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Hospital characteristics, inpatient processes of care, and readmissions among older adults with hip fractures

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Abstract

OBJECTIVES—Readmissions are common after hospitalization for hip fracture among older adults. Little is known regarding hospital-level predictors of readmission after hip fracture or potentially related inpatient care processes.

DESIGN, SETTING, AND PARTICIPANTS—We used claims data to carry out a retrospective cohort study of fee-for-service Medicare beneficiaries who underwent hip fracture surgery between 2007 and 2009.

MEASUREMENTS—We obtained information on hospital case volumes, teaching status, bed count, nurse staffing, and technological capabilities from Medicare files, and used multivariable logistic regression to measure the association of these factors with an endpoint of readmission or death at 30 days, and with the timing of surgery.

RESULTS—Among 458,526 patients in our sample, those treated in the highest-volume hospitals (over 175 cases for the study period) had a lower odds of readmission or death at 30 days than patients treated in low-volume hospitals (12 cases or fewer; adjusted odds ratio (OR) 0.87, 95% confidence interval (CI): 0.83, 0.92, p<0.001). Higher nurse skill mix (adjusted OR: 0.88; 95% CI: 0.8, 0.96; p=0.007) and higher nurse-bed ratio (adjusted OR: 0.98; 95% CI: 0.97, 0.99; p<0.001) were also associated with improved 30-day outcomes. Increasing hospital case volume was associated with a lower odds of surgical delay beyond 48 hours.

CONCLUSION—Better nurse staffing and higher case volumes are associated with lower rates of readmission and mortality after hip fracture surgery; patients treated at high-volume centers experienced fewer delays in treatment, potentially indicating better inpatient care processes.

Keywords

Hip fracture; readmission; volume-outcome relationships

INTRODUCTION

Hip fracture is a worldwide public health problem with significant negative consequences for health, survival, and function.[1] Hip fractures occur at a rate of 414 and 957 per 100 000 among men and women in the US,[2] at an estimated annual cost of over $5.4 billion.[3]

Reducing hospital readmissions has emerged as a major priority for health care policy.[4] Approximately 20% of Medicare beneficiaries are readmitted within 30 days of hospital discharge, and Medicare's Hospital Readmissions Reductions Program includes financial penalties for hospitals with excessive readmission rates.[5]

Hospital readmissions occur in 14-19% of patients after hip fracture.[6, 7] While past studies have defined patient-level determinants of readmission after hip fracture,[8] little is known regarding the association of hospital facility characteristics, such as teaching status and nurse staffing, and case volumes with readmissions in this group., Identifying potentially modifiable hospital characteristics that are associated with readmissions after hip fracture may provide a basis for systems-level efforts to reduce readmissions after hip fracture.[9]

Using data on fee-for-service Medicare beneficiaries with hip fractures, we conducted a retrospective cohort study to examine the association of hospital case volumes and selected hospital characteristics with mortality and hospital readmission within 30 days of discharge. We also explored the association of these factors with delays in surgery beyond 48 hours after admission, a recommended practice for hip fracture care[10] that may be associated with adverse postoperative outcomes.[11] We hypothesized that greater surgical volume and hospital teaching status, nurse staffing, and bed size would be associated with fewer delays in care and lower rates of readmission or death after hip fracture surgery.

METHODS

Data source/patient population

This analysis was approved by the University of Pennsylvania Institutional Review Board, which waived the requirement for informed consent.

We merged patient-level data from (1) 100% Medicare Provider Analysis and Review (MedPAR) files, which include hospital discharge data; (2) the Medicare Beneficiary Denominator File, which includes data on HMO enrollment and vital status; and (3) the Medicare Nursing Home Minimum Data Set, which includes information on long- and short-stay residents in Medicare and Medicaid-certified nursing homes. Patient, information was linked across datasets using unique encrypted patient identifiers. Hospital characteristics data came from the Medicare Provider of Services file, which was linked to MedPAR files using unique facility identifiers.

Our sample included fee-for service Medicare beneficiaries discharged with an International Classification of Diseases, 9th edition, Clinical Modification (ICD-9-CM) diagnosis code for a femoral neck, intertrochanteric, or subtrochanteric fracture (ICD-9-CM diagnosis codes 820.00-09; 820.10-19; 820.21-2; 820.31-2; 820.8-9) and an ICD-9-CM procedure code for hemiarthroplasty, total hip arthroplasty, or an appropriate fixation procedure (ICD-9-CM procedure codes 00.70-7; 00.85-7; 81.5-3; 81.40; 78.55; 79.15; 79.25; 79.35; 79.55; 79.65; 79.85; 79.95) between June 30, 2007 and July 1, 2009. We excluded patients whose discharge was to another acute care hospital and for whom data on facility characteristics was not available; to ensure that each patient had at least 6 months of available claims prior to the date of fracture to allow for assessment of baseline comorbidities, we excluded patients who were younger than 65.5 years old at admission. For patients with multiple hospitalizations for hip fracture, the first admission was the index.

