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ADHERENCE TO ANTIRETROVIRAL THERAPY AMONG HIV-INFECTED ADULTS IN THE UNITED STATES

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Abstract

National estimates of antiretroviral therapy (ART) adherence and adherence support services utilization are needed to inform efforts to improve the health of HIV-infected persons in the United States. In a nationally representative sample of HIV-infected adults receiving medical care, 86% self-reported taking all ART doses in the past 72 hours. Overall, 20% reported using adherence support services and 2% reported an unmet need for services. If all nonadherent persons not receiving adherence support and all persons with a self-perceived unmet need for adherence support accessed services, resources to support ~42,673 additional persons would be needed. Factors associated with lower adherence included younger age, female gender, depression, stimulant use, binge alcohol use, greater than once-daily dosing, longer time since HIV diagnosis, and patient beliefs. Predictors of adherence are multifactorial so multiple targeted strategies to improve adherence are warranted. Providing adherence support services to all those in need may require additional resources.

Maximizing the percentage of HIV-infected persons achieving each step of the HIV care continuum is essential for reducing morbidity and mortality and minimizing the likelihood of onward HIV transmission (Cohen et al., 2011; Hall et al., 2013). In the United States, the largest drop-offs in the HIV care continuum are retention (55% of those diagnosed are not retained in care) and viral suppression (22% of those prescribed antiretroviral therapy [ART] do not achieve viral suppression; Hall et al., 2013). As was noted by Gardner and colleagues (Gardner, McLees, Steiner, Del Rio, & Burman, 2011), adherence is a key reason for this suboptimal level of suppression. While ART adherence is extremely well studied, there are no nationally representative US estimates of adherence among HIV-infected adults in care since 1998 (Kumar & Encinosa, 2010) and, to our knowledge, no estimates of the size of the HIV-infected population that needs adherence support services. Estimating the size of the population in need of adherence support and the factors associated with nonadherence can inform resource planning and targeted adherence interventions to improve population-level health outcomes among HIV-infected persons.

Moreover, recent changes in ART prescription practices and drug development require a renewed focus on the challenges of adherence. The latest clinical guidelines for HIV care recommend offering ART to all patients regardless of CD4+ T-lymphocyte cell (CD4) count

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(Panel on Antiretroviral Guidelines for Adults and Adolescents, 2013), which may have important implications for efforts to improve adherence. As more patients are prescribed ART, there may be a corresponding increase in the number of persons in need of adherence support. In addition, adherence may be more challenging for persons with less advanced disease if feeling healthy affects their beliefs about the necessity of adherence (Gonzalez et al., 2007). Even without changes in ART prescription guidelines, decreases in mortality and a relatively stable annual number of new infections has resulted in more persons being prescribed ART for a longer duration than was seen previously. On the other hand, better-tolerated regimens with less frequent dosing are now available, which may improve adherence among HIV-infected persons. Finally, because the success of "treatment as prevention" requires adherence to ART (Celum, Hallett, & Baeten, 2013), understanding the factors associated with adherence among HIV-infected persons may have important public health benefits.

This analysis addresses the following questions: What percentage of HIV-infected adults in care in the United States self-reported adherence to all ART doses during the past 3 days? Is self-reported adherence associated with viral suppression? What factors are independently associated with adherence in this population? Finally, what percentage of people use or have an unmet need for adherence support services?

METHODS

MEDICAL MONITORING PROJECT (MMP) DESIGN AND DATA COLLECTION

The Medical Monitoring Project (MMP) is a national HIV surveillance system designed to produce representative estimates of behavioral and clinical characteristics of HIV-infected adults receiving medical care in the United States (Blair et al., 2014; Frankel et al., 2012; McNaghten et al., 2007). MMP is a complex-sample, cross-sectional survey. For the 2009 data collection cycle, US states and territories were sampled first, followed by facilities providing HIV care, and then by HIV-infected adults (persons aged 18 years and older) who had at least one medical care visit during January–April 2009 at participating facilities. Data were collected through face-to-face interviews and medical record abstractions from June 2009 through May 2010. All sampled states and territories participated in MMP: California (including the separately funded jurisdictions of Los Angeles County and San Francisco), Delaware, Florida, Georgia, Illinois (including Chicago), Indiana, Michigan, Mississippi, New Jersey, New York (including New York City), North Carolina, Oregon, Pennsylvania (including Philadelphia), Puerto Rico, Texas (including Houston), Virginia, and Washington. Of 603 facilities sampled in participating states, 461 participated in MMP (facility response rate, 76%). Most of the HIV care facilities sampled were private practices, (60%, 95% confidence interval [CI] [51, 69]), followed by hospital-based facilities (30%, CI [26, 34]) and community health centers (19%, CI [13, 25]). The remainder were clinical research facilities (10%, CI [8, 13]), state or local health department clinics (5%, CI [3, 7]), community-based service organizations (4%, CI [2, 6]), and Veterans Administration facilities (4%, CI [2, 5]). A facility could belong to multiple categories. Of the 9,338 persons sampled from participating facilities, 4,217 completed the interview and had their medical records abstracted (patient-level response rate, 51%). Patients were recruited to participate in

