

Health Belief Model-Informed Predictors and Complementary Psychosocial Factors Associated with Antiretroviral Therapy Adherence among Black Adults with HIV

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Received date: April 14, 2026, **Accepted date:** June 02, 2026

Citation: Serrano VB, Prescott M, Moore DJ, Montoya JL. Health Belief Model-Informed Predictors and Complementary Psychosocial Factors Associated with Antiretroviral Therapy Adherence among Black Adults with HIV. J AIDS HIV Treat. 2026;8(1):21–30.

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Abstract

Objective: Black individuals in the United States are disproportionately affected by HIV and experience disparities in antiretroviral therapy (ART) adherence. This study examined components of the Health Belief Model (HBM) and related psychosocial factors as predictors of ART adherence across multiple adherence measures.

Methods: Participants were 91 Black adults with HIV recruited from a federally qualified health center (FQHC) and enrolled in a single-arm text messaging-based adherence support intervention. ART adherence was assessed using three measures: (1) a continuous adherence measure, (2) a visual analog scale (VAS), and (3) daily text message-reported responses. Selected HBM constructs (perceived benefits, perceived severity, perceived barriers, and self-efficacy) and related psychosocial factors (supports and beliefs) were examined as predictors of these three adherence outcomes. Linear mixed-effects models assessed associations between psychosocial predictors and longitudinal adherence outcomes.

Results: The sample was primarily comprised of men and older individuals, most of whom had disclosed their HIV status to others. In multivariable models including all predictors, greater self-efficacy was associated with higher adherence on both the continuous adherence measure ($\beta = .18, t = 2.11, p = .04$) and VAS ($\beta = .21, t = 2.54, p = .01$), but not the daily text message responses. Greater perceived barriers were associated with lower adherence on the continuous adherence measure and VAS (p 's $< .001$) and showed a trend toward lower text message responses ($t = -0.79, p = .06$). Greater support for adherence was marginally associated with higher VAS scores ($t = 1.95, p = .06$). Other psychosocial predictors were not significantly associated with adherence outcomes.

Conclusions: In this older cohort of Black adults receiving HIV care, self-efficacy and perceived barriers emerged as the most salient correlates of retrospective self-reported ART adherence. Findings support the potential value of interventions that strengthen self-efficacy and reduce perceived adherence challenges.

Keywords: HIV, Medication adherence, Health belief model, Psychosocial predictors, Self-efficacy, African Americans, Longitudinal studies, Treatment outcome

Introduction

Antiretroviral therapy (ART) adherence is critical for achieving HIV viral suppression, improving health outcomes, and preventing HIV transmission among people with HIV (PWH). However, maintaining consistent ART adherence can be challenging and is influenced by multiple psychosocial

and behavioral factors, including attitudes and beliefs about HIV and its treatment [1]. Black PWH continue to experience lower rates of ART adherence and poorer HIV-related outcomes compared to White PWH [2–4]. Accordingly, identifying modifiable psychosocial factors associated with ART adherence among Black PWH remains an important area of investigation.

Understanding the psychosocial and behavioral mechanisms associated with ART adherence is critical in populations disproportionately affected by HIV. The Health Belief Model (HBM) offers a framework for examining how individual beliefs and perceptions influence health-related behaviors such as medication adherence [5]. According to the HBM, individuals are more likely to engage in health-promoting behaviors when they perceive a health threat as severe, believe they are susceptible to that threat, recognize benefits to taking action, and perceive minimal barriers to doing so. The model also incorporates the concept of self-efficacy, or the belief in one's ability to successfully perform a behavior [6]. In the context of ART adherence, this means that beliefs about the seriousness of HIV, the effectiveness of ART, the difficulty of managing a daily regimen, and confidence in one's ability to adhere all play a role in whether a person takes their medication consistently.

Prior research applying components of HBM, such as self-efficacy, to ART adherence has shown that these factors are strong predictors of whether people with HIV take medication as prescribed [7,8]. However, these relationships have not been consistently explored among exclusively Black PWH, who may experience ART adherence through the lens of unique cultural, social, and structural realities, including stigma, distrust of healthcare systems, and limited social support. A deeper understanding of how HBM constructs operate within this population may help identify new leverage points for intervention.

