Racial, ethnic, and gender disparities in hospitalizations among persons with HIV in the United States and Canada, 2005–2015

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Objective: To examine recent trends and differences in all-cause and cause-specific hospitalization rates by race, ethnicity, and gender among persons with HIV (PWH) in the United States and Canada.

Design: HIV clinical cohort consortium.

Methods: We followed PWH at least 18 years old in care 2005–2015 in six clinical cohorts. We used modified Clinical Classifications Software to categorize hospital discharge diagnoses. Incidence rate ratios (IRR) were estimated using Poisson regression with robust variances to compare racial and ethnic groups, stratified by gender, adjusted for cohort, calendar year, injection drug use history, and annually updated age, $CD4^+$, and HIV viral load.

Results: Among 27 085 patients (122 566 person-years), 80% were cisgender men, 1% transgender, 43% White, 33% Black, 17% Hispanic of any race, and 1% Indigenous. Unadjusted all-cause hospitalization rates were higher for Black [IRR 1.46, 95% confidence interval (CI) 1.32–1.61] and Indigenous (1.99, 1.44–2.74) versus White cisgender men, and for Indigenous versus White cisgender women (2.55, 1.68–3.89). Unadjusted AIDS-related hospitalization rates were also higher for Black, Hispanic, and Indigenous versus White cisgender men (all $P < 0.05$). Transgender patients had 1.50 times (1.05–2.14) and cisgender women 1.37 times (1.26–1.48) the unadjusted hospitalization rate of cisgender men. In adjusted analyses, among both cisgender men and women, Black patients had higher rates of cardiovascular and renal/genitourinary hospitalizations compared to Whites (all $P < 0.05$).

Conclusion: Black, Hispanic, Indigenous, women, and transgender PWH in the United States and Canada experienced substantially higher hospitalization rates than White patients and cisgender men, respectively. Disparities likely have several causes,

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including differences in virologic suppression and chronic conditions such as diabetes and renal disease.

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Introduction

Effective combination antiretroviral therapy (ART) has decreased AIDS-related morbidity, mortality, and hospitalizations among persons with HIV (PWH) in the United States and Canada [1–4]. Despite these improvements, disparities in hospitalization rates emerged between different sub-populations of PWH. Through the mid-2000s, women and Black PWH continued to be hospitalized 30–40% more frequently than men and White PWH, respectively, overall and for hospitalizations due to non-AIDS-defining infections, cardiovascular, and renal conditions [3,5,6].

HIV care changes in the last decade might have affected demographic disparities in hospitalization rates. PWH are now diagnosed and initiate ART earlier in HIV infection, and are likelier to be virologically suppressed, partly because of more effective ART, with notable reductions in morbidity and mortality [7,8]. Yet Black, Hispanic, and Indigenous (including Native American, Alaska Native, and Aboriginal individuals) PWH still frequently enter HIV care with $CD4^+$ cell counts less than 350 cells/μl or an AIDS-defining illness (ADI) [9–11]. Women, Black, and Indigenous PWH are likelier to experience viral rebound or unsuppressed viral loads [8,12], and Black and Indigenous PWH experience worse HIV care retention [13,14]. Uncontrolled viremia and resulting immunocompromised status put these patients at continued risk of AIDS and non-AIDS morbidity.

Non-HIV clinical characteristics might also have affected hospitalization disparities. End-stage renal disease rates among PWH decreased after 2000, but women and Black PWH have substantially higher rates than men and White PWH, respectively [15]. Black PWH are at higher risk of developing hypertension and type 2 diabetes mellitus, risk factors for more severe morbidity [16]. Women are at higher risk of developing type 2 diabetes mellitus compared with men with HIV [16]. In contrast, PWH who develop end-stage liver disease are likelier to be men and White [17].

It is not known how these trends have affected demographic differences in hospitalizations among United States and Canadian PWH, though some studies suggest disparities persist [18–20]. Additionally, there is sparse evidence on hospitalization rates among smaller sub-groups of PWH, such as Asian, Hispanic, Indigenous, and transgender individuals. We aimed to describe hospitalization rates stratified by racial, ethnic, and gender groups among PWH in clinical care between 2005 and 2015 in the United States and Canada.

Methods

Study population and follow-up

This study was based in the North American AIDS Cohort Collaboration on Research and Design (NA-ACCORD), a collaboration of over 20 cohorts including more than 180 000 PWH [21,22]. Five United States and one Canadian clinical cohorts that collected hospitalization data for the period 2005–2015, including *International Classification of Diseases* (*ICD*) codes for discharge diagnoses, were eligible for this study. Each cohort captures hospitalization data, including admission and discharge dates and discharge diagnoses, from electronic health records in its medical system. Prospective data collection was approved by local Institutional Review Boards (IRBs), and secondary data analysis by the University of North Carolina IRB.

Patients aged at least 18 years contributed person-time at risk from cohort entry or 1 January 2005, whichever occurred later, until death or 31 December 2015, whichever occurred first. NA-ACCORD defines cohort entry as the first of at least two outpatient HIV visits in a 12-month period [23]. Person-time was censored at loss to follow-up (LTFU), defined as 12 months with no outpatient $CD4^+$ cell count or HIV viral load measurement, but patients who re-entered HIV care, defined as an outpatient $CD4^+$ cell count or viral load, contributed additional person-time. A sensitivity analysis used 18 months to define LTFU. Inpatient days were not counted as person-time.

