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A Social Problem-Solving Model of Adherence to HIV Medications

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Abstract

HIV medication adherence remains a challenge and limits the degree to which treatment benefit can be maximized. The purpose of this paper is to test an explanatory model of HIV medication adherence using a social problem-solving (SPS) framework. Associations of SPS with adherence are hypothesized to be direct and/or indirect via psychological health. HIV+ adults were interviewed using validated measures of SPS, psychological health, and antiretroviral (ART) medication adherence. Structural equation modeling (SEM) techniques were employed to test hypothesized relationships and to evaluate overall fit of the model to the data. SEM supported an indirect association (but not direct) of SPS on adherence via psychological health among the 545 HIV+ adults included in the analyses. Overall, the findings resulted in a model of adherence that offered very good fit to the data and correctly classified 97% of the cases as adherent versus non-adherent. Results support the use of SPS as a conceptual framework for understanding adherence to ART. Findings offer rationale and direction for SPS interventions to enhance adherence by improving psychological health. Such approaches, if effective, have the potential to positively impact psychological well being and adherence, thereby maximizing clinical benefit from treatment, which is linked to lower mortality from AIDS.

Keywords

Social Problem-Solving; HIV; AIDS; Adherence; Compliance; Psychological Distress; Structural Equation Modeling

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The widespread use of antiretroviral therapy (ART) for HIV disease has resulted in substantial decreases in HIV-related mortality since the mid-1990s (Murphy, Collier, Kalish, Assmann, Para, Flanigan, Kumar, Mintz, Wallach, & Nemo, 2001). There remain, however, significant obstacles to maximizing benefit from ART, with a concerning proportion of those on ART failing to reach the 90+% adherence necessary for maximum benefit (Belzer, Fuchs, Luftman, & Tucker, 1999; Garcia de Olalla, Knobel, Carmona, Guelar, Lopez-Colomes, & Cayla, 2002; Johnson, Catz, Remien, Rotheram-Borus, Morin, Charlebois, Gore-Felton, Goldstein, Wolfe, Lightfoot, Chesney, & NIMH HLP Team, 2003; Paterson, Swindells, Mohr, Brester, Vergis, Squier, Wagener, & Singh, 2000; Singh, Berman, Swindells, Justis, Mohr, Squier, & Wagener, 1999; Spire, Duran, Souville, Leport, Raffi, & Moatti, 2002). Demanding dosing schedules and debilitating side effects are characteristic of many ART regimens and as a result, many people are unsuccessful in taking medications as prescribed (Bartlett, 2002; Chesney, 1999; Chesney, Ickovics, Hecht, Sikipa, & Rabkin, 1999).

There are many factors linked to nonadherence in the literature, including (a) treatment factors such as e.g. regimen complexity and side effects, (b) individual factors, such as psychological distress and substance use, and (c) environmental factors, such as provider relationships and

healthcare access (Fogarty, Roter, Larson, Burke, Gillespie, & Levy, 2002; Johnson et al., 2003; Johnson, Charlebois, Morin, Catz, Goldstein, Remien, Rotheram-Borus, Mickalian, Kittel, Samimy-Muzaffar, Lightfoot, Gore-Felton, Chesney, & NIMH HLP Team, 2005; Remien, Hirky, Johnson, Weinhardt, Whittier, & Minh-Le, 2003). Interventions to address these factors have met with varying success (Fogarty et al., 2002; Simoni, Frick, Pantalone, & Turner, 2003). A lack of a cohesive model to support intervention may be responsible for inconsistent results.

Social problem-solving (SPS) represents an unexplored avenue for conceptualizing and intervening with HIV medication nonadherence. The SPS model describes constructive and dysfunctional styles of solving problems that effect health and adjustment (D'Zurilla & Goldfried, 1971; D'Zurilla & Nezu, 1989; Nezu, 2004). In this model, the primary components of SPS have specific, testable properties that theoretically influence adjustment. For example, the problem orientation component explains how individuals' motivations and mood regulatory properties affect perceptions of competencies and abilities, and propensity for positive and negative moods when facing problems. The problem-solving skills component describes the ways in which a person may rationally solve problems, or be likely to ineffectively solve problems in an impulsive, careless or avoidant manner. Theoretically, these components work together to form SPS styles.

A positive orientation motivates an individual to rationally solve problems that are encountered, and together these components comprise a constructive problem-solving style (D'Zurilla, Nezu, & Maydeu-Olivares, 2004). Conversely, individuals who possess a more negative orientation are more likely to rely on impulsive, careless, or avoidant ways to solve their problems, and this reflects a dysfunctional problem-solving style (D'Zurilla et al., 2004). While constructive and dysfunctional problem-solving styles are inversely related, they are not necessarily polar ends of a problem-solving continuum. Conceptually, a person can have a negative problem orientation and may therefore have a strong negative emotional response in the face of a problem. However, this person may still deal with the problem in a rational manner, thus displaying constructive and dysfunctional problem-solving tendencies in their attempts to cope with their problem. The current study will test this theoretically supported separation of a constructive style and a dysfunctional problem-solving style as compared to a single problem-solving construct.

