Title

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Journal

The Journal of Infectious Diseases, 228(12)

ISSN

0022-1899

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Publication Date

2023-12-20

DOI

10.1093/infdis/jiad396

Peer reviewed

The Journal of Infectious Diseases

MAJOR ARTICLE

Hospital Readmissions Among Persons With Human Immunodeficiency Virus in the United States and Canada, 2005–2018: A Collaboration of Cohort Studies

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Background. Hospital readmission trends for persons with human immunodeficiency virus (PWH) in North America in the context of policy changes, improved antiretroviral therapy (ART), and aging are not well-known. We examined readmissions during 2005–2018 among adult PWH in NA-ACCORD.

Methods. Linear risk regression estimated calendar trends in 30-day readmissions, adjusted for demographics, CD4 count, AIDS history, virologic suppression (<400 copies/mL), and cohort.

Results. We examined 20 189 hospitalizations among 8823 PWH (73% cisgender men, 38% White, 38% Black). PWH hospitalized in 2018 versus 2005 had higher median age (54 vs 44 years), CD4 count (469 vs 274 cells/μL), and virologic suppression (83% vs 49%). Unadjusted 30-day readmissions decreased from 20.1% (95% confidence interval [CI], 17.9%–22.3%) in 2005 to 16.3% (95% CI, 14.1%–18.5%) in 2018. Absolute annual trends were −0.34% (95% CI, −.48% to −.19%) in unadjusted and −0.19% (95% CI, −.35% to −.02%) in adjusted analyses. By index hospitalization reason, there were significant adjusted decreases only for cardiovascular and psychiatric hospitalizations. Readmission reason was most frequently in the same diagnostic category as the index hospitalization.

Conclusions. Readmissions decreased over 2005–2018 but remained higher than the general population's. Significant decreases after adjusting for CD4 count and virologic suppression suggest that factors alongside improved ART contributed to lower readmissions. Efforts are needed to further prevent readmissions in PWH.

Keywords. HIV; aging; healthcare utilization; hospitalization; readmission.

Preventing hospital readmissions is a major focus of clinical care and health policy in the United States (US) and Canada. In the US, persons with human immunodeficiency virus (PWH) have previously been shown to have frequent hospital readmissions. Nationwide studies with data through 2011 reported 30-day readmission rates close to 20% among PWH, compared with 11% among people without human immunodeficiency virus (HIV) [1, 2]. More recent studies among PWH have examined readmissions in a single US state, or among at-risk subgroups such as PWH with substance use [3–5], but little is known about contemporary readmission rates among all PWH.

Yet, changes in health policy and in the clinical and demographic characteristics of PWH in North America might have affected readmissions. In 2010, the US Patient Protection and Affordable Care Act (ACA) created the Hospital Readmissions Reduction Program (HRRP), which introduced financial penalties from the Centers for Medicare and Medicaid Services (CMS) for hospitals with higher-than-expected readmissions among Medicare beneficiaries for certain conditions, leading to a decrease in readmissions in this population [6]. PWH might have benefited from HRRP-associated readmission prevention efforts, as 35% of their hospitalizations are covered by Medicare [7], and benefits also extend to inpatients covered by other payers and hospitalized

Received 05 June 2023; editorial decision 06 September 2023; accepted 08 September 2023; published online 12 September 2023

[a]The NA-ACCORD Collaborating Cohorts and representatives are listed in the Notes.

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The Journal of Infectious Diseases® 2023;228:1699–708

https://doi.org/10.1093/infdis/jiad396

for nontarget conditions [6, 8, 9]. In addition, some hospitals have identified PWH as a priority population for readmission prevention interventions [10]. The ACA-associated increase in the proportion of PWH with health insurance coverage, which enables access to outpatient care, could also have contributed to lower readmissions [11].

The clinical and demographic profile of PWH in the US and Canada has also changed in recent years. The expansion of antiretroviral therapy (ART) to all PWH and earlier ART initiation, with more effective and less toxic regimens, have improved virologic suppression rates and CD4 cell counts, decreased AIDS-defining illness and mortality rates, and increased life expectancy for PWH [12–15]. As a result, the population of PWH in the US and Canada is aging, with an increasing comorbidity burden [16–18]. Reflective of these trends, PWH hospitalized in recent years are older, have higher CD4 counts, and are more likely to be virologically suppressed and hospitalized for non-AIDS-related reasons [19, 20]. While greater virologic suppression rates, higher CD4 counts, and less frequent AIDS-related hospitalizations could lower readmissions, older age and a higher prevalence of comorbidities could contribute to higher readmissions. In the context of health policy and HIV care changes, we examined readmission trends from 2005 to 2018 in a large HIV cohort collaboration in the US and Canada.

