An empirical test of the Information, Motivation and Behavioral Skills model of antiretroviral therapy adherence

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Abstract
Nearly perfect adherence to demanding antiretroviral therapy (ART) is now recognized as essential for HIV-positive patients to realize its life sustaining benefits. Despite the dire consequences of non-adherence, a large number of patients do not follow their ART regimen. While many factors influence adherence, the literature is dominated by studies on only one or a small set of them. Multivariate, theory-based models of adherence behavior are of great interest. The current study tested one such model, the Information, Motivation and Behavioral Skills (IMB) model of ART adherence (Fisher et al., under review). A sample of HIV-positive patients on ART in clinical care in Puerto Rico ($N = 200$) provided data on adherence-related information, motivation and behavioral skills as well as adherence behavior *per se*. Structural equation model tests used to assess the propositions of the IMB model of ART adherence provided support for the interrelations between the elements proposed by the model and extended previous work. Implications for future research and intervention development are discussed.

Introduction

In 1996, the introduction of ART for HIV provided one of the first opportunities to change what was often a fatal illness into a chronic, manageable disease. When taken as prescribed, ART has consistently been associated with decreases in viral load, increases in CD4 T-cell counts and reduced rates of hospitalization, progression to AIDS and mortality (Arnsten et al., 2000; Bangsberg et al., 2000, 2004; Hogg, Yip, Chan, O'Shaughnessy, & Montaner, 2000; Jensen-Fangel et al., 2004; Pradier et al., 2001; Roca, Gomez, & Arnedo, 2000). Unfortunately, even the slightest digression from one's prescribed regimen can make these potential benefits temporarily or permanently unattainable. ART adherence rates that fall below 80% have been associated with the development of antiretroviral drug resistant strains of HIV (Bangsberg et al., 2000; Ickovics & Chesney, 1997; Knobel et al., 2002; Spire et al., 2002; Walsh, Horne, Dalton, Burgess, & Gazzard, 2001; Zaccarelli et al., 2002) that are often cross-resistant to ART medications falling in the same drug class, quickly exhausting potential treatment options. Adherence rates below 90–95% have been associated with rises in HIV RNA copy number (Blaschke, 1997; Knobel et al., 2002), significant decreases in CD4 counts (Singh et al., 1999) and increases in mortality rates

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(Garcia de Olalla et al., 2002; Hogg et al., 2000). In sum, for HIV-positive individuals able to maintain nearly perfect adherence, ART offers an opportunity for longer, healthier lives. Failure to adhere may have dire consequences for the individual, and given the increasing numbers of new HIV infections which involve treatment resistant strains of HIV (Boden et al., 1999; Hecht, Colfax, Swanson, & Chesney, 1998; Little et al., 2002; Richman, 2001), can also have a disastrous impact on the epidemic as a whole.

Despite the life-threatening consequences of non-adherence, about 57–77% of individuals on ART (Belzer, Fuchs, Luftman, & Tucker, 1999; Montessori et al., 2000; Rigsby et al., 2000; Singh et al., 1999; Spire et al., 2002) are unable to reach or maintain the 95% adherence rate now considered optimal (Bartlett, 2002; Low-Beer, Yip, O'Shaughnessy, Hogg, & Montaner, 2000; Paterson et al., 2000). This has created a critical need to identify factors influencing ART adherence and to develop interventions that target such factors.

Although substantial progress has been made in recent years in better understanding why individuals fail to adhere, well-tested, multivariate, conceptual models of ART adherence are rare. Thus far, exploration of the determinants of ART adherence has been dominated by the 'single-variable', predictive approach. While this work has provided valuable information regarding the associations between *individual* variables and adherence, it does not present a sufficiently complex view of the factors associated with ART adherence. Multivariate, theory-based models are only now emerging (e.g., Fisher, Fisher, Amico, & Harman, under review), and the evaluation of such models is critical in the development of effective interventions. The current study was developed to evaluate one such model, IMB (Fisher et al., under review), which offers a dynamic, multivariate account of ART adherence.

As indicated in Figure 1, the IMB model of adherence (Fisher et al., under review) identifies adherence-related information, motivation and behavioral skills as critical determinants of ART adherence. Adherence-related *information*, a prerequisite of adequate adherence encompasses accurate information concerning one's specific regimen, about how to utilize ART, about the requirements for adequate adherence, about specific side effects associated with one's regimen, and information about potential drug interactions. Also included in the information construct are faulty heuristics and implicit theories (e.g., the
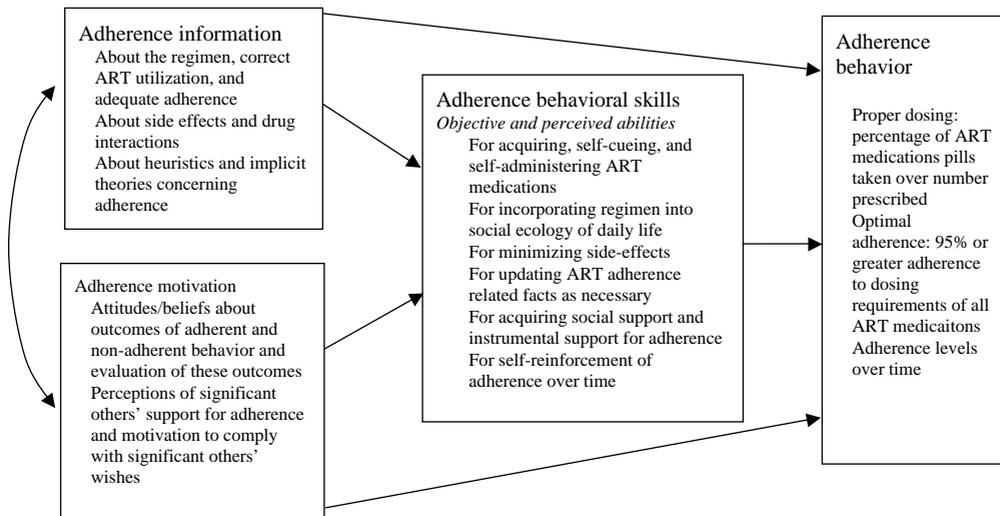

Figure 1. IMB model of ART adherence (adapted from Fisher et al., under review).

notion that 'If I'm feeling well, then missing a few doses doesn't really matter') play an important role in negatively affecting adherence.

