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Are There Modifiable Risk Factors for Hospital Readmission After Total Hip Arthroplasty in a US Healthcare System?

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Abstract

Background Although total hip arthroplasty (THA) is a successful procedure, 4% to 11% of patients who undergo THA are readmitted to the hospital. Prior studies have reported rates and risk factors of THA readmission but have been limited to single-center samples, administrative claims data, or Medicare patients. As a result, hospital readmission risk factors for a large proportion of patients undergoing THA are not fully understood.

Questions/purposes (1) What is the incidence of hospital readmissions after primary THA and the reasons for readmission? (2) What are the risk factors for hospital readmissions in a large, integrated healthcare system using current perioperative care protocols?

Methods The Kaiser Permanente (KP) Total Joint Replacement Registry (TJRR) was used to identify all patients with primary unilateral THAs registered between January 1, 2009, and December 31, 2011. The KPTJRR's voluntary participation is 95%. A logistic regression model was used to study the relationship of risk factors (including patient, clinical, and system-related) and the likelihood of 30-day readmission. Readmissions were identified using electronic health and claims records to capture readmissions within and outside the system. Odds ratio (OR) and 95% confidence intervals (CIs) were calculated. Of the 12,030 patients undergoing primary THAs included in the study, 59% (n = 7093) were women and average patient age was 66.5 years (± 10.7).

Results There were 436 (3.6%) patients with hospital readmissions within 30 days of the index procedure. The most common reasons for readmission were infection and inflammatory reaction resulting from internal joint prosthetic (International Classification of Diseases, 9th Revision, Clinical Modification [ICD-9-CM] 996.66, 7.0%); other postoperative infection (ICD-9-CM 998:59, 5.5%); unspecified septicemia (ICD-9-CM 038.9, 4.9%); and dislocation of a prosthetic joint (ICD-9-CM 996.42, 4.7%). In adjusted models, the following factors were associated with an increased likelihood of 30-day

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that a waiver of informed consent for the study was obtained.

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readmission: medical complications (OR, 2.80; 95% CI, 1.59-4.93); discharge to facilities other than home (OR, 1.89; 95% CI, 1.39–2.58); length of stay of 5 or more days (OR, 1.80; 95% CI, 1.22–2.65) versus 3 days; morbid obesity (OR, 1.74; 95% CI, 1.25–2.43); surgeries performed by high-volume surgeons compared with medium volume (OR, 1.53; 95% CI, 1.14–2.08); procedures at lower-volume (OR, 1.41; 95% CI, 1.07–1.85) and medium-volume hospitals (OR, 1.81; 95% CI, 1.20–2.72) compared with high-volume ones; sex (men: OR, 1.51; 95% CI, 1.18–1.92); obesity (OR, 1.32; 95% CI, 1.02–1.72); race (black: OR, 1.26; 95% CI, 1.02–1.57); increasing age (OR, 1.03; 95% CI, 1.01–1.04); and certain comorbidities (pulmonary circulation disease, chronic pulmonary disease, hypothyroidism, and psychoses).

Conclusions The 30-day hospital readmission rate after primary THA was 3.6%. Modifiable factors, including obesity, comorbidities, medical complications, and system-related factors (hospital), have the potential to be addressed by improving the health of patients before this elective procedure, patient and family education and planning, and with the development of high-volume centers of excellence. Nonmodifiable factors such as age, sex, and race can be used to establish patient and family expectations regarding risk of readmission after THA. Contrary to other studies and the finding of increased hospital volume associated with lower risk of readmission, higher volume surgeons had a higher risk of patient readmission, which may be attributable to the referral patterns in our organization.

Level of Evidence Level III, therapeutic study.

Introduction

In 2013, healthcare spending within the United States reached USD 2.9 trillion and accounted for 18% of the national gross domestic product [8]. With an aging population and an estimated 30 million Americans newly insured through the Affordable Healthcare Act, increased cumulative spending is projected to reach USD 5 trillion by 2022 [8]. Medicare hospital readmissions accounted for USD 12 billion in spending and an estimated 76% of patient readmissions are potentially preventable [19, 20]. Increasingly, payers and providers are recognizing the need to prevent complications, address increasing demand, lower costs, and improve quality of care.

