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ORIGINAL PAPER

Non-planning Impulsivity But Not Behavioral Impulsivity is Associated with HIV Medication Non-adherence

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Abstract

Despite advances in HIV antiretroviral medications, some patients do not achieve adequate medication adherence or suppressed viral load. The aim of this study was to identify the relationship between factors of impulsivity and medication non-adherence. It was hypothesized that impulsivity would have a direct association with non-adherence, after accounting for other known correlates. Participants included 322 HIV positive individuals (*M* age = 49, 56% male, 64% Black/African American). Impulsivity was measured using the Barratt Impulsiveness Scale-Brief (BIS-Brief). Factor analysis was conducted to determine if BIS-Brief resulted in a unidimensional or multi-factor solution. Results were suggestive of a two-factor solution: behavioral impulsivity and non-planning impulsivity. Structural equation modeling found non-planning impulsivity was associated with non-adherence ($\beta = 0.18$, $p = 0.016$), while no significant association was observed for behavioral impulsiveness. Results suggest that strategies related to planning for future consequences may be beneficial for impulsive persons with medication adherence difficulties.

Keywords HIV · Medication adherence · Antiretroviral therapy · Impulsivity

Resumen

A pesar de los avances en los medicamentos antirretrovirales contra el VIH, algunos no logran una adherencia adecuada a los medicamentos ni suprimen la carga viral. El objetivo de este estudio fue identificar la relación entre los factores de impulsividad y la adherencia a la medicación. Se formuló la hipótesis de que la impulsividad tendría una asociación directa con la falta de adherencia, después de tener en cuenta otros correlativos conocidos. Los participantes incluyeron 322 individuos VIH positivos (*M* edad = 49, 56% hombres, 64% Black/African American). La impulsividad se midió usando la Barratt Impulsiveness Scale-Brief (BIS-Brief). El análisis factorial se realizó para determinar si BIS-Brief dio como resultado una solución unidimensional o multifactorial. Los resultados sugirieron una solución de dos factores: impulsividad conductual e impulsividad no planificada. El modelado de ecuaciones estructurales encontró que la impulsividad no planificada se asoció negativamente con la adherencia ($\beta = 0.18$, $p = 0.02$), mientras que no se observó una asociación significativa para la impulsividad conductual. Los resultados sugieren que las estrategias relacionadas con la planificación de las consecuencias futuras pueden ser beneficiosas para las personas impulsivas con dificultades de adherencia.

Introduction

In the United States, more than 1.2 million persons are living with HIV infection and an estimated 37,600 new cases occur each year [1]. Advances in HIV antiretroviral medications have greatly improved the health and quality of life for persons living with HIV (PLWH), such that individuals receiving treatment for HIV can achieve life expectancies similar to individuals without the virus [2]. Satisfactory adherence to HIV antiretroviral medication regimens, typically defined in the literature as 80–95% of doses, is

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required to achieve these health benefits, yet PLWH continue to report challenges with adherence [3]. If optimal adherence were achieved, health outcomes for those with HIV would be improved and transmission of the virus would be significantly reduced [4].

Non-adherence to antiretroviral medication persists, as a recent study found that nearly one third of PLWH reported less than 95% medication adherence in the past month [5]. Additional studies have found that 84% of patients reported difficulties with following dosage and schedule instructions [6] and 16% of patients reported missing at least one dose in the past 3 days [3]. Among PLWH who are in care and receiving antiretroviral medications, 23–40% are unsuccessful in achieving a suppressed viral load, the biomarker that indicates effective antiretroviral adherence [5, 7]. In addition, chronic non-adherence can result in the development of ART-resistant strains of the virus, rendering currently available medications ineffective for these patients, while increasing the risk of transmission of ART-resistant strains and increasing cost of treatment [8].

Psychological factors, including depression and anxiety, are among the most common factors known to negatively impact medication adherence and quality of life among PLWH [9, 10]. Substance use is also negatively associated with medication adherence and engagement in HIV healthcare services [11].

