DOI: 10.1111/j.1475-6773.2007.00750.x
RESEARCH ARTICLE

Associations between Outpatient and Inpatient Service Use among Persons with HIV Infection: A Positive or Negative Relationship?

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Objective. To examine the prospective association between frequency of outpatient visits and subsequent inpatient admissions.
Data Sources. Medical record data on 13,942 patients with HIV infection seen in 10 HIV speciality care sites across the United States.
Study Design. This observational study followed a cohort of HIV-infected patients who were in care in the first half of 2001. Numbers of inpatient admissions and outpatient visits were calculated for each patient for each 3-month period, from 2001 through 2004.
Analysis. Negative binomial and logistic regression analyses using random-effects models examined the effects of inpatient admissions and outpatient visits in the previous period on inpatient and outpatient service utilization, controlling for background characteristics and HIV disease stage.
Results. For 3-month periods, between 5 and 9 percent of patients had an inpatient admission. The linear association between number of outpatient visits and any inpatient admission in the subsequent period was positive (adjusted odds ratio = 1.05; 95 percent confidence interval [CI] = 1.04, 1.06). However, patients with zero prior outpatient visits had significantly greater admission rates than those with one prior visit. Hospitalization rates were also higher among those with a prior hospitalization and those with more advanced HIV disease.
Conclusions. These results suggest a J-shaped relationship between outpatient use and inpatient use among persons with HIV disease. Those in worse health have greater utilization of both inpatient and outpatient care. However, having no outpatient visits may also increase the likelihood of subsequent hospitalization. Although outpatient care cannot be justified as a cost-saving mechanism, maintaining regular clinical monitoring of patients is important.

Key Words. HIV infection, inpatient service use, outpatient service use

In the first decade of the HIV epidemic, efforts were made to develop community-based systems of care, in part to reduce the frequency and cost of inpatient treatment (Mor et al. 1994). These efforts culminated in 1990 with the passage of the Ryan White CARE Act, which provides funds to support and enhance community-based care for HIV disease (Bowen et al. 1992). One premise of such programs is that appropriate outpatient care could reduce the incidence of costly inpatient episodes. Closer outpatient disease management could potentially avoid hospitalization by discovering and treating incipient conditions. If this is correct, one would expect to find a negative relationship between outpatient and inpatient utilization. Alternatively, sicker patients might consume higher levels of both inpatient and outpatient care, leading to a positive relationship between inpatient and outpatient utilization.

Relatively few studies of persons with HIV have investigated the association between inpatient and outpatient service use. Most research examines inpatient and outpatient use in separate analyses (e.g., Shapiro et al. 1999; Fleishman et al. 2005). Cunningham et al. (1996) reported a positive association between number of ambulatory visits and the probability of having had a prior hospitalization. However, the sample was recruited from patients hospitalized for HIV-related conditions, raising the potential for selection bias. Pezzin and Fleishman (2003) developed a complex econometric model to examine the effect of number of ambulatory visits on inpatient and emergency department use. Overall, the association between number of ambulatory visits and number of inpatient episodes was not significant.

These studies were based on data collected before the introduction of highly active antiretroviral therapy (HAART) in 1996. It is not clear if similar relationships would be obtained in the current treatment environment. The introduction of HAART was associated with substantial declines in inpatient censuses of patients with HIV (Torres and Barr 1997; Fleishman and Hellinger 2001; Gebo, Diener-West, and Moore 2001; Paul et al. 2002). Despite the reductions, HIV-related inpatient utilization is still far from rare; among 15,211 HIV-infected patients from several care sites in 2001, 20.4 percent had one or

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more inpatient episodes (Fleishman et al. 2005). Inpatient care remains a major component of overall expenses for treating HIV infection (Gebo et al. 2006).

This study examines the association between ambulatory visits and inpatient admissions, using data from 2001 to 2004 in a large sample of HIV patients in care. We examine whether ambulatory care helps to prevent subsequent inpatient care (i.e., a negative relationship) or whether outpatient and inpatient care are complementary (i.e., a positive relationship). If both processes are at work, the relationship could be nonlinear.

METHODS

Participating Sites

The HIV Research Network (HIVRN) is a consortium of 17 sites that provide primary and subspecialty care to HIV patients. To participate, a site had to have a minimum data set available, including patients' age, sex, race, HIV transmission risk factor, CD4 and HIV-1 RNA test results, and use of antiretroviral medication. Analyses used data from 10 sites that treat adult patients and collect data on hospital admissions and outpatient visits. Sites were located in urban areas in the Eastern (four), Midwestern (two), Southern (two), and Western United States (two). In the first quarter of 2001, the number of patients at each site ranged from 363 to 3,013; six sites had over 1,300 patients each. Eight sites were clinics located in major medical centers; two were not located in medical centers (i.e., community-based). Six had academic affiliations. No sites were private practices.

Data Collection

This analysis uses data collected from January 1, 2001 through December 31, 2004. Each site provided data on an annual basis. Data elements were abstracted from records at each site and sent to a data-coordinating center after personal identifying information was removed. After quality control review, we combined data across sites to achieve a uniformly constructed multisite database. Data for each patient were merged across years, using a coded patient identification number.