Within orthopaedics, the Centers for Medicare & Medicaid Services has focused on 30-day readmissions after elective total joint arthroplasty (TJA) as a quality indicator and has initiated a "no pay" policy for readmissions after these procedures [18, 29]. Although THA is an effective, high-volume procedure [11, 12, 15], 4% to 10.9% of patients are readmitted to the hospital after the procedure [5, 7, 30, 32–34]. Reported patient risk factors for readmission after THA include age, male sex, black race, weight (obese and underweight status), diabetic status, cardiac disease, patient comorbidities, general health status, longer hospital length of stay (LOS), discharge disposition, revision procedures, distance between hospital and home, and insurance coverage status [2, 5, 13, 26–28, 30, 31, 34].

Although prior studies have reported rate and risk factors of THA readmission, the findings have been limited as a result of single-center samples or reliance on administrative claims data. Single-center studies are usually undersized in samp le, lack the capability to capture readmissions outside their specific hospital system, and produce results that are not generalizable to other hospital settings. Medicare studies are also constrained because they are based on administrative claims databases with limited patient and clinical information. In addition, Medicare studies are restricted to patients aged 65 years and older. This is particularly important given that almost one-third of patients undergoing THA are younger than 65 years and constitute the fastest growing group in arthroplasty demand [16, 33]. A review of the literature on patient readmissions after THA shows that most previous US-based studies have been done at single institutions or use administrative data (Table 1). As a result, readmission risk factors for a large segment of the TJA population are not well understood.

Therefore, the purpose of our study was to examine the rate of hospital readmissions after primary THA as well as the reasons for readmission and the modifiable and nonmodifiable risk factors for hospital readmissions in a large, integrated healthcare system using current perioperative care protocols.

Materials and Methods

Kaiser Permanente's (KP) Total Joint Replacement Registry (TJRR) was used to identify the study cohort [21, 23]. Kaiser Permanente is an integrated healthcare system that serves over nine million patients in seven geographical regions throughout the United States. Three of the eight regions (northern California, southern California, and Hawaii) participating in the Registry were used in our study; the three regions included 32 KP hospitals with patients from 176 surgeons. These regions were included because they share a common inpatient and outpatient electronic health record system and the majority of cases took place at KP hospitals. Non-KP hospitals were excluded from the analysis because a different inpatient electronic health record was used at these facilities during the study period and therefore complete information necessary to conduct this study was not available from these locations.

Table 1. Review of literature: THA risk factors for readmission

Study	Sample	Readmission rate (%)*	Most common reasons for readmission	Risk factors for readmission												
				Age	Sex	BMI	Race	LOS	Comorbidities	Discharge status	Complications	Procedure type	Insurance coverage	Distance home/ hospital	Surgeon volume	Hospital volume
Current				X	X	X	X	X	X	X	X				X	X
Avram et al. (2013) [2]	1589 Single Canadian institution	2.2†	Septic complications related to joint	X												
Schaier et al. (2013) [27]	998 Single US institution	4.0†	Surgical complications medical complications					X	X			X				
Vorhies et al. (2011) [30]	1802 US Medicare patient safety monitoring system	6.8	Cardiac related					-								
Clement et al. (2013) [5]	1583 US tertiary academic hospital network	6.5	Deep infection, pain, hematoma	X		X		X								
Zhan et al. (2007) [33]	200,000 US HCUP NIS	4.9–8.9	Not reported	X					X			X	X			
Cram et al. (2011)[6]	1,453,493 US Medicare Part A beneficiaries	5.9–8.5	Not reported													
Saucedo et al. (2013)[26]	6414 (hip/knee) single US institution	3.4–7.2†	Infection, dislocation, periprosthetic fracture, wound	X		X		X	X				X			
Bozic et al. (2010)[4]	182,146 (hip/knee) perspective database with 312 US hospitals	4.0	Not reported												X	X
Lavernia et al. (2013) [17]	27,019 state of Florida (US) discharges	5.0†	Infection						X	X			X			
Pugely et al. (2013)[24]	9441 ACS NSQIP	4.2–5.2§	Not reported			X			X							
Zmistowski et al. (2013)[34]	5426 (hip/knee) single US institution	5.3†	Infection	X	X	X	X	X	X	X		X		X		

