Quality of Sleep: Associations with Antiretroviral Nonadherence

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Abstract

Poor quality of sleep (QOS) is frequently reported in HIV-positive individuals; however, despite its clinical and public health significance, few studies have examined the correlation between QOS and antiretroviral (ARV) adherence. The objective of this study was to estimate the prevalence of sleep disturbances, determine the characteristics of those with poor QOS, and establish the relationship between QOS and ARV nonadherence among HIV-positive individuals. We conducted a cross-sectional secondary data analysis of 2845 HIV-positive adults taking ARV therapy from the Healthy Living Project baseline cohort. Mean self-reported ARV nonadherence was estimated using a 3-day measure. QOS was assessed using three questions regarding sleep pattern changes, amount of bother from difficulty falling/staying asleep, and amount of bother from vivid dreams. Over 68% of individuals reported sleep pattern changes, 50.3% reported difficulty falling/staying asleep, and 20.5% reported bother from vivid dreams. Depression, suicidal ideation, unemployment, use of illicit substances, history of incarceration, and HIV viral load were all independently associated with poor QOS. Individuals reporting feeling bothered about difficulty falling/staying asleep had a 1.66 higher odds of nonadherence (95% confidence interval [CI]=1.18, 2.33; $p=0.004$). Those reporting the highest degree of bother from difficulty falling/staying asleep and from vivid dreams had a 1.42 (95% CI=1.13, 1.78; $p=0.002$) and 1.31 (95% CI=0.98, 1.75; $p=0.07$) higher odds of nonadherence, respectively. With higher incremental reports of poor QOS there were considerable increases in ARV nonadherence. Recognition and timely treatment of sleep difficulties may result in reduced ARV nonadherence with beneficial clinical and public health implications.

Introduction

OVER 70% OF HIV-POSITIVE ADULTS report sleep disturbances at some point during their illness,¹ in comparison to 10–35% of the general population.^{2,3} Research has revealed the detrimental effects of poor quality of sleep (QOS) and insomnia on general health and quality of life.^{4–7} Through cross-sectional and longitudinal studies, it has been revealed that people suffering from sleep disturbances endure impaired daytime functioning (such as difficulty with attention and concentration, fatigue, impaired memory, decreased ability to accomplish daily tasks, etc.),^{8,9} have an increased risk of motor vehicle accidents,¹⁰ may experience a higher incidence of type 2 diabetes¹¹ and psychiatric disorders,¹² and have increased health care utilization.¹³ Among other untoward effects, chronic sleep disturbances possess an inflammatory component^{14,15} that is associated with cardiovascular morbidity and mortality.^{16–20} Furthermore, sleep problems are common in the aging population^{21–24} and have been shown to be associated with decreased health-related quality

of life²⁴ and increased mortality²⁵ in the elderly. Therefore, due to the high prevalence of sleep disturbances,^{1,26–29} these problems are of particular concern in the aging HIV-positive population that is at a high risk of morbidity and mortality.

Although understudied, sleep disturbances are thought to adversely affect the health of HIV-positive individuals for numerous reasons, such as their potential relationship with antiretroviral (ARV) nonadherence.^{30,31} Reductions in adherence to ARV therapy have been associated with loss of virologic control and treatment failure,³² which in turn may result in the emergence of viral strains with ARV resistance, disease progression,³³ and elevated risk of transmission of drug-resistant virus.^{34–36} Therefore, in individuals whose ARV nonadherence is in part due to sleep problems, the recognition and timely treatment of sleep difficulties may positively impact ARV adherence and prevent consequences of nonadherence.

Despite its clinical and public health significance, few studies have examined the association between QOS and ARV nonadherence among HIV-positive individuals.^{30,31}

Additionally, the characteristics of the HIV-infected population who suffers the most from poor QOS are not well identified. Therefore, the aims of our study were to report the prevalence of QOS problems in a large sample of HIV-positive adults, identify the characteristics of those experiencing poor QOS, and establish the association between QOS and ARV nonadherence. We hypothesized that poor QOS was associated with an increased risk of ARV nonadherence.

