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THIRTY-DAY HOSPITAL READMISSION RATE AMONG ADULTS LIVING WITH HIV

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Abstract

Objective—Thirty-day hospital readmission rate is receiving increasing attention as a quality of care indicator. The objective of this study was to determine readmission rates and to identify factors associated with readmission among persons living with HIV.

Design—Prospective multicenter observational cohort.

Setting—Nine U.S. HIV clinics affiliated through the HIV Research Network.

Subjects—Patients engaged in HIV care during 2005–2010.

Main outcome measure(s)—Readmission rate was defined as the proportion of hospitalizations followed by a readmission within 30 days. Factors in multivariate analyses included diagnostic categories, patient demographic and clinical characteristics, and having an outpatient follow-up visit.

Results—Among 11,651 total index hospitalizations, the 30-day readmission rate was 19.3%. AIDS defining illnesses (ADI, 9.6% of index hospitalizations) and non-AIDS defining infections (26.4% of index hospitalizations) had readmission rates of 26.2% and 16.6%, respectively. Factors independently associated with readmission included lower CD4 count (AOR 1.80 [1.53, 2.11] for CD4 <50 vs. 351 cells/μl), longer length of stay (1.77 [1.53, 2.04] for 9 days vs. 1–3 days), and several diagnostic categories including ADI. Having an outpatient follow-up clinic visit was not associated with lower readmission risk (AHR 0.98 [0.88, 1.08]).

Conclusions—The 19.3% readmission rate exceeds the 13.2% rate reported for the general population of 18–64 year-olds. HIV providers may use the 19.3% rate as a basis of comparison. Policymakers may consider the impact of HIV when estimating expected readmissions for a hospital or region. Preventing or recovering from severe immune dysfunction may be the most important factor to reducing readmissions.

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Conflicts of Interest

JAF and PTK have none to declare.

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SAB and JAF contributed to study design, data analysis, and manuscript writing. BRY and ALA contributed to study design and manuscript writing. PTK and RDM contributed to data collection and study design. KAG contributed to data collection, study design, and manuscript writing. All authors have read and approved the final manuscript.

Keywords

Readmission; HIV; AIDS defining illness; Outpatient hospital follow-up; Healthcare utilization

INTRODUCTION

Readmission to a hospital within 30 days is common in the general U.S. population. For adults under 65 years-old, the 30-day readmission rate for all causes has been estimated at 13.2% (extrapolated from Wier, et al 2008) [1], and for Medicare beneficiaries 65 and older, at 19.5% [2]. The rate of readmission among persons living with HIV (PLWH) may be relatively high given the multiple complications of HIV, potentially toxic drug regimens, and social marginalization of many PLWH. Data on 30-day readmissions in HIV are limited to a single-site study, which reported a rate during 2006–2008 of 25.2% [3].

Thirty-day readmission rates are increasingly becoming a benchmark for hospital quality of care and reimbursement [4–7]. A basis of comparison specific to HIV will be important to clinicians, hospital administrators, and policymakers attempting to create best-practice readmission targets for populations which include substantial numbers of PLWH.

Understanding factors associated with readmission among PLWH may indicate ways to improve care and reduce readmissions. Of particular interest are the reason for the initial (index) hospitalization, CD4 cell count (CD4), and use of antiretroviral therapy (ART) at discharge. Also of interest is having a post-discharge clinic follow-up visit. Such visits have been associated with decreased risk of readmission among (HIV-uninfected) patients with chronic obstructive pulmonary disease (COPD) and congestive heart failure (CHF) [8, 9].

This study has two aims. The first is to describe the 30 day readmission rate in a multicenter HIV cohort. The second is to evaluate associations between readmission and clinical factors of interest.

METHODS

Patient Population and Data Collection

The HIV Research Network (HIVRN) is a research collaboration that includes 12 sites providing longitudinal HIV care to adult patients in 11 US cities [10]. Sites collect demographic, laboratory, inpatient, and outpatient utilization data, strip these data of identifying characteristics, and submit them to a coordinating center, where they are reviewed and combined. Ethical review boards at each site and at the coordinating center have approved the collection and use of these data.

Nine HIVRN sites for which no readmission data has previously been published were included in this study. These sites collect complete hospitalization data, including International Classification of Diseases, Ninth Revision (ICD-9) discharge codes. Six of these sites had data for 2005–2010, and 3 had only 2010 data. After preliminary analyses identified no univariate or multivariate associations between readmission and calendar year, data from these 3 sites were combined with the initial 6 sites in all final analyses. The 9 sites are located in the Northeast (3), West (3), South (2), and Midwest (1) regions of the U.S.

Index Hospitalizations and 30-day Readmissions

Following the Centers for Medicare and Medicaid Services' methodology, index hospitalizations were defined by the following criteria: 1) being a first-ever hospitalization or being any hospitalization which occurs >30 days after the most recent previous

hospitalization, and 2) having a live discharge [11]. In other words, most hospitalizations are index hospitalizations; the exceptions are those which are, themselves, 30-day readmissions and those which end in death.

Because of the need to observe 30 days before a potential index hospitalization, hospital admissions prior to Feb 1 of the first year of hospitalization data were excluded as potential index hospitalizations. Because of the need to observe for 30-day readmissions, index hospitalizations with discharges after November 30, 2010 were excluded.

