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Predictors and Cost of Readmission in Total Knee Arthroplasty

Kenneth L. Urish, MD, PhD[1], **Yongmei Qin, MD, MS**[2], **Benjamin Y. Li, BS**[3], **Tudor Borza, MD, MS**[4], **Michael Sessine**[5], **Peter Kirk, MS**[6], **Brent K. Hollenbeck, MD, MS**[7], **Jonathan E. Helm, PhD**[8], **Mariel S. Lavieri, PhD**[9], **Ted A. Skolarus, MD, MPH**[10], and **Bruce L. Jacobs, MD, MPH**[11]

[1]Arthritis and Arthroplasty Design Group, The Bone and Joint Center, Magee Womens Hospital of the University of Pittsburgh Medical Center; Department of Orthopaedic Surgery, Department of Bioengineering, and Clinical and Translational Science Institute, University of Pittsburgh; Department of Biomedical Engineering, Carnegie Mellon University, 300 Halket Street, Suite 1601, Pittsburgh, PA 15232

[2]Department of Urology, Division of Oncology; Dow Division for Urologic Health Service Research, University of Michigan, Ann Arbor, MI

[3]Department of Urology, Division of Oncology, MI; Dow Division for Urologic Health Service Research, University of Michigan, Ann Arbor

[4]Department of Urology, Division of Oncology; Dow Division for Urologic Health Service Research, University of Michigan, Ann Arbor, MI

[5]Department of Urology, Division of Oncology; Dow Division for Urologic Health Service Research, University of Michigan, Ann Arbor, MI

[6]Department of Urology, Division of Oncology; Dow Division for Urologic Health Service Research, University of Michigan, Ann Arbor, MI

[7]Department of Urology, Division of Oncology; Dow Division for Urologic Health Service Research, University of Michigan, Ann Arbor, MI

[8]Health Services Research & Development, Center for Clinical Management Research, VA Ann Arbor Healthcare System, Ann Arbor, MI

[9]Department of Industrial and Operations Engineering, University of Michigan, Ann Arbor, MI

[10]Department of Urology, Division of Oncology; Dow Division for Urologic Health Service Research, Health Services Research & Development, Center for Clinical Management Research, VA Ann Arbor Healthcare System, University of Michigan, Ann Arbor, MI

[11]Department of Urology, University of Pittsburgh, Pittsburgh, PA

Abstract

Corresponding Author: Kenneth L. Urish, urishk2@upmc.edu.

Background—The Comprehensive Care for Joint Replacement (CJR) bundle was created to decrease total knee arthroplasty (TKA) cost. To help accomplish this, there is a focus on reducing TKA readmissions. However, there is a lack of national representative sample of all-payer hospital admissions to direct strategy, identify risk factors for readmission, and understand actual readmission cost.

Methods—We utilized the Nationwide Readmission Database (NRD) to examine national readmission rates, predictors of readmission, and associated readmission costs for elective TKA procedures. We fit a multivariable logistic regression model to examine factors associated with readmission. Then, we determined mean readmission costs and calculated the readmission cost when distributed across the entire TKA population.

Results—We identified 224,465 patients having TKA surgery across all states participating in NRD. The mean unadjusted 30-day TKA readmission rate was 4%. The greatest predictors of readmission were congestive heart failure (odds ratio [OR] 2.51, 95% confidence interval [CI] 2.62-2.80), renal disease (OR 2.19, 95% CI 2.03-2.37), and length of stay greater than 4 days (OR 2.4, 95% CI 2.25-2.61). The overall median cost for each readmission was $6,753±175. Extrapolating the readmission cost for the entire TKA population resulted in the readmission cost being 2% of the overall 30-day procedure cost.

Conclusions—A major focus of the CJR bundle is improving cost and quality by limiting readmission rates. TKA readmissions are low and comprise a small percentage of total TKA cost, suggesting that they may not be the optimal measure of quality care or a significant driver of overall cost.

Keywords

Total Knee Arthroplasty; Readmission Rate; Comprehensive Care for Joint Replacement; Nationwide Readmission Database

INTRODUCTION

As one of the largest procedural expenditures for Medicare, total knee arthroplasty (TKA) has been under intense scrutiny to decrease costs [1]. The Affordable Care Act of 2012 began a long anticipated shift in Medicare reimbursement policy from a fee-for-service model to one linked to quality of care [2]. As part of this effort, Medicare launched the Comprehensive Care for Joint Replacement (CJR) model to bundle all of the hospital, professional, and 90-day post-discharge services into a single payment for TKA [3]. Currently, this bundled care pertains only to select regions, but it is anticipated that it will soon expand across the United States. Following the pattern of Medicare, it is expected that private insurers will adopt this strategy. The logic behind bundled care involves tying all parties of the episode of care together to align their interests [4]. Hospitals in charge of the overall episode have already improved inpatient efficiency [5]. Understanding excess costs of post-discharge care has become essential and reducing readmissions rates is an obvious and assumed initial target.