Outcome variables

Our principal outcome variable was a composite of readmission to an acute care hospital for any cause within 30 days of the index discharge as identified in MedPAR files or death from any cause within 30 days of discharge as identified in the Denominator file. We opted to include death in our primary endpoint, since failing to account for death in this context could lead to spurious findings due to survivor bias. Additional analyses examined death at 30 days and readmission at 30 days as separate endpoints, as well as a binary endpoint indicating a delay in the receipt of surgery of at least 48 hours, based on a difference of 2 days or more between the date of admission and the date of hip fracture surgery listed in MedPAR files.

Main exposure variables

We obtained data from Medicare POS files on hospital teaching status, bed count, technological capacity, nurse-to-bed ratio, and nurse skill mix. Teaching versus non-teaching status was determined based on the presence of a residency program at that hospital. The ratio of residents to total beds was used to characterize teaching facilities as “minor,” “major,” and “very major” using previously defined cutoffs based on resident-to-bed ratios.[12]

Hospitals with the capacity for open heart surgery, organ transplant, or availability of a burn unit were defined as “high-technology” facilities.[13] Nurse-to-bed ratio was defined as the ratio of full-time employee registered nurses and licensed practical nurses to hospital beds. Nurse skill mix was defined as the ratio of full-time registered nurses and licensed practical nurses to all full time employee nurses.

We calculated the hip fracture volume for each hospital in our study cohort across the full period observed in the sample and divided hospital hip fracture volume into quartiles based on the distribution of case volumes across all hospitals. Hospitals in the lowest (first) quartile performed 12 or fewer cases over the study period; hospitals in the second quartile performed between 13 and 72 cases; hospitals in the third quartile performed between 73 and 175 cases; and hospitals in the fourth (highest) quartile performed more than 175 cases.

Additional independent variables

We obtained data on patient age, sex, and race from MedPAR files; fracture types were classified as femoral neck fracture, intertrochanteric fracture, and subtrochanteric fracture using ICD-9-CM codes[14]; additional information was obtained from ICD-9-CM codes regarding the presence or absence of pathological fracture. Procedure types were classified as hemiarthroplasty, total hip arthroplasty, and internal fixation based on ICD-9-CM codes.[14]

Data on 17 comorbidities were obtained based on principal and secondary diagnosis codes from the index admission and all hospitalizations for the preceding 6 months using established algorithms.[15, 16] We identified patients treated in a nursing facility for either long-term care or post-acute care during the 6 months prior to fracture based on the presence of 1 or more relevant MDS assessments during this period.[14]

Statistical Analyses

We used descriptive statistics to characterize the distributions of all patient- and facility-level variables; we used chi-squared tests and the Wilcoxon rank-sum test to compare the distributions of specific hospital- and patient-level factors among patients who did and did not meet our primary and secondary endpoints.

We used multivariate logistic regression to estimate the association of hospital characteristics and hospital hip fracture volumes with each of the study outcomes while holding baseline patient characteristics constant. All models used robust standard errors that adjusted for clustering at the level of the hospital facility.[17] Analyses used SAS 9.3 (SAS Institute, Cary, NC).

RESULTS

Over the study period, we observed 496,958 first-time admissions for hip fractures among feefor service Medicare beneficiaries aged 65.5 years and older. We excluded 9,351 (1.9%) whose were transferred to another hospital, 2,786 patients (0.6%) with incomplete hospital data, and 2,9081 (6%) patients who had no listed surgical procedure. After exclusions, our sample included 458,526 patients treated across 3,485 hospitals.

Characteristics of our sample appear in Table 1. 73% were women, 94% were white, and 7% of patients were residents in a nursing home before admission. 49% presented with femoral neck fracture, while 42% presented with intertrochanteric fractures. Within 30 days after hospital discharge, 8% died, 16% were readmitted, and 22% met the combined outcome of readmission or death. During hospitalization, 29.6% of patients experienced a delay of 48 hours or more between admission and surgery. Of the hospitals in our study sample, (Table 2) 81% were non-teaching facilities, while 5% were major teaching hospitals. 57% of hospitals had 200 beds or less, while 17% had 400 beds or more.