* Most proportions are for 30-day readmission, ranges are for 30 and 90 days readmissions unless otherwise specified; †unplanned readmissions only specified in manuscript; §hip and knee readmission rates combined; BMI = body mass index; LOS = length of stay; HCUP NIS = Healthcare Cost and Utilization Project–Nationwide Inpatient Sample; ACS-NSQIP = American College of Surgeons National Surgical Quality Improvement Program.

Table 2. THA study sample patient characteristics by 30-day readmission status, 2009–2011

Patient characteristic	Total sample (N = 12,030)		No readmission (N = 11,594 [96.4%])		Readmitted within 30 days (N = 436 [3.6%])		p value
	Number	Percent	Number	Percent	Number	Percent	
Age category (years)							
< 65	5190	43.1	5066	97.6	124	2.4	< 0.001
≥ 65	6840	56.9	6528	95.4	312	4.6	
Age (years), mean (SD)	66.5	10.7	66.4	10.7	70.5	10.2	< 0.001
Gender							
Female	7093	59.0	6858	96.7	235	3.3	0.029
Male	4937	41.0	4736	95.9	201	4.1	
Race							
White	9260	77.0	8921	96.3	339	3.7	0.009
Black	1056	8.8	1008	95.5	48	4.6	
Hispanic	1002	8.3	979	97.7	23	2.3	
Asian	481	4.0	466	96.9	15	3.1	
Other/multi	207	1.7	196	94.7	11	5.3	
Unknown	24	0.2	24	100.0	0	0.0	
BMI category (kg/m^2)							
< 30	7192	59.8	6963	96.8	229	3.2	0.002
30–34.9	3034	25.2	2915	96.1	119	3.9	
≥ 35	1802	15.0	1714	95.1	88	4.9	
Unknown	2	0.0	2	100.0	0	0.0	
ASA score							
1–2	7504	62.4	7297	97.2	207	2.8	< 0.001
≥ 3	4438	36.9	4209	94.8	229	5.2	
Unknown	88	0.7	88	100.0	0	0.0	
Diabetes							
No	9759	81.1	9443	96.8	316	3.2	< 0.001
Yes	2271	18.9	2151	94.7	120	5.3	
Surgical complication	580	4.8	540	93.1	40	6.9	< 0.001
Nonsurgical complication	89	0.7	70	78.7	19	21.4	< 0.001
Comorbidities							
Hypertension	7308	61.1	6996	95.7	312	4.3	< 0.001
Chronic pulmonary disease	1794	15.0	1698	94.7	96	5.4	< 0.001
Hypothyroidism	1627	13.6	1549	95.2	78	4.8	0.008
Deficiency anemia	1449	12.1	1373	94.8	76	5.2	< 0.001
Renal failure	1058	8.8	989	93.5	69	6.5	< 0.001
Psychoses	755	6.3	712	94.3	43	5.7	0.002
Fluid and electrolyte disorders	729	6.1	694	95.2	35	4.8	0.085
Depression	678	5.7	653	96.3	25	3.7	0.951
Peripheral vascular disease	579	4.8	533	92.1	46	7.9	< 0.001
Valvular disease	456	3.8	426	93.4	30	6.6	< 0.001
Rheumatoid arthritis/collagen	353	3.0	332	94.1	21	6.0	0.019
Congestive heart failure	342	2.9	315	92.1	27	7.9	< 0.001
Other neurological disorders	331	2.8	306	92.5	25	7.6	< 0.001
Chronic blood loss anemia	326	2.7	308	94.5	18	5.5	0.067
Liver disease	278	2.3	263	94.6	15	5.4	0.115
Alcohol abuse	260	2.2	248	95.4	12	4.6	0.398
Coagulopathy	243	2.0	228	93.8	15	6.2	0.034

