (MSM) in the Multicenter AIDS Cohort Study (MACS): A Generalized Linear Mixed Model (GLMM) approach with random effects
32. Darilay A, Jacobson L, Behavior and Data Working Groups. Marginal vs Event Questionnaire. October 2010
33. Kaslow RA, Ostrow DG, Detels R, et al. The Multicenter AIDS Cohort Study: rationale, organization, and selected characteristics of the participants. Am J Epidemiol. 1987; 126(2):310–318
34. Dudley J, Jin S, Hoover D, Metz S, et al. The Multicenter AIDS Cohort Study: retention after 9 ½ years. Am J Epidemiol. 1995; 142(3):323–330
35. MACS Public Data Set. http://www.statepi.jhsph.edu/macs/pdt.html [Accessed January 3, 2013]
36. Gribble JN, Miller HG, Cooley PC, et al. The impact of T-ACASI interviewing on reported drug use among men who have sex with men. Subst Use Misuse. 2000; 35(6–8):869–890
37. Multicenter AIDS Cohort Study Data Working Group Meeting. CAMACS Report October 2011
38. Ostrow DG, Fox KJ, Chmiel JS, Silvestre A, Visscher BR, Vanable PA, Jacobson LP, Strathdee SA. Attitudes towards highly active antiretroviral therapy are associated with sexual risk taking among HIV-infected and uninfected homosexual men. AIDS 2002;16:775–780
39. Crawford I, Hammack PL, McKirnan DJ, Ostrow D, Zamboni BD, Robinson B, Hope B. Sexual sensation seeking, reduced concern about HIV and sexual risk behavior among gay men in primary relationships. AIDS Care 2003;15;513–524
40. Vanable PA, Ostrow DG, McKirnan DJ, Taywaditep KJ, Hope BA. Impact of combination therapies on HIV risk perceptions and sexual risk among HIV-positive and HIVnegative gay and bisexual men. Health Psychology 2000;19:134–145
41. Vanable PA, Ostrow DG, McKirnan DJ. Viral load and HIV treatment attitudes as correlates of sexual risk behavior among HIV-positive gay men. Journal of Psychosomatic Research 2003;54:263–269
42. Ostrow D, Fox K, Kleeberger C, Jacobson LP, Chmiel JS, Silvestre A, Visscher BR, Strathdee SA. Psychosocial correlates of incomplete adherence to HIV antiretroviral therapy (HAART): Mental health matters. 8th Conference on Retroviruses and Opportunistic Infections, Chicago, IL 2001
43. Vosburgh HW, Mansergh G, Sullivan PS, Purcell DW. A Review of the Literature on Event-Level Substance Use and Sexual Risk Behavior Among Men Who Have Sex with Men. AIDS Behav. 2012 Feb 10. [Epub ahead of print]
44. Feinberg SE, Tanur JM. Large-scale social surveys: Perspectives, problems, and prospects. Behavioral Science 1983;28:135–153
45. Blair E, Sudman S, Bradburn NM, Stocking C. How to ask questions about drinking and sex: Response effects in measuring consumer behavior. Journal of Marketing Research 1977;14:316–321
46. Bradburn, N.; Sudman, S.; Blair, E. Improving interview method and questionnaire design. San Francisco: Jossey-Bass; 1979.
47. Miller HG, Turner CF, Moses LE. AIDS: The second decade (Ch. 6: Methodological issues in AIDS surveys). Washington, D.C.: National Academy Press; 1990
48. Birnbaum IM, Parker ES. Acute effects of alcohol on storage and retrieval. Alcohol and human memory. Wiley: New York; 1977. p. 99-108
49. Eich JE. State-dependent retrieval of information in human episodic memory. Alcohol and human memory. Wiley: New York; 1977. p. 141-157