Published in final edited form as:
J Acquir Immune Defic Syndr. 2010 March 1; 53(3): 397–404. doi:10.1097/QAI.0b013e3181bcdc16.

Inpatient Health Services Utilization Among HIV-Infected Adult Patients in Care 2002–2007

Baligh R. Yehia, MD[1], **John A. Fleishman, PhD**[2], **Perrin L. Hicks, MPH**[1], **Michelande Ridore, BA**[1], **Richard D. Moore, MD, MHSc**[1], and **Kelly A. Gebo, MD, MPH**[1] **for the HIV Research Network**

[1]Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, Maryland
[2]Agency for Healthcare Research and Quality, Rockville, Maryland

Abstract

Objective—This study examines the frequency of inpatient hospitalization, the number of inpatient days, and factors associated with inpatient utilization in a multi-state HIV cohort between 2002 and 2007.

Design—A prospective cohort study of HIV-infected adults in care at 11 U.S. HIV primary and specialty care sites located in different geographic regions.

Methods—Demographic, clinical, and resource utilization data were collected from medical records for the years 2002–2007. Rates of resource use were calculated for number of hospital admissions, total inpatient days, and mean length of stay (LOS) per admission.

Results—Annual inpatient hospitalization rates significantly decreased from 35 to 27 per 100 persons from 2002 to 2007. The number of inpatient days per year significantly decreased over time, while mean LOS per admission was stable. Women, patients 50 years or older, Blacks, injection drug users, and patients without private insurance had higher hospitalization rates than their counterparts. Admission rates were lower for patients with high CD4 counts and low HIV-1 RNA levels.

Conclusion—Inpatient hospitalization rates and number of inpatient days decreased for HIV patients in this multi-state cohort between 2002 and 2007. Sociodemographic disparities in inpatient utilization persist.

Keywords

HIV; hospitalization; utilization; highly active antiretroviral therapy; length of stay

Introduction

The introduction of highly active antiretroviral therapy (HAART) considerably decreased inpatient health care utilization by people with HIV infection.[1–8] In recent years, however, the

Correspondence/Reprint Requests: Dr. Baligh Yehia, Johns Hopkins University School of Medicine, 1830 E. Monument St., Room 435, Baltimore, MD 21287, Phone: 352-256-8938, Fax: 410-955-7889, byehia@jhmi.edu.

Disclaimer: The views expressed in this paper are those of the authors. No official endorsement by DHHS, the National Institutes of Health, the Agency for Healthcare Research and Quality, the Robert Wood Johnson Foundation, or the Department of Veterans Affairs is intended or should be inferred.

Meetings: This research was in part presented at the 12th International Workshop on HIV Observational Databases, Malaga, Spain, March 27–30, 2008.

decrease in hospitalization rates has been less dramatic and at times stagnant.[1,9–11] This plateau in hospital utilization may be explained by the aging of the HIV infected population[12–20], an increase in complications due to comorbid diseases, and side effects of antiretroviral therapy.[9,21–25] Furthermore, decreases in inpatient utilization have not been uniform, with women, Blacks, and older patients requiring more frequent hospitalizations than their counterparts.[4,26–28]

Since 2002, the landscape of HIV epidemiology, therapy, and testing has changed. HIV/AIDS surveillance data from the Centers for Disease Control and Prevention (CDC) collected between 2003 and 2006 noted an increase in cases in people aged 45 years and older and continued disparity in race/ethnicity, with 49% of all new HIV/AIDS cases in 2006 occurring in Blacks.[29] Many new HIV therapies were approved by the US Food and Drug Administration (FDA) during this time period, including the introduction of 3 novel classes of medications - fusion inhibitors, entry inhibitors, and integrase inhibitors.30 Rapid oral HIV testing was also approved for use, which potentially has led to increased population screening and detection of new HIV/AIDS cases.30

Advances in HIV therapy and testing combined with changing epidemiological patterns require an updated evaluation of HIV inpatient health services utilization. One might expect increases in inpatient utilization due to comorbidities and factors associated with aging; on the other hand, new antiretroviral treatments may have effected further reductions in the need for hospitalization. The HIV Research Network (HIVRN) previously reported on hospital health services utilization during the years 2000 – 2002.[9] This study examines inpatient utilization and factors associated with inpatient utilization in a multi-state HIV cohort between 2002 and 2007.

Methods

Site Selection

The HIV Research Network (HIVRN) is a consortium of 21 sites that provide primary and subspecialty care to adult and pediatric HIV patients in 14 cities throughout the United States. HIVRN sites were selected from members of the HIV Quality Care Network of the Infectious Diseases Society of America. To be included, a site had to have a minimum data set available in electronic format or through paper abstraction, including patients' age, sex, race, HIV transmission risk factor, AIDS-defining illnesses, CD4 level, HIV-1 RNA, and use of antiretroviral medication. Twelve of these 21 participating sites also collected data on resource utilization for adult patients, including hospital admission with length of stay. Data from 11 of these sites, located in the Eastern U.S. (6), Midwestern U.S. (1), Southern U.S. (1), and Western U.S. (3), were included in this analysis. (One site dropped out of the study during the observation period and is not included in analyses.) Nine sites have academic affiliations; two are community-based.

Data Collection

The data elements described here were abstracted from electronic or paper records at each individual site. Abstracted data were sent in electronic format to a data coordinating center after personal identifying information was removed. A uniform format was used for the analytic database. For this analysis, data collection encompassed the time period of January 1, 2002 through December 31, 2007. The date of the encounter (not the date of billing or payment of claim) was used.

Electronic data received by the coordinating center were assessed to ensure that each data element was correctly formatted and that all elements were captured. Data elements with

incorrect formatting, with unknown or incomplete information, or other inaccuracies were reviewed with the site and corrected. After this verification process, the data were combined across sites to achieve a uniformly constructed multi-site database. A variable identifying the site was included in this database.