Methods

We performed a cross-sectional, secondary analysis of baseline data of the Healthy Living Project (HLP)³⁷ in order to determine the prevalence of sleep disturbances, identify the characteristics of those reporting poor QOS, and ascertain the relationship between QOS and ARV nonadherence in HIV-positive subjects. The HLP was a multi-site randomized controlled trial to determine the effect of an individually delivered cognitive behavioral intervention on sexual transmission risk behaviors of HIV-positive participants. In this study, participants were recruited from clinics, community agencies, and media advertisements in New York City, Milwaukee, Los Angeles, and San Francisco. Potential participants were required to be at least 18 years of age, provide written informed consent and medical documentation of their HIV infection, be free of severe neuropsychological impairment or psychosis, and not be currently involved in another behavioral intervention study related to HIV. Baseline data were collected on 2846 HIV-positive participants who were on ARV therapy. The HLP protocol received approval from the University of California, San Francisco Committee on Human Research. Mean ARV adherence was estimated based on self-report using the AIDS Clinical Trials Group (ACTG)³⁸ measure of 3-day adherence for each ARV separately and averaged among an individual's entire ARV regimen. This measure was dichotomized to 0% versus greater than 0% nonadherence.

QOS was assessed using three questions regarding sleep pattern changes ("sleep pattern changes in the past week"),³⁹ sleep bother ("amount of bother with difficulty falling or staying asleep in the past 3 months"),⁴⁰ and dream bother ("amount of bother with experience of vivid dreams in the past 3 months"). Participants endorsed the question regarding sleep pattern changes in the past week on a four-point scale (0, I can sleep as well as usual; 1, I don't sleep as well as I used to; 2, I wake up 1 to 2 hours earlier than usual and find it hard to get back to sleep; 3, I wake up several hours earlier than I used to and cannot get back to sleep). The questions regarding sleep and dream bother in the past three months were also endorsed on a four-point scale (0, Have not experienced this problem or does not bother me at all; 1, Bothers me a little; 2, Bothers me quite a bit; 3, Bothers me a lot). These QOS questions will be referred to throughout the text as questions regarding sleep pattern changes, sleep bother, and dream bother, respectively.

To determine the prevalence of sleep disturbances, the question regarding sleep pattern changes was dichotomized as "I can sleep as well as usual" versus all other options. We dichotomized sleep bother and dream bother as "have not experienced this problem or does not bother me at all" or "bothers me a little" in comparison with "bothers me quite a bit" or "bothers me a great deal." Using descriptive statistics

we estimated the prevalence of any sleep pattern changes in the past week, quite a bit or a great deal of sleep bother in the past 3 months, and quite a bit or a great deal of dream bother in the past 3 months.

To compare the characteristics of those reporting poor QOS versus those with little to no QOS difficulties, we determined the independent correlates of the dichotomized forms of sleep pattern changes, sleep bother, and dream bother. Available exploratory variables included age, gender, race, sexual orientation, current employment, ever living in a shelter, ever being incarcerated, suicidal ideation in the past week, ever use of illicit substances (defined as crack, cocaine, heroin, and methadone), CD4⁺ cell count, log₁₀ HIV viral load, length of HIV infection, and use of efavirenz (an ARV with central nervous system adverse effects). These variables were included in the multivariable logistic regression model. Backward selection was used until all remaining variables had a *p* value ≤ 0.1.

Last, we examined the relationship between ARV nonadherence, dichotomized at 0%, and QOS, using the full scale of QOS question responses. The reason to utilize the full scale of QOS responses (i.e., as a categorical variable) was to examine any gradual changes in ARV nonadherence with steady decreases in sleep quality. Using bivariate logistic regression, we initially determined the unadjusted association between mean ARV nonadherence regressed onto covariates including age, gender, race, sexual orientation, level of education, ever living in a shelter, ever being incarcerated, suicidal ideation, log₁₀ HIV viral load, length of HIV infection, and use of illicit substances. Then, we investigated the association between ARV non-adherence and sleep pattern changes, sleep bother, or dream bother, while controlling for all remaining variables with a *p* value of ≤ 0.2 in the bivariable analyses for the association with ARV nonadherence. Using backward selection, we excluded variables until all those remaining had a *p* value ≤ 0.1.