The readmission rates of TKA are low between 2-6%, and there are a large number of predictors of readmission [6]. Large databases that are able to track post-discharge readmissions and charge data are scarce, and these databases lack a national representative sample of all-payer hospital admissions across a wide geographic region. This is a disadvantage of using the National Inpatient Sample or Medicare databases, two large databases used to study TKA readmissions for health policy research. The Nationwide Readmissions Database (NRD) was developed to address these gaps. The NRD is the largest database of all-payer hospital admissions that can follow readmissions across different hospitals and accounts for 49% of all hospitalizations in the United States [7].

For these reasons, we used the NRD to examine national readmission rates, predictors of readmission, and associated readmission costs for elective TKA procedures. The objective was to quantify 30 day NRD readmission rates for TKA, identify predictors of readmission, and quantify readmission cost as a function of overall care for the population. We hypothesized that TKA readmission rates and costs associated with readmission aggregated over the entire population would be low. Findings from this study will inform policy makers about patterns of TKA readmissions and the actual contribution of readmission rate cost across all payers and geographic regions in the United States.

METHODS

Data source and study population

We utilized the Healthcare Cost and Utilization Project's NRD to identify adult men and women (18 years or older) who underwent TKA in 2014. The NRD was developed to provide a nationally representative dataset to examine hospital readmissions [7]. Sampled from the State Inpatient Database, the NRD is the largest database of all-payer hospital admissions that contains patient linkages to follow readmissions across different hospitals [7]. Initial data was released for 2014 and first became available in 2016 [7].

We chose to study TKA because it is one of the conditions included in the recently implemented CJR bundle payment model wherein Medicare pays a hospital a single payment to cover the costs of hospital, professional, and post-acute care services that occur within 90 days of the procedure [3]. We identified TKA using designated *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) codes. As there may be more than one procedure code for each patient, we included all patients with the ICD-9 procedure code 8154 and excluded any patients with the ICD-9 procedure code 8151, 8006, 8155, 0080, 0081, 0082, 0083, 0084, 27486, 27487, 274888 and diagnosis codes 73310, 73314, 73315, 73316, 808, 820, 821, 827, 828. Using these criteria, our study consisted of 224,465 patients. These codes were used in an attempt to include elective TKA and exclude TKA performed for trauma or neoplasm.

Outcomes

The objective of this study was to assess readmission rates among patients undergoing TKA. First, we defined a readmission as a hospital admission that occurred within 30 days of the index surgery. We used a 30-day time period to be consistent with the readmission definition used by the Hospital Readmissions Reduction Program [8].

Statistical analysis

We first compared patient demographics as well as clinical, payer, and hospital characteristics among TKA patients readmitted and not readmitted. We then examined readmitted patients stratified by payer type (i.e., Medicare or non-Medicare). Non-Medicare payers included Medicaid, private insurance, uninsured, and other insurance types. Comorbidity was measured using the adaptation of the Charlson index by Deyo and colleagues in which ICD-9 diagnosis and procedure codes were used to identify the presence or absence of 16 comorbid conditions.[9] Rural areas included micropolitan areas. A teaching hospital was defined as one that was a member of the Council of Teaching Hospitals, had an Accreditation Council for Graduate Medical Education approved residency program, or had a ratio of full-time equivalent interns and residents to beds of 0.25 or higher [10]. Parametric continuous variables were compared using Student-t-tests, non-parametric continuous variables were compared using the Wilcoxon Rank Sum test, and categorical variables were compared using chi-square tests.

Next, we fit univariable and multivariable logistic regression models to examine factors associated with readmission. For the multivariable model, covariates included age, sex, median household income, comorbidities, index admission length of stay, primary payer (i.e., Medicare or non-Medicare), hospital type (i.e., teaching or non-teaching), urban vs. rural location, and hospital size. The effect of each covariate was adjusted for all other covariates in the model.

Lastly, we focused on readmission costs. Specifically, we calculated readmission costs using an established method [11, 12] based on total readmission charges and hospital-specific cost-to-charge ratios developed by the Healthcare Cost and Utilization Project [13]. The cost-to-charge ratio provides a way to estimate the cost of hospital services, as opposed to the charges put forth by hospitals. We determined mean readmission costs and then calculated what the readmission cost would be if distributed across the entire TKA population.

