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Depression, ART Adherence, and Receipt of Case Management Services by Adults with HIV in North Carolina, Medical Monitoring Project, 2009–2013

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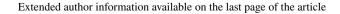
Abstract

Depression among persons with HIV is associated with antiretroviral therapy (ART) interruption and discontinuation, virological failure, and poor clinical and survival outcomes. Case management services can address needs for emotional counseling and other supportive services to facilitate HIV care engagement. Using 2009–2013 North Carolina Medical Monitoring Project data from 910 persons engaged in HIV care, we estimated associations of case management utilization with "probable current depression" and with 100% ART dose adherence. After weighting, 53.2% of patients reported receiving case management, 21.7% reported depression, and 87.0% reported ART adherence. Depression prevalence was higher among those reporting case management (24.9%) than among other patients (17.6%) ($p < 0.01$). Case management was associated with depression among patients living above the poverty level [adjusted prevalence ratio (aPR), 2.05; 95% confidence interval (CI) 1.25–3.36], and not among other patients (aPR, 1.01; 95% CI 0.72–1.43). Receipt of case management was not associated with ART adherence (aPR, 1.00; 95% CI 0.95–1.05). Our analysis indicates a need for more effective depression treatment, even among persons receiving case management services. Self-reported ART adherence was high overall, though lower among persons experiencing depression (unadjusted prevalence ratio, 0.92; 95% CI 0.86–0.99). Optimal HIV clinical and prevention outcomes require addressing psychological wellbeing, monitoring of ART adherence, and effective case management services.

Keywords Supportive services · Quality care · Unmet need · Patient adherence · HIV care

Resumen

La depresión en personas con VIH está asociada con la interrupción y descontinuación de terapia antirretroviral (TAR), fallo virológico, y resultados clínicos y de sobrevivencia deficientes. Los servicios de atención individualizada pueden abordar las necesidades de consejería emocional y otros servicios de apoyo para facilitar el enlace y cuidado del VIH. Con el uso datos del *North Carolina Medical Monitoring Project* (Proyecto del Monitoreo Médico de Carolina del Norte, MMP – por sus siglas en inglés) de 2009-2013, de 910 personas recibiendo cuidado para el VIH, estimamos asociaciones entre el uso de atención individualizada y "depresión actual probable" con 100% de cumplimiento de TAR. Después de ponderación, 53.2% de pacientes reportaron recibir atención individualizada, 21.7% reportaron depresión, y 87.0% reportaron cumplimiento con TAR. La prevalencia de depresión resultó ser más alta en aquellos reportando atención individualizada (24.9%) que en otros pacientes (17.6%) ($p < 0.01$). Hubo una asociación entre la atención individualizada y depresión en pacientes viviendo arriba del nivel de pobreza [tasa de prevalencia ajustada (aPR, 1.01; 95% intervalo de confianza (IC), 1.25-3.36], y no en otros pacientes (aPR, 1.01; 95% IC 0.72-1.43). No hubo asociación entre la recepción de atención individualizada y cumplimiento con TAR (aPR, 1.00; 95% IC 0.95-1.05). Nuestro análisis indica una necesidad para el tratamiento de depresión más efectivo, aún en personas recibiendo atención individualizada. Cumplimiento con TAR auto reportado resultó ser elevado generalmente, aunque bajo en personas enfrentando depresión (tasa de prevalencia no corregida, 0.92; 95% IC, 0.86-0.99).

Extended author information available on the last page of the article

Resultados clínicos y de prevención de VIH óptimos requieren abordar el bienestar psicológico, monitoreo de cumplimiento con TAR, y servicios de atención individualizada efectivos.

Introduction

As recently emphasized in the *U.S. National HIV/AIDS Strategy* (*NHAS*): *Updated to 2020*, prompt diagnosis of HIV infection, timely linkage to and retention in care, antiretroviral therapy (ART) adherence, and resources for unmet needs are important for effective HIV treatment and prevention. Primary NHAS goals include increasing the percentage of persons with HIV who are retained in HIV medical care to at least 90%, and increasing the percentage who are virally suppressed to at least 80% [1].

Depression, the most prevalent psychiatric disorder among persons with HIV other than substance use disorders, has important implications for patient retention, quality of life, and HIV transmission [2]. Depression prevalence among persons with HIV engaged in HIV care is 20%–30% [3], at least twice the depression prevalence in the general United States (US) population [4, 5]. Depression and depressive symptoms are associated with poorer ART adherence [6, 7], which is associated in turn with virological failure [8, 9] and poorer immunological outcomes [8], increasing the likelihood of poor health and HIV transmission [10].

