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Antiretroviral treatment adherence as a mediating factor between psychosocial variables and HIV viral load

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Abstract

Psychosocial factors may directly impact HIV health measures such as viral load (VL), whether or not patients are taking antiretroviral treatment (ART) consistently. Structural equation modeling plus Baron and Kenny's (1986) four-step approach were used to test a mediated model predicting VL among 246 HIV-infected adults who were on ART. Exogenous variables were social support, barriers to adherence, and stress. Moderators were alcohol use, marijuana use, and neurocognitive impairment. A small positive association between marijuana use and ART adherence approached significance. Only barriers to adherence predicted a decrease in adherence rates and an increase in VL. No other factors were significantly associated with either VL or adherence and no interaction effects between exogenous variables and moderators were identified. The association between

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barriers to adherence and VL was partially mediated by ART adherence. Findings provide modest support for a direct link between psychosocial variables and a virologic response to ART.

Keywords

adherence; alcohol; antiretroviral; HIV; marijuana; psychosocial; treatment; viral load

More than 600,000 people in the United States have died from complications related to infection with HIV since the beginning of the epidemic (Centers for Disease Control and Prevention [CDC], 2013). Prior to the introduction of protease inhibitors, HIV was the leading cause of death among adults 25 to 44 years of age in the United States; death rates have fallen 79% since 1995 as a result of highly active combination antiretroviral therapy (ART) and other new medications (CDC, National Center for Health Statistics, 2011). ART adherence improves health outcomes by promoting the ability of ART to suppress viral replication and improve immune function and is believed to be central to successful treatment for people living with HIV (PLWH; Bangsberg et al., 2000).

Inadequate adherence is associated with increased mortality, viral replication, and increased risk of transmitting HIV to others. Non-adherence has been linked to multiple psychosocial factors including exposure to trauma and stressful life events (Mugavero et al., 2009). Social support is another psychosocial factor known to have an impact on ART adherence (DiMatteo, 2004). In some studies, the association between support and adherence has been shown to be indirect, operating through other variables such as self-efficacy and depression (DiIorio et al., 2009).

Medical models, accounting only for factors with a direct biological association to health outcomes, have been the predominant paradigm of health and disease. However, it is becoming more commonly accepted that illness and wellness are the result of an interaction between biological, psychological, and social factors (Falvo, 2013). While our study does not test a model, the original biopsychosocial model suggested that psychosocial, cognitive, and behavioral factors might directly influence a biomedical outcome (Engel, 1977). The model has been successfully applied to disease processes and causes, but less successfully applied to actual health outcomes (Alonso, 2004). When used to examine health outcomes, the biopsychosocial model has been used to predict pain symptoms (McLean, Clauw, Abelson, & Liberzon, 2005), gastrointestinal distress (Levy et al., 2006), and common measures of chronic disease such as blood pressure and blood sugar (McCabe, Schneiderman, Field, & Skyler, 2013).

A considerable body of evidence suggests that stressors may adversely affect biomarkers of disease progression, particularly CD4⁺ T cell count and mortality, for PLWH (Ironson & Hayward, 2008; Ironson et al., 2005; Mugavero et al., 2009). Unlike VL, these health outcomes have been clearly linked to the stress-response system, also termed the hypothalamic-pituitary-adrenal (HPA) axis. In a comprehensive review of empirical studies, Cole (2008) suggested that sympathetic nervous system and HPA axis mediation may exist between psychosocial factors and HIV pathogenesis; that is, how HIV causes illness, particularly immunosuppression. Less support exists for a direct link between HPA axis

function and VL. Social support may act as a protective factor to improve virologic response and slow HIV disease progression (Ironson & Hayward, 2008; Leserman, 2008); however, results are mixed. Several studies have found significant associations between social support and immunologic response or HIV symptoms (Ashton et al., 2005; Solano et al., 1993). Other research has not found a relationship between social support and either biomarkers (Ironson et al., 2005) or other clinical evidence of HIV disease progression (Solano et al., 2002; Thornton et al., 2000), although these studies demonstrated stronger evidence for affecting clinical and immunologic disease progression (i.e., CD4+ T cell count) than for affecting VL.