Adherence-related *motivation* refers to a personal and social motivation to follow one's ART regimen as prescribed. Personal motivation includes one's attitudes and beliefs about the consequences outcomes of both optimal and sub-optimal adherence. Social motivation includes perceptions of support for adherence behaviors from important others, as well as one's motivation to comply with their wishes.

While the motivation and information constructs of the model may share some variability, motivation to adhere to one's ART regimen is not necessarily related to one's level of accurate information about one's regimen. As indicated in Figure 1, one may be highly motivated to adhere to ART, yet have inaccurate information about ART. Similarly, one may have entirely accurate information about ART, but have little motivation to adhere.

Adherence-related information and motivation are each related to the performance of ART adherence *behavioral skills*, specifically when individuals are well informed about ART and motivated they acquire and execute behaviors for adequately and consistently ensuring ART adherence. Adherence-related behavioral skills include both the objective ability and perceived efficacy (Bandura, 1977) for performing critical behaviors, such as acquiring and self-administering ART medications consistently over time, achieving a good fit between one's regimen and the natural ecology of daily life, taking steps to minimize side effects, obtaining ART-related information and/or support when needed, and developing strategies to reward and reinforce ART adherence behaviors.

As indicated in Figure 1, for complex or novel behaviors the IMB model posits a *direct* relation between behavioral skills and adherence behavior, in which adherence-related information and motivation relate to adherence behavior primarily *through* behavioral skills. In effect, since the skills presently required to establish and maintain adequate ART adherence are typically complex or novel, behavioral skills will mediate the relations between information and motivation and ART adherence behavior, and the direct paths from information and motivation to adherence behavior are anticipated to be negligible. Thus, an informed and motivated person who lacks the objective skills necessary to acquire, self-cue, and take medication or the confidence in his or her efficacy to do so, will have difficulty establishing or maintaining adequate adherence. If at some point regimens are available for which the requisite skills for ART adherence are simple or automated (e.g., a transdermal patch that must be changed monthly), information and motivation would be expected to relate to adherence behavior directly.

Finally, the IMB model of ART adherence (Fisher et al., under review) predicts that high levels of ART adherence will result in favorable health outcomes, and that poor adherence will result in unfavorable health outcomes, which is quite consistent with the current literature (e.g., Hogg et al., 2000; Pradier et al., 2001; Roca et al., 2000). Moreover, longitudinally, these favorable or unfavorable health outcomes will affect subsequent levels of adherence-related information, motivation, and behavioral skills through a feedback loop (for details, see Fisher et al., under review). The model also identifies several potential personal or environmental factors (e.g., substance use problems, unstable housing, or severe mental health issues) that will moderate (i.e., strengthen or weaken) the relations between adherence-related information, motivation, behavioral skills, and adherence. Thus, the IMB model of adherence provides a comprehensive, multivariate, theory-grounded approach to conceptualizing ART adherence behavior.

Recently, Starace, Massa, Mariniello, Amico, & Fisher (in press) presented an initial multivariate test of the IMB model of ART adherence with a sample of HIV-positive

patients in clinical care in Italy. Their results generally supported the model, but had limitations in terms of small sample size. Moreover, the results were limited to a single geographic locality and it was unclear if their findings would generalize to other countries and/or cultures, or to ART adherence in the context of other medical health care systems. The current study tests the IMB model of ART adherence with a larger sample than Starace et al. (in press) in a sample of HIV-positive patients receiving clinical care in San Juan, Puerto Rico. Specifically, the determinants of ART adherence identified by the IMB model of ART adherence (adherence-related information, motivation and behavioral skills) were used in a series of structural equation model tests to evaluate both the fit of the IMB model of adherence to the sample data and whether or not the structural assumptions of the model (e.g., mediation) appropriately described the interrelations among the IMB model constructs.

Methods

Participants

HIV-positive patients in clinical care in four HIV care clinics in and near San Juan, Puerto Rico ($N = 200$) completed measures of IMB model constructs with the assistance of interviewers between March and May 2001. Four trained interviewers recruited participants from the waiting areas of the clinic sites and administered questionnaires. Three of the clinics serviced only HIV-positive patients during the days of recruitment and one served patients with diverse medical concerns. The majority of participants came from the HIV specialty clinics. For the clinics where all patients were HIV-positive, an announcement regarding the project and a call for participants, as well as written material placed around the waiting area detailing the project, were used to recruit patients. Case managers also referred patients for participation in the project. Participants from the clinic that served diverse medical needs were recruited discretely by referral from staff. Only those who were currently prescribed antiretroviral medications were eligible to participate. Whether or not a patient was currently on ART was confirmed by the clinic staff prior to participation. Participants were reimbursed $15.00 for completion of the survey. All interested and eligible patients signed informed consents prior to participation in the research. All of these research procedures were approved by relevant university and hospital/clinic institutional review boards.

