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Unplanned readmission after total joint arthroplasty: rates, reasons, and risk factors.

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Unplanned Readmission After Total Joint Arthroplasty: Rates, Reasons, and Risk Factors

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Background: There has been a major and alarming increase in readmission rates following total joint arthroplasty. With proposed changes in reimbursement policy, increased rates of unplanned readmission following arthroplasty will penalize providers. In particular, it has been proposed that specific complications—so-called ''zero-tolerance'' complications—are unacceptable and that their treatment will not qualify for reimbursement. The purpose of this study was to identify the incidence, causes, and risk factors for readmission following total joint arthroplasty.

Methods: An institutional arthroplasty database was utilized to identify those patients undergoing total knee or hip arthroplasty from January 2004 through December 2008. A total of 10,633 admissions for primary arthroplasty (5207 knees and 5426 hips) were identified. The same database was used to identify patients requiring an unplanned readmission within ninety days of discharge. Multivariate logistic regression was utilized to determine the independent predictors of readmission within ninety days.

Results: There were 591 unplanned readmissions within ninety days of discharge following 564 (5.3%) of the 10,633 admissions for total joint arthroplasty. The most common cause of readmission was joint-related infection, followed by stiffness. Black race, male sex, discharge to inpatient rehabilitation, increased duration of hospital stay, unilateral replacement, decreased age, decreased distance between home and the hospital, and total knee replacement were independent predictors of readmission within ninety days.

Conclusions: The high incidence of readmissions secondary to potential ''zero-tolerance'' events suggests that these are not easily preventable complications. In addition, longer hospitalization and discharge to an inpatient continued-care facility increased the risk of readmission.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Total joint arthroplasty has become an established, highly successful treatment for arthritis of the hip or knee[1,2], providing complete pain relief and return of joint function for most patients. By 2030, more than 3,000,000 total knee arthroplasties and 500,000 total hip arthroplasties are expected to be performed annually in the United States[3]. With this projected exponential growth in total joint arthroplasty, there are concerns of an overwhelming workload for the medical community and an increasing financial burden on society[4]. Despite the great success of arthroplasty, complications associated with surgery occur, leading to prolonged inpatient care, hospital readmission, or even reoperation[5-8]. Minimization of such complications, always an important goal for patients and their surgeons, would have a major impact on reducing the health-care burden.

Early readmission following total joint arthroplasty has been of particular recent interest. Limiting unplanned readmissions has become a driving force in many pay-for-performance compensation models, as such readmissions are unnerving for the patient and costly for the hospital[9,10]. Readmission rates of 4% to 8.5% (in sample sizes of 1802 to 1,453,493) have been reported within thirty days of discharge following total joint arthroplasty[7,11-13]. Cram et al. found a dramatic increase in readmission rates after both primary and revision total hip

arthroplasty in United States Medicare patients over the past two decades[7]. After decreasing from 9.8% to 7.4% from 1991 to 2004, readmission rates within ninety days after primary hip arthroplasty rapidly increased to 11.9% by 2008. The authors attributed this increase to changes in the duration of hospital stay and discharge disposition—an argument that has been contested[14]. In two separate analyses, Vorhies et al. found no association between the duration of stay and readmission rates in Medicare patients after hip and knee arthroplasty[11,12]. Bini et al. found that patients discharged to a skilled nursing facility after total hip arthroplasty had a greater risk of readmission compared with those discharged home (odds ratio = 1.9) after adjusting for sex, age, and level of health[15].

Although research has made substantial contributions to our knowledge regarding readmission in this population, many questions remain. Attempts to decrease future readmission rates will depend on an understanding of the causes of readmission and its predisposing factors. The goals of the present study were to determine the true incidence of unplanned readmission at a single large-volume institution, to determine the specific indications for these readmissions, and to identify predisposing factors for readmission.