In addition to clarifying predictors of ART adherence, observing differences in methods of measuring adherence is also of great importance. Traditional methods such as self-report questionnaires offer insight into adherence behaviors but are subject to recall and social desirability biases. More objective or behavioral indicators, such as viral load or pharmacy refill data, are often unavailable in research studies or in community-based contexts. In recent years, mobile health (mHealth) approaches, particularly text messaging, have emerged as innovative tools to support and assess adherence. These measures allow for more real-time data. Text messaging interventions offer reminders, encouragement, and information that may reduce barriers and increase self-efficacy for ART adherence [9,10]. Further, SMS-based adherence measures may capture day-to-day adherence behavior more proximally than retrospective self-report and have demonstrated stronger associations with biologic indicators of HIV outcomes in prior work [11,12].

The present study aimed to examine multiple measures of ART adherence, including a self-reported continuous measure of adherence, a visual analog scale (VAS), and text message responses, among Black adults with HIV. Study participants were receiving care at a large federally-qualified health center (FQHC) and elected to participate in a study providing text

messaging to support ART adherence [13,14]. We assessed associations between four of six HBM constructs (perceived benefits of ART, severity of non-adherence, barriers to ART adherence, and self-efficacy for managing ART) alongside related psychosocial factors (supports and beliefs about ART adherence) and three complementary longitudinal adherence outcomes. By using multiple measures of ART adherence, this study aimed to identify psychosocial predictors of ART adherence in a sample at elevated risk for non-adherence and poorer HIV outcomes. We hypothesized that greater perceived benefits, self-efficacy, and supports and lower perceived barriers would be associated with higher ART adherence across measures.

Methods

Participants

Participants were a clinic-based sample of 91 Black/African American adults with HIV who were receiving HIV care at a large FQHC serving low-income and medically underserved populations. Although recruitment focused on Black adults with HIV receiving care at the FQHC broadly, the final sample was predominantly older Black men, most of whom had disclosed their HIV status to others. Study enrollment took place between November 2017 and July 2019 as part of the Individual Community Care for HIV/AIDS Now: Getting Engaged (iC-CHANGE) study [13–15]. In the iC-CHANGE study, participants received daily text message reminders for ART and attended in person study visits at 12-week intervals to complete psychosocial questionnaires (91.2% completed 48-week study interval). To be eligible, participants had to have a current ART prescription and to have been prescribed ART for at least two months at the time of enrollment. Additional inclusion criteria included the ability to speak English and provide informed consent. Individuals were excluded if they had severe neurocognitive impairments (e.g., dementia) that would prevent meaningful participation or if they were unable to commit to completing the study due to expected relocation or extended absence from the San Diego area during the study period (24 or 48 weeks). All participants provided written informed consent prior to participation and were treated in accordance with the American Psychological Association's Ethical Principles of Psychologists and Code of Conduct. Study procedures were approved by the Institutional Review Board at the University of California, San Diego (IRB #161608).

Measures

Demographics

All participants had demographic information collected at baseline including self-reported data on their age, sex at birth, gender, highest education level attained, annual income individual and household, marital status,

employment status, ethnicity, race, and HIV disclosure. Given its significance to psychosocial functioning and adherence, depressive symptoms were also assessed at baseline using the Beck Depression Inventory-II (BDI-II) [16], a 21-item self-report questionnaire intended to measure the prevalence and severity of depressive symptoms over the past two weeks. Higher scores were associated with higher severity of depressive symptoms (e.g. 0 = “I do not feel sad”, 3 = “I am so sad or unhappy that I can’t stand it”). A total score was derived by summing across the 21-item measure (range: 0-63) and examined as a continuous variable.

Selected HBM constructs (Measured at baseline)

Constructs from the HBM were approximated using items drawn from multiple instruments, rather than measured using a single standardized HBM scale, each described below.