Measures

The Spanish version of the IMB ART adherence questionnaire (Amico et al., 2001) contained sets of ART adherence information, motivation, behavioral skills and behavior items consistent with those used in previous research (Starace et al., in press). In addition, a modified version of the Adherence to Combination Therapy Questionnaire (AACTG) (Chesney et al., 2000) was used to assess rates of ART adherence. The original AACTG uses self-report of doses *missed* over the past three days. Because we were concerned that patients in the current population might be reluctant to report actually missing doses, we modified the instrument and asked participants to report number of doses *taken*. Adherence was then calculated as the number of doses taken over the number prescribed during the time period. Participants completed these measures in an interview format.

Responses from the AACTG questionnaire were used to calculate adherence over the past three days. Rates of adherence were defined as the percentage of prescribed pills actually taken of the total number of pills prescribed over a three-day period.

Adherence-related information was measured by three behaviorally relevant knowledge items that could be rated by the participant as 'true', 'false' or 'not sure/don't know'. These mapped closely onto the information construct of the IMB model (Figure 1) and onto the items used in Starace et al. (in press). Responses to the three items 'I know what to do' (e.g., 'Whether or not to take the pill later if I miss a dose of any of my HIV medications', 'If I take non-prescription drugs, e.g., Tylenol or recreational drugs such as crack, cocaine, heroine, etc., I know how they could affect the way my HIV pills work' and 'I know what the side effects of my combination therapy medication might be') were scored as follows: three = correct response, two = unsure and one = incorrect response. Total scores could range from three to nine points.

Similar to Starace et al. (in press), we then created two groups to represent participants who were very well informed and those who were not as well informed. Since the median in the sample fell between eight and nine points, we defined those who were well informed as having perfect scores (nine), and those who were less well informed as having less than perfect scores. One hundred and thirty-eight participants (69%) were classified as well informed, while 62 (31%) were classified as less well informed. These two groups can be understood as reflecting a participant's relative amount of accurate information in the context of a generally well-informed cohort.

Adherence-related *motivation* was also measured consistent with the IMB model (Figure 1) and with Starace et al.'s (in press) measure of this construct. Participants used a five-point Likert scale to respond to each of eight items designed to tap aspects of adherence-related motivation, including 'attitudes about ART and ART adherence' (e.g., 'Continuing to take my medications as directed when I am experiencing side effects' would be rated very good to very bad) and 'perceptions of significant others' support for ART adherence' (e.g., 'The people who are important to me think I should take all my combination therapy medications according to the doctor's orders' would be rated strongly disagree to strongly agree). Item responses were summed and averaged. As we anticipated, given that the motivation construct was comprised of items that may not co-vary (e.g., having a positive attitude towards ART medications can be independent of the degree of support one has for medication-taking behavior from those who are important to one), the scale's inter-item consistency was low ($\alpha = 0.52$, 0.62 standardized) and no single item deletion offered an improvement in consistency. Total motivation scores represented the average response across the eight items, and ranged from one to five, where five represents higher motivation. Across the sample, participants demonstrated a high degree of adherence motivation (M = 4.72, SD = 0.262).

Finally, consistent with the IMB model and with Starace et al. (in press), adherence-related *behavioral skills* were represented by six behaviorally relevant items that represented the diverse set of skills required for adequate ART adherence. Items included assessments of the participants' skills for taking medication as prescribed in the presence of a number of barriers (e.g., 'I have no problems taking my combination therapy medications correctly, even when it's difficult to work them into my schedule', 'I can always take my combination therapy medications according to the doctor's orders (even when I am at work, when I am out with my friends or during the week-end)' and 'If I need more information about any of the combination therapy drugs I'm taking, I feel confident that I know how to reach someone to find out the information'). Participants rated the extent to which they agreed or

disagreed with each statement on a five-point scale, and scores were recoded so that higher scores reflected greater skills. As might be expected given the diverse barriers represented by behavioral skills items, inter-item consistency was low ($\alpha = 0.35$, 0.41 standardized). Scores across the six items were summed and averaged to represent a composite skills index. Overall, the sample reported a high level of behavioral skills ($M = 4.40$, $SD = 0.621$).

Analyses

Evaluation of the IMB model of ART adherence included several different analyses; the first involved the evaluation of a full IMB model, where the three IMB model constructs (information, motivation and behavioral skills) were used in a structural model to account for optimal adherence. This analysis focused on assessing the structural mediation hypotheses of the model: that information and motivation would significantly relate to behavioral skills and not directly to adherence behavior and that behavioral skills would significantly relate to optimal adherence. As a just-identified model, parameter estimates were the primary tools for evaluation.

   The second analysis allowed for an assessment of the IMB model constructs' association with optimal adherence. We fitted a restricted model where each of the paths between information and adherence behavior and between motivation and adherence behavior were removed from the model. Standard model fit indices (e.g., χ^2, CFI, RMSEA: Bollen, 1989; Kline, 1998) were used to evaluate this restricted model, providing an evaluation of the general fit of the critical IMB constructs to the sample data.

   The third analysis focused on the structural features of the IMB model of ART adherence by assessing the differences in the χ^2 values obtained when the less restricted models were compared to the fit obtained for the restricted (mediated) model. All path analyses were estimated using MPLUS software (Muthen & Muthen, 2001), with weighted least square mean and variance adjusted chi-square (WLSMV) estimation (Muthen & Muthen, 2002) to assess the parameters in the full model and fit to the sample data in the restricted model. The comparative fit between the restricted model and alternative models were evaluated using standard weighted least square (WLS) estimation and associated χ^2 difference tests (Muthen & Muthen, 2002).