When an index hospitalization was followed by a “chain” of multiple readmissions, each with <30 day intervals (the overall span of the chain may have exceeded 30 days), all of the readmissions in the chain were excluded from being index hospitalizations.

Same day readmissions were considered readmissions.

Patients were in active care if they had a visit to the HIV clinic and a CD4 test recorded in a calendar year. Because patients not in active care may have received care at other centers, any available hospitalization records for such patient years (n=1,042) were excluded. Patients could resume active care after a period out of care. Hospitalizations for clinical trials (ICD9 V70.7; n=87), for rehabilitation (V57.8–V57.9; n=32), and with illogical dates (e.g. beginning within the span of another hospitalization; n=9) were excluded.

Independent Variables

Factors evaluated for association with readmission included year of index hospitalization, geographic region, age, gender, race/ethnicity, injection drug use (IDU, either alone or in combination with other HIV risk factors), CD4, HIV RNA <400 copies/mL, ART (defined as one or more antiretroviral medicines) at discharge, length of stay (LOS), primary insurance, diagnostic category for index hospitalization, and outpatient follow-up. For CD4, HIV RNA, and insurance category, the first values within the year of hospitalization were used. We hypothesized that ART use in the 30 days after discharge may increase readmission risk either through direct adverse effects, through drug interactions, or because of an immune reconstitution inflammatory syndrome (IRIS). ART at discharge was categorized as none, discharge on ART after being admitted on ART, and discharge on ART when not admitted on ART (felt to be the highest risk scenario for toxicity or IRIS). In the second case, the ART regimen need not have been the same on admission and discharge; in the third case, patients may have previously used ART but were not using it on the admission date.

Assigning each hospitalization to a single diagnostic category was done using previously published methods [12–14]. In brief, the first listed ICD-9 code referring to neither HIV nor chronic Hepatitis C infection was defined as the primary code. This code was assigned to one of 18 categories using multi-level Clinical Classification Software from the Agency for Healthcare Research and Quality [15]. The classification was modified in two ways. First, infections were reassigned from organ system categories to the infection category (for example, pneumonia was reassigned from pulmonary to infection). Second, an AIDS defining illness (ADI) category was constructed from ICD-9 codes according to the 1993 Centers for Disease Control and Prevention criteria [16]. Recurrent bacterial pneumonia was defined as any bacterial pneumonia hospitalization occurring within >30 days but ≤365 days of a previous such hospitalization.

Analyses

For each index hospitalization, a dichotomous dependent variable indicated whether any readmission occurred within 30 days. To estimate associations with independent variables,

we used repeated measures logistic models adjusted for clustering of multiple index hospitalizations within patient using generalized estimating equations with robust variance estimators.

Supplementary Analysis Examining the Effect of Outpatient Visits—Including an indicator of any outpatient visit prior to readmission was problematic for the logistic regression analysis as it could introduce time dependent bias (patients who were readmitted within a few days would have had little chance for a visit). Cox proportional hazard models, with time to outpatient visit treated as a time-dependent covariate, can estimate an association without introducing this bias [2, 8]. Time to first outpatient visit (primary HIV or specialty care) that occurred within 30 days, but prior to any readmission, was determined for each index hospitalization. Outpatient visits that occurred on the same day as a readmission were excluded on the premise that the patient appeared for the visit in need of hospitalization. For analysis, outpatient visits that occurred on the day of discharge from an index hospitalization were assigned a follow-up time of 0.1 day; same day readmissions were assigned 0.25 day. We fit Cox models with variance adjusted for clustering of multiple index hospitalizations within patient. However, the proportional hazard assumption was violated (Schoenfeld residuals $p < 0.05$) for four variables: year of hospitalization, CD4, LOS, and diagnostic category. In order to obtain a valid, fully adjusted estimate, the multivariate Cox model was stratified by each of these four variables. The full, stratified multivariate model results are presented in a Supplementary Table.

In all analyses, a 2-sided type 1 error of 5% was considered statistically significant. Analyses were performed using Stata 12.1 (StataCorp LP, College Station, TX) [17].

RESULTS

A total of 19,943 adult patients were in active care for at least one year during 2005–2010 at the 9 study sites. A total of 5,536 patients had 1 index hospitalization, of whom 3,926 (71%) were never readmitted within 30 days and 1,610 (29%) were readmitted. Patients were more likely to be readmitted within 30 days if they had more index hospitalizations, were female (versus male), Black (versus white), or IDU (versus MSM) (Table 1).

Among the full patient sample, 15,951 total hospitalizations occurred in 2005–2010. Of these hospitalizations, 303 (1.9%) were not counted as index hospitalizations because they occurred in January of the first analytic year, 224 (1.4%) because discharge occurred after November 30, 2010, and 142 (0.9%) because of death during hospitalization. Of the remaining 15,282 hospitalizations, 11,651 (75.5%) were index hospitalizations; 2,252 (14.6%) were first readmissions within 30 days; and 1,379 (8.9%) were subsequent readmissions in a chain.

Of 11,651 index hospitalizations, 2,252 were followed by a readmission within 30 days, yielding an overall readmission rate of 19.3%. When readmission occurred, 69% of instances consisted of a single readmission, 18% a chain of 2 readmissions, and 13% a chain of 3 or more readmissions. The median time to first readmission was 11 days (IQR, 5–19).

