Connecting to Support: How Use of an mHealth App Explains Antiretroviral Medication Adherence among People with HIV and Substance Use Disorders

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Abstract

Background: Despite the increasing popularity of mobile health (mHealth) technologies, little is known about which types of mHealth system engagement might affect the maintenance of antiretroviral therapy (ART) among people with HIV (PWH) and substance use disorders (SUD).

Objective: Using longitudinal and detailed system logs and weekly survey data, we tested a mediation model, where mHealth engagement indicators were treated as predictors, substance use and confidence in HIV management as joint mediators, and ART adherence as the outcome. We further distinguished the initiation and intensity of system engagement by mode (expression vs. reception) and by communication levels (intraindividual vs. dyadic vs. network).

Methods: Tailored for PWH living with SUD, the mHealth app was distributed among 208 participants aged over 18 from two U.S. health clinics. Supervised by medical professionals, participants received weekly surveys through the app to report their health status and medication adherence data. System use was passively collected through the app, operationalized as transformed click-level data, aggregated weekly, and connected to survey responses with a 7-day lagged window. Linear regression and structure equation models (SEMs) with cluster-robust standard errors were employed for analyses, controlling within-person autocorrelation and group-level error correlations. Racial groups were examined as moderators in the SEMs to address specific research questions.

Results: We found that 1) intensity, not initiation, of system use, 2) dyadic message expression and reception, and 3) network expression, positively predicted medication adherence via joint mediators (substance use and confidence in HIV management). However, intraindividual reception (i.e., re-reading saved entries for personal motivation) negatively predicts medication adherence via joint mediators. We also found Black participants have distinct usage patterns, suggesting the need to tailor mHealth interventions for this subgroup.

Conclusions: These findings highlight the importance of considering the intensity of system engagement, rather than initiation alone, when designing mHealth interventions for PWH and tailoring these systems to Black communities.

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Conclusion: These findings highlight the importance of considering the intensity of system engagement, rather than initiation alone, when designing mHealth interventions for PWH and tailoring these systems to Black communities.

Keywords: Information and communication technologies; ICTs; mHealth; medication adherence; HIV care; antiretroviral therapy; substance use; social support; patient management; health disparities

Introduction

Mobile health (mHealth) technology has emerged as a promising avenue in healthcare for addressing the complex challenges faced by people with HIV (PWH) [1,2]. This population often grapples with their stigmatized condition while struggling with substance use disorders (SUD) as an additional burden [3]. Substance use may not only exacerbate the progression and transmission of HIV but also hamper adherence to antiretroviral therapy (ART), which suppresses HIV viral load, thus reducing HIV transmission and preventing health consequences of HIV infection [4]. As the current human rights framework advocates that global HIV prevention needs to consider supporting individual treatment [5,6], the present study focuses on understanding the potential benefits of mHealth technologies for PWH living with SUD for maintaining antiretroviral medication adherence.

Most mHealth apps leverage the technological affordances of mobile phones to improve the health of users. The “anytime-anyplace” mobile access enables wide reach and improves how we coordinate and communicate [7-10]. In addition, mobile log data help identify evidence-based strategies for health intervention and message delivery [11-15]. Researchers have conducted studies that differentiate message expression from message reception across various communication levels, and found composing one-on-one messages is associated with greater perceived bonding and drafting public forum posts is linked to decreased risky drinking behaviors [16].

The present paper aims to understand how mHealth systems can best serve PWH to maintain medication adherence to ART, defined as consistent and proper compliance with the prescribed medication regimens for HIV viral load suppression. Numerous mobile technologies have been developed for interventions to enhance medication adherence among PWH [17]. For example, some focused on the effectiveness of electronic adherence monitoring devices (EAM) that remind patients to take pills [18]. Others adopted text message services to deliver motivational and skill-building content [19], launched social media campaigns that promote adherence and testing [20], and designed mobile games to make medication adherence enjoyable and goal-oriented [21]. However, there is a lack of understanding of *how* these interventions are beneficial for medication adherence. For instance, it is unclear how different communicative behaviors supported by the system would shape medication adherence, and how temporal attributes should be considered when analyzing the system logs data.