Table 2. continued

Patient characteristic	Total sample (N = 12,030)		No readmission (N = 11,594 [96.4%])		Readmitted within 30 days (N = 436 [3.6%])		p value
	Number	Percent	Number	Percent	Number	Percent	
Solid tumor without metastasis	148	1.2	139	93.9	9	6.1	0.111
Drug abuse	135	1.1	127	94.1	8	5.9	0.155
Pulmonary circulation disease	112	0.9	99	88.4	13	11.6	< 0.001
Weight loss	97	0.8	93	95.9	4	4.1	0.8
Paralysis	68	0.6	61	89.7	7	10.3	0.003
Lymphoma	48	0.4	47	97.9	1	2.1	0.563
Metastatic cancer	31	0.3	29	93.6	2	6.5	0.404
Acquired immune deficiency syndrome	23	0.2	23	100.0	.	.	0.351
Peptic ulcer disease with bleeding	1	0.0	1	100.0	.	.	0.846

BMI = body mass index; ASA = American Society of Anesthesiologists.

Inclusion criteria included primary unilateral THA for osteoarthritis and age 18 years or older during the time period from January 1, 2009, to December 31, 2011. Patients undergoing revisions or bilateral primary THAs were not included in the study. Individuals who died or terminated membership within 30 days of the operative date without a readmission during the same timeframe were also excluded and considered lost to followup (n = 36 [0.3%]). The KPTJRR's voluntary participation is 95%. Readmissions were captured for all individuals who remain members using the comprehensive electronic health and claims records, which identify visits within and outside the KP system.

Patient, procedure, surgeon, and hospital variables were evaluated as risk factors for readmission. Patient-specific risk factors included: age (continuous); sex; race (white, black, Hispanic, Asian, other); body mass index (BMI; nonobese BMI < 30 kg/m^2; obese BMI 30–34 kg/m^2; morbidly obese BMI ≥ 35 kg/m^2); American Society of Anesthesiologists (ASA) score (< 3 versus ≥ 3) [9]; comorbidities (determined using the Elixhauser comorbidity algorithm) [10]; in-hospital medical complications (including pneumonia, acute myocardial infarction, and acute stroke); and in-hospital surgical complications (including surgery and implant-related). The Agency for Healthcare Research and Quality Inpatient Quality Indicators Technical Specifications were used to identify in-hospital complications (Appendix 1; supplemental materials are available with the online version of CORR®) [1]. Procedure variables evaluated included discharge disposition (home versus other) and LOS (categorized into ≤ 2, ≤ 3, ≤ 4, and ≥ 5 days). Surgeon-related variables included whether the surgeon had a TJA fellowship and the surgeon's average yearly volume of procedures performed (categorized as: low = < 20 cases/year, medium = 20–49 cases/year, or high = ≥ 50 cases/year). Hospital volume was also evaluated (categorized as: low = < 100 cases/year, medium = 100–199 cases/year, or high = ≥ 200 cases/year). Average surgeon and hospital yearly volumes were calculated using both primary and revision procedures (continuous) performed during the calendar year.

The endpoint of our study was any inpatient hospital readmission within 30 days of discharge after the hospital stay associated with patient index primary THA. The information was obtained from patient electronic medical records maintained by the healthcare system.

Means (SDs, frequencies, and proportions) were used to describe the study patient sample. If a different distribution was observed in readmission rates by the sample characteristics ($p < 0.20$), the risk factor was included in the final multivariate models. Collinearity was checked using tolerance values (< 0.1), outliers were reviewed, and model fit was checked using goodness-of-fit tests. A logistic regression, through a generalized linear model, was used to evaluate the relationship between 30-day readmission and the risk factors studied while accounting for the nesting of observations within the hospital variable. Crude and adjusted estimates of likelihood of readmission for each risk factor were provided. Odds ratio (OR), 95% confidence interval (CI), and p values based on a Wald test were reported. Missing data were minimal in the data set and cases with missing data (n = 215 [1.8%]) were excluded from the final model; variables with missing values are as specified in all tables. All tests were two-tailed, and $\alpha = 0.05$ was considered statistically significant. Data were analyzed using SAS (Version 9.2; SAS Institute, Cary, NC, USA).

