Published in final edited form as:

Psychol Addict Behav. 2010 March ; 24(1): 109–118. doi:10.1037/a0018190.

Relationships over Time between Mental Health Symptoms and Transmission Risk Among Persons Living with HIV

W. Scott Comulada,
University of California at Los Angeles

Mary Jane Rotheram-Borus,
University of California at Los Angeles

Willo Pequegnat,
National Institutes of Health

Robert E. Weiss,
University of California at Los Angeles

Katherine A. Desmond,
University of California at Los Angeles

Elizabeth Mayfield Arnold,
Wake Forest University

Robert H. Remien,
New York State Psychiatric Institute and Columbia University

Stephen F. Morin,
University of California at San Francisco

Lance S. Weinhardt,
Medical College of Wisconsin

Mallory O. Johnson, and
University of California at San Francisco

Margaret A. Chesney
National Institutes of Health

Abstract

Relationships between mental health symptoms (anxiety and depression) or a positive state of mind and behavior associated with HIV transmission (substance use and risky sexual behavior) were explored in a longitudinal study on persons living with HIV (PLH; $n = 936$) who were participants in a transmission-prevention trial. Bivariate longitudinal regressions were used to estimate the correlations between mental health symptoms and HIV-related transmission acts for three time frames: at the baseline interview; over 25 months; and from assessment to assessment. At baseline, mental health symptoms were associated with transmission acts. Elevated levels of mental health

Correspondence concerning this article should be addressed to W. Scott Comulada, 10920 Wilshire Blvd., Suite 350, Los Angeles, CA, 90024, USA. Telephone: +1 310 794 0938; Fax: +1 310 794 2495; scomulad@ucla.edu.

Publisher's Disclaimer: The following manuscript is the final accepted manuscript. It has not been subjected to the final copyediting, fact-checking, and proofreading required for formal publication. It is not the definitive, publisher-authenticated version. The American Psychological Association and its Council of Editors disclaim any responsibility or liabilities for errors or omissions of this manuscript version, any version derived from this manuscript by NIH, or other third parties. The published version is available at www.apa.org/journals/adb

symptoms at baseline were associated with decreasing alcohol or marijuana use over 25 months. Over 25 months, an increasingly positive state of mind was associated with decreasing alcohol or marijuana use; an increasingly positive state of mind in the immediate condition and increasing depressive symptoms in the lagged condition were related to increasing risky sexual behavior. Our findings suggest that mental health symptoms precede a decrease in substance use and challenge self-medication theories. Changes in mental health symptoms and sexual behavior occur more in tandem.

Keywords

HIV; Mental Health; Depression; Anxiety; Substance Abuse; Sexual behavior

Stopping or reducing substance use and unprotected sex among persons living with HIV (PLH) reduces the risk of transmission of HIV from PLH to others. Therefore, it is critical to understand the factors associated with substance use and unprotected sex, i.e. HIV transmission behaviors, in order to inform the design of behavioral interventions for PLH. Numerous cross-sectional studies have established relationships between mental health symptoms and HIV transmission behaviors (e.g., Bing et al., 2001). These findings are particularly salient, given the high rates of mental health symptoms and disorders among PLH (Bing et al., 2001; Lyketos, Hanson, Fishman, McHugh, & Treisman, 1994; McClure, Catz, Prejean, Brantley, & Jones, 1996; Remien et al., 2006). In one representative sample of adult PLH under regular medical care in the United States, half screened positive for a mental disorder (48%; Bing et al., 2001). What have been lacking are studies to test how these cross-sectional relationships play out over time. It is the goal of this paper to explore relationships between mental health symptoms and HIV transmission behaviors that were assessed over a two-year period in a cohort of PLH.

Substance use increases the risk of HIV transmission directly, through contaminated injections, as well as indirectly, through decreased anti-retroviral medication (ARV) adherence (Crepaz & Marks, 2002; Freeman, Rodriguez, & French, 1996; Mehta et al., 2006; Mehta, S., Moore, R.D., & Graham, 1997; Samet et al., 1992). Extensive research has been conducted in the general population on the associations between substance abuse and measures of mental health, including depression, anxiety, and mood disorders (Kessler, 2004; Merikangas, 1998). Cross-sectional studies have established links between mental health symptoms and substance use in HIV-positive populations (Bing et al., 2001; Chander, Himelhoch, & Moore, 2006; Lightfoot et al., 2005; Rotheram-Borus et al., 1999). Conclusive and consistent evidence has not been found pointing to a causal relationship between mental health and substance use in either direction. Some studies suggest that substance use disorders can cause mental health symptoms while others suggest that individuals use substances to cope with mental health symptoms and self-medicate (Merikangas, 1998). For example, alcohol is consumed for its tension-reducing properties (Tension-Reduction theory; Conger, 1956). Among male PLH, methamphetamine is used for self-medication of negative affect associated with HIV positive serostatus (Robinson & Rempel, 2006).

Similar to substance use, sexual risk-taking, as measured by both the number of unprotected vaginal or anal sex acts and the number of sexual partners of unknown or HIV negative serostatus, is associated with HIV transmission (Aral & Peterman, 2002). Substance use and sexual risk-taking are also related behaviors (Crepaz & Marks, 2002; Drumright et al., 2006; Hayaki, Anderson, & Stein, 2006). Unlike links between mental health and substance use, links between mental health and sexual risk have been harder to establish in cross-sectional studies of PLH. Two literature reviews of cross-sectional studies on PLH found inconsistent links between emotional states, including depression and anxiety, and sexual risk behavior. In his review of studies from 1993 to 1999, Kalichman (2000) found negative emotions, including

depression and anxiety, to be positively related to sexual risk in some PLH, e.g. PLH seeking HIV prevention services who continue to practice unprotected sex. He also found positive moods to be positively related to sexual risk. In their review of studies from 1980 to 2001, Crepaz and Marks (2002) found little evidence for associations between negative emotions and sexual risk.

We are unaware of longitudinal studies that have examined the relationship between mental health and substance use or sexual risk. Mental health symptoms may have more complex relationships with transmission risks over time that cannot be fully examined with cross-sectional studies. For example, mental health symptoms at baseline and the trajectory of mental health symptoms over time may each be related to the trajectory of hard drug use over time, potentially in different ways. Elevated mental health symptoms and hard drug use at baseline may reflect PLH with established mental health and drug use patterns. Conversely, PLH whose mental health symptoms increased during the study may reflect a different subset of PLH who are switching from hard drugs to other drugs.

