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Age-Associated Predictors of Medication Adherence in HIV+ Adults:

Health Beliefs, Self-Efficacy, and Neurocognitive Status

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ABSTRACT

Objective: Although most agree that poor adherence to antiretrovirals is a common problem, relatively few factors have been shown to consistently predict treatment failure. In this study, a theoretical framework encompassing demographic characteristics, health beliefs/attitudes, treatment self-efficacy, and neurocognitive status was examined in relationship to highly active antiretroviral therapy (HAART) adherence. **Design:** Prospective, cross-sectional observational design. **Main Outcome Measures:** Neuropsychological test performance, health beliefs and attitudes, and medication adherence tracked over a one-month period using electronic monitoring technology (MEMS caps). **Results:** The rate of poor adherence was twice as high among younger participants than older participants (68% and 33%, respectively). Results of binary logistic regression revealed that low self-efficacy and lack of perceived treatment utility predicted poor adherence among younger individuals, while decreased levels of neurocognitive functioning remained the sole predictor of poor adherence among older participants. **Conclusion:** These data support components of the health beliefs model in predicting medication adherence among younger HIV+ individuals. However, risk of adherence failure in those aged 50 and older appears most related to neurocognitive status.

Keywords: HIV, HAART, adherence, health beliefs, cognitive function

The introduction of highly active antiretroviral therapy (HAART) has transformed the treatment of HIV infection by improving the clinical course of the disease and substantially reducing HIV/AIDS associated morbidity and mortality (Garcia et al., 2002; Hogg et al., 1998; Murphy et al., 2001; Ory & Mack, 1998; Palella et al., 1998). Early optimism concerning the benefits of these medications has been tempered, however, by evidence that even modest or occasional nonadherence can greatly diminish the benefits of treatment and lead to serious personal and public health consequences. Research has demonstrated that suboptimal adherence (i.e., taking less than 90 to 95% of prescribed doses) is associated with increased risk of adverse virologic and clinical outcomes, including increased viral replication and the development of drug-resistant HIV strains (Bangsberg et al., 2000; Gifford et al., 2000; Liu et al., 2001; Wainberg & Friedland, 1998), as well as a host of clinically significant health-related setbacks (Paterson et al., 2000).

Given the relationship between suboptimal medication adherence and adverse clinical outcomes in HIV, efforts to identify factors predictive of adherence are clearly needed. Previous studies have examined the role of demographic characteristics (e.g., age, ethnicity, socioeconomic status), psychiatric status, substance abuse, health beliefs, social support, regimen complexity, and cognitive functioning in predicting HAART compliance (Chesney, Morin, & Sherr, 2000; Gifford et al., 2000; Hinkin, et al., 2002; Kalichman, Ramachandran, & Catz, 1999; Rabkin & Chesney, 1999; Smith, Rapkin, Morrison, & Kammerman, 1997; Stein et al., 2000). However, the prediction of medication adherence is a complex issue and undoubtedly multifactorial in nature. Most studies to date have focused on individual elements and few have

considered a combination of variables that relate to patients' adherence behavior and intentions to adhere. Research that considers several of these explanatory factors simultaneously is needed.

The most widely used theoretical framework for explaining health-related behaviors is the Health Beliefs Model (HBM), which was first introduced by Rosenstock (1974). The model has been studied within the context of a variety of health problems, including cancer, heart disease, diabetes, and more recently, HIV (for review, see Dimatteo, 2004; Janz & Becker, 1984). The HBM is derived from a well-established body of psychological and behavioral theory and hypothesizes that health behaviors depend mainly on the desire to avoid illness and the belief that certain actions will prevent or alleviate disease. The model consists of a number of dimensions, including: (1) *perceived susceptibility to illness*, which is the belief that one is at risk of contracting a disease or, in the case of a previously established infection, belief in the validity of the diagnosis (2) *perceived illness severity*, which includes feelings regarding the seriousness of contracting an illness or of leaving it untreated (3) *perceived benefits of treatment*, which relates to beliefs in the effectiveness of various actions in reducing disease threat and (4) *perceived barriers to treatment compliance*, which describes a cost/benefit analysis in which individuals weigh the treatment's effectiveness against potential negative consequences of compliance, such as disruption of daily activities and adverse side-effects. In addition to these four dimensions, the HBM also postulates that diverse demographic, psychosocial, and psychological variables may affect individuals' perceptions and thereby indirectly influence health-related behaviors.