Of the 12,030 primary THAs included in our study, 59% (n = 7093) were performed in women. The average age of all patients in the cohort was 66.5 (SD = 10.7) years.

Table 3. THA study sample procedure, surgeon, and hospital characteristics by 30-day readmission status, 2009–2011

Variables	Categories	Total sample (N = 12,030)		No readmission (n = 11,594 [96.4%])		Readmitted within 30 days (n = 436 [3.6%])		p value
		Number	Percent	Number	Percent	Number	Percent	
LOS category (days)	≤ 2	5069	42.1	4904	96.7	165	3.3	< 0.001
	3	5105	42.4	4949	96.9	156	3.1	
	4	1125	9.4	1073	95.4	52	4.6	
	≥ 5	647	5.4	584	90.3	63	9.7	
	Unknown	84	0.7	84	100.0	0	0.0	
LOS (days), mean		2.9	1.5	2.8	1.5	3.4	2.8	< 0.001
Discharge disposition	Home	9455	78.6	9200	97.3	255	2.7	< 0.001
	Other	2511	20.9	2330	92.8	181	7.2	
	Unknown	64	0.5	64	100.0	0	0.0	
Surgeon's TJA fellowship	No	5001	41.6	4806	96.1	195	3.9	0.178
	Yes	6992	58.1	6752	96.6	240	3.4	
	Unknown	37	0.3	36	97.3	1	2.7	
Surgeon volume, cases/year	< 20	1746	14.5	1676	96.0	70	4.0	0.013
	20–49	6425	53.4	6222	96.8	203	3.2	
	≥ 50	3859	32.1	3696	95.8	163	4.2	
Hospital volume, cases/year	< 100	1808	15.0	1730	95.7	78	4.3	0.051
	100–199	7854	65.3	7565	96.3	289	3.7	
	≥ 200	2368	19.7	2299	97.1	69	2.9	

LOS = length of stay; TJA = total joint arthroplasty.

Most patients had an ASA score less than or equal to 2 (n = 7507 [62%]) at the time of surgery. Prevalence of patient obesity (BMI ≥ 30 kg/m^2) was 40% (n = 4836) and of diabetes was 19% (n = 2271; Table 2). Most patients had at least one comorbidity (n = 10,052 [84%]) with the most prevalent comorbidities being hypertension (n = 7308 [61%]), chronic pulmonary disease (n = 1794 [15%]), hypothyroidism (n = 1627 [14%]), and deficiency anemia (n = 1449 [12%]). The majority of THAs were performed in medium-volume hospitals (n = 7854 [65%]) by medium-volume surgeons (n = 6425 [53%]; Table 3). Patients' average LOS was 2.9 (± 1.5) days, and 79% (n = 9455) were discharged home after their procedure. There were 580 (4.8%) surgical complications and 89 (0.7%) medical complications in our study cohort during the hospital stay associated with the index operation.

Results

Incidence of and Reasons for Hospital Readmissions After Primary THA

There were 436 (3.6%) patients with 471 total readmissions (some patients had multiple readmissions) within 30 days of the index procedure. The readmission rate in patients aged 65 and older was 4.6%. The most common reasons for readmission were infection and inflammatory reaction resulting from internal joint prosthesis (International Classification of Diseases, 9th Revision, Clinical Modifications [ICD-9-CM] 996.66; n = 33 of 471 [7.0%]), other postoperative infection (ICD-9-CM 998:59; n = 26 of 471 [5.5%]), unspecified septicemia (ICD-9-CM 038.9; n = 23 of 471 [4.9%]), dislocation of a prosthetic joint (ICD-9-CM 996.42; n = 22 of 471 [4.7%]), and a hematoma complicating the procedure (ICD-9-CM 998.12; n = 19 of 471 [4.0%]) (Appendix 2; supplemental materials are available with the online version of CORR®).