One approach both to facilitating treatment of depression and to improving ART adherence is the provision of case management services [11], which have been used to decrease unmet need for supportive services and to improve HIV medical care among persons with HIV [12, 13]. Most studies assessing the effectiveness of case management for persons with HIV have described the ability of these services to increase linkage to care [14–17], ART uptake [18], and virologic suppression [19], and to decrease unmet need for emotional counseling [18]. Few studies have examined the relationship between case management services and current depression or depressive symptoms among persons with HIV [20]. In addition, the role of case management services in facilitating ART adherence has not been well established [21, 22].

In North Carolina (NC), case management services are offered to clients based on apparent need and availability of services. The services may be provided through the Ryan White HIV/AIDS Program, which provides funding for state and local programs to assist low-income persons with HIV through medical case management, oral health management, home health care, transportation assistance, hospice care, and the AIDS Drug Assistance Program (ADAP) [23]. Public health officials continue to see increases in the HIV burden among low-income residents in southern states, where financial strain, psychosocial trauma, substance use, and long travel distance to providers are correlated with a high prevalence of mental health illnesses [24]. In addition, poverty, poor healthcare infrastructures, legislative policies, and stigma contribute to the HIV burden in southern states [25]. In 2015, the HIV prevalence rate among persons living with diagnosed or undiagnosed HIV in NC was 414.1 per 100,000 person-years [26]. The rate of new HIV diagnoses in 2016 was 16.8 per 100,000 person-years in the South, compared to 11.2, 10.2, and 7.5 in the Northeast, West, and Midwest, respectively [27]. In the same year, NC ranked 6th among US states in the number of new diagnoses (n = 1414), with 16.5 per 100,000 person-years [27, 28]. Improved understanding of the relationships between case management service provision and both depression and ART adherence is needed, particularly among persons residing in NC with barriers to medical care access.

We used 2009–2013 data from the Medical Monitoring Project (MMP), a national survey of persons with HIV receiving medical care, to assess the prevalence and correlates of case management services, probable current depression, and 100% ART dose adherence in NC [29]. We also examined the associations between case management utilization and both depression and ART adherence in this setting.

Methods

Medical Monitoring Project (MMP)

MMP is a supplemental HIV surveillance system that uses a three-stage probability proportional to size sampling design to obtain nationally representative, annual cross-sectional samples of adults receiving outpatient HIV medical care in the US. The multi-stage sampling scheme and weighting procedures have been described in detail [30–32]. NC was randomly selected as one of the primary sampling units in the first sampling stage. For each of the five cycles of data we analyzed (annual cross-sections in 2009–2013), MMP first sampled outpatient facilities in NC with probability proportional to estimated patient load, and then used comprehensive lists obtained from the facilities to sample adults living with HIV aged 18 years or older who had at least one HIV medical care visit in a participating facility between January and April of the cycle year. Data were collected via face-to-face interviews between June of the cycle year and May of the subsequent year (e.g., 2009 cycle collection = June

2009–May 2010). The overall response rates for 2009–2013, combining facilities and patients and adjusting for unknown eligibility, were 39.4, 30.4, 26.3, 30.9, and 48.5%, respectively. The resulting interview data included a total of 910 respondents with HIV: 602 males (67.2%), 297 females (31.3%), 10 transgender persons (1.3%), and 1 intersex person (0.1%). Among self-identified transgender persons, data on transmen and transwomen were not available for analysis.
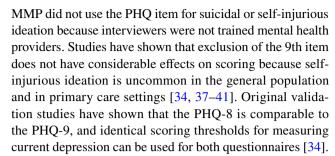
The first half of the twelve-section MMP questionnaire asked participants about demographic characteristics (including age, education status, and sexual orientation), personal experiences regarding access to HIV care, and related barriers (e.g., HIV testing and care experiences, met and unmet needs, stigma and discrimination, etc.). The second half of the questionnaire included questions on sexual behaviors, substance abuse, transmission risk factors, partners' behaviors, gynecological and reproductive history, health conditions and preventive therapy, HIV prevention activities, and depression.

Case Management Utilization, Depression, and ART Adherence

Our exposure of interest, case management utilization, was assessed based on responses to the MMP question, "During the past 12 months, did you get case management services?" There were no other survey items on case management, nor did the questionnaire provide a specific definition for case management services.