This study examines the relationships between mental health symptoms and HIV transmission risks over time through the use of bivariate longitudinal regressions fit to reports by PLH. Bivariate longitudinal models are increasingly popular to understand complex relationships between two time-varying factors (Audraine-McGovern, Rodriguez, & Moss, 2003; Comulada & Weiss, 2007; Sy, Taylor, & Cumberland, 1997) and may provide additional insight over univariate longitudinal models that treat one time-varying factor as an outcome and the other factor as a time-invariant or time-varying covariate (Weiss, 2005). By treating both factors as outcomes, bivariate longitudinal models simultaneously compare how baseline levels of one factor are related to the trajectory of the other factor, and vice versa. If it is found, for example, that baseline levels of mental health symptoms are related to substance use trajectories, but baseline levels of substance use are not related to mental health symptom trajectories, then mental health is shown to precede changes in substance use. While longitudinal findings do not establish causality, e.g. there may be unmeasured factors affecting both mental health symptoms and substance use, the findings can establish temporal precedence and inform a causal framework. Furthermore, the bivariate longitudinal regression models the relationship between the trajectories of both factors, which cannot be done with a univariate longitudinal model.

We expect that the cross-sectional relationships that have been found in previous research between mental health symptoms and HIV transmission behaviors will also be present in the longitudinal relationships for bivariate outcomes. We hypothesize that there will be positive associations between concurrent assessments of mental health symptoms and both elevated levels of substance use and elevated levels of risky sexual behavior at each time point. Due to the lack of longitudinal studies to refer to, hypothesizing the direction of association between baseline levels and trajectories over time is more difficult. In particular, learning that one is HIV positive (Kalichman, Greenberg, & Abel, 1997; Marks, Burris, & Peterman, 1999; Rotheram-Borus et al., 2001; Wolitski, MacGowan, Higgins, & Jorgensen, 1997) and knowing one's HIV status over a longer period of time (Lightfoot et al., 2005; Rotheram-Borus et al., 1999) often lead to substantial reductions in substance use. Therefore, it is unclear whether substance use and sexual behavior will be significantly associated with symptoms of poor mental health over time among PLH.

We examine these relationships within the context of a randomized controlled trial of an intervention, the Healthy Living Program (Gore-Felton et al., 2005; Weinhardt et al., 2004). The intervention led to significant reductions in substance use (Wong et al., 2008) and the number of unprotected sex acts (Healthy Living Project Team, 2007) over 25 months. Though the intervention is not a focus of the current paper, we hypothesize that the intervention may

have influenced the relationship between mental health symptoms and transmission risk behaviors over time in unpredictable ways. Therefore, we examine these relationships separately by study arm as well as in the combined sample. When analyzing the full sample, we adjust for intervention assignment in our bivariate longitudinal models.

Method

Participants

Between 2000 and 2002, HIV-positive individuals were recruited from community agencies, AIDS service organizations, and medical clinics in four cities (San Francisco, Los Angeles, New York City, and Milwaukee) for a clinical trial of an individually administered cognitive-behavioral intervention. Eligibility criteria required PLH to be at least 18 years of age, speak English or Spanish, provide written informed consent, provide written medical documentation of their HIV-positive serostatus, not be currently involved in another behavioral intervention study related to HIV, and not show signs of severe neuropsychological impairment or psychosis. Eligibility criteria also included the requirement that the PLH had to have reported unprotected vaginal or anal intercourse in the previous 3 months with a sex partner whose HIV serostatus was negative or unknown. Of 3818 PLH screened for the intervention study, 1072 (28%) were eligible; 936 (87%) of eligible PLH agreed to participate and were randomized to either the *intervention condition* (n=467) and received the Healthy Living Program immediately, or to the *lagged condition* (n=469) and were offered the program after their 25-month follow-up assessment.

Study design

All procedures and forms were reviewed and approved by the sites' Institutional Review Boards, including an incentive that ranged from \$30 to \$60 and a \$10 child care cost reimbursement per assessment. A highly trained assessment team diverse in ethnicity, gender, and sexual orientation conducted interviews using laptop computers to record responses. Interviews utilized audio computer-assisted self-interviewing (ACASI) and computer-assisted personal interviewing (CAPI) developed by the Questionnaire Development System (Nova Research Company, Bethesda, MD).

PLH were assessed 5, 10, 15, 20, and 25 months after the baseline interview. In the intervention condition, the follow-up rates were 83.7%, 81.2%, 77.5%, 73.4%, and 73% at the follow-up assessments. Among PLH in the control condition, the rates were 88.3%, 83.6%, 82.7%, 79.3%, and 80.8%. All six assessments were completed by 64% of PLH in the intervention and by 70% of those in the lagged condition. Analyses were conducted on randomized PLH with at least one follow-up (91%; n = 415 in the intervention and n = 436 in the lagged condition).

The Healthy Living Program—The intervention addressed three separate behavior changes: improvements in coping skills, reductions in sexual and substance use risk acts, and improvements in health behaviors. In 15 individual case management sessions over a period of up to 15 months, facilitators with diverse ethnic, gender, and sexual orientations delivered a manual-based but individually tailored intervention (Gore-Felton et al., 2005; Weinhardt, 2004).

Measures

All measures were administered at each of the six assessments, unless indicated below. *Recent* acts refer to the last three months for all measures.

Mental health symptoms—The Beck Depression Inventory (*BDI*; Beck, 1967) assesses the severity of depressive symptoms during the past week across 21 items ($\alpha = .89$ at

baseline) scored from absent (0) to severe (3) and summed across items (range 0–63). The State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970) assesses anxiety as indicated by perceptions of tension and apprehension; PLH completed 20 items indicating transitory anxiety states which sums ratings on a 4-point scale (alpha for positive items = .84 at baseline; .91 at baseline for negatively scaled items). The STAI was not assessed at the 10-month follow-up assessment.

The Positive States of Mind scale (PSOM)—The PSOM (Horowitz, Adler, & Kegeles, 1988) assesses the extent to which PLH are able to stabilize themselves in a positive state of mind, despite daily stress and challenges. We included items that reflect focused attention, productivity, responsible care giving, restful repose, sensuous nonsexual pleasure, and sharing. An overall PSOM score was calculated by summing the responses on a 0–3 scale from “Unable to have it” to “Have it easily” (6 items, alpha = .80 at baseline). The PSOM was not assessed at the 10-month follow-up.

