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Retention in Care is More Strongly Associated with Viral Suppression in HIV-Infected Patients with Lower versus Higher CD4 Counts

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Abstract

Background—Retention in care is important for all HIV-infected patients, but may be more important for people with advanced HIV disease. We evaluated whether the association between retention in care and viral suppression differed by HIV disease severity.

Methods—A repeated cross-sectional analysis (2006–2011) involving 35,433 adults at 18 U.S. HIV clinics. Multivariable logistic regression models examined associations between retention measures (HRSA retention measure, 6-month gap, and 3-month visit constancy) and viral suppression (HIV-1 RNA <400 copies/mL) for HIV disease severity groups defined by CD4 count: <200, 201–350, 351–500, and >500 cells/mm³.

Results—Overall, patients met the HRSA measure in 84% of person-years, did not have a 6-month gap in 76%, and had visits in all 4 quarters in 37%; patients achieved viral suppression in 72% of person-years. The association between retention in care and viral suppression differed by disease severity, and was strongest for patients with lower CD4 counts: <200 [adjusted odds ratio=2.33, 95% confidence interval 2.16–2.51], 201–350 [1.96, 1.81–2.12], 351–500 [1.65, 1.53–1.78], and >500 cells/mm³ [1.22, 1.14–1.30] using the HRSA retention measure as a representative example.

Conclusions—This is one of the first studies to report the impact of HIV disease severity on retention in care and viral suppression, demonstrating that retention in care is more strongly associated with viral suppression in patients with lower CD4 counts. These results have important implications for improving the health of patients with advanced HIV disease and for test and treat approaches to HIV prevention.

Keywords

retention in care; engagement in care; retention measures; viral suppression; HIV disease severity; CD4 count

Introduction

To fully benefit from antiretroviral therapy (ART), HIV-infected individuals must be aware of their infection, link to and consistently engage in care, and receive and adhere to HIV treatment.^{1,2} Retention in HIV care is a critical step in this process, associated with improved survival, decreased HIV-related complications, and reduced HIV transmission to others.^{3–13} These benefits, in part, are due to the strong relationship between retention in care and HIV viral suppression.^{14–17}

Multiple studies indicate that patients retained in care are more likely to achieve viral suppression compared to those not engaged in regular care.^{14–17} Among 2,197 South Carolina HIV-infected residents entering care between 2004 and 2007, 50% were retained in care. Patients retained in care had a greater decrease in HIV viral load from baseline compared to those with suboptimal retention in care.¹⁶ Likewise, among 8,235 patients followed for 12 months at 6 academic HIV clinics, retention in care, regardless of the measure used, was significantly associated with viral suppression.¹⁴

However, prior studies did not account for HIV disease severity, as measured by CD4 count. It is unclear whether retention in care is more strongly associated with viral suppression in

patients with lower versus higher CD4 counts. Retention in care is potentially more important for medication adherence in people with lower CD4 counts, who may have higher pill burdens and greater chances for drug toxicity related to treatment of opportunistic infections and other HIV complications.^{18,19} Alternatively, patients with higher CD4 counts, who may experience minimal symptoms related to their HIV infection, may require more consistent engagement in care to promote high levels of adherence to therapy.²⁰ This study extends prior research by evaluating whether the association between retention in care and viral suppression differs among patients with different disease severity.

Methods

Study Sample and Data Collection

We conducted a series of annual cross-sectional analyses using data from the HIV Research Network (HIVRN), a consortium of 22 clinics that provide care to HIV-infected patients.^{21,22} Data were abstracted from medical records at each site and sent to a data coordinating center after personal identifying information was removed. After quality control and verification, data were combined across sites to produce a uniform database. The study was approved by Institutional Review Board at the Johns Hopkins School of Medicine and at each participating site.

Data from 18 sites, located in the Northeastern (8), Midwestern (1), Southern (5), and Western (4) United States, were included in this analysis. The remaining four HIVRN sites discontinued participation or did not provide complete data during the study period. Adult patients (age ≥ 18 years) with at least one primary HIV outpatient visit and one CD4 test in any calendar year between January 1, 2006 and December 31, 2010 were eligible for inclusion.