MMP through one of two strategies: enrollment by MMP staff or enrollment by facility staff. The strategy depended on clinic needs, project area needs, local requirements, and the number of patients selected from a given facility.

Data were weighted on the basis of known probabilities of selection at state or territory, facility, and patient levels (Harding, Iachan, Johnson, Kyle, & Skarbinski, 2013). In addition, to adjust for potential nonresponse bias, predictors of nonresponse were determined from analysis of data from all sampled facilities and 88% of sampled patients. Data were then weighted by using predictors of patient-level response, including facility size, race/ethnicity, time since HIV diagnosis, and age group (Heeringa, West, & Berglund, 2010; Särndal & Lundström, 2005). After weighting for probability of selection and nonresponse, the 4,217 participants in the 2009 MMP data collection cycle were estimated to represent a population of 421,186 (CI [378,187, 464,186) HIV-infected adults receiving medical care in the United States during January–April 2009.

ETHICS STATEMENT

In accordance with the federal human subjects protection regulations at 45 Code of Federal Regulations 46.101c and 46.102d (Protection of Human Subjects, 2009) and with the Guidelines for Defining Public Health Research and Public Health Non-Research (Centers for Disease Control and Prevention, 2010), MMP was determined by the National Center for HIV, Viral Hepatitis, STD and TB Prevention's Office of the Associate Director for Science at the Centers for Disease Control and Prevention (CDC) to be a nonresearch, public health surveillance activity used for disease control program or policy purposes. As such, MMP is not subject to human subjects regulations, including federal institutional review board (IRB) review. Participating states or territories and facilities obtained local institutional review board approval to conduct MMP if required locally. Informed consent was obtained from all interviewed participants.

ANALYTIC METHODS

In this analysis we included MMP participants who reported current ART use and provided complete information about adherence to ART dosing. This analytic sample consisted of 3,606 persons representing 362,049 HIV-infected adults receiving medical care (CI [324,252, 399,846]). We estimated the prevalence of self-reported 100% adherence to ART doses (dose adherence) in the past 3 days using AIDS Clinical Trials Group measures (Chesney et al., 2000). These questions asked about each medication the patient was prescribed at the time of interview and how often the participant missed a dose over a specified time frame. If the participant only took part of a dose, they were instructed to report this as missing the dose. A card with pictures of antiretroviral medications was used to aid recall. Additionally, participants were asked about adherence to medication schedule (schedule adherence) and, among those with special instructions for taking their medications (i.e., with food), about adherence to those instructions (instruction adherence) in the past 3 days.

We used modified Rao-Scott chi-square tests to assess the relationship between adherence and two measures of viral suppression from the medical record, (1) most recent viral load

undetectable or <= 200 copies/ml (recent viral suppression) and (2) all viral loads in past 12 months undetectable or <= 200 copies/ml (durable viral suppression). We also examined the relationship between adherence and self-reported use of, and unmet need for, adherence support services, defined for the participant as "Professional help remembering to take your HIV medicines on time or correctly." We then used multivariable logistic regression to identify factors independently associated with adherence, using a backward elimination modeling strategy with $p < 0.10$ inclusion and $p < 0.05$ retention criteria. Candidate variables for inclusion in the models are listed in Table 1, with the exception of the sexual behavior and orientation variable, which was excluded due to collinearity with gender. Stimulant use was defined as injection or noninjection use of methamphetamines, other amphetamines, cocaine, or crack. Binge drinking was defined as five or more drinks in one sitting for men and four or more drinks in one sitting for women. A dose of ART was defined as either a single tablet or multiple tablets taken concurrently. All measures were based on in person interviews, with the exception of the HIV disease stage and viral suppression variables, which were based on medical record abstraction. All analyses accounted for clustering, unequal selection probabilities, and patient and facility nonresponse. Data were weighted for nonresponse (Heeringa et al., 2010; Särndal & Lundström, 2005) and all analyses accounted for the complex sample design and unequal selection probabilities by using the survey procedures in SAS 9.3 (SAS Institute Inc., Cary, NC, USA) and SUDAAN 10.0.1 (RTI International, Research Triangle Park, NC, USA). All percentages reported are weighted to account for the complex sample design.