Considerable evidence attests to the applicability of the SPS model to the study of persons facing health-related conditions (Elliott, Grant, & Miller, 2004). Dysfunctional problem-solving styles have consistently been predictive of depression and other indicators of poor adjustment (e.g., self-reported disability, anxiety) in cross-sectional (Elliott et al., 2004; Elliott & Marmarosh, 1994) and prospective (Elliott, Shewchuk, & Richards, 2001) research. The mood regulatory properties have also been demonstrated in the prospective prediction of post-partum depression (Elliott, Shewchuk, Richeson, Pickelman, & et al., 1996). Other data indicate that a more constructive style is associated with greater life satisfaction among persons with chronic disease (Elliott, Shewchuk, Miller, & Richards, 2001) and with positive shifts in perspective among persons facing permanent and disabling conditions such as spinal cord injury (Elliott, 1999).

SPS styles appear particularly applicable to the study of adjustment of persons living with chronic health conditions, because these individuals "...simultaneously cope with the tasks and symptoms" associated with their condition while meeting the demands and "...perform roles essential to the function of everyday life" (Elliott et al., 2004, p. 129). Indeed, emerging evidence indicates that SPS styles are implicated in the development of health complications that are prevented by adherence to behavioral self-care regimens (e.g., decubitus ulcers; Elliott, Bush, & Chen, In Press). Adherence to any therapeutic regimen is less likely when adherence

involves complex self-care behavior on a daily, long-term basis, with little or no apparent relation to an eventual outcome (Turk & Meichenbaum, 1989). Most therapeutic regimens associated with chronic illness are not positively rewarding, given the effort, time and ambiguous linkage between the behavior and a positive (or negative) outcome.

Dysfunctional problem-solving styles are associated with risk-taking behaviors (on self-report measures; Dreer, Elliott, & Tucker, 2004; Elliott, Johnson, & Jackson, 1997) and associated with a lower likelihood to comply with therapeutic guidelines for behavior as directed by clinical staff (in an inpatient treatment program for persons with dual diagnoses; Herrick & Elliot, 2001). Constructive SPS styles may also promote adherence to therapeutic regimens indirectly by providing an individual with the cognitive attitudes, emotional regulation and instrumental skills necessary for coping effectively with everyday demands and stress, and by promoting a more optimal emotional tone (evident under routine and stressful conditions; Elliott, Sherwin, Harkins, & Marmarosh, 1995). Alternately, dysfunctional problem-solving styles may interfere directly with adherence by impeding prescription refills, side effects management, follow-up appointment keeping, medication reminder mechanisms, and coping with illness-related stigma. Perri et al. found training in SPS helped participants in a weight-loss program to effectively address problems that would have directly and indirectly compromised their adherence such as scheduling difficulties, managing life stress, completing therapeutic assignments, and warding off emotional distress that could interrupt regimens or trigger a relapse of unhealthy behavioral patterns (Perri, Nezu, McKelvey, Shermer, Renjilian, & Viegnener, 2001).

Given the complex issues that have been linked to adherence to ART and the resulting challenge of complying with a treatment regimen, an SPS framework offers promise in clarifying and improving HIV treatment adherence. The purpose of this paper is to test, through structural equation modeling (SEM), a model of ART adherence in which SPS influences medication adherence both directly and indirectly through psychosocial health.

Method

Participants

HIV+ individuals in the San Francisco Bay Area were screened for recruitment into the Healthy Living Project (HLP), a clinical trial of a comprehensive cognitive-behavioral sexual risk reduction intervention that also included coping skills and treatment adherence intervention modules. Recruitment and screening of potential respondents were undertaken in community agencies and medical clinics serving HIV+ clients. Brochures, posters, media advertisements and word of mouth were used to recruit respondents. Respondents were at least 18 years of age, provided written informed consent and medical documentation of HIV infection, and were free of severe neuropsychological impairment or psychosis, as assessed by senior project personnel.

Overview of Assessment Procedures

The data reported in this paper are from the baseline interview that served as screening determination for HLP. All procedures were approved by the Institutional Review Board. Interviews were conducted in private offices over a period of 2−4 hours with regular breaks to minimize respondent fatigue.

Procedures involved Audio Computer Assisted Self-Interviewing (ACASI) and Computer Assisted Personal Interviewing (CAPI) using QDS by Nova Research Company. ACASI allows respondents to listen to items via headphones while reading items on a computer monitor and to enter responses directly into the computer. This approach has been proposed as an

effective method of decreasing social desirability and thereby enhancing veracity of self-report (Gribble, Miller, Rogers, & Turner, 1999; Turner, Ku, Rogers, Lindberg, Pleck, & Sonenstein, 1998). With CAPI, an interviewer reads items from a computer and enters responses directly into the computer.

Respondents were compensated US$50 for completing the interview and those needing child care were eligible to receive US$10 to defray child care costs.