Perceived benefits of ART and perceived severity of HIV without ART

Both perceived benefits of ART and perceived severity of HIV without ART were captured at baseline using a 30-item Beliefs Related to Medications self-report measure, adapted from the Horne *et al.* [17]. Belief about Medicines Questionnaire to be specific to PWH and ART. In the 30-item scale, participants rated their agreement with each statement on a 5-point Likert scale, ranging from 1 (Strongly Agree) to 5 (Strongly Disagree). Four items relating to the benefit of taking ART (e.g., *My health at present depends on my anti-HIV medicines*) were used to derive a score for perceived benefits of ART, with higher scores indicating greater perceived benefits ($\alpha = .72$). Similarly, four items relating to perceived severity of HIV without ART (e.g., *Without my anti-HIV medication, I would be very ill*) were used to derive a score for perceived severity, with higher scores indicating greater perceived severity ($\alpha = .71$).

Barriers to ART adherence

Barriers to ART adherence were similarly assessed at baseline with a questionnaire that identified potential obstacles that could interfere with participants' ability to take their medications as prescribed ($\alpha = .79$). Participants were asked to indicate whether any of the listed barriers had ever caused them to skip their medications, with responses recorded as “yes” (1) or “no” (0). The barriers included a range of factors, such as physical and emotional challenges (e.g., being depressed), concerns about side effects, stigma or discrimination, financial or logistical challenges (e.g., transportation problems, lack of insurance), and personal or cultural beliefs. Participants were also asked about factors like forgetting to take medications, feeling that the medications were unnecessary or harmful, and social influences such as sharing medications with others. The total number of barriers endorsed by each participant was calculated by summing the “yes” responses across the items.

A higher count of endorsed barriers indicated more perceived obstacles to consistent ART adherence.

Self-efficacy for managing medications and treatments

Self-efficacy was measured at baseline using a 26-item self-report questionnaire ($\alpha = .96$) adapted from PROMIS [18], a measurement of various health domains that has been validated for use in ethnically diverse samples [19]. Items were measured from 1–5 with 1 corresponding to “Not at all confident” and 5 to “Very confident”. Items were differentiated between medication (e.g. *“I know what to do when my medication refill looks different than usual”*) and treatments (e.g. *“I can follow a full treatment plan (including medication, diet, physical activity)”*). Higher scores were associated with greater self-efficacy in managing medications and treatments.

Related psychosocial measures (Measured at baseline)

Supports to ART adherence

Supports to ART adherence were assessed at baseline using a questionnaire designed to capture various strategies and factors that may facilitate medication adherence ($\alpha = .44$). This low internal consistency likely reflects the heterogeneous nature of potential supports, which were designed to capture a broad range of behavioral, interpersonal, and structural supports rather than a single underlying construct. Specifically, participants were asked to indicate whether specific support mechanisms had ever helped them in taking their medications, with responses recorded as either “yes” (1) or “no” (0). The items assessed included both external supports (e.g., reminders from others or using a pill box) and internal factors (e.g., understanding the importance of medications or believing in their effectiveness). Some examples of support mechanisms assessed in the questionnaire included taking medications at the same time of day, using a medication diary or alarm, having someone remind them to take their medication, feeling healthy, understanding the purpose of the medications, and having a supportive relationship with healthcare providers. Each of these items was used to capture different dimensions of support that participants may have relied on in adhering to ART. The total number of supports endorsed by each participant was calculated by summing the “yes” responses across all items. A higher count of endorsed supports indicated greater identification and use of strategies to aid adherence to ART.

Beliefs about ART

Beliefs about ART were assessed at baseline using three items adapted from prior work by Bird & Bogart [20], to capture beliefs related to HIV and its treatment ($\alpha = .78$). The three items examined focused on participants' perceptions regarding the safety and effectiveness of HIV medications. Participants rated

their agreement with each statement on a 5-point Likert scale, ranging from 1 (*Strongly Agree*) to 5 (*Strongly Disagree*), with higher scores indicating stronger beliefs in the effectiveness of ART.