Substance use—Similar to Rotheram-Borus et al. (2008), we assessed substance use as recent use of alcohol, marijuana, and hard drugs (barbiturates, cocaine, crack, gamma hydroxybutyrate (GHB), hallucinogens, heroin, inhalants, ketamine, 3,4-methylenedioxymethamphetamine (MDMA, ecstasy), methadone, opiates, sedatives, speedball, steroids, and stimulants (i.e., methamphetamine, amphetamine). For each drug, the frequency of recent use was reported (and recoded to a count of days used in the past 3 months) as “never” (0), “less than once a month” (1.5), “once a month” (3), “2 to 3 times a month” (7.5), “once a week” (12), “2 to 3 times a week” (30), “4 to 6 times a week” (60), “once a day” or “more than once a day” (90). We analyzed two summary measures: 1) the sum of days in which alcohol or marijuana use was reported (possible range = 0 to 180); 2) sum of days for which all hard drug use was reported (possible range = 0 to 1350).

Risky sexual behavior—Partner serostatus, the number of vaginal and anal sex acts, and associated condom use were reported individually for the first five sexual partners of each gender. After five partners, summaries of the frequency of condom use were recorded. From these reports, we calculated two indices: 1) the numbers of partners whose HIV serostatus was negative or unknown, hereafter referred to as HIV-negative partners; and 2) the numbers of risky sex acts unprotected by condoms with HIV-negative partners. The number of risky sex acts was directly calculated for 87% of PLH who reported at all time points five or fewer recent partners of each gender. If PLH had more than five partners, the number of unprotected sex acts with partners beyond the fifth was estimated, based on the summary reports plus detailed reports for the first five partners. These estimates were made for 201 out of 4,697 observations (4%) across all time points, using multiple imputation procedures (Healthy Living Project Team, 2007). Results were similar between analyses based on only a complete (no imputation) data set and on a data set including observations with imputed values; analyses on the imputed data are presented in this paper.

Background characteristics—Demographic characteristics included age at the baseline assessment; gender; and race / ethnicity, classified as African American not Latino / Hispanic, Latino / Hispanic, or Caucasian. An HIV transmission risk group measure established by the Centers for Disease Control (2001) was created from responses in the baseline assessment. Participants were grouped into one of four risk groups based on the following hierarchy: 1) female gender; 2) male gender and using injection drugs (IDU); 3) male gender, not IDU, and engaging in sex with other men; or 4) male gender and neither IDU nor engaging in sex with other men. Participants were also classified by whether they were randomized to the immediate intervention condition or lagged control condition.

Data analyses

Preliminary analyses—The distributions of each outcome needed to be normalized in order to conduct the analyses. To reduce positive skewness in the distributions of the depression, anxiety, and PSOM outcomes, a small constant was added and the square root was taken. For the measures of transmission risk, a small constant was added and logarithmic transformations were applied. After transformation, skew statistics based on the third moment were satisfactory for mental health outcomes (−.16 to .44), the days of alcohol / marijuana use (−.02), and the days of hard drug use (.47); skew statistics were still high (.83 for the number of HIV-negative partners and 1.09 for the number of unprotected sex acts). To ensure our inferences were not unduly influenced by the distribution of the sexual behavior outcomes, we compared standard errors obtained from our regression models fit to sexual behavior outcomes to those obtained by bootstrapping. Bootstrapping was conducted by replicating one hundred data sets with replacement from our original data. Regressions were fit to each replicate data set and standard errors were calculated as the standard deviations of the 100 regression parameter estimates. Standard errors differed very little between the regressions and bootstrapped method; inferences between methods were the same. We present p-values based on the regressions.

We tested the association between mental health and HIV transmission risk outcomes and baseline characteristics, including age, ethnicity, and HIV-transmission risk group. We tested correlations between each outcome and age. We conducted analysis of variance (ANOVA) to test for associations between each outcome and ethnicity, as well as between each outcome and the risk group categories.

Bivariate longitudinal regressions—We jointly modeled paired outcomes, i.e. a mental health and HIV transmission risk outcome, as continuous measures using bivariate longitudinal linear regressions. These models fit a regression for each paired outcome and capture three different types of variability. There is variation in *PLH baseline levels*, i.e. random intercepts, which indicate variation in the levels of mental health and transmission risk each PLH reported at recruitment. There is also variation in *PLH time trends*, i.e. random slopes, which describe variation in the linear change in mental health and transmission risks reported by the individual PLH over time. Individual PLH baseline levels and time trends allow each PLH to differ from the intercept and slope regression parameters, respectively, that are estimated for the entire sample. Residuals describe variation from *assessment to assessment* around each PLH's long term time trend.

Outcomes are correlated through a shared covariance structure that incorporates correlations between PLH baseline levels and time trends within each outcome and between paired outcomes (a mental health outcome and an outcome reflecting HIV transmission risk -- sex or drugs). Residual correlations between paired outcomes are also modeled. We report on correlations between paired outcomes to explore longitudinal relationships between mental health symptoms and HIV transmission risks. Correlations between baseline levels and time trends show the degree of association between paired outcomes within PLH at recruitment and over 25 months, respectively; for example, PLH with increased mental health symptoms at recruitment or PLH with increasing mental health symptoms over time might be likely to engage in more risk behaviors over time compared to other PLH over 25 months. Correlations between residuals indicate the degree to which an individual's ups and downs in both outcomes tend to track together. For example, a PLH's mental health symptoms and substance use may not be related at recruitment but may be related when considering concurrent measurements across all time points.

It is likely that the trajectories of mental health and HIV transmission risks over time are affected by the PLH's demographic and personal risk history. Therefore, all models included parameters for age at baseline, ethnicity, the HIV transmission risk group classification, and

time from the baseline assessment. To examine the association of mental health with transmission risk over time, unrelated to the impacts of the Healthy Living Program, we examined the relationships between mental health and HIV transmission risk separately among PLH in each intervention condition (i.e., those receiving the Healthy Living Program immediately or lagged by 25 months). Most results were similar across intervention conditions; therefore, we combined the two groups, and present analyses based upon the entire sample as well. Analyses on the entire sample adjusted for the intervention condition by the addition of an indicator for intervention condition and a time by intervention condition interaction for each outcome. Covariate estimates are not presented in this paper, but are available from the authors upon request.

All analyses were conducted using SAS 9.1 software (SAS Institute, Inc., 1997). Outcome pairs were modeled with the PROC MIXED procedure. We present p-values from Wald tests of the covariance parameter estimates and standard errors.

Results

Participants

The analysis sample, i.e. PLH with at least one follow-up ($n = 851$), was similar to the subset of PLH lost to follow up ($n = 85$) on gender, ethnicity, the HIV transmission risk group classification, HIV transmission risk measures (the frequency of alcohol or marijuana use, the frequency of hard drug use, the numbers of HIV-negative partners, and the numbers of risky sex acts with HIV negative sex partners), PSOM scores, and anxiety symptoms. PLH lost to follow up were two years younger, on average, (mean = 38.1 versus 40.0 years; t -test = -2.30 , $df = 934$, $p = .02$) and reported more depressive symptoms (median BDI = 14 versus 11; Wilcoxon two-sample test, $p < .01$) than PLH in the analysis sample.