METHODS

Data Source and Study Population

This study was based in the North American AIDS Cohort Collaboration on Research and Design (NA-ACCORD), a consortium of cohorts following PWH aged ≥18 years linked to care, defined as having ≥2 visits in a 12-month period [21]. We included 6 clinical cohorts based at academic centers and integrated health systems (5 in the US, 1 in Canada) that collected hospitalization data from 2005 to 2018, including admission and discharge dates and discharge diagnoses. Hospitalization data were captured from the electronic health records of each cohort's medical system. Each site's institutional review board (IRB) approved data collection, and the University of North Carolina IRB approved this secondary analysis.

We examined index hospitalizations between 1 January 2005 and 30 November 2018, among PWH in care. Index hospitalizations were defined as having a live discharge and no hospital discharge in the prior 30 days, that is, an index hospitalization could not be a 30-day readmission. Being in care was defined as having a CD4 count, HIV viral load (VL), or NA-ACCORD enrollment date in the 12 months prior to index hospitalization.

Study Measures

We categorized the top-ranked discharge *International Classification of Diseases, Ninth Revision* (*ICD-9*) diagnosis codes using Clinical Classifications Software (CCS) [22]. Any *ICD, Tenth Revision* (*ICD-10*) codes were back-converted to *ICD-9* prior to categorization using General Equivalence Mappings from CMS [23]. As in prior analyses, we modified the CCS to create a separate category for AIDS-defining illness (including opportunistic infections and AIDS-defining cancers) and to reassign infections from organ systems to a non-AIDS-defining infections category [2, 19, 20, 24]. Using a previously validated approach, if the top-ranked diagnosis code was for HIV or chronic hepatitis C virus infection, the second-ranked code was used [25, 26].

The primary outcome of interest was 30-day readmission, defined as a hospital admission within 30 days of the index hospitalization discharge. The covariates of interest were gender, race/ethnicity, age, HIV acquisition risk factor, CD4 count, VL, history of AIDS-defining illness, and NA-ACCORD cohort, all measured on index hospital admission date. For CD4 count and VL, we used the closest measurement in the year prior to and including index hospital admission date. In a sensitivity analysis, we used only measurements prior to admission date, if available, to avoid capturing changes due to acute illness. In another sensitivity analysis, we only included index hospitalizations that had an available CD4 count and VL measurement in the 6 months prior to and including index hospital admission date.

Statistical Analysis

We estimated the probability of hospital readmission within 30 days of index hospitalization discharge. We used linear risk models to estimate the absolute change per year in readmission probability, with hospital discharge year as a linear variable. We used generalized estimating equations to account for PWH contributing >1 index hospitalization. We estimated unadjusted trends and trends adjusted for all aforementioned covariates. For modeling, we created categories for age (<40, 40–49, 50–59, ≥60 years), CD4 count (<50, 50–200, 201–350, 351–500, >500 cells/μL), and VL (<400 or ≥400 copies/mL). We used 400 copies/mL as a threshold for VL to account for the limit of quantification of some assays used at the beginning of the study period. In adjusted analyses, we excluded index hospitalizations missing CD4 count (1.8%) or VL (2.2%), and those among transgender PWH (<1%) due to the very small sample size leading to model nonconvergence issues.

To examine readmissions by reason for index hospitalization, we estimated the unadjusted probability of 30-day readmission stratified by index diagnostic category for the 10 most frequent categories. To facilitate comparisons between categories, we adjusted for differences in PWH characteristics between categories and over time by standardizing the 30-day readmission probability for each category to the distribution of covariates of all index hospitalizations in 2012, the midpoint of the study period. We standardized only by age, CD4 count,

and VL, to have sufficient sample size in each stratum. We obtained 95% confidence intervals (CIs) for standardized estimates using a nonparametric bootstrap with 200 replicates [27]. We estimated unadjusted and adjusted calendar time trends by index diagnostic category, using the same modeling approach as for all-cause hospitalizations. For index hospitalizations with a 30-day readmission, we also described the distribution of diagnostic categories for the first readmission.

We evaluated the potential impact of competing mortality risk on our analyses by describing mortality within 30 days of index discharge and examining a composite endpoint of hospital readmission or mortality within 30 days of index discharge. Because we could not differentiate planned and unplanned readmissions, we also conducted a sensitivity analysis excluding index hospitalizations in the non-AIDS-defining cancer category, which might have higher planned readmissions for chemotherapy. In analyses stratified by diagnostic category, linear risk models did not converge for several categories. Therefore, we also conducted an analysis using Poisson regression models to estimate the relative instead of absolute calendar time trends by category. All analyses were conducted in SAS version 9.4 software (SAS Institute, Cary, North Carolina) with a prespecified α of .05.