Definitions of Variables

For each patient, the number of hospital admissions and outpatient clinic/office visits were computed for each 3-month period between January 1, 2001 and December 31, 2004 (i.e., 16 periods). Outpatient encounters were limited

to nonemergency department visits to a health care provider for primary care; they excluded visits in which a health care provider was not seen (e.g., laboratory tests only). We chose to aggregate utilization in 3-month periods because shorter periods might not provide sufficient opportunity for both inpatient and outpatient utilization to occur, and longer periods—such as 1 year—might obscure effects taking place over a shorter time period. Unfortunately, there is no a priori conceptual rationale that would suggest an optimal choice of time period.

Race/ethnicity was coded as white, black, Hispanic, or other. Age was categorized as 18–34, 35–49, and 50 years or older. HIV transmission risk factors included injection drug use (IDU), men who had sex with men (MSM), heterosexual transmission (HET), or combinations of risk factors (i.e., MSM-IDU and HET-IDU). A residual category combined patients with other HIV risks and those with unknown risk factors ($n = 374$ "other" and 443 "unknown").

Analyses used the lowest CD4 counts recorded in each 3-month period, categorized as < 50, 51–200, 201–500, > 500 cells/mm^3. A separate category was used if CD4 was not recorded in a period. In addition, each HIV-1 RNA (viral load) test result was classified as undetectable (i.e., < 400 copies/mL) or detectable. If all recorded viral load levels were undetectable in a given period, a patient was classified as "undetectable" for that period, otherwise, as "detectable." HIV-1 RNA was classified as "no test reported" if no tests appeared in the record in a period.

HAART was defined as any multidrug combination that included either (1) three or more nucleoside reverse transcriptase inhibitors [NRTIs] (before 2004), (2) one or more protease inhibitors [PI], (3) a non-nucleoside reverse transcriptase inhibitor [NNRTIs], or (4) an entry inhibitor.

Insurance was categorized as private, Medicaid, Medicare, or Ryan White/uninsured for each period. A small number of patients with dual Medicaid/Medicare coverage ($n = 380$ in the first quarter of 2001) were classified as Medicaid. (The small number with dual eligibility results from some sites' recording only one source of payment.) Patients recorded as self-pay and those covered by local governmental programs (e.g., county relief) were considered to be uninsured. Patients with no information on insurance in a period were coded as "missing."

Inclusion Criteria

Patients were included in the analyses if they were ≥ 18 years old and were "active" patients in the first 6 months of 2001. Active patients had at least one

of the following during this period: an outpatient visit, an inpatient episode, a CD4 test, or an HIV-1 RNA test. Conversely, a patient was considered ineligible for the analyses if no utilization or lab events were recorded for the first 6 months of 2001. Overall, 14,016 patients were active in the first half of 2001. Patients missing gender ($n = 42$) or race/ethnicity data ($n = 32$) were removed from the analysis, reducing the analysis cohort to $n = 13{,}942$.

For each subsequent period (2–16), the patient was considered active if any one of an outpatient visit, an inpatient episode, a CD4, or an HIV-1 RNA test was recorded. For example, a patient with a CD4 test but no inpatient or outpatient use was assumed to be under care and was coded as having zero inpatient and outpatient use. We distinguished patients with intermittent activity who were presumably still in the system but temporarily inactive, from those who may have died, dropped out of care, or were lost to follow-up. For the former, we imputed zero inpatient and outpatient use for all inactive periods between two active ones. We also used preliminary data from 2005 to determine active status; a member of the cohort with inpatient, outpatient, or lab use in 2005 was considered active for all preceding periods. In contrast, if a patient became inactive in one period and was consistently inactive thereafter, the patient was considered to have dropped out. Data for periods before dropout were included in analyses. Periods after a patient dropped out were excluded from analyses.

Data Analyses

To consider possible nonlinearity in the association between outpatient visits and inpatient use, we categorized outpatient visits as 0, 1, 2, 3, 4, 5, and 6 or more. We examined the proportion with an admission and the mean number of admissions for each outpatient visit category.

We conducted separate multivariate analyses of (1) number of inpatient admissions and (2) number of outpatient visits, using *Stata 9.1*. Analyses pooled observations for all 3-month periods. The unit of analysis was the person-period; each patient could thus contribute multiple observations to the analysis. Because patients could contribute multiple (1–16) observations, we used random effects models; the random effect (for the intercept) induces a constant within-person correlation across time periods (Fitzmaurice, Laird, and Ware 2004). We used random-effects negative binomial regression to estimate effects (adjusted incidence rate ratios) of independent variables on (1) number of inpatient admissions and (2) number of outpatient visits in each 3-month period. For analyses of count data, negative binomial regression is

more robust than Poisson regression when the variance is not equivalent to the mean of the distribution (Long 1997). The key threshold for inpatient visits may be none versus any; outpatient care may affect the likelihood of any hospitalization more than the number. Thus, we also conducted random-effects logistic regression analysis of any inpatient episode in a period.