After adjustment for patient factors, the odds of death or readmission at 30 days was lower among patients admitted to hospitals with higher nurse to bed ratios (Table 3; adjusted OR: 0.98, 95% CI: 0.97, 0.99, p=0.001) and higher levels of nurse skill mix (adjusted OR: 0.88, 95% CI 0.8, 0.96, p=0.007). Patients treated in major teaching hospitals experienced a 15% greater adjusted odds of readmission or death at 30 days (adjusted OR 1.15, 95% CI 1.1, 1.2, p<0.001); small but statistically significant increases in the adjusted odds of readmission or death were observed among patients treated in hospitals with more than 200 beds versus patients treated in smaller facilities.

Patients admitted to hospitals with lower volumes of hip fracture patients experienced statistically significant increases in the risk of readmission or death within 30 days after discharge after adjustment for other variables, with the risk of this adverse endpoint increasing progressively across volume categories. Compared to patients admitted to facilities in the lowest quartile of hip fracture volume (12 cases or fewer over the study period), those admitted to facilities in the highest quartile (over 175 cases) had lower odds of readmission or death (OR 0.87, 95% CI 0.83, 0.92, p <0.001).

Findings were qualitatively similar in supplementary analyses that examined hospital readmission as a discrete outcome; the adjusted odds of 30-day mortality was lower among patients treated among the highest-volume versus the lowest volume facilities, (adjusted OR 0.83, 95% CI 0.77, 0.9, p<0.001) but did not vary according to other hospital characteristics. The odds of surgical delay greater than 48 hours were increased for patients treated in teaching versus non-teaching facilities and in larger versus smaller hospitals and at low- versus high-technology hospitals; the odds of surgical delay decreased progressively with increasing case volumes (adjusted OR, highest versus lowest quartile 0.61, 95% CI 0.55, 0.68, P<0.001).

DISCUSSION

In this analysis of 458,526 Medicare beneficiaries hospitalized with hip fractures, we observed higher nurse/bed ratio, better nursing skill mix, and higher volumes of hip fracture cases to be associated with lower odds of readmission or mortality at 30 days. Additionally, patients treated at high-volume centers experienced fewer delays in treatment, potentially indicating better inpatient care processes within these facilities. Paradoxically, patients admitted to teaching hospitals and to larger hospitals (200 beds or more) experienced a greater odds of readmission or mortality and of experiencing delays in care when compared to patients who were admitted to non-teaching hospitals and facilities with fewer than 200 beds.

Approximately 16% of patients within our sample were readmitted within 30 days after hospital discharge; while this figure is consistent with prior cohort studies of hip fracture patients,[18] it is slightly lower than reported rates of readmission for Medicare patients in general,[5] and skilled nursing facility patients specifically.[19] Readmission after hip fracture is largely caused by nonsurgical problems, including postoperative medical events,[8, 18] and a substantial fraction of readmissions may be due to preventable causes.[20]

The strengths of this study are its large patient population, and our adjustment for a range of patient comorbidities in models used to test our hypotheses regarding the association of specific hospital-level factors with 30-day outcomes. Most importantly, our finding of hospital-level differences in nurse staffing, nurse skill mix, and hip fracture case volumes as potential predictors of readmission or mortality after hip fracture highlight potentially modifiable hospital-level factors that may influence outcomes for hip fracture patients.

Our observations regarding the association between nurse staffing and outcomes are consistent with prior work in general medical and surgical populations. Nurse to bed ratio has previously been found to be associated with decreased in-hospital mortality[21] and 30-day readmission rate[22] among general medical and surgical cohorts. Needleman et al concluded that higher staffing level by registered nurses was associated with greater differences in outcomes for medical versus surgical inpatients, potentially due to differences in baseline health;[23] our findings argue that nurse staffing may play an important role in determining outcomes for hip fracture patients, potentially by facilitating more effective transitions of care within a frail elderly population.

A major finding of our work is the observation that patients admitted to hospitals treating higher volumes of hip fracture patients have lower odds of mortality and readmission than do patients admitted to lower-volume facilities. Although past research has produced conflicting findings on the association between hip fracture case volume and outcomes,[24-26] past volume-outcome studies in the context of hip fracture have not focused on hospital readmission. Notably, Horwitz et al[27] and Tsai et al[28] recently found readmission rates to be lower among surgical patients treated in high-volume hospitals after adjusting for hospital and patient characteristics. Our work suggests that differences in care practices at high- versus low-volume institutions, potentially including but not limited to differences in surgical timing, may hold particular importance in determining readmission outcomes for hip fracture patients.