It is important to consider the role of cognitive and substance abuse factors that may mediate relationships between psychosocial predictors and health outcomes. Many PLWH are affected by neurocognitive impairment and drug or alcohol abuse. Mild forms of HIV-associated neurocognitive disorders (HAND) continue to be observed in more than 50% of PLWH (Heaton et al., 2011) and such impairment can hinder ART adherence (Hinkin, Castellon, & Durvasula, 2002). There is also substantive evidence of a link between alcohol and general illicit drug use with ART nonadherence (Bryant, Nelson, Braithwaite, & Roach, 2010), but research regarding adherence and marijuana use in particular has been mixed (De Jong, Prentiss, McFarland, Machekano, & Israelski, 2005). Further, research concerning marijuana use, and its effects upon virologic, immunologic, and other health measures of HIV, remains limited.

While correlates of ART adherence have been studied extensively, there remains a gap in research examining relationships of common biopsychosocial factors and their influence on HIV-related health and VL. Our study sought to explore whether several psychosocial variables had a direct effect upon VL or had an indirect association with VL via full mediation of ART adherence.

Methods

Sample

Our study tested a directional model to predict VL, mediated by ART adherence. Constant variables were age, education, and gender. Independent variables were social support, stress, and barriers to treatment adherence, moderated by cognitive and behavioral factors (neurocognitive impairment, alcohol use, and marijuana use). Cross-sectional data were gathered between 2009 and 2012 at baseline of a prospective randomized controlled trial for HIV-infected adults with a history of alcohol abuse or dependence within the previous 2 years. The Florida International University Institutional Review Board approved protocols for the parent study (IRB-102607-01) and for our study (IRB-13-0072). Participants were provided a written document of informed consent, including a description of potential risks and benefits of study participation. Participants were recruited from community-based organizations in low-income areas of Miami-Dade and Broward counties, Florida. Many of the sites were residential drug and alcohol treatment facilities. The inclusion criteria were: being between 18 and 60 years of age, having HIV infection, having consumed any alcohol in the previous 3 months, having a history of alcohol abuse or dependence within the previous 2 years, facility in English, and currently not displaying signs of major psychiatric

disorder. An additional criterion for the study was self-report of current prescription for ART. Of the 370 participants recruited, 73.8% ($n = 273$) had been prescribed ART and were eligible for the study. Some of the 273 participants were removed upon analysis as described below.

Measures—Assessment methods included: (a) computer-assisted personal interview (CAPI), (b) audio computer-assisted self-interview (ACASI) for subjective sensitive topics, (c) paper and pen as specified for neurological measures, and (d) timeline follow-back using a calendar format. ART adherence was the self-reported percentage of time ART medications were taken as prescribed over the course of a week, per the Community Programs for Clinical Research on AIDS (CPCRA; Mannheimer, Matts, Telzak, & Chesney, 2010). The adherence score was calculated as the mean of the combined total amount of each medication taken during the previous week, according to the scale: *all* (100%), *most* (75%), *about half* (50%), *few* (25%), or *none* (0%). The instrument has been correlated with other self-report adherence instruments and has effectively predicted biologic outcomes such as VL and CD4+ T cell count (Mannheimer, Friedland, Matts, Child, & Chesney, 2002). The participant supplied documentation of recent VL upon entry into the study. Lab measures must have been collected 1 month before or after the date of baseline assessment. VL was log₁₀-transformed for analysis.

Tangible social support was measured using four items from the Medical Outcomes Study (MOS; Sherbourne & Stewart, 1991). The MOS is a functional subscale of the 19-item social support measure, which examined the degree to which the participant had help for medical or daily living needs. Each item is rated from (1) *none of the time* to (5) *all of the time*. A higher score indicated greater tangible support. For our study data, the MOS had strong internal consistency with a Cronbach's alpha of 0.89 for the tangible support subscale. All subscales have shown strong reliability over time (alphas > 0.91) and the four tangible support subscale items had high convergent validity with scale items correlating from 0.72 to 0.87 (Sherbourne & Stewart, 1991).