To bridge this gap, we investigated both the initiation and intensity of mHealth engagement at the networked (one-to-many), dyadic (one-to-one), and intraindividual (self-to-self) communication levels to predict ART medication adherence among PWH. In addition, we tested two sets of indirect pathways—different forms of substance use as risk factors and confidence in HIV management as a protective factor—that potentially mediated the relationships between mHealth engagement and ART medication adherence. Finally, this paper explores whether the mediation model differs between Black and White populations and provides insights into designing and implementing mHealth interventions that promote medication adherence for different racial communities.

Medication Adherence and mHealth

Research highlights the direct relationship between medication adherence among PWH and improved clinical outcomes, including viral load suppression [22], enhanced immune function [23], and a reduced risk of transmission [24]. Therefore, medication adherence has become a key factor in both individual health and public health efforts to control the spread of the virus.

Traditional interventions have often fallen short in engaging and retaining PWH in care due to various barriers, such as stigma, limited access to healthcare facilities, and social isolation [25,26]. Interventions based on mHealth including smartphone apps and text messaging systems have shown promise in bridging these gaps. Studies have also shown that mobile applications are feasible and acceptable for use among PWH [27]. The use of mHealth interventions leverages distinct characteristics of smartphones and other portable web-connected devices: mobility [28], micro-coordination [29], portability [30], availability [31], locatability [32], and multimediality [33]. The mass adoption of smartphones

makes them among the most affordable and accessible channels for information and communication interventions [34]. As such, mHealth systems are effective at reaching targeted populations and delivering timely interventions [35].

Although generally seen as providing continuous social support, education, and monitoring, mHealth platforms can provide a wide range of distinct communication features. For example, mHealth researchers have distinguished the potential effects of message reception and expression in journal writing, one-to-one messaging, and group discussion posting [16,36,37]. Recently, scholars also theorized that distinct health outcomes are associated with message reception (i.e., viewing existing content) and expression of messages (i.e., sharing one's own thoughts and feelings) at the intraindividual, dyadic, and network communication level [16]. More specifically, at the intraindividual level, *expression* occurs whenever people actively generate new, personal content (e.g., creating a journal entry), whereas *reception* refers to reflecting on self-generated content (e.g., reading one's own previous writing). At the dyadic level, reception and expression occur when individuals receive and send, respectively, one-on-one messages. At the network level, *expression* means crafting a message that can potentially be seen by many readers, whereas reception means viewing content available within such public forums. By comparing the effects of system use at these distinct communication levels, as opposed to treating communication as a single entity, we can gain a more accurate understanding of the interactions within digital health interventions.

To further explicate mobile system use, the initiation and intensity of system use need to be distinguished over an extended period. People may have distinct mHealth engagement pattern, depending on whether someone decides to start using a certain feature on a given day (i.e., initiation) and the depth of usage once they start (i.e., intensity). Distinguishing between these two metrics helps probe into mHealth engagement in two steps: (1) determining whether an individual used a feature each day – which is binary, and (2) measuring the intensity of the engagement once initiated – which is continuous. The two-step operationalization also echoes what digital media researchers refer to as the "session of use," meaning the extent of engagement users spend on a specific URL once they activate the interface [38]. Over time, initiation can be seen as a habitual repetition of engagement as the user consistently activating the feature. On the other hand, intensity represents the depth of use during the activated session. Although the initiation of system use is a prerequisite for a mHealth intervention, the intensity or depth of engagement, such as "lasting longer than 10 minutes", may be just as critical in delivering the intervention [39,40].

Thus, we hypothesize that the initiation and intensity of message exchange, including reception and expression, at the three communication levels will predict ART medication adherence. As the mHealth is designed to improve health, we hypothesize that engaging with the communication features will predict enhanced medication adherence.

H1: The initiation of message reception at the (a) intraindividual, (b) dyadic, and (c) network level positively predicts ART medication adherence.

H2: The intensity of message reception at the (a) intraindividual, (b) dyadic, and (c) network level positively predicts ART medication adherence.

H3: The initiation of message expression at the (a) intraindividual, (b) dyadic, and (c) network level positively predicts ART medication adherence.

H4: The intensity of message expression at the (a) intraindividual, (b) dyadic, and (c) network level positively predicts ART medication adherence.

Substance Use Disorders as Risk Factors

Although mHealth interventions have shown significant potential in improving medication adherence, it is crucial to address potential risk factors, notably SUD which are linked to poor medication adherence. The misuse of a range of substances, including opioids, alcohol, and stimulants, poses substantial threats and could undermine the effectiveness of mHealth interventions [41,42] (Shrestha & Copenhaver, 2018; Socias & Milloy, 2018).