Impulsiveness may serve as a barrier to action with regard to antiretroviral medication, as rapid and unplanned decisions may interfere with goals to adhere to one's medication schedule. Impulsivity is an integral psychological factor in understanding and measuring human personality and behavior. Impulsivity has been defined as "a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to the impulsive individuals or to others" (p. 1748) [12]. As such, persons higher on impulsivity are likely to select immediate rewards without consideration of potential negative impacts on health, relationships, finances, or other areas of functioning. Impulsivity is associated with several mental health and addictive disorders. For instance, impulsivity is a common symptom in depression and bipolar disorders [13]. Research has also identified impulsivity as one of the most commonly reported factors associated with risky behaviors, including heavy alcohol use, illicit drug use, and risky sexual behaviors [14–16].

There are numerous measures of impulsivity, including trait or personality questionnaires and behavioral assessments (e.g., simulated gambling tasks). Impulsivity measures typically include several factors or subscales. Among the most commonly used measures are the Barratt Impulsiveness Scales (BIS) [17]. Factor analyses of the original 30-item BIS identified three subscales: motor/behavioral impulsiveness, attentional/cognitive impulsiveness, and non-planning impulsiveness [18, 19]. Motor or behavioral impulsiveness is defined as acting without thinking or on the spur of the moment. Attentional impulsiveness is defined as difficulty focusing on a task at hand, while non-planning impulsivity is characterized as present-moment focus without regard for future consequences. Recent data from patients diagnosed with bipolar disorder suggests that non-planning impulsivity is associated with poor medication adherence [20].

The purpose of the present study was to examine the association between impulsivity and non-adherence to antiretroviral medication among persons living with HIV. This study is the first to explore the direct role of impulsivity on non-adherence to antiretroviral medications. The primary aim was to utilize a brief version of the BIS (BIS-Brief) [21] to test the hypothesis that impulsivity would be associated with medication non-adherence among participants in a large epidemiological study. We first assessed whether the measure detected a unidimensional factor or multi-factor solution. Next, we sought to determine whether impulsiveness (or its components) was significantly associated with medication non-adherence while controlling for other known correlates of non-adherence, including substance use and psychosocial characteristics. We hypothesized that impulsivity would be significantly associated with greater number of missed medication days, after accounting for the variance explained by other known correlates of poor adherence.

Methods

Participants

The current study recruited 322 participants from the Florida Cohort Study, a longitudinal study designed to monitor and improve health outcomes for individuals living with HIV infection [5]. The Florida Cohort study aims to examine how individual, clinic, and community level factors influence access to care and HIV outcome variables, including medication non-adherence, CD4 count, and viral load. Data presented were collected at 6-month follow up assessments conducted between 2015 and 2017. The study procedures were approved by the institutional review boards at the University of Florida, Florida International University, and the Florida Department of Health.

Procedure

Trained research staff recruited participants for baseline assessments at HIV healthcare facilities, including county health departments, community agencies, and hospital-based infectious disease clinics. Participants who provided informed consent were asked to complete a baseline

questionnaire on paper or using a computer equipped with Research Electronic Data Capture (REDCap) technology. Participants had the option to complete the assessment privately or with the assistance of a research staff member. Participants were contacted 6 months after their baseline assessment to complete a follow-up survey. Participants were compensated for their participation and could withdraw from the study at any time.

Measures

Demographic Variables

Participants reported demographic information, including age, gender, race/ethnicity, education, and homelessness.

Antiretroviral Medication Non-adherence

Non-adherence to HIV medications was assessed through self-report and objective measures. Using a continuous item from a validated brief measure [22], self-reported non-adherence was defined as the number of days in the past 30 days when at least one medication dose was missed. HIV viral load was also collected as an objective measurement of non-adherence, and used to provide concurrent validity for the self-report non-adherence measure. Self-report measures of adherence have been found to be reliable and useful for predicting clinical outcomes, including viral load [23].