Depression, our first outcome of interest, was identified from responses on the 8-item Patient Health Questionnaire (PHQ-8) [33]. For the analysis, we coded probable current depression (*major* or *other*) based on Kroenke and Spitzer's 2002 algorithm of experiencing at least two depressive symptoms for ''more than half the days'' in the preceding 2 weeks, with at least one symptom being depressed mood or anhedonia. We defined the depression outcome as "probable current depression" (though for succinctness our results refer simply to "depression") due to the lack of diagnosis by a licensed clinician.

Kroenke and Spitzer's algorithm yields similar classifications as a total PHQ-8 score ≥ 10, which we also examined in sensitivity analyses as a second operational definition of probable current depression [33, 34]. The PHQ-8 assigns a score for the number of days in the previous 2 weeks that the respondent experienced each of the eight criteria for depression from the *Diagnostic and Statistical Manual of Mental Disorders, fourth edition* (DSM-IV) [35]. Each PHQ item is scored as 0 ("not at all" in the previous 2 weeks), 1, 2, or 3 ("nearly every day"), yielding total PHQ-8 scores between 0 and 24. Although suicide is an important problem, especially among persons living with HIV, with approximately 1 in 5 reporting suicidal ideation in the previous week [36],

MMP did not use the PHQ item for suicidal or self-injurious ideation because interviewers were not trained mental health providers. Studies have shown that exclusion of the 9th item does not have considerable effects on scoring because self-injurious ideation is uncommon in the general population and in primary care settings [34, 37–41]. Original validation studies have shown that the PHQ-8 is comparable to the PHQ-9, and identical scoring thresholds for measuring current depression can be used for both questionnaires [34].

ART adherence, our second outcome of interest, was defined as 100% ART dose adherence in the past 3 days, an AIDS Clinical Trials Group measure [42]. At the time of interview, participants were asked, "In the past 3 days, were you 100% dose adherent to your ART medicine?" ART dose was defined as either a single tablet or multiple tablets taken concurrently. If the respondent missed part of a dose, he or she was instructed to report this as a missed dose. Participants living with HIV were recorded as either 100% ART dose adherent or not 100% ART dose adherent in the past 72 hrs. on the basis of this question. In sensitivity analyses, we also analyzed ART schedule adherence, which was based on the MMP question, "In the past 3 days, were you 100% schedule adherent to your ART medicine?"

Additional Measures

Various characteristics were considered as potential correlates and/or effect measure modifiers of the associations between utilization of case management services in the previous 12 months and our two outcomes (probable current depression and 100% ART dose adherence in the past 3 days). Sociodemographic factors included age (18–29, 30–39, 40–49, ≥ 50 years), gender (men, women, transgender/intersex), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic/Latino, other), sexual orientation (heterosexual, homosexual, bisexual, other/unclassified), education (< high school, high school or equivalent, > high school), annual household income ($0–$19,999, $20,000–$39,999, $40,000–$74,999, ≥ $75,000), federal poverty level (living at or below, versus above, the poverty level, defined per 2012 standards using household income and size) [43], and health insurance (public or private, Ryan White/ADAP only, uninsured). Because NC has many rural areas requiring long travel distances to visit medical providers, we examined the need for transportation assistance services in the previous 12 months (yes/no). Behavioral factors of interest included alcohol consumption in the previous 12 months (yes/no) and current smoking status (yes/no).

Analytical Methods

MMP respondents with missing or incomplete data on case management utilization, depression, or ART adherence were

excluded from analyses using those variables. Patients not taking ART were excluded from the denominator for adherence percentages. The distributions of sociodemographic and behavioral variables, utilization of case management services in the previous 12 months, probable current depression, and 100% ART dose adherence in the past 3 days were summarized with unweighted counts and weighted percentages. All variables were coded as dichotomous, nominal, or ordinal categorical. Bivariable associations of sociodemographic and behavioral characteristics with (1) case management utilization in the previous 12 months, (2) probable current depression, and (3) 100% ART dose adherence in the past 3 days were examined with Rao–Scott Chi square statistics that accounted for the survey design, and prevalence ratios (PRs) with 95% confidence intervals (CIs) obtained from weighted Poisson models with robust variance estimation.

We estimated the association between case management utilization in the past 12 months and each of our two outcome variables (probable current depression and 100% ART dose adherence) using weighted multivariable Poisson models with robust variance to account for any violations of the distribution assumptions. Since associations in our cross-sectional data could reflect (1) targeting of case management services with respect to prior (unmeasured) depression and ART adherence status, as well as (2) any effects of past-year case management services on current depression and ART adherence status, our interest in estimating these associations was not to infer causality between case management and our outcomes. Rather, our intent was to assess current unmet need for depression treatment and ART adherence support according to prior case management utilization, such that targets for future investigation and intervention could be identified.