Each model included dummy variables indicating age group, gender, race/ethnicity, HIV risk factor, use of HAART, insurance, undetectable HIV-1 RNA, and lowest CD4 count in a period. The latter four variables could vary across periods. All multivariate analyses included binary indicators for each care site, to capture site-specific variation in utilization patterns, and binary indicators for each period.

The regression models included lagged effects of inpatient and outpatient utilization. Thus, the model for period 2 included utilization in period 1; the model for period 3 included utilization in period 2, etc. Observations for the first period could not be included in these analyses, which did not include utilization data before 2001. Six-hundred forty-three patients (4.6 percent) had data for only the first period and were excluded from multivariate analyses. We examined several different specifications for the lagged utilization variables. For lagged inpatient admissions, we used either the number of inpatient admissions or a dichotomous variable indicating any inpatient admission (versus none). For lagged outpatient visits, we used either the number of outpatient visits or the set of indicator variables representing categories of outpatient visits in the prior period, with six or more visits as the omitted reference category.

The lagged effects are the focus for examining the association between inpatient and outpatient service use. Within a time period, the temporal order is not clear; some outpatient visits could occur after inpatient episodes and thus should not be interpreted as influencing prior inpatient use. Using variables from a prior time period makes the temporal ordering clearer.

Sensitivity Analyses. To examine sensitivity of results to the choice of time period over which utilization is aggregated, we repeated analyses using 6-month periods (i.e., eight periods). Other sensitivity analyses included (1) removing HAART from the model, as HAART receipt could be a mediating pathway for the effects of causally prior variables, (2) examining admissions specifically for opportunistic infections (OIs), which might be especially preventable by routine outpatient monitoring, (3) removing person-periods in which a patient had a hospitalization but no outpatient or laboratory use, as this could reflect receipt of outpatient care at a non-HIVRN provider, (4) examining patients with 12 or more active periods, as their data are most complete.

RESULTS

A total of 13,942 patients had inpatient or outpatient utilization or a CD4 test or HIV-1 RNA test in the first 6 months of 2001. Table 1 shows demographic and clinical characteristics of the sample for the first 3-month period. Patients were predominantly male and of minority race/ethnicity (46.5 percent black and 21.9 percent Hispanic). Both MSM and heterosexual HIV transmission were common, and IDU was a transmission factor for nearly one quarter.[1] Mean and median CD4 nadir were 382 and 335 cells/mm^3, respectively. Viral load was undetectable for 30 percent; over 60 percent received HAART.

Between 91 and 95 percent of patients had no inpatient admission in a 3-month period. The percentage with one admission ranged between 6.9 and 4.1 percent per period. The proportion with two or more admissions in a period was thus relatively small. Over all periods, 8,647 patients (62 percent) had no admission. In each period, the median number of outpatient visits was 1; across all periods the mean was 1.40 visits per period (SD = 1.6).[2] No outpatient visit was recorded for 25–34 percent of patients, depending on the period; 4 percent of patients had no outpatient visit in any period (results not shown).

Attrition

Overall, 1,814 (13 percent) were active for all 16 periods. Another 6,019 (43 percent) were active in the last quarter of 2004 or in 2005 but were inactive for one or more preceding periods; these patients were not considered to have dropped out, and inpatient and outpatient utilization were coded as zero for intermittent inactive periods. Another 3,021 (22 percent) had several uninterrupted periods of activity and then dropped out, and 3,088 (22 percent) had active periods interrupted by at least one inactive period before dropping out. For the latter group, inpatient and outpatient utilization were coded as zero for intermittent inactive periods before drop out. Of the 6,109 dropouts, 1,353 (22 percent) were known to have died.

Inpatient Admissions

The 13,299 patients in analyses with lagged variables contributed a total of 151,091 person-period observations, an average of 11.4 periods per person. We calculated the mean number of inpatient admissions and the proportion with one or more admissions across all 3-month periods, stratified by the number of outpatient visits in the prior period. The mean number of admissions (standard error) was 0.074 (0.002) for zero prior outpatient visits, 0.060 (0.001) for one visit, 0.086 (0.002) for two, 0.117 (0.004) for three, 0.154 (0.006)

Table 1: Demographic and Clinical Characteristics of Cohort at Period 1 ($N = 13{,}942$)

Variable	*Number (%)*
Gender	
Male	9,841 (70.6%)
Female	4,101 (29.4%)
Race/ethnicity	
White	4,210 (30.2%)
Black	6,489 (46.5%)
Hispanic	3,059 (21.9%)
Other	184 (1.3%)
HIV transmission risk	
MSM	5,391 (38.7%)
IDU	1,731 (12.4%)
Heterosexual	4,290 (30.8%)
Heterosexual-IDU	1,109 (7.9%)
MSM-IDU	604 (4.3%)
Other	374 (2.7%)
Missing	443 (3.2%)
Age	
18–34	3,056 (21.9%)
35–49	8,558 (61.4%)
50 and older	2,328 (16.7%)
Lowest CD4 in period 1	
≤ 50	788 (5.7%)
$51 \leq$ CD4 ≤ 200	1,747 (12.5%)
$201 \leq$ CD4 ≤ 500	3,899 (28.0%)
>500	2,521 (18.1%)
No test reported	4,987 (35.8%)
Insurance in period 1	
Private	1,391 (10.0%)
Medicaid	4,766 (34.2%)
Medicare	1,544 (11.1%)
Uninsured/Ryan White	2,540 (18.2%)
Missing	3,701 (26.6%)
HIV-1 RNA in period 1	
>400 copies/ml	5,396 (38.7%)
≤ 400 copies/ml	4,131 (29.6%)
No Test reported	4,415 (31.7%)
HAART in period 1	
No	4,787 (34.3%)
Yes	9,155 (65.7%)