While some authors have postulated that the HBM may be useful in the prediction of medication adherence among HIV-infected individuals (Reynolds et al., 2004), very few studies have actually incorporated the model in their investigations. One of the first such studies by Gao

and colleagues (2000) investigated the relationship between disease severity, health beliefs, and medication adherence in 72 HIV positive individuals. Their investigation found that perceived susceptibility to illness and perceived barriers to treatment (i.e., difficulty following the doctor's instructions) were both significantly related to medication adherence. Similarly, Durvasula and colleagues (2002) reported that higher levels of perceived treatment utility and intentions to adhere were associated with HAART adherence in a group of HIV+ men, while greater perceived barriers to treatment predicted poor adherence among women. Likewise, a qualitative study conducted by Malcolm, Ng, Rosen, and Stone (2003) found that subjects with excellent adherence were more likely to believe in the efficacy of treatment medication. While the findings from these investigations lend some support for specific dimensions of the HBM, small sample sizes and limited measurement of both health beliefs and medication adherence hamper interpretation of results.

Other constructs closely related to the HBM and thought to be predictive of medication adherence include self-efficacy and locus of control. Self-efficacy has been defined as the conviction that one can successfully execute a specific behavior (Bandura, 1977, 1986). According to Bandura's framework, health-related knowledge and beliefs alone are insufficient to achieve behavior change. In the study of HIV, self-efficacy has been linked to a variety of health-promoting behaviors, including medication adherence (Gifford et al., 2000; Johnson et al., 2003; Molassiotis et al., 2002). Locus of control is a related concept which attempts to characterize whether an individual's source of reinforcement for health-related behavior is primarily internal, external, or simply a matter of chance. Although less well investigated than self-efficacy, at least one study has found a relationship between internal locus of control and increased medication adherence among HIV positive individuals (Molassiotis et al., 2002).

In addition to health-related knowledge and beliefs, numerous researchers have pointed to the importance of neurocognitive status in predicting medication adherence in HIV (Albert et al., 1999; Chesney, Morin, & Sherr, 2000; Hinkin et al., 2002). It is well known that HIV infection can lead to significant cognitive compromise, ranging from subtle deficits in processing speed and efficiency to a pronounced dementia syndrome. Memory impairment (characterized by forgetfulness), motor and psychomotor slowing, attentional deficits, and executive systems dysfunction have all been repeatedly observed among HIV individuals (Bornstein et al., 1992; Heaton et al., 1995; Hinkin, van Gorp, & Satz, 1995; Miller et al., 1990). Not surprisingly, such neurocognitive deficits have been shown to be negatively associated with adherence to HAART (Hinkin et al., 2002, 2004). Despite these findings, however, assessment of neuropsychological functioning is often insufficiently addressed in studies of medication adherence in this population.

Further complicating research in this arena are the changing demographics of HIV infection. A major shift has begun to occur within the epidemic such that the number of new cases of HIV infection among middle-aged and older adults is growing (Levy, 1998). The pronounced improvement in HIV-associated mortality and morbidity is also adding to the ranks of the older HIV-infected population. Despite these changing demographics, however, little is known about the ways in which aging affects adherence in HIV/AIDS. The extent to which factors associated with poor medication adherence in younger adults generalize to older individuals remains unclear. This gap in present knowledge underscores the need for more investigations of age-related differences in adherence behavior.

In this study, a theoretical framework encompassing demographic characteristics, psychiatric functioning, health beliefs/attitudes, treatment self-efficacy, locus of control, and

neurocognitive status was examined in relationship to antiretroviral adherence. Given the dearth of research on older HIV+ individuals in particular, both younger and older cohorts were recruited for participation. Based on previous findings from our lab and elsewhere (Hinkin et al., 2002; Moatti et al., 2000; Paterson et al., 2000; Wilson et al., 2002), older adults were expected to demonstrate higher rates of medication adherence than their younger counterparts. Furthermore, it was predicted that the HBM and related variables would be predictive of adherence behavior in each cohort.