Table 2 lists time-varying patient demographic and clinical factors for the 11,651 index hospitalizations. Thirty-day readmission was more likely when patients had lower CD4 counts (occurring 26.1% of the time at CD4 ≤ 50 cells/ μ L), HIV RNA ≥ 400 copies/ml, longer LOS (26.7% when LOS ≥ 9 days), Medicaid insurance, and were discharged on ART but not admitted on ART.

Figure 1 shows 30-day readmission rates associated with the 10 most frequent diagnostic categories for index hospitalizations. Oncologic hospitalizations had the highest readmission rate at 27.8%; however oncologic hospitalizations comprised only 3.6% of index hospitalizations. ADI had a readmission rate of 26.2%, while comprising 9.6% of index hospitalizations. Non-ADI infection had among the lowest readmission rates (16.6%) but was the most frequent category (26.4% of index hospitalizations).

Table 3 shows univariate and multivariate logistic regression results. Increasing readmission risk was consistently seen with progressively lower CD4 counts. In the multivariate model, compared to CD4 ≥351, adjusted odds ratios (AOR) were 1.19 [1.04, 1.37], 1.42 [1.24, 1.64], and 1.80 [1.53, 2.11] for CD4 201–350, 51–200, and <50 cells/μl, respectively. Progressively longer LOS exhibited a similar pattern of increasing readmission risk. ADI was significantly associated in both univariate (OR vs. non-AIDS defining infection 1.77 [1.51, 2.09]) and multivariate (1.40 [1.17, 1.66]) analyses. Compared to hospitalizations covered by Medicaid, uninsured hospitalizations had lower readmission risk in both models. No independent associations were seen for age, gender, race, IDU, geographic region, HIV RNA level, and antiretroviral use.

Table 4 shows characteristics of the 2,252 index hospitalization/first readmission pairs. Overall, readmissions occurred in the same diagnostic category as the index hospitalization 35.7% of the time. This varied from 21.9% for kidney/genitourinary to 46.2% for oncologic (Table 4, *italicized cells*). Non-AIDS defining infection and ADI were the most common readmission categories when all index hospitalizations were combined.

Supplementary Analysis Examining the Effect of Outpatient Visits

An outpatient visit within 30 days of discharge and prior to any readmission occurred after 7,730 (66%) index hospitalizations. The median time to these visits was 7 days (IQR, 4–13). Having a visit within 30 days was not associated with readmission in a univariate (hazard ratio 1.00 [0.90, 1.10]) or in a fully adjusted (0.98 [0.88, 1.08]) Cox model (complete model results in the Supplementary Table). The results for other variables evaluated in Cox regressions were similar to the logistic results.

DISCUSSION

The 30-day hospital readmission rate among persons engaged in outpatient HIV care in our multisite cohort was 19.3%. Some diagnostic categories substantially exceeded the overall rate, with ADI as high as 26.2%. Factors independently associated with readmission included lower CD4 count and longer LOS. ART use and post-discharge outpatient follow-up were not associated with readmission. The majority of readmissions were for different diagnoses than their associated index hospitalizations.

The rate of 19.3% exceeds the rate of 13.2% for adults 18–64 years-old extrapolated from the findings of the 2008 Healthcare Cost and Utilization Project (HCUP, which included all non-federal hospitalizations in 15 U.S. states) and nearly equals the rate (19.5%) among Medicare beneficiaries aged 65 years and older [1, 2]. The median age (IQR) in our cohort was 46 (40–53) years.

The rate of 19.3% is lower than the 25.2% rate reported from a large HIV clinic in Dallas [3]. One reason for the different rates could be differences in health status. The Dallas population had more index hospitalizations occur in the setting of CD4 <50 cells (31% vs. 18%) and more index hospitalizations due to ADI (41% vs. 9.6%).

The independent associations with lower CD4 and with ADI indicate that advanced HIV disease contributes more to readmission risk than do demographic factors or complications of ART. Having a low CD4 count predisposes to frequent illnesses, both infectious and non-infectious [12, 18–23], and an association between lower CD4 and hospital readmission has been seen in other studies [3, 24, 25]. From a public perspective, HIV diagnosis, engagement in care, and use of ART at high CD4 counts may reduce future readmission rates. From the perspective of a patient with a low CD4 who has an index hospitalization, immune reconstitution with ART can be expected to reduce future hospitalizations. However, even with good adherence to ART, 30 days may be too short to see an effect. Decreasing the incidence of illnesses probably requires several months [13, 26, 27], and the most relevant readmission window for assessing quality of care may thus be longer than 30 days.

A long LOS potentially indicates a more complicated index hospitalization. Similar to our findings, longer LOS was associated with readmission in the general Medicare population [2].

The association between having no insurance and lower readmission risk resembles findings in the 2008 HCUP analysis and may reflect economic barriers to seeking any medical care, including presenting to an emergency room or clinic for potential readmission [1].