Results

Sample description

The majority of the 200 HIV-positive participants (99%) attended one of the three HIV specialty care clinics involved in the study. Sixty-five percent of the sample was male, 34% was female and 0.5% was transgender. The majority reported being Latino/a (84%), followed by Black (7%) and White (5%). The age of participants ranged from 19–81 years, with an average of 39 ($SD = 8.93$). Thirteen percent had earned a bachelor's degree, 23% had some university training, 25% had earned a high-school diploma and 21% had completed some high school. The majority of participants were unemployed (59%), had government provided/funded insurance (86%) and lived on marginal incomes (84% reported annual family incomes of US$10,000 or less). Most were heterosexual (73%), with 19% reporting homosexual and 8% reporting bisexual orientations. The average number of years since HIV diagnosis was 6.82 ($SD = 4.53$; range $= 0.08$ to 21 years). Forty-two percent reported contracting HIV from heterosexual sex, 21% through sex with men,

34% through needle/equipment sharing, 1% through blood transfusion and 2% reported 'other'. This distribution differs slightly from the epidemiological trend of the epidemic in Puerto Rico, in that the current sample has lower rates of IDU-infected individuals (34% in the current sample versus 51% in Puerto Rico according to 2001 estimates) (CDC, 2004).

Rates of adherence

Complete AACTG data was provided by 196 participants. Participants' ART regimens included one to six antiretroviral medications (M = 2.61, median = 3, SD = 0.843), with a total of one to 11 doses per day (M = 4.91, median = 5, SD = 1.57) and a total number of pills per day ranging from one to 11 (M = 5.26, median = 6, SD = 2.05). The most common antiretroviral in the sample's ART regimens was combivir, followed by viracept and zerit. Participants were on ART for an average of 3.78 years (SD = 2.85). Adherence, as measured by the AACTG, ranged from 0–100%, with an average of 91% adherence. The distribution of percent adherence was highly kurtotic (9.56) and negatively skewed (−3.15). Rates of adherence were used to create a dichotomous variable reflecting whether or not a participant met the currently recognized standard of ≥95% (Bartlett, 2002; Low-Beer et al., 2000) for adequate adherence. One hundred and fifty-six participants (80%) reported optimal adherence (95% or greater rates of adherence) and 40 participants (20%) reported sub-optimal adherence (less than 95% rates of adherence). This dichotomous variable, with optimal adherence scored as one and sub-optimal adherence scored as zero, served as the outcome variable in our analyses.

Evaluation of the IMB model of ART adherence

Prior to evaluating the IMB model of ART adherence, we assessed the general equivalence of participants between sites. Although four clinics agreed to participate in the current research, we used the data from three clinics (N = 48, 88 and 62) because only two surveys were collected at the fourth clinic site, which was the only participating site that was a private general practitioner's office. Because this office treated a small number of HIV-positive patients, privacy issues precluded aggressive or overt recruitment strategies at this site. The included clinic sites were comparable in terms of years patients were on ART, rates of adherence, gender distributions, reported sexual orientation, level of educational attainment and how the patient contracted HIV. Although we did find differences in terms of age and annual income, these were not included as covariates as they demonstrated no significant relation to adherence. Across the demographic variables, and relative to the dependent variable of interest, sites appeared generally comparable and the data collected from each site was combined for analyses.

Using the full set of data, collapsing across clinic sites, the IMB model of ART adherence was assessed as a full model using four variables: adherence-related information, motivation, behavioral skills and adherence *per se* (defined as optimal versus sub-optimal adherence). The full path model was estimated using weighted least square mean and variance adjusted chi-square (WLSMV) (Muthen & Muthen, 2002) and parameter estimates were evaluated in terms of significance and direction. As depicted in Figure 2, the mediated structural hypotheses of the IMB model of ART adherence were supported. Specifically, both adherence-related information and motivation related significantly and positively to behavioral skills, but did not significantly relate directly to optimal adherence. Moreover, as predicted by the model, adherence-related behavioral skills were significantly and positively associated with optional adherence. The elements in the model accounted for
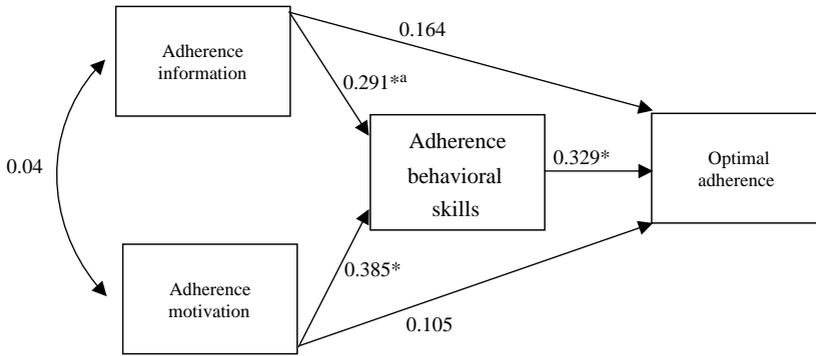
Figure 2. IMB model of ART adherence: Full model. WLSMV estimation.
*$p < 0.05$.; $N = 200$; [a]coefficient for the path from the dichotomous information variable to the continuous behavioral skills variable (0.135) was divided by the standard deviation of the dichotomous information deficit variable 0.4636 to produce the standardized coefficient (0.291).