RESULTS

Study Sample

There were 20 189 index hospitalizations among 8823 PWH, who contributed a median of 1 index hospitalization per person (interquartile range [IQR], 1–3). Of the hospitalized PWH, 73% were cisgender men, 38% were White, and 38% were Black (Table 1). Compared with PWH hospitalized in 2005, those hospitalized in 2018 were older (median age, 54 vs 44 years), had a higher CD4 count (median, 469 vs 274 cells/μL), and were more likely to have a VL <400 copies/mL (83% vs 49%). For both CD4 counts and VLs, measurements were taken a median of 1.6 months (IQR, 0.5–3.2 months) prior to index hospital admission, with 91% measured <6 months prior.

Table 1. Characteristics of Persons With HIV With an Index Hospitalization in 6 Cohorts of the North American AIDS Cohort Collaboration on Research and Design (NA-ACCORD), 2005–2018

Characteristic[a]	All Hospitalized PWH (N = 8823)	PWH Hospitalized in 2005 (n = 1002)	PWH Hospitalized in 2018 (n = 962)
Gender			
Cisgender men	6448 (73)	707 (71)	718 (75)
Cisgender women	2295 (26)	290 (29)	229 (24)
Transgender persons	80 (1)	5 (<1)	15 (2)
Race/ethnicity			
White	3355 (38)	367 (37)	365 (38)
Black	3309 (38)	398 (40)	405 (42)
Hispanic	1412 (16)	157 (16)	141 (15)
Other or missing	747 (8)	80 (8)	51 (5)
Age, y, median (IQR)	47 (39–55)	44 (38–51)	54 (45–61)
HIV risk group			
MSM	3652 (41)	394 (39)	409 (43)
IDU	1705 (19)	245 (24)	173 (18)
Heterosexual, other, or missing	3466 (39)	363 (36)	380 (40)
CD4 count, cells/μL, median (IQR)	382 (183–603)	274 (120–473)	469 (263–728)
HIV RNA <400 copies/mL	5483 (62)	495 (49)	795 (83)
History of AIDS-defining condition	3202 (36)	476 (48)	413 (43)
Enrolled in US-based cohort	7952 (90)	925 (92)	854 (89)

Data are presented as No. (%) unless otherwise indicated.

Abbreviations: HIV, human immunodeficiency virus; IDU, injection drug use; IQR, interquartile range; MSM, men who have sex with men; PWH, persons with human immunodeficiency virus; US, United States.

[a]For PWH with >1 index hospitalization, characteristics for the first index hospitalization are displayed.

Readmissions Over Time

Over the study period, 3554 of 20 189 index hospitalizations had a 30-day readmission, a probability of 17.6% (95% CI, 17.0%–18.2%) (Table 2). The unadjusted probability decreased from 20.1% (95% CI, 17.9%–22.3%) in 2005 to 16.3% (95% CI, 14.1%–18.5%) in 2018, with an absolute change of −0.34% per year (95% CI, −.48% to −.19%) (Figure 1). After adjusting for age, gender, race/ethnicity, HIV risk group, history of AIDS-defining illness, most recent CD4 count and VL at admission, and NA-ACCORD cohort, the absolute change was −0.19% per year (95% CI, −.35% to −.02%). In this adjusted model (Table 3), compared with PWH with CD4 count >500 cells/μL, the increase in absolute risk was 10.14% (95% CI, 7.53%–12.74%), 5.52% (95% CI, 3.70%–7.35%), 2.53% (95% CI, .93%–4.12%), and 1.48% (95% CI, −.07% to 3.03%) for those with CD4 count <50, 51–200, 201–350, and 351–500, respectively. Older age and a history of AIDS-defining illness were also associated with a greater readmission probability, while race/ethnicity, HIV risk factor, and other covariates were not associated with readmission (Table 3).

Mortality within 30 days of index discharge was stable across the study period, with 1.7% (95% CI, 1.3%–2.1%) in 2005–2007, 2.0% (95% CI, 1.6%–2.4%) in 2008–2010, 1.6% (95% CI, 1.3%–1.9%) in 2011–2014, and 1.8% (95% CI, 1.4%–2.1%) in 2015–2018. Findings when using a composite endpoint of readmission or death within 30 days of discharge, and for other sensitivity analyses, were identical or similar to the primary findings (Supplementary Table 1).