Baseline characteristics are shown in Table I by intervention condition; PLH were similar across conditions. At baseline ($n = 851$), ages of the PLH ranged from 19 to 66. Most PLH were male (79%), of whom 72% reported having sex with other men. A third of PLH were White (32%) and a little less than half had a high school education or less (43%).

At baseline, forty percent of PLH reported BDI scores over 13 (mean = 13.1, $SD = 8.9$), indicating clinically relevant depressive symptoms and nearly as many (36%; mean = 36.9, $SD = 11.2$) of PLH had STAI scores over 39, indicating clinically relevant anxiety symptoms. The mean PSOM score was 12.6 and $SD = 3.6$.

At baseline, half of PLH had used alcohol or marijuana 12 days or more in the last three months (recently); while hard drugs were used at least one day by over half (61%). Recent hard drug rates were 1% for barbiturates, 25% for cocaine, 26% for crack, 3% for GHB, 5% for hallucinogens, 6% for heroin, 21% for inhalants, 4% for ketamine, 7% for MDMA, 5% for methadone, 4% for opiates, 10% for sedatives, 4% for speedball, 5% for steroids, and 21% for stimulants. PLH reported a median of two HIV-negative partners (range = 0–295) and two risky sex acts (range = 0–500). Most PLH (71%) were using anti-retroviral medications. The median self-reported CD4 count was 375, and 36% of PLH self-reported HIV-1 RNA of undetectable levels.

At baseline, substance use and risky sexual behavior varied by demographics and HIV-transmission risk group; mental health outcomes did not. Significant but small correlations were found between age and the logged number of risky sex acts ($\rho = -.11$, $p < .01$), as well as logged frequency of hard drug use ($\rho = .08$, $p = .02$). Significant ethnic differences were found with regard to alcohol use ($F = 2.81$, $df = 3$, 846, $p = .04$) and the number of HIV-negative partners ($F = 11.49$, $df = 3$, 846, $p < .01$). Specifically, African Americans used alcohol less

frequently than Whites and African Americans had fewer HIV-negative partners than Hispanics or Whites (all $p < .01$); no other pairwise ethnic comparisons were significant. By definition, substance use and risky sexual behavior differed by HIV-transmission risk group, e.g. IDU reported a significantly higher frequency of hard drug use than females and non-IDU who were also non-MSM (all $p < .01$); IDU and MSM were similar on reported hard drug use frequencies.

Table II displays mean values for each outcome by assessment. Overall, mental health symptoms and HIV transmission risks decreased over time. Discerning patterns at the individual level requires the use of bivariate longitudinal models, which are outlined below.

Bivariate longitudinal models

Correlations estimated from each of the bivariate models are shown in Table III for each intervention condition and in Table IV for the entire sample. For each pair of outcomes (mental health and transmission risk), we present correlations between both measures' baseline levels (B-B), both measures' time trends (T-T), and between one measure's baseline level and the other measure's time trend (B-T). We also present correlations of residuals (R-R), indicating the degree to which individual variability in the two measures is associated; i.e., showing whether, when an individual departs from his usual patterns in one behavior, he or she also changes in the other behavior.

Substance use—Baseline relationships between mental health symptoms and substance use emerged. At baseline, lower PSOM scores were related to elevated levels of hard drug use in the lagged condition (B-B $\rho = -.16$, $p < .01$) and entire sample (B-B $\rho = -.13$, $p = .02$). A consistent but smaller relationship was found among those in the immediate intervention group. In the lagged condition, lower PSOM scores were related to elevated alcohol / marijuana use at baseline (B-B $\rho = -.14$, $p = .05$). This relationship was not detected in the immediate intervention group, and was not significant in the entire sample. At baseline, elevated levels of depressive symptoms were related to elevated hard drug use in the lagged condition (B-B $\rho = .21$, $p < .01$), but again this relationship was not found among those in the other study condition, and did not reach significance in the entire sample. At baseline, elevated levels of anxiety symptoms in the lagged (B-B $\rho = .21$, $p < .01$) and intervention (B-B $\rho = .13$, $p = .04$) conditions were related to elevated hard drug use. Surprisingly, the correlation in the entire sample was not significant (B-B $\rho = .11$, $p = .06$).

Both elevated baseline PSOM scores (B-T $\rho = .36$, $p < .01$) and lower levels of baseline mental health symptoms in the entire sample (B-T $\rho = -.18$, $p < .01$ for depression and B-T $\rho = -.22$, $p < .01$ for anxiety) were related to increasing alcohol / marijuana use over time; similar patterns were found in one or both of the intervention conditions. In the lagged condition, lower levels of anxiety symptoms at baseline were related to increasing hard drug use over time (B-T $\rho = -.33$, $p = .02$); this relationship was in the same direction but not significant in the entire sample. In the intervention condition, we were unable to fit a bivariate model to explore this relationship. In the immediate condition, we found a positive relationship between elevated levels of baseline depressive symptoms and increasing hard drug use over time (B-T $\rho = .20$, $p = .04$), but this relationship was not found in the lagged group or the whole sample. Increasing PSOM scores were related to decreasing alcohol / marijuana use over time for the entire sample (T-T $\rho = -.72$, $p < .01$), with consistent findings by study condition.

From assessment to assessment, elevated levels of depressive and anxiety symptoms were modestly but significantly related to both elevated hard drug use and alcohol / marijuana use (R-R $\rho = .05$ to $.11$, all $p < .05$ in the entire sample, with similar patterns by study condition). From assessment to assessment, lower PSOM scores were significantly related to hard drug use (R-R $\rho = -.10$, $p < .01$ in the entire sample); similar assessment to assessment

relationships were found in one or both of the intervention conditions. We did not find any other significant relationships between substance use and mental health symptoms in either intervention condition or the entire sample.

Risky sexual behavior—At baseline, lower levels of depressive symptoms in the entire sample and both intervention conditions (B-B $\rho = -.15$ to $-.16$, all $p < .05$) and elevated PSOM scores in the entire sample (B-B $\rho = .11$, $p = .04$, with similar but non-significant results in each intervention condition) were related to having more HIV-negative partners. The following relationships were not significant in the entire sample but were in the same direction as significant relationships that were found in the intervention or lagged condition: 1) In the intervention condition, elevated levels of anxiety symptoms were related to lower numbers of HIV-negative partners at baseline (B-B $\rho = -.17$, $p = .03$); lower PSOM scores were related to increasing numbers of HIV-negative partners over time (T-T $\rho = -.44$, $p = .04$). 2) In the lagged condition, increasing depressive symptoms were related to decreasing numbers of HIV-negative partners over time (T-T $\rho = -.39$, $p = .02$).

