Characterization of Re-admission and Emergency Department Visits Within 90 Days Following Lower-Extremity Arthroplasty

Elina Huerfano, MD · Alejandro Gonzalez Della Valle, MD · Kate Shanaghan · Federico Girardi · Stavros Memtsoudis, MD · Jiabin Liu, MD

Received: 10 April 2018/Accepted: 25 June 2018/Published online: 29 August 2018
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Abstract *Background:* Acute care events including emergency department (ED) visits and unscheduled inpatient re-admissions following lower-extremity arthroplasty are not fully understood. *Question/Purposes:* The purpose of this study was to characterize acute care events occurring after discharge in patients who received a lower-extremity arthroplasty: the incidence, timing, and risk factors of inpatient admission and ED visits within 90 days of discharge. *Methods:* The New York State Inpatient and Emergency Department Databases were used to identify patients who underwent elective total knee arthroplasty (TKA) or total hip arthroplasty (THA) from 2009 to 2013 (124,234 and 76,411 patients, respectively). Multivariate logistic regression analysis was used to determine the predictors of and the most frequent reasons for unscheduled acute care within 90 days of discharge. *Results:* Unscheduled acute care was needed in 13.79% of patients (8.81% of inpatient re-admissions and 4.98% of ED visits), most often in the first week after discharge (61.05% of all inpatient re-admissions and 20.46% of all ED visits). Most of these visits were for musculoskeletal pain, peri-prosthetic joint or wound infection, cardiac complications, blood transfusion, psychiatric

events, mechanical complications, and deep vein thrombosis. Predictors for the need for acute care after TKA included African American and Hispanic race or ethnicity, Medicaid coverage, and neuraxial anesthesia. Predictors for the need for acute care after THA included older age (over 85 years), African American race, and Medicaid coverage. *Conclusion:* We identified demographic and procedure-related variables associated with an increased risk of ED visits and inpatient re-admissions after TKA or THA. Understanding these variables will contribute to improved care quality.

Keyword total hip arthroplasty · total knee arthroplasty · re-admissions · emergency department visits · complications

Introduction

The re-admission rates among patients who have undergone total knee arthroplasty (TKA) and total hip arthroplasty (THA) are a measure of care quality and cost [21]. The Hospital Re-admissions Reduction Program (HRRP), authorized under the Patient Protection and Affordable Care Act, requires the Centers for Medicare and Medicaid Services (CMS) to evaluate and penalize hospitals using the rate of re-admissions as an index of clinical effectiveness [7]. For this reason, hospital re-admissions have been the focus of intense research in recent years [3, 14, 23, 26–30, 40]. Although inpatient (IP) re-admissions are important quality indicators, they provide an incomplete picture of patients' needs for acute, unscheduled, post-discharge care. This is due to the fact that some patients receive emergency department (ED) care not followed by IP re-admission [35]. In 2015, CMS proposed the Comprehensive Care for Joint Replacement (CJR) model that tested bundled payments and quality measurements for an episode of care associated with total joint arthroplasty (TJA), which included ED visits in addition to IP re-admission [11].

Level of Evidence: Level III: retrospective cohort study

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s11420-018-9622-8>) contains supplementary material, which is available to authorized users.

E. Huerfano, MD · A. Gonzalez Della Valle, MD (✉) · K. Shanaghan, · F. Girardi,
Department of Orthopaedic Surgery, Hospital for Special Surgery,
535 East 70th Street,
New York, NY 10021, USA
e-mail: gonzaleza@hss.edu

S. Memtsoudis, MD · J. Liu, MD
Department of Anesthesia, Hospital for Special Surgery,
535 East 70th Street,
New York, NY 10021, USA

Variables associated with an increased risk of re-admission can be grouped into several categories, including patient factors (such as demographic variables and baseline health status) [3, 5, 26, 27, 30, 40], as well as factors related to the procedure, the hospital [23], the course of hospitalization [26, 28, 30, 32, 36], and the discharge disposition [5, 23, 26, 29, 32, 40]. Although there are ample studies on the factors associated with re-admission after TJA, most have analyzed a limited number of patients from a single institution without generalizability [1, 3, 29–31, 40], and others have analyzed either preoperative [20] or in-hospital variables [28, 40]. While ED visits are an important hospital quality indicator [22], only a few studies have analyzed ED visits in the immediate post-discharge period [16, 19, 34].