ART adherence outcomes (Measured longitudinally every 12 weeks)

Continuous self-reported adherence measure

Participants completed self-report assessments of ART adherence at baseline and every 12 weeks thereafter, using a 3-item measure of adherence [21]. These items captured participants' perceived adherence over the past 30 days. Responses were scored such that higher values indicated better adherence, with the exception of the item asking how many days the participant had missed at least one dose ("In the last 30 days, on how many days did you miss at least one dose of any of your HIV medicines?"), which was reverse coded. Scores for that item were constrained between 0 and 30 to reflect the number of missed days.

Visual Analog Scale (VAS)

A visual analog scale was also used to assess self-perceived ART adherence, recorded at baseline and at 12-week study intervals. Participants were asked to indicate the percentage of their ART medications they believed they had taken in the past 30 days by placing an "X" along a horizontal line ranging from 0 to 100. The placement of the "X" was translated into a numeric value (e.g., a mark at the midpoint of the line was recorded as 50%). This method allowed for a more intuitive, continuous measure of adherence compared to the categorical format of the questionnaire.

Daily text message-reported responses

ART adherence was also measured through participants' engagement with the iTAB (Individualized Texting for Adherence Building) text messaging system, implemented as part of the iC-CHANGE intervention. From this intervention, we derived 12-week epochs of ART adherence as measured by text message responses. Specifically, participants opted into either a 24-week or 48-week messaging protocol, with most choosing the longer study duration ($n=83$). Daily medication reminders were delivered via SMS, prompting participants to reply "Y" (yes), "N" (no), or "S" (snooze for one hour) based on whether they had taken their ART medication. Example prompts included messages such as "You are an asset to your community! Please take your [participant-selected preferred medication name]." If a participant responded "N," the system automatically sent a supportive message encouraging medication adherence and offering help if needed (e.g., "Please take a moment for your health ASAP. Call us if you need assistance or have a question"). If participants failed

to respond or replied "N" for three consecutive prompts, a non-compliance alert was triggered, which led to follow-up outreach by care coordinators at the FQHC to explore possible barriers to adherence and re-engage participants in care. From this system, 12-week epochs were derived by capturing the proportion of "Yes" responses to the total number of messages sent.

Statistical analyses

To examine the relationship between HBM constructs and ART adherence across study visits, we conducted a series of linear mixed-effects regressions. The three adherence outcomes were modeled separately: (1) the continuous self-reported adherence measure [21], (2) the VAS, and (3) the proportion of text messages responses within the 12-week epochs. All models included a random intercept for participant, to account for within-subject correlation across study visits. For each outcome, all HBM constructs and related psychosocial measures were included simultaneously in each model, reflecting the theoretical assumption that beliefs interact and co-contribute to adherence behavior. Baseline demographic and behavioral variables (i.e., all variables in **Table 1**) were screened for their association with the outcomes and included in final models if they were trending towards statistical significance at $\alpha = 0.1$.

Results

Adherence at study conclusion for each measure was relatively high, such that mean adherence as measured by questionnaire was 82.93 ($SD = 19.30$), mean adherence as measured by VAS was 90.89 ($SD = 28.03$), and the mean proportion of affirmative text message responses to reminder prompts relative to total reminders sent was 80.02 ($SD = 20.60$). We examined whether HBM constructs and related psychosocial measures predicted ART adherence across three outcome measures, using full models that simultaneously included all six predictors: perceived benefits of ART, perceived severity of non-adherence, perceived barriers of ART adherence, self-efficacy for medication-taking, supports for ART adherence, and beliefs about ART. Multicollinearity across predictors was low ($VIFs < 3.11$), thus, we proceeded with examining full models to provide a more robust account of adherence behavior than individual predictor models, consistent with the components of the HBM's theoretical structure. Among screened covariates (listed in **Table 1**), only depression was associated with adherence outcomes, and thus included in final models (presented in **Tables 2–4**).