Method

Research Participants

A total of 185 HIV-seropositive adults were enrolled in the current study. Participants were recruited using fliers posted in infectious disease clinics at two university-affiliated medical centers and from community agencies in the Los Angeles area that specialize in providing services to HIV-infected individuals. Special effort was made to enroll participants representative of the changing demographics of the HIV/AIDS epidemic. Therefore, recruitment strategies focused particular attention on women, ethnic minorities, and individuals over the age of 50. When describing the research, potential subjects were told that the study aimed to investigate the links between adherence to HIV medication and variables such as age, cognitive functioning, mood, health beliefs, and social support. Inclusion criteria for the investigation was established to include individuals of both male and female gender, those who were HIV positive (confirmed with Western Blot analysis), 18 years of age or older, and those taking a protease inhibitor in pill form without need for refrigeration. Subjects also had to be community-dwelling (e.g., not residing in a board and care facility, nursing home, or hospice environment), be responsible for administering their own medications, agree to use the MEMS cap device for the

duration of the investigation, and demonstrate the manual dexterity necessary for opening their pill bottle. Individuals were excluded from participation in the study if they met DSM-IV criteria for current or past psychotic spectrum disorders, including schizophrenia, schizophreniform disorder, or bipolar disorder, had a history of learning disability, seizure disorder, stroke, closed-head injury with loss of consciousness in excess of 30 minutes, or any other neurological disease, CNS opportunistic infection, or neoplasm. Participants were not excluded based on HIV disease severity.

At the time of participation, 63% of subjects met Centers for Disease Control and Prevention diagnostic criteria for AIDS (1993) and all were on self-administered HAART. Sixty-nine percent of participants were African American, 17% were Caucasian, 9% were Hispanic, 3% were multi-racial, and 2% were Asian or American Indian. Women comprised 22% of the sample. Mean age of participants was 44 years (7.3) with a range of 25-69. As suggested by several National Institutes of Health-sponsored conferences on aging and AIDS, a cut-off point of 50 years was used to define 'older' subjects. Using this cut-point, 24% of subjects were classified as older. The majority of participants had completed high school with a mean of 13.14 (2.3) years of education. Premorbid intellectual functioning, as estimated with the North American Adult Reading Test (NAART), was in the average range (mean verbal IQ = 103.16, SD = 10.6). Overall prevalence of substance abuse disorders was relatively low, with 10.3% and 9.7% of subjects meeting DSM-IV diagnostic criteria for alcohol and drug abuse/dependence, respectively. Additional demographic data are presented in Table 1.

Measures

Health beliefs and attitudes. Health beliefs, locus of control, and treatment self-efficacy were assessed using self-report questionnaires. Subjects' health beliefs and attitudes toward

treatment were measured using the Adherence Determination Questionnaire [ADQ (DiMatteo et al., 1993)]. The ADQ is based on the Health Beliefs Model and consists of 38 brief statements rated on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). A total of 7 subscales are derived from the measure and include (1) interpersonal aspects of care and relationship with treating professionals (2) perceived utility of treatment (3) perceived illness severity (4) perceived susceptibility to illness progression (5) subjective norms (i.e., belief that family and friends support adherence to a treatment plan) (6) intentions to comply with treatment and (7) support/barriers to adherence. Locus of control was measured using the Multidimensional Health Locus of Control scale [MHLC (Wallston, Wallston, & DeVellis, 1978)]. The MHLC assesses the extent to which an individual's source of reinforcement for health-related behavior is primarily internal (e.g., "I am directly responsible for my health"), dependent upon powerful others (e.g., "If I see an excellent doctor regularly, I am less likely to have health problems"), or a matter of chance (e.g., "When I stay healthy, I am just plain lucky"). Finally, treatment adherence self-efficacy was measured by asking participants "How sure are you that you will be able to take most or all of your antiretroviral medication as directed?" and "How sure are you that you will be able to take most or all of your other medications for HIV, such as medications for treating or preventing opportunistic infections like PCP or CMV, as directed?". Subjects rated their responses to each question on a scale of 0 (not sure) to 10 (very sure) and the summation of these items served as the total treatment adherence self-efficacy score.