The purpose of this study is to characterize acute care events occurring after discharge in patients who received a lower-extremity TJA in New York State between 2009 and 2013. Specifically, we aimed to study (1) the incidence of both IP admission and ED visits occurring within 90 days of discharge, (2) the timing of these acute events, and (3) the risk factors for these events.

Material and Methods

This study was exempted from review by the institutional review board in our institution (protocol number, 2017-0716).

We acquired the New York State Inpatient Database (SID) and New York State Emergency Department Database (SEDD) via the Healthcare Cost and Utilization Project (HCUP). The HCUP is a family of health care databases sponsored by the Agency for Healthcare Research and Quality that includes information for all payors; these are often characterized as “discharge-level” files, indicating that each record in a database represents one discharge abstract from a hospital setting, which can be an IP admission or ED visit.

Each discharge abstract includes information on demographics, admission status, hospital characteristics, discharge, and diagnostic and procedure codes based on International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). The full list of variables is available at the HCUP website (<http://www.hcup-us.ahrq.gov/nisoverview.jsp>).

We identified all patients discharged after undergoing primary TKA (code 81.54, $n = 142,197$) or primary THA (code 81.51, $n = 90,961$) in the New York SID database from January 1, 2009, to September 30, 2013. Patients were excluded if they did not reside in New York State ($n = 7832$ and $n = 6887$, respectively); if they left against medical advice ($n = 19$ and $n = 15$, respectively); if they died during hospitalization ($n = 68$ and $n = 76$, respectively); or if their age was less than 18 years ($n = 25$ and $n = 35$, respectively). In addition, patients were excluded if they had undergone bilateral procedures ($n = 6372$ and $n = 1089$, respectively) or if the admission was not elective ($n = 3390$ and $n = 5137$, respectively). In order to ensure that only elective, unilateral, and primary procedures were included, we added the clinical exclusion criteria developed by the Yale New Haven Health

Services Corporation/Center for Outcomes Research and Evaluation (YNHHSC/CORE) prepared by CMS [38]. These criteria exclude index admissions for patients with femur, hip, or pelvic fracture or malignant neoplasm ($n = 149$ and $n = 1152$, respectively) and patients undergoing partial, resurfacing, or revision procedures and with a procedure code for removal of implanted devices/prostheses ($n = 108$ and $n = 159$, respectively).

After exclusions, the final cohort included 124,234 TKA and 76,411 THA patient discharges in the New York SID dataset. These two cohorts of patients were then cross-referenced with entries in the entire SID and SEDD databases from 2009 to 2013, which contained over 12.8 and 33 million valid entries, respectively.

The average patient age was 66.4 ± 10.3 years for TKA and 64.9 ± 11.9 years for THA. The majority of patients were women (TKA, 65.74%; THA, 56.34%), white (TKA, 74.62%; THA, 81.09%), and insured by Medicare (TKA, 53.09%; THA, 49.74%).

The primary outcomes were IP re-admissions and ED visits within 90 days of surgical discharge. IP re-admissions and ED visits were identified via the visit linking variable (“visitlink”) from the corresponding SID and SEDD databases, respectively. For patients with multiple IP and ED visits, only the first post-discharge visit was included. For patients who had both an ED encounter and IP admission occurring on the same day, only the latter was considered in the analysis, assuming it was the primary encounter. IP re-admissions that were considered planned based on YNHHSC/CORE definition [38] and patients re-admitted to undergo another elective joint replacement were not included in the analysis. The timing of the post-discharge event, the primary diagnosis for the acute care visit, and the associated hospital charges were summarized and reported.

The causes of IP re-admissions and ED visits were characterized and analyzed based on the primary ICD-9 diagnosis codes and grouping in surgical or medical clinically relevant categories including seven diagnoses that CMS considers complications specific to THA and TKA (acute myocardial infarction, pneumonia, sepsis/septicemia/shock, surgical site bleeding, pulmonary embolism, mechanical complications [including dislocation, loosening, periprosthetic fracture, and prosthetic breakdown], and periprosthetic joint infection or wound infection). Several other complications were also included in the analysis: cardiac complication excluding acute myocardial infarction, deep vein thrombosis (DVT), acute kidney failure, and complications related to the gastrointestinal, genitourinary, or central nervous system. Administration of blood transfusions, musculoskeletal pain, nausea and/or vomiting, psychiatric events (including anxiety and depression), and drug abuse were also analyzed. (See Online Resource Table 1 for a list of events and the ICD-9 codes used to create each category.)