Impulsivity

The Barratt Impulsiveness Scale-Brief (BIS-Brief) [21] is an eight-item version of the 30-item BIS (BIS-11) [18]. The BIS is one of the most commonly used self-report measures of impulsivity and has well-established psychometric properties, including reliability and validity in diverse samples [19]. Steinberg and colleagues [21] found the brief version to have similar reliability estimates as the original 30-item scale, with Cronbach's alphas of 0.78 and 0.83 respectively. The BIS-Brief has also been found to have similar construct validity to the original BIS-11 [21], making the shortened form ideal for large epidemiological studies. As such, the brief version was identified as a valid and reliable measure of impulsivity with the least amount of burden on participants.

The BIS-Brief uses a four-point Likert-type scale, ranging from "never" to "almost always or always." Examples of items include "I do things without thinking" and "I act on the spur of the moment." Prior studies have not established a cut-off score to designate high impulsiveness, and recommend use of continuous impulsiveness score [21].

Substance Use

Participants self-reported frequency of substance use over the past 6 months. Response options included never, less than monthly, one-to-three times per month, one-to-three times per week, four-to-six times per week, and daily. Other drugs of abuse (e.g., heroin, cocaine, sedatives) were assessed in the original study, but were not included in the present analyses due to low rates of recent use. For the purpose of the present study, alcohol and marijuana use data were included.

Mental Health

The Patient Health Questionnaire (PHQ) [24] and the Generalized Anxiety Disorder (GAD) [25] scales were used to assess mental health symptoms. The PHQ-8 is an 8-item Likert-type scale and is a valid and reliable measure of depressive symptoms in clinical and research samples. Similarly, the GAD-7 is a 7-item Likert type scale with strong psychometric properties for assessing anxiety symptoms in research and clinical practice. Higher scores on the PHQ and GAD are indicative of greater symptom severity.

Statistical Analyses

Statistical analyses were conducted using SPSS Version 22 and SPSS AMOS software (IBM, 2014). Distributions were checked for normality and potential outliers to determine whether corrective transformations were necessary. Descriptive sample characteristics were examined via univariate analyses (e.g., mean, standard deviation, percentages). Pearson correlation, *t* tests, and Chi squared analyses were conducted to determine bivariate associations among participant characteristics and medication non-adherence.

Next, a unidimensional construct of impulsivity was assessed using the eight items of the BIS-Brief. Principle Components Analyses (PCA) and Confirmatory Factor Analyses (CFA) methods were conducted using SPSS and AMOS software [26] to examine the BIS-Brief measure as a unidimensional or multi-factor construct.

Structural Equation Modeling (SEM) was used to determine the relationships among independent variables and the outcome of medication non-adherence (i.e., number of days missing a medication dose in the past 30 days). Using AMOS software, regression paths were created between independent factors and medication non-adherence, while correlations paths were constructed among independent factors to account for intercorrelations and multicollinearity. Independent factors included significant sociodemographic variables, mental health, substance use, and impulsivity. Latent constructs were created for mental health (depression and anxiety) and substance abuse

(indicated by alcohol and marijuana). Multicollinearity was assessed among latent constructs by allowing for possible significant correlations to be included in the model based on associations previously established in the literature (e.g., substance use and impulsivity). A full information maximum likelihood approach was used to determine unbiased estimates of associations. Assessment of normality and overall model fit indices were examined.

Results

Sample Characteristics

The present study consisted of 322 patients living with HIV and prescribed antiretroviral medications. Table 1 provides demographic information and sample characteristics. The sample had slightly more male participants (55.6%) and most identified as Black/non-Hispanic (64.0%). Participants ranged in age from 22 to 78 years with a mean age