The association between adherence and depression,⁴¹ as well as the link between QOS and depression has previously been explored^{42–50}; therefore, we investigated the relationship between sleep and other correlates that were identified a priori, such as unemployment, history of homelessness and incarceration, suicidal ideation, use of illicit substances, as well as demographic information, CD4⁺ cell count, HIV viral load, length of HIV infection, and use of efavirenz. Our goal was to focus on these variables and examine their association with QOS and nonadherence. However, because sleep difficulties are common with depression and are typically included as a symptom of depression, we attempted to disentangle the association of depression and QOS on ARV adherence. Therefore, we conducted a parallel analysis to explore the relationship between QOS and depression, as well as the association between ARV nonadherence and QOS while adjusting for depression, measured with the Beck Depression Inventory.^{39,51}

A two-sided *p* value < 0.05 was considered statistically significant for variables included in the final models. All analyses were conducted using STATA, version 11 (StataCorp, College Station, TX).

Results

Data from 2845 HIV-positive subjects on ARVs were analyzed (Table 1). One individual on ARVs had not responded

TABLE 1. BASELINE CHARACTERISTICS OF STUDY POPULATION (N=2845)

Mean age (SD), y	42.0 (7.6) ^a
Male at birth, <i>n</i> (%)	2109 (74.1)
Race/ethnicity, <i>n</i> (%)	
Black	1374 (48.3)
White	754 (26.5)
Hispanic	526 (18.5)
Other	191 (6.7)
Sexual orientation, <i>n</i> (%)	
Homosexual	1234 (43.4)
Heterosexual	1222 (43.0)
Bisexual	328 (11.5)
Other	61 (2.1)
Education, <i>n</i> (%)	
< High school degree	720 (25.3)
High school degree	766 (26.9)
Some college	1359 (47.8)
Ever lived in a shelter/welfare hotel, <i>n</i> (%)	1142 (40.1)
Ever incarcerated, <i>n</i> (%)	1444 (50.8)
Ever used the following substances, <i>n</i> (%)	
Alcohol	2496 (87.7)
Marijuana	2078 (73.0)
Illicit substances ^b	1947 (68.4)
Mean Beck Depression Inventory score (SD)	12.8 (8.8) ^c
Mean absolute CD4 ⁺ cell count (SD), cells/mm ³	427 (292) ^d
Mean log ₁₀ HIV viral load (SD), log ₁₀ copies/mL	2.57 (1.28) ^e
Mean years since HIV diagnosis (SD), y	8.6 (4.5) ^f
NNRTI-based antiretroviral regimen, <i>n</i> (%)	1263 (44.4)
Efavirenz-containing regimen, <i>n</i> (%)	610 (21.5)
PI-based antiretroviral regimen, <i>n</i> (%)	1677 (59.0)

^a*n*=2843.^bHeroin, cocaine, crack, and methadone.^c*n*=2838.^d*n*=2656.^e*n*=2552.^f*n*=2808.

SD, standard deviation; NNRTI, non-nucleoside reverse transcriptase inhibitor; PI, protease inhibitor.

to the any of the QOS questions. A total of 1854 (65.2%) subjects reported 0% nonadherence to their ARV regimen. In this study, 68.1% stated that they experienced sleep pattern changes in the past week, 50.3% reported feeling quite a bit or a great deal of sleep bother, and 20.5% recounted feeling quite a bit or a great deal of dream bother in the past 3 months.