From assessment to assessment in the entire sample, lower PSOM scores were modestly associated with elevated numbers of risky sex acts (R-R $\rho = -.05$, $p = .05$) and elevated levels of anxiety symptoms were modestly associated with elevated numbers of HIV-negative partners (R-R $\rho = .07$, $p < .01$); similar assessment to assessment relationships were found in one or both of the intervention conditions. We did not find any other significant relationships between risky sexual behavior and mental health symptoms in either intervention condition or the entire sample.

Discussion

The current study used bivariate longitudinal models to address an important gap in the literature regarding the longitudinal relationships between mental health and both substance use and sexual behavior; past literature in this area has been primarily cross-sectional. Our findings on baseline relationships were consistent with previous cross-sectional studies. Mental health symptoms were common among the PLH, similar to other researchers' findings using cross-sectional data (Bing et al., 2001; Lyketsos, Hanson, Fishman, McHugh, & Treisman, 1994; McClure, Catz, Prejean, Brantley, & Jones, 1996; Remien et al., 2006). At baseline, 40% of PLH showed clinically significant levels of depression, and 36% had anxiety symptoms that were clinically significant. Twenty-five percent reported symptoms of both depression and anxiety. These high rates of mental health symptoms among PLH who were continuing to engage in substance use and unsafe sex highlight the need to understand how patterns of mental health symptoms relate to the transmission of HIV over time, to the uninfected population.

We did not find strong evidence that the relationship between mental health symptoms and HIV-transmission risk acts varied by intervention condition. Some findings were significant in one intervention condition but not the other. However, we did not find consistent patterns as to how PLH may have differed across intervention conditions in their relationships between mental health symptoms and HIV-transmission risk acts. Furthermore, we did not find any instances where significant relationships were in opposite directions across intervention conditions.

Relationships we found between elevated levels of mental health symptoms and substance use at baseline and from assessment to assessment corroborated findings from previous cross-sectional studies (Bing et al., 2001; Chander, Himelhoch, & Moore, 2006; Lightfoot et al., 2005; Rotheram-Borus et al., 1999). Longitudinal findings on the relationship between an increasing positive state of mind and decreasing alcohol / marijuana use over time was a natural extension of findings from cross-sectional studies.

Elevated levels of mental health symptoms at baseline were related to decreasing substance use over time; relationships between baseline levels of substance use and mental health time trends were not found. These findings suggest that mental symptoms precede a decrease in substance use and are counterintuitive and inconsistent with theories about using drugs to self-medicate for symptoms of depression or anxiety, e.g. the Tension-Reduction theory. A possible explanation follows, at least for findings related to alcohol / marijuana use. Among hard drug users, limiting substance use to alcohol and marijuana is often perceived as a significant reduction in risk (Luna, 1997). Perhaps alcohol and marijuana are seen as less harmful drugs in our cohort of PLH, over half of whom reported using hard drugs at baseline. Alcohol and marijuana may be used more recreationally rather than as an escape or coping resource; an improved mood may lead to increasing use over time. Another possible explanation is a ceiling effect. PLH with lower levels of mental health symptoms at baseline may develop mental health symptoms and increase substance use over the course of the study, whereas PLH with elevated mental health symptoms at baseline may be more likely to decrease or maintain the same level of mental health symptoms and substance use over time. In order to test for ceiling effects, we conducted post-hoc comparisons in which PLH in the entire sample were split into two groups based off the clinical threshold at baseline. Among PLH above and below the clinical cutoff for depressive symptoms, relationships between baseline levels of depressive symptoms and substance use time trends remained in the same direction compared to relationships in the entire sample; relationships tended to lose significance in the depressed and nondepressed subsamples. We were unable to fit models to subsamples of PLH with and without clinically relevant anxiety symptoms. Post-hoc comparisons were inconclusive as to whether or not a ceiling effect was present.

Relationships between mental health symptoms and risky sexual behavior reflected cross-sectional findings in the literature where significant results were found (Kalichman, 2000). Relationships between elevated levels of mental health symptoms and elevated risky sexual behavior were found at baseline; inverse relationships that we found from assessment to assessment contradicted mainstream findings, though these relationships were quite small.

Relationships that emerged between mental health symptoms and sexual behavior occurred in tandem, as significant relationships between baseline and time trends were lacking. Both increasing PSOM scores in the intervention condition and increasing depressive symptoms in the lagged condition were related to decreasing numbers of HIV negative sexual partners over time. These findings are consistent with cross-sectional studies that have found both positive and negative moods to be associated with risky sexual behavior (Kalichman, 2000). For example, PLH may experience positive moods at the time of unsafe sex and experience regret and negative moods later. A limitation in exploring sexual behavior in our study is that we used measures that were assessed from the perspective of the PLH and aggregated partner-level information. However, sexual risk always emerges in a partnership: the patterns of risk within a partnership get established early and are typically maintained over time. There are really qualitatively different types of sexual relationships: some PLH engage with a relatively small number of partners and within each partnership these patterns of risk are stable over time. Those with more partners do not establish stable patterns within the partnership, especially when there is only one encounter. In these types of sexual partnerships, risk is reflective of the type of relationship, rather than the mental health status of the PLH.

In addition to the assessment of partner-level behavior, future research may also benefit by including measures of psychiatric diagnoses or measures to cover a greater number of symptom clusters. For example, it would have been desirable to assess mania and transmission-related acts over time. It would have also been desirable to have biological markers of substance use and sexual risk. We did examine rates of sexually transmitted diseases among the sample at

the baseline interview, but the rate was far too low (2–3%) to allow us to use biological markers of STD as indications of transmission risk.

It is important to recognize the subpopulation of PLH the current study represents. Despite high follow-up rates, one potentially important selection effect may be the loss of PLH exhibiting more depressive symptoms after the baseline assessment. There may have been relationships between depressive symptoms and transmission acts that were attenuated in the sample we retained over time.