Table 1 Sample characteristics and association with medication non-adherence

	Frequency	%	Non-adherence days[a]	*t/r*	*p*
Gender				0.49	.689
Male	179	55.6	1.64		
Female	122	37.9	2.03		
Transgender	15	4.7	0.86		
Race/ethnicity				0.74	.531
Black, non-Hispanic	206	64.0	1.93		
White, non-Hispanic	73	22.7	1.26		
Hispanic	32	9.9	1.61		
Other	5	1.6	3.20		
Education				4.36	.014
< High school	104	32.3	2.53		
High school or GED	105	32.6	1.85		
> High school	107	33.2	0.93		
Homelessness				14.16	<.001
No	254	78.9	1.38		
Yes	58	18.0	3.55		
Alcohol use frequency				2.62	.025
None	115	36.9	1.30		
Less than monthly	65	20.1	1.86		
1–3 times a month	60	19.2	2.32		
1–3 times a week	50	16.0	1.36		
4–6 times a week	10	3.2	5.60		
Daily	12	3.8	2.58		
Marijuana use frequency				1.96	.084
None	203	65.1	1.41		
Less than monthly	29	9.3	3.21		
1–3 times a month	27	8.7	3.30		
1–3 times a week	12	3.8	2.17		
4–6 times a week	7	2.2	0.71		
Daily	29	9.3	1.79		
Age, mean (SD)	48.9	10.4	–	− 0.05	.394
BIS-Brief, mean (SD)	15.9	4.2	–	0.21	<.001
Behavioral impulsivity, mean (SD)	8.2	2.7	–	0.12	.039
Non-planning impulsivity, mean (SD)	7.6	2.7	–	0.21	<.001
PHQ depression score, mean (SD)	7.9	5.8	–	0.15	.011
GAD anxiety score, mean (SD	6.8	5.8	–	0.14	.016

Statistical comparison of group variables via mean difference (*t* test) and continuous variables by Pearson correlation (*r*). [a]Mean number of non-adherence days in the past 30 days

of 48.9 (SD = 10.4). Level of education reported by participants was found to be balanced among the categories of less than a high school diploma (32.3%), high school graduate or equivalent (32.6%), and education beyond high school (33.2%). Additionally, recent homelessness was reported by 58 individuals (18.0%).

On average, participants reported antiretroviral medications non-adherence on nearly 2 days ($M = 1.78$, $SD = 4.0$) in the past month, which translates to an average medication adherence of 94% for the present sample. Comparing rates to commonly utilized adherence thresholds, 16% of the current sample were at or below the 90% medication adherence level and 33% of the sample were below the 95% medication adherence level. The majority (88.6%) of participants in the current study with available viral load data achieved undetectable viral load (≤ 200 copies/ml) per data from their most recent clinic visit in the past 6 months (note: viral load data was unavailable for 28 participants). Using Chi square analysis, self-reported adherence data were associated with viral load data, such that participants reporting ≤ 90% adherence were more likely to have a detectable viral load, $\chi^2 = 4.52$, $p = 0.034$, when compared to those reported > 90% adherence level.

Participant scores on the BIS-Brief ranged from 8 to 29, with a mean score of 15.9 (SD = 4.18). An acceptable distribution of scores was observed (skewness = 0.316, kurtosis = − 0.312). Internal consistency was also found to be in the acceptable range (Cronbach's alpha = 0.71) based on previously published standards for brief non-clinical measures [27].

Examination of BIS-Brief

Examination of the BIS-Brief was conducted using Principle Components Analyses (PCA) and Confirmatory Factor Analyses (CFA) methods. PCA resulted in a correlation matrix with values ranging between $r = 0.017$ and $r = 0.558$, with the overall determinant value of 0.144. As shown in Table 2, using the default eigenvalue cut off of 1, results indicated a two-component model, with initial eigenvalues explaining 33.5 and 23.9% of the variance, respectively, for a sum of 57.5% explained. Tests of normality were within acceptable range, Kaiser–Meyer–Olkin measure of sampling adequacy was 0.756, Bartlett's test of Sphericity was significant χ^2 (28) = 602.72, $p < 0.001$. For the purpose of this study, and based on the literature, the two observed factors were labeled Behavioral Impulsivity and Non-Planning Impulsivity. These factors are consistent with previous factors identified in studies using the BIS [17, 18].