Risk Factors for Hospital Readmissions

After adjusting for all other variables, age, sex, race, BMI, surgeon volume, hospital volume, discharge disposition, medical complications, LOS at the index procedure, and comorbidities were associated with patient risk of 30-day readmission (Table 4). Specifically, for every added year in patient age, their likelihood of 30-day readmission was 3% higher (95% CI, 1–4). Men were 51% (95% CI, 18–92) more likely to be readmitted than women. Black patients had a 26% (95% CI, 2–57) higher likelihood of readmission than white patients. Obese patients had a

Table 4. Crude and adjusted* associations of patient, procedure, surgeon, and hospital risk factors with likelihood of 30-day readmission after THA

Risk factor	Crude OR (95% CI)	Adjusted OR (95% CI)*	p value
Age (per 1-year increments)	1.04 (1.03–1.05)	1.03 (1.01–1.04)	< 0.001
Men versus women	1.23 (1.00–1.51)	1.51 (1.18–1.92)	0.001
Race (reference: white)			0.007
Asian	0.77 (0.42–1.41)	0.83 (0.55–1.27)	0.398
Black	1.23 (0.99–1.52)	1.26 (1.02–1.57)	0.034
Hispanic	0.59 (0.36–0.97)	0.67 (0.41–1.10)	0.118
Other/multi	1.38 (0.80–2.37)	1.54 (0.92–2.55)	0.098
BMI category (kg/m^2; reference: < 30)			0.004
≥ 30 and < 35	1.23 (0.95–1.59)	1.32 (1.02–1.72)	0.037
≥ 35	1.55 (1.19–2.02)	1.74 (1.25–2.43)	0.001
ASA score category: ≥ 3 versus 1–2	1.98 (1.69–2.32)	1.06 (0.81–1.38)	0.685
Diabetes	1.65 (1.30–2.10)	1.14 (0.89–1.48)	0.298
Surgical complication	2.06 (1.39–3.06)	1.21 (0.81–1.80)	0.360
Medical complication	7.47 (4.24–13.15)	2.80 (1.59–4.93)	< 0.001
Congestive heart failure	2.35 (1.47–3.76)	0.87 (0.51–1.47)	0.592
Valvular disease	1.92 (1.15–3.20)	1.20 (0.70–2.08)	0.507
Pulmonary circulation disease	3.55 (2.32–5.44)	1.70 (1.08–2.70)	0.023
Perivascular disease	2.47 (1.73–3.52)	1.30 (0.88–1.92)	0.194
Paralysis	3.12 (1.60–6.11)	1.82 (0.94–3.51)	0.075
Neurologic disorders	2.25 (1.27–3.98)	1.53 (0.82–2.83)	0.180
Chronic pulmonary disease	1.63 (1.41–1.89)	1.27 (1.08–1.48)	0.003
Hypothyroidism	1.41 (1.16–1.71)	1.31 (1.06–1.63)	0.012
Renal failure	1.99 (1.49–2.67)	1.16 (0.83–1.62)	0.382
Liver disease	1.51 (0.94–2.42)	1.49 (0.87–2.55)	0.148
Solid tumor without metastasis	1.72 (0.88–3.39)	1.17 (0.57–2.37)	0.672
Rheumatoid arthritis	1.70 (1.14–2.52)	1.61 (1.09–2.37)	0.106
Coagulopathy	1.73 (1.09–2.73)	1.05 (0.63–1.74)	0.865
Fluid and electrolyte disorders	1.35 (0.97–1.90)	0.78 (0.56–1.07)	0.119
Blood loss anemia	1.47 (0.80–2.70)	1.42 (0.85–2.39)	0.185
Deficiency anemia	1.58 (1.23–2.03)	1.24 (0.96–1.61)	0.106
Drug abuse	1.63 (0.75–3.55)	1.80 (0.77–4.21)	0.176
Psychoses	1.67 (1.36–2.06)	1.32 (1.03–1.69)	0.028
Hypertension	1.62 (1.25–2.10)	1.02 (0.76–1.36)	0.897
LOS (reference, 3 days)			0.012
≤ 2 days	1.04 (0.84–1.27)	1.13 (0.92–1.39)	0.252
4 days	1.53 (1.17–2.02)	1.22 (0.93–1.60)	0.141
≥ 5 days	3.36 (2.39–4.74)	1.80 (1.22–2.65)	0.003
Discharge disposition: other versus home	2.92 (2.25–3.80)	1.89 (1.39–2.58)	< 0.001
TJA fellowship training	1.11 (0.87–1.42)	1.11 (0.87–1.43)	0.393
Surgeon volume, cases/year (reference, ≥ 50)			0.022
20–50	0.74 (0.57–0.96)	0.65 (0.48–0.88)	0.006
< 20	0.93 (0.65–1.32)	0.74 (0.48–1.14)	0.169
Hospital volume, cases/year (reference, ≥ 200)			0.012
100–199	1.27 (0.99–1.64)	1.41 (1.07–1.85)	0.016
< 100	1.49 (1.01–2.18)	1.81 (1.20–2.72)	0.004