Outpatient follow-up visits provide an opportunity to review discharge medications and response to treatment. The lack of association between outpatient clinic follow-up and lower readmission risk is surprising in light of recent studies that showed such associations among Medicare beneficiaries over 65 with COPD and CHF [8, 9]. The younger age of the HIVRN population may explain the difference in findings. Similar to our results, several general population studies have failed to detect a protective effect of early outpatient follow-up, though these studies have generally examined longer intervals (90, 180, and 365 days) after index discharge [28–31]. Confirmatory studies among PLWH are needed. Because outpatient visits may have been preferentially offered to the sickest patients or to those most likely to keep their appointments, prospective trials of increasing outpatient follow-up would provide more reliable evidence.

The majority of readmissions occurred in different diagnostic categories than their associated index hospitalizations. Hence, readmissions may tend to be from issues which present after discharge, or, if signs are present during the index hospitalization, they may not be the focus of attention.

Clinicians may use our findings in several ways. First, the readmission rate in our multicenter cohort may serve as a basis of comparison for assessing quality of inpatient care of PLWH. Second, clinicians may target readmission prevention efforts toward patients with CD4 <200, with LOS >5 days, and for ADI and other high-risk reasons for readmission. Third, increasing early outpatient follow-up visits requires further investigation as a means of reducing readmissions. Other interventions, not assessed in the present study, have also shown promise in the general population and should be evaluated among PLWH. These include patient education, patient navigators, medicine reconciliation, and nurse home visits [32–35].

Hospital administrators and healthcare policymakers may use our findings when estimating expected readmission rates at hospital and regional levels. Compared to hospitals that serve few PLWH, hospitals serving more PLWH may have an increased overall readmission rate. Accurate calculation of expected rates is important. The Affordable Care Act has mandated public reporting and payment penalties for hospitals with higher-than-expected readmission rates for common diagnoses among Medicare enrollees over 65 years-old [4–6, 11, 36].

Readmissions among PLWH will have increasing impact on hospitals' Medicare readmission rates as PLWH, already with a median age of 50 [37], grow older. The effect will also be highly relevant if public reporting and payment penalties are expanded to new groups, for example to Medicaid enrollees.

Our study is limited by lack of a matched control group of HIV-uninfected subjects. It is possible that our readmission rate exceeds that found for 18–64 year-olds in the HCUP analysis because our findings reflect high local readmission patterns in the cities where our sites are located. However, there are several reasons to doubt this. First are the strong associations with low CD4 and with ADI. Second, the interquartile ratio for variation nationwide in Medicare readmission rates between hospital referral regions was only 1.10 [7], much smaller than the ratio of 1.46 (19.3%/13.2%) which exists between our rate and the HCUP rate. Third, while not nationally representative, our sample includes sites in 8 geographically distributed cities. These reasons notwithstanding, the implications for public reporting and payment penalties make confirmation of our findings by direct comparison to HIV-uninfected controls important.

Another limitation is the lack of hospitalization data on PLWH who are not engaged in outpatient HIV care. Statewide or national databases may be able to account for such persons. A final limitation is that while our sites make attempts to collect hospitalization data from neighboring hospitals, this may be incomplete. However, an analysis of state-wide insurance claims at one HIVRN site revealed that 91% of all hospitalizations occurred at the home hospital [14]. In the Dallas study, 78% of readmissions occurred at the home hospital [3]. Hence, while we feel we are capturing the vast majority of readmissions, our rate may slightly underestimate the true readmission rate.