Information on patient demographics and comorbidities was collected. Comorbidity burden was determined using ICD-9 codes listed in the primary surgical record as preexisting conditions and as previously described by HCUP (<http://www.hcup-us.ahrq.gov/toolssoftware/>

[comorbidity/Table2-FY12-V3_7.pdf](#)). The HCUP database included hospital identification, which was used to calculate the hospital-specific surgical volume (low, less than 500 cases; medium, 500 to 1000 cases; or high, more than 1000 cases).

Statistical Analysis

Data analysis was executed using STATA 14.2 statistical software (StataCorp LP, College Station, TX, USA). The primary aim of the study was to estimate the incidence of acute care visits after surgery, as either IP or ED. Student *t* test was used to analyze continuous variables. Pearson χ^2 tests were applied for categorical variables. Logistic regression was performed using hospital-based acute care as the dependent variable and other risk factors as independent variables.

Risk factors associated with the need for acute care and those associated with the need for acute care for the six most frequent reasons for acute post-discharge care for each primary surgical procedure were evaluated using a two-step logistic regression analysis. The first step was univariable regression analysis. The variables of interest included a set of patient demographic information, whether patients received neuraxial anesthesia, insurance payer, hospital volume, and comorbidities. Variables with statistical significance at the $p < 0.1$ level were then included into the second step multivariable regression analysis. Variables with statistical significance ($p < 0.01$) were then plotted in figure.

Results

Among the 200,645 patients analyzed in the study (124,234 TKA and 76,411 THA patients), 27,676 (13.79%) required acute care within the first 90 days following discharge. Patients who required acute care were older ($p < 0.001$), less likely to be white ($p < 0.001$), more likely to be covered by Medicare or Medicaid ($p < 0.001$), and had a higher Deyo Comorbidity Index ($p < 0.001$) (Tables 1 and 2).

Among patients who underwent TKA, 18,115 (14.58%) required acute care within 90 days of discharge. ED visits were recorded for 5.21% of patients ($n = 6468$) and IP admission in 9.37% of patients ($n = 11,647$). In those who underwent THA, 9561 (12.50%) required acute care. ED visits were recorded in 4.61% of patients ($n = 3526$) and IP admissions in 7.89% ($n = 6035$) (Tables 3 and 4).

The incidence of acute care events was highest immediately after discharge and then trended down throughout the 90-day period. For TKA, 20.28% (1312 out of 6468 events) of the ED visits and 60.31% (7024 out of 11,647 events) of the IP re-admissions occurred during the first week after discharge. The majority of IP re-admissions in this group (48.67%) occurred within 24 h after discharge; 11.5% of ED visits and 6.23% of IP re-admissions occurred during the second week (Figs. 1 and 2). A similar pattern was observed in the THA cohort: 20.79% (733 out of 3526 events) of the ED visits and 62.5% (3772 out of 6035 events) of the IP re-admissions occurred during the first week; 11.37 and 7.64%

events, respectively, occurred during the second week (Figs. 3 and 4).

The six most frequent diagnoses associated with an acute care event within 90 days of discharge after TKA were musculoskeletal pain (12.2%), peri-prosthetic joint infection and wound infection (11.8%), cardiac complication excluding acute myocardial infarction (9.6%), administration of blood transfusion (9.1%), psychiatric events (8.3%), and DVT (5.1%) (Table 3). The six most frequent diagnoses associated with an acute care event after THA were peri-prosthetic joint/wound infection (8.2%), blood transfusion (7.9%), cardiac complication excluding acute myocardial infarction (7.2%), psychiatric events (6.0%), mechanical complication (including loosening, dislocation, and fractures [5.4%]), and musculoskeletal pain (3.9%) (Table 4).