Stress was measured with 40 items modified from the Life Experiences Survey (Sarason, Johnson, & Siegel, 1978) and the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983). The first section is a list of 32 events common to people in a wide variety of situations such as divorce, moving, and loss. If a participant indicated that an event occurred in the previous 3 months, s/he rated it: (1) *very bad*, (2) *somewhat bad*, (3) *somewhat good*, or (4) *very good*. Items rated (1) or (2) were reverse scored and summed for a negative impact score. Items rated 3 or 4 were not counted. Eight additional items listed issues more specific to PLWH and rated on the degree to which each issue bothered the participant from (1) *not at all* to (5) *extremely*. Items scored (3), (4), or (5) were recoded from 1–3 respectively and added to the negative impact score for a total of 88 possible points. Reliability for this measure was strong for our participants with a Cronbach's alpha calculated at 0.95.

Barriers to adherence, a self-report tool used by the CPCRA, offers 10 possible reasons for missing doses of ART with dichotomous (*yes/no*) responses (Mannheimer et al., 2002).

Options included: *I forget to take my pills, I was away from home, and I am too busy*. Internal consistency of items was 0.81.

Three neuropsychological tests were administered to derive scores in a range of cognitive domains including memory, information processing, and executive functions. The tests selected have been used in previous studies with PLWH who use alcohol and other drugs, and have well-developed norms and high reliability and validity.

The Auditory Verbal Learning Test, University of California Los Angeles/World Health Organization Version (AVLT; Maj et al., 1994) measures immediate verbal memory and learning. Our study utilized the total of immediate recall scores for trials 1–5, with higher scores indicating greater functioning. The instrument demonstrated high test-retest reliability, with alpha scores ranging from 0.51 to 0.72 (Lezak, 2004). The Color Trails Test 2 (CTT-2) assessed attention, information processing, and psychomotor coordination. Analysis used the raw time in seconds, with higher scores indicating poorer functioning. The CTT-2 was developed for the World Health Organization Multicenter Study of HIV infection (D’Elia, Satz, Uchiyama, & White, 1996). The instrument has shown strong agreement with other cognitive assessments in PLWH (Maj et al., 1994) and has displayed good temporal stability with test-retest reliability between 0.85–1.00 (D’Elia et al., 1996). The Category Test Short Form-Booklet Format (Wetzel & Boll, 1987) assesses executive functions and problem-solving ability. We used the total raw error score, with higher scores indicating poorer functioning. Test-retest coefficients have varied from 0.60 to 0.96 depending upon the severity of impairment in the sample (Wetzel & Boll, 1987). The raw neurocognitive scores were dichotomized; participants who scored at least one standard deviation below normative means on at least two instruments were identified as displaying greater neurocognitive impairment (Antinori et al., 2007). Normative data for CTT-2 and AVLT were obtained from professional manuals provided for the instruments. Norms for the AVLT were retrieved from *The Handbook of Normative Data for Neuropsychological Assessment* (Mitrushina, Boone, Razan, & D’Elia, 2005). Comparison groups were assumed to be healthy, uninfected populations.

Recent alcohol and marijuana use were assessed by timeline follow-back using a calendar format to enhance accurate recall and to provide a continuous history of drug and alcohol consumption. These two variables were measured by asking the total number of drinks consumed and total number of times using marijuana in the previous 3 months. Up to 3 months recall of alcohol and other drug use is known to provide reliable data (Schroder, Carey, & Vanable, 2003). An analysis of test-retest reliability yielded intra-class correlations ranging from 0.70 to 0.94 in a drug-using sample (Fals-Stewart, O’Farrell, Freitas, McFarlin, & Rutigliano, 2000). It should be noted that data on other drug use were available; however, very few participants reported use of substances other than alcohol and marijuana.

Analytic strategy—Descriptive statistics and skewness/kurtosis values were calculated for all of the variables in the model. Means and standard distributions were calculated for all continuous variables; percentages were provided for categorical and ordinal variables. Missing data bias was evaluated by computing a dummy variable that reflected the presence

or absence of missing data for each variable. A full information maximum likelihood method was used to accommodate the missing data. Robust Maximum Likelihood framework accommodated issues of data distribution (Yuan & Bentler, 2000). A limited information approach provided approximate sample size and statistical power, accounting for at least 5% of variance in the outcome (Jaccard & Wan, 1996). To assess non-model-based outliers, leverage indices were examined for each participant based on his/her multivariate profile for the variables included in the model analyses. A leverage score four times greater than the mean leverage indicated the presence of outliers. Only outlier cases that were uninterpretable and significantly impossible were eliminated from final model analysis ($n = 27$). A model-based outlier was defined as a participant with an absolute standardized DFBeta coefficient less than 1.0 and none were detected based upon this criterion.