Interviewer Training and Quality Assurance

Interviewers were trained with the use of a detailed assessment manual, practice with the computer programs, participation in an intensive 3-day training program, and review and certification of audiotaped interviews with standardized criteria. Interviews were audiotaped and a systematic sample was reviewed for protocol adherence with feedback and correction provided on a regular basis.

Measures

Demographics / background—Detailed background and demographic questions assessed respondent age, race/ethnicity, gender, sexual orientation, educational, employment status, and self-reported CD4 count and viral load.

Social support—A global score on the Social Provisions Scale (Cutrona, 1989; Cutrona & Russell, 1990) was used to assess level, type, and perceived satisfaction with available social supports. This score was an average of the 6 SPS subscales: guidance, reliable alliance, reassurance of worth, attachment, social integration, and opportunity for nurturance (α for total score is .82, current sample).

Substance use—Use of licit and illicit substances in the past three months was assessed including alcohol, cocaine/crack, and stimulants. Daily alcohol use and any hard drug use (heroin, cocaine, speed, etc.) were each dichotomized.

Depression—Depression was assessed with the 21-item Beck Depression Inventory (BDI) (Beck, 1967; Beck & Steer, 1984) (α current sample= .85) which has been widely used in studies with HIV-infected patients to evaluate the severity of depressive symptoms (Griffin & Rabkin, 1997).

Perceived stress—Perceived stress was assessed with the 10-item form of the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983) by summing ratings on a 5-point scale (α current sample = .83).

Positive states of mind—Positive affect was assessed with the 6-item Positive States of Mind Scale (Adler, Horowitz, Garcia, & Moyer, 1998; Horowitz, Adler, & Kegeles, 1988). Ratings on a 4-point scale are summed such that higher scores reflect a greater capacity to focus attention on the positive aspects of experiences (α current sample = .80).

Social problem-solving—The Social Problem-Solving Inventory-Revised (SPSI-R; D'Zurilla, Nezu, & Maydeu-Olivares, 2002) is a self-report measure of SPS styles. We used the 25 item short version in this study. Items are rated on a 5-point Likert scale from *not very true of me (0)* to *extremely true of me (4).* The SPSI-R is based on a five-dimensional model of SPS and includes five scales (D'Zurilla & Nezu, 1999). Two of the scales measure problem orientation dimensions: Positive Problem Orientation and Negative Problem Orientation. The remaining scales are considered problem-solving skills scales: Rational Problem-Solving, Impulsive/Careless Style, and Avoidance Style. The Positive Orientation scale (PPO) assesses

a general cognitive set, including the tendency to view problems in a positive light, to see them as challenges, and to be optimistic of the existence of a solution and one's ability to detect and implement effective solutions. The Negative Orientation (NPO) scale assesses a cognitive-behavioral set that hinders effective problem-solving. The Rational Problem-Solving scale (RPS) assesses the tendency to systematically and deliberately use effective problem-solving techniques that include defining the problem, generating alternatives, evaluating alternatives, implementing solutions and evaluating outcomes. The Impulsive/Careless Style scale (ICS) measures a tendency to implement skills in an impulsive, incomplete and haphazard manner. The Avoidance Style scale (AS) assesses the degree to which a respondent ignores a problem, procrastinates, and waits for a problem to resolve spontaneously.

Internal consistency estimates computed for the scale on the 52-item version have ranged from .76 (PPO) to .92 (RPS), and test-retest (3 weeks) reliability ranged from .72 (PPO) to .88 (NPO; D'Zurilla, et al., 2002). Criterion-referenced validity is evidenced by significant correlations with relevant scales on the Problem-Solving Inventory (Heppner, 1988) and with other theoretically related constructs as stress, somatic symptoms, anxiety, depression, hopelessness, and suicidality (D'Zurilla et al. 2002). The SPSI-R scales have been predictably associated with self-esteem, life satisfaction, extraversion, social adjustment, and social skills (Nezu, 2004). We explored through SEM the predictive properties of the theoretically distinct elements of constructive (PPO, RPS) and dysfunctional (NPO, AS, ICS; D'Zurilla et al., 2004) styles in the current study.

Medication adherence—Self-reported ART adherence was assessed over a three-day period using an adherence survey developed for use in AIDS Clinical Trials (Chesney, Ickovics, Chambers, Gifford, Neidig, Zwickl, & Wu, 2000). Respondents indicated how many pills they had skipped during each of the previous three days. This measure has been used widely with diverse samples. For the present study, we calculated percent adherence based on number of pills actually taken divided by number of pills prescribed. Respondents were classified as having achieved less than 90% adherence versus 90% or higher adherence, consistent with current literature on minimum levels of adherence to achieve HIV viral suppression and clinical benefit (Garcia de Olalla et al., 2002; Paterson et al., 2000). In the present study, a value of one on the adherence variable indicated less than 90% adherence whereas a value of zero indicates greater than 90% adherence.