Psychiatric symptomatology. A structured psychiatric interview was conducted with each participant under the supervision of a licensed clinical psychologist with expertise in diagnostic interviewing (S. A. C.). Common psychiatric symptoms, including depression, anxiety, apathy, and irritability were further measured using standardized self-report

questionnaires. The Beck Depression Inventory [BDI (Beck, Steer, & Brown, 1996)] and the Beck Anxiety Inventory [BAI (Beck & Steer, 1990)] were used to assess depression and anxiety, respectively. Symptoms of apathy and irritability were evaluated using an adaptation of the Neuropsychiatric Inventory [NPI (Cummings et al., 1994)].

Neurocognitive status. Participants completed a comprehensive battery of neuropsychological tests (see Appendix) to assess functioning in the areas of attention/working memory, speed of information processing, learning and memory, verbal fluency, executive functioning, and pure motor speed. Test scores were converted to demographically corrected *t*-scores (with a mean of 50 and a standard deviation of 10) using published normative data and grouped by neurocognitive domain. Domain *t*-scores were obtained by calculating the mean *t*-score for all tests comprising a given domain. A global *t*-score was calculated by summing individual *t*-scores and dividing by the number of tests administered.

Medication adherence. MEMS caps were used to assess participants' HAART adherence over a 4-week period. MEMS caps employ a pressure-activated microprocessor in the medication bottle cap that automatically records the date, time, and duration of bottle opening. Data are retrieved from the cap using a specially designed communication module connected to a personal computer. For the majority of subjects (64%), MEMS caps were employed to track adherence to protease inhibitors. For those participants on a protease-sparing regimen, MEMS caps were used to track adherence to another antiretroviral medication (e.g., nucleoside reverse transcriptase inhibitor or non-nucleoside reverse transcriptase inhibitor). Participants who took at least 95% of their prescribed doses were classified as good adherers. Those who took less than 95% of doses were classified as poor adherers.

Procedure

After providing written informed consent, participants completed self-report questionnaires, a structured psychiatric interview, and neurocognitive testing as described above. Subjects then received instructions regarding the use of MEMS caps and were scheduled to return for follow-up 1 month later. At the follow-up visit, MEMS caps were collected and the data was downloaded. Each subject received \$80 for participating in the study, which was approved by the institutional review boards of both UCLA and the West Los Angeles VA Healthcare Center.

Data Analysis

All data was analyzed using the Statistical Package for Social Sciences, version 11.0 (2001). Descriptive statistics were conducted on all variables to summarize the data. In order to examine predictors of medication adherence separately among younger and older participants, the sample was divided into two groups as a function of age ('younger' < 50 years, 'older' \geq 50 years). Medication adherence was dichotomized on the basis of whether participants were able to adhere to at least 95% of prescribed doses. A series of univariate analyses were then conducted to determine the relationship between psychosocial, health belief, and neurocognitive variables and adherence groupings in both younger and older participants. Independent t-tests were conducted for continuous variables and chi-square analyses were used for categorical data. A multivariate model was then created for each group using forward stepwise binary logistic regression (with standard entry criteria) for all variables reaching significance during univariate analyses ($p < .05$). Ninety-five percent confidence intervals were calculated for resulting odds ratios (CI_{or}). Overall model fit was evaluated using the Goodness-of-Fit statistic.

Results

Demographic and Clinical Characteristics

Demographic and clinical characteristics were compared between younger and older participants using one-way analysis of variance (ANOVA) and chi-square statistics. No differences were found between groups with respect to gender, years of education, ethnicity, sexual orientation, relationship status, drug or alcohol abuse, length of HIV illness, or number of years on HIV medications. However, membership in the older cohort was associated with older age [$F(1,183) = 211.02, p < .01$], a higher income [$\chi^2(184) = 4.65, p = .03$], and increased likelihood of cognitive impairment [$\chi^2(185) = 3.18, p = .04$]. Broken down by cohort, mean age was 56.3 (4.8) years among individuals in the older group and 41.0 (5.0) years among individuals in the younger group. With respect to income, 66.7% of older subjects reported annual earnings of over \$10,000 compared to only 48.2% of younger participants. Finally, while 77.5% of elders demonstrated global cognitive impairment on neuropsychological testing, the proportion of younger subjects with similar deficits was found to be 68.9%.

Medication Adherence

The mean adherence rate across all 185 participants was 75.8%, with older subjects achieving a mean adherence rate of 84.9% and younger subjects achieving a mean adherence rate of 72.8%, a difference that is statistically significant, $F(1,183) = 11.78, p = .001$). As can be seen in Fig. 1, the percentage of subjects classified as poor adherers was twice as high among younger than older subjects (68% and 33%, respectively), a difference which is again statistically significant, [$\chi^2(185) = 16.84, p < .001$].