HAART, highly active antiretroviral therapy; IDU, injection drug use; MSM, men who had sex with men.

for four, 0.177 (0.010) for five, and 0.240 (0.010) for six or more. The corresponding proportions with any admission were 0.058 (0.001), 0.048 (0.001), 0.066 (0.002), 0.089 (0.002), 0.116 (0.004), 0.128 (0.06), and 0.162 (0.006). The mean number of admissions was higher for patients with zero outpatient visits than for those with one. In all periods, the mean number of admissions rose as the number of outpatient visits increased from one. A similar pattern was observed for the proportion of patients with any admission. With the exception of zero outpatient visits, the association between inpatient and prior outpatient utilization was predominantly positive in direction. (Analyses that stratified by number of outpatient visits in the same period produced similar results.) Pooling all periods, the correlation between number of admissions and number of outpatient visits in the previous period was 0.09.

Table 2 shows three analyses of inpatient admissions for periods 2–16. Models 1 and 2 are negative binomial regression analyses of the number of admissions per period, using the categorical representation of prior outpatient visits (Model 1) or the number of prior outpatient visits (Model 2). The third model is a logistic regression of any admission, using the categorical representation of prior outpatient visits and a binary variable for any prior admission.

The different specifications gave consistent results: for each model, inpatient admissions in the previous period, whether specified as the number of visits or any visit, were strongly positively related to admissions in the subsequent period. In Model 2, the linear representation of the number of previous outpatient visits was also significantly positively associated with number of subsequent admissions. For the categorical representation of prior outpatient visits, the admission rate (Model 1) or odds of admission (Model 3) increased as prior outpatient visits rose from one through four, consistent with the positive relationship obtained in Model 3, albeit with some leveling off at five prior visits. In Models 1 and 3, however, patients with zero outpatient use in the prior period had significantly higher inpatient utilization than those with one visit. Tests of equality of the coefficients for zero and one visit were rejected, with χ^2 values (1 df) of 45.71 for Model 1 and 40.28 for Model 3. Thus, there is some evidence for a J-shaped relationship between outpatient use and inpatient admissions.

The coefficients for the demographic and clinical variables were consistent across the three models, suggesting robustness to variations in the specification of the prior utilization variables. The odds of admission were higher among women, blacks or Hispanics, IDUs, and among older patients. Patients with Medicaid or Medicare coverage had higher inpatient use than those with private insurance, but those with no insurance did not differ from

Table 2: Regression Analyses of Inpatient Admissions, 3-Month Periods

Variable	*Model 1 Number of Admissions*	*Model 2 Number of Admissions*	*Model 3 Any Admission*
Previous period			
Outpatient visits			
0	0.73 (0.66–0.81)	—	0.63 (0.55–0.72)
1	0.60 (0.54–0.66)	—	0.51 (0.45–0.58)
2	0.70 (0.63–0.77)	—	0.60 (0.53–0.68)
3	0.80 (0.72–0.89)	—	0.70 (0.61–0.80)
4	0.93 (0.83–1.04)	—	0.86 (0.74–0.99)
5	0.91 (0.80–1.04)	—	0.82 (0.69–0.97)
6+	—	—	—
Outpatient visits (number)	—	1.05 (1.04–1.06)	—
Inpatient admissions (number)	1.38 (1.35–1.42)	1.38 (1.34–1.42)	—
Any inpatient admission	—	—	2.52 (2.36–2.69)
Gender			
Male	—	—	—
Female	1.22 (1.13–1.32)	1.22 (1.14–1.32)	1.26 (1.17–1.37)
Race/ethnicity			
White	—	—	—
Black	1.31 (1.21–1.42)	1.31 (1.20–1.42)	1.31 (1.20–1.43)
Hispanic	1.11 (1.01–1.23)	1.12 (1.01–1.23)	1.12 (1.00–1.25)
Other	0.75 (0.56–1.01)	0.76 (0.56–1.02)	0.77 (0.56–1.06)
HIV transmission			
MSM	—	—	—
IDU	1.90 (1.71–2.11)	1.92 (1.73–2.13)	1.98 (1.77–2.22)
HET	1.08 (0.99–1.18)	1.08 (0.99–1.18)	1.09 (0.99–1.19)
HET-IDU	1.66 (1.48–1.87)	1.67 (1.49–1.88)	1.73 (1.53–1.96)
MSM-IDU	1.51 (1.31–1.74)	1.52 (1.32–1.75)	1.54 (1.32–1.79)
Other/missing	1.40 (1.21–1.61)	1.41 (1.22–1.63)	1.40 (1.20–1.63)
Age			
18–34	0.98 (0.91–1.06)	0.99 (0.92–1.07)	0.98 (0.90–1.07)
35–49	—	—	—
50+	1.40 (1.29–1.51)	1.40 (1.29–1.51)	1.43 (1.31–1.55)
Lowest CD4 count in a period			
≤ 50	4.68 (4.26–5.15)	4.76 (4.33–5.24)	7.33 (6.56–8.20)
$50 < \text{CD4} \leq 200$	2.39 (2.19–2.61)	2.41 (2.21–2.64)	2.62 (2.38–2.89)
$200 < \text{CD4} \leq 500$	1.33 (1.23–1.44)	1.34 (1.24–1.45)	1.35 (1.24–1.47)
>500	—	—	—
No test recorded	1.23 (1.10–1.37)	1.23 (1.11–1.37)	1.15 (1.02–1.30)
HIV-1 RNA			
>400 copies/ml	—	—	—
≤ 400 copies/ml	0.83 (0.78–0.88)	0.82 (0.77–0.87)	0.80 (0.74–0.86)
No test recorded	1.08 (0.99–1.18)	1.07 (0.98–1.17)	1.13 (1.01–1.26)
HAART			
No	—	—	—
Yes	0.88 (0.84–0.93)	0.87 (0.93–0.92)	0.84 (0.79–0.89)