In model development, all other variables (i.e., sociodemographic variables) were assessed as potential confounders or effect measure modifiers of the associations between the exposure (i.e., case management utilization) and each of the two outcomes (i.e., probable current depression, 100% ART dose adherence). We identified potential confounders of the associations between case management and both depression and ART dose adherence (separately) based on a literature review and directed acyclic graphs [44]. We assessed effect measure modification for each predictor variable in the models using a product interaction term and an adjusted Wald test with alpha = 0.15 to increase power to detect true interactions [45]. We assessed collinearity among variables using variance inflation factors; none was detected. Analyses were performed using Stata version 14 (StataCorp, College Station, TX) and SAS 9.4 (SAS Institute Inc., Cary, NC). Except where noted, all analyses incorporated the MMP-provided sample design and weights, to account for clustering, unequal selection, and nonresponse.

Results

Patient Characteristics

Adults with HIV receiving care in NC during 2009–2013 were predominantly age 40 years and older (74.8%), men (67.2%), non-Hispanic Black (61.6%), and heterosexual (59.3%) (see Table 1). Slightly more than half (54.6%) had more than a high school education. A majority (62.6%) reported a yearly household income less than $20,000; 45.5% were living at or below the poverty level [43]. Most (75.0%) reported having public or private health insurance coverage in the previous 12 months; 22.3% reported having only Ryan White/ADAP coverage, and 2.7% (n = 25) reported having no coverage. About one-fourth needed transportation assistance. A majority of patients used alcohol in the previous 12 months (64.0%) and a large minority were current smokers (43.7%). Just over half of patients (53.2%) reported using case management services in the previous 12 months. Approximately one in five patients (21.7%) experienced probable current depression, and 87.0% of patients receiving ART reported being 100% ART dose adherent in the past 3 days. A total of 8.6% of participants were not receiving ART.

Factors Associated with Case Management Utilization in Bivariable Analyses

Women were more likely to utilize case management services in the previous 12 months than were men (PR, 1.15; 95% CI 1.01–1.31), as were patients with less than a high school education (PR, 1.43; 95% CI 1.21–1.69, versus those with more education) (results not shown). Respondents living at or below the poverty level were more likely to receive case management services than those living above the poverty line (PR, 1.42; 95% CI 1.22–1.66). Patients who received assistance from Ryan White/ADAP (versus private or public insurance), needed transportation assistance in the previous 12 months, or reported current smoking were all more likely to have received case management services in the previous 12 months.

Factors Associated with Probable Current Depression in Bivariable Analyses

Women were more likely than men to be currently depressed (PR, 1.44; 95% CI 1.17–1.77), as were those living at or below the poverty level (PR, 1.59; 95% CI 1.15–2.19, versus those living above the poverty level) (see Table 2). The prevalence of depression was also greater for those who needed transportation assistance (PR, 1.66; 95% CI 1.25–2.19), as

Table 1 Sociodemographic and behavioral characteristics of participants in the North Carolina Medical Monitoring Project, 2009–2013

	Unweighted N	Weighted %[a]	95% CI[b]
Total N	910		
Age			
18–29	52	6.1	(4.1–8.1)
30–39	164	19.1	(15.4–22.7)
40–49	307	34.1	(31.0–37.2)
≥ 50	387	40.7	(36.1–45.2)
Gender			
Men	602	67.2	(63.8–70.7)
Women	297	31.3	(28.0–34.6)
Transgender	10	1.3	(0.48–2.29)
Intersex	1	0.1	(0.00–0.38)
Race/ethnicity			
Non–Hispanic White	267	29.4	(23.4–35.5)
Non-Hispanic Black	561	61.6	(54.5–68.7)
Hispanic or Latino	25	2.9	(1.7–4.1)
Other	57	6.1	(4.2–8.1)
Sexual orientation			
Heterosexual	548	59.3	(54.0–64.7)
Homosexual	283	31.6	(26.4–36.8)
Bisexual	71	8.0	(6.1–9.7)
Other/unclassified	8	1.1	(0.3–1.9)
Education			
> High school	501	54.6	(48.6–60.6)
High school or equivalent	237	26.7	(21.5–31.9)
< High school	172	18.7	(15.4–22.0)
Income (annual household)[c]			
$0–$19,999	538	62.6	(57.7–67.4)
$20,000–$39,999	174	21.3	(18.6–24.1)
$40,000–$74,999	94	11.1	(8.3–14.0)
≥ $75,000	44	5.0	(3.2–6.8)
Poverty level[c]			
Above poverty level	457	54.5	(50.2–58.9)
At or below poverty level	393	45.5	(41.1–49.8)
Health insurance (past 12 months)[c]			
Yes (Public or Private)	691	75.0	(70.9–79.0)
Uninsured (Ryan White/ADAP only)	192	22.3	(18.7–25.9)
Uninsured	25	2.7	(1.5–3.9)
Needed transportation (past 12 months)			
No	671	74.3	(71.0–77.6)
Yes	239	25.7	(22.4–29.0)
Alcohol use (past 12 months)[c]			
No	334	36.0	(31.9–40.1)
Yes	572	64.0	(60.0–68.1)
Current smoker[c]			
No	507	56.3	(51.8–60.8)
Yes	399	43.7	(39.2–48.2)
Case management services (past 12 months)[c]			
No	433	46.8	(41.4–52.2)
Yes	474	53.2	(47.8–58.6)
100% ART dose adherence (past 3 days)[c,d]			
Yes, 100% ART dose adherent	709	79.6	(77.0–82.2)