Retention Measures

We applied three previously described measures of retention for each patient in every calendar year included in the analysis.²³ First, the U.S. Health Resources and Services Administration HIV/AIDS Bureau (HRSA HAB) medical visits performance measure dichotomously defines retention as having 2 or more outpatient visits separated by ≥ 90 days during a calendar year.²⁴ Second, the 6-month gap in care measure reflects whether a patient had ≥ 6 months between sequential outpatient visits, with no gap signifying retention in care. Patients were also coded as having a gap if there were no outpatient visits in the last six months of a calendar year. Third, 3-month visit constancy, an ordinal measure, is the number of 3-month intervals in a calendar year in which a patient completes at least 1 outpatient visit (range, 1–4). Outpatient visits refer only to primary HIV care appointments made to HIVRN clinics and do not include nursing, pharmacy, laboratory, or other types of visits.

Outcome Variable

HIV viral suppression was the binary outcome of interest, categorized as suppressed (HIV-1 RNA ≤ 400 copies/mL) and not suppressed (HIV-1 RNA > 400 copies/mL). We used the last HIV-1 RNA value reported in each calendar year. Earlier studies focused on test results reported in a window 120 days prior to the end of a calendar year.¹⁴ Overall, 69% of values occurred in the 120-day window. Because many patients only had HIV-1 RNA tests prior to this window, we included an indicator variable in analyses reflecting whether the last test occurred earlier than Sept 2 in a calendar year.

Sociodemographic and Clinical Variables

For each year of observation, patients' age as of January 1 was divided into four groups: 18–29, 30–39, 40–49, and over 50 years old. Race/ethnicity was categorized as non-Hispanic White, non-Hispanic Black, Hispanic, and other/missing. HIV transmission risk factor was grouped into men who had sex with men (MSM), heterosexual transmission (HET), injection drug use (IDU), and other/missing. Patients who had IDU in combination with another risk factor (e.g. MSM, heterosexual transmission) were classified as IDU. Insurance coverage in each year was categorized as private, Medicaid, Medicare (including dual eligibles), uninsured, or other/missing. Patients whose care was funded by Ryan White, those recorded as self-pay, and those covered by local governmental programs were classified as uninsured. Patients were considered to be on ART if they concomitantly received 3 antiretroviral drugs during the calendar year. First CD4 count recorded in each calendar year was grouped as 200, 201–350, 351–500, and > 500 cells/mm³.

Statistical Analyses

The patient-year was the unit of analysis, reflecting the common practice of measuring retention in care and viral suppression on a calendar year basis.²⁴ Analyses were limited to patient-years in which the patient was at least 18 years old and in care, defined as having at least one primary HIV outpatient visit and one CD4 test in the year. We excluded 1,368 patient-years in which individuals died, as they did not provide adequate time to measure retention and the outcome. Of the 123,991 patient years between 2006–2011 that met inclusion criteria, 1,968 (1.6%) had no HIV-1 RNA test reported; these observations were also removed from analyses.

Because the HRSA HAB medical visits and 6-month gap in care measures require at least six months of observation, we excluded data for 8,263 patient-years for those who enrolled at HIVRN clinics between July and December of their first calendar year in care; data for subsequent years were included for these patients. Moreover, the 3-month visit constancy measure cannot be applied to patients without four calendar quarters of data; therefore, for analyses using this variable, we excluded the first calendar year in care for an additional 4,562 patient-years (total = 12,825) in which persons entered care at HIVRN clinics after March. Thus, analyses using the HRSA HAB or the 6-month gap measures incorporated 113,760 patient-years from 35,433 persons; analyses using the 3-month visit constancy measure incorporated 109,198 patient-years for 33,439 persons. Eighteen percent of the larger sample contributed one year of data to the analyses, 62% between 2 and 6 years, and 20% all 7 years.