RESULTS

Most HIV-infected persons receiving care were 40 or older, male, had clinical or immunologic AIDS, had been HIV-diagnosed for 10 or more years, and were prescribed one daily ART dose (Table 1). Reported dose adherence was 86%, schedule adherence was 72%, and instruction adherence was 69% (Table 2). Overall, 60% reported being adherent to all three measures over the past 3 days.

Among persons with dose adherence information, all forms of self-reported adherence were associated with having a suppressed viral load at one's most recent test and with durable viral suppression over the past 12 months (Table 2). Examination of prevalence ratios indicated that dose adherence was the best predictor of recent and durable viral suppression. Persons reporting dose adherence were 25% and 33% more likely to have recent and durable viral suppression, respectively. The estimated number of dose nonadherent persons in the United States was 52,024 (CI [44,886–59,162).

In multivariable analysis, persons age 18–29 and 30–39 compared to those age 50 and older (adjusted prevalence ratio [aPR] 0.86, CI [0.79, 0.94] and aPR 0.94, CI [0.90, 0.99], respectively), women compared to men (aPR 0.96, CI [0.93, 0.99]), those who were depressed (aPR 0.96, CI [0.93, 1.00]), used stimulant drugs (aPR 0.87, CI [0.81, 0.92]), binge drank (aPR 0.90, CI [0.86, 0.94]), had more than one daily ART dose (aPR 0.95, CI [0.92, 0.98]), were bothered by side effects (aPR 0.95, CI [0.90, 0.99]), were unsure if they could take medications as directed (aPR 0.69, CI [0.61, 0.78]), were unsure if their body will become resistant to HIV medications if they do not take medications exactly as instructed

(aPR 0.94, CI [0.90, 0.99]), and were HIV-infected for more than 10 years compared to less than 5 years (aPR 0.95, CI [0.91, 0.98]) were independently less likely to report adherence to ART doses (Table 3). Dose adherence did not vary by HIV disease stage, with 85% of persons with AIDS reporting dose adherence compared to 87% of persons without AIDS and with nadir CD4 counts 200–499 cells/μL, and 83% of persons without AIDS and nadir CD4 counts ≥ 500 cells/μL ($p = 0.3433$) (Table 1).

Overall, 20% (CI [17, 23]) reported using adherence support services, 2% (CI [1, 2]) reported an unmet need for adherence support services, and 78% (CI [75, 81]) reported not using or needing adherence support services (Table 4). Use of these services was significantly associated with dose adherence ($P < 0.0001$), with 83% (CI [80, 86]) of those reporting use of adherence support also reporting 100% dose adherence. In contrast, among the group with an unmet need for adherence support, only 46% (CI [34, 59]) were dose adherent. Approximately 13% (CI [11, 15]) of those not perceiving themselves in need of adherence support services were dose nonadherent, and we estimate the number of persons in this group in the United States to be 36,167 (CI [29,956, 42,379]), or 10% (CI [9, 11]) of all HIV-infected persons taking ART. The estimated number of persons reporting an unmet need for adherence support in the United States (regardless of their reported adherence) was 6,505 (CI [4,736, 8,275]), or 2% (CI [1, 3]) of all HIV-infected persons on ART.

In all, we estimate that if all nonadherent persons not receiving adherence support and all those with a self-perceived unmet need for adherence support were referred to services, this would require resources to support approximately 42,673 (CI [36,249, 49,097]) additional persons nationally or 12% (CI [10, 13]) of all HIV-infected person in medical care on ART. Compared to those not needing additional adherence support services, the demographics of this group are similar in terms of race and sexual orientation (data not shown). However, persons in need of adherence support were more likely than those with no need for additional adherence support to be over 50, female, and diagnosed for more than 5 years (all $p < 0.05$).