Definitions of Variables

Age was divided into three groups, 18 to 30, 31 to 49, and 50 years old and greater. Patients' race/ethnicity was categorized as White, Black, Hispanic, other, and missing. HIV transmission risk factor was grouped into injection drug use (IDU) and non-injection drug use (non-IDU), which included men who had sex with men (MSM), heterosexual transmission (HET), and HIV acquired from blood products or other routes. Patients who had IDU in combination with another risk factor (e.g., MSM, HET) were classified as IDU. Insurance was categorized into private, Medicaid, Medicare, Ryan White/uninsured, and missing. Patients with both Medicare and Medicaid insurance comprised a dual Medicaid/Medicare category.

HAART was defined as the concomitant use of 3 antiretroviral drugs, either from two of the following classes (nucleoside/nucleotide reverse transcriptase inhibitors [NRTIs], non-nucleoside reverse transcriptase inhibitors [NNRTs], protease inhibitors [PIs], or a fusion inhibitor) or 3 NRTIs. This definition of HAART was as inclusive as possible and unlikely to exclude any preferred drug combinations. Patients were considered to be on HAART if they received any of these combinations during a calendar year.

The CD4 and HIV-1 RNA laboratory values used in this analysis were the first values obtained in each calendar year. CD4 count was categorized as ≤ 50, 51–200, 201–500, > 500 cells/mm^3. HIV-1 RNA was categorized as < 401, 401–10,000, 10,001–100,000, and $> 100{,}000$ copies/ml.

The number of inpatient admissions and length of stay (LOS) were collected for every patient over each 12-month time period. Hospitalization rates were calculated using the total number of admissions per person per year. LOS for each admission was calculated by subtracting the admission date from the discharge date and adding one; same day admissions and discharges thus count as 1 day. We calculated total inpatient days by summing LOS for each admission during the year for each patient. Patients with no inpatient utilization had total days set to zero. Mean LOS per admission was calculated for each patient by dividing the total number of inpatient days by number of admissions during a year; for patients with only one admission in a year, mean LOS per admission equals total number of inpatient days. For patients with no inpatient admissions, mean LOS per admission was not calculated.

Data Analysis

Descriptive analyses of the demographic and clinical characteristics of the patients were conducted, including gender, age, race/ethnicity, HIV transmission risk factor, CD4 count, HIV-1 RNA, use of HAART, and insurance. To retain patients with missing data in the analyses, the category of "missing" was included for HIV-1 RNA, risk factor, race/ethnicity, and insurance.

Analyses of any hospitalization in a year were conducted using logistic regression. For multivariate analyses of number of inpatient admissions and total inpatient days in a year, we used negative binomial regression to estimate effects (incidence rate ratios) for calendar year, demographics, and clinical variables. 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.[31] We also conducted linear regression analyses of the mean length of stay per admission. The analysis of mean length of stay per admission was restricted to patients with a

hospitalization (N=10,097 patients). We also performed a second negative binomial regression of total inpatient days, restricted to patients with one or more admissions. All multivariate analyses included binary indicators for each care site to capture site-specific variation in utilization patterns.

This analysis was limited to adult (≥18 years old) patients who were in longitudinal HIV primary care, as defined by at least one visit to the outpatient clinic plus one CD4 count within each calendar year for the analysis. Patients who did not meet these criteria in a given year were not included in analyses for that year, although they were included in analyses for other years in which they met the criteria for receiving HIV primary care. Thus, the HIVRN represents an open cohort with patients entering and leaving care. Multivariate analyses pooled data for the years 2002–2007. Data were obtained for 14,496 patients in 2002, 14,714 in 2003, 14,687 in 2004, 14,923 in 2005, 15,129 in 2006, and 15,368 in 2007. A total of 8,400 patients provided data for one year, 5,382 had data for 2 years, 3,612 for 3 years, 3,168 for 4 years, 3,035 for 5 years, and 5,245 for 6 years. Overall, 28,842 individual patients provided data for at least one year.

Because the same patient can appear in multiple years, data from different years are not fully independent. In multivariate analyses, we therefore used generalized estimating equations (population-averaged models), with each patient as a cluster, independence working correlation, and robust standard errors, to deal with the correlation across years for individual patients.[32] All analyses were conducted in STATA 10.0 (College Station, TX).

Results

Demographic and clinical characteristics of the study sample for each year are presented in Table 1. In each year, the majority of the sample was male, of minority race/ethnicity, and between 31 to 49 years old. HIV transmission involved IDU in approximately 20% of the sample. Most study participants had Medicaid, or were classified as Ryan White/uninsured.

From 2002 to 2007, the proportion of study participants over the age of 50 increased, from 17% to 29%. The proportion of Whites decreased slightly, from 29% to 27%; however, the proportions of Blacks and Hispanics were consistent across time. IDU as a cause of HIV transmission decreased over the study period, from 24% to 19%. The median initial CD4 cell count of the year increased across time, from 354 in 2002 to 399 cells/mm^3 in 2007. The percentage of patients with undetectable HIV-1 RNA increased from 40% in 2002 to 56% in 2007. The distribution of insurance type differed over time, with a decrease in the number of patients with Ryan White funding or no insurance. The proportion receiving HAART increased across time, especially after 2005.

Frequency and Rates of Hospitalization

Frequency of hospital admissions varied from 2002 to 2007. (Table 2) In 2002, 19.3% of patients had one or more hospital admissions. The percentage dropped consistently over time, to 14.8 in 2007. In 2002, 11.5% of patients had one hospital admission, 4.0% had 2, and 3.8% had 3 or more. These proportions also dropped over time, to 9.4% with one admission in 2007, 2.8 with 2, and 2.6 with 3 or more. Annual inpatient hospitalization rates significantly decreased from 35 per 100 persons in 2002 to 27 per 100 persons in 2007.

After adjustment for demographic and clinical variables, inpatient hospitalization rates significantly decreased across time. (Table 3) A test of the joint significance of the 5 coefficients for year was significant (chi-square = 24.9, df=5, p=0.001). The major decrease occurred in 2005. A contrast of the coefficients for 2004 and 2005 was significant (chi-

square=11.13, p=0.001). Comparisons between other pairs of adjacent years were not significant, including the slight increase between 2005 and 2006.