Standard descriptive analyses of demographic and clinical characteristics of the sample were conducted using the larger sample of 113,760 person-years. Because viral suppression was a binary outcome, multivariable logistic regression models were used to estimate the association between each measure of retention and viral suppression, adjusting for CD4 group as well as time of HIV-1 RNA measurement, age, sex, race/ethnicity, HIV transmission risk factor, insurance, and use of ART. Separate models were estimated for each retention measure. To evaluate whether the association between retention in care and viral suppression differed for patients with different disease severity, we included interaction terms between CD4 group and each measure of retention. All models adjusted for calendar year to account for any changes in clinic policies or treatment guidelines during the study period. In addition, we adjusted for differences in the odds of viral suppression across sites by including indicator variables for each site. All covariates were treated as categorical to allow a flexible specification for their association with the odds of viral suppression.²⁵ Generalized estimating equations with a robust variance estimator and an exchangeable correlation structure were used to account for repeated measures of individuals over time.²⁶

Statistical analyses were performed using Stata 12.1 (Stata Corporation, College Station, TX).

Results

A total of 35,433 unique adult patients received care at 18 HIVRN sites between 2006 and 2011. (Table 1) Yearly sample size increased from 16,594 patients in 2006 to 22,237 patients in 2011. The proportion of patients who were 50 years or older increased from 26% in 2006 to 36% in 2011. Distributions of sex and race/ethnicity were stable over time, with the majority of patients being male and of minority race/ethnicity. MSM and HET were the predominant HIV risk behaviors. Use of ART increased from 76% to 88% during the study period. Median first CD4 count in the year rose from 399 to 476 cells/mm³. In each year, between 83–85% of patients met the HRSA HAB measure, 75–78% did not have a 6-month gap, and 34–39% had visits in all 4 quarters. The percentage achieving viral suppression increased from 60% in 2006 to 79% in 2011.

Figure 1 shows unadjusted proportions of patient-years in which viral suppression was achieved, by CD4 group and each retention measure. For each retention measure, three results are clear: (1) the higher the initial CD4 count, the greater the probability of viral suppression; (2) patients who were retained in care had a higher probability of viral suppression than those not retained in care; and (3) the difference in the effect of retention in care on viral suppression was greater at lower than higher CD4 counts.

Adjusting for CD4 group and sociodemographic factors, all three retention measures were significantly associated with viral suppression. (Tables 2 and 3) The interaction between retention in care and CD4 group was significant ($P < 0.01$) for each retention measure: χ^2 (3df) = 103.69 for HRSA HAB, χ^2 (3df) = 185.39 for 6-month gap, and χ^2 (9df) = 248.88 for 3-month visit constancy.

Table 4 shows adjusted odds ratios (AOR) for the effect of retention in care on viral suppression at different CD4 counts. For each retention measure, associations with viral suppression were stronger at more advanced disease stages. Using the HRSA HAB measure as a representative example, the association between retention in care and viral suppression was strongest for patients with lower CD4 counts: 200 [adjusted odds ratio=2.33, 95% confidence interval 2.16–2.51], 201–350 [1.96, 1.81–2.12], 351–500 [1.65, 1.53–1.78], and >500 cells/mm³ [1.22, 1.14–1.30]. Pairwise comparisons of AOR in adjacent CD4 groups were significant ($P < 0.05$), with two exceptions (Table 4).

Discussion

These results, from a large multisite sample, provide new information on the relationship between HIV disease severity, retention in care, and viral suppression. All three retention measures (HRSA HAB, 6-month gap in care, and 3-month visit constancy) were significantly associated with viral suppression. However, the association between retention in care and viral suppression differed by disease severity; it was strongest among patients with low CD4 counts. While it is well established that retention in care is important for all HIV-infected patients, our data suggest that retention in care may be even more central to achieving optimal virologic outcomes for persons with advanced HIV disease.

Consistent with earlier studies, patients retained in care were more likely to achieve viral suppression.^{14–17} Variations in adherence to ART and patients' ability to manage their HIV infection may explain these differences. Among 1,972 patients receiving ART at 60 clinics in Brazil, missed appointments were independently associated with poor adherence to therapy.²⁷ Similarly, Kleeberge and colleagues document a significant association between

poor retention in care and low self-reported ART adherence.²⁸ An evaluation of factors influencing engagement in care notes that sporadic users had difficulty integrating new information, managing stigma, and maintaining normality in their lives compared to regular users of care.²⁹ New patient-centered, retention in care interventions are needed to address the complex socioeconomic and clinical needs of HIV-infected individuals not engaged in care.