Past mHealth studies have examined how these interventions can potentially lead to a reduction in craving and substance use [43]. Such interventions can mitigate the challenges associated with SUD through craving management, coping assistance, and tailored feedback and reminders. Reduction in substance use eventually improves medication adherence and health outcomes; a large body of evidence consistently shows that hard drug (e.g., cocaine, heroin) users and hazardous alcohol users report higher ART non-adherence as well as a greater chance of AIDS progression or death [4,44,45].

Thus, we hypothesize that the relationship between mHealth engagement and medication adherence will be mediated by patients' substance use, specifically their use of (a) heroin/opioids, (b) alcohol, and (c) stimulants. We also hypothesize that mHealth engagement predicts less substance use, which will in turn be associated with higher medication adherence.

H5: The relationship between the engagement with mHealth and medication adherence will be mediated by substance use, including (a) heroin/opioids, (b) alcohol, and (c) stimulants.

Confidence in HIV Management as a Protective Factor

In contrast to SUD, confidence in HIV management serves as a protective factor that may encourage PWH to adhere to ART treatment and potentially enhance the effectiveness of mHealth interventions. Confidence in HIV management denotes a patient's belief in the efficacy of their healthcare regimen, the trust they vest in their healthcare providers, and their self-care capability. Research has shown patients who regularly interact with mHealth apps may develop a sense of self-efficacy and a stronger belief in the efficacy of their treatment, as they were empowered through the support network. Likewise, confidence in HIV management may significantly motivate ART adherence. Research shows that individuals who have confidence in the care they are receiving are more likely to follow their prescribed medication regimens diligently [46,47]. Patients confident in their HIV management are more likely to overcome barriers and prioritize medication adherence, improving health outcomes.

As mHealth apps enhance confidence in HIV management, patients may become more motivated and empowered to adhere to their medication regimens, ultimately improving their overall health and well-being. Thus, we hypothesize that mHealth engagement will positively predict confidence in HIV management, which will in turn be associated with higher medication adherence.

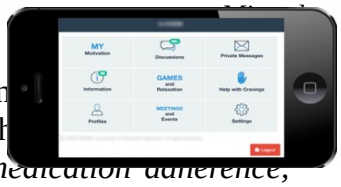
H6: The relationship between engagement with the mHealth app and medication adherence will be mediated by confidence in HIV management.

Racial Disparities in Health

Racial disparities in healthcare have long been a concerning and pervasive issue, with profound implications for health outcomes across various populations. Racial and ethnic minorities such as Black and Hispanic populations often experience lower medication adherence rates with an average of 7.5 percentage points lower than those of the White population [48]. Prevalence of comorbid conditions that intersect with HIV care such as substance use disorders are also highly prevalent in racial and ethnic minorities [49] while facing unique challenges such as access to addiction treatment [50]. In addition, studies have indicated racial minorities had greater medical mistrust as compared to their white counterparts, which potentially hinders treatment discussions with their providers [51].

On the other hand, research has unveiled insights into the differences in mHealth utilization and preference among various racial groups. According to a recent national survey [52], Black adults exhibit a stronger inclination towards utilizing mHealth for health decision-making, sharing health information, and engaging in discussions with their providers, compared to non-Hispanic White adults. This is consistent with past reports indicating the Black U.S. population has higher smartphone ownership (83%) than non-Hispanic whites (74.2%) [53], suggesting the value of mHealth interventions for racial minorities.

Given the potential racial differences in mHealth utilization, substance use, confidence in



HIV management, and health behaviors, we raise three research question[s] developing targeted interventions that bridge racial disparities in medication adh[erence].

RQ1: For Black participants, which types of mHealth engagement predict medication adherence, and through which mediators?

RQ2: For White participants, which types of mHealth engagement predict medication adherence, and through which mediators?

RQ3: How does the relationship between mHealth engagement and medication adherence differ between Black and White participants?

Methods

Data Collection

The study was approved by the Institutional Review Board (IRB) at the university and funded by [Agency blind]. The app (app's name blind) was specifically designed for PWH living with substance use and provided vulnerable patients with information resources, communication functions, and health support tools. It was distinguished from other apps by offering interactions in an unstigmatized environment that was also free of advertising, and scammers (publication blind).