Readmissions by Reason for Index Hospitalization

Among the 10 most frequent diagnostic categories of index hospitalization (together comprising 83% of all index hospitalizations), the unadjusted probability of 30-day readmission ranged from 15.1% (95% CI, 14.1%–16.1%) for index hospitalizations due to a non-AIDS-defining infection, to 26.2% (95%

Table 2. Probability and Calendar Time Trends for 30-Day Hospital Readmission Over Calendar Years 2005–2018, by Diagnostic Category of Index Hospitalization

Diagnostic Category[a]	No. (%)	Probability of 30-Day Readmission, % (95% CI)		Absolute Change per Year, % (95% CI)	
		Unadjusted	Standardized[b]	Unadjusted[c]	Adjusted[d]
All-cause	20 189 (100)	17.6 (17.0–18.2)	NA	−0.34 (−.48 to −.19)	−0.19 (−.35 to −.02)
Non-AIDS-defining infection	5306 (26)	15.1 (14.1–16.1)	14.4 (13.6–15.3)	−0.27 (−.52 to −.01)	−0.20 (−.47 to .07)
Cardiovascular	2157 (11)	18.5 (16.7–20.2)	18.4 (16.8–20.0)	−0.46 (−.91 to −.02)	−0.47 (−.94 to −.01)
Liver/gastrointestinal	1814 (9)	17.5 (15.6–19.3)	17.8 (15.9–19.3)	−0.15 (−.63 to .32)	−0.06 (−.58 to .45)
Psychiatric	1659 (8)	15.9 (14.0–17.7)	17.3 (15.5–19.2)	−0.37 (−.83 to .08)	−0.46 (−.92 to −.00)
Injury	1028 (5)	20.3 (17.8–22.9)	20.6 (18.2–22.6)	−0.65 (−1.35 to .05)	…
AIDS-defining illness	1024 (5)	26.2 (23.5–28.9)	27.0 (22.7–31.2)	0.14 (−.56 to .84)	0.22 (−.51 to .96)
Non-AIDS-defining cancer	1007 (5)	24.5 (21.8–27.3)	24.5 (22.1–27.4)	−0.38 (−1.15 to .39)	…
Renal/genitourinary	1005 (5)	18.2 (15.8–20.6)	17.8 (15.6–19.4)	−0.18 (−.78 to .43)	…
Pulmonary	946 (5)	17.7 (15.1–20.2)	16.3 (14.4–18.3)	−0.12 (−.74 to .50)	…
Endocrine/metabolic	908 (4)	18.7 (16.1–21.3)	19.1 (16.4–21.3)	−0.32 (−.98 to .34)	−0.06 (−.77 to .64)

Numbers not displayed could not be estimated due to model nonconvergence.

Abbreviations: CI, confidence interval; NA, not applicable.

[a]For each index hospitalization, the top-ranked discharge diagnosis was categorized using modified Clinical Classifications Software [22].

[b]Probabilities for each category were standardized to the age, CD4 count, and human immunodeficiency virus (HIV) viral load distribution of all index hospitalizations in 2012. The nonparametric bootstrap with 200 replicates was used to obtain 95% CIs.

[c]Estimated using a separate linear risk model for each category, with generalized estimating equations (GEEs) to account for persons with HIV contributing >1 readmission to the analysis. Models include only calendar year, as a linear variable.

[d]Estimated using separate linear risk models with GEEs, adjusted for age, gender, race/ethnicity, HIV acquisition risk factor, history of AIDS-defining illness, CD4 count, HIV viral load, and North American AIDS Cohort Collaboration on Research and Design (NA-ACCORD) cohort, all measured at index hospital admission.

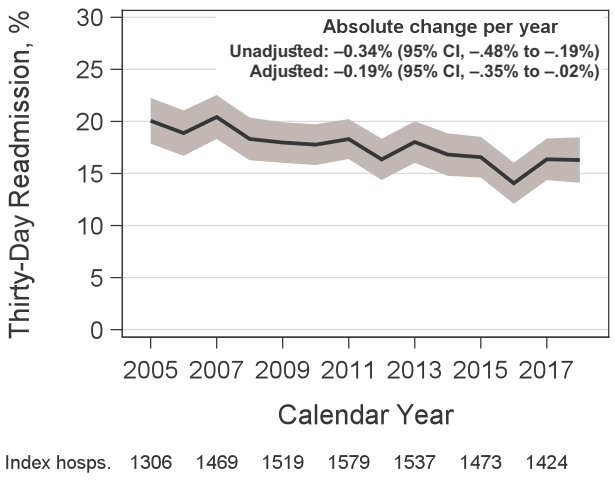

Figure 1. Unadjusted probability of 30-day hospital readmission over time, with unadjusted and adjusted calendar time trends and 95% confidence intervals (CIs). Shaded area is the 95% confidence band. The covariates in the adjusted model are age, gender, race/ethnicity, human immunodeficiency virus (HIV) acquisition risk factor, history of AIDS-defining illness, CD4 count and HIV RNA viral load, and North American AIDS Cohort Collaboration on Research and Design (NA-ACCORD) cohort.