Data Analysis

The primary goal of this study was to evaluate the associations of SPS factors with psychological health and adherence. Moreover, we wanted to evaluate whether SPS had a direct association with adherence or if psychological health would mediate the relationship between SPS and adherence. Given the substantial sample size, the presence of multiple measures of psychological health, and our interest in assessing the indirect effect of SPS on adherence mediated by psychological health, we used SEM to investigate the relationships among these variables. Unlike standard regression approaches, which assume that explanatory and mediating variables are measured without error, SEMs that feature multiple measures of important constructs (e.g., SPS, psychological health) return regression coefficients among latent variables that are cleansed of measurement error. Conceptualizing a mediating variable as a latent variable also removes any bias in the analysis that arises from lack of perfect reliability of observed mediating variables (Hoyle and Kenny, 1999). Bias in the mediating variable can weaken the statistical power of indirect effect tests, prompting investigators to miss important research findings. Moreover, an attractive feature of the SEM approach for assessing statistical mediation is that all direct and indirect effects may be tested simultaneously with the same sample in the presence of all other hypothesized effects. Lastly, recent simulation evidence (MacKinnon, Lockwood, & Williams, 2004) points to the improved performance of

resampling approaches such as the bootstrap for computing indirect effect standard errors and confidence limits relative to more traditional methods that assume an underlying normal distribution of the indirect effect. While it is possible to build resampling programs in standard statistical software programs to compute standard errors and confidence limits of indirect effects, there seems little reason to do so given that resampling is readily available in several SEM programs (e.g., AMOS, LISREL, Mplus) via the bootstrap (Efron & Tibshirani, 1993).

We first assessed components of the measurement model comprised of correlated latent factors and their observed indicators (Anderson & Gerbing, 1988). We next included variables commonly investigated in the adherence literature as covariates and fit our hypothesized structural model to the data, first considering only the direct effects of SPS on adherence and then introducing psychological health as an intermediate latent construct in a second latent variable model. We then refined this indirect effects model by omitting two non-significant path coefficients (described below in the Results section), and refitting the model. This third model constitutes our final analysis, which is depicted in Figure 1. All SEMs were estimated using Mplus version 3.11 (Muthén & Muthén, 2004).

To evaluate the global fit of measurement models, we report the chi-square tests of model fit and several descriptive fit indices, noted below. Though scale scores were approximately normally distributed, we opted to report a maximum likelihood-based chi-square test of model fit and parameter estimate standard errors that are robust to departures from normality derived from the Mplus MLR estimator (Yuan & Bentler, 2000). Even with corrections for non-normal data, the chi-square test of absolute model fit can be sensitive to trivial misspecifications in the model's structure (Bollen & Long, 1993). Consequently, we report the following descriptive measures of model fit that are often used to evaluate the soundness of a model: the standardized root mean residual (SRMR; Bollen, 1989), the Tucker-Lewis Index (TLI; Bentler & Bonnett, 1980), and the Root Mean Square Error of Approximation (RMSEA; Browne & Cudek, 1993). Hu and Bentler (1999) provide recent simulation evidence and guidelines suggesting that TLI values of .95 or higher, RMSEA values of .06 or lower, and SRMR values of .08 or lower indicate good model fit when these fit statistics are considered together (Hu & Bentler, 1999).

We used the same method to evaluate our full structural models that include adherence, with the following changes prompted by the categorical nature of the adherence variable: instead of using a maximum likelihood-based estimator, we used the weighted least-squares mean and variance-adjusted (WLSMV) estimator available in Mplus to compute model fit chi-square values. The RMSEA and TLI descriptive fit measures are based upon the WLSMV estimator's chi-square value. Instead of the SRMR, we substituted the weighted mean residual (WRMR) descriptive fit statistic, which is suitable for use with categorical outcome data. Simulation evidence suggests WRMR values that fall below .90 indicate acceptable model fit (Muthén & Muthén, 2004). To compute accurate, efficient standard errors and confidence limits for the indirect influence of SPS on adherence via psychological health, we employed the bias-corrected bootstrap (MacKinnon, Lockwood, & Williams, 2004; Shrout & Bolger, 2002). Following the recommendations of Hox (2002), we set the number of bootstrap samples above 5000 to insure precision of reported bias-corrected bootstrap-based confidence intervals. For each estimated parameter, we report its unstandardized estimate, its standard error (SE), the estimate divided by its standard error (*Z*), 95% confidence limits, and the standardized parameter estimate.

Results

Of the 867 individuals that completed the assessment, 552 (63%) were currently on ART medications. We report results from the 545 on ART for whom we have complete adherence

and covariate data. Demographic, background, and treatment descriptive data are presented in Table 1. Overall, 29% of those on ART reported missing doses in the prior three days sufficient to classify them as nonadherent (less than 90% of expected doses).