	Unweighted N	Weighted %[a]	95% CI[b]
Table 1 (continued)			
No, not 100% ART dose adherent	106	11.9	(9.2–14.5)
Not taking ART	77	8.6	(6.1–11.0)
Probable current depression[c]			
No	706	78.3	(75.2–81.4)
Yes	197	21.7	(18.6–24.8)

[a]Percentages are weighted to account for probability of selection and nonresponse

[b]95% confidence interval

[c]Frequencies do not add up to total sample size (n = 910) due to missing data

[d]ART = antiretroviral therapy

well as for current smokers (PR, 1.40; 95% CI 1.07–1.85, versus non-smokers). Persons who received case management services in the previous 12 months were 41% more likely to be depressed (PR, 1.41; 95% CI 1.09–1.83, versus persons who did not). We found no statistically significant associations between probable current depression and age, race/ethnicity, sexual orientation, education, income, health insurance status, or alcohol use (past 12 months).

Factors Associated with 100% ART Dose Adherence in Bivariable Analyses

Women were less likely than men to report 100% ART dose adherence in the past 3 days (PR, 0.92; 95% CI 0.86–0.98), as were non-Hispanic Blacks (PR, 0.92; 95% CI 0.88–0.96, versus non-Hispanic Whites) (see Table 3). Respondents with less than a high school education were 10% less likely (PR, 0.90; 95% CI 0.83–0.98) to be adherent compared to individuals with more than a high school education. Persons living at or below the poverty level were 7% less likely (PR, 0.93; 95% CI 0.87–0.99) to be adherent compared to persons living above the poverty level. Current smokers were less likely to be adherent compared to non-smokers (PR, 0.91; 95% CI 0.85–0.98). Patients reporting probable current depression were less likely to be adherent than those not experiencing probable current depression (PR, 0.92; 95% CI 0.86–0.99). We found no associations between 100% ART dose adherence in the past 3 days and age, sexual orientation, income, health insurance status, need for transportation assistance (past 12 months), or alcohol use (past 12 months).

Multivariable Associations Between the Exposure and Outcomes of Interest

We found poverty level to be a significant effect measure modifier of the association between case management utilization in the previous 12 months and probable current depression (Wald p-value = 0.02; N = 58 respondents were missing data on poverty). After adjustment for gender, sexual orientation, education, annual household income, health insurance status, and need for transportation assistance, utilization of case management services in the previous 12 months was associated with probable current depression among persons living above the poverty level (adjusted prevalence ratio [aPR], 2.05; 95% CI 1.25–3.36), but not among those living at or below the poverty level (aPR, 1.01; 95% CI 0.72–1.43) (N = 842; 10 participants were missing data on case management utilization and/or probable current depression) (see Table 4). Similar associations were obtained in sensitivity analyses where depression was defined as a PHQ-8 score ≥ 10 (aPR, 2.05; 95% CI 1.31–3.20 for above poverty level; aPR, 0.91; 95% CI 0.64–1.30 for at or below poverty level).

Adjusted for gender, race/ethnicity, education, annual household income, poverty level, health insurance status, need for transportation assistance (past 12 months), and probable current depression, 100% ART dose adherence did not differ between those who did or did not receive case management services in the past 12 months (aPR, 1.00; 95% CI 0.95–1.05), nor did 100% ART schedule adherence (aPR, 1.01; 95% CI 0.95–1.08) (N = 812; 21 participants were missing data on case management utilization and/or ART adherence, and 77 were not taking ART).