CI, 23.5%–28.9%) for index hospitalizations due to an AIDS-defining illness (Table 2). When standardized to the age, CD4 count, and VL distribution of 2012, readmission probabilities were similar to unadjusted estimates, ranging from 14.4% (95% CI, 13.6%–15.3%) for index hospitalizations due to a non-AIDS-defining infection to 27.0% (95% CI, 22.7%–31.2%) for index hospitalizations due to an AIDS-defining illness. In the most recent calendar period, 2015–2018 (Supplementary Table 2), unadjusted readmissions remained highest for index hospitalizations due to an AIDS-defining illness (26.2% [95% CI, 19.2%–33.1%]), followed by index hospitalizations due to non-AIDS-defining cancer (23.1% [95% CI, 17.7%–28.5%]).

We observed an unadjusted decrease over time in readmissions only for index hospitalizations in the non-AIDS-defining infection and cardiovascular categories, with absolute changes per year of −0.27% (95% CI, −.52% to −.01%) and −0.46% (95% CI, −.91% to −.02%), respectively (Table 2). In adjusted analyses, there was a significant decrease in readmissions only for index hospitalizations in the cardiovascular and psychiatric categories, with an absolute change of −0.47% per year (95% CI, −.94% to −.01%) and −0.46% per year (95% CI, −.92% to −.00%), respectively. Adjusted trends could not be estimated for 4 of the 10 categories due to model nonconvergence. When using Poisson regression to estimate relative instead of absolute trends, we were able to estimate unadjusted and adjusted trends for all 10 categories (Supplementary Table 3). Unadjusted findings were similar to the primary analysis. In adjusted models, we observed a significant decrease in readmissions only for index hospitalizations in the cardiovascular category.

For 9 of the 10 examined categories, the most frequent diagnostic category of the first 30-day readmission was the same as the index hospitalization, accounting for 24%–53% of

Table 3. Adjusted Risk Differences and 95% Confidence Intervals for the Probability of 30-Day Readmission

Characteristic[a]	Adjusted Risk Difference, % (95% CI)[b]
Hospitalization year, by 1-y increase	−0.19 (−.35 to −.02)
Gender	
Cisgender men	1 (ref.)
Cisgender women	−0.31 (−1.92 to 1.31)
Race/ethnicity	
Black	−0.88 (−2.54 to .78)
White	1 (ref.)
Hispanic	0.26 (−1.70 to 2.22)
Other	2.62 (0.00–5.24)
Age, y	
<40	1 (ref.)
40–49	1.09 (−.61 to 2.80)
50–59	2.42 (.64–4.20)
≥60	3.28 (1.26–5.30)
HIV risk group	
MSM	1 (ref.)
IDU	0.63 (−1.14 to 2.40)
Heterosexual/other	0.02 (−1.68 to 1.72)
CD4 count, cells/μL	
<50	10.14 (7.53–12.74)
50–200	5.52 (3.70–7.35)
201–350	2.53 (.93–4.12)
351–500	1.48 (−.07 to 3.03)
>500	1 (ref.)
HIV RNA ≥400 vs <400 copies/mL	0.99 (−.48 to 2.47)
History of clinical AIDS, yes vs no	3.34 (2.09–4.60)

Abbreviations: CI, confidence interval; HIV, human immunodeficiency virus; IDU, injection drug use; MSM, men who have sex with men.

[a]For CD4 count and HIV RNA viral load, we used the closest measurement in the year prior to and including hospital admission date.

[b]Estimates and 95% CIs from a single linear risk regression model including all variables in the table and North American AIDS Cohort Collaboration on Research and Design (NA-ACCORD) cohort.

readmissions (Table 4, Supplementary Figure 1). Non-AIDS-defining infection was a frequent reason for readmission across index hospitalization categories, accounting for 12%–26% of readmissions. Sepsis/bacteremia was the most frequent diagnosis in the non-AIDS-defining infection category, for both index hospitalizations and readmissions (Supplementary Tables 4 and 5).

DISCUSSION

Unadjusted 30-day hospital readmissions decreased among PWH in care in the US and Canada, from 20% in 2005 to 16% in 2018. In adjusted analyses, we found a significant decrease in readmissions for all-cause index hospitalizations and for index hospitalizations due to cardiovascular and psychiatric conditions. Index hospitalizations for AIDS-defining illness and for non-AIDS-defining cancer had the highest probability of readmission, including in the most recent calendar period. Overall, the diagnostic category of readmission was frequently concordant with the index hospitalization category.