Materials and Methods

After institutional review board approval, a query of our institution's electronic database of arthroplasty procedures identified 11,936 primary total joint arthroplasties performed from January 1, 2004, to December 31, 2008, at our urban, large-volume referral center for total joint arthroplasty. Admissions were excluded if the patient was transferred to another hospital for care (seven admissions) or died prior to discharge (nine admissions). This reduced the cohort to 11,915 total joint arthroplasty procedures performed in 10,633 admissions of 9686 patients. Of these 11,915 procedures, 5749 (48.2%) were total hip arthroplasties and 6166 (51.8%) were total knee arthroplasties. The 5749 total hip arthroplasties were performed during 5426 admissions, with 5103 (88.8%) of the joints replaced in a unilateral procedure and 646 (11.2%) replaced as part of simultaneous bilateral procedures. The 6166 total knee arthroplasties were performed during 5207 admissions, with 4248 (68.9%) of the joints replaced in a unilateral procedure and 1918 (31.1%) replaced as part of simultaneous bilateral procedures. The 9686 patients had a mean age of 63.7 years (range, eleven to ninety-eight years) at the time of the index admission, and 5475 (56.5%) were female.

All patients readmitted within ninety days of discharge following a primary total joint arthroplasty were identified. Readmissions were excluded from the analysis if they were indisputably planned readmissions (e.g., readmissions for a second stage of a staged bilateral arthroplasty) or unrelated to the total joint arthroplasty in question (e.g., arthroplasty of another joint).

The causes of unplanned readmissions were assessed to determine if they were related, clearly unrelated, or possibly related to the index surgery. In addition, these readmissions were classified into categories on the basis of the primary cause of the readmission. The proportion of readmissions due to each cause is reported, with emphasis on the top ten causes. An important fraction of the unplanned readmissions in this study resulted from knee stiffness after total knee arthroplasty. Knee stiffness is evaluated at the time of follow-up visits, and manipulation under anesthesia may be performed at between four and twelve weeks in patients who have not achieved 90° of flexion and who have symptomatic stiffness. This subgroup of patients was included in the analysis as unplanned readmissions despite the fact that the manipulation under anesthesia is performed as an outpatient procedure in the majority of such cases.

Finally, predictors of the requirement for least one readmission within thirty and ninety days following joint arthroplasty were identified by comparing the following factors between admissions that required readmission and those

that did not: age, type of joint (hip or knee), number of joints (simultaneous bilateral or unilateral), ethnicity, duration of stay, discharge disposition (home, skilled nursing facility, or inpatient rehabilitation), body mass index (BMI), Charlson Comorbidity Index[16], and distance between the patient's home and our institution. These factors were also investigated as potential independent predictors of specific causes of unplanned readmission within ninety days (infection, stiffness, and an aggregate of all other causes). The Charlson Comorbidity Index is an index that quantifies overall quality of health on the basis of comorbidities[16]. The modification by Deyo et al. allows for calculation of the Charlson Comorbidity Index with use of ICD-9 (International Classification of Diseases, Ninth Revision) billing codes and has been validated for predicting postoperative complications in patients undergoing orthopaedic spinal procedures[17]. The distance between the patient's home and our institution was calculated by converting the patient's zip code to longitude and latitude coordinates (utilizing gazetteer data from www.geonames.org) and then utilizing the Haversine equation to determine the distance[18].

Descriptive statistics were utilized to report the cohort demographics, incidence of readmission, and reasons for readmission. Bivariate analysis was utilized to describe the relationship between the possible predictive variables and readmission. To determine the independent predictors of readmission, outcomes were modeled with use of logistic regression. A full model was created utilizing all possible independent variables, and backward stepwise regression was then used to systematically prune the model. To overcome skewness of two of the variables, duration of stay and distance from the hospital, a logarithmic transformation was applied to these variables before the multivariate analysis was performed. Cases with missing data were excluded from the multivariate analysis; this was done for 787 (7.4%) of the 10,633 admissions (646 lacking the distance from the center and 141 lacking BMI data). Because of concerns regarding coding accuracy in the administrative database, an attempt to validate the calculation of the Charlson Comorbidity Index in this study was made. Of the readmitted patients, 505 had data available to calculate the Charlson Comorbidity Index at both the arthroplasty admission and the subsequent readmission. A paired t test showed no significant difference (p = 0.41) between the Charlson Comorbidity Index at the two times, indicating that the index was reproducible.