Continued

Table 2: *Continued*

Variable	*Model 1 Number of Admissions*	*Model 2 Number of Admissions*	*Model 3 Any Admission*
Insurance			
Private	—	—	—
Medicaid	1.47 (1.31–1.65)	1.47 (1.31–1.64)	1.57 (1.38–1.78)
Medicare	1.51 (1.34–1.71)	1.51 (1.33–1.70)	1.59 (1.39–1.82)
Ryan White/none	1.02 (0.89–1.15)	1.01 (0.89–1.15)	1.01 (0.88–1.16)
Missing	0.95 (0.85–1.07)	0.97 (0.86–1.09)	0.93 (0.82–1.06)

Note: $N = 13{,}299$ patients; 151,091 person-periods. 95% confidence intervals in parentheses.

Analyses also included dummy variables controlling for data collection site and period (results not shown).

Analyses were conducted using random effects negative binomial regression for number of admissions, and random effects logistic regression for any admission. Entries are exponentiated coefficients and represent incidence rate ratios (for number of admissions) or adjusted odds ratios (for any admission).

HAART, highly active antiretroviral therapy; IDU, injection drug use; MSM, men who had sex with men; HET, heterosexual transmission.

those with private insurance. Inpatient use was highest among patients with the greatest immunosuppression; the admission rate dropped as CD4 count increased. Patients with undetectable viral loads had significantly lower inpatient use than those who were detectable. HAART use was significantly negatively related to inpatient admissions.

Sensitivity Analyses

Table 3 presents selected results of additional sensitivity analyses, using the logistic regression model for any inpatient admission (Model 3 in Table 2). Removing HAART from the model had very little impact on the magnitude of the coefficients for prior outpatient and inpatient use, compared with Model 3 in Table 2. Analyzing only admissions to treat OIs resulted in a greater difference in the coefficients for zero and one prior visit [0.23 (= 0.85–0.62 in Table 3) versus 0.13 (= 0.73 – 0.60 in Table 2)], but the basic J-curve pattern remained. In the third analysis, which used 6-month periods, inpatient use was slightly higher for those with zero prior outpatient visits than for those with one prior visit, who in turn had higher inpatient use than those with two outpatient visits. Thus, the general J-shaped relationship was observed for 6-month periods, although the major difference was between those with zero and those with two visits. Next, we omitted periods in which a patient had only inpatient use and no outpatient use or laboratory results; such patients might be

Table 3: Logistic Regressions of Any Inpatient Admission, 3-Month Periods: Sensitivity Analyses

Variable	*HAART Excluded*	*OI-related Admissions*	*6-Month Periods with Only IP Use*	*Dropping Periods*	*12+Active Periods*
Previous period					
Outpatient visits					
0	0.648	0.853	0.743	0.698	0.717
1	0.514	0.618	0.697	0.518	0.526
2	0.603	0.670	0.639	0.617	0.621
3	0.703	0.890	0.736	0.727	0.705
4	0.858	1.110	0.760	0.899	0.876
5	0.816	1.021	0.842	0.849	0.830
6+(reference)	—	—	—	—	—
Any inpatient admission	2.519	4.052	3.051	2.450	2.210
χ^2 test of equality of coefficients for 0 and 1 OP visit	46.27	12.29	8.20*	66.06	38.20
p-value (1 df)	<0.001	<0.001	<0.004	<0.001	<0.001
N (patients)	13,299	13,299	12,644	13,262	6,008
N (periods)	151,091	151,091	70,042	149,939	89,200

Analyses also included other independent variables shown in Model 3 of Table 2, and dummy variables controlling for data collection site and period (results not shown). Analyses were conducted using random effects logistic regression for any admission. Entries are exponentiated coefficients and represent adjusted odds-ratios.