19% of the variability in adherence group membership. Thus, support was provided for the IMB model's major assertions that adherence-related information, motivation and behavioral skills are important determinants of adherence behavior and that ART adherence behavior is influenced by information and motivation primarily through their effects on behavioral skills.

In order to assess the overall fit of a mediated IMB model of ART adherence, we evaluated a mediated (restricted) model's fit to the sample data, again using WLSMV estimation. As depicted in Figure 3, the restricted model demonstrated good fit to the sample data (χ^2 (2, $N = 200$) = 5.063, $p = 0.078$, CFI = 0.958, RMSEA = 0.088), accounting for 17% of the variability in adherence group membership. This restricted model was then used in comparison to alternative models that added a non-mediated path from information to optimal adherence and one that added a non-mediated path from motivation to optimal adherence to test for mediation. Mediation would be indicated by non-significant differences in model fit between the restricted (mediated) model and alternative models that are less restrictive.
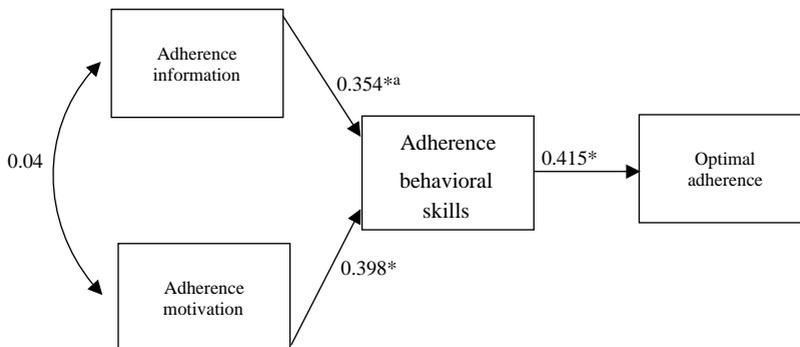

Figure 3. IMB model of ART adherence: Restricted model. WLSMV estimation. χ^2 (2, $N = 200$) = 5.063, $p = 0.078$, CFI = 0.958, RMSEA = 0.088.
*$p < 0.05$; $N = 200$; [a]coefficient for the path from the dichotomous information variable to the continuous behavioral skills variable (0.164) was divided by the standard deviation of the dichotomous information deficit variable 0.4636 to produce the standardized coefficient (0.354).

In order to perform chi-square difference tests, the restricted model was first re-estimated using the WLS estimator, as WLSMV chi-square cannot be compared across models (Muthen & Muthen, 2002). The WLS generated model fit for the restricted model (χ^2 (2, $N = 200$) $= 4.299$) was compared to the fit of the first alternative model where the non-mediated path from information to optimal adherence was added (χ^2 (1, $N = 200$) $= 1.760$). The resulting difference in fit (χ^2 (1, $N = 200$) $= 2.539$, $p = 0.11$) suggested that the two models were generally comparable and that the more parsimonious model provided a sufficient and preferable fit to sample data. Similarly, the addition of a path from motivation to optimal adherence (χ^2 (1, $N = 200$) $= 3.320$) did not significantly improve model fit (χ^2 (1, $N = 200$) $= 0.979$, $p = 0.32$). Thus, it appeared that the mediated model provided a good fit to the sample data.

Discussion

The current study contributes to growing efforts to understand ART adherence behavior in the context of theoretical models of health behavior. The IMB model of ART adherence (Fisher et al., under review) is one of the few models of ART adherence in the literature that is based on a well-validated theory of health behavior change (Fisher, Fisher, & Harman, 2003) and clearly articulates the personal, social and environmental factors presumed to influence ART adherence, as well as the manner in which such factors interrelate. It gained preliminary support with a sample of HIV-positive patients receiving care in Italy (Starace et al., in press) and the current study extended that support in important ways. With a larger sample, in the context of a very different health care system, with somewhat different but parallel measures and in a different country and culture, we assessed the IMB model in a sample of HIV-positive patients receiving clinical care in Puerto Rico.

The IMB model of ART adherence (see Figure 1) hypothesizes that adherence-related information, motivation and behavioral skills are the critical determinants of adherence behavior. Accurate information about one's ART regimen and about what constitutes adequate adherence, high levels of adherence-related motivation and strong adherence-related behavioral skills are posited to underlie optimal adherence. The model also specifies that the relations between adherence-related information and motivation and adherence behavior are mediated by adherence-related behavioral skills. Simply stated, even a well informed or highly motivated individual will have difficulty achieving and sustaining optimal adherence if he or she lacks the objective skills required to acquire or self-administer medication or feels incapable of performing such behaviors.

Results of the current study provided strong support for the IMB model of ART adherence. The IMB model of ART adherence provided a good fit to the sample data (see Figure 2). Evaluation of a full, non-mediated model indicated that information and motivation were positively associated with adherence-related behavioral skills, and that behavioral skills were in turn positively related to optimal adherence. The path coefficients for the non-mediated or direct relations between adherence-related information and optimal adherence and between adherence-related motivation and optimal adherence were non-significant. In comparison to partially mediated models, the fully mediated model provided a more parsimonious explanation of adherence behavior. Thus, the analyses provided support for both the overall and specific structural propositions of the IMB model.