Discussion

The Southern region of the US has disproportionately high HIV infection rates [46] and greater political, societal, and structural barriers to optimal clinical outcomes and prevention of HIV transmission [25]. This study is one of the first to report prevalence estimates of case management utilization, current depression, and ART adherence using representative data on persons with HIV receiving HIV medical care in a southern state.

Among persons receiving HIV medical care in our setting, 53.2% reported receiving case management services in the past 12 months. It is difficult to place this estimate in context, since the only available national estimate—56.5%—was reported from the 1996–1997 HIV Cost and Services

Table 2 Probable current depression by sociodemographic and behavioral characteristics, North Carolina Medical Monitoring Project, 2009–2013

	Probable current depression		PR (95% CI)[b]	X^2 p-value[c]
	N	%[a]		
Total (N = 900)	195	21.5		
Age				
18–29	8	13.3	1.0	0.27
30–39	39	23.0	1.72 (0.70–4.26)	
40–49	73	24.4	1.83 (0.86–3.91)	
≥ 50	75	19.7	1.48 (0.69–3.17)	
Gender				
Men	115	19.1	1.0	< 0.01
Women	80	27.6	1.44 (1.17–1.77)	
Transgender/intersex	0	–	–	
Race/ethnicity				
Non-Hispanic White	63	23.2	1.0	0.76
Non-Hispanic Black	113	20.3	0.87 (0.65–1.18)	
Hispanic or Latino	6	24.7	1.07 (0.52–2.18)	
Other	13	23.9	1.03 (0.58–1.82)	
Sexual orientation				
Heterosexual	124	22.8	1.0	0.08
Homosexual	51	17.8	0.78 (0.62–0.98)	
Bisexual/other/unclassified	20	26.2	1.15 (0.79–1.68)	
Education				
> High school	98	19.8	1.0	0.39
High school or equivalent	57	23.9	1.21 (0.95–1.54)	
< High school	40	23.1	1.17 (0.78–1.74)	
Income (annual household)[d]				
$0–$19,999	131	24.6	1.0	0.07
$20,000–$39,999	31	16.7	0.68 (0.42–1.08)	
$40,000–$74,999	11	14.1	0.57 (0.31–1.03)	
≥ $75,000	7	16.5	0.67 (0.34–1.34)	
Poverty level[d]				
Above poverty level	76	16.8	1.0	< 0.01
At or below poverty level	104	26.7	1.59 (1.15–2.19)	
Health insurance (past 12 months)[d]				
Yes (public or private)	151	21.8	1.0	0.90
Uninsured (Ryan White/ADAP only)	37	20.3	0.93 (0.66–1.31)	
Uninsured	6	20.0	0.92 (0.42–2.00)	
Needed transportation assistance (past 12 months)				
No	124	18.4	1.0	< 0.01
Yes	71	30.5	1.66 (1.25–2.19)	
Alcohol use (past 12 months)[d]				
No	78	23.2	1.0	0.30
Yes	117	20.6	0.89 (0.71–1.11)	
Current smoker[d]				
No	92	18.2	1.0	0.01
Yes	102	25.6	1.40 (1.07–1.85)	
Case management services (past 12 months)				
No	77	17.6	1.0	< 0.01
Yes	118	24.9	1.41 (1.09–1.83)	

[a]Percentages are weighted to account for probability of selection and nonresponse

[b]PR (95% CI) = crude estimate of prevalence ratio and 95% confidence interval from Poisson regression

[c]p-value from Rao–Scott Chi square statistic

[d]Frequencies do not add up to total depression sample size (N = 195) due to missing data

Table 3 100% ART dose adherence in the past 3 days by sociodemographic and behavioral characteristics, North Carolina Medical Monitoring Project, 2009–2013