Measurement Models

Our measurement models were informed by the SPS literature, which has indicated a single and dualistic approach to SPS. Specifically, we first constructed a measurement model consisting of (1) a single latent factor, social problem-solving, measured by positive problem orientation (PPO), negative problem orientation (NPO), rational problem-solving (RPS), avoidant problem-solving (AS), and impulsive/careless problem-solving (ICS), and (2) a single latent psychological health variable was measured by the Beck Depression Inventory (BDI), Positive States of Mind (PSOM), Perceived Stress Scale (PSS), and social support as measured by the Social Provisions Scale (SPS). The fit of this model to the data was poor, however: χ^2 (26) = 313.40, $p < .0001$; TLI = .77, RMSEA = .14, SRMR = .08. Examination of the scale correlations (Table 2) supported recent conceptualizations that problem-solving should be separated into two factors, constructive problem-solving style (measured by PPO and RCS) and dysfunctional problem-solving styles (measured by NPO, AS, and ICS). Refitting the measurement model with two problem-solving factors resulted in overall model fit that is very good and meets all recommended fit criteria: χ^2 (24) = 109.48, $p < .0001$; TLI = .99, RMSEA = .08, SRMR = .03.

Structural Equation Models Involving Adherence

Following satisfactory fitting of the measurement model, we introduced adherence into the analysis and stipulated an initial structural model containing only direct effects from dysfunctional and constructive SPS to adherence. Because previous findings suggest links between daily alcohol use, hard drug use, gender, age, and race and adherence (Fogarty et al., 2002; Johnson et al., 2003), we included age in years, daily alcohol use in the past three months (yes vs. no), any hard drug use (yes vs. no), gender (male vs. female vs. other), and race (Black vs. Latino vs. White vs. Other) as covariates of adherence and psychological health. The fit of this model was generally satisfactory: χ^2 (27) = 53.63, p = .002; TLI = .96, RMSEA = .04, WRMR = .90. The path from constructive SPS to adherence was significant (Estimate = −.073, SE = .029, Z = −2.49, p = .01), though the path from dysfunctional SPS to adherence was not significant (Estimate = .031, SE = .020, Z = 1.55, p = .12). A nested model comparison of the original modeling including the direct effects to the more restricted model not including direct effects showed, however, that the more restricted model without direct effects fit the data worse than the model that incorporates direct effects: χ^2 (2) = 29.02, p < .0001. When considered jointly, retention of the direct effects results in a better-fitting model.

We next investigated the intermediate influence of psychological health on these relationships by specifying a second structural model that featured paths linking the two SPS factors to psychological health and adherence, as well as a path from psychological health to adherence. Results from this model indicated good fit overall: χ^2 (26) = 47.74, p = .006; TLI = .96, RMSEA = .04, WRMR = .86. Examination of model parameter estimates (see Table 3) revealed that the direct effect of constructive problem-solving on adherence was not significant (Estimate = .005, SE = .033, Z = .17, p =.87). Similarly, the direct effect of dysfunctional problem-solving on adherence was not significant (Estimate = −.029, SE = .025, Z = −1.12, p = .25). By contrast, the indirect effect of constructive problem-solving on adherence mediated by psychological health was significant (Estimate = −.054, SE = .021, Z = −2.58, p = .01), as was the indirect effect of dysfunctional problem-solving on adherence mediated by psychological health (Estimate = .051, SE = .018, Z = 2.85, p = .004). The two SPS factors and covariates accounted for 60% of the variance of the latent psychological health variable.

Given the absence of direct effects of SPS on adherence, we refit the model with those direct effects removed from the analysis. The resulting fit was good and met recommend fit criteria: χ^2 (27) = 48.55, p = .007; TLI = .96, RMSEA = .04, WRMR = .86. A nested model comparison of the original modeling including the direct effects to the more restricted model not including direct effects showed that the more restricted model without direct effects fit the data as well as the model that incorporates direct effects: χ^2 (2) = 1.32, p = .51, providing unequivocal evidence that once the model includes indirect effects, the impact of direct effects from SPS factors to adherence is negligible. Furthermore, results for the indirect effects remained stable relative to the model that included direct effects: the indirect effect from constructive SPS to adherence via psychological health was significant (Estimate = −.039, SE = .012, Z = −3.35, p < .001). The indirect effect of dysfunctional problem-solving on adherence mediated by psychological health was also significant (Estimate = .036, SE = .009, Z = 3.93, p < .001). In this analysis, the two SPS latent factors accounted for 60% of the variance in the latent psychological health variable, which is identical to our starting model. All other estimated parameters are similar across the two models. Unstandardized estimates, standard errors, Z statistics, and 95% confidence intervals arising from this model are shown in Table 3; standardized parameter estimates and significance levels are reported in Figure 1.

The stability of results across the two models coupled with the parsimony of the second model led us to prefer the reduced model without direct effects of SPS on adherence to the more complex model that incorporates those direct effects. Taken collectively, these results suggest that our findings are robust to the inclusion of several commonly incorporated covariates that impact adherence, and that SPS factors are associated with medication adherence via psychological health. This model correctly classified 97% of the cases as adherent versus non-adherent.