* Adjusted for all variables listed on this table. Final model N = 11,815, n = 215 (2%) excluded as a result of missing values; OR = odds ratio; CI = confidence interval; BMI = body mass index; ASA = American Society of Anesthesiologists; LOS = length of stay; TJA = total joint arthroplasty.

32% (95% CI, 2–72) higher likelihood of readmission than nonobese patients. Morbidly obese patients had a 74% (95% CI, 25–143) higher likelihood of readmission than nonobese patients. Patients who had their surgeries performed by medium-volume surgeons had a 35% (95% CI, 12–52) lower likelihood of readmission than those operated on by high-volume surgeons; patients of low-volume compared with high-volume surgeons did not have a different risk of readmission (OR, 0.74; 95% CI, 0.48–1.14). Patients who had procedures at lower volume hospitals had a 41% (95% CI, 7–85) higher risk of readmission and those at medium-volume had a 81% (95% CI, 20–172) higher risk of readmission than those at high-volume hospitals.

Patients with medical complications during index THA had a 180% (95% CI, 59–393) higher risk of readmission and those discharged to other facilities instead of to home had a 89% (95% CI, 39–158) higher likelihood of readmission. Patients with a LOS of 5 or more days were 80% (95% CI, 22–165) more likely to be readmitted than those with a LOS of 3 days. Patients with pulmonary circulation disease (OR, 1.7; 95% CI, 1.08–2.70), chronic pulmonary disease (OR, 1.27; 95% CI, 1.08–1.48), hypothyroidism (OR, 1.31; 95% CI, 1.06–1.63), or psychoses (OR, 1.32; 95% CI, 1.03–1.69) had a higher likelihood of readmission compared with patients without these comorbidities.

Discussion

In a large cohort of patients undergoing primary THA in a US integrated healthcare system, the overall 30-day hospital readmission rate was 3.6%. Unlike prior US studies, our findings were based on prospective data collection and complete capture of hospital readmissions with a known minimal loss to followup. Our sample also included patients younger than age 65 years, who are more representative of the general US THA population. The large sample size, taken over a contemporary time period, more closely reflects current perioperative management of patients undergoing THA. Risk factors of hospital readmission included patient, surgeon, and hospital factors—specifically, age, sex (men), race (black), BMI (> 35 kg/m^2), surgeon volume (high), hospital volume (low), discharge disposition (other than home), medical complications during the index THA hospitalization, LOS of the index procedure (> 4 days), and some comorbidities that were associated with likelihood of 30-day hospital readmission. Infection was the most common reason for readmission.