Moderation analysis was conducted by creating product terms between each independent variable and each moderator, which represented the interaction effect (Jaccard, Turrissi, & Wan, 1990). All predictor variables were centered to protect against multicollinearity and to ease interpretation. The hypothesized multivariate linear regression model was analyzed using Mplus software, version 5.1. The Structural Equation Modeling approach tested a linear moderated model such that $Y = b_0 + b_1X_1 + b_2X_2 + b_3X_1X_2 + e$. Non-significant product terms were sequentially dropped from the model until only significant terms remained. Fit indices, path values, and confidence intervals were reported.

Interaction effects and mediation were analyzed separately (Ryu, West, & Sousa, 2009). No interaction effects were identified. Linear regression for testing mediation was conducted using SPSS version 20; missing data were imputed using expectation maximization likelihood. After confirming that all variables considered for a mediation model were correlated, mediation was tested in four traditional steps (Baron & Kenny, 1986): (a) test associations between independent variables and the mediator, (b) test associations between independent and dependent variables, (c) test the relationship between mediator and dependent variables, and (d) regress the independent variables on the dependent variables, controlling for the mediator to assess whether the association between independent and dependent variables persisted. In addition, a Sobel Test was conducted to confirm mediation (Sobel, 1982).

Results

The mean age of participants was 45 years; 66% were male, 77.3% reported their race as Black, and 13.5% reported their ethnicity as Hispanic (see Table 1). Most (55.9%) participants reported at least high school graduation, but few (9%) were employed. On average, participants reported drinking 173 drinks and using marijuana 19.17 times in the previous 90 days. Mean number of years with HIV was 12.14; 60% of participants sought care within 12 weeks of HIV diagnosis while 25% had waited for more than 1 year to seek care. Neurocognitive impairment was observed in 34% of participants. Mean scores on all three neurocognitive measures were significantly lower than mean scores for uninfected norms. Experiencing any adherence barriers was reported by only 11% of participants; most frequently selected barriers were: *I feel worse when I take the pills, I forget to take the pills,*

I was away from home, and I had problems taking pills at specified times (with meals, on an empty stomach, etc.). Tangible social support scores ranged from 0 to 30 with a mean score of 13.3. Stress scores ranged from 7 to 164 with a mean score of 59.74. Mean self-reported ART adherence over a 1-week period was 93.5%, with 81.5% of participants reporting adherence of at least 95%. VL ranged from undetectable to more than 900,000 copies/mL with a mean VL of 16,246 copies/mL (median = 11,984 copies/mL); 28% had less than 50 viral copies/mL.

Table 2 reports bivariate correlations among the variables in the model before the directional structural equation model was tested. After examining diagnostics, the final moderated model was tested (see Figure 1); both significant and non-significant, unstandardized path coefficients of the final model are presented with non-significant product terms removed. All exogenous variables were assumed to be correlated. Unstandardized path coefficients, standard errors, and 95% confidence intervals are listed in Table 3. The final model was just identified. As such, fit indices are uninformative and not reported.

The final model explained 31% of variance in ART adherence and 18% of variance in log₁₀ VL. When examining associations between predictors and outcomes, two significant paths were identified. Each increase in number of barriers to adherence predicted a 10.06% decrease in adherence to ART and also predicted a 0.42 unit increase in log₁₀ VL.

A modest association between marijuana use and ART adherence was observed and approached significance ($\beta = 0.15$, $p = 0.057$); however, the variable, *barriers to medication adherence*, was the only independent variable significantly associated with both ART adherence and VL in the Structural Equation Modeling model, so it was chosen for testing in a mediated relationship. Barriers and ART adherence ($r = -0.50$), ART adherence and VL ($r = -0.26$), and barriers and VL ($r = 0.36$) were significantly correlated at $p < 0.01$.