Study measures

Annual hospitalization rates were calculated as the number of hospitalizations divided by the person-time in a calendar year, allowing more than one hospitalization per patient. Hospitalizations with same-day discharge were not counted as outcomes, as these are rare events and undistinguishable from outpatient procedures (e.g. endoscopies). Hospitalizations that occurred prior to NA-ACCORD cohort entry could not count as outcomes. We used modified Clinical Classifications Software to categorize *ICD, Ninth Revision, Clinical Modification (ICD-9-CM)* codes for the primary discharge diagnosis [6,24]. Each hospitalization contributed to only

one category. The primary discharge diagnosis for each hospitalization was the top-ranked ICD code. Using a validated approach, if the top-ranked diagnosis was HIV or chronic hepatitis C infection, we used the next diagnosis [25]. *ICD-10* codes (11% of hospitalizations) were converted to *ICD-9-CM*. Primary analyses examined all-cause hospitalizations, and secondary analyses examined cause-specific hospitalizations for the 10 most frequent categories. In cause-specific analyses, patients hospitalized for one cause remained at risk of subsequent hospitalization for the same cause or any other cause.

Race, ethnicity, and birth gender were self-reported by patients at clinic registration and collected from electronic health records. Transgender patients were identified from locally collected data ($n = 149$), or as individuals who reported female birth gender as well as MSM as HIV risk factor ($n = 8$). Methods for identifying transgender patients vary by cohort and include health record reviews and gender identity questions on intake forms [26]. We did not have data on specific gender identity. Patients not identified as transgender were assumed to be cisgender. Because of small numbers, we examined transgender patients in a secondary analysis comparing gender groups.

Covariates included NA-ACCORD cohort, calendar year, injection drug use (IDU) as HIV acquisition risk factor, and annually updated age, $CD4^+$ cell count, and viral load. Categories were created for age (<40, 40–49, 50–59, ≥60 years), $CD4^+$ cell count (<50, 50–200, 201–350, 351–500, >500 cells/μl), and viral load (<400, ≥400 copies/ml; the highest assay quantification limit used during the study period). For each calendar year, we used the earliest $CD4^+$ and viral load measurement, or, if none was available, the earliest measurement in the last 6 months of the previous year or first 6 months of the following year.

To assess the possible impact of demographic differences in mortality on our analyses, we estimated mortality rates overall and by gender, race, and ethnicity, counting deaths that occurred during the person-time defined as above.

Statistical analysis

To describe changes over time and demographic differences in clinical factors that may affect hospitalization rates, we plotted the proportion of patients with viral load less than 400 copies/ml and median $CD4^+$ cell counts across calendar years, stratified by race, ethnicity, and gender. For all-cause hospitalizations, we plotted unadjusted and standardized annual rates, stratified by race, ethnicity, and gender. Rates were standardized to the entire sample's distribution of covariates in 2010, adjusting for changes over time and differences between groups.

We estimated incidence rate ratios (IRR) using Poisson regression models with generalized estimating equations with an independent correlation matrix to account for patients contributing more than one hospitalization. We fit separate models to estimate calendar time trends stratified by race, ethnicity, and gender, and to compare rates between racial and ethnic groups stratified by gender. Unadjusted models included only NA-ACCORD cohort as a covariate. Adjusted models included all covariates. To further evaluate the role of viral suppression, $CD4^+$ cell count, and IDU risk factor on hospitalization rates, we conducted a sensitivity analysis with a partially adjusted model including only NA-ACCORD cohort, calendar year, and age as covariates. We also conducted a sensitivity analysis restricted to patients without IDU risk factor.

IRR for trends were reported as a mean percentage change, for example, an IRR of 0.95 per 1-year increase was reported as a −5% annual rate change. Because of small group sizes, we did not estimate trends and annual rates for Asian, Indigenous, and multiracial/other cisgender women, or for transgender patients. *P* values were two-sided. Analyses were conducted in SAS, v9.4 (SAS Institute, Cary, North Carolina, USA).

Results

Study sample

Of 28 057 patients in care in 2005–2015 in the six eligible cohorts, 27 085 (97%) patients with known gender, race, and ethnicity were included and contributed 122 566 person-years of follow-up. The included patients were 80% cisgender men, 19% cisgender women, and 1% transgender adults; 43% White, 33% Black, 17% Hispanic of any race, 4% Asian, 1% Indigenous, and 2% multiracial/other. Gender distribution differed by race and ethnicity, with 8% of White and 35% of Black patients being cisgender women (Table 1). Twenty-eight percent of Indigenous patients were enrolled in a United States-based cohort, whereas 88–99% of other groups were enrolled in a United States-based cohort. White patients had higher $CD4^+$ cell counts at cohort entry than other groups (median 425 versus 350–396 cells/μl). Among cisgender men, cisgender women, and transgender patients, respectively, 13, 15, and 18% had a history of IDU, and median $CD4^+$ cell counts at cohort entry were 389, 374, and 369 (not shown). During follow-up, the overall mortality rate was 1.4 deaths per 100 person-years [95% confidence interval (CI) 1.3–1.5]. The highest mortality rates per 100 person-years were observed for Black patients among cisgender men (1.8, 95% CI 1.7–2.0), and for Indigenous patients among cisgender women (3.0, 95% CI 1.7–5.4), respectively (Table, Supplemental Digital Content 1, http://links.lww.com/QAD/C59).

Of 122 566 included person-years, 2.5% were missing either a viral load or $CD4^+$ measurement, and this did not vary substantially by gender, race, and ethnicity, ranging

Table 1. Characteristics of 27 085 patients in care in six North American AIDS Cohort Collaboration on Research and Design cohorts 2005–2015, stratified by race and ethnicity.