DISCUSSION

Similar to other recent studies using self-reported measures (O'Connor et al., 2013; Tedaldi et al., 2012), we found that 86% of HIV-infected persons reported 100% dose adherence. However, 40% were nonadherent to at least one aspect of their regimen. All measures of self-reported adherence correlated highly with recent and durable viral suppression, but self-report of dose adherence was the most highly predictive of both recent and durable viral suppression. Recent guidelines for improving adherence recommend routine collection of self-reported adherence (Thompson et al., 2012) and tools have been developed to assist providers with implementation (Amico, Zuniga, Wilson, Gross, & Young, 2013). Regularly asking questions about missed ART doses is a simple intervention that remains a standard of care for HIV-infected persons.

Consistent with the body of literature on ART adherence (Chesney, 2003), factors found to be associated with poorer adherence fell into four broad areas: demographics (younger age, female gender), psychosocial comorbidities (depression, stimulant use, binge drinking),

regimen characteristics (dosing frequency, side effects), and patient beliefs (self-efficacy, beliefs about the need for adherence to prevent resistance). We also found poorer adherence among those who had been diagnosed with HIV for 10 or more years. Although in bivariate analysis, we found lower adherence among nonwhite persons and those with lower socioeconomic status, these associations were no longer significant in multivariate logistic regression models.

These findings suggest several areas for intervention that could improve adherence at the population level. First, with regard to demographic subpopulations more likely to be nonadherent independent of other factors associated with nonadherence, interventions that specifically address the needs of youth and women are warranted. Younger persons may have different health-related concerns and motivations than older persons (Barclay et al., 2007), which could be incorporated into adherence messages. Similarly, the issues faced by women living with HIV are different from those of men (Interagency Federal Working Group, 2013), so tailored programs for women that address these barriers may be helpful.

Addressing psychosocial comorbidities such as depression and substance use problems among patients may improve their adherence, as well as their general health and well-being. A recent meta-analysis found that treating depression enhances adherence (Sin & Dimatteo, 2014), although effective adherence interventions for HIV-infected drug users may be more challenging (Binford, Kahana, & Altice, 2012). Ensuring providers have access to case managers and appropriate referrals to mental health and substance abuse treatment may help.

Minimizing side-effects and dosing are ways providers may modify treatment regimens to support optimal adherence among their patients. Single tablet regimens have been found to be effective in improving adherence and enhancing patient quality of life (Aldir, Horta, & Serrado, 2013), and our results show that patients with once-daily dosing were more likely to be adherent.

Addressing patient beliefs about adherence and ART are also important for sustained behavior change. Regularly assessing a patient's self-efficacy about taking medications and beliefs about the consequences of nonadherence may also provide information that allows for appropriate intervention to improve adherence. The Information-Motivation-Behavioral Skills (IMB) model points to the importance of these factors for adherence and has served as the basis for several effective adherence interventions (Fisher, Amico, Fisher, & Harman, 2008; Horvath, Smolenski, & Amico, 2014). Peer-based adherence support models have also shown promise in improving adherence (Kenya, Chida, Symes, & Shor-Posner, 2011).

Finally, our finding that persons diagnosed for 10 or more years were less adherent has important implications. Given that an estimated 54% of HIV-infected persons receiving medical care have been diagnosed 10 or more years (Blair et al., 2014) and advances in treatment mean that life expectancy for HIV-infected persons can approach that of the general population, more efforts to promote adherence in persons with long-standing HIV infection may be warranted. Our results support the importance of ongoing adherence monitoring and support, even among persons with good adherence, as adherence is a dynamic behavior that may be hard for some to sustain over long periods of time.

We estimate that one in ten HIV-infected persons on ART is nonadherent and does not perceive him or herself to need professional assistance with adherence support. Providers can address this incongruity and increase knowledge about the negative effects of nonadherence by regularly integrating adherence education and support into all clinical encounters (CDC, n.d.; Thompson et al., 2012). We found that patients using professional adherence support reported high levels of dose adherence. We estimate that if all nonadherent HIV-infected persons who were not already using adherence support and those with a self-perceived unmet need for adherence support were referred to adherence support services, this would require resources to support approximately 42,673 additional persons or 12% of all HIV-infected persons on ART. Weiser and colleagues found that, while 83% of Ryan White HIV/ AIDS Program funded HIV care facilities provided onsite adherence support counseling, these services were only available at 35% of nonfunded facilities (Weiser, Beer, Do, Shah, & Skarbinski, 2012).