We observed worsened readmission outcomes and more frequent delays in surgical treatment among hip fracture patients treated at larger facilities and at teaching hospitals; these observations contrast with past work suggesting improved survival at teaching facilities for general medical and surgical cohorts[29] and for hip fracture patients in particular,[30] although more recent work has not observed marked differences in outcomes for patients treated at teaching versus non-teaching hospitals.[25] Potential explanations for our findings could relate to differences in transitional care processes at smaller versus larger hospitals and at teaching versus non-teaching facilities, or to differences that may exist between tertiary referral centers and smaller institutions in the allocation of resources towards hip fracture patients versus patients with other conditions; as smaller hospitals and non-teaching facilities may often be focused on serving local communities rather than a larger referral area, care in these hospitals may also be more effectively integrated with local community resources.

The current study has several limitations. Our study cohort included only Medicare fee-for-service patients; thus, our results may not be generalizable to patients enrolled in other Medicare programs; similarly, since MDS assessments are not required for residents of nursing homes not certified by Medicare and Medicaid, we were unable to assess prior nursing home residence for patients treated in non-certified facilities. Although we attempted to adjust for potential confounders, our results may still be biased if sicker patients were not distributed equally among different hospitals in the study sample. As a result, our findings should not be taken to indicate causal relationships between hospital factors and different outcomes. While we examined a range of potentially important hospital characteristics, our analysis did not consider other hospital factors, such as trauma center designation, that may have affected outcomes. As our latest available data were from 2009, our findings may not be generalizable to later years. As we focused on acute care hospital characteristics, we cannot comment on the potential impact of variations in the quality of post-hospital care on readmissions.

CONCLUSION

Our results highlight nurse staffing, nurse skill mix, and hospital volume as potential predictors of readmission or death after hip fracture. Our results may inform future health policy interventions to reduce readmission after hip fracture; these may include efforts to increase the number and skill level of nursing staff at hospitals that care for hip fracture patients, selectively refer hip fracture patients to high-volume centers, and disseminate successful strategies for implementing best practices for hip fracture care from higher- to lower-performing institutions.

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Table 1

Patient characteristics and outcomes within the study cohort (N=458,526)

Variable		N (%)
Patient Characteristics		
Sex	Female	333945 (72.8%)
	Male	124581 (27.2%)
Race	White	429020 (93.6%)
	Black	16235 (3.5%)
	Other	13271 (2.9%)
Age category	≤ 75	80316 (17.5%)
	76-80	81084 (17.7%)
	81-85	117064 (25.5%)
	86-90	109265 (23.8%)
	≥91	70797 (15.4%)
Co-morbidities	Alzheimer's disease	120693 (26.3%)
	Angina	5459 (1.2%)
	Cancer	58372 (12.7%)
	Congestive heart failure	86692 (18.9%)
	Chronic lung disease	85088 (18.6%)
	Diabetes	93268 (20.3%)
	Hypertension	298394 (65.1%)
	Liver Disease	5228 (1.1%)
	Electrolyte Disturbance	109710 (23.9%)
	Paraplegia	13693 (3.0%)
	Pathological fracture	634 (0.1%)
	Arrhythmias	118255 (25.8%)
	Pulmonary fibrosis	6073 (1.3%)
	Renal failure	50430 (11.0%)
	Unstable angina	2287 (0.5%)
	Valvular abnormalities	44428 (9.7%)
	Weight loss	23895 (5.2%)
Fracture location	Femoral neck	224374 (48.9%)
	Intertrochanteric	191072 (41.7%)
	Subtrochanteric	18957 (4.1%)
	Multiple locations	24123 (5.3%)
Surgery type	Internal fixation	279230 (60.9%)
	Arthroplasty	15121 (3.3%)
	Hemiarthroplasty	164175 (35.8%)
Admitted from a nursing home		32086 (7.0%)
Outcomes		
Received surgery > 48h after admission		135,869 (29.6%)
Died within 30 days from discharge		38147 (8.3%)

Variable	N (%)
Readmitted within 30 days from discharge	70965 (15.5%)
Readmitted or died within 30 days from discharge	98878 (21.6%)

Table 2

Characteristics of hospitals included in the study sample (N=3,485)

Variable		N (%)
Teaching status[a]	Non teaching	2821 (81.0%)
	Minor teaching	489 (14.0%)
	Major teaching	175 (5.0%)
Mean nurse-to-bed ratio (SD)[b]		1.32 (1.2)
Mean nurse skill mix (SD)[c]		0.85 (0.1)
Advanced technological capabilities present[d]		1203 (34.5%)
Bed count	<200	1994 (57.2%)
	200-400	911 (26.1%)
	>400	580 (16.6%)
Mean hip fracture case volume over the study period (SD)		131.6 (128.7)
Hip fracture volume category	1st quartile (1-12 cases)	863 (24.8%)
	2nd quartile (13-72 cases)	886 (25.4%)
	3rd quartile (73-175 cases)	861 (24.7%)
	4th quartile (176 or more)	875 (25.1%)