The high rates of adherence we found in our sample of HIV-positive patients in clinical care in Puerto Rico stand in contrast to previous research in the United States, which generally has found that between 57% and 77% of HIV- positive patients report adherence

rates below 90% (Belzer et al., 1999; Montessori et al., 2000; Rigsby et al., 2000; Singh et al., 1999; Spire et al., 2002), but is quite consistent with the higher rates of adherence reported in resource poor areas and countries (Attawell & Mundy, 2003). For example, Oyugi et al. (2004) recently reported average adherence rates, across a number of measures, of 91–94% adherence in their work with resource poor HIV-positive persons in Uganda. Additionally, Attawell and Mundy's (2003) recent review summarizes a number of studies that have found similarly high rates of adherence in resource poor countries. Thus, in areas where resources are limited and there are substantial barriers to even gaining access to ART, perhaps non-adherence may be less prevalent. While we recognize that somewhat higher rates of adherence have been associated with self-report measures of adherence, in comparison to more objective measures (Arnsten et al., 2001; Walsh, Mandalia, & Gazzard, 2002), the validity of self-report in terms of association with disease progression and blood concentrations of ART medications (Haubrich et al., 1999; Hecht et al., 1998; Kleeberger et al., 2001; Knobel et al., 2002; Moatti & Spire, 2000; Murri et al., 2000; Nieuwkerk et al., 2001) has been well established. Thus, the rates of adherence reported by the current sample may reflect a genuine high degree of adherence in HIV-positive individuals receiving care in Puerto Rico, but further research using a multiple methods approach to assess adherence behavior is needed.

Similar to previous research with the IMB model in other health domains (Fisher & Fisher, 1993; Misovich, Fisher, & Fisher, 1998), the present assessment of adherence-related behavioral skills, which conceptually includes both objective skills and perceived efficacy, focused operationally primarily on participants' perceived efficacy in performing complex adherence behaviors over time. Assessing objective skills related to adherence as well would require the repeated observations of patients as they navigate in their natural environments, which was not possible in the current study. While a complete assessment of behavioral skills would include perceptions of efficacy *and* objective skills, it is not uncommon for behavioral skills to be assessed primarily through perceived efficacy due to the difficulty associated with assessment of the objective skills. Nevertheless, it has been shown that perceived efficacy is related to levels of objective behavioral skills (Williams et al., 1998). Thus, while perceived efficacy and behavioral skills represent conceptually distinct constructs, they have, in practice, shown a positive relation in studies of health behavior (King, Humen, Smith, Phan, & Teo, 2001; Stewart, Strack, & Graves, 1999).

In the current research, the assessment of adherence did not distinguish between different types of regimen. While this is consistent with previous literature, recent work (Bangsberg et al., 2003) has suggested that the relation between rates of adherence and outcomes such as optimal viral suppression and the development of resistance are complex and partially dependent on the specific characteristics of one's regimen (e.g., boosted versus non-boosted PI regimens). In the current sample, 97% of the participants were on non-boosted regimens, which do appear to demonstrate the bell curve association between the development of resistance and rates of adherence (Bangsberg, Moss, & Deeks, 2004). As boosted regimens become more common, specific regimen type should be taken into account, as the adherence-resistance relationship may differ for boosted versus non-boosted regimens.

Seven years after the introduction of ART, the study of adherence to its demanding and often complicated regimens has made substantial progress. The development of theories of ART adherence that draw from well-validated models of health behavior and behavior change is a promising new direction that provides a structure to the current literature and ease of translation from theory to practice. The identification of critical determinants of

ART adherence and how these factors might interact to influence behavior is an essential prerequisite in helping HIV-positive patients to achieve and maintain high levels of ART adherence. The current study offers support for the IMB model of adherence and furthers efforts to better understand ART adherence as a dynamic behavior that occurs in the context of an individual's personal, social and environmental context. Ultimately, the true potential of any theory-grounded model of ART adherence will involve the evaluation of its ability to produce effective ART adherence interventions. Such efforts with the IMB model of ART adherence are underway and will make substantial contributions to the theory-driven efforts to prolong and improve the quality of life for HIV-positive patients on ART through behavior change interventions.

Acknowledgements

References

Amico, K. R., Toro-Alfonso, J., Fisher, J. D., Andujar, I., & Acalderón, J. (2001). Adaptation of the adherence to combination therapy questionnaire and interview. Unpublished manuscript , University of Puerto Rico.

Arnsten, J. H., Demas, P. A., Farsadegan, H., Grant, R. W., Gourevitch, M. N., Chang, C. J., et al. (2001). Antiretroviral therapy adherence and viral suppression in HIV-infected drug users: Comparison of self-report and electronic monitoring. *Clinical Infections Disease*, *33*, 1417–1423.

Arnsten, J., Demas, P., Gourevitch, M., Buono, D., Farzadegan H., & Schoenbaum, E. (2000). Adherence and viral load in HIV-infected drug users: Comparison of self-report and medication event monitors (MEMS). Paper presented at the Seventh Conference on Retroviruses and Opportunistic Infections, San Francisco.

Attawell, K., & Mundy, J. (2003). Provision of antiretroviral therapy in resource-limited settings: A review of experience up to August 2003. The health systems resource centre (HSRC). Retrieved on August 26 2004 from http://www.who.int/3by5/publications/documents/en/ARTpaper_DFID_WHO.pdf

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*, 191–215.

Bangsberg, D. R., Charlebois, E. D., Grant, R. M., Holodniy, M., Deeks, S. G., Perry, S. F., et al. (2003). High levels of adherence do not prevent accumulation of HIV drug resistance. *AIDS*, *17*, 1925–1932.

Bangsberg, D. R., Hecht, F. M., Clague, H., Charlebois, E., Ciccarone, D., Chesney, M., & Moss, A. R. (2000). Provider estimate and structured patient report of adherence compared with unannounced pill count. Paper presented at the Seventh Conference on Retroviruses and Opportunistic Infections, San Francisco.