In summary, we have found a high rate of 30-day readmission among PLWH in our multisite cohort. While awaiting data from additional cohorts, HIV providers may use the 19.3% rate as a preliminary basis of comparison for their practices. Policymakers may note this rate when considering adjustment for HIV in estimating expected hospital readmission rates used in public reporting and reimbursement calculations. The associations of readmission with low CD4 and ADI, the lack of association with outpatient follow-up visits or with discharge on ART, and the finding that patients more-often-than-not are readmitted for a different cause than for the index hospitalization, together suggest that the majority of readmissions among PLWH are due to the high frequency of illnesses inherently associated with advanced HIV disease and may not be the result of failed treatment plans or medication errors. Prevention of advanced HIV disease and/or recovery from it may have the largest impact in reducing readmissions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Wier, LM.; Barrett, ML.; Steiner, C.; Jiang, HJ. All-cause readmissions by payer and age, 2008. HCUP Statistical Brief #115 Agency for Healthcare Research and Quality, 2011. Jan 9. 2012 Available at: <http://www.hcup-us.ahrq.gov/reports/statbriefs/sb115.pdf>
2. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the medicare fee-for-service program. *N Engl J Med*. 2009; 360(14):1418–28. [PubMed: 19339721]
3. Nijhawan AE, Clark C, Kaplan R, Moore B, Halm EA, Amarasingham R. An electronic medical record-based model to predict 30-day risk of readmission and death among HIV-infected inpatients. *J Acquir Immune Defic Syndr*. 2012; 61(3):349–58. [PubMed: 23095935]
4. U.S. Hospital compare. [Accessed November 19, 2012] Available at: <http://www.hospitalcompare.hhs.gov>
5. Axon RN, Williams MV. Hospital readmission as an accountability measure. *JAMA*. 2011; 305(5): 504–5. [PubMed: 21285430]
6. Berenson RA, Paulus RA, Kalman NS. Medicare's readmissions-reduction program--a positive alternative. *N Engl J Med*. 2012; 366(15):1364–6. [PubMed: 22455754]
7. Goodman, DC.; Fisher, ES.; Chiang-Hua, C. After hospitalization: A dartmouth atlas report on post-acute care for medicare beneficiaries. The Dartmouth Institute for Health Policy and Clinical Practice; 2011.
8. Sharma G, Kuo YF, Freeman JL, Zhang DD, Goodwin JS. Outpatient follow-up visit and 30-day emergency department visit and readmission in patients hospitalized for chronic obstructive pulmonary disease. *Arch Intern Med*. 2010; 170(18):1664–70. [PubMed: 20937926]
9. Hernandez AF, Greiner MA, Fonarow GC, et al. Relationship between early physician follow-up and 30-day readmission among medicare beneficiaries hospitalized for heart failure. *JAMA*. 2010; 303(17):1716–22. [PubMed: 20442387]
10. 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):21–6. [PubMed: 12048359]
11. Bernheim, SM.; Grady, JN.; Spivack, S.; Bartczak, K. 2012 measures maintenance technical report: Acute myocardial infarction, heart failure, and pneumonia 30-day risk-standardized readmission measures: Report prepared for the centers for medicare and medicaid services. 2012.
12. Berry SA, Fleishman JA, Moore RD, Gebo KA. HIV Research Network. Trends in reasons for hospitalization in a multisite united states cohort of persons living with HIV, 2001–2008. *J Acquir Immune Defic Syndr*. 2012; 59(4):368–75. [PubMed: 22240460]
13. Berry SA, Manabe YC, Moore RD, Gebo KA. Hospitalization risk following initiation of highly active antiretroviral therapy. *HIV Med*. 2010; 11(5):289–98. [PubMed: 20002778]
14. 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): 143–52. [PubMed: 11404536]
15. Elixhauser, A.; Steiner, C.; Palmer, L. Clinical classifications software (CCS), 2008. U.S. Agency for Healthcare Research and Quality; 2008.
16. 1993 revised classification system for HIV infection and expanded surveillance case definition for AIDS among adolescents and adults. *MMWR Recomm Rep*. 1992; 41(RR-17):1–19.
17. StataCorp. Stata statistical software: Release 12.1. 2012.
18. Hasse B, Ledergerber B, Furrer H, et al. Morbidity and aging in HIV-infected persons: The swiss HIV cohort study. *Clin Infect Dis*. 2011; 53(11):1130–9. [PubMed: 21998280]
19. Crum-Cianflone NF, Grandits G, Echols S, et al. Trends and causes of hospitalizations among HIV-infected persons during the late HAART era: What is the impact of CD4 counts and HAART use? *J Acquir Immune Defic Syndr*. 2010; 54(3):248–57. [PubMed: 20658748]
20. Lichtenstein KA, Armon C, Buchacz K, et al. Low CD4+ T cell count is a risk factor for cardiovascular disease events in the HIV outpatient study. *Clin Infect Dis*. 2010; 51(4):435–47. [PubMed: 20597691]

21. Kalayjian RC, Lau B, Mechekeano RN, et al. Risk factors for chronic kidney disease in a large cohort of HIV-1 infected individuals initiating antiretroviral therapy in routine care. *AIDS*. 2012; 26(15):1907–15. [PubMed: 22824630]
22. Petoumenos K, Worm SW, Fontas E, et al. Predicting the short-term risk of diabetes in HIV-positive patients: The data collection on adverse events of anti-HIV drugs (D:A:D) study. *J Int AIDS Soc*. 2012; 15(2):17426. [PubMed: 23078769]
23. Yong MK, Elliott JH, Woolley IJ, Hoy JF. Low CD4 count is associated with an increased risk of fragility fracture in HIV-infected patients. *J Acquir Immune Defic Syndr*. 2011; 57(3):205–10. [PubMed: 21522014]
24. Nosyk B, Sun H, Li X, Palepu A, Anis AH. Highly active antiretroviral therapy and hospital readmission: Comparison of a matched cohort. *BMC Infect Dis*. 2006; 6:146. [PubMed: 17022826]
25. Palepu A, Sun H, Kuyper L, Schechter MT, O'Shaughnessy MV, Anis AH. Predictors of early hospital readmission in HIV-infected patients with pneumonia. *J Gen Intern Med*. 2003; 18(4):242–7. [PubMed: 12709090]
26. Bosch RJ, Wang R, Vaida F, Lederman MM, Albrecht MA. Changes in the slope of the CD4 cell count increase after initiation of potent antiretroviral treatment. *J Acquir Immune Defic Syndr*. 2006; 43(4):433–5. [PubMed: 17183628]
27. Chu C, Selwyn PA. An epidemic in evolution: The need for new models of HIV care in the chronic disease era. *J Urban Health*. 2011
28. Gill JM, Mainous AG 3rd, Nsereko M. Does having an outpatient visit after hospital discharge reduce the likelihood of readmission? *Del Med J*. 2003; 75(8):291–8. [PubMed: 12971228]
29. Weinberger M, Oddone EZ, Henderson WG. Does increased access to primary care reduce hospital readmissions? veterans affairs cooperative study group on primary care and hospital readmission. *N Engl J Med*. 1996; 334(22):1441–7. [PubMed: 8618584]
30. Einstadter D, Cebul RD, Franta PR. Effect of a nurse case manager on postdischarge follow-up. *J Gen Intern Med*. 1996; 11(11):684–8. [PubMed: 9120655]
31. Piette JD, Moos RH. The influence of distance on ambulatory care use, death, and readmission following a myocardial infarction. *Health Serv Res*. 1996; 31(5):573–91. [PubMed: 8943991]
32. Hansen LO, Young RS, Hinami K, Leung A, Williams MV. Interventions to reduce 30-day rehospitalization: A systematic review. *Ann Intern Med*. 2011; 155(8):520–8. [PubMed: 22007045]
33. Naylor MD, Broton D, Campbell R, et al. Comprehensive discharge planning and home follow-up of hospitalized elders: A randomized clinical trial. *JAMA*. 1999; 281(7):613–20. [PubMed: 10029122]
34. Naylor MD, Broton DA, Campbell RL, Maislin G, McCauley KM, Schwartz JS. Transitional care of older adults hospitalized with heart failure: A randomized, controlled trial. *J Am Geriatr Soc*. 2004; 52(5):675–84. [PubMed: 15086645]
35. Coleman EA, Parry C, Chalmers S, Min SJ. The care transitions intervention: Results of a randomized controlled trial. *Arch Intern Med*. 2006; 166(17):1822–8. [PubMed: 17000937]
36. Medicare Payment Policy. Washington, DC: Medicare Payment Advisory Committee; 2007. Report to congress.
37. HIV surveillance report. 2010. Available at: <http://www.cdc.gov/hiv/topics/surveillance/resources/reports/>