Our sample is representative of the subpopulation of PLH who continue to engage in sexual risk acts after learning they are HIV positive, approximately 34% to 50% of PLH (Crepaz and Marks, 2002). We recruited PLH engaging in sexual behaviors that could transmit HIV to HIV-negative sex partners because the behavioral intervention targeted risky sexual behavior. Though this is not a representative sample of the population of PLH, the demographic profile of the sample matches the profile of PLH in the statistics of the Centers for Disease Control and Prevention (2007). The sample is predominantly of ethnic minority heritage and has substantial numbers of women, MSM, and heterosexual males, both injecting drug users and those likely to have acquired HIV through sexual transmission. Furthermore, PLH seeking HIV prevention services who continue to practice unprotected sex are the subpopulation of PLH where cross-sectional relationships between negative emotions and sexual risk have emerged (Kalichman, 2000); we expect longitudinal relationships between mental health symptoms and HIV-transmission risk behaviors to be at least as pronounced if not more so in this subpopulation.

Given these limitations, our findings provide a first step in disentangling the complex temporal relationship between mental health and HIV-transmission risk. More longitudinal studies are needed, especially longitudinal studies designed to facilitate mediational analyses. The challenge remains to establish causality and identify common factors of mental health and HIV-transmission risk. New data capture methods are also needed. Longitudinal studies, including ours, are wedded to retrospective reports. The assessment of moods can be confounded by even a short window of time, e.g. PLH may experience positive moods prior to substance use and negative moods afterwards. Daily diaries are a step in the right direction by providing more frequent assessments compared to retrospective reports, and in turn, less recall bias. A few studies have used daily diaries to assess mental health and substance use with limited success. See for example, Tournier et al. (2003). However, diaries still rely on pen and paper as the data capture tool and may be perceived as both inconvenient and intrusive by a study participant. Emerging technologies, e.g. smart mobile phones, enable real-time data capture through devices that participants are already using in their daily lives. Future longitudinal studies employing both improved analytic tools and data capture methods will provide a stronger basis to establish causality between mental health and HIV-transmission risk.

Acknowledgments

This study was funded by cooperative agreements between the United States National Institute of Mental Health and the University of California, Los Angeles (U10MH057615); New York State Psychiatric Institute and Columbia University (U10MH057636); the Medical College of Wisconsin (U10MH057631); and the University of California, San Francisco (U10MH057616).

References

- Aral SO, Peterman TA. A stratified approach to untangling the behavioral/biomedical outcomes conundrum. *Sexually Transmitted Diseases* 2002;29:530–532. [PubMed: 12218844]

- Audraine-McGovern J, Rodriguez D, Moss HB. Smoking progression and physical activity. *Cancer Epidemiol Biomarkers & Prevention* 2003;12:1121–1129.
- Comulada WS, Weiss RE. On models for binomial data with random numbers of trials. *Biometrics* 2007;63:610–617. [PubMed: 17688514]
- Beck, AT. *Depression: causes and treatment*. Philadelphia: University of Pennsylvania Press; 1967.
- Bing EG, Burnam MA, Longshore D, Fleishman JA, Sherbourne CD, London AS, Turner BJ, Ferd E, Beckman R, Vitiello B, Morton SC, Orlando M, Bozzette SA, Ortiz-Barron L, Shapiro M. Psychiatric disorders and drug use among human immunodeficiency virus-infected adults in the United States. *Archives of General Psychiatry* 2001;58:721–728. [PubMed: 11483137]
- Centers for Disease Control. *HIV/AIDS Surveillance Report* 2001;13:1–41.
- Centers for Disease Control. *HIV/AIDS Surveillance Report* 2007;17:1–54.
- Chander G, Himelhoch S, Moore RD. Substance abuse and psychiatric disorders in HIV-positive patients: epidemiology and impact on antiretroviral therapy. *Drugs* 2006;66:769–789. [PubMed: 16706551]
- Conger JJ. Reinforcement theory and the dynamics of alcoholism. *Quarterly Journal of Studies on Alcohol* 1956;17:296–305. [PubMed: 13336262]
- Crepaz N, Marks G. Towards an understanding of sexual risk behavior in people living with HIV: a review of social, psychological, and medical findings. *AIDS* 2002;16:135–149. [PubMed: 11807297]
- 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. *Journal of Acquired Immune Deficiency Syndromes* 2006;43:344–350. [PubMed: 16980913]
- Freeman RC, Rodriguez GM, French JF. Compliance with AZT treatment regimen of HIV-seropositive injection drug users: a neglected issue. *AIDS Education and Prevention* 1996;18:58–71. [PubMed: 8703641]
- Gore-Felton C, Rotheram-Borus MJ, Weinhardt LS, Kelly JA, Lightfoot M, Kirshenbaum SB, Johnson MO, Chesney MA, Catz SL, Ehrhardt AA, Remien RH, Morin SF. The NIMH Healthy Living Project Team. The Healthy Living Project: an individually tailored, multidimensional intervention for HIV-infected persons. *AIDS Education and Prevention* 2005;17(1Suppl A):21–39. [PubMed: 15843115]
- Hayaki J, Anderson B, Stein M. Sexual risk behaviors among substance users: relationship to impulsivity. *Psychology of Addictive Behaviors* 2006;20:328–332. [PubMed: 16938071]
- Healthy Living Project Team. Effects of a behavioral intervention to reduce risk of transmission among people living with HIV: The Healthy Living Project randomized controlled study. *Journal of Acquired Immune Deficiency Syndromes* 2007;44:213–221. [PubMed: 17146375]
- Horowitz M, Adler NE, Kegeles S. A scale for measuring the occurrence of positive states of mind: A preliminary report. *Psychosomatic Medicine* 1988;50:477–483. [PubMed: 3186891]
- Kalichman SC. HIV transmission risk behaviors of men and women living with HIV-AIDS: Prevalence, predictors, and emerging clinical interventions. *Clinical Psychology: Science and Practice* 2000;7:32–47.
- Kalichman SC, Greenberg J, Abel GG. HIV-seropositive men who engage in high-risk sexual behavior: psychological characteristics and implications for prevention. *AIDS Care* 1997;9:441–450. [PubMed: 9337888]
- Kessler RC. The epidemiology of dual diagnosis. *Biological Psychiatry* 2004;56:730–737. [PubMed: 15556117]
- Lightfoot M, Rogers T, Goldstein R, Rotheram-Borus MJ, May S, Kirshenbaum S, Weinhardt L, Zadoretzky C, Kittel L, Johnson M, Gore-Felton C, Morin SF. Predictors of substance use frequency and reductions in seriousness of use among persons living with HIV. *Drug and Alcohol Dependence* 2005;77:129–138. [PubMed: 15664714]
- Luna, GC. *Youth Living with HIV: Self-evident truths*. Binghamton (NY): Haworth Press; 1997.
- Lyketsos CG, Hanson A, Fishman M, McHugh PR, Treisman GJ. Screening for psychiatric morbidity in a medical outpatient clinic for HIV infection: the need for a psychiatric presence. *International Journal of Psychiatry in Medicine* 1994;24:103–113. [PubMed: 7960418]
- Marks G, Burris S, Peterman TA. Reducing sexual transmission of HIV from those who know they are infected: the need for personal and collective responsibility. *AIDS* 1999;13:297–306. [PubMed: 10199219]