Demographic Variables and Psychiatric Status

A series of univariate analyses were then conducted to examine the impact of demographic/psychosocial variables and psychiatric status on medication adherence in both younger and older cohorts. Findings revealed that poor adherence among younger HIV

seropositive adults was associated with current drug abuse/dependence [$\chi^2(140) = 5.65, p = .02$] and lack of independent financial resources [$\chi^2(140) = 3.69, p = .05$]. More specifically, of those younger adults meeting DSM-IV diagnostic criteria for drug abuse/dependence, only 6.3% were classified as good adherers compared to 35.8% of subjects without a drug abuse/dependence diagnosis. Younger participants who were financially supported by others (e.g., family, friends, government programs) were also less likely to be adherent, with only 28.2% classified as good adherers compared to 46.7% of subjects with independent financial resources. With respect to psychiatric symptomatology, higher levels of apathy [$t(138) = -1.92, p = .05$] were found to be associated with substandard medication adherence in this cohort.

In contrast, poor adherence among older participants was found to be associated with both income level [$\chi^2(45) = 4.05, p = .04$] and sexual orientation [$\chi^2(45) = 4.64, p = .03$]. More specifically, older adults with an annual income of at least \$10,000 per year were more likely to be classified as good adherers than those with smaller incomes (76.7% and 46.7%, respectively). In addition, elders who identified themselves as gay or bisexual were also more likely to be classified as good adherers when compared to their heterosexual counterparts (82.4% and 47.1%, respectively). Psychiatric variables (i.e., anxiety, depression, irritability, apathy) were not predictive of medication adherence among older adults.

Health Beliefs, Locus of Control, and Self-Efficacy

A series of univariate analyses was conducted to assess the relationship between medication adherence and each dimension of the Health Beliefs Model in both younger and older cohorts. Results revealed that lower perceived treatment utility [$t(138) = 3.49, p < .01$], reduced sense that family and friends support treatment compliance [$t(138) = 2.29, p = .02$], weaker intentions to adhere [$t(138) = 2.47, p = .02$], and greater perceived barriers to treatment [$t(138)$

= -1.93, $p = .05$] were all associated with poor medication adherence in this sample. Poor adherence among younger individuals was also found to be associated with less internal locus of control [$t(138) = 2.20, p = .03$], greater chance locus of control [$t(138) = -1.96, p = .05$], and lower levels of treatment adherence self-efficacy [$t(138) = 3.08, p < .01$].

Examination of these variables within the older cohort revealed that poor medication adherence was associated with less internal locus of control [$t(43) = 1.39, p = .05$] and the perception that family and friends support regular adherence to a treatment plan [$t(43) = -2.34, p = .03$]. Interestingly, treatment adherence self-efficacy and other dimensions of the Health Beliefs Model were not associated with adherence among older subjects.

Neurocognitive Status

Independent t -test analyses were conducted to examine the relationship between neurocognitive functioning and medication adherence in both younger and older participants. Neurocognitive status was not significantly associated with treatment compliance among young HIV seropositive adults; however, a number of neuropsychological domains were found to be related to adherence among older individuals. More specifically, poor adherence in this cohort was associated with weaker performance on measures of both learning and memory [$t(43) = 2.07, p = .05$] and executive functioning [$t(43) = 2.59, p = .01$]. Similarly, non-adherent elders demonstrated significantly reduced levels of global cognitive functioning [$t(43) = 2.74, p < .01$].

Multivariate Models

After completing the series of univariate analyses described above, a multivariate model was constructed to identify the most robust predictors of medication adherence in each cohort. Stepwise logistic binary regression was used with standard entry criteria (probability of F-to-enter ≤ 0.05 and probability of F-to-remove ≥ 0.10). Only those variables demonstrating

statistical significance ($p < .05$) during univariate analyses were entered into each of the models. Results of multivariate analyses for the younger cohort are displayed in Table 2. The overall multivariate model was significant [$\chi^2(2,140) = 22.27, p < .001$] and correctly classified 73.0% of cases. Results show that both perceived treatment utility ($\beta = 0.162, p = .004$) and treatment adherence self efficacy ($\beta = 0.285, p = .01$) made independent, and statistically significant, contributions to the prediction of medication adherence. After controlling for other predictors in the model, the odds of good medication adherence increased by 1.176 (CI_{or} 1.06 - 1.31) with each unit increase in perceived treatment utility and by 1.330 (CI_{or} 1.06 - 1.67) with each unit increase in treatment self-efficacy.