APPENDIX: HIVRN Details

HIVRN Sites (participating sites marked with an *)

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.)*

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

Fenway Health, Boston, Massachusetts (Stephen Boswell, M.D.)

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

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

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

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

Parkland Health and Hospital System, Dallas, Texas (Ank Nijhawan, M.D., Muhammad Akbar, 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., Stephen Arpadi, M.D.)*

Tampa General Health Care, Tampa, Florida (Charurut Somboonwit, 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 (Robert Mills, Ph.D., Faye Malitz, M.S.)

Data Coordinating Center

Johns Hopkins University (Richard Moore, M.D., Jeanne Keruly, C.R.N.P., Kelly Gebo, M.D., Cindy Voss, M.A.)

Figure 1.

Readmission rates for the 10 most frequent diagnostic categories

* Representative diagnoses are the three most frequent diagnoses within each category.

CA, cancer; PCP, *Pneumocystis pneumonia*; KI, kidney injury; COPD, chronic obstructive pulmonary disease; NOS, not otherwise specified; HD, heart disease.

Table 1

Patient characteristics stratified by having any index hospitalization(s)* and by having any 30 day readmission(s)

	Patients Having No Index Hospitalizations	Patients Having Index Hospitalization(s) But No 30 Day Readmissions	Patients Having At Least One 30 Day Readmission	P-value for Patients with Index but no Readmissions vs. those with Readmissions**
N	14,407	3,926 (71)	1,610 (29)	
Years in Care, median (IQR)	1 (1 – 4)	4 (2 – 6)	3 (2 – 5)	0.08
Index Hospitalizations, median (IQR)	0	1 (1 – 2)	3 (1 – 4)	<0.001
30 Day Readmissions, median (IQR)	0	0	1 (1 – 2)	
Age in First Analytic Year, median (IQR)	43 (36 – 49)	44 (38 – 51)	45 (39 – 51)	0.01
Gender				0.01
Male	10,715 (74)	2,734 (72)	1,065 (28)	
Female	3,692 (26)	1,192 (69)	545 (31)	
Race/Ethnicity				<0.001
Non-Hispanic Black	6,463 (45)	1,890 (69)	863 (31)	
Non-Hispanic White	4,256 (30)	1,035 (74)	361 (26)	
Hispanic	2,986 (21)	908 (71)	363 (29)	
Other/Unknown	702 (5)	93 (80)	23 (20)	
HIV Risk Factor(s)				<0.001
MSM Only	5,956 (41)	1,271 (75)	434 (25)	
HET Only	5,033 (35)	1,344 (72)	534 (28)	
IDU†	2,245 (16)	1,032 (66)	521 (34)	
Other/Unknown	1,171 (8)	279 (70)	121 (30)	
U.S. Geographic Region				<0.001
Northeast	5,162 (36)	1,816 (71)	744 (29)	
South	3,671 (25)	975 (67)	480 (33)	
West	4,160 (29)	1,083 (74)	375 (26)	
Midwest	1,411 (10)	52 (83)	11 (17)	

Values are N (%) unless otherwise noted.

* Index hospitalizations defined by 1) being a first-ever hospitalization or being any hospitalization which occurs >30 days after the most recent previous hospitalization, and 2) having a live discharge.