Over all 6 years, hospitalization rates were higher among women than men (incidence rate ratio (IRR)= 1.23, 95% CI [1.17, 1.30]), and higher among those with lower initial CD4 counts. Compared to their respective reference categories, patients 50 years or older (1.45 [1.33, 1.58]), Blacks (1.20 [1.12, 1.28]), and IDUs (1.46 [1.38, 1.54)] had higher hospitalization rates, as did patients with higher HIV-1 RNA levels. After adjusting for CD4 and viral load, receipt of HAART did not significantly affect inpatient admission rates. Patients with Medicaid (2.18 [1.98, 2.39]), Medicare (2.15 [1.93, 2.40)], and dual Medicaid/Medicare (2.38 [2.07, 2.74]) coverage had higher hospitalization rates than those with private insurance. Logistic regression analysis of any inpatient hospitalizations revealed similar results as negative binomial regression.

Number of Inpatient Days per Year

The mean number of inpatient days per year decreased from 2.5 days (standard error [SE] = 0.075) in 2002 to 1.9 days (SE=0.079) in 2007. Among patients with a hospitalization in a year (15,156 hospitalizations among 10,097 patients), the mean number of inpatient days per year was 13.2 days (SE = 0.32, n=2,801) in 2002, decreasing to 12.4 days (SE=0.31, n=2,377) in 2005, and then rising slightly to 13.1 (SE=0.47, n=2,274) in 2007. The largest reduction in mean number of inpatient days per year occurred in 2005. (Table 2)

Using multivariate negative binomial regression to adjust for other variables, the pattern of results for number of inpatient days per year was similar to that for any admissions. The number of inpatient days per year was similar in 2002–2004, but dropped in 2005. Compared to 2002, the rate for inpatient days dropped by 14% in 2005 and 135% in 2006. The pairwise comparison of the coefficients of 2005 and 2004 was significant (chi-square=5.05, p=0.02), while other contrasts between pairs of adjacent years were not significant.

Similar to results for number of inpatient hospitalizations, women (IRR=1.29 [1.19, 1.39]), patients 50 years or older (1.71 [1.51, 1.93]), Black and Hispanic patients (1.25 [1.14, 1.36] and 1.14 [1.00, 1.30], respectively), and IDUs (1.62 [1.50, 1.75]) had more inpatient days than their respective reference groups. Compared to those with private insurance, patients with Medicaid (2.43[2.14, 2.77]), Medicare (2.51 [2.15, 2.92]), and dual Medicaid/Medicare coverage (2.65 [2.18, 3.23]) demonstrated a higher total number of inpatient days than those with private coverage. Lower CD4 counts and higher levels of HIV-1 RNA were each associated with more inpatient days. Receipt of HAART was not associated with number of inpatient days.

Among 10,097 patients with one or more admissions (Table 4), the total number of inpatient days did not differ significantly over time. The rate was lower in 2005 than 2004, but this difference was not statistically significant.

Mean Length of Stay per Admission

Among patients with a hospitalization, the mean LOS per admission was stable in 2002–2005, but dropped to 6.50 days (SE= 0.13) in 2006, a significant difference from 2005 (p=.04). (Table 2) In multivariate linear regression analyses, mean LOS per admission did not change significantly over time (Table 4). Patients 50 years or older (coefficient=0.80 95% Confidence Interval [0.33, 1.28]), Blacks (0.34 [0.01, 0.66]), Hispanics (0.53 [0.10, 0.97), and IDUs (0.37 [0.05, 0.68]) had higher mean LOS per admission then younger patients, Whites, and non-IDUs, respectively. Thus, for example, the mean LOS per admission was 0.80 days longer for patients aged 50 or older, compared with younger ones. Low CD4 count and high HIV-1 RNA

were associated with longer mean LOS per admission, as was Ryan White/uninsured status (0.73 [0.18, 1.28]), compared to patients with private insurance. In contrast to previous analyses, receipt of HAART was significantly associated with shorter mean LOS per admission (−0.46 [−0.81, −0.12])

Discussion

Despite the aging of the HIV infected population and the increase in comorbidities[9,21,23,25], hospitalization rates in this US-based cohort have declined in the current HAART era. The current study demonstrates a decrease in inpatient admission rates and inpatient days over a six-year period, 2002 to 2007, with the biggest change in 2005. The notable decrease in 2005 could be due to the availability of ART with once daily dosing and fewer side effects.

Inpatient healthcare utilization has had a generally downward trend since the introduction of HAART. Numerous studies demonstrate a significant decline in hospitalizations in the early HAART era, with a less steep decline in the most recent studies.[1–7,10,11] From 1998 to 2002, little or no change in inpatient admission rates was observed in two large multi-state HIV cohorts.[9,11] More recent data have documented a decline in hospitalization rates. One study comparing the number of hospital admissions per person living with HIV in 6 states noted a 20% reduction between the years 2000 and 2004.[34] Additionally, the HIV Outpatient Study reported a decrease in the hospitalization rate per 100 person-years from 14.93 to 11.21 between the periods 2000–2002 and 2003–2005.[1] Our data show a 10% reduction in hospitalization rate between 2002 and 2007; a 25% reduction was demonstrated in the HIV Outpatient Study during a similar time period.[1]When evaluating this literature, one must distinguish studies using the hospitalization as the unit of analysis,[2,10,34] from studies that use the patient as the unit of analysis. It is possible that the aggregate number of hospitalizations could increase, due to increasing prevalence of HIV infection, but the overall hospitalization rate could nevertheless decline, as in the current study. Future studies will be needed to see if these trends continue as the HIV infected population ages and develops more comorbidities.