- McClure JB, Catz SL, Prejean J, Brantley PJ, Jones GN. Factors associated with depression in a heterogeneous HIV-infected sample. *Journal of Psychosomatic Research* 1996;40:407–415.
- Mehta SH, Galai N, Astemborski J, Celentano DD, Strathdee SA, Vlahov D, Nelson KE. HIV incidence among injection drug users in Baltimore Maryland (1988–2004). *Journal of Acquired Immune Deficiency Syndromes* 2006;43:368–372. [PubMed: 16980912]
- Mehta S, Moore RD, Graham NM. Potential factors affecting adherence with HIV therapy [Editorial]. *AIDS* 1997;11:1665–1670. [PubMed: 9386800]
- Merikangas KR, Mehta RL, Molnar BE, Walters EE, Swendsen JD, Aguilar-Gaziola S, Bijl R, Borges G, Caraveo-Anduaga JJ, Dewit DJ, Kolody B, Vega WA, Wittchen HU, Kessler RC. Comorbidity of substance use disorders with mood and anxiety disorders: Results of the International Consortium in Psychiatric Epidemiology. *Addictive Behaviors* 1998;23:893–907. [PubMed: 9801724]
- Remien RH, Exner T, Kertzner RM, Ehrhardt AA, Rotheram-Borus MJ, Johnson MO, Weinhardt LS, Kittel LE, Goldstein RB, Pinto RM, Morin SF, Chesney MA, Lightfoot M, Gore-Felton C, Dodge B, Kelly JA. Depressive symptomatology among HIV-Positive women in the era of HAART: A stress and coping model. *American Journal of Community Psychology* 2006;38:275–285. [PubMed: 16967343]
- Robinson L, Rempel H. Methamphetamine use and HIV symptom self-management. *Journal of the Association of Nurses in AIDS Care* 2006;17:7–14. [PubMed: 16979510]
- Rotheram-Borus MJ, Desmond K, Comulada WS, Wong L, Arnold EM, Johnson M, Pequegnat W, Morin S, Weinhardt L, Ehrhardt A, Lightfoot M. The Healthy Living Trial Group. Reducing sexual and drug acts among marginally housed adults living with HIV. *American Journal of Public Health*. 2008 (pub ahead of print).
- Rotheram-Borus MJ, Murphy DA, Swendeman D, Chao B, Chabon B, Zhou S, Birnbaum J, O'Hara P. Substance use and its relationship to depression, anxiety, and isolation among youth living with HIV. *International Journal of Behavioral Medicine* 1999;6:293–311. [PubMed: 16250672]
- Rotheram-Borus MJ, Murphy DA, Wight RG, Lee MB, Lightfoot M, Swendeman D, Birnbaum JM, Wright W. Improving the quality of life among young people living with HIV. *Evaluation and Program Planning* 2001;24:227–237.
- Samet JH, Libman H, Steger KA, Dhawan RK, Chen J, Shevitz AH, Dewees-Dunk R, Levenson S, Kufe D, Craven DE. Compliance with zidovudine therapy in patients infected with human immunodeficiency virus, type 1: a cross-sectional study in a municipal hospital clinic. *American Journal of Medicine* 1992;92:495–502. [PubMed: 1580296]
- SAS Institute, Inc. SAS/STAT Software: Changes and Enhancements through Release 6.12. SAS Institute, Inc; Cary, NC: 1997.
- Spielberger, CD.; Gorsuch, RL.; Lushene, RE. Manual for the State-Trait Anxiety Inventory (Self-Evaluation Questionnaire). Palo Alto: Consulting Psychologists Press; 1970.
- Sy JP, Taylor JMG, Cumberland WG. A stochastic model for the analysis of bivariate longitudinal AIDS data. *Biometrics* 1997;53:542–555. [PubMed: 9192450]
- Tourniera M, Sorbaraa F, Gindrea C, Swendsenb JD, Verdoux H. Cannabis use and anxiety in daily life: a naturalistic investigation in a non-clinical population. *Psychiatry Research* 2003;118:1–8. [PubMed: 12759155]
- Weinhardt LS, Kelly JA, Brondino MJ, Rotheram-Borus MJ, Kirshenbaum SB, Chesney MA, Remien RH, Morin SF, Lightfoot M, Ehrhardt AA, Johnson MO, Catz SL, Pinkerton SD, Benotsch EG, Hong D, Gore-Felton C. HIV transmission risk behavior among men and women living with HIV in cities in the United States. *Journal of Acquired Immune Deficiency Syndromes* 2004;36:1057–1066. [PubMed: 15247559]
- Weiss, RE. Modeling Longitudinal Data. Vol. Chapter 13. New York: Springer-Verlag; 2005.
- Wolitski RJ, MacGowan RG, Higgins DL, Jorgensen CM. The effects of counseling and testing on risk-related practices and help-seeking behavior. *AIDS Education and Prevention* 1997;9(3Suppl):52–67. [PubMed: 9241398]
- Wong FL, Rotheram-Borus MJ, Lightfoot M, Comulada S, Cumberland W, Weinhardt LS, Remien RH, Chesney M, Johnson M. the Healthy Living Trial Group. Effects of behavioral intervention on substance use among people living with HIV: The Healthy Living Project randomized controlled study. *Addiction* 2008;103:1206–1214. [PubMed: 18494840]

Table 1

Demographic and HIV-transmission risk group characteristics of persons living with HIV (PLH) at baseline

Variable	Immediate condition	Lagged condition	Total sample
N	415	436	851
Age (M/ SD)	39.8/ 7.1	40.3/ 7.6	40.0/ 7.3
Ethnicity			
African American	50.6	40.8	45.6
Hispanic	11.6	17.0	14.3
White	30.8	33.5	32.2
Other	7.0	8.2	7.9
High school education or less	43.9	42.2	43.0
HIV-transmission risk group ^a			
Gender			
Female	21.9	20.0	20.9
Male			
IDU	11.6	11.2	11.4
Non-IDU / MSM	55.9	58.5	57.2
Non-IDU / non-MSM	10.6	10.3	10.5

Note. All values are percentages unless otherwise indicated.