Multivariable logistic regression in the TKA cohort identified African American race (OR, 1.43; 95% CI, 1.31–1.56) and Hispanic ethnicity (OR, 1.24; 95% CI, 1.13–1.37), Medicaid coverage (OR, 1.22; 95% CI, 1.08–1.39), and neuraxial anesthesia (OR, 1.13; 95% CI, 1.08–1.19) as risk factors for the need of acute care. The patients with the following preoperative characteristics had higher odds of seeking acute care: chronic congestive heart failure (OR, 1.42; 95% CI, 1.23–1.63), arrhythmia (OR, 1.34; 95% CI, 1.25–1.45), pulmonary circulatory disease (OR, 1.47; 95% CI, 1.21–1.78), peripheral vascular disease (OR, 1.22; 95% CI, 1.03–1.45), chronic obstructive pulmonary disease (OR, 1.35; 95% CI, 1.27–1.44), diabetes with complications (OR, 1.65; 95% CI, 1.37–1.99), renal disease (OR, 1.39; 95% CI, 1.08–1.79), rheumatoid disease (OR, 1.26; 95% CI, 1.13–1.04), coagulopathy (OR, 1.35; 95% CI, 1.13–1.06), weight loss (OR, 2.05; 95% CI, 1.14–3.67), electrolyte abnormalities (OR, 1.19; 95% CI, 1.09–1.29), anemia/blood transfusion (OR, 1.38; 95% CI, 0.99–1.94), psychiatric event (OR, 1.82; 95% CI, 1.35–2.46), and neurological disease (OR, 1.59; 95% CI, 1.36–1.86) (Fig. 5).

In the THA cohort, older age (over 85 years) (OR, 1.67; 95% CI, 1.38–2.01), African American race (OR, 1.55; 95% CI, 1.36–1.75), and Medicaid coverage (OR, 1.46; 95% CI, 1.22–1.73) were identified as risk factors for seeking acute care. Significance of patient comorbidities showed similar patterns as in the TKA cohort (Fig. 6).

Lower odds of seeking acute care after TJA were identified in patients with private insurance (TKA: OR, 0.59; 95% CI, 0.54–0.64; THA: OR, 0.64; 95% CI, 0.57–0.71), having surgery in a hospital with a high surgical volume (TKA: OR, 0.73; 95% CI, 0.68–0.78; THA: OR, 0.68; 95% CI, 0.63–0.74), and age under 85 years (TKA: OR, 0.69; 95% CI, 0.62–0.76; THA: OR, 0.82; 95% CI, 0.71–0.93).

The risk factors associated with the six most frequent acute care events within 90-day post-discharge from TKA and THA are related to patients' underlying specific comorbidity burdens. Patients with congestive heart failure (TKA: OR, 1.52; 95% CI, 1.11–2.07) and arrhythmia (TKA: OR, 14.53; 95% CI, 11.76–17.94; THA: OR, 16.45; 95% CI, 12.93–20.93) had higher odds of seeking acute post-operative care for cardiac complication, excluding acute myocardial infarction. Patients with pre-existing coagulopathy (TKA: OR, 1.5; 95% CI, 0.99–2.27; THA: OR, 1.93;

Table 1 Demographic information of all patients who underwent total knee arthroplasty

Variable	All patients		Control patients		Acute care patients		<i>p</i> value
	<i>n</i> /mean	%/ <i>SD</i>	<i>n</i> /mean	%/ <i>SD</i>	<i>n</i> /mean	%/ <i>SD</i>	
Patients	124,234		106,119		18,115		
Age	66.4	10.3	66.2	10.1	67.2	11.1	< 0.001
Sex							
Male	42,558	34.26	36,480	34.38	6078	33.55	0.031
Female	81,676	65.74	69,639	65.62	12,037	66.45	
Race and ethnicity							
White	92,701	74.62	80,138	75.52	12,563	69.35	< 0.001
Black	11,639	9.37	9331	8.79	2308	12.74	
Hispanic	9127	7.35	7478	7.05	1649	9.1	
Other	10,767	8.67	9172	8.64	1595	8.8	
Payor							
Medicare	65,960	53.09	54,952	51.78	11,008	60.77	< 0.001
Medicaid	6475	5.21	5057	4.77	1418	7.83	
Private	43,070	34.67	38,623	36.4	4447	24.55	
Other	951	0.77	796	0.75	155	0.86	
No charge	22	0.02	21	0.02	1	0.01	
Other	7756	6.24	6670	6.29	1086	6	
Deyo Comorbidity Index							
0	70,291	56.58	61,920	58.35	8371	46.21	< 0.001
1	36,962	29.75	30,909	29.13	6053	33.41	
2	11,482	9.24	9131	8.6	2351	12.98	
3	3587	2.89	2765	2.61	822	4.54	
4	1239	1	896	0.84	343	1.89	
5	413	0.33	305	0.29	108	0.6	
≥ 6	260	0.21	193	0.18	67	0.37	

n number of patients, *SD* standard deviation

Table 2 Demographic information of all patients who underwent total hip arthroplasty