The study enrolled 208 participants aged over 18 receiving HIV treatment at two U.S. health clinics. All participants had a history of substance use disorder (SUD) within the past 12 months or were presently engaged in an SUD program. Installation of the app on their smartphones was mandatory, through which they received weekly surveys capturing health status and medication adherence. Supervised by staff with experience in HIV care delivery settings, the app facilitated communication during critical moments to provide necessary support to participants.

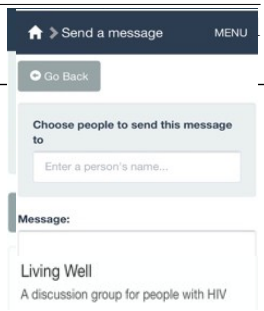
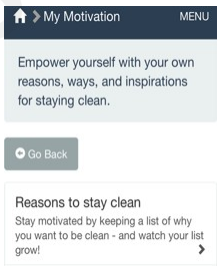
Two types of data were integrated by the user's unique ID. The first was system engagement data that was passively collected through the app usage logs. To note, while the present paper only included system-use data from communication functionalities, the app provides additional non-communication features. The second came from the baseline and weekly surveys, which asked about demographic information, substance use, confidence in HIV management, and ART medication adherence.

Measurement

mHealth Engagement. The "clicks," representing interaction frequency with app functions, served as a measure of participants' system engagement. The count of clicks was aggregated weekly, transformed into their squared root format, and lagged by seven days before being incorporated into the modeling process, aligning with the weekly surveys that collected health information from the *prior* week. See Table 1 for more details regarding the operationalization of system engagement.

Table 1. Operationalization of mHealth engagement variables across three communication levels on the App

Engagement variables		Operationalization	App interface
Communication levels	**Message mode**	**Count of clicks per user per day on specific app page(s)**	(Home Page)

Network	Message reception	App page indicates the user is viewing a message/comment posted on the discussion forum	
	Message expression	App page indicates the user is creating, saving, or editing a message/comment posted on the discussion forum	
Dyadic	Message reception	App page indicates the user is viewing a private one-on-one message thread	(Private Messaging)
	Message expression	App page indicates the user is creating, saving, or editing a private one-on-one message	
Intraindividual	Message reception	App page indicates the user is viewing a self-written journal entry saved in the past	(My Motivation) 
	Message expression	App page indicates the user is composing a new journal entry	

Medication adherence. The app administered weekly surveys prompting participants to report the frequency of missed doses of HIV medications within the past week. Responses, ranging from 0-7 indicating the number of missed doses, were then reverse-coded with higher values indicating stronger adherence to the medication regimen.

S*ubstance use*. The app administered weekly surveys presenting participants with four options (i.e., heroin, opioid, alcohol, and stimulants) and asked, “Which of the following, if any, have you used in the last 7 days? (Check all that apply).” To capture whether users engaged with any substance use, checked options were encoded as binary variables. Heroin and opioid were combined as one category. Hence, three substance use variables were created to measure the recent use of heroin/opioids, alcohol, and stimulants.

Confidence in HIV management. The app administered weekly surveys prompting participants to report their (1) confidence to keep the next appointment with the HIV care provider, (2) confidence to take all HIV medications during the next week, and (3) confidence in the belief that the HIV viral load “is undetectable right now.” Responses on a seven-point Likert scale to the three items were averaged (Cronbach $\alpha = 0.80$).

Demographics. Gender, race, age, and years of education were acquired via baseline survey.

Analytical Strategies

The unit of analysis was each response to the weekly survey. The click-level data was aggregated into seven-day windows lagged one week prior to the survey input. We then transformed the aggregated clicks into the number of days with non-zero clicks (i.e., initiation) and the sum of the square root of daily clicks (i.e., intensity).

The aggregated, transformed, and lagged system engagement variables were treated as predictors (see “measurement” above for more details). System engagement predictors are deemed

significant in the sense that they predict medication adherence via the joint mediators (opioid, alcohol, stimulant, and confidence in HIV). To control the temporal autocorrelation, we fit linear regression with cluster-robust standard errors (CRSE) for H1-H4 (total), and Structural Equation Modeling (SEMs) with CRSE for H5-H6, which are typically used for controlling the error correlations at the group level. In our context, SEMs with CRSE adjusted for the within-person temporal autocorrelation between observations for each app user. To answer RQ1-RQ3, a moderator indicating racial groups (Blacks or Whites) was added to the SEMs[1].

