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## Network support, technology use, depression, and ART adherence among HIV-positive MSM of color

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### ABSTRACT

Depression is associated with poor antiretroviral therapy (ART) adherence among people living with HIV/AIDS. This relationship may be moderated by an individual's social network characteristics. Our study sought to examine social network correlates of treatment adherence among HIV-positive men recruited from social service agencies throughout Los Angeles County ( $N=150$ ) to inform technology-driven social support interventions for this population. We administered egocentric social network and computer-assisted survey interviews focused on demographic characteristics, health history, depressive symptoms, and ART adherence, where adherence was assessed by the number of reasons participants missed taking their medication, if ever. Significant univariate correlates of adherence were included in a multivariable regression analysis, where the moderating effect of having a network member who reminds participants to take their HIV medication on the relationship between depression and adherence was tested. Over 60% of participants reported clinically significant depressive symptoms; this was significantly associated with lower adherence among those without someone in their social network to remind them about taking their HIV medication, even after adjusting for covariates in an ordinary least squares regression (adjusted mean difference  $b = -1.61$ ,  $SE = 0.42$ ,  $p = 0.0003$ ). Having a network member who reminds participants to take their ART medication significantly ameliorated the negative association between depression and treatment adherence, especially for those reporting greater depressive symptoms ( $p = 0.0394$ ). Additionally, participants demonstrated high rates of technology use to communicate with social network members. In order to achieve the aims of the National HIV/AIDS Strategy, innovative interventions addressing mental health to improve ART adherence are needed. Network strategies that leverage technology may be helpful for improving ART adherence among HIV-positive men with comorbid depressive symptoms.

### ARTICLE HISTORY

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### KEYWORDS

Depression; ART adherence;  
social networks; technology

## Introduction

Men who have sex with men (MSM) account for nearly three-quarters of all new HIV diagnoses among men in the United States (Centers for Disease Control and Prevention, 2015). The National HIV/AIDS Strategy aims to increase access to care, improve health outcomes for people living with HIV, and reduce HIV-related disparities (White House Office of National AIDS Policy, 2015). Treatment adherence for HIV-positive people is key to maintaining viral suppression, reducing drug resistance, improving overall health and wellbeing, and reducing transmission risk to others (Chesney, 2006; Cohen et al., 2011; World Health Organization, 2003). In California, recent data indicate that 60% of HIV-positive MSM have achieved viral suppression; this percentage is lower for MSM of color (California Department of Public Health Office of AIDS, 2014).

Patient-level barriers to adherence have been identified in previous research, including depression and

low levels of social support. Gonzalez and colleagues found depression was significantly associated with treatment non-adherence, which was consistent over time, across samples, and inclusive of those who were clinically depressed as well as those who self-reported depressive symptoms (Gonzalez, Batchelder, Psaros, & Safren, 2011). However, supportive social support networks increase use of primary care and consistent medication adherence among HIV-positive individuals (Hamilton, Razzano, & Martin, 2007; Ramaswamy et al., 2013). For example, Reich and colleagues found that having positive support from one or more "important" persons within one's social network produced better mental health outcomes (Reich, Lounsbury, Zaid-Muhammad, & Rapkin, 2010).

Technology use among HIV-positive individuals has been studied as a tool for treatment adherence interventions. Multiple studies have examined text messaging through cell phones, online social networking sites, and

chat rooms (Fox, 2011; Lester et al., 2009; Rhodes et al., 2010). A study involving HIV-positive individuals found 76% used online social networking and participants who owned a mobile phone were found to report better ART adherence (Horvath et al., 2012). These studies exemplify opportunities to leverage mobile technologies to meet the social networking needs of and improve ART treatment adherence for HIV-positive people.

### **Conceptual framework**

Theories of social support offer an understanding of human relationships and the effects they have on stressful situations (Callaghan & Morrissey, 1993; Cohen & McKay, 1984; Cohen & Wills, 1985). The buffering effect of social support theory supposes that social networks can attenuate the negative effects of chronic stress (Cohen & McKay, 1984). Positive social networks can promote psychological adjustment through consistent positive interactions and exchange of benefits. Support is often conceptualized in terms of one's social network structure or the functions provided by its members (Taylor, 2007). Structure relates to one's social network and linkages within a community, and is characterized by the type, number, and strength of connections (Wills & Ainette, 2012). Functional social support can be divided into two primary types: emotional (i.e., love, trust) and instrumental (i.e., tangible aid, services) (Cohen & Wills, 1985; House, Umberson, & Landis, 1988).