Next, Fig. 1 shows a CFA which builds upon the results described above. Figure 1a displays a poor fitting model for the unidimensional factor of impulsiveness. Figure 1b shows a second CFA that was constructed for a two-factor solution of impulsiveness, as suggested by the PCA. This resulted in moderate-to-strong factor loadings and adequate fit, with a relative Chi square of 1.77 ($p = 0.02$), an RMSEA of 0.049 (90% CI 0.02–0.08), a TLI of 0.95, an IFI of 0.98, and a CFI of 0.97.

Bivariate Associations Among Independent and Dependent Factors

Table 1 also displays bivariate associations (i.e., *t* tests and Pearson correlations) between sample characteristics and medication non-adherence. No significant differences in medication non-adherence were observed for gender ($t = 0.49$, $p = 0.689$) or race ($t = 0.74$, $p = 0.531$). Education was related to medication non-adherence, such that those with less years of education reported more missed medication doses in the past 30 days ($t = 4.36$, $p = 0.014$). Participants reporting recent homelessness were more likely to miss medication doses in the past 30 days ($t = 14.16$, $p < 0.001$). Higher scores on the depression ($r = 0.15$, $p = 0.011$) and anxiety ($r = 0.14$, $p = 0.016$) measures were also associated with higher rates of medication non-adherence. Participants reporting more frequent use of alcohol

Table 2 Factor loadings and communalities based on a principle components analysis

	Non-planning impulsivity	Behavioral impulsivity	Communality
1. I plan tasks carefully	**0.63**	0.12	0.41
4. I am self-controlled	**0.77**	− 0.05	0.59
5. I concentrate easily	**0.81**	− 0.01	0.62
6. I am a careful thinker	**0.80**	0.21	0.69
2. I do things without thinking	0.05	**0.78**	0.61
3. I don't pay attention	0.07	**0.61**	0.38
7. I say things without thinking	0.12	**0.80**	0.66
8. I act on the spur of the moment	0.02	**0.78**	0.59

Kaiser–Meyer–Olkin measure of sampling adequacy was 0.756, Bartlett's test of Sphericity was significant χ^2 (28) = 602.72, p < 0.001. Default eigenvalue cut off of 1. Eigenvalues explaining 33.5 and 23.9 percent of the variance, respectively, for a sum of 57.5% explained

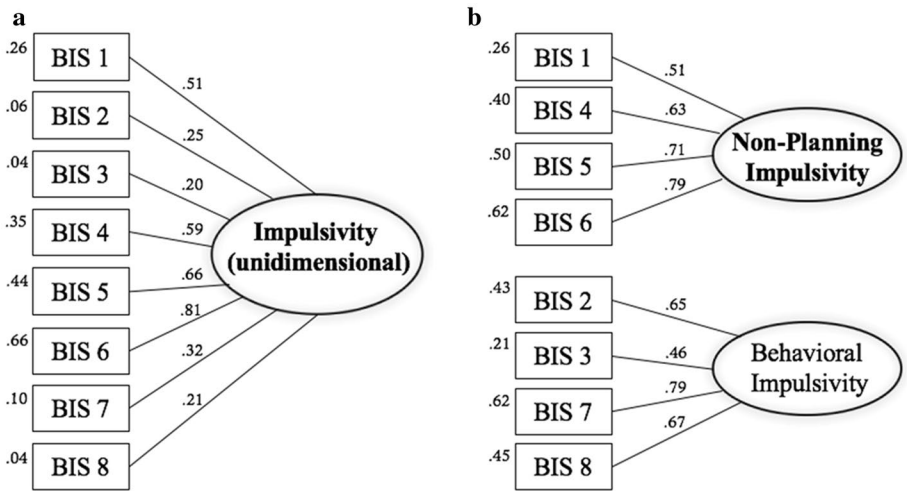

Fig. 1 Factor structure for Barratt Impulsiveness Scale-Brief in an HIV sample. *Note* Initial scale analysis (Model a) suggested poor fit, with several factor loadings < 0.40; Corrected structure (Model b) based on the two factor solution identified in PCA resulted in adequate fit. Model **a** CMIN/DF = 13.80, TLI = 0.20, IFI = 0.57, CFI = 0.56, RMSEA = 0.20, Model **b** CMIN/DF = 1.77, TLI = 0.95, IFI = 0.98, CFI = 0.97, RMSEA = 0.049