Bangsberg, D. R., Moss, A. R., & Deeks, S. G. (2004). Paradoxes of adherence and drug resistance to HIV antiretroviral therapy. *Journal of Antimicrobial Chemotherapy*, *53*, 696–699.

Bartlett, J. A. (2002). Addressing the challenges of adherence. *Journal of Acquired Immune Deficiency Syndromes*, *29*, 2–10.

Belzer, M. E., Fuchs, D. N., Luftman, G. S., & Tucker, D. J. (1999). Antiretroviral adherence issues among HIV-positive adolescents and young adults. *Journal of Adolescent Health*, *25*, 316–319.

Blaschke, T. (1997). Noncompliance and resistance to protease inhibitors. Paper presented at the Fourth Conference of Retroviruses and Opportunistic Infections, Washington, DC.

Boden, D., Hurley, A., Zhang, L., Cao, Y., Guo, Y., Jones, E., et al. (1999). HIV-1 drug resistance in newly infected individuals. *Journal of the American Medical Association*, *282*, 1135–1141.

Bollen, K. A. (1989). *Structural equations with latent variables*. New York: Wiley

CDC (2004). AIDS Public Information Data Set (APIDS) 2001. Retrieved July 7, 2004 from http://www.cdc.gov/hiv/softward/apids.htm

Chesney, M. A., Ickovics, J. R., Chambrers, D. B., Gifford, A. L., Neidig, J., Zwickl, B., et al. (2000). Self-reported adherence to antiretroviral medications among participants in HIV clinical trials: The AACTG Adherence Instruments. *AIDS Care*, *12*, 255–266.

Fisher, J. D., Fisher, W. A., Amico, K. R., & Harman, J. J. (under review). An information, motivation, behavioral, skills model of adherence to antiretroviral therapy.

Fisher, W. A., & Fisher, J. D. (1993). A general social psychological model for changing AIDS risk behavior. In J. B. Pryor (Ed.), *The social psychology of HIV infection* (pp. 127–153). Hillsdale, NJ: Lawrence Erlbaum.

Fisher, W. A., Fisher, J. D., & Harman, J. J. (2003). The information, motivation, behavioral, skills model as a general model of health behavior change: Theoretical approaches to individual-level change. In J. Suls, & K. Wallston (Eds.), *Social psychological foundations of health* (pp. 127–153). London: Blackwell.

Garcia de Olalla, P., Knobel, H., Carmona, A., Guelar, A., Lopez-Colomes, J. L., & Cayla, J. A. (2002). Impact of adherence and highly active antiretroviral therapy on survival in HIV-infected patients. *Journal of Acquired Immune Deficiency Syndrome*, *1*, 105–110.

Haubrich, R. H., Little, S. J., Currier, J. S., Forthal, D. N., Kemper, C. A., Beall, G., et al. (1999). The value of patient-reported adherence to antiretroviral therapy in predicting virologic and immunologic response. *AIDS*, *13*, 1099–1107.

Hecht, F. M., Colfax, G., Swanson, M., & Chesney, M. A. (1998). Adherence and effectiveness of protease inhibitors in clinical practice. Abstract of presentation from the Fifth conference on Retroviruses and Opportunistic Infections, Chicago.

Hogg, R. S., Yip, B., Chan, K., O'Shaughnessy, M. V., & Montaner, S. G. (2000). Nonadherence to triple combination therapy is predictive of AIDS progression and death in HIV-positive men and women. Paper presented at the Seventh Conference on Retroviruses and Opportunistic Infections, San Francisco.

Ickovics, J., & Chesney, M. (1997). Issues regarding antiretroviral treatment for patients with HIV-1 infection. *Journal of the American Medical Association*, *278*, 1233–1234.

Jensen-Fangel, A., Pederson, L., Pederson, C., Larsen, C. S., Tauris, P., Moller, A., et al. (2004). Low mortality in HIV-infected patients starting highly active antiretroviral therapy: A comparison with the general population. *AIDS*, *18*, 89–97.

King, K. M., Humen, D. P., Smith, H. L., Phan, C. L., & Teo, K. K. (2001). Psychosocial components of cardiac recovery and rehabilitation attendance. *Health*, *85*, 290–294.

Kleeberger, C. A., Phair, J. P., Strathdee, S. A., Detels, R., Kingsly, L., & Jacobson, L. P. (2001). Effect of computer-assisted self-interviews on reporting of sexual HIV risk behaviors in a general populations sample: A methodological experiment. *Journal of Acquired Immune Deficiency Syndromes and Human Retrovirology*, *26*, 82–92.

Kline, R. B. (1998). *Principles and practice of structural equation modelling*. New York: Guilford Press.

Knobel, H., Alonso, J., Casado, J. L., Collazos, J., Gonzalez, J., Ruiz, I., et al. (2002). Validation of a simplified medication adherence questionnaire in a large cohort of HIV-infected patients: The GEEMA Study. *AIDS*, *16*, 605–613.

Little, S. J., Holte, S., Routy, J., Daar, E. S., Markowitz, M., Collier, A. C., et al. (2002). Antiretroviral-drug resistance among patients recently infected with HIV. *New England Journal of Medicine*, *347*, 385–394.

Low-Beer, S., Yip, B., O'Shaughnessy, M., Hogg, R., & Montaner, J. (2000). Adherence to triple therapy and viral load response. *Journal of Acquired Immune Deficiency Syndromes*, *23*, 360–361.