Discussion

To our knowledge, this is the first application of SEM in a large sample to examine the indirect influence of SPS on adherence to HIV ART medications. By using modern SEM methods to fit the mediation models in a large sample of HIV infected persons with multiple measures of SPS and psychological health, we obtained the best estimates possible. Our findings indicate that SPS styles are associated with adjustment of persons with HIV; moreover, this effect extends beyond their psychological adjustment to the degree to which these individuals may adhere to their prescribed medications for HIV. When we included psychological health in our analyses, we found no support for a direct relationship between SPS and medication adherence. However, it appears that our alternative explanation was supported: A constructive problem-solving style was associated with a more optimal psychological adjustment, and a greater likelihood to adhere to recommended regimens. A dysfunctional problem-solving style was associated with poorer psychological adjustment, which was associated with compromised adherence. Overall, our model accurately classified 97% of the cases as adherent or nonadherent, representing a vast improvement from other attempts to predict adherence. For example, medical providers were only able to correctly classify their patients as adherent or nonadherent between 24−62% of the time, depending specific measures and cutoff used (Bangsberg, Hecht, Clague, Charlebois, Ciccarone, Chesney, & Moss, 2001; Miller, Liu, Hays, Golin, Beck, Asch, Ma, Kaplan, & Wenger, 2002).

The impact of SPS interventions on psychological health is well documented in the literature (Mynors-Wallis, Gath, Day, & Baker, 2000; Nezu, Nezu, & Perri, 1989) and psychological distress is reported at higher levels among HIV-infected persons as compared to uninfected individuals (Cohen, Hoffman, Cromwell, Schmeidler, Ebrahim, Carrera, Endorf, Alfonso, & Jacobson, 2002; Savard, Laberge, Gauthier, & et al., 1996; Valente, 2003). Likewise, the relationship between psychological distress and ART adherence is strongly supported through

biomedical and behavioral research (Bartlett, 2002; Catz, Kelly, Bogart, Benotsch, & McAuliffe, 2000; Fogarty et al., 2002; Holzemer, Corless, Nokes, Turner, Brown, Powell-Cope, Inouye, Henry, Nicholas, & Portillo, 1999; Spire et al., 2002). The current findings linking these areas offer rationale, guidance, and direction for SPS interventions to improve adherence through the mechanism of improved psychological health.

SPS is an attractive model for studying adherence to HIV medications because problem-solving interventions can be effectively provided in individual (Richards & Perri, 1978) and group formats (Nezu et al., 1989). SPS interventions can also be adapted for use in brief interactions in primary care clinics (Mynors-Wallis et al., 2000; Mynors-Wallis, Gath, Lloyd-Thomas, & Tomlinson, 1995) and in ongoing telephone sessions with low-cost service providers (Grant, Elliott, Weaver, Bartolucci, & Giger, 2002). Problem-solving interventions appear to be particularly useful in promoting optimal adjustment, alleviating distress, and reducing relapse among persons with chronic health conditions (Nezu, Nezu, Felgoise, McClure, & Houts, 2003) (Perri et al., 2001).

Controlled, randomized trials of SPS interventions are needed to assess the impact on adherence to HIV treatment. SPS interventions can be modified for use with HIV-positive populations to include problems specific to HIV that may contribute to psychological distress such as stigma, loss of social support, challenges of health care decision making, and fears over transmission of HIV to others. Efficacy trials of SPS interventions can rigorously test the relationships detected in this study and can evaluate hypotheses regarding the impact of SPS interventions on medication adherence. Similarly, further research can shed light on which format (group vs. individual) and modality (in-person vs. phone) is most effective for HIV+ populations. If effective, such interventions would offer clinicians a strategy for improving psychological well being and medication adherence among individuals with chronic illness such as HIV disease.

The lack of a direct association between SPS and adherence, independent of psychological health, may be due to the facility with which effective problem solvers take on the task of medication taking. Specifically, for some, adhering to a medication regimen may not rise to a high enough level of challenge to require active problem-solving and may be handled routinely with no other than perfunctory coping attention. Rather, the data support the hypothesis that poor problem-solving results in an impaired ability to ward off psychological distress, which is then associated with poor treatment adherence.

There are limitations of note in the current study, namely, reliance on self-reported data, cross-sectional design and the use of convenience sample. Currently, there is no gold standard for measuring adherence to antiretroviral medications. Self-reports of adherence are suspected of being inflated because of recall, social desirability, and other biases. To minimize such biases, we employed several techniques. First, we used a validated measure of adherence that has demonstrated meaningful relationships with important outcomes in other studies, such as viral load. Second, we used ACASI interviewing for the adherence portion of the interview, thereby removing the interviewer's presence and minimizing social desirability bias. Finally, we included instructions that contained recall cues, which asked the respondent to think back through events in the past three days and the computer referred to each day by name. Such approaches to adherence assessment have shown favorable effects in other studies (Bangsberg, Bronstone, & Hofmann, 2002; Stewart, 1998).