In our cohort, patients with higher CD4 counts were more likely to achieve viral suppression; however, we note that the difference in the effect of retention in care on viral suppression was greater in patients with lower compared to higher CD4 counts. This pattern persisted independent of the measure of retention utilized. People with low CD4 counts are at increased risk of polypharmacy, opportunistic infections, and other HIV-related complications.^{30,31} In addition, HIV-related stigma, fear of disclosing one's HIV status, and lack of psychological coping resources contribute to late entry into care with lower CD4 counts.³² Maintaining a continuous, high-quality, relationship with a provider may help patients with advanced HIV disease better manage these issues, and may explain why viral suppression is more strongly associated with retention in care in this population compared to individuals with higher CD4 counts.³³

Several limitations of this study should be acknowledged. We did not have access to appointment schedules and thus could not examine other measures of retention such as appointment adherence and missed visits. Second, our data do not reflect visits to multiple providers by the same patient. It is possible that patients may switch to a different provider in the same locality, emigrate from the area, or become incarcerated or institutionalized but still be receiving care. Third, we did not measure adherence to or duration of HIV treatment. Future studies should investigate how ART adherence and duration of ART treatment influences the relationship between retention in care and viral suppression. Fourth, although multi-site studies have greater generalizability than single-site studies, the HIVRN data are not nationally representative; rates of retention may differ among providers with smaller HIV patient caseloads or with a different mix of patients. Fifth, we removed data for the first year in care for those patients with insufficient time to observe the retention measures. Some patients with only one year in care were thus excluded altogether. Of 9,483 persons with only one year of data, 3,255 were removed from analyses using the HRSA HAB or 6-month gap measures and 5,213 from analyses using the continuity measure. Those with only one year in care linked to but did not establish consistent care. Prior studies have described and examined retention in this population;^{16,26,34,35} including a study from the HIVRN, which demonstrated that 22% of 22,984 HIV-infected adults initiating care between 2001–2009 never established care (defined as having no outpatient visits 6 months after enrollment).² Additional research is warranted to better understand patterns of care and their effect on clinical outcomes during the first year of care and the last year of life.

The timing of the HIV-1 RNA measure is another limitation. For 31% of the person-years, the measure occurred relatively early in the calendar year (i.e., before September). Failure to be retained could have occurred after the HIV-1 RNA measurement. It is possible that virologic failure could lead some patients to conclude that treatment was ineffective and motivate dropout. Thus, the analyses show an association between retention and virological suppression, but the parameter estimates cannot be interpreted as representing a causal effect. Ancillary analyses (results not shown) included a three-way interaction between retention, CD4 count, and the indicator of HIV-1 RNA measure prior to September. This interaction was not significant for the HRSA HAB and the gap measures. It was significant for the quarters measure, but inspection of results showed that the major overall pattern of weaker association at higher CD4 counts remained both for pre-September and post-September measures of suppression.

This study is one of the first to report the impact of HIV disease severity on retention in care and viral suppression, demonstrating that retention in care is more strongly associated with viral suppression in patients with low CD4 counts. Our findings have important implications for improving the health of patients with advanced HIV disease and emphasize the role of retention in care in test and treat approaches to HIV prevention, demonstrating the added value of retaining people with lower CD4 counts in care.

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Figure 1.
Proportion of HIV-Infected Persons with Viral Suppression by Retention Measure and CD4 Group

Table 1

Demographic and Clinical Characteristics of the Sample, Overall and by Calendar Year