Misovich, S. J., Fisher, W. A., & Fisher, J. D. (1998). A measure of AIDS-prevention information, motivation, behavioral skills and behavior. In C. Davis, et al. (Eds.), *Sexuality related measures: A compendium* (2nd edition). Thousand Oaks, CA: Sage; New York: Guilford Press.

Moatti, J. P., & Spire, B. (2000). Living with HIV/AIDS and adherence to antiretroviral treatments. In J. P. Moatti, Y. Souteyrand, A. Prieur, T. Sandfort, & P. Aggleton (Eds.), *AIDS in Europe: New challenges for the social sciences* (pp. 57–73). New York: Routledge.

Montessori, V., Heath, K. V., Yip, B., Hogg, R. S., O'Shaughnessy, M. V., & Montaner, S. G. (2000). Predictors of adherence with triple-combination antiretroviral therapy. Paper presented at the Seventh Conference on Retroviruses and Opportunistic Infections, San Francisco.

Murri, R., Ammassari, A., Gallicano, K., De Luca, A., Cingolani, A., Jacobson, D., et al. (2000). Patient-reported nonadherence to HAART is related to protease inhibitor levels. *Journal of Acquired Immune Deficiency Syndromes*, *24*, 123–128.

Muthen, L. K., & Muthen, B. O. (2001). *MPLUS; Statistical analysis with latent variables user's guide* (2nd edition). Los Angeles, CA: Author.

Muthen, L. K., & Muthen, B. O. (2002). Modeling with categorical latent variables using MPLUS. Course offered at MPLUS Short Courses in Washington, DC.

Nieuwkerk, P. T., Sprangers, M. A., Burger, D. M., Hoetelmans, R. M., Hugen, P. W., Danner, S. A., et al. (2001). Limited patient adherence to highly active antiretroviral therapy for HIV-1 infection in an observational cohort study. *Archives of Internal Medicine*, *161*, 1962–1968.

Oyugi, J. H., Byakika-Tusiime, J., Pharm, B., Charlebois, E. D., Kityo, C., Mugerwa, R., et al. (2004). Multiple validated measures of adherence indicates high levels of adherence to generic HIV antiretroviral therapy in a resource limited setting. *Journal of Acquired Immune Deficiency Syndromes*, *36*, 1100–1102.

Paterson, D. L., Swindells, S., Mohr, J., Brester, M., Vergis, E. N., Squier, C., et al. (2000). Adherence to protease inhibitor therapy and outcomes in patients with HIV infection. *Annals of Internal Medicine*, *133*, 21–30.

Pradier, C., Carrieri, P., Bentz, L., Spire, B., Dellamonica, P., & Moreau, J. P. (2001). Impact of short-term adherence on virological and immunological success of HAART: A case study among French HIV-infected IDUs. *International Journal of STD & AIDS*, *12*, 324–328.

Richman, D. D. (2001). Clinical implications of HIV fitness. Paper presented at the 41st Interscience Conference on Antimicrobial Agents and Chemotherapy, Chicago.

Rigsby, M. O., Rosen, M. I., Beauvais, J. E., Cramer, J. A., Rainey, P. M., O'Malley, S. S., et al. (2000). Cue-dose training with monetary reinforcement: Pilot study of an antiretroviral adherence intervention. *Journal of General Internal Medicine*, *15*, 841–847.

Roca, B., Gomez, C. J., & Arnedo, A. (2000). Adherence, side effects and efficacy of stavudine plus lamivudine plus nelfinavir in treatment-experienced HIV-infected patients. *Journal of Infection*, *41*, 50–54.

Singh, N., Berman, S. M., Swindells, S., Justis, J. C., Mohr, J. A., Squier, C., et al. (1999). Adherence of human immunodeficiency virus-infected patients to antiretroviral therapy. *Clinical Infectious Diseases*, *29*, 824–830.

Spire, B., Duran, S., Souville, M., Leport, C., Raffi, F., Moatti, J. P., et al. (2002). Adherence to highly active antiretroviral therapies (HAART) in HIV-infected patients: From a predictive to dynamic approach. *Social Science and Medicine*, *54*, 1481–1496.

Starace, F., Massa, A., Mariniello, A. P. S., Amico, K. R., & Fisher, J. D. (in press). Application of the IMB model to assess HIV treatment adherence. *Journal of Health Psychology* (in press).

Stewart, J., Strack, S., & Graves, P. (1999). Self-efficacy, outcome expectancy, dental health value and dental plaque. *American Journal of Health Behavior*, *23*(4), 303–310.

Walsh, J. C., Horne, R., Dalton, M., Burgess, A. P., & Gazzard, B. G. (2001). Reasons for nonadherence to antiretroviral therapy: Patients' perspectives provide evidence of multiple causes. *AIDS Care*, *13*, 709–720.

Walsh, J. C., Mandalia, S., & Gazzard, B. G. (2002). Responses to a one-month self-report on adherence to antiretroviral therapy are consistent with electronic data and virological treatment outcome. *AIDS*, *16*, 269–277.

Williams, S. S., Doyle, T. M., Pittman, L. D., Weiss, L. H., Fisher, J. D., & Fisher, W. A. (1998). Role-played safer sex skills of heterosexual college students influenced by both personal and partner factors. *AIDS and Behavior*, *2*, 177–187.

Zaccarelli, M., Barracchini, A., De Longis, P., Perno, C. F., Soldani, F., Liuzzi, G., et al. (2002). Factors related to virologic failure among HIV-positive injecting drug users treated with combination antiretroviral therapy including two nucleoside reverse transcriptase inhibitors and nevirapine. *AIDS Patient Care and STDs*, *16*, 67–73.