In the unadjusted model predicting adherence as measured by the continuous self-reported adherence measure, greater self-efficacy ($\beta = .38$, $SE = .11$, $t = 3.5$, $p < .001$), lower perceived barriers ($\beta = -.98$, $SE = .41$, $t = -2.40$, $p = .02$), and greater

perceived supports ($\beta = 1.66$, $SE = .67$, $t = 2.49$, $p = .01$) were associated with higher ART adherence. No other variables reached statistical significance (all $p > .05$). When controlling for depression, self-efficacy and perceived barriers remained significant but perceived supports did not (**Table 2**).

In the unadjusted model of adherence based on the VAS, greater self-efficacy ($\beta = 0.39$, $SE = 0.11$, $t = 3.46$, $p < .001$), lower perceived barriers ($\beta = -0.98$, $SE = 0.42$, $t = -2.32$, $p = .02$), and greater supports for ART ($\beta = 1.85$, $SE = 0.70$, $t = 2.66$, $p = .01$) were significantly associated with higher ART adherence. Of

Table 1. Participant characteristics.

Variable	Descriptive Statistics (n=91)
48-week study (vs. 24-week study)	83 (91.2%)
Age (median)	50 years (IQR: 36-57, range 23-66)
Gender identity	
Male	74 (81.3%)
Female	12 (15%)
Genderqueer/gender non-conforming	1 (1.1%)
Transwoman	1 (1.1%)
Education	
Completed high school/ GED	8 (8.9%)
Some college	18 (19.8%)
Completed college	47 (51.6%)
Some or completed post-graduate education	12 (13.3%)
Ethnicity	
Hispanic/Latino/Spanish	9 (9.9%)
Self-identified races other than Black	
American Indian or Alaska Native	9 (9.9%)
Asian American or Asian Origin	1 (1.1%)
White	3 (3.3%)
Other	5 (5.5%)
Income	
<\$10,000	41 (45.1%)
\$10,000 to \$19,999	26 (28.6%)
>\$20,000	22 (24.2%)
Employment status	
Full-time employment	19 (20.9%)
Receiving disability benefits	26 (28.6%)
Unemployed	27 (29.7%)
Relationship status	
Single	69 (75.8%)
In a committed relationship	16 (17.6%)
Other	5 (5.5%)
HIV disclosure	
Ever disclosed	82 (90.1%)
Disclosed to family	66 (72.5%)
Disclosed to friends	72 (79.1%)
Beck Depression Inventory	11.6 (9.8)

the remaining predictors, perceived benefits of ART ($\beta = 1.88, p = .08$) and perceived severity of HIV non-adherence ($\beta = -1.62, p = .08$) trended toward significance. When controlling for depression, supports for ART adherence lowered to marginal significance ($p = .06$); notably, the internal consistency of the supports measure was low ($\alpha = .44$), which may limit the interpretability of this finding. Self-efficacy and barriers to adherence remained significant predictors (**Table 3**).

For the daily text message responses, greater perceived barriers to ART adherence were associated with a lower ART adherence ($\beta = -0.012, SE = 0.006, t = -2.00, p = .049$) in the unadjusted model (i.e., model without depression included as a covariate). Perceived barriers to ART adherence showed

a trend-level association after controlling for depression ($p = .06$; see **Table 4**). Other HBM predictors were not significantly associated with the daily text message responses.

Discussion

This study examined psychosocial predictors of ART adherence in a sample of Black, predominantly older men, living with HIV, using constructs from the HBM and related psychosocial variables (supports and beliefs about ART). Across the three longitudinal ART adherence outcome measures, we found that self-efficacy and perceived barriers were consistently associated with ART adherence in questionnaire-based measures of adherence, though not a text message-

Table 2. Final model of HBM variables predicting ART adherence as measured by a 3-item self-report questionnaire, after controlling for depression due to its univariate association with each outcome.