Results

A total of 173 participants used at least one communication feature (network, dyadic, or intraindividual) during the study period. The resulting sample (N = 173) had a mean age of 46 (SD = 11.2), 77.46% male (N = 134), and 64.16% Black (N = 111). Overall, 42.2% had at least some college-level education, and 60.12% reported illegal/street drugs (including marijuana) or prescription medication abuse in the 30 days before joining this study. On average, participants used this mHealth app for a median of 13 (SD = 23; Range = 1-141) days over the 6-month period. The zero-order correlations for all the numerical variables were presented in Table 2.

Table 2. Zero-order correlations for the numerical variables (N = 173)

Expression Types	1	2	3	4	5	6	7	8	9
1. Medication adherence	1.0								
2. Confidence in HIV management	0.24 (<.001)	1.0							
3. Intensity of network reception	0.02 (.69)	0.07 (.064)	1.0						
4. Intensity of network expression	0.01 (.76)	0.04 (.28)	0.70 (<.001)	1.0					
5. Intensity of intraindividual reception	0.02 (.58)	0.01 (.75)	0.43 (<.001)	0.36 (<.001)	1.0				
6. Intensity of intraindividual expression	-0.04 (.27)	0.01 (.73)	0.30 (<.001)	0.20 (<.001)	0.62 (<.001)	1.0			
7. Intensity of dyadic reception	0.01 (.73)	0.06 (.13)	0.37 (<.001)	0.25 (<.001)	0.41 (<.001)	0.34 (<.001)	1.0		
8. Intensity of dyadic expression	-0.005 (.90)	0.04 (.25)	0.20 (<.001)	0.11 (<.001)	0.51 (<.001)	0.41 (<.001)	0.54 (<.001)	1.0	
9. Age	0.09 (.019)	0.20 (<.001)	-0.07 (<.001)	-0.09 (<.001)	0.04 (.079)	0.06 (.006)	-0.03 (.21)	0.07 (<.001)	1.0

Note. P value is in the parentheses.

Total Effects of System Use on Medication Adherence (H1-H4)

The total effects of the initiation and intensity of system use, either by message mode or by communication level (12 variables in total), were not significant in predicting medication adherence. H1-H4 were not supported.

Indirect Effects through Substance Use and Confidence in HIV Management (H5-H6)

The mediation model based on SEM showed an adequate model fit, $\chi^2(6) = 19.70$, $P = .003$,

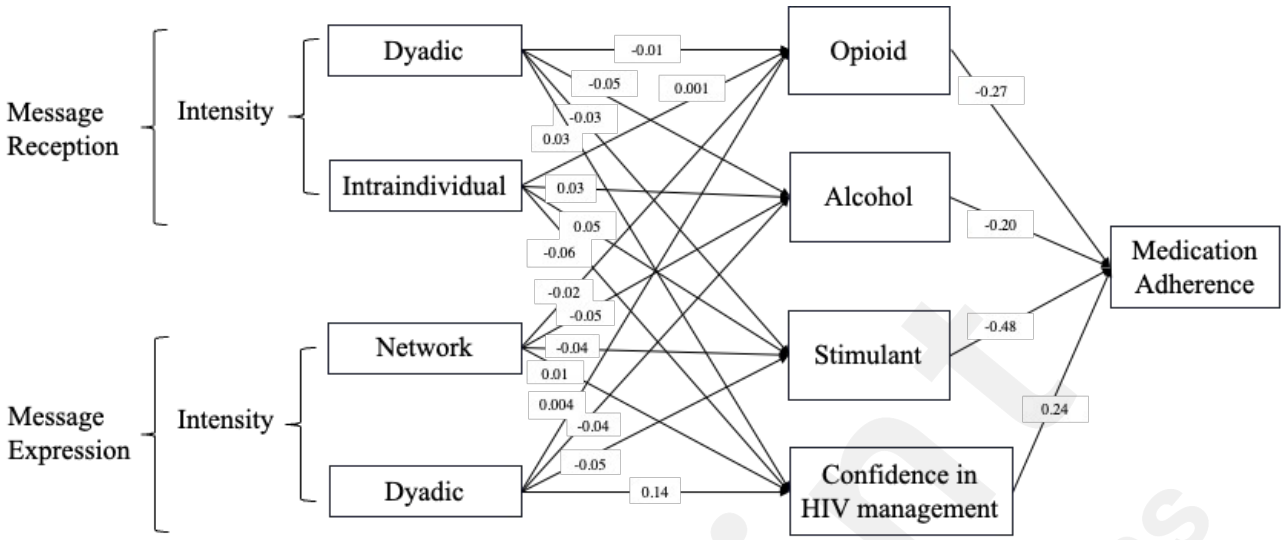
[1] For robustness check, we also specified an SEM model in which system use is treated as a single latent component measured by the 12 system use variables. The results exhibited higher model fit and confirmed the association between the app use and medication adherence.