Variable	All patients		Control patients		Acute care patients		<i>p</i> value
	<i>n</i> /mean	%/ <i>SD</i>	<i>n</i> /mean	%/ <i>SD</i>	<i>n</i> /mean	%/ <i>SD</i>	
Patients	76,411		66,850		9561		
Age	64.9	11.9	64.63	11.72	67.14	13.15	< 0.001
Sex							
Male	33,360	43.66	29,359	43.92	4001	41.85	< 0.001
Female	43,050	56.34	37,490	56.08	5560	58.15	
Race and ethnicity							
White	61,959	81.09	54,592	81.66	7367	77.05	< 0.001
Black	5846	7.65	4771	7.14	1075	11.24	
Hispanic	3299	4.32	2828	4.23	471	4.93	
Other	5307	6.95	4659	6.97	648	6.78	
Payor							
Medicare	38,006	49.74	32,187	48.15	5819	60.86	< 0.001
Medicaid	3728	4.88	2942	4	786	8	
Private	31,988	41.86	29,364	43.93	2624	27.44	
Other	576	0.75	497	0.74	79	0.83	
No charge	10	0.01	9	0.01	1	0.01	
Other	2103	2.75	1851	2.77	252	2.64	
Deyo Comorbidity Index							
0	48,500	63.47	43,690	65.36	4810	50.31	< 0.001
1	18,998	24.86	16,089	24.07	2909	30.43	
2	5729	7.5	4619	6.91	1110	11.61	
3	1900	2.49	1480	2.21	420	4.39	
4	680	0.89	507	0.76	173	1.81	
5	234	0.31	166	0.25	68	0.71	
≥ 6	370	0.48	299	0.45	71	0.74	

n number of patients, *SD* standard deviation

Table 3 Reason for seeking acute care after total knee arthroplasty

Variable	SEDD (ED visits)		SID (re-admissions)		Total	Events (%)	Events in 1000 patients
	<i>n</i>	Events (%)	<i>n</i>	Events (%)			
All events	6468		11,647		18,115		
Musculoskeletal pain	860	13.3	661	5.7	1521	12.2	12.2
Peri-prosthetic joint/wound infection	146	2.3	1320	11.3	1466	11.8	11.8
Cardiac events	192	3.0	996	8.6	1188	9.6	9.6
Blood transfusion	0	0.0	1129	9.7	1129	9.1	9.1
Psychiatric events	300	4.6	730	6.3	1030	8.3	8.3
Deep venous thrombosis	99	1.5	538	4.6	637	5.1	5.1
Acute renal failure	13	0.2	574	4.9	587	4.7	4.7
Nausea and/or vomiting	396	6.1	62	0.5	458	3.7	3.7
Pneumonia	41	0.6	372	3.2	413	3.3	3.3
Surgical site bleeding	61	0.9	351	3.0	412	3.3	3.3
Mechanical complications	12	0.2	384	3.3	396	3.2	3.2
Drug abuse	163	2.5	214	1.8	377	3.0	3.0
Sepsis/septicemia/shock	9	0.1	341	2.9	350	2.8	2.8
Myocardial infarction	29	0.4	244	2.1	273	2.2	2.2
Pulmonary complication	3	0.0	186	1.6	189	1.5	1.5
Gastrointestinal complications	7	0.1	156	1.3	163	1.3	1.3
Fracture	0	0.0	86	0.7	86	0.7	0.7
Medication	31	0.5	51	0.4	82	0.7	0.7
Opioid-related complications	23	0.4	57	0.5	80	0.6	0.6
Dislocation	9	0.1	31	0.3	40	0.3	0.3
Alcohol	4	0.1	32	0.3	36	0.3	0.3
Poisoning	12	0.2	16	0.1	28	0.2	0.2
Genitourinary complications	4	0.1	20	0.2	24	0.2	0.2
Pulmonary embolism	3	0.0	8	0.1	11	0.1	0.1
Central nervous system complications	1	0.0	5	0.0	6	0.0	0.0
Rupture of tendon	0	0.0	2	0.0	2	0.0	0.0
Post-operative stiffness	0	0.0	0	0.0	0	0.0	0.0

n number of patients, *SEDD* State Emergency Department Database, *SID* State Inpatient Database