Characteristic	White, not Hispanic (*N* = 11 526) No. (%) or median (IQR)	Black, not Hispanic (*N* = 8947) No. (%) or median (IQR)	Hispanic, any race (*N* = 4611) No. (%) or median (IQR)	Asian, not Hispanic (*N* = 1052) No. (%) or median (IQR)	Indigenous, not Hispanic (*N* = 320) No. (%) or median (IQR)	Multiracial/other, not Hispanic (*N* = 629) No. (%) or median (IQR)
Gender						
Cisgender men	10 507 (91%)	5803 (65%)	3786 (82%)	925 (88%)	225 (70%)	515 (82%)
Cisgender women	975 (8%)	3095 (35%)	782 (17%)	115 (11%)	91 (28%)	109 (17%)
Transgender[a]	44 (<1%)	49 (<1%)	43 (1%)	12 (1%)	4 (1%)	5 (<1%)
HIV risk factor						
MSM	7942 (69%)	2556 (29%)	2530 (55%)	722 (69%)	90 (28%)	362 (58%)
IDU	1506 (13%)	1450 (16%)	449 (10%)	52 (5%)	114 (36%)	45 (7%)
Heterosexual or other	2078 (18%)	4941 (55%)	1632 (35%)	278 (26%)	116 (36%)	222 (35%)
Enrolled in a United States-based cohort	10 119 (88%)	8395 (94%)	4543 (99%)	925 (88%)	91 (28%)	602 (96%)
Cohort enrollment year	2007 (2003–2012)	2008 (2004–2012)	2008 (2005–2012)	2010 (2005–2013)	2008 (2004–2011)	2011 (2005–2014)
Age at study start (years)	42 (35–50)	41 (32–48)	39 (32–47)	37 (31–44)	36 (30–43)	38 (30–46)
HIV viral load <400 copies/ml at study start[b]	5832 (52%)	3338 (39%)	2082 (46%)	467 (45%)	103 (35%)	303 (50%)
$CD4^+$ cell count at enrollment[c] (cells/μl)	425 (233–628)	350 (158–548)	372 (184–573)	372 (210–550)	307 (177–510)	396 (231–607)

IDU, injection drug use; NA-ACCORD, North American AIDS Cohort Collaboration on Research and Design.
[a]Includes 149 patients identified either from locally collected data, and 8 patients having female birth gender and MSM as HIV risk factor.
[b]Missing for 679 patients.
[c]$CD4^+$ cell count at enrollment was the closest measurement a year before to 30 days after enrollment date and was missing for 2334 patients.
IQR, interquartile range.

1.2–5.0% of person-years by group. From 2005 to 2015, the proportion of patients with viral load less than 400 copies/ml and median $CD4^+$ cell counts increased in all groups (Figure, Supplemental Digital Content 2, http://links.lww.com/QAD/C59).

Of 21 036 included hospitalizations, the most frequent diagnostic category was non-AIDS-defining infection (25%) followed by cardiovascular (10%) (Table, Supplemental Digital Content 3, http://links.lww.com/QAD/C59). Non-AIDS-defining infection was the most common category across all race, ethnicity, and gender groups (Table, Supplemental Digital Content 4, http://links.lww.com/QAD/C59). The second most frequent category was psychiatric for Black and multiracial/other cisgender women, and pregnancy for Asian and Indigenous cisgender women.

All-cause hospitalization rates over time

Among all patients, unadjusted all-cause hospitalization rates per 100 person-years were 22.6 in 2005 (95% CI 20.9–24.4) and 13.2 in 2015 (12.3–14.2). Annual unadjusted rates were generally lowest among White and Asian cisgender men and highest among Black and Hispanic cisgender women (Fig. 1a and b). Unadjusted all-cause rates decreased for most groups over time, with mean annual changes of −3% (95% CI −4 to −2) for White cisgender men, −6% (−7 to −4) for Black cisgender men, −7% (−10 to −3) for White cisgender women, and −5% (−7 to −3) for Black cisgender women (Table 2). In 2015, unadjusted hospitalization rates per 100 person-years were 11.7 for White cisgender men (10.4–13.2), 15.5 (13.3–18.0) for Black cisgender men, 13.5 (9.7–18.8) for White cisgender women, and 18.4 (15.4–22.1) for Black cisgender women (Table, Supplemental Digital Content 5, http://links.lww.com/QAD/C59). The 2015 unadjusted rates per 100 person-years among all cisgender men and women were 12.2 (11.3–13.3) and 17.2 (15.0–19.8), respectively. Standardized rates appeared stable over time in each racial, ethnic, and gender group (Fig. 1c and d). In adjusted models, there was no significant decrease in rates in any group (Table 2). Over the study period, unadjusted hospitalizations rates per 100 person-years were 24.7 (18.0–33.8) for Indigenous cisgender men, 42.0 (29.7–59.3) for Indigenous cisgender women, and 24.8 (17.4–35.5) for transgender patients.