Results of multivariate analyses for the older cohort are presented in Table 3. The overall multivariate model was again significant [$\chi^2(1,45) = 5.97, p = .02$] and correctly classified 76.9% of cases. Results show that neurocognitive functioning ($\beta = 0.022, p = .02$) remained the sole significant predictor of medication adherence among older subjects. After controlling for other predictors in the model, the odds of good medication adherence decreased by 1.220 (CI_{or} 1.03 - 1.42) with each unit decrease in global cognitive functioning.

Discussion

In this study, a theoretical framework encompassing demographic characteristics, psychiatric functioning, health beliefs/attitudes, treatment self-efficacy, locus of control, and neurocognitive status was examined in relationship to HAART adherence in an ethnically diverse sample of HIV+ individuals. Consistent with previous research (Ammassari et al., 2001; Duran et al., 2001; Gordillo, del Amo, Soriano, & Gonzalez-Lahoz, 1999; Hinkin et al., 2004; Paterson et al., 2000), we found older age to be associated with significantly better medication adherence. More specifically, HIV-infected adults aged 50 years and older were two times more

likely to achieve a 95% adherence rate than were younger subjects. Several explanatory factors for this finding can be offered. First, it may be that taking medication requires less alteration in lifestyle for elders. Older individuals are more likely to have prior experience taking medication for other age-related illnesses and therefore may already have become more accustomed to such a routine. Secondly, it may be that the lifestyle alterations necessary for successful adherence are less burdensome for older individuals, who may more easily be able to accommodate pill-taking into their daily lives. Older age may also be associated with increased recognition of mortality and therefore greater motivation to follow illness prevention strategies and treatment recommendations set forth by health care providers. Alternatively, increased medication adherence among older adults may be explained, in part, by a survivor effect in that individuals who maintain greater compliance with treatment recommendations may actually outlive those who are less adherent.

The current study also examined predictors of medication adherence among younger and older cohorts and found that factors associated with adherence varied significantly as a function of age. With respect to younger individuals, results provide support for the hypothesis that components of the HBM are influential in determining adherence behavior. Multivariate analyses revealed that greater perceived treatment utility and heightened feelings of self-efficacy were both predictive of adherence in this cohort. These findings are congruent with HBM theory, which asserts that individuals would be unlikely to maintain complex and disruptive treatment behaviors if they lacked confidence in their ability to succeed or did not believe in the effectiveness of the medication prescribed. While both perceived treatment utility and self-efficacy have been found to be associated with medication adherence in a number of previous studies (Durvasula et al., 2002; Gifford et al., 2000; Johnson et al., 2003; Malcolm, Ng, Rosen,

& Stone, 2003; Molassiotis et al., 2002; Pinheiro, de-Carvalho-Leite, Drachler, & Silveira, 2002; Wagner, Remien, Carballo-Diequez, & Dolezal, 2002), it was surprising that other dimensions of the HBM, such as perceived vulnerability/susceptibility and perceived illness severity, were not related to adherence behavior in this sample.

While our data supports a link between components of HBM and medication adherence in individuals under the age of 50, we found that health beliefs and attitudes in older adults were unrelated to HAART adherence. More specifically, results of multivariate analyses revealed that adherence behavior in this cohort was predicted solely by neurocognitive status and bore no relationship to self-efficacy, perceived treatment utility, or any other dimension of HBM theory. While these data suggest that the HBM is not a useful model for predicting HAART adherence in an older HIV-infected cohort, additional research is needed to replicate this finding and rule out alternative explanations for these results (e.g., a relative reduction in statistical power). Our findings are consistent, however, with previous research demonstrating that decrements in neurocognitive functioning are associated with suboptimal medication compliance (Chesney, Morin, & Sherr, 2000; Durvasula, Golin, & Stefaniak, 1998; Hinkin et al., 2002). Interestingly, results of univariate analyses suggest that the relationship between cognitive functioning and poor adherence among older adults in our study was driven primarily by decrements in learning and memory and executive functioning. Individuals experiencing forgetfulness and/or impairment in the ability to plan ahead and execute goal-driven behaviors appear to be at highest risk of adherence failure. These neurocognitive deficits may be more prevalent among older HIV-infected individuals due to factors such as increased risk of cerebrovascular disease, age-related cognitive dysfunction, age-related decrements in immuno-competence, comorbid illness, and/or medication-associated toxicity. While younger and older groups in our study did not