Multiple factors could be contributing to this decline in hospitalizations. With the advent of once-daily regimens with fewer side effects and newer antiretroviral agents for resistant HIV, HAART therapy has become easier for providers to administer and for both naïve and experienced patients to tolerate. As a result, there has been a rise in the median CD4 count across time in the HIVRN cohort as well as other groups. Similarly, HIV-1 RNA has decreased from a median of 1,778 copies/mL in 2000 to 400 copies/mL in 2007. Presumably, the introduction of HAART has led to improvement in immune status and a decrease in the proportion of hospitalizations from AIDS defining illnesses (ADI).[1,11] After controlling for CD4 and HIV-1 RNA, receipt of HAART did not significantly affect admission rates or total number of inpatient days among the full analytic sample. Although some have theorized that there is an increase in short term morbidity after starting patients on HAART35–37, in this study, over a longer term, inpatient days per year did not decline for patients on HAART.

In prior studies, mean length of stay per admission steadily declined from nearly 14 days in 1993 to 8.85 days in 2000.[2,10] Between 2000 and 2002, mean LOS per admission did not appreciably change in the HIVRN.[9] In a multi-state study, mean LOS per admission remained relatively stable, from 8.3 to 8.4 days, between 2000 and 2004.[34] Our data demonstrated only slight changes in mean LOS per admission between 2002 and 2007. However, a significant decrease in mean number of inpatient days per year was observed. The decrease in inpatient days reflects the lower admission rates; the length of an individual inpatient episode did not change appreciably.

Disparities in inpatient utilization still exist for women, Blacks, IDUs, and older patients.[4,26–28] Multiple studies have demonstrated a higher hospitalization rate for HIV-infected women compared to men.[3,9–11,26] Similarly, even after adjustment for other factors, Black race/ethnicity has repeatedly been associated with increased hospitalization rates.[9–11,38] It has been hypothesized that patients with lower socioeconomic status have increased hospitalization rates[39]; in this study patients with public insurance were more likely to be hospitalized than those with private insurance. These sociodemographic differences were observed despite adjusting for CD4 count, the major indicator of HIV-related health status.

Older age has been associated with increased hospitalization rates in prior research.[9] HIV patients older than 50 years of age account for a rising proportion of all inpatient admissions, most likely attributable to comorbidities associated with increasing age, namely diabetes, malignancy, and cardiovascular disease.[10,11] Additional studies will need to examine trends in hospitalization diagnoses by age group. Consistent with prior studies, IDUs have higher hospitalization rates than non-IDUs.[4,9,27,28] Our data did not differentiate between active and past drug use. Therefore, future studies will be needed to investigate hospitalizations rates comparing active to past drug users.

When compared to the general population, HIV-infected patients have longer than average LOS.[40] As immune function improves, HIV patients may be admitted for medical reasons unrelated to HIV diagnosis. Schneider and colleagues noted that HIV-infected patients hospitalized without an opportunistic infection (OI) had shorter length of stay when compared to patients with OIs.[41] In addition, data from an international multi-site study conducted during the HAART era examining LOS for treatment of community acquired pneumonia found no significant difference in LOS between HIV-infected and HIV-negative patients.42 These studies indicate that non-HIV-associated conditions can influence LOS, and may ultimately decrease overall HIV LOS and bring it closer to that of the general population.

This study is subject to several limitations. First, sites in our sample were not selected by a statistically derived algorithm and are not nationally representative. However, the sites in the sample do encompass a broad geographic distribution, and multi-site studies afford greater generalizability than single-site studies. Second, HIVRN sites are highly experienced in the treatment of HIV, with high rates of HAART usage and OI prophylaxis.[43] Our results may not generalize to sites with less provider experience with HIV, smaller caseload of HIV patients, or rural location. Third, our analysis did not include hospital admission diagnoses. This limited our ability to analyze the relationship between admitting diagnosis and inpatient utilization patterns. Lastly, inpatient utilization may be underestimated if patients were treated at hospitals outside HIVRN sites. Each HIVRN site attempts to capture all utilization data, including care provided at the home institution and by other neighboring providers. An unpublished analysis of Medicaid claims data at one site noted that 96% of all admissions occurred at the home hospital. While this one site demonstrates high retention of care among patients, we are do not have comparable data from other HIVRN sites and cannot be certain that they have similar retention patterns.

In conclusion, annual inpatient hospitalization rates and number of inpatient days per year significantly decreased for HIV patients in this multi-state cohort between 2002 and 2007, with the largest decrease occurring in 2005. Decreased admission rates and inpatient days were associated with high CD4 counts, and low HIV-1 RNA. Women, Blacks, HIV transmission from IDU, and older patients still display relatively high inpatient utilization, pointing to persistence of disparities despite advances in HIV treatment.

Acknowledgments

Sponsorship: Supported by the Agency for Healthcare Research and Quality (290-01-0012) and the National Institutes of Aging (R01 AG026250) and Drug Abuse (K23-DA00523 and K24 DA 00432). Dr. Gebo also received support from a Johns Hopkins Clinician Scientist Award.

APPENDIX

Participating Sites

Alameda County Medical Center, Oakland, California (Howard Edelstein, M.D.)

Children's Hospital of Philadelphia, Philadelphia, Pennsylvania (Richard Rutstein, M.D.)

Community Health Network, Rochester, New York (Roberto Corales, D.O.)

Community Medical Alliance, Boston, Massachusetts (James Hellinger, M.D.)

Drexel University, Philadelphia, Pennsylvania (Sara Allen, C.R.N.P., Peter Sklar, M.D.)

Henry Ford Hospital Detroit, Michigan (Norman Markowitz, M.D.)

Johns Hopkins University, Baltimore, Maryland (Kelly Gebo, M.D., Richard Moore, M.D)

Montefiore Medical Group, Bronx, New York (Robert Beil, M.D.)

Montefiore Medical Center, Bronx, New York (Lawrence Hanau, M.D.)

Nemechek Health Renewal, Kansas City, Missouri (Patrick Nemechek, D.O.)

Oregon Health and Science University, Portland, Oregon (P. Todd Korthuis, M.D.)

Parkland Health and Hospital System, Dallas, Texas (laura Armas, M.D.)

St. Jude's Children's Hospital and University of Tennessee, Memphis, Tennessee (Aditya Gaur, M.D.)

St. Luke's Roosevelt Hospital Center, New York, New York (Victoria Sharp, M.D.)

Tampa General Health Care, Tampa, Florida (Charurut Somboonwit, M.D.)