Hospitalization rates by gender, race, and ethnicity

In unadjusted analyses, Black cisgender men had 1.46 times (95% CI 1.32–1.61) and Indigenous cisgender men 1.99 times (1.44–2.74) the all-cause hospitalization rates of White cisgender men (Table 2). All-cause hospitalization rates were lower for Asian compared with White cisgender men, with an unadjusted IRR of 0.62 (0.50–0.75). There was no association between rates and Hispanic ethnicity or multiracial/other race. Estimates were similar in adjusted models. Indigenous cisgender women experienced 2.55 times (1.68–3.89) the all-cause hospitalization rate of White cisgender women in unadjusted analyses, and 1.82 times (1.27–2.59) in adjusted analyses. Cisgender women in remaining race and ethnicity groups did not have different hospitalization

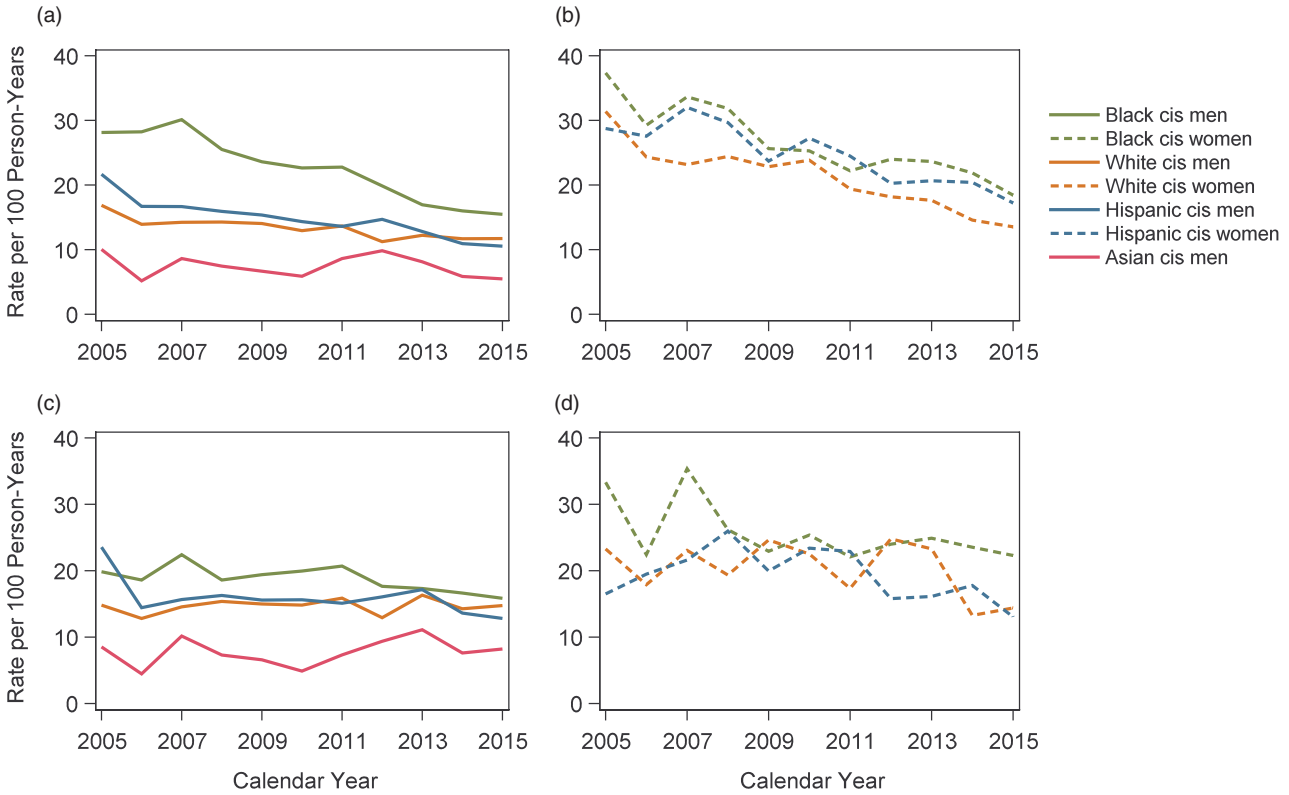

Fig. 1. Annual all-cause hospitalization rates stratified by race, ethnicity, and gender. Panels a and b show unadjusted rates. Panels c and d show rates standardized to the distribution in 2010 in the entire study sample of age, $CD4^+$ cell count, HIV viral load, and history of injection drug use as HIV acquisition risk factor. Standardization strata were defined according to the following categories: age less than 40, 40–49, 50–59, and at least 60 years; $CD4^+$ cell count <50, 50–200, 201–350, 351–500, and more than 500 cells/μl; HIV viral load less than 400 and ≥400 copies/ml; History of injection drug use as HIV acquisition risk factor, yes or no. Due to small group sizes, annual rates were not estimated for Asian cisgender women, Indigenous, multiracial/other, or transgender patients.

rates compared with White cisgender women, in unadjusted or adjusted analyses.

Sensitivity analyses

Using 18 months to define LTFU, IRR estimates were similar to the main findings (Table, Supplemental Digital Content 6, http://links.lww.com/QAD/C59). Adjusting only for NA-ACCORD cohort, calendar year, and age, estimates closely resembled unadjusted estimates (Table, Supplemental Digital Content 7, http://links.lww.com/QAD/C59). Excluding patients with IDU risk factor, results were also similar to the main findings, though estimates among cisgender women were less precise because of reduced sample size (Table, Supplemental Digital Content 8, http://links.lww.com/QAD/C59).