Predictor	B	SE	t	p	95% CI
Study Visit	0.04	0.57	0.07	.94	[-1.06, 1.15]
Beliefs about ART	-0.35	0.67	-0.52	.60	[-1.66, 0.96]
Perceived benefits of ART	0.13	0.78	0.16	.87	[-1.40, 1.66]
Perceived severity of non-adherence	-0.96	0.67	-1.43	.16	[-2.28, 0.36]
Supports for ART adherence	0.58	0.51	1.14	.26	[-0.42, 1.58]
Self-efficacy for medication-taking	0.18	0.08	2.11	.04	[0.01, 0.34]
Perceived barriers to ART adherence	-1.24	0.31	-3.94	< .001	[-1.86, -0.62]

Table 3. Final model of HBM variables predicting ART adherence as measured by the VAS (visual analog scale), after controlling for depression.

Predictor	B	SE	t	p	95% CI
Study Visit	0.12	0.41	0.31	.76	[-0.67, 0.91]
Beliefs about ART	-0.26	0.66	-0.40	.69	[-1.55, 1.03]
Perceived benefits of ART	0.54	0.76	0.71	.48	[-0.96, 2.04]
Perceived severity of non-adherence	-1.01	0.66	-1.53	.13	[-2.31, 0.29]
Supports for ART adherence	0.62	0.50	1.24	.06	[-0.36, 1.61]
Self-efficacy for medication-taking	0.21	0.08	2.54	.01	[0.05, 0.37]
Perceived barriers to ART adherence	-1.09	0.31	-3.54	< .001	[-1.69, -0.48]

Table 4. Final model of HBM variables predicting ART adherence as measured by confirmatory responses to ART text message reminders, after controlling for depression.

Predictor	B	SE	t	p	95% CI
Study Visit	0.003	0.007	0.39	.66	[-0.01, 0.02]
Beliefs about ART	-0.002	0.009	-0.24	.81	[-0.02, 0.02]
Perceived benefits of ART	0.003	0.011	0.25	.81	[-0.02, 0.02]
Perceived severity of non-adherence	0.001	0.009	0.14	.89	[-0.02, 0.02]
Supports for ART adherence	0.002	0.007	0.23	.82	[-0.01, 0.02]
Self-efficacy for medication-taking	0.001	0.002	0.67	.51	[-0.01, 0.02]
Perceived barriers to ART adherence	-0.004	0.004	-1.79	.06	[-0.01, 0.01]

based measure of engagement and adherence. These findings suggest that within this sample, confidence in one's ability to manage ART-taking as well as barriers to ART-taking (e.g., logistical challenges) may be particularly influential factors in overall ART adherence over time. Other HBM variables, including perceived severity and perceived benefits, showed weaker or marginal associations with adherence outcomes.

Among several studies examining PWH, self-efficacy has been found to be a consistent and salient predictor of ART adherence [22–25]. Nevertheless, considering the disproportionate impact of HIV on Black individuals, studies specific to this population are of great importance. In this sample of predominantly older Black men with HIV, we found self-efficacy to be a significant predictor of adherence for retrospective self-reported measures of adherence (i.e., study visits occurring every 12 weeks), though not a significant predictor of text message responses to adherence prompts that were provided on a daily basis. The findings of the present study are similar to a study from Voisin *et al.* [26], in which higher self-efficacy, as well as fewer behavioral barriers (e.g., not engaging in consistent substance use), were found to be associated with better ART adherence among young Black men who have sex with men, as measured by a self-report scale that was then dichotomized by greater or less than 90% adherence. Another study examining older Black adults with HIV also found self-efficacy to be a significant predictor of ART adherence (measured by self-report questionnaire that was dichotomized by 95% adherence; [27]. Our study mirrors these findings, further supporting that self-efficacy remains a salient predictor of ART adherence among Black PWH. Nevertheless, the lack of association between self-efficacy and daily text message responses may suggest that different adherence measurement approaches capture somewhat distinct aspects of adherence-related behavior. Because SMS-based adherence measures may more proximally reflect day-to-day adherence behavior, these findings raise the possibility that self-efficacy may be more strongly related to perceptions or retrospective reporting of adherence than to moment-to-moment adherence behavior itself. This distinction further highlights the importance of considering how different adherence measurement approaches may capture distinct aspects of adherence behavior.