differ significantly with respect to length of HIV infection, duration of illness may also prove to have deleterious effects on neurocognitive functioning.

Interpretation of the findings presented here must be considered in light of the study's strengths and limitations. First, it is important to note that the demographic characteristics of our sample are consistent with the most recent surveillance data published by the Center for Disease Control and Prevention (2003). Participants therefore represent the spectrum of HIV-positive persons living in the United States. Second, unlike previous investigations which have examined only select portions of HBM theory in relation to HAART adherence (Durvasula et al., 2002; Ka'opua & Mueller, 2004; Malcolm, Ng, Rosen, & Stone, 2003; Wagner et al., 2002), the current study was comprehensive in its measurement of HBM-associated health beliefs and attitudes. An advantage of this approach was that various dimensions of the model could be examined simultaneously as predictors of medication adherence. Third, despite changing demographics within the HIV/AIDS pandemic, very few investigators have shifted attention to the growing number of older individuals living with this disease. As the current study has demonstrated, factors found to be associated with poor medication adherence in younger individuals may not generalize to an older cohort. This finding clearly has significant implications for the development of intervention programs aimed at improving medication adherence among HIV+ individuals. Finally, the use of objective techniques to track medication adherence and to assess neurocognitive status represents a significant methodological improvement over past studies in this research domain. It has been reported that self-report techniques, particularly when used to assess socially-desirable behaviors such as adherence to physicians' instructions, are subject to bias and frequently overestimate the behavior in question (Arnsten et al., 2001; Chesney et al., 2000; Haubrich et al., 1999; Liu et al., 2001; Melbourne et

al., 1999; Samet, Sullivan, Traphagen, & Ickovics, 2001). The lack of concordance between self-reported cognitive status and actual performance on neurocognitive tests in HIV samples is also well documented (Hecht, Grant, Swanson, & Chesney, 1998; Hinkin et al., 1996; Rourke, Halman, & Bassel, 1999). Earlier studies relying on self-report data as an index of medication adherence or cognitive status are therefore potentially weakened by this confound.

Despite the strengths of the current study, there are several limitations to our findings. First, our investigation was limited to a cross-sectional design and therefore associations between health beliefs/attitudes, neurocognitive status, and adherence behavior can not be interpreted as causal. While an association was found between health beliefs and medication adherence among younger HIV-infected individuals for example, it is not possible to tease apart whether such attitudes reflect antecedents or consequences of illness. Second, it should be noted that there are potential drawbacks in using multiple statistical tests to determine significance among variables, most notably an increased chance of making a Type I error. Given the exploratory nature of this investigation and the importance of identifying potential treatment predictors in a disease like HIV, however, more conservative analytic approaches are not always considered the most appropriate (Parker & Rothenberg, 1989). A strength of our study is the use of multivariate modeling, a technique that is helpful in teasing apart variables that ultimately have little or no contribution to the dependent variable (in this case, HAART adherence) when examined simultaneously with other predictors. Another viable criticism may stem from the decision to use a 95% threshold to define good adherence. While several widely cited papers have found that such high adherence rates are necessary to achieve optimal viral suppression (Paterson et al., 2000) and slow the rate at which drug-resistant strains of the virus emerge (Gifford et al., 2000), others have reported that the development of drug-resistant mutations declines only modestly in

response to higher levels of adherence (Bangsberg et al., 2004). Finally, using a cutoff of 50 years to define older age is admittedly arbitrary. Most of the aging literature employs a lower bound of 65 years, and sometimes even older, to define older age. The decision to adopt this cutoff was based on several National Institutes of Health-sponsored work groups and conferences on aging and HIV/AIDS. Although it is recognized that clinically significant age-related declines in cognition do not typically emerge before the sixth or seventh decade of life, our data suggests that the effects of both age and advancing HIV-infection may confer greater risk of neurocognitive impairment and, in turn, compromised medication adherence among older adults.