Source of Funding
No external funds were received for this study.

Results

The query of the institutional electronic database identified 698 readmissions within ninety days of discharge following total joint arthroplasty. After chart review, 591 (84.7%) of these 698 readmissions were identified as having been unplanned. The 591 unplanned readmissions occurred within the first ninety days following 564 (5.3%) of the 10,633 discharges and involved 562 (5.8%) of the 9686 patients. Of these 591 readmissions, 348 (58.9%) occurred within the first thirty days following 331 (3.1%) of the 10,633 discharges (Fig. 1). When stratified by distance from the treating institution, a noticeable association between higher unplanned readmission rates and close proximity was observed, with a thirty-day readmission rate of 5.53% and a ninety-day rate of 8.53% for patients residing within 10 km (Table I; p < 0.001 compared with greater distances at both time periods).

The most common cause of unplanned readmission within ninety days was joint-related infection. Superficial or deep infections caused 125 (35.9%) of the 348 readmissions within thirty days and 150 (25.4%) of the 591 readmissions within ninety days. Joint stiffness led to eight (2.3%) of the 348 readmissions within thirty days and 141 (23.9%) of the

TABLE I Rates of Unplanned Readmission Stratified by Distance from the Arthroplasty Hospital			
Distance *(km)*	All Admissions	Readmission within Thirty Days	Readmission within Ninety Days
0 to 10	1828	101 (5.53%)	156 (8.53%)
>10 to 20	2119	62 (2.93%)	107 (5.05%)
>20 to 50	3860	93 (2.41%)	164 (4.25%)
>50 to 100	1488	37 (2.49%)	72 (4.84%)
>100 to 200	472	13 (2.75%)	23 (4.87%)
>200	210	4 (1.90%)	7 (3.33%)

591 readmissions within ninety days. The next most common causes of readmission within ninety days were wound problems (10.5%, sixty-two), cardiovascular issues (6.6%, thirty-nine), and venous thromboembolism (VTE) (5.8%, thirty-four) (Table II). When unplanned readmissions were stratified by the type of joint arthroplasty, infection was the most common cause of readmission following total hip arthroplasty and knee stiffness was the most common cause of readmission following total knee arthroplasty (Figs. 2-A and 2-B). Of the 591 readmissions within ninety days, 484 (81.9%) were clearly related to the primary joint arthroplasty, thirty-one (5.2%) were clearly unrelated, and seventy-six (12.9%) were possibly related.

The rate of unplanned readmission was greater for knee arthroplasties than for hip arthroplasties within thirty days following discharge (p = 0.002) and within ninety days (p < 0.001) (Table III). Multivariate analysis indicated that male sex, increased duration of hospital stay, decreased distance to the hospital, and discharge to an inpatient facility rather than home were significant independent predictors of unplanned readmission within thirty days (see Appendix). Similarly, knee replacement, male sex,

Fig. 1

Burden of readmission (number of readmissions as a proportion of total primary arthroplasty admissions) as a function of time after discharge up to ninety days. Readmissions following knee and hip arthroplasty are reported separately.