This analysis is subject to several limitations. Our adherence measures are self-reported, a method found to overestimate adherence; however, in this and other studies self-reported measures were associated with clinical markers such as viral load and other more objective means of assessing adherence (Chesney, 2006; Simoni et al., 2006). While we find a strong association between our measure of dose adherence in the past 3 days and the patient's most recent viral load, the measures were not necessarily contemporaneous; however, the viral load test always preceded the self-report of adherence. It is possible that if adherence and viral load were measured simultaneously the associations would be stronger than those we present. In addition, the data were collected during 2009–2010, and since then treatment guidelines have moved towards recommending ART prescription at higher CD4+ T-lymphocyte cell counts and more tolerable single tablet regimens have been developed. To the extent that this has changed the population taking ART, levels of adherence and factors associated with adherence among the current HIV patient population may be different than those identified here. However, given that an estimated 88% of HIV-infected persons receiving care were already taking ART in 2009–2010 (Blair et al., 2014) and that adherence behaviors and many of the social and psychological forces that shape them are unlikely to vary widely from year to year, we have confidence in the relevance of our findings for the present time period. Another potential limitation is that, while the data were adjusted to minimize nonresponse bias based on known characteristics of nonresponders, the possibility of residual nonresponse bias exists. Although the characteristics of our sample in terms of age, HIV disease stage, and length of time since HIV diagnosis are similar to those of all HIV diagnosed persons (CDC, 2013), it is possible that persons who did not participate in MMP may be less adherent compared to those who did participate, and the factors associated with their adherence may be different than those presented here. In addition, the precision of adherence estimates among some subpopulations, such as transgender persons, may have been limited by small sample sizes. Further, because MMP has a cross-sectional, observational design, causality cannot be determined. Finally, because the sample design does not allow for assessment of regional differences and the focus of this analysis is adherence in the United States, geographic variation in adherence and its correlates was not assessed.

CONCLUSION

These are the first national estimates of ART adherence in the post-HAART era, and were collected from a diverse, population-based sample of HIV-infected patients receiving care in a wide range of facilities with varying characteristics (e.g., small and large, urban and rural). In addition, we were able to comprehensively assess a wide range of sociodemographic, regimen, and health belief factors within this population. As such, our estimates help inform how we are doing as a nation with regard to adherence—one of the primary determinants of treatment success for HIV-infected persons and the key to maximizing the final step in the HIV care continuum—and highlight key barriers to improvements in adherence. Although CDC has identified several effective behavioral interventions that improve adherence (Charania et al., 2014), information about which interventions are most effective for which populations in specific settings is still needed (Amico & Orrell, 2013; Herbst et al., 2012). Our findings support the importance of multiple targeted strategies to improve adherence: youth- and woman-centered care; treatment of psychosocial comorbidities; promotion of less complex and more tolerable regimens; improving patients' information, motivation, and skills regarding adherence; and continued monitoring to promote consistent adherence over time.

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TABLE 1

Selected Characteristics of HIV-infected Adults Taking Antiretroviral Therapy by Self-Reported 100% Dose Adherence, Past 3 Days—Medical Monitoring Project, United States, 2009

	Total (n = 3606)			Dose Adherent (n = 3080)			Dose Nonadherent (n = 526)			
	n	**wt. col. %**	**95% CI**	***n***	**wt. row %**	**95% CI**	***n***	**wt. row %**	**95% CI**	**Rao-Scott χ^2 P value**
Age at interview (years)										
18–29	227	6	[5, 7]	176	78	[72, 84]	51	22	[16, 28]	0.0005
30–39	589	16	[15, 18]	487	82	[78, 85]	102	18	[15, 22]	
40–49	1428	40	[38, 42]	1224	86	[84, 88]	204	14	[12, 16]	
50+	1362	38	[36, 40]	1193	88	[86, 90]	169	12	[10, 14]	
Gender										
Male	2636	73	[70, 76]	2284	87	[85, 89]	352	13	[11, 15]	0.0008
Female	914	26	[22, 29]	755	83	[80, 85]	159	17	[15, 20]	
Transgender	56	2	[1, 2]	41	75	[65, 85]	15	25	[15, 35]	
Sexual orientation										
Homosexual	1515	42	[38, 47]	1315	87	[85, 89]	200	13	[11, 15]	0.2130
Heterosexual	1752	48	[43, 53]	1490	85	[83, 87]	262	15	[13, 17]	
Bisexual	282	8	[7, 9]	228	82	[79, 86]	54	18	[14, 21]	
Other/unclassified	57	2	[1, 2]	47	85	[77, 93]	10	15	[7, 23]	
Sexual behavior and orientation										
Men who have sex with men	1732	48	[43, 53]	1490	86	[84, 88]	242	14	[12, 16]	0.0038
Men who only have sex with women	873	24	[21, 26]	766	88	[85, 91]	107	12	[9, 15]	
Women who have sex with men	893	25	[22, 28]	736	82	[80, 85]	157	18	[15, 20]	
Other	108	3	[2, 4]	88	84	[78, 90]	20	16	[10, 22]	
Race/ethnicity										
Black or African American, non-Hispanic	1412	40	[31, 48]	1175	83	[81, 85]	237	17	[15, 19]	0.0558
Hispanic or Latino	770	20	[14, 25]	659	86	[83, 89]	111	14	[11, 17]	
White, non-Hispanic	1260	36	[30, 43]	1104	88	[85, 91]	156	12	[9, 15]	
Other	164	4	[4, 5]	142	88	[82, 93]	22	12	[7, 18]	
Foreign born										