All analyses were performed using SAS v9.4 (Cary, NC). The probability of a type I error was set at 0.05, and all testing was two-sided. Since patients cannot be identified, our institutional review board exempted this study from review.

RESULTS

We identified 224,465 patients having TKA surgery across all states participating in NRD in 2014 (Table 1). The mean unadjusted 30-day TKA readmission rate was 4%. Several patient, clinical, payer, and hospital characteristics were associated with 30-day readmissions, including age, sex, median household income, comorbidities, index hospital length of stay, discharge destination, primary payer, location, hospital type, and hospital size (all $p<0.01$).

The differences in readmission rates between Medicare and non-Medicare patients are demonstrated in Table 2. Although statistically significant, the 30-day readmission rates were clinically similar between the Medicare and non-Medicare patients (4% versus 3%). The majority of readmissions (57% of Medicare patients and 54% of non-Medicare patients) occurred after the first week from discharge. The majority of readmissions in both groups occurred with a length of stay of three days or more (80% for Medicare patients and 72% for non-Medicare patients, p<0.0001). Medicare patients had a lower readmission rate on discharge at day 2 than non-Medicare patients (19% versus 28%, p<0.0001). Medicare patients had a much higher rate of readmission from a skilled nursing facility than non-Medicare patients (48% versus 25%, p<0.0001).

Adjusted predictors of readmission are demonstrated in Table 3. These results were based on a completed univariate analysis. In the adjusted analysis, male gender, decreased median household income, comorbidities, length of stay, Medicare payer, non-teaching hospital, rural hospital setting, and decreased hospital bed size were all associated with a higher likelihood of readmission (all p<0.05).

The inpatient costs of readmission were examined and then extrapolated across the entire TKA population. The overall median cost for each readmission was $6,753±175 (IQR). The mean cost of readmission was $10,465± 15,257 (SD). This was 36% of the overall total in-patient cost for the first 30 days from the index procedure. Extrapolating the readmission cost for the entire TKA population resulted in the readmission cost being 2% of the overall 30-day procedure cost.

DISCUSSION

The Centers for Medicare and Medicaid Services' CJR bundle has focused efforts on improving quality of care for patients receiving a TKA. A major focus in assessing quality of care and reducing cost includes readmission rates. Our study has three main findings with implications for health policy related to arthroplasty readmissions. First, the overall readmission rate was low at 4%. Second, the greatest clinical predictors of readmission were renal disease, congestive heart failure, and length of stay greater than 4 days. Finally, readmissions compromised 36% of the actual cost of care in the initial 30 days for readmitted patients and 2% of the cost for all patients receiving a TKA.

In comparison to other orthopaedic procedures, TKA readmission rates were low. This is in agreement with other national health service databases [14–22]. An analysis of the National Surgical Quality Improvement Program (NSQIP) database demonstrated that the average 30-day readmission rates for arthroplasty, the highest volume procedure, was 2.8%. The readmission rate for TKA's is lower than that of other orthopaedic procedures. For example, readmission rates for spine, posterior spinal instrumentation, and fusion for lumbar stenosis are approximately 10% and rates for orthopaedic procedures to address hip fractures are approximately 10-15% [23].

In addition, TKA readmission rates are dramatically below rates for other common non-orthopaedic surgical procedures. In cardiothoracic surgery, readmission rates following cardiac artery bypass grafting are 16% [24]. A range of colorectal procedures have readmissions between 10 to 25% [25]. Bladder cancer patients undergoing a radical cystectomy have readmission rates around 25%.[26] Other common procedures have readmission rates greater than TKA, including appendectomy at 6% [24]. The majority of these procedures are not elective as compared to TKA, resulting in an expected increase in readmissions as there are less options on patient selection for comorbidities. It would be expected that TKA has lower readmission rates. Here, these other procedures give an interesting perspective in the unique challenges required to lower readmission rates for TKA, where the rate of readmission is already very low.

Other groups have tried to identify modifiable and non-modifiable predictors of readmission to identify patients at increased risk, determine strategies to decrease risk, and set patient expectations in arthroplasty procedures. In our study, the greatest predictors of readmission were renal disease, congestive heart failure, and length of stay greater than 4 days (all had odds ratios > 1.5). These modifiable medical comorbidities suggest the importance of preoperative optimization to lower readmission rates. Patients with an increased length of stay should be identified as a high-risk group and followed closely after discharge. Many other large, national databases and institutional studies have observed the strong predictor in length of stay on readmission rates [27–30]. A longer length of stay implies that a patient had a more complicated course during their admission [31].