95% CI, 1.12–3.32) carried higher odds of requiring blood transfusion. Patients with neurological disease (TKA: OR, 2.81; 95% CI, 2.01–3.94; THA: OR, 2.5; 95% CI, 1.45–4.32) have higher odds of seeking acute care for psychiatric events.

Patients who received neuraxial anesthesia had higher odds of seeking acute care due to pain (TKA: OR, 1.65; 99% CI, 1.401–0.95; THA: OR, 1.55; 95% CI, 1.13–2.13), but had lower odds of peri-prosthetic joint/wound infection (THA: OR, 0.52; 95% CI, 0.78–0.9) and blood transfusion (THA: OR, 0.62; 95% CI, 0.49–0.79).

Age showed a bidirectional impact on the odds ratios for various acute care events: lower odds for pain (TKA: OR, 0.34; 95% CI, 0.25–0.47; THA: OR, 0.48, 95% CI, 0.26–0.85) and psychiatric events (TKA: OR, 0.35, 95% CI, 0.26–0.47; THA: OR, 0.36, 95% CI, 0.24–0.54) but higher odds for cardiac complication, excluding acute myocardial infarction (TKA: OR, 4.48, 95% CI, 2.27–8.83; THA: OR, 7.92, 95% CI, 3.91–16.05) and blood transfusion (TKA: OR, 2.74, 95% CI, 1.56–4.84; THA: OR, 3.56, 95% CI, 1.99–6.35) (see Online Resource Figs. 1–12).

Discussion

We undertook this study to characterize acute care events including ED visits and IP re-admissions after lower-

extremity arthroplasty. Using a large database, we estimated the incidence, timing, and risk factors associated with these events within 90 days after surgical discharge.

This study has several limitations. First, the study design was retrospective and observational, limiting the causal inferences that can be drawn from our data. Second, our study is limited by a number of factors inherent to secondary data analysis of large administrative databases; the accuracy of information is difficult to validate and intrinsic differences in the methods of data collection and the population of patients analyzed results in variability of reported comorbidities and surgical complications [4], and coding error cannot be fully eliminated [18]. Third, our study was limited to acute care events that occurred in ED and IP settings. Data for ambulatory surgery and other outpatient services from hospital-owned facilities were not included in this analysis, as this information is contained in the State Ambulatory Surgery and Services Databases. It is possible that we did not capture patients re-admitted for ambulatory surgery, such as manipulation under anesthesia.

The rate of patients requiring acute, unscheduled post-discharge care was 13.79%: 8.81% were IP re-admissions and 4.98% were ED visits. Other investigators used data files from SID and SEDD to assess the need for acute care within 30 days post-arthroplasty in California, Florida, Nebraska, and New York [16, 24]. Trimba et al. reported a rate of 10.2% (5.1% IP re-admissions and 5.8% ED visits) [34],