CFI = 0.824, and *SRMR* = 0.018. Substance use and confidence in HIV management jointly mediated the relationship between four types of system use and medication adherence. Via these joint mediators, three system use predictors indirectly predicted *improved* medication adherence: the intensity of dyadic reception (coefficient = 0.036, 95% CI [0.007, 0.064], *P* = .014), the intensity of dyadic expression (coefficient = 0.067, 95% CI [0.008, 0.126], *P* = .026), the intensity of network expression (coefficient = 0.039, 95% CI [0.006, 0.071], *P* = .020. Notably, the intensity of intraindividual reception predicted *worsened* medication adherence via the joint mediators (coefficient = -0.043, 95% CI [-0.086, -0.001], *P* = .047).

Figure 1 demonstrates the estimated indirect pathways between significant system engagement predictors and medication adherence[2], via the four joint mediators, by decomposing the indirect effects into the constituting *a*-paths (linking engagement metrics to mediators) and *b*-paths (linking mediators to medication adherence outcomes). All the mediators were allowed to co-vary with each other. Full estimates of the coefficients of both the joint and individual mediators are reported in Appendix 1.

[2] For clarity, only statistically significant predictors are presented in the diagram. The four listed predictors are significant in that they predict medication adherence via the joint mediators. This presentation rule also applies to Figure 2.

Figure 1. Mediation model showing mHealth engagement predicting medication adherence via substance use and confidence in HIV management (all participants)

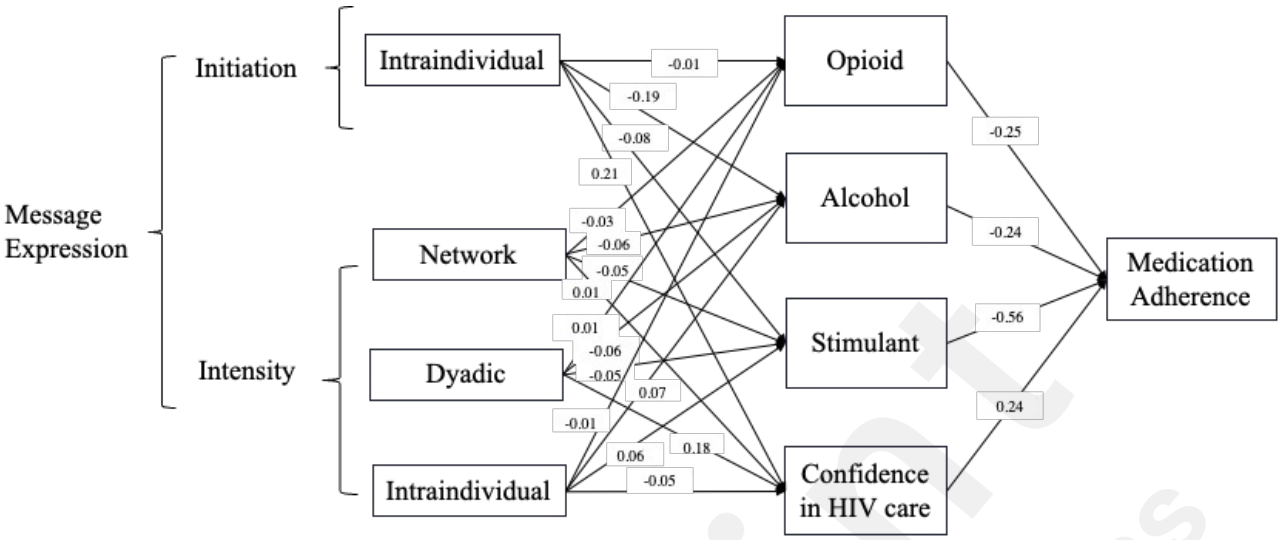


Racial Differences (RQ1-RQ3)

Race was entered as a binary moderator (i.e., whether the users identified themselves as Black) to the SEM. The moderated mediation SEM model showed an adequate model fit, $\chi^2(6) = 17.22$, $P = .009$, CFI = 0.929, and SRMR = 0.011. Subgroup-specific estimates were then extracted from this moderated mediation model.