University of California, San Diego, La Jolla, California (Stephen Spector, M.D.)

University of California, San Diego, California (W. Christopher Mathews, M.D.)

Wayne State University, Detroit, Michigan (Jonathan Cohn, M.D.)

Sponsoring Agencies

Agency for Healthcare Research and Quality, Rockville, Maryland (Fred Hellinger, Ph.D., John Fleishman, Ph.D., Irene Fraser, Ph.D.)

Health Resources and Services Administration, Rockville, Maryland (Alice Kroliczak, Ph.D., Robert Mills, Ph.D.)

Substance Abuse and Mental Health Services Administration, Rockville, MD (Kevin Mulvey, Ph.D., Pat Roth)

Data Coordinating Center

Johns Hopkins University (Richard Moore, M.D., Jeanne Keruly, C.R.N.P., Kelly Gebo, M.D., Perrin Hicks, M.P.H., Michelande Ridoré, B.A., Cindy Voss, M.S., Bonnie Cameron, M.S.)

References

1. Buchacz K, Baker RK, Moorman AC, et al. Rates of hospitalizations and associated diagnoses in a large multisite cohort of HIV patients in the United States, 1994–2005. AIDS 2008;22(11):1345–1354. [PubMed: 18580614]
2. Fleishman JA, Hellinger FJ. Trends in HIV-related inpatient admissions from 1993 to 1997: a seven-state study. J Acquir Immune Defic Syndr 2001;28(1):73–80. [PubMed: 11579280]
3. Floris-Moore M, Lo Y, Klein RS, et al. Gender and hospitalization patterns among HIV-infected drug users before and after the availability of highly active antiretroviral therapy. J Acquir Immune Defic Syndr 2003;34(3):331–337. [PubMed: 14600580]
4. Gebo KA, Diener-West M, Moore RD. Hospitalization rates in an urban cohort after the introduction of highly active antiretroviral therapy. J Acquir Immune Defic Syndr 2001;27(2):143–152. [PubMed: 11404536]
5. Mouton Y, Alfandari S, Valette M, et al. Impact of protease inhibitors on AIDS-defining events and hospitalizations in 10 French AIDS reference centres. Federation National des Centres de Lutte contre le SIDA. AIDS 1997;11(12):F101–F105. [PubMed: 9342061]
6. Paul S, Gilbert HM, Lande L, et al. Impact of antiretroviral therapy on decreasing hospitalization rates of HIV-infected patients in 2001. AIDS Res Hum Retroviruses 2002;18(7):501–506. [PubMed: 12015903]
7. Paul S, Gilbert HM, Ziecheck W, et al. The impact of potent antiretroviral therapy on the characteristics of hospitalized patients with HIV infection. AIDS 1999;13(3):415–418. [PubMed: 10199233]
8. Torres RA, Barr M. Impact of combination therapy for HIV infection on inpatient census. N Engl J Med 1997;336(21):1531–1532. [PubMed: 9157292]
9. Fleishman JA, Gebo KA, Reilly ED, et al. Hospital and outpatient health services utilization among HIV-infected adults in care 2000–2002. Med Care 2005;43(9 Suppl):III40–III52. [PubMed: 16116308]
10. Fleishman JA, Hellinger FH. Recent trends in HIV-related inpatient admissions 1996–2000: a 7-state study. J Acquir Immune Defic Syndr 2003;34(1):102–110. [PubMed: 14501801]
11. Gebo KA, Fleishman JA, Moore RD. Hospitalizations for metabolic conditions, opportunistic infections, and injection drug use among HIV patients: trends between 1996 and 2000 in 12 states. J Acquir Immune Defic Syndr 2005;40(5):609–616. [PubMed: 16284539]
12. Casau NC. Perspective on HIV infection and aging: emerging research on the horizon. Clin Infect Dis 2005;41(6):855–863. [PubMed: 16107986]
13. Cloud GC, Browne R, Salooja N, et al. Newly diagnosed HIV infection in an octogenarian: the elderly are not 'immune'. Age Ageing 2003;32(3):353–354. [PubMed: 12720627]
14. Grabar S, Weiss L, Costagliola D. HIV infection in older patients in the HAART era. J Antimicrob Chemother 2006;57(1):4–7. [PubMed: 16284223]
15. Manfredi R. HIV disease and advanced age: an increasing therapeutic challenge. Drugs Aging 2002;19(9):647–669. [PubMed: 12381235]
16. Manfredi R. HIV infection and advanced age emerging epidemiological, clinical, and management issues. Ageing Res Rev 2004;3(1):31–54. [PubMed: 15164725]
17. Centers for Disease Control and Prevention. AIDS among persons aged > or = 50 years--United States, 1991–1996. Morb Mortal Wkly Rep 1998;47(2):21–27.
18. Centers for Disease Control and Prevention. HIV/AIDS Surveillance Supplemental Report, 2002. Atlanta: U.S.: Department of Health and Human Services, Centers for Disease Control and Prevention; 2002.
19. Shah S, Mildvan D. HIV and Aging. Curr Infect Dis Rep 2006;8(3):241–247. [PubMed: 16643776]
20. Ship JA, Wolff A, Selik RM. Epidemiology of acquired immune deficiency syndrome in persons aged 50 years or older. J Acquir Immune Defic Syndr 1991;4(1):84–88. [PubMed: 1984059]