Fig. 2-A
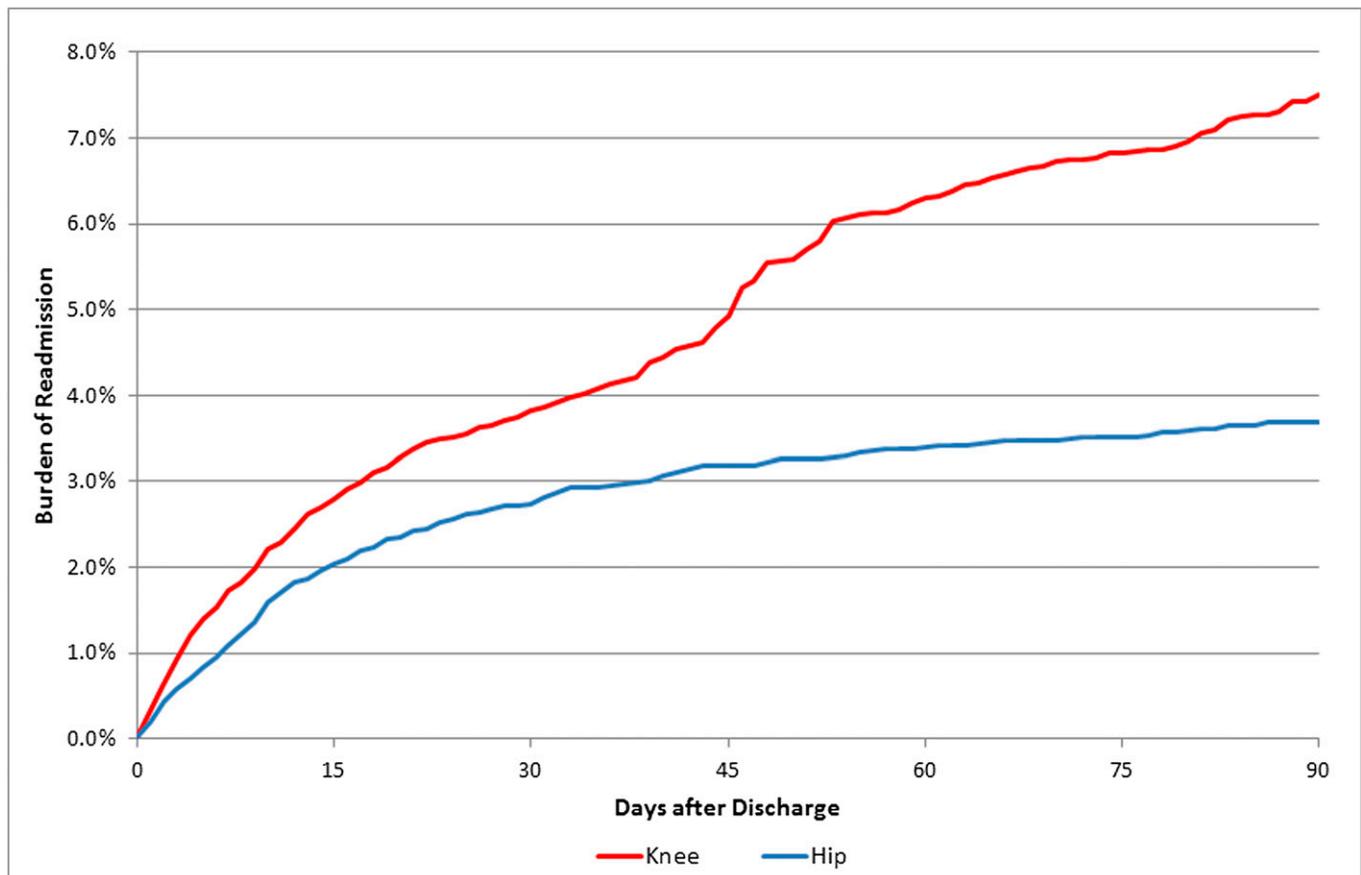