Numerous researchers have documented the relationship between social support and depression (Aneshensel & Frerichs, 1982; Aneshensel & Stone, 1982; George, Blazer, Hughes, & Fowler, 1989; Lin & Dean, 1984). While HIV researchers have conceptualized depression as mediating the relationship between social support and ART treatment adherence (Gonzalez et al., 2004; Simoni, Frick, Lockhart, & Liebovitz, 2002) the potential role of social support as a moderator on the relationship between depression and ART adherence remains underexplored. The moderating role of social support is theoretically grounded in network literature, which suggests that functional social networks are dynamic over time (Cohen, Mermelstein, Kamarck, & Hoberman, 1985) and the buffering hypothesis of social support, which suggests that supportive social networks attenuate negative symptoms associated with stress (Cohen & Wills, 1985). This relationship holds particular promise for intervention development in the context of new technologies, as social networks have the potential to promote health via social media and other online platforms (Young et al., 2014).

While there is an understanding that social support can work to promote medication adherence among people living with HIV, interventions aimed at utilizing

social networks to improve adherence have been mixed (Remien et al., 2005; Simoni et al., 2009; Simoni, Pantalone, Plummer, & Huang, 2007). More information is needed on the relationships between depression, social support and ART adherence. This study aims to examine social network correlates of HIV medication adherence in order to identify specific intervention targets. We sought to answer the following: What is the structure of HIV-positive MSM of color's social networks; what network variables are associated with improved medication adherence; and does having a social network member who reminds participants to take their medication moderate the relationship between depression and adherence?

### **Methods**

#### **Procedures**

Participants were 18 years of age or older, English or Spanish speakers, and identified as HIV-positive cisgender men. To recruit eligible participants within the greater Los Angeles area, we conducted outreach within AIDS service organizations and support groups as well as posted flyers in coffee shops, bars, clubs, and other social venues. In addition, we relied on email advertisement through a registry of HIV-positive individuals kept by the University of California, Los Angeles. Interested participants called our project office for screening by the study coordinator. Eligible participants were scheduled for an interview at a location of their choice. Two types of data collection strategies were employed to gather information: a computer assisted survey and an interviewer administered social network interview. The surveys were completed on a study computer and lasted 15–20 min. Research assistants were available during this time to answer questions. Participants then completed a 30-minute social network interview facilitated by the research assistant using an iPad as has been done previously (Rice, 2010). Participants were paid \$20 each as incentive. Data collection occurred from November 2013 to June 2014. All protocols were approved by University of California, Los Angeles.

#### **Measures**

##### **Demographic characteristics**

Included: age, race/ethnicity, sexual orientation, highest educational attainment, current employment, relationship status, and AIDS diagnosis.

##### **Depressive symptoms**

Assessed using the 10-item CES-D (Andresen, Malmgren, Carter, & Patrick, 1994), participants were

asked how they felt or behaved during the previous seven days, with responses ranging from 0 = rarely or none of the time (less than 1 day) to 3 = all of the time (5–7 days). Scores ranged from 0 to 30, with higher sum scores suggesting greater depressive symptoms. In a study examining the reliability and validity of the 10-item CES-D among HIV-positive patients enrolled in a drug treatment program in British Columbia, Canada, the internal reliability was 0.88 (Zhang et al., 2012). Cronbach's alpha for this study was 0.83. CES-D 10 scores were dichotomized using a sum score of 10 or higher to indicate the presence significant depressive symptoms and nine or less to indicate no presence of significant depressive symptoms (Andresen et al., 1994; Zhang et al., 2012).

### Social support

Utilizing social network interview methodology, information was gathered regarding social network size, density, relationship type, communication frequency, method of communication, emotional vs. instrumental

support, and other characteristics (e.g., known HIV status of members, HIV disclosure to members). Network characteristics were dichotomized to reflect whether a participant had a least one network member who fit a certain described characteristic (e.g., has at least one person who reminds them to take their HIV medications: Yes/No) and used in the univariate analysis because the proportions of each type of network member were skewed (Valente, 2010).