In conclusion, most studies investigating medication adherence in HIV have focused on a handful of risk factors and few have attempted to test more comprehensive models of adherence behavior. More research is needed, like the present study, which considers several explanatory factors simultaneously. Moreover, in order for research in this domain to translate into improved health outcomes for persons living with HIV, intervention strategies must be developed to target factors associated with treatment failure in this population. Findings from the current study indicate that HAART adherence in younger individuals can be predicted, in part, by perceived treatment utility and feelings of self-efficacy. These health beliefs are potentially modifiable and underscore the need for psychological and behavioral interventions with this group. Such programs may be less effective with older individuals, however, whose adherence behavior is more likely to be complicated by neurocognitive dysfunction. Finally, more research targeting older HIV-infected adults is clearly needed, particularly as new evidence emerges to suggest age-related differences in factors associated with medication adherence. Given the “graying” of the HIV-infected populace, increased focus on this group remains critical.

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Appendix

Neuropsychological test battery by domain.

Attention/working memory

Paced Serial Addition Test

Speed of information processing

Symbol Digit Modalities Test

Trail Making Test, Part A

Learning and memory

California Verbal Learning Test, Trials 1-5

California Verbal Learning Test, Short Delay Free Recall

California Verbal Learning Test, Long Delay Free Recall

Verbal fluency

Controlled Oral Word Association Test

Executive functioning

Booklet Category Test

Trail Making Test, Part B

Stroop Color Word Test, Interference Trial

Motor functioning

Grooved Pegboard, Dominant Hand

Grooved Pegboard, Non-dominant Hand

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Table 1.

Sample Demographics and Clinical Characteristics.

Characteristic	n	% of sample	M (SD)
Age	185		44.01 (7.3)
Education	185		13.14 (2.3)
# Years since HIV diagnosis	170		8.08 (4.7)
# Years on HIV meds	170		5.7 (3.4)
Gender			
Male	144	77.8	
Female	41	22.2	
Ethnicity			
African American	127	68.6	
Caucasian	32	17.3	
Hispanic	18	9.7	
Asian	2	1.1	
American Indian	1	0.5	
Multi-racial	5	2.7	
Sexual Orientation			
Heterosexual	74	40.0	
Homosexual	62	33.5	
Bisexual	16	8.6	
Transgender	1	0.5	
Relationship Status			
Single	106	57.3	
Committed relationship	79	42.7	
Income			
≤ \$10,000	87	47.0	
> \$10,000	97	52.4	
Employment Status			
Full-time	11	5.9	
Part-time	13	7.0	
Unemployed	8	4.3	
Disability	102	55.1	
Welfare	34	18.4	
Other	17	9.3	
Substance Abuse/Dependence			
Drug	18	9.7	
Alcohol	19	10.3	

Note. n=185

Table 2.

Multivariate Logistic Regression Analysis Predicting Adherence Versus Non-Adherence Among

Younger HIV+ Individuals.

Variable	B	Wald	df	<i>p</i>	Odds Ratio	95% CI _{or}
ADQ S2 Perceived Utility	0.162	8.503	1	.004*	1.176	1.055 - 1.311
Self-efficacy	0.285	6.182	1	.013*	1.330	1.062 - 1.665
Financial resources			1	.059		
Current drug abuse/dependence			1	.063		
Apathy/Indifference			1	.126		
ADQ S5 Subjective Norms			1	.550		
ADQ S6 Intentions			1	.682		
ADQ S7 Support/Barriers			1	.522		
MHLC Internal			1	.141		
MHLC Chance			1	.366		

Note. n=140

Table 3.

Multivariate Logistic Regression Analysis Predicting Adherence Versus Non-Adherence Among Older HIV+ Individuals.

Variable	B	Wald	df	<i>p</i>	Odds Ratio	95% CI _{or}
Global cognitive functioning	0.022	5.249	1	.022*	1.220	1.030 - 1.420
Income			1	.591		
Sexual orientation			1	.202		
ADQ S5 Subjective Norms			1	.059		
MHLC Internal			1	.453		

Note. n=45

Figure 1.

HAART Adherence as a Function of Age.