^aIDU = Injecting drug user; MSM = man engaging in sex with other men

Table II

Means (standard deviations) of PLH's mental health outcomes, substance use, and risky sexual behavior for each assessment.

Outcome	Outcome timeframe	Baseline (N = 851)	5 months (N = 805)	10 months (N = 771)	15 months (N = 750)	20 months (N = 715)	25 months (N = 720)
<i>Mental health</i>							
Beck Depression Inventory	Past week	13.1 (8.9)	11.9 (8.5)	11.5 (8.4)	10.8 (7.9)	10.7 (8.4)	10.5 (8.7)
Positive States of Mind ^a	Past week	12.6 (3.6)	12.8 (3.5)		13.1 (3.5)	13.1 (3.5)	13.1 (3.5)
State Trait Anxiety Inventory ^a	At time of assessment	36.9 (11.2)	36.5 (11.4)		35.5 (10.7)	35.1 (10.6)	34.8 (10.8)
<i>Substance use</i>							
	Past three months						
Days of alcohol or marijuana use		32.3 (43.1)	31.3 (44.4)	28.7 (39.8)	26.8 (39.1)	29.2 (40.5)	27.7 (41.1)
Days of hard drug use		30.3 (66.8)	22.7 (46.4)	22.9 (46.5)	22.5 (58.5)	20.9 (48.5)	21.0 (58.5)
<i>Risky sexual behavior</i>							
	Past three months						
Numers of HIV-negative partners		5.1 (16.6)	3.3 (9.9)	2.9 (8.8)	3.0 (21.4)	2.2 (9.7)	2.1 (9.3)
Numbers of risky sex acts		8.9 (29.8)	4.5 (13.5)	3.8 (13.6)	3.7 (16.6)	2.6 (8.9)	3.2 (13.5)

^aNot assessed at 10 months

Table III

Correlations between PLH's mental health and transmission risk are estimated in each intervention condition for three time frames: PLH's baseline levels (B), PLH's time trends (T), and from assessment to assessment (A). Each correlation is estimated from bivariate longitudinal models and adjusted for age at baseline, ethnicity, HIV-transmission risk group (women, IDU males, non-IDU gay males, non-IDU heterosexual males), and the number of months from the baseline assessment.

Substance use / Risky sexual behavior	BDI ^a			PSOM ^b			STAI ^c		
	B	T	A	B	T	A	B	T	A
Lagged condition (N = 436)									
Days of alcohol or marijuana use									
Baseline levels (B)	.10	.04		-.014 *	.09		.09	-.19	
Time trends (T)	-.21 *	.22		.38 **	-.091	0	-.22 *	.40	
Assessment to assessment (A)			.03			-.002			.04
Days of hard drug use									
Baseline levels (B)	.21 **	.04		-.016 **			.21 **	-.28	
Time trends (T)	-.16	.13			†		-.33 *	.45	
Assessment to assessment (A)			.09 **			-.09 **			.07 *
Numers of HIV-negative sex partners									
Baseline levels (B)	-.15 *	.04		.12	-.002		-.02	-.08	
Time trends (T)	.07	-.39 *		-.010	.45		-.11	.13	
Assessment to assessment (A)			.02			-.005			.06
Numbers of unprotected sex acts									
Baseline levels (B)	-.01	.03		.05	-.018		-.01	-.04	
Time trends (T)	-.06	-.17		-.007	.48		-.06	.24	
Assessment to assessment (A)			.03			-.008 *			.06
Intervention condition (N = 415)									
Days of alcohol or marijuana use									
Baseline levels (B)	-.03	.16		.01	-.004		.02	.23	
Time trends (T)	-.14	.10		.34 **	-.064 **		-.24 *	.09	
Assessment to assessment (A)			.07 **			-.003			.06

Substance use / Risky sexual behavior	BDI ^a			PSOM ^b			STAI ^c		
	B	T	A	B	T	A	B	T	A
Days of hard drug use									
Baseline levels (B)	-.09	.14		-.04	-.08		.13 *		
Time trends (T)	.20 *	.20		-.06	-.64			†	
Assessment to assessment (A)			.15 **			-.08 *			.13 **
Numbers of HIV-negative sex partners									
Baseline levels (B)	-.16 *	-.04		.09	.11		-.17 *	.17	
Time trends (T)	.09	.11		.11	-.44 *		.05	.25	
Assessment to assessment (A)			.03			-.01			.08 *
Numbers of unprotected sex acts									
Baseline levels (B)	.00	-.11		.03	.20		-.11	.29	
Time trends (T)	-.02	.13		.01	-.45		-.01	.23	
Assessment to assessment (A)			.04			-.004			.00

^aBeck Depression Inventory^bPositive States of Mind^cState Trait Anxiety Inventory*
p < .05**
p < .01

† Unable to fit bivariate longitudinal models with time trends for these outcome pairs

Table IV

Correlations between PLH's mental health and substance use or risky sexual behavior in the entire sample are estimated for three time frames: PLH's baseline levels (B), PLH's time trends (T), and assessment to assessment (A). Each correlation is estimated from bivariate longitudinal models and adjusted for age at baseline, ethnicity, HIV-transmission risk group (women, IDU males, non-IDU gay males, non-IDU heterosexual males), the number of months from the baseline assessment, and intervention condition.

Substance use / Risky sexual behavior	BDI ^a			PSOM ^b			STAI ^c		
	B	T	A	B	T	A	B	T	A
Entire sample (N = 851)									
Days of alcohol or marijuana use									
Baseline levels (B)	.04	.10		-.07	.01		.05	-.02	
Time trends (T)	-.18 **	.16		.36 **	-.72 **		-.22 **	.26	
Assessment to assessment (A)			.05 **			-.03			.05 *
Days of hard drug use									
Baseline levels (B)	.07	.09		-.13 *	-.06		.11	-.10	
Time trends (T)	.03	.17		.02	-.27		-.02	.36	
Assessment to assessment (A)			.11 **			-.10 **			.10 **
Numbers of HIV-negative partners									
Baseline levels (B)	-.16 **	.00		.11 *	.05		-.10	.04	
Time trends (T)	.08	-.15		-.003	-.02		-.04	.19	
Assessment to assessment (A)			.02			-.03			.07 **
Numbers of risky sex acts									
Baseline levels (B)	-.01	-.04		.04	.07		-.06	.10	
Time trends (T)	-.03	.01		-.03	-.20		-.03	.23	
Assessment to assessment (A)			.03			-.05 *			.03

^aBeck Depression Inventory

^bPositive States of Mind

^cState Trait Anxiety Inventory

* p < .05

** p < .01