** Wilcoxon rank sum test used for continuous variables and chi-square test for categorical variables

† IDU category included patients with only IDU and also patients with IDU in combination with either MSM or HET

IDU, injection drug use; HET, heterosexual; MSM, men who have sex with men

Table 2

Time-varying patient demographic and clinical characteristics for the 11,651 index hospitalizations, stratified by having any 30 day readmission

	Index Hospitalizations without Subsequent 30 Day Readmission	Index Hospitalizations with Subsequent 30 Day Readmission(s)	P-value *
N	9,399	2,252	
Year of Hospitalization			
2005	1,377 (80)	350 (20)	0.44
2006	1,468 (80)	362 (20)	
2007	1,577 (80)	390 (20)	
2008	1,660 (80)	408 (20)	
2009	1,642 (81)	374 (19)	
2010	1,675 (82)	368 (18)	
Age at Admission (years)			
Median (IQR)	46 (40 – 53)	47 (41 – 53)	0.41
18 – 34	1,073 (83)	219 (17)	0.15
35 – 44	2,845 (80)	717 (20)	
45 – 54	3,552 (81)	859 (19)	
55 – 64	1,536 (81)	371 (19)	
65	393 (82)	86 (18)	
CD4 (cells/L)			
Median (IQR)	260 (100 – 461)	189 (52 – 376)	<0.001
50	1,565 (74)	554 (26)	<0.001
51 – 200	2,245 (79)	605 (21)	
201 – 350	2,101 (82)	464 (18)	
351	3,488 (85)	629 (15)	
HIV RNA (copies/mL)			
< 400	3,732 (82)	813 (18)	0.002
400	5,484 (80)	1,380 (20)	
Unknown/missing	183 (76)	59 (24)	
ART use at discharge			0.001
None	3,435 (80)	858 (20)	
Discharged on ART after being admitted on ART	5,808 (81)	1,332 (19)	
Discharged on ART when not admitted on ART	156 (72)	62 (28)	
Length of stay (days)			
Median (IQR)	4 (3 – 7)	5 (3 – 9)	<0.001
1 – 3	3,451 (84)	637 (16)	<0.001
4 – 5	2,648 (83)	561 (17)	
6 – 8	1,757 (78)	491 (22)	
9	1,543 (73)	563 (27)	
Primary Insurance			<0.001
Medicaid	4,900 (79)	1,268 (21)	

	Index Hospitalizations without Subsequent 30 Day Readmission	Index Hospitalizations with Subsequent 30 Day Readmission(s)	P-value *
Medicare [†]	2,322 (81)	549 (19)	
Private	780 (83)	164 (17)	
Uninsured/Ryan White	318 (89)	39 (11)	
Missing/Unknown	1,079 (82)	232 (18)	

Values are N (%) unless otherwise noted.

* Wilcoxon rank sum test used for continuous variables and chi-square test for categorical variables

[†] Medicare category included 698 hospitalizations with dual Medicare/Medicaid insurance

Table 3

Logistic regression models of readmission

	Univariate Odds Ratios (95% CI)	Multivariate Odds Ratios (95% CI)
Year of Hospitalization		
2005	1.00 (Ref)	1.00 (Ref)
2006	0.97 (0.82, 1.15)	0.98 (0.82, 1.16)
2007	0.97 (0.82, 1.15)	1.00 (0.85, 1.19)
2008	0.97 (0.82, 1.14)	0.98 (0.83, 1.16)
2009	0.90 (0.76, 1.06)	0.94 (0.78, 1.12)
2010	0.86 (0.73, 1.02)	0.90 (0.75, 1.07)
U.S. Geographic Region		
Northeast	1.00 (Ref)	1.00 (Ref)
South	1.07 (0.96, 1.21)	1.03 (0.89, 1.19)
West	0.97 (0.85, 1.10)	1.03 (0.89, 1.20)
Midwest	0.76 (0.41, 1.41)	0.90 (0.47, 1.69)
Age group (years)		
18 – 34	1.00 (Ref)	1.00 (Ref)
35 – 44	1.23 (1.03, 1.47)	1.17 (0.97, 1.40)
45 – 54	1.18 (1.00, 1.41)	1.15 (0.96, 1.39)
55 – 64	1.18 (0.97, 1.44)	1.17 (0.95, 1.44)
65	1.07 (0.80, 1.44)	1.15 (0.84, 1.59)
Gender		
Male	1.00 (Ref)	1.00 (Ref)
Female	1.02 (0.92, 1.14)	1.03 (0.92, 1.15)
Race/Ethnicity		
White/Other [†]	1.00 (Ref)	1.00 (Ref)
Non-Hispanic Black	1.13 (1.00, 1.28)	1.05 (0.91, 1.21)
Hispanic	1.04 (0.89, 1.20)	0.99 (0.85, 1.17)
IDU as HIV Risk Factor		
No	1.00 (Ref)	1.00 (Ref)
Yes	1.06 (0.96, 1.18)	1.04 (0.92, 1.17)
CD4 (cells/L)		
50	1.96 (1.71, 2.25)	1.80 (1.53, 2.11)
51 – 200	1.49 (1.31, 1.71)	1.42 (1.24, 1.64)
201 – 350	1.22 (1.07, 1.40)	1.19 (1.04, 1.37)
351	1.00 (Ref)	1.00 (Ref)
HIV RNA (copies/mL)		
< 400	0.86 (0.78, 0.95)	1.11 (0.99, 1.25)
400 or unknown	1.00 (Ref)	1.00 (Ref)
ART use at discharge		
None	1.00 (Ref)	1.00 (Ref)
Discharged on ART after being admitted on ART	0.92 (0.83, 1.02)	0.93 (0.84, 1.04)