Table 2 includes the correlates of each sleep quality question (including age, race, sexual orientation, current employment, ever living in a shelter, ever being incarcerated, use of illicit substances, suicidal ideation in the past week, log₁₀ HIV viral load, use of efavirenz). Across all three questions, the odds of reporting poor QOS were higher for those who were unemployed or ever incarcerated. Participants with suicidal ideation had approximately twofold higher odds of QOS problems. Use of illicit substances and increases in HIV viral load were associated with sleep pattern changes and sleep bother. Ever living in a shelter was among other correlates of sleep bother that trended toward statistical significance. Individuals who were homosexual, bisexual, or of Latino ethnicity also had 26%, 56%, and 37% higher odds of sleep bother, respectively. As expected, individuals on an efavirenz-based ARV regimen had 2.32 higher odds of having

bother from vivid dreams; however, the association between use of efavirenz and both sleep pattern changes and sleep bother did not reach statistical significance (both *p* values > 0.6).

After adjusting for covariates, sleep pattern changes and sleep bother were highly correlated with ARV nonadherence (Table 3); however, the association between dream bother and ARV nonadherence did not reach statistical significance at an α of 0.05. Individuals who woke up several hours earlier than in the past and could not get back to sleep had 66% higher odds of nonadherence in comparison to those who slept as well as usual. Similarly, those who reported a great deal of bother from difficulty falling or staying asleep, as well as those with a great deal of bother from vivid dreams in the past three months had a 42% and 31% higher odds of nonadherence, respectively, compared to those who did not experience these problems. Additionally, individuals who reported not sleeping as well as usual and those with quite a bit of sleep bother had a 23% and 35% higher odds of nonadherence, respectively.

Among other correlates of ARV nonadherence, individuals who had ever lived in a shelter, had expressed suicidal ideation, and were substance users had an approximately 30%, 30%, and 20% higher odds of nonadherence, respectively (Table 3). In these models, African Americans had 35% higher odds of nonadherence in comparison to Whites. Lastly, there was a 20% higher odds of nonadherence with every 10 years decrease in age.

There was a statistically significant association between all QOS questions and depression (sleep pattern changes: odds ratio [OR]=1.16; 95% confidence interval [CI]=1.14, 1.17; *p*<0.001; sleep bother: OR=1.09; 95% CI=1.08, 1.10; *p*<0.001; dream bother: OR=1.07; 95% CI=1.06, 1.08; *p*<0.001). Additionally, depression was independently associated with ARV nonadherence (OR=1.04; 95% CI=1.03, 1.05; *p*<0.001), whereby adjustment for depression in each multivariate regression model resulted in a null association between QOS and ARV nonadherence (all *p* values > 0.44).

Discussion

In this sample, there was a high prevalence of poor QOS by self-report, with over half of the individuals expressing unfavorable changes in their sleep pattern during the past week. Bother associated with difficulty falling or staying asleep and bother due to vivid dreams in the past 3 months were also prevalent. This large database, which included a wide range of variables on a diverse sample of persons living with HIV, afforded the opportunity to investigate the potential relevance of a range of factors with both sleep quality and ARV nonadherence. Depression, suicidal ideation, unemployment, use of illicit substances, history of incarceration, and HIV viral load were notable correlates of sleep problems. Other variables associated with sleep bother included homosexual/bisexual orientation, Latino ethnicity, and ever living in a shelter.

We determined that with heightened QOS difficulties there were gradual and considerable increases in ARV nonadherence. Individuals who reported early awakening by several hours with inability to get back to sleep, those with a great deal of bother from difficulty falling or staying asleep, and those with a great deal of bother from vivid dreams all

TABLE 2. MULTIVARIABLE LOGISTIC REGRESSION MODEL OF THE INDEPENDENT CORRELATES OF SLEEP PATTERN CHANGES, SLEEP BOTHER, AND DREAM BOTHER