Notes:

[a]Non-teaching: resident-to-bed ratio = 0; minor teaching: resident-to-bed ratio above 0 but below 0.25; major teaching: resident-to-bed ratio ≥ 0.25

[b]Nurse-to-bed ratio calculated as full-time employee nurses divided by total number of hospital beds

[c]Nurse skill mix calculated as total number of full-time-employee registered nurses and licensed practical nurses divided by total number of full-time employee nurses

[d]Advanced technological capabilities were present if a hospital could perform open heart surgery or organ transplantation, or had a burn unit

Table 3

Associations between hospital characteristics and study outcomes among 458,526 Medicare beneficiaries with hip fracture

	Received surgery > 48h after admission		Readmission/death at 30 days		Death at 30 days		Readmission at 30 days	
	Adjusted OR (95% CI)	P	Adjusted OR[a] (95% CI)	P	Adjusted OR[a] (95% CI)	P	Adjusted OR[a] (95% CI)	P
Teaching status[b]								
Non-teaching	Reference		Reference		Reference		Reference	
Minor teaching	1.11 (1.02,1.2)	0.012	1.02 (1,1.05)	0.074	0.97 (0.93,1.0)	0.066	1.05 (1.02,1.08)	0.003
Major teaching	1.71 (1.5, 1.96)	<0.001	1.15 (1.1,1.2)	<0.001	1 (0.94,1.07)	0.971	1.2 (1.13,1.26)	<0.001
Nurse-bed ratio[c]	0.97 (0.95,1.0)	0.058	0.98 (0.97,0.99)	<0.001	0.99 (0.98,1)	0.207	0.98 (0.96,0.99)	<0.001
Nurse skill mix[d]	0.84 (0.69,1.02)	0.085	0.88 (0.8,0.96)	0.007	0.9 (0.78,1.04)	0.153	0.88 (0.8,0.97)	0.008
Advanced technology present[e]	0.87 (0.81,0.93)	0.856	0.97 (0.95,1)	0.050	1.01 (0.97,1.04)	0.678	0.96 (0.93,0.98)	0.003
Facility size								
< 200 beds	Reference		Reference		Reference		Reference	
200-399 beds	1.33 (1.22,1.44)	<0.001	1.05 (1.02,1.08)	<0.001	0.98 (0.94,1.02)	0.309	1.08 (1.04,1.12)	<0.001
>399 beds	1.5 (1.36,1.66)	<0.001	1.05 (1.01,1.09)	0.012	0.98 (0.93,1.02)	0.301	1.08 (1.03,1.12)	0.001
Case volume								
Quartile 1 (≤12)	Reference		Reference		Reference		Reference	
Quartile 2 (13-73)	0.89 (0.81,0.97)	0.009	0.93 (0.88,0.98)	0.009	0.88 (0.82,0.95)	0.001	0.99 (0.93,1.05)	0.764
Quartile 3 (74-175)	0.77 (0.7,0.84)	<0.001	0.91 (0.86,0.96)	<0.001	0.86 (0.8,0.93)	<0.001	0.97 (0.91,1.03)	0.331
Quartile 4 (>175)	0.61 (0.55,0.68)	<0.001	0.87 (0.83,0.92)	<0.001	0.83 (0.77,0.9)	<0.001	0.94 (0.89,1)	0.070

Notes:

[a]Regression models adjusted for age; sex; race (black, white, other); fracture location (femoral neck, intertrochanteric, subtrochanteric, multiple locations); surgery type (internal fixation, hemiarthroplasty, total hip arthroplasty); nursing home residence; and 17 comorbidities (Alzheimer's disease, angina, cancer, congestive heart failure, chronic lung disease, diabetes, hypertension, liver disease, electrolyte Disturbance, paraplegia, pathological fracture, arrhythmias, pulmonary fibrosis, renal failure, unstable angina, valvular abnormalities, weight loss)

[b]Non-teaching: resident-to-bed ratio = 0; minor teaching: resident-to-bed ratio above 0 but below 0.25; major teaching: resident-to-bed ratio ≥ 0.25

[c]Nurse-to-bed ratio calculated as full-time employee nurses divided by total number of hospital beds

[d]Nurse skill mix calculated as total number of full-time-employee registered nurses and licensed practical nurses divided by total number of full-time employee nurses

[e]Advanced technological capabilities determined to be present if a hospital had capacity to perform open heart surgery or organ transplantation, or had a burn unit. OR: Odds ratio; CI: confidence interval.