were more likely to report non-adherence ($t=2.62$, $p=0.025$, while no such association was detected for marijuana use ($t=1.96$, $p=0.084$). Lastly, behavioral impulsivity ($r=0.12$, $p=0.039$) and non-planning impulsivity ($r=0.21$, $p<0.001$) were associated with medication non-adherence in these univariate unadjusted analyses.

Next, we examined multicollinearity among variables to be included in the final model. Mental health variables were found to be significantly associated with homelessness and impulsivity. Specifically, participants who reported recent homelessness also scored higher on measures of depression ($r=0.21$, $p<0.001$) and anxiety ($r=0.19$, $p=0.001$). A significant positive association was observed between behavioral impulsivity and measures of depression ($r=0.18$, $p=0.002$) and anxiety ($r=0.21$, $p<0.001$). Similarly, there was a significant positive association between non-planning impulsivity and depression ($r=0.37$, $p<0.001$) and anxiety ($r=0.33$, $p<0.001$). To account for potential multicollinearity effects, we included these correlations in the final structural model.

Structural Equation Model of Factors Associated with Medication Non-adherence

Figure 2 presents a structural equation model designed to test the main hypotheses, that higher impulsiveness would be associated with medication non-adherence. Based on the confirmatory factor analyses described above, impulsivity consisted of two latent constructs: behavioral impulsiveness and non-planning impulsiveness. The latent construct of behavioral impulsiveness did not reveal a significant direct association with medication non-adherence, $\beta=0.04$, $p=0.58$. Conversely, the impulsivity construct termed non-planning was significantly associated with medication non-adherence, $\beta=0.18$, $p=0.016$. To account for the likelihood of multicollinearity among predictive factors, correlations were included in the model. The two factors of impulsivity were significantly correlated, $r=0.24$, $p=0.002$.

In the multivariate model, mental health symptoms did not significantly regress on medication non-adherence, $\beta=0.01$, $p=0.89$. However, mental health was significantly associated with behavioral impulsiveness, $r=0.26$, $p<0.001$ and with non-planning impulsiveness, $r=0.43$, $p<0.001$. Substance use did not have a significant independent relationship with medication non-adherence in this sample, $\beta=0.08$, $p=0.33$. A small significant correlation was detected between substance use and behavioral impulsiveness, $r=0.29$, $p=0.04$.

Overall, model fit indices suggested a close fit, with a total Chi square of 136.0 and 80 degrees of freedom, for a relative Chi square of 1.70 ($p<0.001$), an RMSEA of 0.047 (90% CI 0.03–0.06), a TLI of 0.92, an IFI of 0.95, and a CFI of 0.95. The present model resulted in a small-to-medium effect size, explaining 10% of the variance in medication non-adherence, $R^2=0.10$.

Discussion

The present study examined impulsiveness in an ongoing epidemiological study, and thus the brief version of the BIS was thought to be the ideal measure of impulsiveness while aiming to limit assessment burden on participants. Previous research with non-HIV samples found that the BIS-Brief assessed a unidimensional construct of impulsiveness and had psychometric properties similar to the original long form measure [21]. Contrary to this unidimensional hypothesis, responses to items on the BIS-Brief from the present sample suggested a two-factor model of impulsivity: behavioral/motor impulsiveness and non-planning impulsiveness. Behavioral or motor impulsiveness refers to acting quickly without thinking, while non-planning impulsiveness is