	<i>Sleep pattern changes model</i> n = 2539		<i>Sleep bother model</i> n = 2397		<i>Dream bother model</i> n = 2652	
	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value
Age	—	—	0.99 (0.98, 1.00)	0.03	0.99 (0.97, 1.00)	0.04
Race	8.19 (3) ^a	0.04	13.11 (3) ^a	0.004	6.35 (3) ^a	0.1
Black/African American	Ref	Ref	Ref	Ref	Ref	Ref
White	0.93 (0.75, 1.14)	0.47	0.90 (0.73, 1.12)	0.34	0.85 (0.66, 1.09)	0.19
Latino	1.21 (0.95, 1.53)	0.12	1.37 (1.09, 1.73)	0.007	1.18 (0.91, 1.52)	0.21
Other	0.72 (0.51, 1.02)	0.06	0.83 (0.58, 1.18)	0.29	1.24 (0.85, 1.82)	0.26
Sexual orientation	—	—	12.14 (3) ^a	0.007	—	—
Heterosexual	—	—	Ref	Ref	—	—
Homosexual	—	—	1.26 (1.04, 1.53)	0.02	—	—
Bisexual	—	—	1.56 (1.18, 2.07)	0.002	—	—
Other	—	—	1.48 (0.85, 2.59)	0.17	—	—
Employment	0.68 (0.57, 0.82)	<0.001	0.74 (0.61, 0.88)	0.001	0.66 (0.53, 0.83)	<0.001
Ever lived in a shelter	—	—	1.17 (0.98, 1.40)	0.09	1.30 (1.06, 1.59)	0.01
Ever incarcerated	1.17 (0.98, 1.40)	0.08	1.23 (1.03, 1.47)	0.02	1.27 (1.04, 1.55)	0.02
Use of illicit substances ^b	1.27 (1.05, 1.53)	0.01	1.22 (1.01, 1.47)	0.04	—	—
Suicidal ideation	2.20 (1.71, 2.82)	<0.001	2.11 (1.69, 2.64)	<0.001	1.85 (1.47, 2.32)	<0.001
Log ₁₀ HIV viral load ^c	1.10 (1.03, 1.18)	0.007	1.13 (1.06, 1.21)	<0.001	—	—
Use of efavirenz	—	—	—	—	2.32 (1.87, 2.86)	<0.001

^a χ^2 (degrees of freedom) for the omnibus Wald test of equality of nonadherence proportions among the four categories.

^bHeroin, cocaine, crack, and methadone.

^cSelf-reported.

OR, odds ratio; CI, confidence interval.

reported higher odds of ARV nonadherence. Even those not sleeping as well as usual and with quite a bit of sleep bother, also reported substantial ARV nonadherence.

Our findings parallel and extend the few previous research studies that have explored the association between sleep disturbance and nonadherence to ARV medications.^{30,31} In a cross-sectional study of HIV-infected women, two thirds of subjects suffered from severe sleep disturbance and their sleep quality was associated with their adherence to medications due to interference with daytime functioning.³¹ Similarly, in another study examining the self-reported symptoms resulting in ARV nonadherence, approximately 10% of non-adherent participants reported insomnia as a cause.³⁰

Correlates of sleep quality in prior studies in HIV-positive individuals include depressive symptoms,^{1,52–54} anxiety,^{1,52,53} use of alcohol and illicit substances,^{1,52} pain,⁵³ fatigue, longer duration of HIV infection,⁵² and unemployment. Fatigue has also been reported to be a very common symptom among HIV-positive individuals, which has been associated with functional limitations, higher mortality, and unemployment.^{55,56} The relationship between several of these correlates (such as depression, use of substances, and unemployment) and QOS was also observed in our study. Conversely, among other correlates of quality of sleep, there are conflicting reports regarding the relationship between QOS and CD4⁺ cell count or HIV viral load.^{1,27,52,54,57,58} In our study, CD4⁺ cell count was not associated with QOS; however, every tenfold increase in HIV viral load was strongly correlated with heightened sleep problems. Additionally, the few studies that have evaluated the association between use of ARV medications and QOS report conflicting results.^{1,52,59} A study by Moyle et al.⁶⁰ concluded that despite the fact that efavirenz altered the time spent in sleep stages, subjects remained sat-

isfied with their QOS and quality of life. Similarly, in our study, subjects on an efavirenz-based ARV regimen reported feeling more bothered by vivid dreams, but this association was not evident with sleep bother or changes in sleep pattern.