Several studies have examined readmissions among PWH engaged in care in North America. For all-cause hospitalizations, the readmission rate was 19.3% during 2005–2010 in the HIV Research Network, and 18.9% during 1996–2016 in a North Carolina HIV cohort [2, 3], which are similar to the estimates in the earlier part of our study period. In addition, several studies have reported population-based readmission rates for PWH, with 19.7% in 2011 in 9 US State Inpatient Databases (SID), 21.8% in 2012 in New York State, and 18.7% in 2011 at an urban medical center in Texas [1, 4, 28]. Our study provides the most recent readmission estimates for PWH, with data through 2018 from 5 cohorts across the US and 1 in Canada. In contrast to our findings, there was no evidence of change in readmissions in the HIV Research Network (HIVRN) from 2005 to 2010 or the North Carolina cohort from 1996 to 2016 [2, 3]. It is possible that a larger sample size was necessary to estimate with precision a relatively small change in readmissions year-to-year. In the HIVRN and SID studies, AIDS-defining illness and cancer hospitalizations had the highest readmission rates, similar to our findings [1, 2].

The decline in readmissions among PWH has several potential explanations. First, we observed a substantial increase in virologic suppression and CD4 counts among hospitalized PWH over the study period. Unsuppressed VLs and lower CD4 counts are strong risk factors for hospitalization and readmission, including for non-AIDS-related admissions [1–3, 19, 20, 24, 29]. In this study, having a CD4 count <50 cells/μL was associated with an adjusted absolute increase of 10% in readmission. There was also a shift during our study period in the distribution of hospitalization causes among PWH, with a decreasing proportion of hospitalizations due to an AIDS-defining illness, a diagnostic category with a high readmission rate, and increasing proportions in other diagnostic categories with lower readmission rates [1, 2, 20]. Earlier HIV diagnosis, the expanded recommendation of ART initiation to all PWH, and use of newer, more effective regimens, which led to increased virologic suppression rates and CD4 counts, likely contributed to the decrease in hospital readmissions.

Since we found significant readmission declines for all-cause index hospitalizations and index hospitalizations in the cardiovascular and psychiatric categories, even after adjusting for CD4 count and viral load, it is likely that other factors also contributed to these trends. Improvements in inpatient and postdischarge care, including discharge planning, patient education, and outpatient follow-up, might have decreased readmissions, especially for specific target conditions. Among Medicare beneficiaries aged ≥65 years in the general population, readmissions decreased following the passage of the ACA for index admissions due to myocardial infarction (MI) and heart failure, the most frequent cardiovascular discharge diagnoses for PWH [6, 20]. While it does not have an HRRP-like program, Canada also experienced a decrease in readmissions after MI and heart

Table 4. Distribution of Diagnostic Categories of 30-Day Readmissions, by Index Hospitalization Diagnostic Category

		Diagnostic Category of the First 30-Day Readmission, by Frequency[a]		
Index Diagnostic Category[a]	No.	First Most Frequent	Second Most Frequent	Third Most Frequent
Non-AIDS-defining infection	802	Non-AIDS-defining infection (46%)	AIDS-defining illness (7%)	Liver/gastrointestinal (6%)
Cardiovascular	398	Cardiovascular (52%)	Non-AIDS-defining infection (12%)	Renal/genitourinary (5%) Symptoms (5%)
Liver/gastrointestinal	317	Liver/gastrointestinal (39%)	Non-AIDS-defining infection (26%)	Non-AIDS-defining cancer (5%) Cardiovascular (5%)
AIDS-defining illness	268	AIDS-defining illness (41%)	Non-AIDS-defining infection (19%)	Pulmonary (5%) Renal/genitourinary (5%)
Psychiatric	263	Psychiatric (53%)	Non-AIDS-defining infection (14%)	Injury (7%)
Non-AIDS-defining cancer	247	Non-AIDS-defining cancer (46%)	Non-AIDS-defining infection (17%)	Liver/gastrointestinal (6%)
Injury	209	Injury (36%)	Psychiatric (19%)	Non-AIDS-defining infection (15%)
Renal/genitourinary	183	Renal/genitourinary (24%)	Non-AIDS-defining infection (21%)	Metabolic/endocrine (8%)
Endocrine/metabolic	170	Non-AIDS-defining infection (25%)	Metabolic/endocrine (25%)	Psychiatric (8%)
Pulmonary	167	Pulmonary (41%)	Non-AIDS-defining infection (15%)	Cardiovascular (10%)

[a]For each hospitalization, the top-ranked discharge diagnosis was categorized using modified Clinical Classifications Software [22].

failure hospitalizations during this period [30, 31]. State/province-level policies could also have played a role, such as financial incentives for postdischarge care plans and visits in British Columbia and Ontario [32, 33]. Importantly, the decline in readmissions in our study occurred despite a 10-year increase in the median age of hospitalized PWH.