*Test compares coefficients for zero and two outpatient visits.

HAART, highly active antiretroviral therapy; OI, opportunistic infection.

receiving primary outpatient care from another provider. Finally, we analyzed patients with 12 or more active periods (out of 16); their data are least affected by dropout or inactive periods. Results of these two analyses were consistent with those in Table 2.

Outpatient Visits

Table 4 shows three regression analyses of outpatient visits for periods 2–16, analogous to the analyses in Table 2. The different specifications produced virtually identical results. Notably, there was no evidence for a J-shaped relationship between prior outpatient visits and subsequent outpatient use. Those with zero prior outpatient visits did not have a higher subsequent outpatient visit rate than those with one prior visit. Instead, the association was monotonic and virtually linear. In addition, the number of inpatient admissions in one period was significantly positively associated with outpatient visits

Table 4: Regression Analyses of Outpatient Visits, 3-Month Periods

Variable	*Number of Visits*	*Number of Visits*	*Any Visit*
Previous period			
Outpatient visits			
0	0.51 (0.50–0.52)	—	0.51 (0.50–0.52)
1	0.56 (0.54–0.57)	—	0.56 (0.54–0.57)
2	0.61 (0.60–0.62)	—	0.61 (0.60–0.62)
3	0.68 (0.67–0.70)	—	0.68 (0.67–0.70)
4	0.74 (0.72–0.76)	—	0.74 (0.72–0.76)
5	0.80 (0.77–0.82)	—	0.79 (0.77–0.82)
6+	—	—	—
Outpatient visits (number)	—	1.08 (1.07–1.08)	—
Inpatient admissions (number)	1.07 (1.05–1.08)	1.07 (1.06–1.08)	—
Any inpatient admission	—	—	1.10 (1.08–1.12)
Gender			
Male	—	—	—
Female	1.06 (1.04–1.08)	1.06 (1.05–1.08)	1.06 (1.04–1.07)
Race/ethnicity			
White	—	—	—
Black	1.04 (1.02–1.06)	1.04 (1.02–1.05)	1.04 (1.02–1.06)
Hispanic	1.05 (1.03–1.07)	1.05 (1.02–1.08)	1.05 (1.03–1.07)
Other	0.99 (0.94–1.05)	0.99 (0.94–1.05)	1.00 (0.94–1.05)
HIV transmission			
MSM	—	—	—
IDU	1.04 (1.01–1.06)	1.04 (1.02–1.07)	1.04 (1.01–1.06)
HET	0.98 (0.96–0.99)	0.97 (0.96–0.99)	0.98 (0.96–0.99)
HET-IDU	1.04 (1.02–1.07)	1.05 (1.02–1.08)	1.04 (1.01–1.07)
MSM-IDU	1.03 (1.00–1.06)	1.04 (1.01–1.07)	1.03 (1.00–1.06)
Other/missing	0.98 (0.95–1.01)	0.98 (0.95–1.01)	0.98 (0.95–1.01)
Age			
18–34	0.97 (0.95–0.98)	0.97 (0.95–0.98)	0.97 (0.95–0.98)
35–49	—	—	—
50+	1.05 (1.03–1.07)	1.06 (1.04–1.08)	1.05 (1.03–1.07)
Lowest CD4 count in a period			
≤ 50	1.32 (1.29–1.35)	1.32 (1.29–1.35)	1.31 (1.29–1.35)
$50 < \text{CD4} \leq 200$	1.16 (1.14–1.18)	1.16 (1.14–1.18)	1.16 (1.14–1.18)
$200 < \text{CD4} \leq 500$	1.05 (1.04–1.07)	1.06 (1.04–1.07)	1.05 (1.04–1.07)
>500	—	—	—
No test recorded	0.93 (0.90–0.95)	0.93 (0.90–0.95)	0.93 (0.90–0.95)
HIV-1 RNA			
>400 copies/ml	—	—	—
≤ 400 copies/ml	0.89 (0.88–0.90)	0.89 (0.88–0.90)	0.89 (0.88–0.90)
No test recorded	0.78 (0.76–0.80)	0.78 (0.76–0.80)	0.78 (0.76–0.80)
HAART			
No	—	—	—
Yes	1.11 (1.10–1.13)	1.12 (1.10–1.13)	1.11 (1.09–1.12)

Continued

Table 4: *Continued*

Variable	*Number of Visits*	*Number of Visits*	*Any Visit*
Insurance			
Private	—	—	—
Medicaid	1.07 (1.05–1.09)	1.07 (1.04–1.09)	1.07 (1.05–1.09)
Medicare	1.08 (1.05–1.10)	1.08 (1.05–1.10)	1.08 (1.05–1.10)
Ryan White/none	1.05 (1.03–1.08)	1.05 (1.03–1.08)	1.05 (1.03–1.08)
Missing	0.03 (0.03–0.03)	0.03 (0.03–0.03)	0.03 (0.02–0.03)

Note: $N = 13{,}299$ patients; 151,091 person-periods. 95% confidence intervals in parentheses.

Analyses also included dummy variables controlling for data collection site and period (results not shown).