	100% ART dose adherence		PR (95% CI)[b]	X^2 p-value[c]
	N	%[a]		
Total (N = 812)	706	87.0		
Age				
18–29	35	86.5	1.0	0.35
30–39	124	87.1	1.01 (0.87–1.16)	
40–49	228	84.2	0.97 (0.85–1.12)	
≥ 50	319	89.3	1.03 (0.90–1.18)	
Gender				
Men	487	89.3	1.0	0.02
Women	212	82.4	0.92 (0.86–0.98)	
Transgender/intersex	7	71.1	0.80 (0.49–1.29)	
Race/ethnicity				
Non-Hispanic White	230	92.3	1.0	< 0.01
Non-Hispanic Black	420	84.6	0.92 (0.88–0.96)	
Hispanic or Latino	20	94.7	1.03 (0.92–1.15)	
Other	36	79.6	0.86 (0.75–1.00)	
Sexual orientation				
Heterosexual	415	85.5	1.0	0.25
Homosexual	232	89.2	1.04 (0.99–1.10)	
Bisexual/other/unclassified	59	88.6	1.04 (0.95–1.13)	
Education				
> High school	407	89.4	1.0	< 0.01
High school or equivalent	178	86.3	0.97 (0.91–1.02)	
< High school	121	80.5	0.90 (0.83–0.98)	
Income (yearly household)[d]				
$0–$19,999	409	85.3	1.0	0.10
$20,000–$39,999	134	85.6	1.00 (0.92–1.09)	
$40,000–$74,999	79	94.8	1.11 (1.03–1.19)	
≥ $75,000	37	91.7	1.08 (0.97–1.19)	
Poverty level[d]				
Above poverty level	375	89.6	1.0	0.02
At or below poverty level	284	83.2	0.93 (0.87–0.99)	
Health insurance (past 12 months)				
Yes (public or private)	536	87.0	1.0	0.99
Ryan White/ADAP only	163	86.8	1.00 (0.94–1.06)	
Uninsured	7	86.1	0.99 (0.78–1.25)	
Needed transportation assistance (past 12 months)				
No	531	88.0	1.0	0.25
Yes	175	84.0	0.95 (0.88–1.04)	
Alcohol use (past 12 months)[d]				
No	262	85.9	1.0	0.47
Yes	442	87.6	1.02 (0.97–1.08)	

Table 3 (continued)

	100% ART dose adherence		PR (95% CI)[b]	X^2 p-value[c]
	N	%[a]		
Current smoker[d]				
No	413	90.4	1.0	0.01
Yes	291	82.4	0.91 (0.85–0.98)	
Probable current depression[d]				
No	563	88.6	1.0	0.01
Yes	140	81.6	0.92 (0.86–0.99)	

[a]Percentages are weighted to account for probability of selection and nonresponse; ART = antiretroviral therapy

[b]PR (95% CI) = crude estimate of prevalence ratio and 95% confidence interval from Poisson regression

[c]p-value from Rao–Scott Chi square statistic

[d]Frequencies do not add up to total 100% ART dose adherence sample size (N = 706) due to missing data

Utilization Survey (HCSUS) and pertained to a shorter 6-month period prior to interview [18]. The probable current depression prevalence for persons with HIV in care in NC based on 2009–2013 MMP data was 21.7%, which is somewhat lower than the 25.6% reported from national 2009 MMP data [5]. Both estimates are about twice their corresponding estimates among the general US population [4].

As is regularly observed [5, 47–49], women were more likely than men to suffer from probable current depression. Persons with HIV in care with a need for transportation assistance were more likely to be depressed, consistent with prior studies of the relationship between mental illness and needs for supportive services [50, 51]. We found no differences in depression in relation to sexual orientation. One study reported that gay men with HIV living in non-metropolitan areas were more likely to suffer from depression, which was largely driven by social constraints [52]. We likely underestimated the proportion of persons with HIV in medical care who are men who have sex with men due to low recruitment of respondents self-identifying as homosexual. As men who have sex with men often face discrimination in health care settings, improved recruitment of these men in studies is important [53].

Among patients with incomes at or below the poverty level, both receipt of case management services and depression prevalence were higher than among patients above the poverty level, but there was no association between case management and depression. By contrast, among patients with household incomes above the poverty level, receipt of case management services and current depression were positively associated. We speculate that the association among patients above the poverty level reflects the targeting of case

Table 4 Associations between utilization of case management services and probable current depression, and 100% ART dose adherence, North Carolina Medical Monitoring Project, 2009–2013

Total (N = 842)	Probable current depression		Prevalence[a]	PR	aPR
	Yes (N)	No (N)	(%)	(95% CI)	(95% CI)[b]
Case management utilization (past 12 months)					
At or below poverty level					
Utilized case management	63	173	27.0	1.02 (0.73–1.44)	1.01 (0.72–1.43)
Did not utilize case management	41	112	26.4	1.0	1.0
Above poverty level					
Utilized case management	45	150	23.0	1.90 (1.26–2.87)	2.05 (1.25–3.36)
Did not utilize case management	31	227	12.1	1.0	1.0
Total (N = 812)	100% ART dose adherence[c]		Prevalence[a]	PR	aPR
	Yes (N)	No (N)	(%)	(95% CI)	(95% CI)[d]
Case management utilization (past 12 months)					
Utilized case management	374	64	85.6	0.97 (0.92–1.02)	1.00 (0.95–1.05)
Did not utilize case management	332	42	88.7	1.0	1.0

[a]Percentages are weighted to account for probability of selection and nonresponse