### Treatment adherence

Adherence questions were adopted from the AIDS Clinical Trials Group (ACTG) Adherence Baseline Questionnaire (Reynolds et al., 2004). Participants were asked about the last time they missed their HIV medication. Those who indicated ever missing their HIV medication were asked a subsequent series of questions regarding how often they missed taking their medications due to various reasons. Standardized scores were constructed by summing the 14 items, dividing this sum by the largest total possible, and multiplying by 100 as has been done previously (Reynolds et al., 2004). Thus, scores can range from 0 to 100, with higher scores indicating greater adherence. Internal reliability for this study was the same as for the original study (Cronbach's alpha = 0.89).

### Data analysis

Chi square, Wilcoxon-Mann-Whitney, and Spearman correlation tests were performed to examine univariate associations between treatment adherence and individual and network characteristics. Significant univariate results were included in the subsequent multivariable regression analysis. A multiplicative term was used in ordinary least squares regression to test the moderating effect of having at least one network member who reminded the participant about taking HIV medications on the relationship between depression and treatment adherence, while controlling for potential confounders (i.e., age, race/ethnicity and network size). All tests were performed at the 5% significance level using SAS 9.4.

### Results

Recruitment efforts resulted in 188 phone calls received by potential participants, the study team contacting and screening 94% ( $n = 176$ ). Of those, 98% ( $n = 172$ ) met eligibility criteria. And of those, 85% ( $n = 146$ ) completed data collection. Reasons for non-participation included: no-shows and not returning a maximum of three calls following missed appointments. Study team members

**Table 1.** Participant characteristics ( $N = 150$ ).

Characteristic	$N$ (%) or mean (SD)	Range
Age (years)	45.98 (10.13)	20–71
Less than 30 years of age	10 (6.67)	
Race/Ethnicity		
White	21 (14.00)	
Black	45 (30.00)	
Other or mixed race <sup>a</sup>	6 (4.00)	
Latino	78 (52.00)	
Sexual Orientation		
Heterosexual/straight	20 (13.51)	
Homosexual/gay	107 (72.30)	
Bisexual	21 (14.19)	
Sexual behavior in the last 12 months		
Sex with only men	112 (74.67)	
Sex with only women	11 (7.33)	
Sex with both men and women	9 (6.00)	
Has not had sex	18 (12.00)	
Men who have sex with men (MSM)	136 (90.67)	
Highest educational attainment		
9th grade or less	21 (14.00)	
10th grade/11th grade	22 (14.67)	
12th grade (high school diploma)	35 (23.33)	
More than high school	72 (48.00)	
Language in which survey was completed		
English	110 (73.33)	
Spanish	40 (26.67)	
Currently employed <sup>b</sup>	29 (19.46)	
Ever married	35 (23.97)	
Currently not married nor living with a partner	126 (84.56)	
Attends a support group	90 (60.40)	
AIDS Diagnosis	82 (55.41)	
Ever skipped taking HIV medication	95 (65.52)	
ACTG adherence score ( $\alpha = 0.89$ )	71.88 (21.19)	11.90–100
CES-D 10 score ( $\alpha = 0.83$ )	12.17 (6.51)	0–26
Presence of significant depressive symptoms <sup>c</sup>	90 (60.40)	

<sup>a</sup>Includes Asian and Native American.

<sup>b</sup>Includes part- and full-time employment.

<sup>c</sup>Having a CES-D 10 score of 10 or higher.

received four additional referrals on-site at community-based organizations, resulting in a final sample of 150 HIV-positive MSM.

The average age of men in the sample was 46 years (SD = 10.13, range = 20–71). More than half self-identified as Latino (52.00%), 30.00% as Black, 14.00% White, and 4.00% as other or mixed race (e.g., Asian, Native American). Based on sexual behavior in the last 12 months and sexual orientation, the majority of participants were classified as MSM (90.67%). Nearly three-quarters had at least a high school education (71.33%). However, less than a quarter currently held any part- or full-time employment (19.46%). More than a quarter completed the survey in Spanish (26.67%); just over half had received an AIDS diagnosis (55.41%). The mean CES-D score was 12.17 (SD = 6.51,

range = 0–26), with 60.40% of the sample reporting a score of 10 or greater. Nearly two-thirds indicated “ever skipped taking HIV medication” (65.52%). The average ACTG adherence score was 71.88 (SD = 21.19, range = 11.90–100). See Table 1 for additional participant characteristics.