The interest in lowering TKA readmission rates is based on the logic that decreased readmissions provide increased quality of care. This assumes that, as readmissions decrease, patient outcomes improve and costs of each episode of care decrease. In our study, we analyzed the cost of care associated with each readmission. The mean cost of each readmission per readmitted patient was $10,465 and is in agreement with other data that report a TKA readmission cost of $10,200 [24]. In the readmitted population, this is one third of the overall cost; a major contributor of the final cost of care. Given these factors, distributing the cost of readmission across the entire population of individuals receiving a TKA results in a cost of readmission per all patients receiving a TKA of $365, only 2% of overall cost. This suggests from a cost perspective that spending more than this limit per patient to reduce readmission rates results in less cost savings. Our cost-benefit analysis suggests this limit is being approached. Previous work is in alignment with these findings. Based on institutional charge data, other groups have determined that the cost burden of TKA is approximately 2.8%. This suggests that the profit margin would have to be greater than 2.8% for the hospital to recover the cost of the procedure and all readmissions related to the procedure.

Similar to all research based on large data sets, this study is dependent on the accuracy of coding and recorded patient data. Our findings should be interpreted in the context of these limitations. We are examining readmission using administrative data, which does not contain all factors that could impact readmission, such as family support or driving distance from the hospital. However, we adjust for several factors that can influence readmissions, such as comorbidities. In addition, by using the NRD database, we are able to examine readmissions for TKA on a national level across all payers. To date, most studies examining TKA readmissions are based on Medicare databases or other administrative databases restricted to a single state or group of states. Our ability to conduct a complete cost analysis is limited as outpatient charge data after inpatient care was unavailable. Follow-up care has been reported to be approximately one third of the total cost of TKA [32]. Finally, our objective was to look at 30 day readmission rates. If analysis was extended to 90 days, the cost of readmissions would increase. Even with a conservative estimate of doubling readmission rates and cost, readmission cost would still be approximately 4% of the overall cost of the total knee arthroplasty for the entire population.

Hospital readmissions are being used as a key performance indicator to gauge the quality of care provided and to help control cost. Some hospital readmissions are avoidable, suggesting suboptimal initial care, but the validity of this assumption has been questioned [33–35]. Our study provides evidence that questions the focus on readmissions in this population. The overall low readmission rate as compared to other targeted diagnoses provide a limited return in quality improvement. Further from a cost perspective, readmission costs are a small portion of the overall cost (2%), given this low readmission rate. This implies that as the limit in these areas are being reached, other drivers of quality and cost that have larger rooms for improvement should be considered. Minimizing readmission rates are important for quality. Identifying the main factors for the other 98% of cost will result in significant improvement in quality and cost.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Demographic and clinical characteristics of patients undergoing total knee arthroplasty.

Characteristics	Total Knee Arthroplasty		P Value[a]
	Not readmitted	Readmitted[*]	
Number of patients (%)	216,649 (96)	7,816 (4)	
Mean age (SD)	67 (9)	66 (10)	<0.0001
Age group (%)			<0.0001
45 to 54	22,338 (10)	662 (8)	
55 to 64	62,831 (29)	1791 (23)	
65 to 74	83,464 (38)	2748 (35)	
75 to 84	42,557 (20)	2178 (28)	
85 or older	5459 (3)	437 (6)	
Sex (%)			<0.0001
Female	136,184 (63)	4456 (57)	
Male	80,465 (37)	3360 (43)	
Median household income, dollars (%)			<0.0001
37,999 or less	43,462 (20)	1781 (23)	
38,000 – 47,999	56,382 (26)	2034 (27)	
48,000 – 63,999	58,611 (27)	2082 (27)	
64,000 or more	54,793 (23)	1787 (23)	
Comorbidities[b] (%)			
Diabetes without complications	41,850 (19)	1858 (24)	<0.0001
Diabetes with complications	4651 (2)	269 (3)	<0.0001
Chronic pulmonary disease	31,081 (14)	1507 (19)	<0.0001
Rheumatologic disease	8778 (4)	376 (5)	0.0009
Renal disease	10,199 (5)	760 (10)	<0.0001
Congestive heart failure	4502 (2)	396 (5)	<0.0001
Obese or overweight[c]	50,121 (23)	1882 (24)	0.005
Length of stay (%)			<0.0001
2 days or less	61,785 (28)	1581 (20)	
3 day	110,213 (51)	3810 (49)	
4 day	23,096 (11)	1101 (14)	
5 days or more	21,555 (10)	1324 (17)	
Discharge destination (%)			<0.0001
Home	58,169 (27)	1515 (19)	
Home Care	97,613 (45)	3079 (39)	
Skilled nursing facility	60,867 (28)	3222 (41)	
Primary Payer (%):			<0.0001
Medicare	127,495 (59)	5369 (69)	