Taken together, these findings suggest that self-efficacy may play an important role in how individuals perceive, manage, and report ART adherence behaviors. As a construct capturing confidence in one's ability to execute adherence-related behaviors, self-efficacy is closely linked to medication-taking in the context of common barriers (e.g., side effects, competing demands, stigma). Higher self-efficacy may facilitate planning, persistence, and the ability to maintain adherence despite psychosocial challenges, which may be particularly salient for Black PWH.

While our study was not limited to younger individuals or men, as in prior research [26,27], it contributes to the literature by examining a broader set of HBM-informed and related constructs in relation to ART adherence. Further, considering that our sample consisted of predominantly older Black men with HIV engaged in HIV care, these findings explore predictors of adherence among a population historically underrepresented in research. Although previous studies have applied HBM constructs to this context, many have relied on cross-sectional study designs or have focused primarily on international samples of PWH. For example, Addo *et al.* [28], guided by the HBM, identified perceived barriers and self-efficacy as significant predictors of ART adherence, though these associations were examined cross-sectionally. Similarly, Yu *et al.* [29] found self-efficacy to be a significant predictor of ART adherence in a cross-sectional study of older Chinese PWH. Together, these studies support the relevance of HBM constructs for understanding ART adherence. Our findings extend this work by examining multiple HBM and related constructs concurrently within a U.S. clinic-based sample of Black adults with HIV, and more specifically among older Black men who self-identified as experiencing adherence challenges. Notably, self-efficacy and perceived barriers emerged as the most consistent predictors, suggesting they may function as more proximal determinants of adherence compared to constructs such as perceived severity and perceived benefits. Further, these findings suggest that perceived barriers may reflect a range of contextual challenges experienced by participants, shaping adherence behavior.

Our use of multiple measures of ART adherence provided a more comprehensive picture of adherence behavior, however, these measures do not represent equivalent indicators of the same underlying behavior, considering the timeline of measures (e.g., daily self-report text message responses versus 12-week interval in person questionnaires). While self-report methods such as the VAS and questionnaires remain standard in clinical settings, incorporating behavioral measures, such as daily text message responses, offers additional insight into daily medication-taking in real-time contexts [30]. Notably, the text message responses reflect participants' engagement with the intervention (i.e., responding to prompts) as well as adherence behavior, whereas the VAS and questionnaire assess retrospective self-reported adherence. A meta-analysis of two randomized controlled trials found that text message reminders were associated with improved adherence [30]. The effectiveness of text messages has been found in numerous other studies. Although the text message responses yielded fewer significant predictors, we observed a marginal association with perceived barriers, reinforcing the importance of reducing day-to-day obstacles to ART use. The distinction between measures of adherence in the present study is important, as predictors of engagement with a text messaging monitoring system may differ from predictors of

retrospective reports of medication-taking itself. Further, a lack of response to a text message prompt may not necessarily indicate an ART dose was not taken. In fact, definitive “No” responses to the text message prompts were relatively rare. Self-efficacy, despite being a significant predictor in other adherence models and in prior literature, was not a significant predictor in the model of affirmative daily text message responses. One possible explanation is that individuals with higher self-efficacy may be less likely to respond to daily text message prompts because they require less external support through engagement with the text messaging intervention, yet still report high adherence retrospectively during study visits. In contrast, individuals experiencing greater barriers may be more likely to engage with text-based reminders, as these supports directly address challenges to adherence. These distinctions meaningfully shape the interpretation of the present findings. The daily SMS prompts used in the present study were originally developed to assess ART adherence behaviors in real time and specifically referenced medication-taking behavior (e.g., “*You are special. Please take your [preferred medication name].*”). Additionally, participants were enrolled in the broader intervention based on self-identified ART adherence challenges. Nevertheless, because responding to daily prompts also requires ongoing participation in the intervention itself, it remains difficult to fully disentangle adherence behavior from engagement with adherence monitoring. Thus, while the SMS outcome was designed to reflect daily ART adherence, it may also partially capture engagement-related processes. Under this interpretation, the divergence across adherence outcomes may suggest that retrospective self-report measures and daily SMS responses capture overlapping but distinct aspects of adherence-related behavior. Accordingly, the text message responses should not be interpreted as directly interchangeable with the retrospective self-report adherence measures.