The mean network size was 9.91 (SD = 6.53, range = 1–33), and the mean network density was 0.34 (SD = 0.21, range = 0–0.89). In the last month, participants spent time with about two-thirds of their social network in-person (67.98%) and communicated with more than half at least once a week (58.20%). Participants used their phones to speak with nearly two-thirds (64.41%) of their social network in the last month (including video chat services, such as Skype) and to write to more than a third (40.43%) of their social network

**Table 2.** Characteristics of participants' networks ( $N = 150$ ).

	Mean (SD)	Mean proportion (SD)	Range
Network size	9.91 (6.53)		1–33
Network density	0.34 (0.21)		0–0.88
Average age (years)	44.39 (7.64)		23.00–67.00
Relationship length (years)	12.76 (8.33)		0.01–44.00
Relationship type			
Friend		0.68 (0.31)	0.00–1.00
Caseworker/social worker/therapist/agency staff		0.18 (0.19)	0.00–1.00
Doctor or nurse		0.08 (0.10)	0.00–0.67
Clergy member		0.03 (0.10)	0.00–0.67
Romantic partner		0.08 (0.14)	0.00–1.00
Family member			
Sibling		0.10 (0.14)	0.00–1.00
Parent		0.03 (0.07)	0.00–0.33
Child		0.006 (0.03)	0.00–0.25
Extended family member		0.06 (0.10)	0.00–0.50
Acquaintance		0.05 (0.12)	0.00–0.67
Co-worker		0.02 (0.06)	0.00–0.35
HIV-positive		0.28 (0.24)	0.00–1.00
Lesbian, gay or bisexual		0.46 (0.30)	0.00–1.00
Disclosed HIV status to		0.82 (0.29)	0.00–1.00
Actively hid HIV status from		0.13 (0.24)	0.00–1.00
In last month:			
Spent time with in person		0.68 (0.31)	0.00–1.00
Talked using the phone <sup>a</sup>		0.64 (0.32)	0.00–1.00
Communicated via writing using the phone <sup>b</sup>		0.40 (0.36)	0.00–1.00
Talked with over the computer <sup>c</sup>		0.12 (0.26)	0.00–1.00
Communicated via writing using the computer <sup>d</sup>		0.24 (0.34)	0.00–1.00
Communicates with at least once a week		0.58 (0.30)	0.00–1.00
Emotional support			
Makes feel liked or loved		0.60 (0.34)	0.00–1.00
Makes feel respected or admired		0.64 (0.35)	0.00–1.00
Would agree with actions or thoughts		0.56 (0.36)	0.00–1.00
Would confide in		0.55 (0.33)	0.00–1.00
Would go to for advice about a problem		0.51 (0.34)	0.00–1.00
Would tell if disagreed with actions or thoughts		0.54 (0.35)	0.00–1.00
Instrumental support			
Reminds about taking HIV Medication		0.19 (0.28)	0.00–1.00
Has ever taken to doctor or other HIV-related appointment		0.12 (0.19)	0.00–1.00
Would help with housework, cooking, or groceries if needed		0.32 (0.28)	0.00–1.00
Would lend \$100 for immediate help		0.30 (0.28)	0.00–1.00
Would help care for children and/or pets if needed		0.25 (0.26)	0.00–1.00
Would provide support if confined to bed for several weeks		0.44 (0.32)	0.00–1.00

<sup>a</sup>Includes FaceTime, voice-to-voice.

<sup>b</sup>Includes Facebook, chat rooms, dating sites, e-mail, text.

<sup>c</sup>Includes Skype, video chat.

<sup>d</sup>Includes Facebook, chat rooms, dating sites, e-mail.

members (e.g., texting, Facebook, email). Participants also used computers to speak with (11.65%) and write to (24.47%) individuals in their social networks (Table 2).