A challenge with sleep research is the close correlation between sleep quality and depression. In fact, several of the items in commonly used depression scales pertain to changes in sleep pattern.^{39,51,61} Patients with depressive disorders often have high rates of sleep disturbances^{42,43} and depression has been reported as a symptom of insomniacs.^{44–47} Due to their close correlation, the separation and disentanglement of these two disorders has been the topic of much research and debate.^{48–50} In a recent study examining whether sleep problems in infancy precede symptoms of anxiety and depression,⁶² it was revealed that dyssomnia at 2 and 24 months were associated with anxiety and depressive symptoms at 3 years of age. Additionally, parasomnia, short sleep duration, and absence of a set bedtime at 24 weeks preceded anxiety and depressive symptoms. These authors found little evidence of a bidirectional association of anxiety or depressive symptoms preceding later sleep problems. One potential mechanism for this causal pathway is that short sleep duration and frequent awakenings affect the hypothalamic-pituitary-adrenal axis⁶³ and the dysregulation of this axis has been associated with anxiety and depression in children.⁶⁴

Our guiding hypothesis was that sleep difficulties may directly or indirectly, via the mediation of depression, result in ARV nonadherence. However, given the cross-sectional nature of our study, we were unable to partition the intertwined effect of depression from QOS. Therefore, it is possible that depression is a confounder and/or a mediator in the relationship between ARV adherence and QOS or that both depression and QOS are byproducts of a factor that is higher up

TABLE 3. MULTIVARIABLE LOGISTIC REGRESSION MODELS OF THE ASSOCIATION BETWEEN SLEEP QUALITY QUESTIONS AND ANTIRETROVIRAL NONADHERENCE (DICHOTOMIZED AT 0%)

	Sleep pattern changes model n = 2404			Sleep bother model n = 2405			Dream bother model n = 2398		
	OR (95% CI)	p Value		OR (95% CI)	p Value		OR (95% CI)	p Value	
Age	0.98 (0.97, 0.99)	0.003		0.98 (0.97, 0.99)	0.003		0.98 (0.97, 0.99)	0.003	
Race	14.79 (3) ^a	0.002		15.34 (3) ^a	0.002		14.26 (3) ^a	0.003	
Black/African American	Ref	Ref		Ref	Ref		Ref	Ref	
White	0.74 (0.60, 0.91)	0.005		0.74 (0.60, 0.91)	0.005		0.75 (0.60, 0.92)	0.006	
Latino	0.67 (0.52, 0.85)	0.001		0.66 (0.52, 0.84)	0.001		0.67 (0.53, 0.85)	0.001	
Other	0.74 (0.51, 1.06)	0.1		0.74 (0.51, 1.06)	0.1		0.74 (0.51, 1.07)	0.11	
Ever lived in a shelter	1.31 (1.09, 1.56)	0.004		1.30 (1.08, 1.56)	0.004		1.30 (1.09, 1.56)	0.004	
Use of illicit substances ^b	1.20 (0.99, 1.45)	0.07		1.19 (0.98, 1.44)	0.07		1.20 (0.99, 1.46)	0.06	
Suicidal ideation	1.29 (1.03, 1.61)	0.03		1.27 (1.02, 1.59)	0.03		1.30 (1.04, 1.61)	0.02	
Log ₁₀ HIV viral load ^c	1.12 (1.04, 1.19)	0.001		1.11 (1.04, 1.19)	0.002		1.12 (1.04, 1.19)	0.001	
Sleep pattern changes	9.64 (4) ^a	0.02		—	—		—	—	
0: I can sleep as well as usual	Ref	Ref		—	—		—	—	
1: I don't sleep as well as I used to	1.23 (1.01, 1.51)	0.04		—	—		—	—	
2: I wake up 1–2 h earlier than usual and find it hard to get back to sleep	1.14 (0.86, 1.50)	0.35		—	—		—	—	
3: I wake up several hours earlier than I used to and cannot get back to sleep	1.66 (1.18, 2.33)	0.004		—	—		—	—	
Amount of bother with difficulty falling/staying asleep in past 3 months	—	—		10.81 (3) ^a	0.01		—	—	
0: Have not experienced this problem or does not bother me at all	—	—		Ref	Ref		—	—	
1: Bother me a little	—	—		1.17 (0.89, 1.53)	0.26		—	—	
2: Bother me quite a bit	—	—		1.35 (1.07, 1.70)	0.01		—	—	
3: Bother me a great deal	—	—		1.42 (1.13, 1.78)	0.002		—	—	
Amount of bother with vivid dreams in past 3 months	—	—		—	—		5.82 (3) ^a	0.12	
0: Have not experienced this problem or does not bother me at all	—	—		—	—		Ref	Ref	
1: Bother me a little	—	—		—	—		1.24 (0.98, 1.57)	0.08	
2: Bother me quite a bit	—	—		—	—		1.18 (0.89, 1.55)	0.25	
3: Bother me a great deal	—	—		—	—		1.31 (0.98, 1.75)	0.07	