Cause-specific hospitalizations

In unadjusted analyses (Table 3), Black patients had higher rates for cardiovascular hospitalizations, with an IRR of 1.58 (1.23–2.01) comparing Black to White cisgender men, and a similar estimate among cisgender women. Black cisgender men also had higher hospitalization rates than White cisgender men for renal/genitourinary and endocrine/metabolic conditions, with IRRs of 3.35 (2.66–4.21) and 2.02 (1.51–2.70), respectively for each category. Compared with White cisgender men, hospitalization rates for ADI were higher for Black, Hispanic, and Indigenous cisgender men. For most categories, hospitalization rates were lower for Asian compared with White cisgender men. Among cisgender women, Black and Hispanic patients had approximately twice the rate of White patients in the category of neoplasms excluding AIDS-defining cancer. In adjusted analyses (Table 4), hospitalization rates for ADI did not differ by race or ethnicity for cisgender men or women, whereas IRR for other categories were similar to unadjusted estimates.

In analyses comparing gender groups (Table, Supplemental Digital Content 9, http://links.lww.com/QAD/C59), cisgender women had higher rates compared with cisgender men for all-cause hospitalization and several diagnostic categories including non-AIDS-defining infection, in both unadjusted and adjusted analyses. Additionally, transgender patients had 1.50 times (1.05–2.14) the rate of cisgender men for all-cause hospitalizations, and 2.51 times (1.35–4.66) for ADI in unadjusted analyses, with similar adjusted estimates.

Table 2. Annual percentage change in rates and incidence rate ratios for all-cause hospitalizations, stratified by gender, among 26 928 cisgender patients in HIV care in six North American AIDS Cohort Collaboration on Research and Design cohorts between 2005 and 2015.

	Annual percentage change (95% CI)		Incidence rate ratio (95% CI)	
Gender[a], race, and ethnicity	Unadjusted[b]	Adjusted[c]	Unadjusted[d]	Adjusted[e]
Cisgender men				
White, not Hispanic	**−3 (−4 to −2)**	0 (−2 to 1)	1 (ref.)	1 (ref.)
Black, not Hispanic	**−6 (−7 to −4)**	−2 (−4 to 0)	**1.46 (1.32–1.61)**	**1.24 (1.11–1.38)**
Hispanic, any race	**−5 (−7 to −3)**	−1 (−4 to 1)	1.01 (0.90–1.13)	0.97 (0.86–1.08)
Asian, not Hispanic	−2 (−8 to 4)	1 (−5 to 7)	**0.62 (0.50–0.75)**	**0.63 (0.52–0.76)**
Indigenous, not Hispanic	1 (−7 to 9)	5 (−4 to 15)	**1.99 (1.44–2.74)**	**1.52 (1.11–2.08)**
Multiracial or other, not Hispanic	4 (−3 to 11)	6 (−2 to 14)	0.82 (0.53–1.28)	0.87 (0.56–1.36)
Cisgender women				
White, not Hispanic	**−7 (−10 to −3)**	−2 (−6 to 2)	1 (ref.)	1 (ref.)
Black, not Hispanic	**−5 (−7 to −3)**	−2 (−4 to 0)	1.13 (0.94–1.35)	1.14 (0.96–1.35)
Hispanic, any race	**−5 (−8 to −1)**	−2 (−6 to 2)	1.10 (0.88–1.38)	1.08 (0.87–1.35)
Asian, not Hispanic[f]			0.68 (0.43–1.08)	0.74 (0.48–1.14)
Indigenous, not Hispanic[f]			**2.55 (1.68–3.89)**	**1.82 (1.27–2.59)**
Multiracial or other, not Hispanic[f]			0.70 (0.35–1.39)	0.80 (0.41–1.57)

Bolded estimates are statistically significant. CI, confidence interval; IDU, injection drug use; NA-ACCORD, North American AIDS Cohort Collaboration on Research and Design; ref., referent.
[a]Transgender patients were identified from locally collected data or as individuals with reported female gender and being MSM.
[b]Estimates and 95% confidence intervals from separate Poisson regression models with generalized estimating equations with an independent correlation matrix to account for patients contributing to more than one hospitalization to the analysis. Models are adjusted for NA-ACCORD cohort only.
[c]Estimates and 95% confidence intervals from separate Poisson regression models with generalized estimating equations with an independent correlation matrix, adjusted for NA-ACCORD cohort, calendar year, IDU risk factor, and annually updated age, $CD4^+$ cell count, and HIV viral load.
[d]Estimates and 95% confidence intervals from two Poisson regression models with generalized estimating equations with an independent correlation matrix, stratified by gender, adjusted for NA-ACCORD cohort only.
[e]Estimates and 95% confidence intervals from two Poisson regression models with generalized estimating equations, stratified by gender, adjusted for NA-ACCORD cohort, calendar year, IDU risk factor, and annually updated age, $CD4^+$ cell count, and HIV viral load.
[f]Trends were not estimated because of small group sizes.

Discussion

Among United States and Canadian PWH in care 2005–2015, unadjusted all-cause hospitalization rates decreased for most racial, ethnic, and gender groups and were highest among Black cisgender women. After adjusting for $CD4^+$, viral load, and age, we did not detect a significant change in rates for any group. In adjusted analyses, Black and Indigenous cisgender men were approximately 1.5 times likelier to be hospitalized than White cisgender men, and transgender patients 1.4 times likelier than cisgender men. Indigenous cisgender women had 1.8 times the adjusted rate of White cisgender women. Adjusted rates were lower for Asian than White cisgender men. In cause-specific analyses, unadjusted hospitalization rates for ADI were higher for Black, Hispanic, and Indigenous versus White cisgender men, and for transgender patients versus cisgender men. Black cisgender men and women also experienced higher adjusted rates than White counterparts for cardiovascular and renal/genitourinary conditions.