21. Bozzette SA, Ake CF, Tam HK, et al. Cardiovascular and cerebrovascular events in patients treated for human immunodeficiency virus infection. N Engl J Med 2003;348(8):702–710. [PubMed: 12594314]
22. Carr A, Samaras K, Burton S, et al. A syndrome of peripheral lipodystrophy, hyperlipidaemia and insulin resistance in patients receiving HIV protease inhibitors. AIDS 1998;12(7):F51–F58. [PubMed: 9619798]
23. Gebo KA, Diener-West M, Moore RD. Hospitalization rates differ by hepatitis C status in an urban HIV cohort. J Acquir Immune Defic Syndr 2003;34(2):165–173. [PubMed: 14526205]
24. Holmberg SD, Moorman AC, Williamson JM, et al. Protease inhibitors and cardiovascular outcomes in patients with HIV-1. Lancet 2002;360(9347):1747–1748. [PubMed: 12480430]
25. Soriano V, Martin-Carbonero L, Garcia-Samaniego J, et al. Mortality due to chronic viral liver disease among patients infected with human immunodeficiency virus. Clin Infect Dis 2001;33(10):1793–1795. [PubMed: 11641832]
26. Betz ME, Gebo KA, Barber E, et al. Patterns of diagnoses in hospital admissions in a multistate cohort of HIV-positive adults in 2001. Med Care 2005;43:III3–III14. [PubMed: 16116304]
27. Schoenbaum EE, Lo Y, Floris-Moore M. Predictors of hospitalization for HIV-positive women and men drug users, 1996–2000. Public Health Rep 2002;117:S60–S66. [PubMed: 12435828]
28. Shapiro MF, Morton SC, McCaffrey DF, et al. Variations in the care of HIV-infected adults in the United States: results from the HIV Cost and Services Utilization Study. JAMA 1999;281(24):2305–2315. [PubMed: 10386555]
29. Centers for Disease Control and Prevention. HIV / AIDS Surveillance Supplemental Report, 2006. Atlanta: U.S.: Department of Health and Human Services, Centers for Disease Control and Prevention; 2008.
30. US Food and Drug Admistration. Antiretroviral drugs used in the treatment of HIV infection. [Accessed June 26, 2009]. Available at: http://www.fda.gov/ForConsumers/ByAudience/ForPatientAdvocates/HIVandAIDSActivities/ucm118915.htm
31. Long, J. Regression Models for Catergorical and Limited Dependent Variables. Thousand Oaks, CA: Sage Publications; 1997.
32. Liang K. Longitudinal data analysis using generalized linear models. Biometrika 1986:13–22.
33. Manabe Y, Breen R, Petri T, et al. Unmasked Tuberculosis and Tuberculosis Immune Reconstitution Inflammatory Disease: a Disease Spectrum after Antiretroviral Therapy Initiation. J Infect Dis 2009;199(3):437–444. [PubMed: 19090776]
34. Hellinger FJ. The changing pattern of hospital care for persons living with HIV: 2000 through 2004. J Acquir Immune Defic Syndr 2007;45(2):239–246. [PubMed: 17414928]
35. Manabe YC, Campbell JD, Sydnor E, et al. Immune reconstitution inflammatory syndrome: risk factors and treatment implications. J Acquir Immune Defic Syndr 2007;46(4):456–462. [PubMed: 18077835]
36. Ratnam I, Chiu C, Kandala NB, et al. Incidence and risk factors for immune reconstitution inflammatory syndrome in an ethnically diverse HIV type 1-infected cohort. Clin Infect Dis 2006;42(3):418–427. [PubMed: 16392092]
37. Shelburne SA, Visnegarwala F, Darcourt J, et al. Incidence and risk factors for immune reconstitution inflammatory syndrome during highly active antiretroviral therapy. AIDS 2005;19(4):399–406. [PubMed: 15750393]
38. The HIV Research Network. Hospital and Outpatient Health Services Utilization Among HIV-Infected Patients in Care in 1999. J Acquir Immune Defic Syndr 2002;30(1):21–26. [PubMed: 12048359]
39. Nosyk B, Li X, Sun H, et al. The effect of homelessness on hospitalisation among patients with HIV/AIDS. AIDS Care 2007;19(4):546–553. [PubMed: 17453596]
40. National Center for Health Statistics. Health, United States, 2007 With Chartbook on Trends in the Health of Americans. Hyattsville, MD: 2007.
41. Schneider JA, Zhang Q, Auerbach A, et al. Do hospitalists or physicians with greater inpatient HIV experience improve HIV care in the era of highly active antiretroviral therapy? Results from a

multicenter trial of academic hospitalists. Clin Infect Dis 2008;46(7):1085–1092. [PubMed: 18444829]

42. Christensen D, Feldman C, Rossi P, et al. HIV infection does not influence clinical outcomes in hospitalized patients with bacterial community-acquired pneumonia: results from the CAPO international cohort study. Clin Infect Dis 2005;41(4):554–556. [PubMed: 16028168]
43. Gebo KA, Fleishman JA, Reilly ED, et al. High rates of primary Mycobacterium avium complex and Pneumocystis jiroveci prophylaxis in the United States. Med Care 2005;43(9 Supp):III23–III30. [PubMed: 16116306]

J Acquir Immune Defic Syndr. Author manuscript; available in PMC 2011 March 1.

Table 1

Demographic and Clinical Characteristics of Sample by Calendar Year

Characteristic	2002 N = 14,496 (%)	2003 N= 14,714 (%)	2004 N= 14,687 (%)	2005 N=14,923 (%)	2006 N=15,129 (%)	2007 N=15,368 (%)
Age (years)						
18–30	1576 (11)	1466 (10)	1478 (10)	1402 (9)	1459 (10)	1437 (9)
31–49	10395 (72)	10430 (71)	10140 (69)	9973 (67)	9728 (64)	9547 (62)
50+	2525 (17)	2818 (19)	3069 (21)	3548 (24)	3942 (26)	4384 (29)
Race/ethnicity						
White	4259 (29)	4407 (30)	4344 (30)	4250 (28)	4091 (27)	4153 (27)
Black	7097 (49)	7028 (48)	6957 (47)	7183 (48)	7490 (50)	7557 (49)
Hispanic	2831 (20)	2978 (20)	3064 (21)	3094 (21)	3053 (20)	3109 (20)
Other	257 (2)	255 (2)	268 (2)	274 (2)	289 (2)	310 (2)
Missing	52 (<1)	46 (<1)	54 (<1)	122 (<1)	206 (1)	239 (2)
Gender						
Male	10273 (71)	10504 (71)	10458 (71)	10668 (71)	10721 (71)	10937 (71)
Female	4223 (29)	4210 (29)	4229 (29)	4255 (29)	4408 (29)	4431 (29)
HIV transmission						
IDU	3491 (24)	3366 (23)	3202 (22)	3085 (21)	2979 (20)	2932 (19)
Non-IDU	10577 (73)	10920 (74)	11007 (75)	11359 (76)	11769 (78)	11997 (78)
Missing	428 (3)	428 (3)	478 (3)	479 (3)	381 (2)	439 (3)
Initial CD4 in Year (cells/mm^3)						
Median	354	364	374	378	388	399
≤50	1410 (10)	1266 (9)	1212 (8)	1238 (8)	1086 (7)	1042 (7)
51–200	2473 (17)	2475 (17)	2387 (16)	2341 (16)	2290 (15)	2265 (15)
201–500	6058 (42)	6319 (43)	6328 (43)	6494 (44)	6543 (43)	6525 (42)
>500	4555 (31)	4654 (32)	4760 (32)	4850 (33)	5210 (34)	5536 (36)
Initial HIV-1 RNA in Year (copies/mL)						
Median	1,778	1,401	961	400	400	400
<401	5782 (40)	6187 (42)	6601 (45)	7258 (49)	7802 (52)	8533 (56)
401 – 10,000	3270 (23)	2978 (20)	2735 (19)	2526 (17)	2316 (15)	2255 (15)