Characteristics	**Total Knee Arthroplasty**		**P Value**[a]
	Not readmitted	**Readmitted**[*]	
Non-Medicare	89,154 (41)	2447 (31)	
Location (%)			<0.0001
Urban	197,227 (91)	7093 (91)	
Rural[d]	19,422 (9)	723 (9)	
Hospital Type (%)			<0.0001
Teaching	122,897 (43)	3251 (42)	
Non-teaching	93,752 (57)	4565 (58)	
Hospital Size (%)			<0.0001
Small	38,395 (18)	1178 (15)	
Medium	58,406 (27)	2197 (28)	
Large	119,848 (55)	4441 (57)	

Abbrevations: SD, standard deviation;

[a]P values: T test for parametric continuous variables, Wilcoxon rank sum test for non-parametric continuous variables, and chi square for proportions.

[b]Represent seven most common comorbidities

[c]Indicated by an International Classification of Diseases, Ninth Revision code

[d]Rural includes micropolitan areas

[*]Represents readmission within 30 days.

Table 2

Characteristics of readmission stratified by payer

Characteristics			P Value[1]
	Medicare	Non-Medicare	
Number of patients (%)	132,864 (59)	91,601 (41)	<0.0001
Any readmission within 30 days (%)	5369 (4)	2447 (3)	<0.0001
Time to readmission (days)			
Mean (SD)	11.5 (9)	11.2 (9)	0.15
Median (IQR)	9 (4–18)	9 (4–18)	0.11
Time to readmission group (%)			0.07
1–7	2331 (43)	1119 (46)	
8–30	3038 (57)	1328 (54)	
Index length of stay, days (%)			<0.0001
2 (or less)	842 (19)	567 (28)	
3	2693 (62)	1117 (56)	
4 (or more)	791 (18)	310 (16)	
Discharge destination (%)			<0.0001
Home	844 (16)	671 (27)	
Home care	1924 (36)	1155 (47)	
Skilled nursing facility	2601 (48)	621 (25)	

Abbreviations: IQR, interquartile range; SD, standard deviation

[1]P value: Wilcoxon ranksum test for continuous variables, chi square for proportions

Table 3

Multivariable analysis of each predictor for 30-day readmission vs no readmission

	Adjusted OR* (95% CI)	p value
	Readmission vs No Readmission	
Age (years)		
45–54	Reference	
55–64	0.94 (0.86–1.03)	0.20
65–74	0.90 (0.81–1.00)	0.04
75–84	1.29 (1.16–1.44)	<0.0001
85 or older	1.91 (1.66–2.20)	<0.0001
Gender		
Female	Reference	
Male	1.36 (1.30–1.42)	<0.0001
Household Income		
$37,999 or less	Reference	
$38,000 – $47,999	0.90 (0.84–0.96)	0.002
$48,000 – $63,999	0.91 (0.85–0.97)	0.004
$64,000 or more	0.85 (0.80–0.91)	<0.0001
Comorbidities		
Diabetes without complications	1.17 (1.10–1.23)	<0.0001
Diabetes with complications	1.22 (1.07–1.40)	0.003
Chronic pulmonary disease	1.35 (1.28–1.43)	<0.0001
Rheumatologic disease	1.20 (1.07–1.33)	0.001
Renal disease	1.55 (1.42–1.68)	<0.0001
Congestive heart failure	1.59 (1.43–1.78)	<0.0001
Obesity	1.07 (1.01–1.30)	0.022
Length of Stay (days)		
2 or less	Reference	
3	1.29 (1.21–1.37)	<0.0001
4	1.69 (1.56–1.83)	0.001
5 or more	1.98 (1.83–2.14)	<0.0001
Medicare vs Non-medicare	1.27 (1.18–1.37)	<0.0001
Teaching vs. Non-teaching	0.95 (0.90–0.99)	0.03
Urban vs rural	1.06 (0.98–1.15)	0.15
Hospital Bedsize		
Small	Reference	
Medium	1.20 (1.12–1.30)	<0.0001
Large	1.15 (1.07–1.23)	<0.0001

*Adjusted for patient and hospital characteristics (age, gender, median household income, comorbidities, index length of stay, primary payer, hospital type, hospital size).