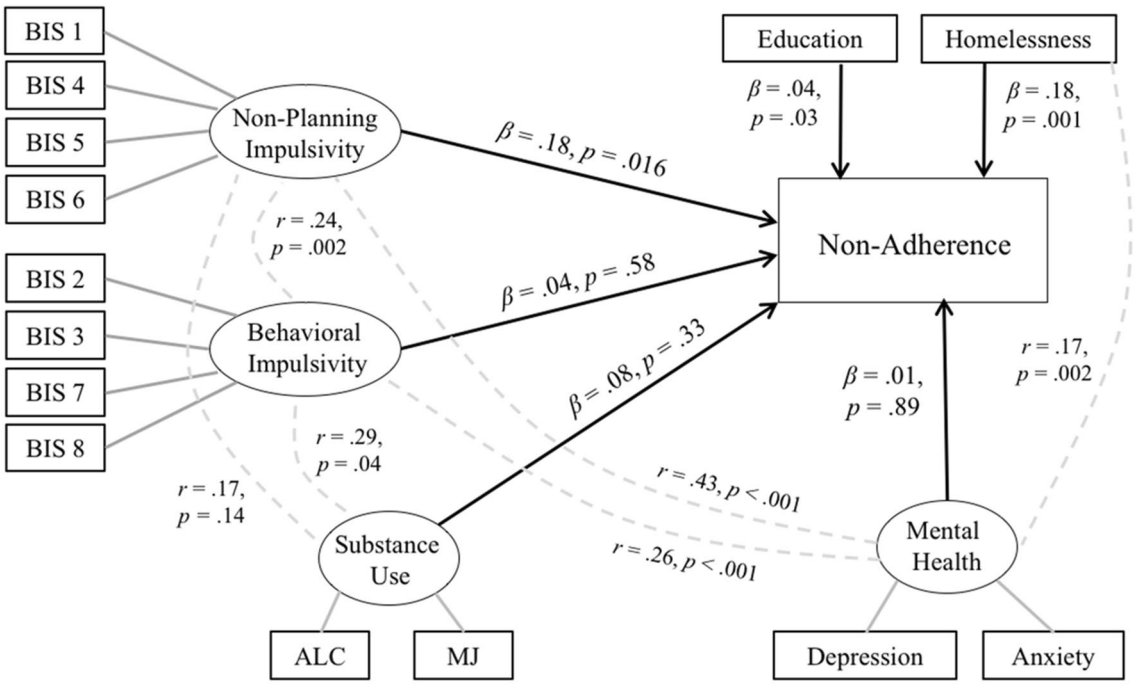

Fig. 2 Complete model predicting non-adherence with AMOS software. *Note* Regression (β) paths indicated by solid lines; correlation (r) paths indicated by broken lines. Model fit statistics: CMIN/DF = 1.70, TLI = 0.92, IFI = 0.95, CFI = 0.95, RMSEA = 0.047

characterized as thinking with an orientation to the present moment without regard for future consequences [17, 18]. Behavioral impulsiveness was not significantly associated with HIV medication non-adherence in multivariate models. Non-planning impulsivity was found to be significantly associated with medication non-adherence, while controlling for the impact of other known predictors. These findings suggest that individuals in treatment for HIV may be at greater risk of missing a medication dose as a result of impulsively making decisions that discount future consequences of non-adherence.

The present study provides evidence of a direct association between non-planning impulsiveness and HIV medication non-adherence. Similar findings have been found in non-HIV samples, such that a significant link between non-planning impulsiveness and poor medication adherence was detected in a sample of patients diagnosed with bipolar disorder [20]. Specifically, their study found non-planning impulsiveness had a direct association with non-adherence to bipolar medication while controlling for indirect effects of substance use and comorbid anxiety disorders [20]. Given that HIV medications do not result in immediate benefit, but rather sustained adherence is required for positive health outcomes, individuals who are overly present-focused may struggle to make the connection between daily adherence and more distal positive health outcomes. Poor medication adherence related to non-planning impulsiveness is likely to negatively impact HIV viral load, reduce overall health and wellbeing, and increase the risk of transmission to uninfected individuals.