Table 4 Reason for seeking acute care after total hip arthroplasty

Variable	SEDD (ED visits)		SID (re-admissions)		Total	Events (%)	Events in 1000 patients
	<i>N</i>	Events (%)	<i>n</i>	Events (%)			
All events	3526		6035		9561		
Peri-prosthetic joint infection/wound Infection	68	1.9	714	11.8	782	8.2	10.2
Blood transfusion	0	0.0	752	12.5	752	7.9	9.8
Cardiac events excluding acute myocardial infarction	97	2.8	588	9.7	685	7.2	9.0
Psychiatric events	160	4.5	415	6.9	575	6.0	7.5
Mechanical complications	91	2.6	427	7.1	518	5.4	6.8
Musculoskeletal pain	161	4.6	213	3.5	374	3.9	4.9
Dislocation	183	5.2	178	2.9	361	3.8	4.7
Deep vein thrombosis	49	1.4	271	4.5	320	3.3	4.2
Drug abuse	130	3.7	178	2.9	308	3.2	4.0
Acute renal failure	2	0.1	301	5.0	303	3.2	4.0
Surgical site bleeding	48	1.4	247	4.1	295	3.1	3.9
Pneumonia	18	0.5	208	3.4	226	2.4	3.0
Nausea and/or vomiting	156	4.4	22	0.4	178	1.9	2.3
Sepsis/septicemia/shock	1	0.0	177	2.9	178	1.9	2.3
Acute myocardial infarction	10	0.3	146	2.4	156	1.6	2.0
Genitourinary complications	8	0.2	145	2.4	153	1.6	2.0
Fracture	0	0.0	144	2.4	144	1.5	1.9
Pulmonary complication	3	0.1	109	1.8	112	1.2	1.5
Opioid-related complications	9	0.3	43	0.7	52	0.5	0.7
Medication	11	0.3	36	0.6	47	0.5	0.6
Alcohol	12	0.3	30	0.5	42	0.4	0.5
Poisoning	7	0.2	8	0.1	15	0.2	0.2
Genitourinary complications	3	0.1	9	0.1	12	0.1	0.2
Central nervous system complications	1	0.0	7	0.1	8	0.1	0.1
Pulmonary embolism	0	0.0	3	0.0	3	0.0	0.0
Rupture of tendon	0	0.0	0	0.0	0	0.0	0.0
Post-operative stiffness	0	0.0	0	0.0	0	0.0	0.0

n number of patients, *SEDD* State Emergency Department Database, *SID* State Inpatient Database

and Finnegan et al. reported a rate of 9.23% (3.42% IP re-admissions and 5.81% ED visits) [16]. In addition, we observed a higher ratio of IP re-admissions to ED visits (1.76) than the previous two investigators (Trimba et al. [34], 0.87; Finnegan et al. [16], 0.59). These differences may be explained by several factors. First, we tracked acute events within 90 days of discharge. Previous studies have reported that a 30-day timeframe may be insufficient to capture late surgery-related ad-

verse events [6, 12]. Second, state-wide differences may exist. Third, our period of study was longer (4 vs. 1 year) and trends in variables related to the procedure, hospital, and discharge disposition can change over time [28]. Finally, we chose to report only the first ED visit for each patient, not counting ED visits followed by IP re-admission.

Recently, Kelly et al. also found that ED visits were more common than IP re-admissions [19]. However, the authors

Fig. 1. Number of emergency department visits over 90 days after discharge from total knee arthroplasty

Fig. 2. Number of inpatient re-admissions over 90 days after discharge from total knee arthroplasty

Fig. 3. Number of emergency department visits over 90 days after discharge from total hip arthroplasty

used the Kaiser Permanente Total Joint Replacement Registry of only three medical centers; and therefore, ED visits or IP re-admissions to other hospitals were not captured.

In our study, 20.46% of all ED visits and 61.05% of all IP re-admissions occurred during the first week post-discharge (Figs. 1, 2, 3, and 4). The highest incidence of unscheduled re-admissions in our study occurred on post-operative day 1 (Figs. 2 and 4). The timing of such acute care events post-discharge has not been extensively studied [34]. A similar temporal trend was observed by Vashi et al., who used SID and SEDD databases of California, Florida, and Nebraska and reported on the time of acute care services within 30 days of discharge from acute care hospitals in medical and surgical patients of different specialties [35]. Our findings and those of other investigators highlight that the effort to reduce the need for acute post-discharge care should focus on the first 2 weeks. It may be speculated that some of these events may have been prevented by a

Fig. 4. Number of inpatient re-admissions over 90 days after discharge from total hip arthroplasty

delayed discharge after surgery. Although some studies have shown that reduced length of stay is not associated with increased rates of acute care events [15, 23, 26, 33, 36], other studies have shown opposite results [13, 14]. Patients with an increased comorbidity burden have a higher risk for an acute care event if the length of stay is reduced without understanding the risk factors associated with these events [6].

The most frequent diagnoses associated with the need of acute care included several well-studied procedure-specific complications, such as peri-prosthetic joint or wound infection, cardiac complications, anemia requiring blood transfusions, mechanical complications, and DVT [26, 30, 40]. We observed an unexpectedly high incidence of acute care visits due to psychiatric events (8.3% for TKA and 6% for THA patients). These diagnoses included depression, anxiety, dementia, schizophrenia, transient mental disorders, and delirium. Other investigators found depression to be an independent risk factor for re-admission after TKA [17, 26, 29]. Our study indicates that psychiatric disorders constitute a common reason for seeking acute care following TKA and THA. Efforts to improve the psychological well-being of high-risk patients may result in a reduced need for acute post-discharge care.