More than two-thirds of participants' social networks were comprised of friends (68.33%); 18.05% were case-workers, social workers, or therapists; 7.70% were doctors or nurses; 3.12% were members of the participant's religious community; and 7.52% were romantic partners. Family made up smaller proportions of participants' social networks compared to other relationship types (9.57% siblings, 5.83% extended family members, 3.45% parents, 0.60% children). Participants reported that 28.10% of their social networks members were HIV-positive and that half were lesbian, gay, or bisexual (45.94%). Additionally, participants disclosed their HIV status to more than three-quarters of their social networks (81.53%), but actively hid their status from 12.81% (Table 2).

Table 3 provides the results from the univariate analyses. Older age (30 years of age or older), Black race/ethnicity, and greater depressive symptoms (higher CES-D 10 scores) were associated with worse adherence (lower ACTG scores). No direct univariate associations were found between the proportion of each network member type and ACTG adherence score.

Figure 1 illustrates the moderating effect of having at least one network member who reminded the participant to take his HIV medications on the relationship between depression and treatment adherence; Table 4 highlights results from the multivariable regression analysis. Although network size was not significant in the univariate analyses, it was included in the final model to account for varying network sizes among participants, which ranged from 1 to 33. Controlling for covariates, adherence scores among younger participants were 23.55 points higher on average ( $p < 0.05$ ) than older participants (>30 years). Black participants had adherence scores that were 9.09 points lower on average compared to participants of other racial/ethnic groups ( $p < 0.05$ ). Among those who did not have at least one individual in their social network to remind them to take their HIV medication, each one-unit increase in the depression score was associated with a 1.61-point reduction in the treatment adherence score ( $p < 0.05$ ). After controlling for age, race/ethnicity and network size, there was a significant interaction effect between depressive symptoms and having at least one network member who reminded the participant about taking HIV medication ( $p < 0.05$ ). That is, the difference in treatment adherence scores between those with and without network support for medication adherence becomes 1.31 points greater with each one-unit increase in depression scores on average ( $p < 0.05$ ).

**Table 3.** Univariate associations between ACTG adherence score and participant characteristics ( $N = 150$ ).

Characteristic	<i>r</i> or mean (SD)	<i>p</i> -value
Age (years)	0.13	0.2015
Less than 30 years of age*		0.0259
Yes	88.89 (12.11)	
No	70.74 (21.22)	
Race/Ethnicity		
White	81.29 (18.51)	0.0579
African American/Black*	65.95 (20.09)	0.0225
other or mixed race <sup>a</sup>	68.57 (25.44)	0.3932
Hispanic	73.70 (21.62)	0.3275
Men who have sex with men (MSM)		0.9248
Yes	71.92 (20.91)	
No	71.43 (25.14)	
Highest educational attainment		0.1476
Less than a high school education	65.96 (23.85)	
High school education or more	74.19 (19.76)	
Language in which survey was completed		0.8438
English	71.75 (24.21)	
Spanish	71.90 (20.75)	
Currently employed <sup>b</sup>		0.2865
Yes	77.50 (15.13)	
No	70.39 (22.36)	
Ever married		0.2115
Yes	76.53 (20.50)	
No	70.22 (21.50)	
Currently not married but living with a partner		0.0655
Yes	61.90 (24.27)	
No	73.66 (20.14)	
Attends a support group		0.3063
Yes	74.51 (18.77)	
No	68.64 (24.02)	
AIDS diagnosis		0.2772
Yes	73.57 (21.89)	
No	70.03 (20.49)	
CES-D 10 score ( $\alpha = 0.83$ )*	-0.29	0.0035
Presence of significant depressive symptoms <sup>c</sup>		0.1758
Yes	69.82 (21.39)	
No	75.63 (20.60)	
Overall social support score ( $\alpha = 0.95$ )	0.16	0.1238
Family social support score ( $\alpha = 0.93$ )	0.11	0.2877
Friend social support score ( $\alpha = 0.94$ )	0.16	0.1230
Significant other social support score ( $\alpha = 0.90$ )	0.15	0.1476
Network size	0.13	0.1937
Network density	0.08	0.4339

<sup>a</sup>Includes Asian and Native American.