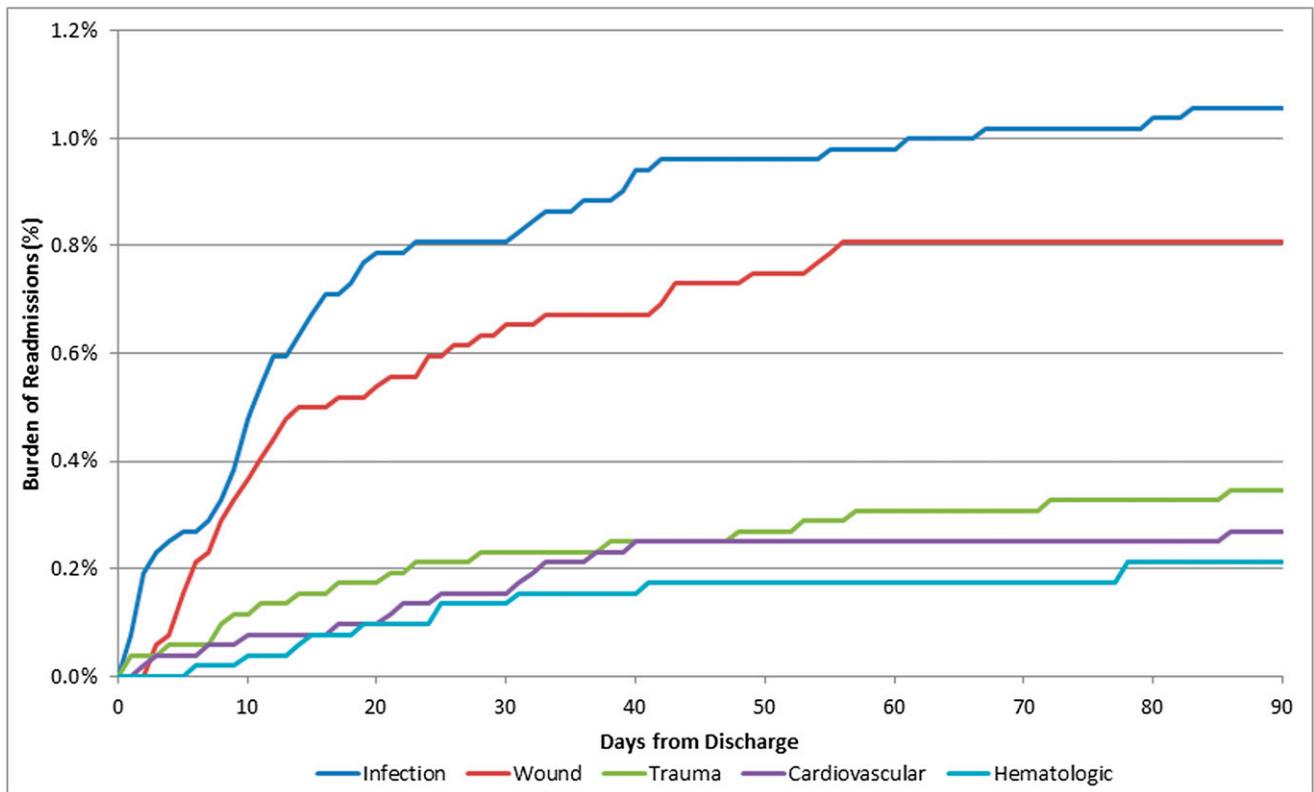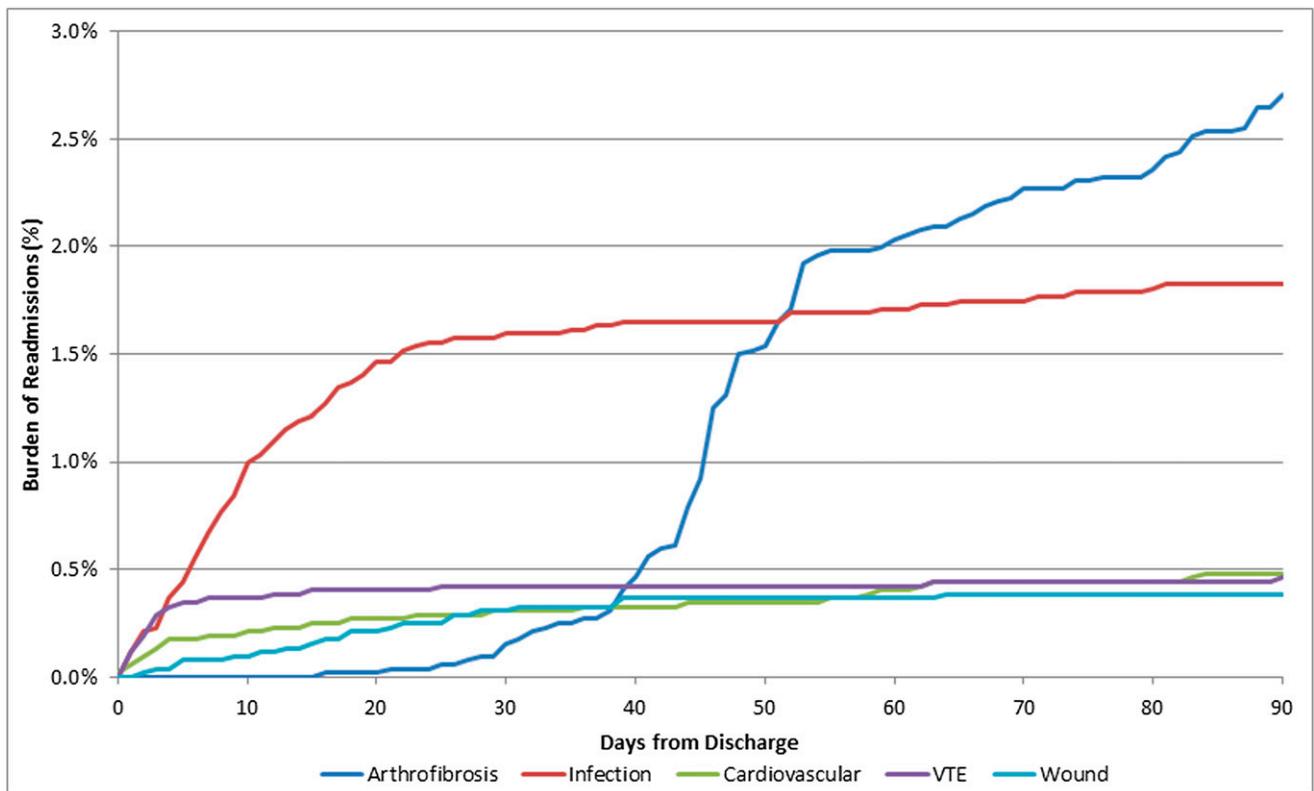