[b]Adjusted prevalence ratios (aPRs) and 95% confidence intervals (CIs) calculated using multivariable Poisson models adjusted for gender, sexual orientation, education, income, health insurance, need for transportation; analyses weighted to account for complex sample design

[c]100% ART dose adherence (past 3 days); ART = antiretroviral therapy

[d]Adjusted prevalence ratios (aPRs) and 95% confidence intervals (CIs) calculated using multivariable Poisson models adjusted for gender, race/ethnicity, education, income, poverty, health insurance, need for transportation, probable current depression; analyses weighted to account for complex sample design

management services to persons suffering from depression, whereas among those at or below the poverty line, case management services would be indicated for many reasons besides depression. In NC, persons with HIV living in poverty utilize case management services for access to medical care, food, job resources, shelter, and transportation. However, 32.3% of patients above the poverty level had yearly household incomes of $20,000 or less, so an array of unmet needs may be common for a sizeable minority of that group as well.

The prevalence of self-reported 100% ART dose adherence in the past 3 days among persons receiving care and on ART in NC was high (87.0%), and similar to the 86.0% prevalence reported using national MMP data from the 2009–2010 cycle [54]. Non-Hispanic Blacks, women, and persons living at or below the poverty level were less likely to be 100% ART dose adherent, as also seen in the national MMP data [54]. The 100% ART dose adherence prevalence estimates were similar for respondents who received case management and those who did not (aPR, 1.00; 95% CI 0.95–1.05). It is possible that appropriately targeted case management services boosted adherence among persons who would otherwise have been non-adherent, but our cross-sectional design precludes estimation of such an effect. An important qualifier is that 8.6% of patients were not taking ART, conceivably because they did not perceive a need to initiate ART, were judged likely to have poor adherence, or

were not treatment-eligible on the basis of clinical guidelines at the time of interview.

The high prevalence of depression, even among those receiving case management services, warrants public health attention and suggests the need for additional resources for case managers, or more support from providers and mental health professionals. In a previous study, a sample of HIV/AIDS case managers across NC participating in a three-month intensive case management training and adherence program reported client-level challenges to adherence such as depression, which were often associated with geographic barriers (e.g., rural residents with transportation needs) and social isolation. Several case managers felt they were not knowledgeable about adherence coordination and counseling or ART medication [55]. Meeting the mental health needs of persons with HIV requires accessible and effective mental health resources, working in coordination with case managers.

A limitation of our study is its cross-sectional design, in which history of case management utilization, probable current depression status, and ART adherence were ascertained simultaneously. The case management survey item provided no information pertaining to frequency of services or the reason they were provided, preventing us from examining the relationships between those important case management aspects and both ART adherence and depression. As noted above, if case management was

targeted to the subset of persons above the poverty level who were depressed, their depression prevalence may have declined from even higher levels but still be higher than among patients to whom case management was not provided. Among persons living at or below the poverty level, an even higher percentage of patients receiving case management might have been depressed without it. However, the cross-sectional design does not allow us to disentangle the extent to which effect estimates reflect case management targeting versus case management effects. Direct assessment of the effectiveness of case management to facilitate depression treatment and ART adherence will require prospective measurement of all three factors and appropriate analytical methods to account for time-varying relationships, repeated intra-individual measures, and bidirectional causality.

Another limitation of our study is that information was self-reported and therefore subject to potential social desirability and recall biases, particularly in the case of ART adherence reporting. Self-reported adherence is known to overestimate adherence and is the least accurate of all measures, however, it is commonly used in HIV clinical care for efficiency [56] and was used in a previous study assessing ART dose adherence using national MMP data [54]. In addition, we did not consider geographical data with respect to the participants' residences. With inconsistent quality and accessibility of health care services in the South, location information may shed light on particular barriers faced by individuals in certain geographic regions within NC [57].

Optimal HIV clinical and prevention outcomes require identifying persons with HIV, linking them to and retaining them in care, prescribing appropriate ART, maintaining adherence, and achieving and maintaining viral suppression. These processes, in turn, require addressing unmet needs and psychological wellbeing, monitoring their impacts on ART adherence, and ensuring the effectiveness of mental health and other medical services. Case management and mental health agencies must be adequately funded, monitored, and evaluated to ensure that persons in HIV care are receiving assistance to improve HIV-related health outcomes.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval The Centers for Disease Control and Prevention determined that the Medical Monitoring Project is a public health surveillance activity. MMP itself is therefore not subject to human subjects regulations including federal institutional review board review. The IRB at the University of North Carolina at Chapel Hill determined that these analyses were exempt from full review (UNC IRB #14-2675).

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