For Black users (RQ1), results suggest that substance use and confidence in HIV management also jointly mediated the relationship between system engagement and medication adherence (see Figure 2 for diagram and Appendix 2 for full estimates). Specifically, via these joint mediators, three system use predictors indirectly predicted *improved* medication adherence: the initiation of intraindividual expression (coefficient = 0.14, 95% CI [0.02, 0.27], $P = .021$), the intensity of network expression (coefficient = 0.05, 95% CI [0.01, 0.09], $P = .007$), and the intensity of dyadic expression (coefficient = 0.08, 95% CI [0.02, 0.15], $P = .012$). Notably,
the intensity of intraindividual expression predicted *worsened* medication adherence via the joint mediators (coefficient = -0.06, 95% CI [-0.11, -0.01], $P = .011$).

Figure 2. Mediation model showing mHealth engagement predicting medication adherence via substance use and confidence in HIV management (Black participants only)



For White participants (RQ2), we lack the evidence that any of the systems use predictors significantly predict medication adherence via joint mediators (see Appendix 3).

Statistically contrasting Black and White participants, the relationship between system engagement and medication adherence yielded distinct patterns (RQ3). Table 3 reports the difference coefficients for Black versus White participants. Specifically, both the initiation (coefficient = 0.22, 95% CI [0.04, 0.40], *P* = .015) and intensity (coefficient = -0.07, 95% CI [-0.13, -0.01], *P* = . 031) of intraindividual expression differed in their relationship with medication adherence for Black and White participants.

Table 3. Difference coefficients estimated for Black and White participants in their mediated relationship between system engagement and medication adherence

Predictors	Difference Coefficient White vs. Black	95% CI	*P* value
Network reception initiation	0.06	(-0.12, 0.25)	.51
Network reception intensity	-0.02	(-0.05, 0.0001)	.051
Network expression initiation	0.01	(-0.32, 0.35)	.93
Network expression intensity	0.03	(-0.07, 0.13)	.57
Dyadic reception initiation	0.16	(-0.07, 0.40)	.17
Dyadic reception intensity	-0.03	(-0.08, 0.02)	.25
Dyadic expression initiation	-0.05	(-0.36, 0.26)	.75
Dyadic expression intensity	0.08	(-0.06, 0.22)	.25
Intraindividual reception initiation	0.41	(-0.01, 0.83)	.056
Intraindividual reception intensity	-0.05	(-0.20, 0.11)	.56
Intraindividual expression initiation	0.22	(0.04, 0.40)	.015
Intraindividual expression intensity	-0.07	(-0.13, -0.01)	.031

Discussion

Principal Results

Emerging mHealth systems hold promise to enhance medication adherence among PWH and SUD. Despite its potential, prior research has yet to fully explain how mobile technologies relate to medication adherence for this underserved population. Our study examines various aspects of

mHealth engagement and their potential impact on medication adherence among PWH, overall and by racial groups.

Our findings reveal that communicative engagement with mHealth does not directly predict medication adherence in PWH. Instead, certain metrics of mHealth engagement indirectly predicted medication adherence through substance use and confidence in HIV management as joint mediators. Specifically, at the dyadic level, we observed that a greater intensity of message reception and expression (i.e., sending and receiving one-on-one messages) were linked to reduced alcohol and stimulant use, as well as increased confidence in HIV management, all of which, in turn, were associated with greater medication adherence. That said, the intensity of dyadic expression was associated with greater opioid use, which predicted worsened medication adherence. At the network level, greater intensity of message expression (i.e., posting on the discussion forum) was related to decreased opioid, alcohol, and stimulant use, as well as increased confidence in management, all of which predicted improved medication adherence. In contrast, at the intraindividual level, a higher intensity of message reception (i.e., reviewing past saved journal entries) was associated with elevated opioid, alcohol, and stimulant use, as well as decreased confidence in management, all of which were signaling reduced medication adherence.