Our findings extend studies from the mid-2000s showing higher hospitalization rates among Black PWH and women for all-cause admissions, non-AIDS-defining infections, cardiovascular conditions, and renal/genitourinary conditions [3,5,6]. Recent studies in Illinois, North Carolina, and New York City also reported higher hospitalization rates for women compared with men and Black compared with White PWH [18–20]. A previous NA-ACCORD analysis found a small decrease in adjusted rates over time overall [27]. In this study, there was no change in adjusted rates stratified by race, ethnicity, and gender. This could indicate that improvements in $CD4^+$ cell count and viral suppression were the major drivers of unadjusted rate decreases in all groups. We might also have had insufficient power in demographic subgroups to detect small rate changes.

The disparities observed in our findings also parallel reports in the general population. Studies have found higher all-cause hospitalization rates for women compared with men in the United States, and for Black compared with White Medicare beneficiaries [28,29]. Additionally, hospitalization rates for stroke and heart failure are higher among Black compared with White people with diabetes [30].

Differences in HIV treatment outcomes likely contributed to the hospitalization disparities we observed. Prior studies have shown that women and transgender patients versus men, and Black and Indigenous versus White PWH, are likelier to experience unsuppressed viral loads or viral rebound [8,12,31]. HIV care interruptions occur more frequently among Black and Indigenous than White PWH [13,14]. Although earlier ART initiation can

Table 3. Unadjusted incidence rate ratios with 95% confidence intervals for cause-specific hospitalizations.

Diagnostic category[b]	Cisgender men (compared with non-Hispanic White cisgender men)[a]					Cisgender women (compared with non-Hispanic White cisgender women)[a]	
	Black, not Hispanic	Hispanic, any race	Asian, not Hispanic	Indigenous, not Hispanic	Multiracial/other, not Hispanic	Black, not Hispanic	Hispanic, any race
Non-AIDS-defining infection	**1.35 (1.19–1.54)**	1.01 (0.86–1.19)	**0.69 (0.52,0.93)**	**3.03 (2.02–4.56)**	0.90 (0.55–1.49)	1.04 (0.81–1.35)	0.99 (0.72–1.37)
Cardiovascular	**1.58 (1.23–2.01)**	0.88 (0.67–1.15)	**0.43 (0.26–0.71)**	1.25 (0.47–3.35)	1.04 (0.36–3.00)	**1.84 (1.10–3.08)**	1.45 (0.89–2.37)
Liver/gastrointestinal	1.15 (0.92–1.45)	1.20 (0.95–1.52)	**0.44 (0.26–0.74)**	**2.17 (1.16–4.08)**	1.13 (0.61–2.09)	1.15 (0.76–1.72)	**1.60 (1.01–2.53)**
Psychiatric	1.24 (0.92–1.67)	0.82 (0.58–1.14)	0.83 (0.48–1.43)	1.16 (0.52–2.59)	0.89 (0.40–1.99)	**0.52 (0.34–0.78)**	0.69 (0.26–1.82)
AIDS-defining illness	**1.90 (1.43–2.51)**	**1.77 (1.33–2.35)**	1.17 (0.50–2.76)	**2.79 (1.50–5.22)**	1.00 (0.39–2.55)	0.89 (0.57–1.37)	0.93 (0.54–1.61)
Neoplasms excluding AIDS-defining cancer	0.98 (0.75–1.28)	0.92 (0.66–1.27)	**0.43 (0.20–0.95)**	1.51 (0.46–4.99)	0.12 (0.03–0.47)	**1.80 (1.13–2.87)**	**2.09 (1.14–3.84)**
Injury/poisoning/complications of therapy	1.21 (0.98–1.49)	**0.75 (0.59–0.97)**	**0.56 (0.34–0.92)**	1.49 (0.84–2.62)	0.65 (0.31–1.36)	0.70 (0.47–1.05)	0.64 (0.38–1.09)
Renal/genitourinary	**3.35 (2.66–4.21)**	**1.65 (1.17–2.32)**	0.68 (0.31–1.49)	1.73 (0.59–5.09)	0.58 (0.22–1.55)	**1.97 (1.28–3.04)**	0.96 (0.52–1.75)
Endocrine/metabolic[c]	**2.02 (1.51–2.70)**	1.11 (0.79–1.56)	0.52 (0.26–1.03)	0.30 (0.04–2.10)	0.54 (0.22–1.33)	1.15 (0.71–1.87)	0.68 (0.36–1.29)
Pulmonary	**1.75 (1.22–2.49)**	0.85 (0.55–1.31)	0.28 (0.12–0.70)	1.60 (0.74–3.48)	0.67 (0.26–1.72)	**1.84 (1.03–3.29)**	**1.93 (1.02–3.66)**

IRR were not estimated for Asian, Indigenous, or multiracial/other cisgender women because of small group sizes. Bolded estimates are statistically significant. *ICD-9-CM*, *International Classification of Diseases, Ninth Revision, Clinical Modification*; IDU, injection drug use; NA-ACCORD, North American AIDS Cohort Collaboration on Research and Design.
[a]Transgender patients were identified from locally collected data or as individuals with reported female gender and being MSM. Estimates and 95% confidence intervals from separate Poisson regression models, stratified by gender, with generalized estimating equations to account for patients contributing more than one hospitalization to the analysis. Models are adjusted for NA-ACCORD cohort only.
[b]Shown are the 10 most frequent diagnostic categories, ordered by frequency. We used modified Clinical Classifications Software to categorize *ICD-9-CM* codes for primary discharge diagnoses. Discharge diagnosis was missing for 204 hospitalizations.
[c]Includes diabetes-related hospitalizations.