In addition, the most frequent diagnoses associated with ED visits that were not followed by IP re-admission were nausea and vomiting (6.1% for TKA and 4.4% for THA patients).

The need for acute care due to musculoskeletal pain was higher after TKA than after THA (Tables 3 and 4). Minority patients and those with a number of preoperative medical comorbidities undergoing surgery with regional anesthesia were at a higher risk.

Minority status was identified as an independent risk factor for seeking acute care. African American patients had higher odds of acute care visits after both TKA and THA (Figs. 5 and 6). Hispanics had higher odds of acute care visits after TKA but not after THA (Fig. 6). Our work and that of other investigators has highlighted the increased risks of complications in these groups [14, 24, 26]. However, the underlying reasons for the observed differences are complex and not completely understood [10, 39]. Additional studies are needed to elucidate this finding.

Insurance coverage plays an important role in outcomes and hospital costs after TJA [9]. Patients with private insurance had lower odds of 90-day acute care after TKA and THA (Figs. 5 and 6). Subgroup analysis of the six most frequent reasons for seeking acute care further illustrated that patients with private insurance had lower odds of events in most of these subgroups. Likewise, Medicaid patients had even higher odds of 90-day acute care events than Medicare patients (Online Resource Figs. 1–12). Similar results of insurance influence on re-admission for the TKA cohort have been reported in the New York State [10] and other regions of the USA [37]. Oronce et al. used the California SID to examine the relationship between patient insurance

Fig. 5. Forest plot of the acute care events in total knee arthroplasty cohort

and odds of 30-day re-admissions [25]. They reported that Medicaid patients experienced the highest re-admission rate and were 86% more likely to be re-admitted than those with private insurance. Browne et al. utilized the Nationwide Inpatient Sample, the largest publicly available all-payer inpatient care database in the USA, to demonstrate that Medicaid payer status is an independent risk factor associated with higher inpatient morbidity, an increased length of hospital stay, increased total cost, and increased frequency of discharge to an inpatient facility [9].

Hospital volume plays an important role in outcomes following TJA [2, 8]. In agreement with D'Apuzzo et al., high hospital procedure volume seems to be a representative protective factor of ED visit and re-admission following TJA in New York State [14].

Several studies have demonstrated that older age is a risk factor for re-admission and complications following TJA [3, 14, 26, 27, 30]. In our study, age was not identified as a risk factor for seeking acute post-operative care in TKA patients (Fig. 5); however, it proved to be a significant risk factor for those seeking

Fig. 6. Forest plot of the acute care events in total hip arthroplasty cohort

care for cardiac reasons after TKA and THA (Online Resource Figs. 3 and 9). A similar finding was observed for the need for blood transfusion (Online Resource Figs. 4 and 8).

Patients' comorbidities significantly affect the odds of acute care visits (Figs. 5 and 6). Patients with more comorbid burden have a higher risk for re-admission [14, 26]. Our study indicated that tissue- or organ-specific preexisting comorbidities were associated with corresponding tissue- or organ-specific post-operative acute care events.

In conclusion, our study highlights the presence of risk factors related to the patient, the procedure, and the hospitalization affecting the incidence of post-discharge acute care events after elective TJR, which in our study was highest immediately after discharge.

Acknowledgements The authors thank Kara Fields and Yu-fen Chiu for their help with manuscript preparation.

Funding Information This study was partially funded by the generous donations of Mr. Glenn Bergenfield, the Sidney Milton and Leoma Simon Foundation, and Mr. and Mrs. David Forber.

Compliance with Ethical Standards

Conflict of Interest: Elina Huerfano, MD, Kate Shanaghan, Federico Girardi, Stavros Memtsoudis, MD, and Jiabin Liu, MD, declare that they have no conflicts of interest. Alejandro Gonzalez Della Valle, MD, reports receiving personal fees from OrthoSensor, Ortho Development, LINK, and Intellijoint, outside the submitted work.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2013.

Informed Consent: Informed consent was waived from all patients for being included in this study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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