The present study found that non-planning impulsiveness was associated with greater mental health symptom severity. The cognitive process of planning involves multiple steps, including setting a predetermined course of action to achieve a goal and continuously monitoring the execution until the goal is achieved [28]. Mental health symptoms, including those related to mood and anxiety, may inhibit the cognitive processes involved in planning. Cognitive impairments among patients with depression have been well documented in the literature, particularly with regards to cognitive flexibility, planning, and memory [29]. It is plausible that persons living with HIV and a comorbid depressive disorder may be at higher risk for medication non-adherence related to non-planning impulsivity. For instance, depressed patients with HIV may have difficulty monitoring and executing their plan to adhere to their HIV medications while managing stressful life events. Furthermore, mental health and homelessness were significantly related in the present sample, and homelessness was found to be significantly associated with non-adherence. The relationship between mental health and homeless may have further attenuated the direct impact of mental health on non-adherence in this sample. Previous research on HIV positive individuals has established a significant link between homelessness and poor health outcomes, including greater odds of being uninsured, poor medication adherence, and higher CD4 count [30].

Clinical and Research Implications

Previous literature highlights the need to reduce non-planning impulsiveness, as it has been found to be associated with poor problem solving and lack of perseverance [31]. Non-planning impulsiveness also contributes to poor mediation adherence among patients with bipolar disorder in a recent study [20] and HIV medication in the current study. Evidenced-based interventions to improve medication adherence include cognitive-behavioral and mindfulness-based treatments [32–35]. While there have been no intervention studies to date that have specifically reduced non-planning impulsiveness, evidence suggests that impulsivity may be a modifiable cognitive process. Previous research has highlighted the brain networks involved in cognitive self-control, including the prefrontal cortex, anterior cingulate, and striatum [36, 37]. Furthermore, behavioral therapies, including mindfulness, were found to modify activation in these brain regions and effectively treat substance use disorders [38, 39].

Limitations

Several limitations should be considered when interpreting the results of the present study. First, this study utilized data from an ongoing epidemiological study, thus measures were not selected for the purpose of the current hypotheses, with exception for the addition of the BIS-Brief. The results of the current study did not support a unidimensional factor of impulsiveness using the BIS-Brief. Additional research is needed to further examine the BIS-Brief as a unidimensional or multidimensional measure of impulsivity. The use of self-report data is also a limitation and hinders our ability to fully understand the response patterns of participants. Self-report data introduces several biases, which may have influenced participant responses, including self-preservation and social desirability biases. The sample size of the current study may also limit the strength of the current findings, as small effect sizes were observed. Future studies with HIV samples should assess the potential influence of bipolar disorder when examining impulsivity, particularly given the association between non-planning impulsivity and medication non-adherence previously detected among patients with bipolar disorder [20]. It is possible that participants in the current study met diagnostic criteria for bipolar disorder, as this was not an exclusion criterion for participation. Lastly, the present study was conducted with participants who are prescribed antiretroviral medications for HIV treatment in the state of Florida. The current findings may not be representative of individuals living with HIV who are not in care or reside in other geographical locations.

Conclusion

The present study adds to the current understanding of both impulsivity and medication non-adherence. Specifically, this study establishes a direct association between non-planning impulsiveness and non-adherence to antiretroviral medications. Persons with present-moment focus and difficulties planning for future consequences may be more likely to decide against medication taking, which jeopardizes their own health and increases risk of transmission to others. Those more susceptible to non-planning impulsiveness may represent a particularly vulnerable population of patients who, despite their best intentions to take their medication, are less able to call to mind the negative impact of non-adherence at critical moments. Future studies should aim to replicate these findings and continue to explore associations between impulsivity and non-adherence.

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Compliance with Ethical Standards

Conflict of interest The authors have no conflicts of interest to declare.

Ethnical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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