Table 4. Adjusted incidence rate ratios with 95% confidence intervals for cause-specific hospitalizations.

Diagnostic category[b]	Cisgender Men (compared to non-Hispanic White cisgender men)[a]					Cisgender women (compared to non-Hispanic White cisgender women)[a]	
	Black, not Hispanic	Hispanic, any race	Asian, not Hispanic	Indigenous, not Hispanic	Multiracial/other, not Hispanic	Black, not Hispanic	Hispanic, any race
Non-AIDS-defining infection	1.10 (0.96–1.25)	0.91 (0.78–1.07)	**0.66 (0.50–0.87)**	**1.97 (1.36–2.87)**	0.90 (0.55–1.48)	1.05 (0.82–1.35)	0.99 (0.71–1.36)
Cardiovascular	**1.59 (1.22–2.08)**	1.05 (0.80–1.38)	**0.57 (0.35–0.92)**	1.40 (0.49–4.03)	1.39 (0.49–3.96)	**1.90 (1.12–3.20)**	1.49 (0.91–2.45)
Liver/gastrointestinal	1.02 (0.79–1.31)	1.18 (0.93–1.49)	**0.46 (0.27–0.77)**	**1.90 (1.00–3.59)**	1.24 (0.67–2.30)	1.07 (0.72–1.59)	1.50 (0.94–2.39)
Psychiatric	1.14 (0.84–1.55)	0.74 (0.53–1.04)	0.74 (0.43–1.28)	0.88 (0.38–2.03)	0.82 (0.37–1.84)	0.63 (0.42–0.94)	0.84 (0.31–2.33)
AIDS-defining illness	1.12 (0.83–1.52)	1.27 (0.96–1.67)	1.00 (0.42–2.39)	1.21 (0.68–2.16)	0.88 (0.35–2.19)	0.81 (0.54–1.20)	0.82 (0.48–1.40)
Neoplasms excluding AIDS-defining cancer	0.83 (0.61–1.11)	0.92 (0.65–1.29)	0.47 (0.22–1.03)	1.44 (0.44–4.70)	**0.14 (0.03–0.56)**	1.78 (1.11–2.86)	**2.01 (1.09–3.72)**
Injury/poisoning/complications of therapy	1.20 (0.96–1.50)	0.80 (0.62–1.04)	0.63 (0.38–1.04)	1.48 (0.84–2.61)	0.76 (0.37–1.58)	0.73 (0.48–1.10)	0.64 (0.37–1.10)
Renal/genitourinary	**2.81 (2.18–3.63)**	**1.64 (1.16–2.32)**	0.73 (0.33–1.61)	1.47 (0.49–4.40)	0.66 (0.25–1.77)	**2.01 (1.29–3.14)**	0.99 (0.54–1.84)
Endocrine/Metabolic[c]	**1.73 (1.28–2.34)**	1.06 (0.75–1.52)	0.54 (0.28–1.07)	0.27 (0.04–1.89)	0.59 (0.24–1.45)	1.06 (0.64–1.75)	0.61 (0.31–1.18)
Pulmonary	**1.59 (1.06–2.39)**	0.88 (0.56–1.39)	**0.32 (0.13–0.79)**	1.26 (0.56–2.82)	0.82 (0.32–2.08)	**1.87 (1.06–3.31)**	1.78 (0.94–3.37)

IRR were not estimated for Asian, Indigenous, or multiracial/other cisgender women because of small group sizes. *ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification*; IDU, injection drug use; NA-ACCORD, North American AIDS Cohort Collaboration on Research and Design.
[a]Transgender patients were identified from locally collected data or as individuals with reported female gender and being MSM. Estimates and 95% confidence intervals from separate Poisson regression models, stratified by gender, with generalized estimating equations to account for patients contributing more than one hospitalization to the analysis. Models are adjusted for NA-ACCORD cohort, calendar year, IDU risk factor, and annually updated age, $CD4^+$ cell count, and HIV viral load.
[b]Shown are the 10 most frequent diagnostic categories, ordered by frequency. We used modified Clinical Classifications Software to categorize *ICD-9-CM* codes for primary discharge diagnoses. Discharge diagnosis was missing for 204 hospitalizations.
[c]Includes diabetes-related hospitalizations.

prevent AIDS and non-AIDS morbidity, Black, Hispanic, and Indigenous PWH continue to experience delayed HIV diagnosis or care compared with White PWH, with low $CD4^+$ cell counts or an ADI diagnosis [7,9–11,32]. Ongoing viral replication and severe immunodeficiency also contribute to end-organ damage, immune dysregulation, and inflammation, which can lead to further non-AIDS morbidity, including myocardial infarction and HIV-associated nephropathy [33,34]. In our study, hospitalization rate disparities were attenuated in fully adjusted models, while models adjusting only for NA-ACCORD cohort, calendar year, and age led to estimates similar to unadjusted analyses, suggesting $CD4^+$ cell count, viral load, and IDU risk factor might have been important contributors. In addition, while median $CD4^+$ cell counts and viral suppression rates increased for all patients, they were lowest for Black and Hispanic cisgender women. These clinical differences can, therefore, partly explain the higher hospitalization rates experienced by some racial, ethnic, and gender groups, not only for all-cause but also ADI and other hospitalization causes.