	Total (n = 3606)			Dose Adherent (n = 3080)			Dose Nonadherent (n = 526)			
	n	**wt. col. %**	**95% CI**	***n***	**wt. row %**	**95% CI**	***n***	**wt. row %**	**95% CI**	**Rao-Scott χ^2 P value**
No	3147	87	[85, 89]	2683	85	[84, 87]	464	15	[13, 16]	0.3694
Yes	457	13	[11, 15]	395	87	[84, 90]	62	13	[10, 16]	
Educational attainment										
< High School	814	22	[20, 25]	670	82	[79, 86]	144	18	[14, 21]	0.0646
High School diploma or equivalent	983	27	[24, 29]	862	88	[85, 91]	121	12	[9, 15]	
> High School	1809	51	[47, 56]	1548	86	[84, 88]	261	14	[12, 16]	
Household at or below poverty guideline										
No	1962	58	[53, 62]	1707	87	[85, 89]	255	13	[11, 15]	0.0049
Yes	1539	42	[38, 47]	1284	84	[82, 85]	255	16	[15, 18]	
Homeless in past 12 months										
No	3303	92	[91, 93]	2837	86	[84, 88]	466	14	[12, 16]	0.0571
Yes	303	8	[7, 9]	243	80	[75, 86]	60	20	[14, 25]	
Incarcerated in past 12 months										
No	3431	95	[94, 96]	2940	86	[74, 88]	491	14	[12, 16]	0.0537
Yes	172	5	[4, 6]	138	80	[74, 86]	34	20	[14, 26]	
Any lapse in health coverage in past 12 months										
No	2771	77	[73, 81]	2385	86	[84, 88]	386	14	[12, 16]	0.1076
Yes	826	23	[19, 27]	688	83	[80, 86]	138	17	[14, 20]	
Meets criteria for other or major depression, past 2 weeks										
No	2721	75	[73, 77]	2376	87	[86, 89]	345	13	[11, 14]	< .0001
Yes	849	25	[23, 27]	673	80	[77, 83]	176	20	[17, 23]	
Injection or noninjection drug use										
No	2641	73	[71, 75]	2330	89	[87, 90]	311	11	[10, 13]	< .0001
Yes	956	27	[25, 29]	742	78	[74, 81]	241	22	[19, 26]	
Injection or noninjection stimulant use										
No	3232	90	[89, 92]	2810	87	[86, 89]	422	13	[11, 14]	< .0001
Yes	363	10	[8, 11]	261	70	[64, 75]	102	30	[25, 36]	
Binge drinking in past 30 days										
No	2993	84	[83, 86]	2609	88	[86, 89]	384	12	[11, 14]	< .0001