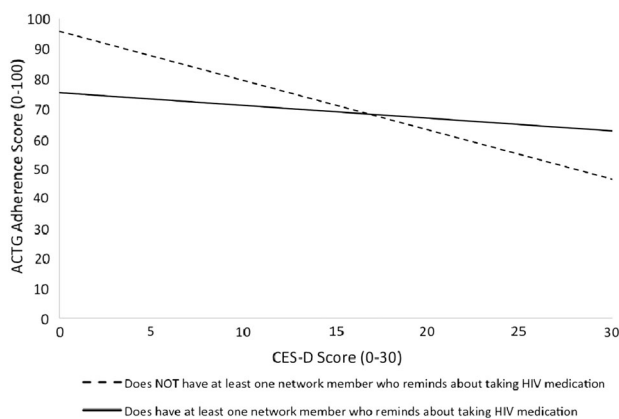
<sup>b</sup>Includes part- and full-time employment.

<sup>c</sup>Having a CES-D 10 score of 10 or higher.

\* $p < 0.05$ .

## Discussion

This study sought to understand the structure of HIV-positive men's social networks and its impact on the relationship between depression and ART adherence. Our sample was predominantly comprised of MSM of color, a population with significant "drop offs" at each step in the HIV treatment cascade (Centers for Disease Control and Prevention, 2012). In Los Angeles County, the most recent data on the HIV continuum of care indicates that 47% of Black MSM and 51% of Latino MSM achieve viral suppression, compared to 57% of White and 58% Asian MSM (Rock Wohl, 2015). Our findings provide key insights for the development of adherence interventions for HIV-positive MSM of color, a key target population for reducing HIV-related health disparities



**Figure 1.** Moderating effect of having at least one network member who reminds about taking HIV medication on the relationship between depression and treatment adherence ( $N = 96$ ).

(The White House, 2015) and contribute to a growing body of literature on the role of social networks, mental health, and technology in the lives of HIV-positive people (Horvath et al., 2012; Horvath, Alemu, Danh, Baker, & Carrico, 2016; K. J. Horvath et al., 2013; Muessig, Nekanti, Bauermeister, Bull, & Hightow-Weidman, 2015).

As reflected by treatment adherence scores, nearly two thirds of the men in our study reported missing doses of their HIV medication. Skipping doses of ART can have serious negative consequences at the individual and community level. For individuals, missed doses can lead to drug resistance and treatment failure (Bangsberg et al., 2001; Sethi, Celentano, Gange, Moore, & Gallant, 2003); in addition, spikes in viral load have been linked to greater odds of forward transmission (McNabb et al., 2001). There are a range of interventions aimed at improving ART adherence (Simoni, Pearson, Pantalone, Marks, & Crepaz, 2006), some of which are tailored specifically for MSM (Horvath et al., 2013). However, few of these interventions have been tailored specifically for MSM of color, a population for whom HIV incidence continues to rise (Centers for Disease Control and

Prevention, 2010; Centers for Disease Control and Prevention, 2008). Our results indicate that Black participants had worse treatment adherence compared to participants of other racial/ethnic groups. These findings underscore the need for ART adherence interventions that are culturally-tailored and strategically deployed to engage Black MSM.

Adherence becomes especially complicated with HIV-positive individuals who have depressive symptoms. A meta-analysis focused on patients who were given preventive- or treatment-related medical recommendations by a physician for a severe chronic condition (e.g., cancer, end-stage renal disease, angina, renal transplant, breast cancer, or rheumatoid arthritis) found that participants with depression were three times less likely to be 100% adherent compared to non-depressed participants (DiMatteo, Lepper, & Croghan, 2000). In our sample, depression was negatively associated with medication adherence. There are several explanations for this finding. Depression can interfere with the tasks required to remain engaged in the HIV Continuum of Care. For example, those patients suffering from comorbid depression may have difficulty mobilizing the resources necessary to schedule and keep HIV-related medical appointments, fill and refill prescriptions, and remember to take medications. A range of interventions for HIV-positive people that address depression have been implemented and evaluated with mixed success, including interventions that contain psychological, physical, and HIV-specific components (Sherr, Clucas, Harding, Sibley, & Catalan, 2011). Providers treating HIV-positive patients should regularly screen for depression (Panel on Antiretroviral Guidelines for Adults and Adolescents, 2016), assess for stigma about receiving mental health services, and make referrals to mental health providers. Integrating mental health and HIV treatment can be helpful in coordinating care and addressing barriers to adherence.