The study's limitations include findings restricted to the US geographic area inclusion criterion (northern California, southern California, and Hawaii). Another limitation was the use of the ICD-9 codes to identify the reason for hospital readmissions. Keeney et al reported 79% of ICD-9 total joint arthroplasty 90-day readmission. ICD-9 diagnostic codes were in moderate concordance with diagnosis documented in the medical record [14]. Although medical diagnoses were more reliable, ICD-9 codes related to surgical site infection were the least reliable [14]. Similarly, Saucedo et al reported discordance rates of 25% for total joint arthroplasty readmission diagnoses based on ICD-9 codes versus physician reviewed diagnoses [25]. Bozic et al reported similar limitations in ICD-9 codes for revision total hip arthroplasty with good concordance for dislocation, periprosthetic joint infection, and mechanical loosening but low concordance for prosthetic implant failure/breakage and other mechanical complication [3]. Limitations of ICD-9 codes for specific diagnoses must be taken into account when interpreting findings based on administrative claims codes. The 30-day all-cause hospital readmission rates in our study were lower than those reported in other studies [5, 6, 17, 24, 30, 32, 33]. This lower rate may reflect differences in case complexity or indications for the index THA. Differences may also be related to the integrated nature of the organization's healthcare delivery model and quality improvement initiatives in arthroplasty management supported by the organization [22]. Understanding the reasons for readmissions and patients at risk for these problems is critical for reducing hospital readmissions. The most common reasons for readmission in our study were infection, hematomas, and wound complications. As a result, we developed patient risk calculators for patients and surgeons to identify individualized patient risk of infection for treatment decision-making to identify which patients are at risk for infection to improve on their medical conditions before surgery where it was possible to do so and to set patient expectations based on their own personal risk profile. In addition to personalized risk factors, patients are also managed with standardized preoperative infection control protocols to further reduce risk of infection.

In evaluating 30-day hospital readmissions, our study identified both modifiable and nonmodifiable readmission risk factors. Modifiable risk factors such as BMI can be addressed before surgery through referral to weight management programs and reduction in BMI. Patients with comorbidities such as pulmonary disease, hypothyroidism, and psychoses often can be improved on preoperatively through medical management of these conditions. Within our system, patients' laboratory results, comorbidities, and other risk factors for poor outcomes are identified preoperatively and managed by care managers to reduce patient risk. For patients with medical complications during the surgery or index hospital stay, LOS and followup must be closely monitored to reduce the risk of readmission. Hospital and surgeon system factors are also critical and

modifiable. Our study found higher hospital volume was associated with lower readmission rates. This suggests high-volume centers such as centers of excellence, which are currently in development in one of our regions, is a potential way to reduce these events from occurring. Contrary to other studies and somewhat counterintuitive given our findings of increased hospital volume associated with lower risk of readmission, we also found that higher volume surgeons had a higher risk of patient readmission [4]. This may be partly attributable to the referral patterns in our organization. In a group medical practice environment, it is possible that complex cases are channeled to high-volume hip specialists, resulting in the observed finding. Differences in volume and readmission findings may result from definitions and/or cutoff points in high- and low-volume surgery, variation in hospital settings, differences in study samples, or other factors. Identification of nonmodifiable risk factors in this study such as age, race, and gender are also important in providing information to patients and surgeons that may determine LOS, set patient expectations, and improve followup care.

The strengths of this study included the assessment of a cohort whose demographic composition was representative of the larger US THA population [22] and the complete capture of rehospitalization data, which has high validity as a result of the prospective nature of the data collection process and the registry's surveillance of cohort attrition. Furthermore, our study sample was large and had power to investigate clinically meaningful relationships, including those with small effect sizes. The choice of the recent time period, January 1, 2009, to December 31, 2011, implies that the study results reflect current clinical practice and can be relied on for making changes in clinical pathways and/or policy decisions. In conclusion, the 30-day hospital readmission rate after primary THA was 3.6%. Modifiable factors, including obesity, comorbidities, medical complications, and system-related factors (hospital and surgeon volume), have the potential to be addressed by identifying patient-personalized risk of specific adverse events before surgery, improving the health of patients before this elective procedure, enhancing patient and family education and planning based on personalized risk, and developing high-volume centers of excellence. Nonmodifiable factors such as age, sex, and race can be used to help set patient and family expectations before surgery regarding risk of readmission after THA. Future studies are needed to evaluate the success of patient optimization and other interventions to reduce hospital readmissions.

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