The decline of almost 4 percentage points in 30-day readmissions in our study represents an important improvement. Among Medicare beneficiaries aged ≥65 years in the general population, the crude readmission rate for all-cause hospitalizations decreased 1.4 percentage points from 2010 to 2016 [34]. For hospitals penalized by CMS, a 4-point decrease in readmissions for HRRP target conditions reflects sufficient improvement to withdraw the penalties [8, 9, 35]. For PWH, who experience approximately 40 000 hospitalizations annually in the US [7], a 4-point readmission decrease would translate to the prevention of many acute events, substantial cost savings, and fewer life disruptions.

Despite observed decreases, readmissions remain a concern for hospitalized PWH. Our study's readmission rate of 16% in 2018 is similar to the 16% rate in 2016 for Medicare beneficiaries ≥65, despite our study population having a median age of 54 years [34]. For members of the general population aged 45–64 years, the 2016 readmission rates (excluding maternal hospitalizations) were 20%, 11%, and 13% for those with Medicaid, private insurance, and no insurance, respectively [34]. In the general population aged >65 years in Ontario (mean age, 78 years), the readmission rate was 12.6% during 2008–2015 [36]. Comparison of estimates among PWH and the general population may be limited by differences in factors leading to readmission, including clinical, health insurance, and home life considerations. For example, clinicians may consider HIV itself a risk factor for worse outcomes and be more likely to admit or readmit based solely on HIV status. Nonetheless, PWH appear to have a persistently elevated readmission risk, consistent with the 2011 SID study, which found higher readmissions for PWH than persons without HIV across 9 US states [1].

Continued efforts are needed to further prevent readmissions in PWH, particularly those with greater immunodeficiency (as marked by low CD4 counts and history of AIDS-defining illness) and unsuppressed VL. Readmissions in our study remained >26% for index hospitalizations due to AIDS-defining illnesses in 2015–2018 and unchanged from earlier calendar periods, highlighting the severity of these conditions and underlying immunodeficiency. Future studies should examine whether readmission trends differ between clinical and demographic subgroups, particularly racial/ethnic groups, as prior work as shown that Black, Hispanic, and Indigenous PWH are more likely to be hospitalized for AIDS-defining illnesses than White PWH [37]. While race/ethnicity was not associated with readmission in our adjusted model, this study did not focus on evaluating readmission disparities by race and ethnicity, and more work is needed in this area.

Strategies to reduce readmissions in PWH include support for ART access and adherence, timely clinical follow-up postdischarge, disease management education, postdischarge home care visits, mental health and substance use disorder treatment, and resources to address homelessness and other socioeconomic barriers [1–3, 5, 28, 29, 38]. A multidisciplinary intervention addressing medical, social, and care coordination needs in PWH led to a 19% relative reduction in readmission odds [10].

Strengths and Limitations

A major strength of this study was the availability of 14 years of administrative and clinical data from a multicenter consortium. With a large sample size, we were able to examine calendar time

trends for all-cause and cause-specific hospitalizations, and the distribution of readmission causes. However, because some NA-ACCORD cohorts only include hospitalizations from their medical system, readmissions in our study could be underestimated if PWH were readmitted to an outside hospital. Studies among PWH and the general population suggest that 20%–25% of readmissions occur at outside hospitals [29, 39–41]. Future studies should investigate readmission patterns among PWH, including same versus different hospital readmission. We also did not have available data after 2018, and studies should continue to monitor readmissions in more recent years, which may have been impacted by recent trends such as coronavirus disease 2019–related disruptions of care. Finally, all PWH in our sample were engaged in care at academic medical centers or integrated health systems, and our findings may not be generalizable to PWH in care in other settings or those who are not in care.

CONCLUSIONS

In a large sample of PWH in the US and Canada, 30-day readmissions decreased by 4 percentage points from 2005 to 2018. Improvements in virologic and immunologic status were likely the major drivers, but the trend persisted after adjusting for these. Other potential contributors include improvements in inpatient and postdischarge care for certain conditions, including efforts driven by health policy. Despite improvements, readmissions remained elevated for PWH, especially for those with AIDS-defining illnesses and lower CD4 counts, and additional efforts are needed to address medical and social needs that contribute to readmission.

Supplementary Data

Supplementary materials are available at *The Journal of Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

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Disclaimer. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health (NIH) or the Centers for Disease Control and Prevention.