Most of the observed associations between HBM-informed and related constructs and ART adherence remained statistically significant even after accounting for depressive symptoms, a known barrier to ART adherence [31]. When controlling for depression, self-efficacy remained a significant predictor in both the continuous self-reported adherence measure and VAS adherence models, suggesting a robust role in medication-taking behavior. Perceived barriers also showed significant or trend-like associations across all three outcomes, suggesting that interventions targeting logistical, psychological, and social barriers may be particularly impactful in this population [32].

This study has several strengths. First, it focused on Black PWH, a population that remains disproportionately affected by HIV. Second, it examined multiple HBM-informed and related constructs, allowing for a more nuanced understanding of adherence determinants beyond single-construct approaches.

Finally, the use of multiple adherence outcome measures allowed for examination of how psychosocial predictors may differ across distinct operationalizations of adherence and intervention engagement. Nevertheless, there are limitations of the present study. First, the sample size of our study was relatively small, and our sample may not be representative of the broader population of Black PWH in the U.S. Second, all predictors and outcomes were assessed through self-report or behavioral proxies, and we did not include HIV viral load data or pharmacy refill information as objective indicators of adherence. While the use of text messages as an adherence proxy is innovative, it may not fully capture actual medication use. Thirdly, our sample consisted primarily of older, clinic-engaged, highly HIV disclosed, Black men in San Diego, which while also a strength, may nevertheless limit generalizability to women, younger individuals, those who are not “out” about their HIV status, or those not engaged in care. Further, these findings may not generalize to other Black communities and people not engaged in care. Lastly, HBM constructs were assessed using items drawn from multiple instruments rather than a single validated HBM scale. While this approach allowed for coverage of several constructs, it did not include all constructs of the HBM (perceived susceptibility and cues to action) and may have introduced variability in construct validity and limited comparability with studies using standardized HBM measures. Additionally, the supports checklist demonstrated low internal consistency, likely reflecting that it was designed to capture a broad range of adherence support strategies rather than a single underlying construct. Thus, this precludes us from making direct comparisons of subscales belonging to a singular, robust, validated scale. Relatedly, the use of items from multiple instruments may have attenuated associations due to inconsistent measurement; thus, null findings for perceived benefits and perceived severity may reflect measurement limitations rather than the absence of true effects of examining HBM, in its entirety, in this context. Cumulatively, the present findings cannot distinguish whether the non-significant associations observed for perceived benefits and severity reflect limitations in measurement or the absence of meaningful relationships in this sample.

Overall, findings from this study emphasize the relevance of self-efficacy and perceived barriers as key determinants of ART adherence among Black PWH. Interventions aiming to improve adherence in this population may benefit from strategies that bolster confidence in one’s ability to take ART consistently and address barriers to adherence. While not the scope of the current project, future work may seek to explore the historical and structural factors that may drive the disparities experienced by Black PWH. Given the importance of supporting ART adherence among Black PWH, such theory-informed approaches are urgently needed to reduce gaps in care and improve health equity.

Funding Sources

Vanessa Serrano was supported by NIMH (F31MH133506). Jessica Montoya was supported by NIDA (5K23DA051324), as was Maximo Prescott (5T32DA031098). This work was also funded by NIMH Award Number P30MH062512 and California HIV Research Program (CHRP) under grant number HD15-SD-059.

Author Contributions

V.B.S. conceptualized the study, conducted the analyses, and drafted the manuscript. M.P. assisted with data preparation and reviewed the manuscript. D.J.M. oversaw the parent study and reviewed the manuscript. J.L.M. contributed to study conceptualization and critically reviewed the manuscript. All authors approved the final version.

Conflicts of Interest

The authors declare no conflicts of interest.

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