Characteristic	Overall N=113,760 PY (%)	Calendar Year	
		2006 N=16,594 (%)	2011 N=22,237 (%)
Age (years)			
18–29	10,577 (9)	1,427 (9)	2,389 (11)
30–39	22,692 (20)	3,922 (24)	3,914 (17)
40–49	44,604 (39)	6,935 (42)	7,936 (36)
50	35,887 (32)	4,310 (26)	7,998 (36)
Sex			
Male	81,225 (71)	11,811 (71)	16,112 (72)
Female	32,535 (29)	4,783 (29)	6,125 (28)
Race/Ethnicity			
White	31,460 (28)	4,833 (29)	5,971 (27)
Black	54,809 (48)	7,954 (48)	10,595 (48)
Hispanic	24,537 (21)	3,399 (20)	5,008 (22)
Other/Missing	2,954 (3)	408 (2)	663 (3)
HIV Risk Factor			
Heterosexual	47,425 (42)	6,796 (41)	9,766 (44)
MSM	42,033 (37)	6,045 (36)	8,020 (36)
IDU	18,561 (16)	3,096 (19)	3,011 (14)
Other/Missing	5,741 (5)	657 (4)	1,440 (6)
Insurance			
Private	20,090 (18)	2,673 (16)	3,669 (17)
Medicaid	40,415 (36)	5,910 (36)	7,646 (34)
Medicare	20,943 (18)	3,204 (19)	4,097 (18)
Ryan White/Uninsured	29,179 (26)	4,405 (27)	6,344 (29)
Other/Missing	3,133 (2)	402 (2)	481 (2)
Use of ART in Year			
No	16,370 (14)	3,687 (22)	2,208 (10)
Yes	95,123 (84)	12,616 (76)	19,675 (88)
Missing	2,267 (2)	291 (2)	354 (2)
First CD4 Count in Year			
200 cell/mm ³	20,358 (18)	3,456 (21)	3,190 (14)
201 – 350 cell/mm ³	22,771 (20)	3,562 (21)	3,976 (18)
351–500 cell/mm ³	24,934 (22)	3,636 (22)	4,797 (22)
> 500 cell/mm ³	45,697 (40)	5,940 (36)	10,274 (46)

Characteristic	Overall N=113,760 PY (%)	Calendar Year	
		2006 N=16,594 (%)	2011 N=22,237 (%)
HRSA HAB Measure			
Not Retained	18,651 (16)	2,878 (17)	3,518 (16)
Retained	95,109 (84)	13,716 (83)	18,719 (84)
6-Month Gap			
Yes (Not Retained)	26,896 (24)	4,098 (25)	5,256 (24)
No (Retained)	86,864 (76)	12,496 (75)	16,981 (76)
3-Month Visit Constancy*			
1	13,795 (13)	2,090 (13)	2,620 (12)
2	22,998 (21)	3,119 (20)	4,795 (23)
3	32,177 (29)	4,548 (29)	6,602 (31)
4	40,228 (37)	6,175 (39)	7,204 (34)
Last HIV-1 RNA in Year			
400 copies/mL	81,452 (72)	10,021 (60)	17,627 (79)
> 400 copies/mL	32,308 (28)	6,573 (40)	4,610 (21)
Time of HIV-1 RNA Measure			
First 245 days of the year	35,606 (31)	5,397 (33)	7,937 (36)
Last 120 days of the year	78,154 (69)	11,197 (67)	14,300 (64)

Abbreviations: ART, antiretroviral therapy; HET, heterosexual transmission; HIV, human immunodeficiency virus; IDU, injection drug use; MSM, men who have sex with men; PY, person-years.

* Analyses based on 109,198 person-years.

Table 2

Multivariable Associations with HIV Viral Suppression – HRSA HAB & 6-Month Gap Measures Month Gap Measures