Characteristic	2002 N = 14,496 (%)	2003 N= 14,714 (%)	2004 N= 14,687 (%)	2005 N=14,923 (%)	2006 N=15,129 (%)	2007 N=15,368 (%)
10,001–100,000	3345 (23)	3317 (23)	3335 (23)	3345 (22)	3112 (21)	2915 (19)
>100,000	1929 (13)	2052 (14)	1903 (13)	1378 (9)	1764 (12)	1486 (10)
Missing	170 (1)	180 (1)	113 (1)	416 (3)	135 (1)	179 (1)
HAART receipt						
No	3793 (26)	3919 (27)	4038 (27)	3706 (25)	3342 (22)	2972 (19)
Yes	10703 (74)	10795 (73)	10649 (73)	11217 (75)	11787 (78)	12396 (81)
Insurance						
Private	1740 (12)	1508 (10)	1510 (10)	1987 (13)	2089 (14)	2255 (15)
Medicaid	5294 (37)	5518 (38)	5259 (36)	5596 (38)	5413 (36)	5408 (35)
Medicare	1808 (12)	1832 (12)	1862 (13)	1738 (12)	2016 (13)	1946 (13)
Medicaid &Medicare	531 (4)	685 (5)	553 (4)	655 (4)	913 (6)	428 (3)
Ryan White/uninsured	3892 (27)	4450 (30)	4441 (30)	3923 (26)	4146 (27)	3554 (23)
Missing	1231 (8)	721 (5)	1062 (7)	1024 (7)	552 (4)	1777 (11)

Table 2

Inpatient Utilization by Calendar Year

	2002 N = 14,496	2003 N= 14,714	2004 N= 14,687	2005 N=14,923	2006 N=15,129	2007 N=15,368
Hospitalizations (number [%])						
0	11,695 (80.7)	11,968 (81.3)	12,091 (82.3)	12,546 (84.1)	12,767 (84.4)	13,094 (85.2)
1	1,669 (11.5)	1,665 (11.3)	1,521 (10.4)	1,492 (10.0)	1,463 (9.7)	1,438 (9.4)
2	580 (4.0)	573 (3.9)	583 (4.0)	462 (3.1)	449 (3.0)	432 (2.8)
3+	552 (3.8)	508 (3.5)	492 (3.4)	423 (2.8)	450 (3.0)	404 (2.6)
Hospitalization Rate (mean [SE])	0.35 (0.008)	0.34 (0.008)	0.32 (0.007)	0.28 (0.007)	0.28 (0.007)	0.27 (0.007)
Inpatient Days (mean [SE])	2.54 (0.08)	2.44 (0.08)	2.30 (0.07)	1.97 (0.06)	1.96 (0.07)	1.94 (0.08)
Inpatient days among hospitalized patients (mean [SE])	13.16 (0.32)	13.06 (0.34)	13.00 (0.31)	12.35 (0.31)	12.52 (0.36)	13.12 (0.47)
Average LOS per hospitalization among hospitalized patients (mean [SE])	6.89 (0.13)	6.86 (0.14)	6.82 (0.14)	6.91 (0.16)	6.50 (0.13)	6.84 (0.23)

Table 3

Multivariate Analysis of Number of Inpatient Admissions, Any Inpatient Admission, and Number of Inpatient Days per Year

Characteristic	No. Inpatient Hospitalizations IRR (95% CI)	Any Inpatient Hospitalization AOR (95% CI)	Number of Inpatient Days IRR (95% CI)
Age (years)			
18–30	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
31–49	1.19 (1.11–1.28)	1.08 (1.00–1.17)	1.28 (1.14–1.43)
50+	1.45 (1.33–1.58)	1.37 (1.26–1.50)	1.71 (1.51–1.93)
Race/ethnicity			
White	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Black	1.20 (1.12–1.28)	1.16 (1.09–1.24)	1.25 (1.14–1.36)
Hispanic	1.05 (0.97–1.14)	1.05 (0.98–1.14)	1.14 (1.00–1.30)
Other	0.85 (0.70–1.03)	0.84 (0.70–1.01)	0.87 (0.66–1.16)
Missing	0.64 (0.47–0.87)	0.58 (0.43–0.79)	0.85 (0.56–1.29)
Gender			
Male	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Female	1.23 (1.17–1.30)	1.28 (1.21–1.35)	1.29 (1.19 – 1.39)
HIV transmission			
Non-IDU	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
IDU	1.46 (1.38–1.54)	1.46 (1.38–1.55)	1.62 (1.50–1.75)
Missing	1.44 (1.28–1.62)	1.40 (1.24–1.57)	1.54 (1.32–1.78)
Initial CD4 in Year(cells/mm^3)			
≤50	4.65 (4.29 – 5.04)	5.59 (5.15– 6.07)	6.98 (6.25 – 7.80)
51–200	2.52 (2.34 – 2.72)	2.37 (2.21 – 2.53)	3.16 (2.84 – 3.51)
201–500	1.38 (1.29 – 1.47)	1.32 (1.25 – 1.40)	1.42 (1.30 – 1.55)
>500	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Initial HIV-1 RNA in Year (copies/mL)			
<400	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
401 – 10000	1.19 (1.11–1.27)	1.17 (1.10–1.24)	1.31 (1.17–1.46)
10000 – 100000	1.32 (1.24–1.40)	1.31 (1.24–1.39)	1.43 (1.32–1.56)
> 100000	1.77 (1.65–1.90)	1.96 (1.84–2.10)	2.12 (1.93–2.34)
Missing	1.34 (1.12–1.60)	1.32 (1.12–1.55)	1.60 (1.22–2.10)
HAART receipt			
No	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Yes	1.04 (0.98–1.10)	0.99 (0.93–1.04)	0.99 (0.91 – 1.08)
Insurance			
Private	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Medicaid	2.18 (1.98–2.39)	2.27 (2.08–2.48)	2.43 (2.14–2.77)
Medicare	2.15 (1.93–2.40)	2.18 (1.97–2.40)	2.51 (2.15–2.92)
Medicaid & Medicare	2.38 (2.07–2.74)	2.31 (2.03–2.63)	2.65 (2.18–3.23)
Ryan White/uninsured	1.23 (1.11–1.36)	1.24 (1.13–1.36)	1.33 (1.15–1.55)