Analyses were conducted using random effects negative binomial regression for number of visits, and random effects logistic regression for any visit. Entries are exponentiated coefficients and represent incidence rate ratios (for number of visits) or adjusted odds-ratios (for any visit).

HAART, highly active antiretroviral therapy; IDU, injection drug use; MSM, men who had sex with men; HET, heterosexual transmission.

in the subsequent period (Models 1 and 2), as was an indicator for any inpatient admission in the previous period (Model 3).

The outpatient visit rate was higher for patients with lowest CD4 counts < 500 cells/mm^3. Patients with undetectable viral load had less outpatient use than those who were detectable. Outpatient visit rates were higher among women, blacks or Hispanics, IDUs, older patients, and those on HAART. Patients with Medicaid or Medicare coverage had higher outpatient use than those with private insurance, even after controlling for CD4 cell count and viral load. In addition, uninsured patients had higher outpatient visit rates than the privately insured, while those with missing insurance data had almost no outpatient use.

DISCUSSION

Overall, the results suggest a positive association between outpatient service use and subsequent inpatient admission. In multivariate analyses, the association between outpatient use and subsequent inpatient use was positive, especially among patients with relatively high prior outpatient use. The results are consistent with a prior study of persons with HIV infection (Cunningham et al. 1996). Other research, not involving patients with HIV infection, also found no evidence that more primary care utilization was associated with lower inpatient use (Weinberger, Oddone, and Henderson 1996; Fortney et al. 2005).

However, closer inspection of the relationship between outpatient use and inpatient admissions suggests a possible nonlinear relationship. Specifically, patients with no outpatient visits tended to have higher inpatient admission rates than those with one visit, while those with one visit had fewer admissions than those with two. Having at least one outpatient visit in a 3-month period may reflect an important threshold of involvement with the health care system. Conversely, persons with no visits may be at relatively higher risk for hospitalization because they may not be receiving even minimal clinical monitoring. Sensitivity analyses suggested that the results were robust to modifications in the model and to the choice of time period. In contrast, analyses of outpatient visits showed a different pattern, with prior outpatient visits monotonically associated with subsequent outpatient visits.

The frequency of outpatient visits is presumably related to the intensity of monitoring of the patient's condition. It seems reasonable that active outpatient disease monitoring would reduce the likelihood or number of inpatient admissions. The literature on ambulatory care-sensitive (ACS) conditions is based on a similar assumption. ACS conditions are those for which "timely and effective outpatient care can help to reduce the risks of hospitalization by either preventing the onset of an illness or condition, controlling an acute episodic illness or condition, or managing a chronic disease or condition" (Billings et al. 1993). Despite the assumption that more outpatient physician visits should result in fewer ACS hospitalizations, a study by Roos et al. (2005) showed a positive relationship between number of ambulatory visits and hospitalization rates for three ACS conditions (not including HIV).

In the early years of the HIV epidemic, most hospitalizations were due to OIs (Fortgang and Moore 1995). In this context, it is conceivable that access to outpatient care could help to prevent the development of OIs. Consistent with this, a multivariate analysis that examined any admission primarily to treat OIs (Table 3) also showed a nonlinear (J-curve) pattern, which was somewhat stronger than the pattern observed for all inpatient admissions. More recently, however, the rate of hospitalizations for OIs has decreased (Gebo, Diener-West, and Moore 2001; Gebo, Fleishman, and Moore 2005), but there appears to be a substantial increase in hospitalization from non-HIV-related causes, such as viral hepatitis and metabolic conditions (Kilbourne et al. 2001; Rockstroh et al. 2005; Barbaro 2006; Lau, Gange, and Moore 2006). Opportunistic infections might qualify as ACS conditions, while other comorbidities might not.

As expected, patients with more advanced HIV disease, as reflected by low CD4 counts, utilized more inpatient services. The admission rate was particularly high for persons with lowest CD4 counts < 50 cells/mm^3 during a

period. Consistent with prior research, CD4 was less strongly associated with the number of outpatient visits (Shapiro et al. 1999; Fleishman et al. 2005).

Patients with data not recorded for CD4 count had fewer outpatient visits than those with CD4 counts above 500 cells/mm^3. Patients who are not using outpatient services do not have the opportunity to receive laboratory tests, resulting in both missing data and lower numbers of outpatient visits. On the other hand, patients without a CD4 test in a period had a higher rate of inpatient admissions than those with CD4 counts above 500. If missing data for this key clinical marker are viewed as reflecting lack of contact with the medical system, then this result does suggest that lack of contact might be related to a greater propensity to use inpatient services.

One limitation pertains to the generalizability of the findings. Data came from 10 HIV care provision sites in urban areas, all of which had large caseloads. Most were affiliated with a major medical center. Using nationally representative data from 1996, Bozzette et al. (1998) reported that 70 percent of HIV patients were seen by providers known to care for substantial numbers of HIV patients, and 18 percent of HIV patients were treated by providers who saw 250 or more patients per month. Trends toward consolidation of care in large providers may have continued since 1996. It is possible that patterns of service utilization differ for patients of providers who see small numbers of HIV-infected patients, or providers in single or small group private practices. Future research should confirm the current results using data from a more heterogeneous—ideally nationally representative—set of HIV care sites.