Characteristic	Adjusted Odds Ratio (95% CI)	
	HRSA HAB Measure	6-Month Gap Measure
Retention Measure		
Not Retained	1 [Reference]	1 [Reference]
Retained	2.33 (2.16–2.51)	1.86 (1.74–2.00)
First CD4 Count in Year		
200 cell/mm ³	1 [Reference]	1 [Reference]
201 – 350 cell/mm ³	2.25 (2.04–2.48)	2.15 (1.97–2.33)
351–500 cell/mm ³	3.57 (3.23–3.94)	3.28 (3.02–3.57)
> 500 cell/mm ³	7.39 (6.74–8.10)	6.15 (5.67–6.66)
Retention Measure by CD4 Count		
Retained and 201–350 cell/mm ³	0.84 (0.75–0.94)	0.91 (0.83–1.00)
Retained and 351–500 cell/mm ³	0.71 (0.64–0.79)	0.80 (0.73–0.88)
Retained and > 500 cell/mm ³	0.52 (0.47–0.58)	0.66 (0.61–0.72)
Time of HIV-1 RNA Measurement		
Last 120 days of the year	1 [Reference]	1 [Reference]
First 245 days of the year	0.87 (0.85–0.90)	0.87 (0.84–0.89)
Age (years)		
18–29	1 [Reference]	1 [Reference]
30–39	1.45 (1.36–1.54)	1.45 (1.36–1.54)
40–49	1.88 (1.77–2.01)	1.89 (1.78–2.01)
50	2.68 (2.51–2.87)	2.71 (2.53–2.90)
Sex		
Male	1 [Reference]	1 [Reference]
Female	0.96 (0.91–1.01)	0.96 (0.91–1.01)
Race/Ethnicity		
White	1 [Reference]	1 [Reference]
Black	0.74 (0.70–0.78)	0.74 (0.70–0.78)
Hispanic	1.07 (1.00–1.14)	1.07 (1.01–1.14)
Other/Unknown	1.11 (0.97–1.26)	1.10 (0.97–1.25)
HIV Risk Factor		
Heterosexual	1 [Reference]	1 [Reference]
MSM	0.87 (0.83–0.92)	0.87 (0.82–0.92)
IDU	0.75 (0.71–0.80)	0.75 (0.70–0.79)
Other/Unknown	0.87 (0.80–0.96)	0.87 (0.79–0.95)

Characteristic	Adjusted Odds Ratio (95% CI)	
	HRSA HAB Measure	6-Month Gap Measure
Insurance		
Private	1 [Reference]	1 [Reference]
Medicaid	0.82 (0.78–0.86)	0.81 (0.77–0.86)
Medicare	0.91 (0.85–0.96)	0.90 (0.85–0.96)
Ryan White/Uninsured	0.96 (0.91–1.02)	0.96 (0.91–1.02)
Other/Unknown	0.90 (0.81–0.99)	0.89 (0.80–0.98)
Use of ART in Year		
No	1 [Reference]	1 [Reference]
Yes	7.66 (7.28–8.06)	7.79 (7.41–8.20)
Missing	4.60 (3.91–5.41)	4.63 (3.94–5.44)
Calendar Year		
2006	1 [Reference]	1 [Reference]
2007	1.07 (1.02–1.11)	1.06 (1.02–1.11)
2008	1.43 (1.37–1.49)	1.42 (1.36–1.48)
2009	1.72 (1.65–1.80)	1.71 (1.63–1.79)
2010	1.79 (1.71–1.88)	1.78 (1.70–1.86)
2011	1.98 (1.89–2.07)	1.97 (1.88–2.06)

Abbreviations: ART, antiretroviral therapy; HET, heterosexual transmission; HIV, human immunodeficiency virus; HRSA HAB, U.S. Health Resources and Services Administration HIV/AIDS Bureau; IDU, injection drug use; MSM, men who have sex with men.

Note: Logistic regression models using generalized estimating equations with exchangeable correlation matrix. Models also included indicators for HIVRN site.

Table 3

Multivariable Associations with HIV Viral Suppression – 3-Month Visit Constancy Measure