Adjusting for $CD4^+$ cell count and viral load, some hospitalization differences by racial, ethnic, and gender groups persisted. One potential explanation is the differences in chronic conditions and risk factors for morbidity between these groups in this region. Rates of type 2 diabetes and chronic kidney disease are higher among women than men, and Black than White PWH [15,16]. Hypertension rates are higher among Black than White PWH [15,16]. Hispanic PWH are also likelier than non-Hispanic White PWH to have cardiovascular conditions, hypertension, and diabetes [35]. These comorbidities put patients at risk of developing cardiovascular, renal, and endocrine/metabolic complications and might have contributed to higher hospitalization rates in these categories and overall. In addition, PWH with IDU as HIV risk factor versus sexual transmission are likelier to develop end-stage renal and liver diseases, partly because of hepatitis C virus co-infection [15,17]. Ongoing IDU can also cause non-AIDS-defining infections, including sepsis/bacteremia and cellulitis/cutaneous abscesses. Over 30% of Indigenous patients in our study had IDU history and potentially ongoing use, which might explain higher rates for hospitalizations for liver/gastrointestinal conditions and non-AIDS-defining infections. Obesity might also have contributed to hospitalization differences. Obesity is more common among women, Black, and Hispanic PWH and is a risk factor for cellulitis/cutaneous abscesses and progression of infections to sepsis [35,36].

In addition to differences in HIV care outcomes and chronic conditions, unmet social needs might contribute to hospitalization disparities. Out-of-pocket health expenses, difficulty finding transportation to clinic, and insurance coverage gaps can prevent PWH from accessing HIV and non-HIV care [37,38]. Caregivers, frequently women, might be unable to seek outpatient care for themselves because of their responsibilities [39]. Vulnerable populations, including people who use drugs and Indigenous, transgender, and immigrant PWH, might delay accessing care because of discrimination or stigma [40–44]. Other barriers, including mental illness, homelessness, and food insecurity, have been associated with poorer health outcomes among PWH and could lead to more frequent hospitalizations [45,46]. Some PWH might also lack a support network to assist with outpatient illness management, requiring inpatient admission. Efforts should continue to be made to provide safe environments and culturally competent care, and resources to mitigate structural factors leading to poorer health outcomes. For example, interventions providing medication-assisted treatment for opioid use disorder in HIV clinics and culturally competent care to Hispanic PWH can improve visit attendance [47,48].

This study's strengths include 11 years of data on HIV care and hospitalizations from six cohorts across the United States and Canada. The study period includes important changes in HIV care, such as ART expansion to all PWH and the introduction of integrase inhibitors, and provides the most recent evidence on racial, ethnic, and gender hospitalization disparities among PWH in this region. It is possible that hospitalization rates were underestimated if patients were hospitalized outside of the cohort's medical system. However, prior analyses in a single cohort showed that this underestimation is unlikely to affect calendar time trend estimates or vary by demographic characteristics [49]. We did not treat death as a competing risk in these analyses but mortality rates were low overall and in all demographic subgroups, suggesting any potential impact on the results would be small. Additionally, higher mortality rates were observed for Black versus other cisgender men and for Indigenous versus other cisgender women, meaning competing death risk would most likely lead to underestimated hospitalization rate disparities.

Patients in this study were engaged in HIV care, therefore, our findings may not be generalizable to all PWH including those who have not been diagnosed with HIV or linked to care. Nonetheless, our study sample included a racially diverse population, in different geographic areas, receiving care coverage through integrated health systems, private insurers, United States Medicaid and Medicare, and Canadian provincial health systems.

To our knowledge, this is the first large study to report that Indigenous and transgender PWH bear a particularly high burden of hospitalizations. However, it is likely that not all transgender patients in our sample were identified, and we were not able to examine transgender men, transgender women, and nonbinary individuals separately. In addition, race and ethnicity do not fully capture the lived experiences of PWH, especially across different

parts of the United States and Canada. We did not capture data on immigration status, which could lead to heterogeneity in health outcomes within a racial or ethnic group. Data on important barriers to care and hospitalization risk factors, such as socioeconomic status, time since HIV diagnosis, and mental health disorders were not available in this study. Future studies should further examine drivers of racial, ethnic, and gender disparities in hospitalizations among PWH and evaluate interventions addressing them.

In conclusion, hospitalization rates decreased among PWH between 2005 and 2015, but several groups remain at higher risk of hospitalization, including cisgender women, Black, Hispanic, and Indigenous patients. Disparities were observed for all-cause hospitalizations and for several causes including ADI, non-AIDS-defining infections, cardiovascular, and renal/genitourinary conditions. In adjusted analyses, hospitalization rates were stable over time in all groups, and several disparities between groups persisted. Efforts to reduce hospitalization rates and disparities among PWH should focus on identifying and addressing medical and socioeconomic conditions that drive disparately high rates.

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Conflicts of interest

K.N.A. serves as a consultant to the All of Us study (NIH) and on the scientific advisory board for TrioHealth, outside the scope of this work. J.J.E. has received grants and personal fees from ViiV, Janssen, and Gilead, and personal fees from Merck. M.J.G. has received honoraria for membership in ad hoc national HIV advisory committee meetings for Merck, Gilead, and ViiV. M.J.S. has received grants from Gilead. J.E.T. has received grants from Allergan, Santen, NightstaRx and consultant fees from Gilead and AbbVie. D.v.D. has served on the advisory boards of Allergan, Achaogen, Qpex, Shionogi, Sanofi-Pasteur, Tetraphase, T2 Biosystems, NeuMedicine, Roche, MedImmune, Astellas, and Merck. D.A.W. has served on the advisory boards of Gilead, Merck, ViiV, and Janssen, and has received grants from Gilead, ViiV, and Merck. All other authors report no potential conflicts of interest.

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