	Total (n = 3606)			Dose Adherent (n = 3080)			Dose Nonadherent (n = 526)			
	n	**wt. col. %**	**95% CI**	***n***	**wt. row %**	**95% CI**	***n***	**wt. row %**	**95% CI**	**Rao-Scott χ^2 P value**
Yes	588	16	[14, 17]	453	76	[72, 80]	135	24	[20, 28]	
One daily ART dose										
No	1489	41	[39, 44]	1225	83	[81, 85]	264	17	[15, 19]	0.0006
Yes	2109	59	[56, 61]	1848	88	[86, 90]	261	12	[10, 14]	
Bothered by side effects										
Never/rarely	2957	83	[81, 84]	2575	87	[86, 89]	382	13	[11, 14]	< .0001
More than half the time	629	17	[16, 19]	488	78	[73, 82]	141	22	[18, 27]	
How sure can take medicine as directed										
Not at all/somewhat	233	7	[5, 8]	121	53	[47, 60]	112	47	[40, 53]	< .0001
Very/extremely	3372	93	[92, 95]	2958	88	[87, 89]	414	12	[11, 13]	
Sure medication positive effect on health										
Not at all/somewhat	434	12	[11, 14]	332	77	[73, 83]	102	23	[18, 27]	< .0001
Very/extremely	3157	88	[86, 89]	2735	87	[85, 88]	422	13	[12, 15]	
Sure that if do not take medications as instructed body will become resistant										
Not at all/somewhat	651	19	[17, 21]	507	79	[75, 82]	144	21	[18, 25]	< .0001
Very/extremely	2900	81	[79, 83]	2530	87	[86, 89]	370	13	[11, 14]	
Satisfaction with social support										
Very/somewhat dissatisfied	412	12	[11, 14]	328	81	[76, 86]	84	19	[14, 24]	0.0095
Very/somewhat satisfied	3079	88	[86, 89]	2659	86	[85, 88]	420	14	[12, 15]	
Time since HIV diagnosis (years)										
< 5	735	21	[19, 23]	656	89	[86, 91]	79	11	[9, 14]	0.0419
5–9	857	24	[22, 26]	733	86	[82, 89]	124	14	[11, 18]	
10+	2012	55	[53, 58]	1689	84	[82, 86]	323	16	[14, 18]	
HIV disease stage										
AIDS or nadir CD4+ 0–199	2630	72	[70, 74]	2236	85	[84, 87]	394	15	[13, 16]	0.3433
No AIDS and nadir CD4 + 200–499	790	23	[21, 25]	687	87	[84, 91]	103	13	[9, 16]	
No AIDS and nadir CD4 + >500	180	5	[4, 7]	152	83	[78, 89]	28	17	[11, 22]	

Notes. Wt., weight; CI, confidence interval; CD4, CD4+ T-lymphocyte count in cell/μL.

TABLE 2

Association Between Self-Reported Dose, Schedule, and Instruction Adherence and Recent and Durable Viral Suppression—Medical Monitoring Project, United States, 2009

	Total (*n* = 3606)			Most recent viral load < 200 (*n* = 2868)					All viral load < 200 past year (*n* = 2324)				
	***n*/N**	**wt. col. %**	**95% CI**	***n*/N**	**wt. row %**	**95% CI**	**PR**	**95% CI**	***n*/N**	**wt. row %**	**(95% CI)**	**PR**	**95% CI**
Dose adherent													
Yes	3080/3606	86	[84, 87]	2524/2868	82	[79, 85]	1.25**	[1.16, 1.36]	2056/2324	66	[64, 69]	1.33**	[1.17, 1.51]
No	526/3606	14	[13, 16]	344/2868	65	[59, 71]	Ref.		268/2324	50	[43, 57]	Ref.	
Schedule adherent													
Yes	2574/3598	72	[70, 74]	2124/2862	83	[80, 86]	1.17**	[1.12, 1.24]	1747/2319	68	[65, 71]	1.27**	[1.15, 1.39]
No	1024/3598	28	[26, 30]	738/2862	71	[67, 75]	Ref.		572/2319	54	[49, 59]	Ref.	
Instruction adherent													
Yes	1654/2399	69	[67, 71]	1308/1868	79	[76, 82]	1.06*	[1.00, 1.11]	1062/1503	64	[61, 68]	1.10*	[1.02, 1.18]
No	745/2399	31	[29, 33]	560/1868	75	[70, 80]	Ref.		441/1503	59	[54, 63]	Ref.	
Dose, schedule, and instruction adherent													
Yes	2109/3516	60	[58, 62]	1744/2793	83	[80, 86]	1.12**	[1.08, 1.16]	1435/2257	68	[65, 71]	1.19**	[1.11, 1.27]
No	1407/3516	40	[38, 42]	1049/2793	74	[70, 78]	Ref.		822/2257	57	[53, 61]	Ref.	

Notes. All adherence measures refer to 100% adherence in the past 3 days; wt., weight; CI, confidence interval; PR, prevalence ratio.

Ref., referent.