Characteristic	Adjusted Odds Ratio (95% CI)
3-Month Visit Constancy	
1	1 [Reference]
2	1.69 (1.52–1.86)
3	2.45 (2.21–2.70)
4	3.48 (3.15–3.85)
First CD4 Count in Year	
200 cell/mm ³	1 [Reference]
201 – 350 cell/mm ³	2.32 (2.07–2.60)
351–500 cell/mm ³	4.04 (3.60–4.54)
> 500 cell/mm ³	8.29 (7.44–9.23)
3-Month Visit Constancy by CD4 Count	
2 quarters and 201–350 cell/mm ³	0.95 (0.82–1.09)
2 quarters and 351–500 cell/mm ³	0.76 (0.66–0.88)
2 quarters and > 500 cell/mm ³	0.65 (0.57–0.74)
3 quarters and 201–350 cell/mm ³	0.87 (0.76–1.01)
3 quarters and 351–500 cell/mm ³	0.71 (0.62–0.82)
3 quarters and > 500 cell/mm ³	0.53 (0.47–0.60)
4 quarters and 201–350 cell/mm ³	0.78 (0.68–0.90)
4 quarters and 351–500 cell/mm ³	0.57 (0.60–0.65)
4 quarters and > 500 cell/mm ³	0.40 (0.35–0.45)
Time of HIV-1 RNA Measurement	
Last 120 days of the year	1 [Reference]
First 245 days of the year	0.94 (0.91–0.97)
Age (years)	
18–29	1 [Reference]
30–39	1.47 (1.37–1.57)
40–49	1.88 (1.76–2.00)
50	2.64 (2.46–2.83)
Sex	
Male	1 [Reference]
Female	0.94 (0.89–0.99)
Race/Ethnicity	
White	1 [Reference]
Black	0.73 (0.69–0.77)
Hispanic	1.04 (0.98–1.11)

Characteristic	Adjusted Odds Ratio (95% CI)
Other/Unknown	1.09 (0.95–1.25)
HIV Risk Factor	
Heterosexual	1 [Reference]
MSM	0.88 (0.84–0.93)
IDU	0.76 (0.71–0.81)
Other/Unknown	0.89 (0.81–0.98)
Insurance	
Private	1 [Reference]
Medicaid	0.80 (0.76–0.85)
Medicare	0.88 (0.83–0.94)
Ryan White/Uninsured	0.95 (0.89–1.01)
Other/Unknown	0.88 (0.80–0.98)
Use of ART in Year	
No	1 [Reference]
Yes	7.30 (6.92–7.70)
Missing	4.60 (3.90–5.44)
Calendar Year	
2006	1 [Reference]
2007	1.08 (1.03–1.12)
2008	1.44 (1.38–1.51)
2009	1.75 (1.67–1.83)
2010	1.85 (1.76–1.94)
2011	2.06 (1.96–2.16)

Abbreviations: ART, antiretroviral therapy; HET, heterosexual transmission; HIV, human immunodeficiency virus; HRSA HAB, U.S. Health Resources and Services Administration HIV/AIDS Bureau; IDU, injection drug use; MSM, men who have sex with men.

Note: Logistic regression models using generalized estimating equations with exchangeable correlation matrix. Models also included indicators for HIVRN site.

Table 4

Association between Retention in Care Measures and Viral Suppression by CD4 Group

Retention Measure	CD4 Group ^{†‡}			
	200 cell/mm ³ AOR (95% CI)	201–350 cell/mm ³ AOR (95% CI)	351–500 cell/mm ³ AOR (95% CI)	> 500 cell/mm ³ AOR (95% CI)
HRSA HAB				
Not Retained	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Retained	2.33 (2.16–2.51)	1.96 (1.81–2.12)	1.65 (1.53–1.78)	1.22 (1.14–1.30)
6-Month Gap				
Yes (Not Retained)	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
No (Retained)	1.86 (1.74–2.00)	1.69 (1.58–1.81)	1.49 (1.39–1.59)	1.23 (1.16–1.30)
3-Month Visit Constancy				
1	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
2	1.69 (1.52–1.86)	1.59 (1.44–1.76) [‡]	1.28 (1.16–1.41)	1.09 (1.01–1.18)
3	2.45 (2.21–2.70)	2.14 (1.94–2.63) [‡]	1.74 (1.58–1.92)	1.30 (1.20–1.41)
4	3.48 (3.15–3.85)	2.72 (2.47–3.01)	1.98 (1.80–2.18)	1.39 (1.29–1.51)

Abbreviations: AOR, adjusted odds ratio; CI, Confidence Interval; HRSA HAB, U.S. Health Resources and Services Administration HIV/AIDS Bureau.

[†] Model included interaction between retention measure and CD4 group, as well as time of HIV-1 RNA measurement, age, sex, race/ethnicity, HIV risk factor, insurance coverage, calendar year, and site of care. See Tables 2 & 3 for complete results.

[‡] Pairwise comparisons of AORs with preceding lower CD4 group were significant ($P < 0.05$) with two exceptions.