Linear regression results for mediation testing are reported in Table 4. Step 1: *Barriers* was significantly and negatively associated with adherence ($\beta = -9.47$; $p < 0.001$). Step 2: *Barriers* was significantly associated with higher VL ($\beta = 0.30$; $p = 0.002$). Step 3: *Adherence* was associated with lower VL ($\beta = -0.02$; $p = 0.05$). Step 4: *Barriers* ceased to be associated with VL when controlling for adherence ($\beta = 0.20$; $p = 0.09$). This suggested that mediation was not full, as confirmed by the Sobel Test ($\beta = 0.99$, $p = 0.32$), but much of the effect of *barriers to adherence* on VL was apparently due to the effect on ART adherence.

Discussion

Results from this study provide modest support for a biopsychosocial approach to understanding the HIV-related health outcome of virologic suppression. In this study, the only psychosocial variable found to be significantly associated with VL was *barriers to adherence to ART*. Interestingly, the number of barriers to adherence was more strongly correlated than actual adherence with VL. A self-reported measure of perceived barriers, this construct may be a proxy for distress intolerance, which would likely be associated with ART non-adherence and ultimately viral replication (Oser, Trafton, Lejuez, & Bonn-Miller,

2013). The relationship between number of barriers and actual adherence rates has been observed in other studies (Catz, Kelly, Bogart, Benotsch, & Mcauliffe, 2000); however, none of these studies included VL as a health outcome. Our study suggests that ART adherence does not fully mediate the relationship between perceived barriers and VL. Were adherence to fully mediate the relationship between barriers and VL, no direct influence of the psychosocial predictor on the biomedical outcome could be supported (Robins & Greenland, 1992). The barriers most frequently selected by participants in this study (mostly logistical issues with taking medication) were similar to those reported in other studies; however a meta-analysis of adherence barriers found that stigma was the most frequent barrier reported by participants in developed countries (Mills et al., 2006). Considering the degree to which this population exhibited neurocognitive impairment, it was not surprising that one of the most commonly selected barriers involved regimen complexity (Hinkin et al., 2002; Wright et al., 2011).

Neither stress nor social support predicted VL or adherence in our study. Identifying direct links between psychosocial factors and HIV biomarkers has proved challenging. Thornton et al. (2000) conducted a longitudinal analysis of CD4+ T cell count and time to AIDS diagnosis, predicted by stressful life events and social support; neither was found to be significantly associated with these outcomes. Solano et al. (1993) reported several psychosocial variables associated with disease progression in PLWH with poorer immune function, although these were not strong predictors for those with higher CD4+ T cell counts. Alternately, multiple studies have revealed effects of stress or social support on HIV biomarkers or other indicators of disease progression (Ashton et al., 2005; Ironson & Hayward, 2008; Ironson et al., 2005; Mugavero et al., 2013). While these studies did not control for ART adherence, one study identified an effect of stress upon CD4+ T cell count decline when accounting for adherence (Remor, Penedo, Shen, & Schneiderman, 2007). As reported for a biopsychosocial model exploring the effects of stress, stability, and treatment adherence on insulin-dependent diabetes (Peyrot, McMurphy, & Kruger, 2013), medication adherence is essential in chronic disease management to achieve optimal health outcomes.

Our study included moderating effects of alcohol and marijuana use. Alcohol abuse in particular has been studied extensively and shown to result in deleterious physical outcomes including poor adherence to health care recommendations, particularly for following a medication regimen (Bryant, 2006); however, our study did not identify such an association with alcohol. This lack of association may be explained by the fact that we did not control for alcohol abuse history, a condition for study enrollment. In contrast, a modest positive association between marijuana use and ART adherence approached statistical significance. Although research has found marijuana use to decrease ART adherence (Corless et al., 2009), some studies have suggested that marijuana use may either have no effect upon adherence (Rosen et al., 2013) or serve to reduce symptoms and improve ART adherence in PLWH (De Jong et al., 2005). It is possible that different degrees of use or dependence may play a role in whether this drug serves to improve or hinder ART adherence (Bonn-Miller, Oser, Bucossi, & Trafton, 2012).