A second limitation of this study pertains to the possibility of unrecorded service utilization. The data collection sites attempted to record all inpatient and outpatient use, wherever it occurred. However, service utilization that occurred at providers outside the HIVRN may not have been recorded. Data relevant to this issue come from interviews in 2003 with a convenience sample of 951 patients from HIVRN sites, who reported the number of inpatient admissions and outpatient visits from all providers for 6 months before the interview. The proportion (denominator *n*) with any concurrent inpatient admission, regardless of site of admission, was 14 percent (14) for those with zero outpatient visits, 13 percent (54) for those with one visit, 9 percent (169) for those with 2, and 10 percent (138), 15 percent (78), 13 percent (39), and 28 percent (452) for those with 3, 4, 5, and 6 or more, respectively. Although the sample sizes are small, these results show a J-curve pattern consistent with results for 6-month periods (Table 3).

For 827 patients whose interview could be linked to their medical record data, agreement between interview and record data regarding the number of admissions for the same 6-month period was 83 percent. Given the possibil-

ities of forgetting an inpatient episode, or reporting an episode that occurred outside the reference period, we believe this level of agreement is high. Moreover, of those with no hospitalization in the medical record ($n = 748$), 87 percent reported no admission in the interview; of those with one or more hospitalization in the medical record ($n = 79$), 81 percent reported any hospitalization in the interview. While interview data may be subject to recall biases, these results suggest that the medical record data are not seriously undercounting inpatient admissions.

It is conceivable that some patients received only inpatient care at participating sites and obtained outpatient care elsewhere. This could give rise to a pattern in which patients with zero outpatient visits had a relatively higher likelihood of hospitalization than those with one visit. However, when we excluded the small number of person-periods (< 1 percent) in which the patient had only an inpatient episode and no outpatient or laboratory utilization, the findings were unchanged.

Forty-four percent of patients dropped out of the analyses. We know that 22 percent of dropouts died, but vital status data were not complete for all dropouts. Other patients who dropped out may have changed providers, been incarcerated, or relocated. The maximum-likelihood estimation in the random effects multivariate analyses assumes that data are missing at random (MAR; Little and Rubin 2002). In the present context, the MAR assumption implies that dropout may be related to observed variables, including prior observed values of the dependent variable. Thus, if the MAR assumption is valid, associations between independent variables and dropout do not compromise the estimates.

The generally positive association between number of outpatient visits and subsequent inpatient use should not be interpreted as a causal effect of the former on the latter. Rather, it is more likely that both types of utilization respond to variations in health status. Sicker patients may be seen more frequently in outpatient settings to monitor their condition and adjust their therapy; sicker patients may also be more likely to require inpatient care. The analyses controlled for two measures of HIV-related disease progression: CD4 counts and HIV-1 RNA. However, we could not control for other unmeasured aspects of health status, such as severity of HIV-related symptoms, which could drive both inpatient and outpatient use.

Outpatient care remains the cornerstone of treatment for HIV infection. Although the present data do not suggest that, overall, more outpatient utilization reduces the likelihood of inpatient use, periodic clinical monitoring on an outpatient basis has inherent value and cannot be evaluated solely in terms of

potentially fewer inpatient admissions. The results do point to the importance of maintaining regular clinical contact with HIV-infected patients. It is noteworthy that all patients in the current sample were already in care and had used services. Overall, the evidence for a heightened likelihood of inpatient service use for those with no prior outpatient use is suggestive, but not conclusive, and requires corroboration using data, such as from insurance claims, that provide fairly complete coverage of all service utilization. If future research confirms that patients with no outpatient use have a greater likelihood of subsequent hospitalization than those with some minimal use, the importance of maintaining regular care, even for established patients, will be highlighted.

ACKNOWLEDGMENT

Disclaimer: The views expressed in this paper are those of the authors. No official endorsement by DHHS or the Agency for Healthcare Research and Quality is intended or should be inferred.

NOTES

1. Data from a nationally representative sample of HIV patients in care in 1996 (HCSUS) estimated that 33 percent of patients in care were black and 18 percent acquired HIV through heterosexual relations (Shapiro et al. 1999). However, the distributions may have changed since 1996. Table 10 in the 2004 HIV/AIDS Surveillance Report (CDC 2005) reports estimated numbers of persons living with HIV/AIDS for 35 areas with name-based HIV reporting. For 2001, the proportion of persons living with HIV/AIDS who were black was 47.6 percent, which is closer to the HIVRN result (46.5 percent) than to HCSUS. The proportion of persons living with HIV/AIDS in 2001 who acquired HIV through heterosexual contact (combining both males and females but excluding children) was 27.1 percent, which is also closer to current results (30.8 percent) than to HCSUS. The CDC statistics pertain to all persons with HIV, and not specifically to those receiving care.
2. The median of one outpatient visit in each 3-month period is consistent with treatment recommendations that stable, adult patients on established HAART regimens have their HIV-1 RNA and CD4 levels assessed every 3–4 months (Hammer et al. 2006).

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