Characteristic	No. Inpatient Hospitalizations IRR (95% CI)	Any Inpatient Hospitalization AOR (95% CI)	Number of Inpatient Days IRR (95% CI)
Missing	1.83 (1.63–2.06)	1.99 (1.78–2.23)	1.99 (1.69–2.35)
Year			
2002	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
2003	0.98 (0.93–1.03)	0.97 (0.91–1.03)	0.98 (0.90–1.06)
2004	0.97 (0.91–1.02)	0.92 (0.86–0.98)	0.95 (0.88–1.04)
2005	0.87 (0.82–0.93)	0.84 (0.79–0.90)	0.86 (0.79–0.93)
2006	0.91(0.86–0.97)	0.84 (0.79–0.90)	0.87 (0.80–0.95)
2007	0.90 (0.84–0.96)	0.81 (0.76–0.86)	0.97 (0.85–1.10)

Note: Analyses conducted on 89,317 observations from 28,842 patients. IRR: incidence rate ratio; AOR: adjusted odds ratio.

Table 4

Multivariate Negative Binomial Regression for Total Number of Inpatient Days and Linear Regression of Mean Length of Stay per Admission, for Patients with a Hospital Admission

Characteristic	Number of Inpatient Days IRR (95% CI)	Mean Length of Stay per Admission coefficient (95% CI)
Age (years)		
18–30	1.0 (Ref)	(Ref)
31–49	1.15 (1.06–1.24)	0.37 (−0.05, 0.79)
50+	1.22 (1.12–1.34)	0.80 (0.33, 1.28)
Race/ethnicity		
White	1.0 (Ref)	(Ref)
Black	1.11 (1.04–1.18)	0.34 (0.01, 0.66)
Hispanic	1.10 (1.02–1.19)	0.53 (0.10, 0.97)
Other	0.99 (0.83–1.18)	0.13 (−0.83, 1.09)
Unknown	1.28 (0.95–1.73)	1.97 (0.38, 3.57)
Gender		
Male	1.0 (Ref)	(Ref)
Female	1.08 (1.02 – 1.14)	0.11 (−0.20, 0.42)
HIV transmission		
Non-IDU	1.0 (Ref)	(Ref)
IDU	1.16 (1.10 –1.22)	0.37 (0.05, 0.68)
Missing	1.22 (1.11 –1.35)	0.62 (0.07, 1.17)
Initial CD4 in Year (cells/mm^3)		
≤50	1.90 (1.76 – 2.06)	2.68 (2.20, 3.15)
51–200	1.49 (1.38 – 1.60)	1.24 (0.81, 1.68)
201–500	1.13 (1.06 – 1.21)	0.27 (−0.10, 0.64)
>500	1.0 (Ref)	(Ref)
Initial HIV-1 RNA in Year (copies/mL)		
< 400	1.0 (Ref)	(Ref)
401 – 10,000	1.11 (1.02–1.20)	0.43 (−0.03, 0.90)
10,001–100,000	1.12 (1.05–1.19)	0.44 (0.11, 0.78)
>100,000	1.19 (1.11–1.27)	0.72 (0.34, 1.09)
Missing	1.23 (1.04–1.46)	1.21 (0.19, 2.23)
HAART receipt		
No	1.0 (Ref)	(Ref)
Yes	0.99 (0.94–1.05)	−0.46 (−0.81, −0.12)
Insurance		
Private	1.0 (Ref)	(Ref)
Medicaid	1.17 (1.07–1.28)	0.44 (−0.03, 0.90)
Medicare	1.22 (1.09–1.36)	0.56 (0.01, 1.11)
Medicaid & Medicare	1.19 (1.04–1.37)	−0.03 (−0.62, 0.56)
Ryan White/uninsured	1.10 (0.99–1.23)	0.73 (0.18, 1.28)

Characteristic	Number of Inpatient Days IRR (95% CI)	Mean Length of Stay per Admission coefficient (95% CI)
Missing	1.10 (0.96–1.23)	0.67 (−0.06, 1.40)
Year		
2002	1.0 (Ref)	(Ref)
2003	1.00 (0.94–1.06)	−0.03 (−0.39,0.33)
2004	1.01 (0.95–1.08)	−0.09 (−0.45, 0.28)
2005	0.96 (0.90–1.02)	−0.01 (−0.42, 0.40)
2006	0.97 (0.91–1.03)	−0.34 (−0.70, 0.01)
2007	1.07 (0.99–1.17)	0.13 (−0.42, 0.67)

Note: N = 10,097 patients with 15,156 admissions. IRR: Incidence rate ratio.