	Univariate Odds Ratios (95% CI)	Multivariate Odds Ratios (95% CI)
Discharged on ART when not admitted on ART	1.59 (1.17, 2.16)	1.11 (0.81, 1.52)
Length of stay (days)		
1 – 3	1.00 (Ref)	1.00 (Ref)
4 – 5	1.15 (1.01, 1.30)	1.12 (0.98, 1.28)
6 – 8	1.51 (1.32, 1.73)	1.41 (1.23, 1.62)
9	1.98 (1.73, 2.26)	1.77 (1.53, 2.04)
Primary Insurance		
Medicaid	1.00 (Ref)	1.00 (Ref)
Medicare	0.91 (0.81, 1.03)	0.94 (0.82, 1.07)
Private	0.81 (0.67, 0.99)	0.83 (0.68, 1.01)
Uninsured/Ryan White	0.47 (0.33, 0.67)	0.52 (0.36, 0.74)
Missing/Unknown	0.83 (0.71, 0.97)	0.85 (0.71, 1.01)
Diagnostic Category		
Non-AIDS defining infection	1.00 (Ref)	1.00 (Ref)
Cardiovascular	1.05 (0.88, 1.25)	1.20 (1.00, 1.44)
AIDS Defining Illness	1.77 (1.51, 2.09)	1.40 (1.17, 1.66)
Gastrointestinal/Liver	1.36 (1.13, 1.64)	1.47 (1.22, 1.77)
Psychiatric	0.99 (0.80, 1.23)	1.00 (0.80, 1.25)
Renal/Genitourinary	1.36 (1.10, 1.69)	1.35 (1.09, 1.69)
Pulmonary	1.19 (0.94, 1.51)	1.22 (0.96, 1.55)
Endocrine/Metabolic/Immune	1.35 (1.07, 1.70)	1.45 (1.15, 1.84)
Injury/Poisoning	1.02 (0.79, 1.31)	1.11 (0.86, 1.44)
Oncologic	1.93 (1.51, 2.46)	2.03 (1.59, 2.59)
Neurologic	1.33 (1.02, 1.74)	1.45 (1.11, 1.90)
Hematologic	1.79 (1.38, 2.33)	1.86 (1.42, 2.44)
Orthopedic	0.84 (0.60, 1.18)	0.98 (0.70, 1.37)
Symptomatic	1.22 (0.90, 1.66)	1.35 (0.99, 1.84)
Obstetric/Gynecologic	0.53 (0.32, 0.88)	0.72 (0.43, 1.20)
Dermatologic	1.47 (0.92, 2.33)	1.46 (0.92, 2.32)
Unclassified/Congenital/Perinatal	0.99 (0.55, 1.77)	1.15 (0.63, 2.08)
Missing	0.96 (0.73, 1.27)	1.02 (0.77, 1.36)

[†] Other/unknown race was combined with White for analysis

Table 4

Reasons for readmission *

Index Hospitalization Category	Most Frequent Category for Readmission (%)	Second Most Frequent Category (%)	Third Most Frequent Category (%)
Non-AIDS Defining Infection	<i>Non-AIDS Defining Infection (40.5)</i>	AIDS Defining Illness (10.3)	Cardiovascular (6.8)
Cardiovascular	<i>Cardiovascular (42.2)</i>	Non-AIDS Defining Infection (11.7)	Kidney/Genitourinary (7.8)
AIDS Defining Illness	<i>AIDS Defining Illness (39.7)</i>	Non-AIDS Defining Infection (17.3)	Kidney/Genitourinary (5.8)
Gastrointestinal/Liver	<i>Gastrointestinal/Liver (35.1)</i>	Non-AIDS Defining Infection (21.1)	Kidney/Genitourinary (8.3)
Psychiatric	<i>Psychiatric (37.7)</i>	Non-AIDS Defining Infection (17.2)	Cardiovascular (7.4)
Kidney/Genitourinary	Non-AIDS Defining Infection (23.4)	<i>Kidney/Genitourinary (21.9)</i>	Endocrine/Metabolic/Immune (8.8)
Pulmonary	<i>Pulmonary (34.5)</i>	Non-AIDS Defining Infection (15.5)	AIDS Defining Illness (12.1)
Endocrine/Metabolic/Immune	<i>Endocrine/Metabolic/Immune (29.6)</i>	Non-AIDS Defining Infection (12.0)	AIDS Defining Illness (10.2)
Injury/Poisoning	Psychiatric (24.7)	<i>Injury/Poisoning (22.2)</i>	Non-AIDS Defining Infection (17.3)
Oncologic	<i>Oncologic (46.2)</i>	Non-AIDS Defining Infection (18.8)	Hematologic (7.7)
All Others Combined	Non-AIDS Defining Infection (17.8)	Missing (8.5)	Hematologic (8.0)
Overall	Non-AIDS Defining Infection (22.6)	AIDS Defining Illness (11.2)	Cardiovascular (9.1)

* Descriptions were restricted to the first readmission following an index hospitalization and do not include data from any subsequent hospitalizations if a series of readmissions, each within 30 days existed. The majority (69%) of index hospitalizations were followed by only a single 30-day readmission.

Italics used when the readmission category is the same as the index category.