Certain limitations of our study should be noted when interpreting results. First, participants were recruited from clinical sites, reducing generalizability to non-clinical samples. We did

not account for intoxication effects of alcohol and other drugs. Also, about one third of the sample were in residential drug or alcohol treatment at the time data were collected, and reporting bias may have existed, particularly for responses to questions about drug and alcohol use. The fact that many participants were engaged in care may also have accounted for the unusually high adherence rates reported in this sample. High adherence rates reported in our study may also be explained by the use of self-report measurements, which have been found to provide inflated values (Cramer, Mattson, Prevey, Scheyer, & Ouellette, 2013). Adherence was not as strongly associated with VL as would be expected, and it is possible that non-adherence was inadvertently measured through the *barriers to adherence* variable. Further, outcomes may not be generalizable to specific ethnic groups, regions, or other demographics such as youth or women. Finally, findings reported were based on a cross-sectional analysis. In examining mediation, Maxwell and Cole (2007) found that estimates using cross-sectional data might be biased (as compared with longitudinal data) because of the failure to allow for autoregressive effects of the mediator and outcome variables. Researchers have cautioned that without a randomized experiment, possible alternative explanations accounting for significant associations could not be ruled out (Baron and Kenny, 1986; Holland, 2013).

Findings from our study support previous reports that viral suppression in PLWH is largely a product of ART adherence, with modest impact from psychosocial factors. Because ART adherence remains the primary predictor of virologic suppression and improved health outcomes for PLWH, fostering adequate medication management must remain a priority in HIV care. It is important to pinpoint specific barriers that may be hindering adequate adherence; for example, in this population of drug and alcohol users with high degrees of neurocognitive impairment, more logistical barriers than psychological barriers were reported. ART adherence rates are also subject to fluctuations based upon changes in stress, social support, and drug and alcohol use. Future research on psychosocial impacts on HIV-related health should also seek to explore multiple other predictors such as mental health, coping, physical activity, and smoking. Thus, maintaining a holistic perspective of health care and regard for the myriad psychosocial factors in the lives of PLWH can improve health outcomes. It is important to assess broader, more ecological models to determine health outcomes such as VL when a biomedical approach alone has failed to eradicate HIV progression and transmission. Findings from our study may help shed light on psychosocial factors associated with HIV-related health and illness that are responsive to such intervention.

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Key Considerations

- An interesting result of our study was that the number of barriers to antiretroviral treatment (ART) adherence was more strongly correlated with viral load (VL) than actual adherence was to VL. Barriers to adherence were likely measuring non-adherence and may be a more accurate measure of treatment behavior than self-reported adherence.
- We found that ART adherence did not fully mediate the relationship between perceived barriers and VL. In other words, other factors beside the use (or non-use) of ART may have influenced health outcomes for people living with HIV in our study.
- A modest positive association between marijuana use and ART adherence approached statistical significance in this study. Marijuana use may have served to reduce symptoms and improve ART adherence among some people living with HIV in our study.

Figure 1.

Regression paths among measured variables in the structural equation model among HIV-infected alcohol abusers ($N=246$).

Note: ART=antiretroviral therapy

* $p < 0.05$; ** $p < 0.01$; Regression coefficients (represented as one-way arrows) are unstandardized.

Table 1

Sociodemographic Characteristics of Participants and Descriptive Statistics of Variables in the Model ($N = 246$)

	Mean (SD)/ N (%)	Skewness/Kurtosis
Age	45.24 (7.04)	-0.58/-0.05
Gender (Male)	161 (66%)	-0.68/-1.55
Hispanic ethnicity (Yes)	33 (13.5%)	-
Race		-
Black	187 (77.3%)	-
White	36 (14.9%)	-
Years education		0.44/-0.18
< 8 th grade	19 (7.8%)	-
Some high school	89 (36.3%)	-
High school graduate	70 (28.6%)	-
Some college/tech	53 (21.6%)	-
College degree	11 (4.5%)	-
Graduate training	3 (1.2%)	-
Employed (Yes)	22 (8.9%)	-
Years with HIV	12.14 (7.4)	0.20/-1.01
Time from HIV diagnosis to seeking care		-
< 12 weeks	164 (60%)	-
3 months to a year	52 (19%)	-
> 1 year	68 (25%)	-
ART adherence	93.5 (19.96%)	-3.59/12.83
VL	16,948 (64,685)	7.06/58.27
VL (undetectable)	69 (28%)	-
Social Support	13.30 (4.85)	-0.23/-0.74
Stress	59.74 (34.25)	-0.029/0.25
Barriers to adherence (zero)	165 (89.2%)	3.37/11.30
Alcohol (# drinks/90 days)	173 (261.18)	3.18/12.02
Marijuana (# times using/90 days)	19.17 (34.77)	1.62/1.11
Neurocognitive impairment (Yes)	84 (34.1%)	0.54 -1.71