Comparison with Prior Work

Our study contributes to the growing body of mHealth research by disentangling system use along several significant dimensions, including message expression versus reception, communication levels, and initiation versus intensity, as noted in previous literature [14,16]. The findings regarding the overall participants highlight the critical role of message intensity, rather than initiation, in shaping mHealth engagement and its impact on medication adherence. This underscores the importance of considering not only habitual use but also the depth of engagement for PWH and SUD to improve ART medication adherence.

Furthermore, our study underscores the need to account for all three communication levels in health interventions, especially when juxtaposing each level with message expression versus reception in both design and analysis. For example, our results highlight that network expression (i.e., posting on the discussion forum) was associated with improved health outcomes, while network reception (i.e., browsing the discussion forum) may not yield the same benefit. This finding aligns with previous studies, which have indicated that individuals who actively engage in expressing themselves within online communities, often referred to as "expressors," tend to perceive more benefits [54,55]. Additionally, providing emotional support in such interactions can also be beneficial for the message senders [56,57], enhancing their skills in developing coping strategies [58]. Another critical implication of our research is that patients who focus on intraindividual communication may signal potential challenges in SUD and, eventually, in their medication adherence. This insight serves as a valuable indicator for healthcare providers to identify individuals who may require additional support and intervention to ensure the success of their medication regimens.

The present study also contributes to our understanding of racial differences in their engagement with and outcomes of mHealth technologies. We observed notable distinctions between Black and White participants in how mHealth system engagement may (or may not) be associated with their medication adherence, despite they were using the same mHealth app. Among Black participants, our results highlight the importance of message expression (Figure 2) as *message expression* at different communication levels, constituting a total of 12 distinct pathways, emerged as a set of critical predictors. These expression predictors, rather than any reception predictors, connect with both risk and protective factors, which in turn, play a pivotal role in predicting medication adherence. Additionally, the two racial groups also differ in the role played by intraindividual expression on medication adherence (Table 3). These disparities underscore the need for a nuanced, race-sensitive approach to medical interventions and healthcare support for PWH. Tailoring strategies based on these findings may help address racial disparities in health outcomes.

The third contribution of this study is methodological, where we introduced two engagement metrics based on longitudinal and timestamped system log data: daily initiation and intensity of system use within each active session. The consideration of time adds an extra layer to enrich our knowledge of mHealth interventions. This can guide health practitioners in tailoring interventions for those showing less intensive use. Another avenue to explore is tracking the evolution of these two engagement types over time. By examining the fluctuations in mHealth engagement, we can extract crucial insights about the dynamic characteristics of these interventions. Attention to these dynamics may help further tailor the design of mHealth interventions to serve the evolving needs of PWH living with SUD. These insights might also inform the roles of healthcare professionals in promoting medication adherence among this population.

Limitations

We acknowledge this study has several limitations. First, this research did not consider the content of messages at the network, dyadic or intraindividual, ignoring the nature of the communication that may play a buffering role. Future research should examine message content to provide a deeper understanding of why, for instance, message reception at the intraindividual level negatively predicted medication adherence through the tested mediators. Second, some participants did not consistently complete the weekly check-in surveys, leading to missing data. Such unbalanced data between users may cause biases in statistical estimation that can be addressed by not fully resolved using data imputation. It is also important to note that our sample is relatively small and does not represent the diverse population of PWH living with SUD. Those who were willing to participate in our study were likely to have greater motivations to maintain medication adherence, potentially biasing results. Future research should aim to include a more diverse and larger sample to enhance generalizability.

Conclusions

To summarize, this study articulates the different aspects of mHealth engagement and emphasizes the importance of the intensity of engagement over initiation for promoting medication adherence in PWH and SUD. The findings highlight the need for nuanced patient engagement strategies and targeted interventions due to the unique usage patterns and associations with ART medication adherence of Black and White participants.

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Supplementary Files

Multimedia Appendixes

Joint and separate indirect effects of all mediators connecting system engagement predictors and medication adherence (all participants).
URL: http://asset.jmir.pub/assets/8c2de3a3f2ce217e820f73f927fbd8fa.docx

Joint and separate indirect effects of all mediators connecting system engagement predictors and medication adherence (Black participants).
URL: http://asset.jmir.pub/assets/e54876a01ce8c0e136d57523432cc8a0.docx

Joint and separate indirect effects of all mediators connecting system engagement predictors and medication adherence (White participants).
URL: http://asset.jmir.pub/assets/26d99916727c84d4a7696c36a2e897d3.docx