The use of cross-sectional data with a non-probability sample precludes causal inferences and limits generalizations that can be made from these findings, though the large, diverse nature of the sample suggests that our research findings may be generally applicable across a broad spectrum of ethnic groups, age groups, and gender. In the present study it was not feasible to include interactions among race, gender, age and other demographic variables with SPS or

psychological health in our analyses. Although the sample size may allow the testing of alternative models, we did not do so out of concern for increased likelihood for detecting spurious findings that are not supported by the literature. Therefore, it is not possible to rule out competing models that suggest alternate causal sequences. Our future research efforts will engage in selective, theory- and literature-driven investigations of the differential effects of ethnicity, age, and gender on the relationships between SPS, psychological health, and ART medication adherence. Furthermore, we plan to explore causal relationships in prospective, experimental research designs. Finally, our division of SPS into constructive and dysfunctional styles is supported by recent developments in SPS theory, but has not been rigorously studied in empirical research. Although data from our large sample supports such a division, we do not know if this factor structure would be found in data from other samples, limiting the degree to which generalizations can be made from our findings.

In conclusion, this study represents an important application of an SPS framework to health-related outcomes such as medication adherence. More research is needed to refine the model and to determine its applicability to different groups based on gender, ethnicity, and to populations such as injection drug users. Empirical tests of SPS interventions through randomized controlled trials are necessary to ascertain the impact on adherence and the cost effectiveness of an SPS approach as compared to other interventions. By improving psychological health, SPS intervention approaches have the potential to enhance adherence to treatment and thereby maximize clinical benefit and survival among those living with HIV and other serious medical conditions.

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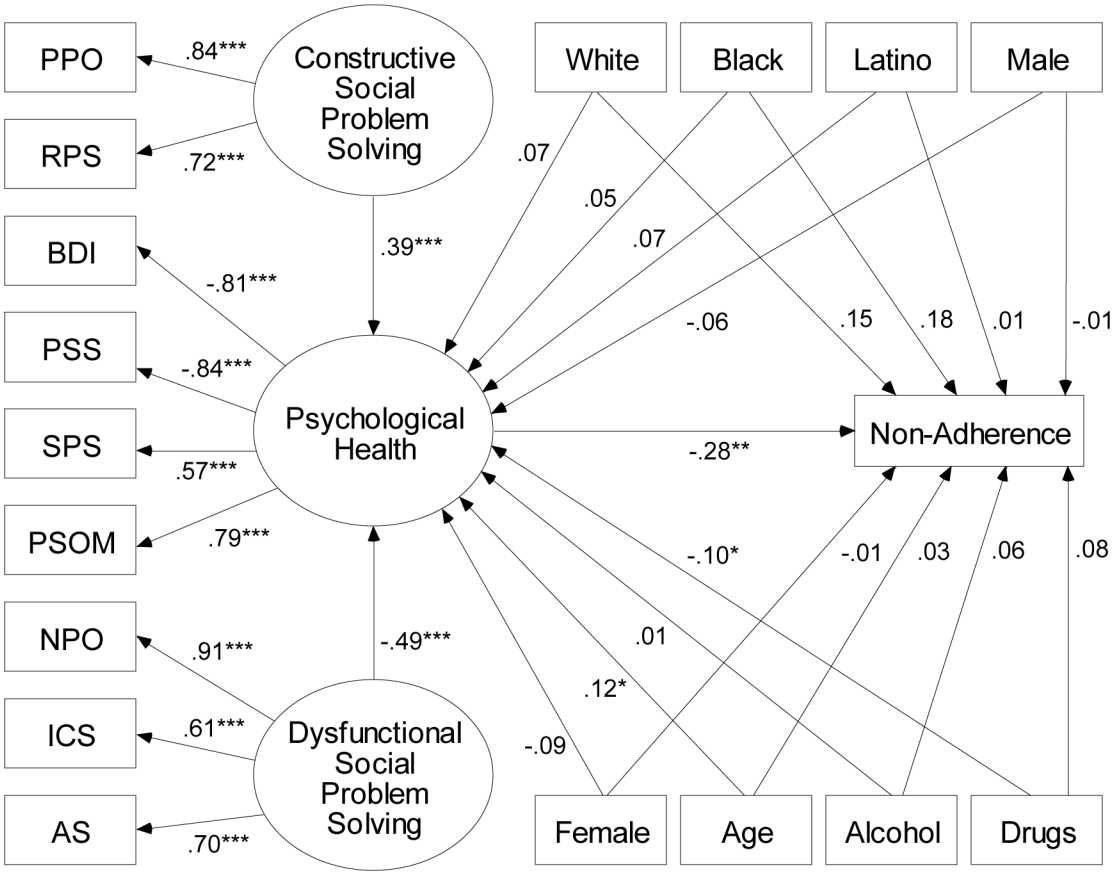

1. .

Structural Model of Social Problem-Solving and Adherence

Notes: *N* = 545. * = p < .05; ** = p < .01; *** = p < .001. PPO = positive problem orientation; RPS= rational problem solving; NPO= negative problem orientation; ICS= impulsive/careless Style; AS= avoidant style; SPS= Social Provisions Scale; BDI= Beck Depression Inventory; PSS= Perceived Stress Scale; PSOM= Positive States of Mind.