* $p < .05$

** $p < .001$

TABLE 3

Factors Associated With Self-Reported 100% Antiretroviral Dose Adherence, Past 3 Days—Medical Monitoring Project, United States, 2009

	PR	CI	aPR	CI
Age at interview (years)				
18–29	0.89	[0.82, 0.95]	0.86	[0.79, 0.94]
30–39	0.93	[0.89, 0.98]	0.94	[0.90, 0.99]
40–49	0.98	[0.95, 1.01]	0.99	[0.97, 1.02]
50+	Ref.		Ref.	
Gender				
Male	Ref.		Ref.	
Female	0.95	[0.93, 0.98]	0.96	[0.93, 0.99]
Transgender	0.86	[0.75, 0.99]	0.93	[0.83, 1.05]
Race/ethnicity				
Black or African American, non-Hispanic	0.94	[0.9, 1.00]		
Hispanic or Latino	0.98	[0.93, 1.03]		
White, non-Hispanic	Ref.			
Other	1.00	[0.92, 1.09]		
Educational attainment				
< High School	0.96	[0.92, 1.00]		
High School diploma or equivalent	1.02	[0.98, 1.08]		
> High School	Ref.			
At or below poverty guideline				
No	Ref.			
Yes	0.96	[0.93, 0.99]		
Homeless in past 12 months				
No	Ref.			
Yes	0.93	[0.86, 1.00]		
Incarcerated in past 12 months				
No	Ref.			
Yes	0.93	[0.85, 1.01]		
Meets criteria for other or major depression, past 2 weeks				

	PR	CI	aPR	CI
No	Ref.		Ref.	
Yes	0.92	[0.88, 0.95]	0.96	[0.93, 1.00]
Injection or noninjection stimulant use				
No	Ref.		Ref.	
Yes	0.80	[0.73, 0.87]	0.87	[0.81, 0.92]
Binge drinking in past 30 days				
No	Ref.		Ref.	
Yes	0.87	(0.82-0.91)	0.90	(0.86-0.94)
One daily ART dose				
No	0.94	[0.91, 0.98]	0.95	[0.92, 0.98]
Yes	Ref.		Ref.	
Bothered by side effects				
Never/rarely	Ref.		Ref.	
More than half the time	0.89	[0.84, 0.95]	0.95	[0.90, 0.99]
How sure can take medicine as directed				
Not at all/somewhat	0.61	[0.54, 0.69]	0.69	[0.61, 0.78]
Very/extremely	Ref.		Ref.	
Sure medication positive effect on health				
Not at all/somewhat	0.89	[0.84, 0.94]		
Very/extremely	Ref.			
Sure that if do not take medications as instructed body will become resistant				
Not at all/somewhat	0.90	[0.86, 0.94]	0.94	[0.90, 0.99]
Very/extremely	Ref.		Ref.	
Satisfaction with social support				
Very/somewhat dissatisfied	0.93	[0.88, 0.99]		
Very/somewhat satisfied	Ref.			
Time since HIV diagnosis [years]				
< 5	Ref.		Ref.	
5–9	0.96	[0.93, 1.00]	0.97	[0.93, 1.00]
10+	0.95	[0.92, 0.99]	0.95	[0.91, 0.98]

Notes. PR, prevalence ratio; CI, confidence interval; aPR, adjusted prevalence ratio; Ref., referent; ART, antiretroviral therapy

TABLE 4

Association Between Self-Reported Dose Adherence and Use and Perceived Need for Adherence Support Services—Medical Monitoring Project, United States, 2009

Adherence Support Services	Adherence	*n*	wgt. %	95% CI	Estimated pop. size	95% CI	% of total pop. taking ART	95% CI
Use	Total	760			72395	[62796, 81994]	20	[17, 23]
	Adherent	629	83	[80, 86]	60021	[51728, 68314]	17	[14, 19]
	Nonadherent	131	17	[14, 20]	12375	[9851, 14899]	3	[3, 4]
Unmet need	Total	66			6505	[4736, 8275]	2	[1, 3]
	Adherent	30	46	[34, 59]	3023	[1988, 4058]	1	[1, 1]
	Nonadherent	36	54	[41, 66]	3482	[2150, 4814]	1	[1, 1]
No use or need	Total	2779			283092	[247801, 318382]	78	[75, 81]
	Adherent	2420	87	[85, 89]	246924	[214955, 278894]	68	[65, 71]
	Nonadherent	359	13	[11, 15]	36167	[29956, 42379]	10	[9, 11]

Notes. Dose adherent refers to 100% adherence in the past 3 days; wgt., weight; CI, confidence interval; pop., population.