Financial support. T. D.-M. received training support from the National Institute on Drug Abuse (grant number T32DA007250) and National Heart, Lung, and Blood Institute (grant number K01HL169020). This work was supported by NIH grants U01AI069918, F31AI124794, F31DA037788, G12MD007583, K01AI093197, K01AI131895, K23EY013707, K24AI065298, K24AI118591, K24DA000432, KL2TR000421, N01CP01004, N02CP055504, N02CP91027, P30AI027757, P30AI027763, P30AI027767, P30AI036219, P30AI050409, P30AI050410, P30AI094189, P30AI110527, P30MH62246, R01AA016893, R01DA011602, R01DA012568, R01AG053100, R24AI067039, R34DA045592, U01AA013566, U01AA020790, U01AI038855, U01AI038858, U01AI068634, U01AI068636, U01AI069432, U01AI069434, U01DA036297, U01DA036935, U10EY008057, U10EY008052, U10EY008067, U01HL146192, U01HL146193, U01HL146194, U01HL146201, U01HL146202, U01HL146203, U01HL146204, U01HL146205, U01HL146208, U01HL146240, U01HL146241, U01HL146242, U01HL146245, U01HL146333, U24AA020794, U54GM133807, UL1RR024131, UL1TR000004, UL1TR000083, UL1TR002378, Z01CP010214, and Z01CP010176; contracts CDC-200-2006-18797 and CDC-200-2015-63931 from the Centers for Disease Control and Prevention; contract number 90047713 from the Agency for Healthcare Research and Quality (AHRQ); contract number 90051652 from the Health Resources and Services Administration; the Grady Health System; and grant numbers CBR-86906, CBR-94036, HCP-97105, and TGF-96118 from the Canadian Institutes of Health Research (CIHR), Ontario Ministry of Health and Long Term Care, and the Government of Alberta, Canada. Additional support was provided by the National Institute of Allergy and Infectious Diseases, National Cancer Institute, National Heart, Lung, and Blood Institute, Eunice Kennedy Shriver National Institute of Child Health and Human Development, National Human Genome Research Institute, National Institute of Mental Health, National Institute on Drug Abuse, National Institute on Aging, National Institute of Dental and Craniofacial Research, National Institute of Neurological Disorders and Stroke, National Institute of Nursing Research, National Institute on Alcohol Abuse and Alcoholism, National Institute on Deafness and Other Communication Disorders, and National Institute of Diabetes and Digestive and Kidney Diseases.

Potential conflicts of interest. K. N. A. reports grants to their institution from NIH; royalties or licenses from Coursera; and consulting fees from NIH and TrioHealth. R. J. B. reports grants to their institution from NIH and support for travel from NIH. J. A. C. reports grants to their institution from NIH and payment or honoraria from Prime Education and Integritas Communications. H. M. C. reports grants to their institution from AHRQ, NIH, and ViiV Healthcare; and participation in a data and safety monitoring board (DSMB) or advisory board for Gilead Sciences, NIH Office of AIDS Research, and ViiV Healthcare. J. J. E. reports grants to their institution from NIH, ViiV Healthcare, Gilead Sciences, and Janssen; consulting fees from ViiV Healthcare, Gilead Sciences, and Merck & Co; and participation on a DSMB or advisory board for TAIMED. K. A. G. reports grants to their institution from the US Department of Defense, NIH, Mental Wellness Foundation, HealthNetwork Foundation, Bloomberg Philanthropies, Defense Health Agency, the State of Maryland, Octapharma, Moriah Fund, and National Center for Advancing Translational Sciences; consulting fees from Spark HealthCare, Teach for America, and Aspen Institute; and participation on a DSMB or advisory board for Pfizer. M. J. G. reports grants to their institution from NIH; and participation on a DSMB or advisor board for Merck & Co, Gilead Sciences, and ViiV Healthcare. B. C. H. reports grants to their institution from NIH. M. A. H. reports grants to their institution from NIH. M. Y. K. reports grants to their institution from Gilead Sciences and ViiV Healthcare; payment or honoraria to their institution from Practice Point Communications CME; leadership in the AIDS Clinical Trials Group (ACTG) Underrepresented Populations Committee (Vice Chair) with payments to their institution; and uncompensated leadership on the Being Alive San Diego Board (member). M. B. K. reports grants to their institution from NIH, ViiV Healthcare, AbbVie, and Gilead Sciences; and consulting fees from ViiV Healthcare, AbbVie, and Gilead Sciences. R. L. reports support for travel from CIHR. V. D. L. reports grants to their institution from CIHR; payment or honoraria from ViiV Healthcare; support for travel from the Conference on Retroviruses and Opportunistic Infections; and participation on a DSMB or advisory board for the Providence Health Care Ethics Board. R. D. M. reports grants to their institution from NIH. S. N. reports grants to their institution from NIH. A. N. reports grants to their institution from Gilead Sciences. P. F. R. reports grants to their institution from NIH and consulting fees from Gilead Sciences and Janssen. J. E. T. reports grants to their institution from the National Eye Institute and ACTG; consulting fees from Gilead Sciences, Canfield, and UpToDate; participation on a DSMB or advisory board for NEI and Tarsier; stock or stock options in Tarsier; and fees for serving as Editor-in-Chief for Ocular

Immunology and Inflammation. All other authors report no potential conflicts.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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