Table 1

Participant Characteristics

Variable	n	% of sample	Mean (SD)	Median
Overall (N=551)				
Age (Years)			42.7 (7.8)	
Gender				
Male	437	80.8		
Female	89	16.5		
Transgender	13	2.4		
Ethnicity				
Black/African American	175	32.5		
Hispanic/Latino	34	6.3		
White	279	51.6		
Other	52	9.6		
Employment Status				
Working	323	59.7		
Not Working	218	40.3		
Sexual Orientation				
Heterosexual	118	21.8		
Homosexual	335	61.9		
Bisexual	72	13.3		
Other/Not Sure	12	2.2		
Education				
< High School	40	13.9		
High School	99	18.3		
Some College	210	38.8		
College Grad.	167	30.1		
CD4 Count			433	290
Viral load				
Undetectable	247	46.8		
Detectable	281	53.2		
Less than 90% adherence	130	29.0		

Table 2

Correlations among key variables (n = 536−541)

	PPO	NPO	RPS	AS	ICS	BDI	PSS	SPS	Mean	SD
Positive Problem Orientation (PPO)	1.0								13.25	3.63
Negative Problem Orientation (NPO)	−.308	1.0							7.94	4.46
Rational Problem-Solving (RPS)	.590	−.249	1.0						12.50	3.79
Avoidant Style (AS)	−.252	.597	−.209	1.0					6.65	4.68
Impulsive/Careless Style (ICS)	−.088*	.520	−.238	.557	1.0				7.29	4.16
Beck Depression Inventory (BDI)	−.401	.518	−.293	.351	.318	1.0			12.26	8.18
Perceived Stress Scale (PSS)	−.391	.606	−.322	.395	.362	.650	1.0		17.78	6.89
Social Provisions Scale Average (SPS)	.309	−.324	.278	−.254	−.265	−.451	−.417	1.0	10.69	1.63
Positive States of Mind (PSOM)	.441	−.504	.304	−.317	−.297	−.619	−.689	.435	13.13	3.32

Table 3

SEM Incorporating Direct Effects of Problem-Solving Factors on Adherence.

Outcome	Explanatory Variable	Estimate (SE)	Z	Lower Confidence Limit	Upper Confidence Limit
PPO	CPS	1.000(—)	—	—	—
RPS	CPS	.932 (.076)	12.269	.783	1.080
NPO	DPS	1.000 (—)	—	—	—
ICS	DPS	.630 (.059)	10.760	.515	.744
AS	DPS	.816 (.065)	12.648	.690	.943
SPS	PH	1.000 (—)	—	—	—
BDI	PH	−7.266 (.584)	−12.440	−8.410	−6.121
PSS	PH	−6.372 (.508)	−12.535	−7.368	−5.376
PSOM	PH	2.884 (.233)	12.390	2.428	3.340
PH	CPS	.121 (.016)	7.401	.089	.153
PH	DPS	−.112 (.013)	−8.629	−.138	−.087
PH	White	.119 (.130)	.912	−.137	.374
PH	Black	.102 (.139)	.734	−.171	.375
PH	Latino	.267 (.208)	1.280	−.142	.675
PH	Male	−.147 (.280)	−.524	−.697	.403
PH	Female	−.213 (.290)	−.734	−.782	.356
PH	Age	.014 (.006)	2.403	.003	.025
PH	Daily Alcohol	.039 (.182)	.212	−.318	.396
PH	Hard Drugs	−.185 (.089)	−2.072	−.360	−.010
Non-Adherence	White	.313 (.214)	1.464	−.106	.732
Non-Adherence	Black	.400 (.220)	1.815	−.032	.832
Non-Adherence	Latino	.042 (.345)	.123	−.634	.719
Non-Adherence	Male	−.026 (.335)	−.077	−.682	.630
Non-Adherence	Female	−.038 (.351)	−.107	−.726	.651
Non-Adherence	Age	.004 (.009)	.425	−.013	.020
Non-Adherence	Daily Alcohol	.258 (.217)	1.188	−.168	.684
Non-Adherence	Hard Drugs	.172 (.125)	1.378	−.073	.417
Non-Adherence	PH	−.324 (.077)	−4.209	−.475	−.173
Non-Adherence (Indirect)	CPS	−.039 (.012)	−3.351	−.065	−.020
Non-Adherence (Indirect)	DPS	.036 (.009)	3.925	.019	.055
CPS (Variance)	—	8.693 (.974)	8.923	6.784	10.603
DPS (Variance)	—	15.623 (1.753)	8.910	12.186	19.059
CPS — DPS (Covariance)	—	−5.266 (.683)	−7.704	−6.605	−3.926

Note: PPO = positive problem orientation; RPS= rational problem-solving; CPS= constructive problem-solving; NPO= negative problem orientation; DPS= dysfunctional problem-solving; ICS= impulsive/careless Style; AS= avoidant style; SPS= Social Provisions Scale; PH= psychological health; BDI= Beck Depression Inventory; PSS= Perceived Stress Scale; PSOM= Positive States of Mind.