Note. ART = antiretroviral therapy; VL = viral load.

Table 2Correlation Matrix for all Variables in the Model ($N = 246$)

	1	2	3	4	5	6	7	8	9	10	11
1. Adhere	1.00										
2. VL	-0.26*	1.00									
3. Support	0.15	-0.01	1.00								
4. Stress	0.04	-0.06	0.02	1.00							
5. Barriers	-0.50*	0.36*	-0.07	0.02	1.00						
6. Neurocognitive Impairment	0.06	-0.08	0.00	0.14	-0.01	1.00					
7. Alcohol	0.01	0.01	-0.07	-0.06	0.00	0.08	1.00				
8. Marijuana	0.11	0.10	-0.04	-0.04	0.04	0.00	-0.04	1.00			
9. Age	0.08	0.01	-0.16	-0.07	0.06	0.14	0.02	0.18	1.00		
10. Gender	0.06	0.08	-0.13	-0.13	0.15	0.03	0.08	0.10	-0.04	1.00	
11. Education	0.01	-0.06	-0.03	-0.17	-0.01	-0.11	-0.04	-0.02	0.00	0.06	1.00

Note. VL = viral load.

* Significant at $p < 0.01$

Table 3
Unstandardized Path Coefficients, Standard Errors, 95% Confidence Intervals, and P-Values ($N = 246$)

		Coefficient	SE	95% CI	<i>p</i>
Support	Adherence	0.56	0.41	-0.49, 1.60	0.17
	VL	0.02	0.13	-0.05, 0.08	0.54
Stress	Adherence	-0.002	0.05	-0.13, 0.13	0.97
	VL	-0.002	0.004	-0.01, 0.01	0.57
Barriers to Adherence	Adherence	-10.06	1.72	-14.49, -5.63	< 0.001
	VL	0.42	0.13	0.08, 0.75	0.001
Neurocognitive Impairment	Adherence	2.09	2.29	-3.81, 7.99	0.36
	VL	-0.25	0.26	-0.91, 0.41	0.33
Marijuana	Adherence	0.15	0.08	-0.05, 0.34	0.06
	VL	0.01	0.01	-0.01, 0.02	0.14
Alcohol	Adherence	0.02	0.07	-0.18, 0.21	0.84
	VL	0.00	0.01	-0.02, 0.02	0.95
Age	Adherence	0.19	0.19	-0.30, 0.69	0.31
	VL	0.02	0.02	-0.04, 0.07	0.44
Education	Adherence	1.51	1.52	-2.40, 5.42	0.32
	VL	-0.15	0.11	-0.44, 0.13	0.16
Gender	Adherence	3.63	2.91	-3.86, 11.11	0.21
	VL	0.20	0.29	-0.45, 0.85	0.49

Note. VL = viral load

Table 4Linear Regressions, Test for Mediation ($N = 246$)

	Unstandardized β	SE	95% CI	p	R ²
Barriers ^{<i>I</i>} Adherence	-9.47	1.03	-11.50, -7.43	0.00	0.35
Barriers VL	0.30	0.10	0.11, 0.49	0.002	0.08
ART Adherence VL	-0.02	0.01	-0.03, -0.003	0.02	0.05
Barriers (control for Adherence) VL	0.21	0.01	-0.03, 0.01	0.09	0.1
Adherence (control for Barriers) VL	-0.01	0.01	-0.03, 0.009	0.29	0.1

Note. VL = viral load; ART = antiretroviral therapy^{*I*} Barriers to ART AdherenceSobel $p = 0.32$