^a χ^2 (degrees of freedom) for the omnibus Wald test of equality of nonadherence proportions among the four categories.

^bHeroin, cocaine, crack, and methadone.

^cSelf-reported.

OR, odds ratio; CI, confidence interval.

in the chain of causality. Carefully designed and implemented longitudinal studies may help tease apart the effects of QOS and depression on ARV adherence. Future research, particularly randomized controlled trials that test the efficacy of sleep interventions and monitor changes in depression, ARV adherence, and quality of life, may aid in developing a conceptual model of the interplay between these variables. Ultimately, it is possible that individually tailored multidimensional interventions that influence both QOS and depression, involving educational and behavioral skills models customized to the patient's needs, in addition to pharmacologically active agents are needed to impact sleep and depression.

A limitation of our study includes the cross-sectional approach with which we cannot establish the sequence of events or determine causality. However, given scant information and research regarding the association between QOS and ARV adherence, a cross-sectional study is a logical starting point to build a foundation upon which other longitudinal cohort and randomized controlled trials can be based. Another drawback of this study is our use of QOS questions that previously have not been validated for the identification of sleep disturbances and that do not include details such as sleep latency and frequency of awakenings. Given that this was a secondary data analysis, we were limited by the questions that were asked. Lastly, it is important to note that a disadvantage with the use of self-reported medication adherence data is that respondents tend to overreport adherence. Future research should estimate ARV adherence using multiple methods (such as pharmacy refill records, pill counts, etc.) where the percentage of individuals with perfect adherence may be less pronounced. Hence, we view these results as preliminary findings leading to future rigorous studies using validated measures of sleep quality and more refined methods of adherence assessment.

Unlike the subjective characteristic of depression, sleep quality contains an objective feature where clinicians have the ability to identify the presence of this problem with a few simple questions. Additionally, inquiries into the patient's QOS may be less emotionally charged, easier to broach, and more socially accepted. Therefore, the recognition of sleep difficulties offers clinicians a chance to further assess ARV nonadherence and may provide an opening to discuss depression and suicidal ideation. Interventions aimed at mitigating poor QOS may result in improved ARV adherence, reduction in cardiovascular sequelae, and enhanced quality of life.

In summary, HIV-positive individuals report a high prevalence of poor QOS and there is a significant association between QOS and ARV adherence. With higher incremental reports of sleep pattern changes, greater bother from difficulty falling asleep or staying asleep, and higher bother from vivid dreams, there are significant reductions in ARV adherence. Poor QOS should prompt an evaluation of ARV adherence, depression, suicidal ideation, and use of illicit substances (such as heroin, cocaine, crack, or methadone). Additionally, the assessment of sleep quality in the HIV-positive patient population is of paramount importance and may lead to improved medication adherence and clinical outcomes.

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