Our findings of the positive moderating influence that having a supportive network member who reminded participants to take their HIV medication had on the relationship between depression and treatment adherence underscores the importance of social support. Interventions, such as Directly Observed Therapy (DOT), have been used to ensure that HIV-positive people take their medications daily (Garvie et al., 2011; Gaur et al., 2010). Some of these interventions include a social support component, which is linked with improved medication adherence (Simoni, Frick, & Huang, 2006); however, many require paraprofessional support. Relying on peer-to-peer support for ART adherence in naturally existing social networks may be a cost-effective way of addressing treatment non-adherence among HIV-positive MSM.

**Table 4.** Multivariable regression analysis of depression on treatment adherence ( $N = 96$ )<sup>^</sup>.

Characteristic	<i>b</i> (SE)	<i>p</i> -value
Intercept	99.76 (7.01)	
Less than 30 years of age (ref = No)*	23.55 (8.27)	0.0055
Non-Hispanic African American/black (ref = No)*	-9.09 (4.24)	0.0349
Network size	-0.25 (0.28)	0.3735
CES-D 10 Score*	-1.61 (0.42)	0.0003
Has at least one network member who reminds about taking HIV medications (ref = No)*	-23.07 (8.92)	0.0113
Interaction between CES-D 10 Score and having at least one network member who reminds about taking HIV medications*	1.31 (0.63)	0.0394

\* $p < 0.05$ .

<sup>^</sup>Among those who reported ever missing taking their HIV medication.



Technology has emerged as an important tool for the treatment of HIV. In our study, participants communicated with 64% of their network members by phone, 40% of their social network members via text, and 24% of their network members via computer. These results indicate important opportunities for technology-based medication adherence support. A number of text-based interventions that provide medication reminders have been mounted (Dowshen, Kuhns, Johnson, Holoyda, & Garofalo, 2012; Pop-Eleches et al., 2011). One social media intervention used an interactive social media platform to encourage medication adherence tracking among HIV-positive men and was feasible and acceptable to users (Horvath et al., 2013). With the increasing importance of technology in everyday life, researchers and practitioners should continue to explore the ways in which new technologies may support medication adherence among HIV-positive people. There may be opportunities for linking HIV-positive patients with depressive symptoms to technology-based interventions that connect them to supportive network members who can remind them to take their medications.

### Limitations

All data relied on self-report, which may overestimate ART adherence (McNabb et al., 2001). The ART adherence scale may also underestimate nonadherence among individuals who continuously miss taking their medication for a single reason and overestimate nonadherence among those who do not miss taking their medication as frequently but do so for several reasons. Future studies should use more advanced methods of adherence tracking, such as pill counting and biomarker data on ART levels (Lehmann et al., 2014). Participants were recruited from community-based agencies and a registry of HIV-positive men interested in research, which may explain the older mean age and substantial percentage of participants with an AIDS diagnosis. As the majority of new infections in the U.S. occur among younger MSM, future research should use methods to engage younger participants, including recruiting online and through smartphone applications (Holloway et al., 2014). Last, due to potential selection bias, HIV-positive men who are most severely depressed or those with low ART adherence may be under-represented.

### Conclusion

Despite limitations, this work advances research to improve treatment adherence among MSM of color. Depression is a common comorbid condition with

HIV diagnosis (Page-Shafer, Delorenze, Satariano, & Winkelstein, 1996). HIV care providers should go beyond routine depression screenings and medication adherence referrals by including a more comprehensive assessment of emotional and instrumental support received through patients' social networks. One such resource is the presence of a supportive social network member who can remind patients to take their medication and help problem solve barriers to adherence. Our work demonstrates the importance of these supportive network members for HIV-positive MSM with depressive symptoms. Adherence reminders might come in a variety of forms. The results presented here indicate a range of technology use among HIV-positive men. Further research should focus on ways to harness social support via technology in the service of sustained medication adherence for HIV-positive MSM of color.

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