Fig. 2-B

Burden of readmission (number of readmissions as a proportion of primary arthroplasty admissions) as a function of time following hip arthroplasty (**Fig. 2-A**) and knee arthroplasty (**Fig. 2-B**) according to the cause of readmission. The five most common causes for each joint are shown.

TABLE II Rates of Unplanned Readmission for the Ten Most Common Indications for All Readmissions*

Cause†	All		Knee		Hip	
	Thirty Days, N = 348	Ninety Days, N = 591	Thirty Days, N = 199	Ninety Days, N = 391	Thirty Days, N = 149	Ninety Days, N = 200
Infection	125 (35.9)	150 (25.4)	83 (41.7)	95 (24.3)	42 (28.2)	55 (27.5)
Stiffness	8 (2.3)	141 (23.9)	8 (4.0)	141 (36.1)	0 (0)	0 (0)
Wound	50 (14.4)	62 (10.5)	16 (8.0)	20 (5.1)	34 (22.8)	42 (21.0)
Cardiovascular	24 (6.9)	39 (6.6)	16 (8.0)	25 (6.4)	8 (5.4)	14 (7.0)
VTE	32 (9.2)	34 (5.8)	22 (11.1)	24 (6.1)	10 (6.7)	10 (5.0)
Trauma	19 (5.5)	32 (5.4)	7 (3.5)	14 (3.6)	12 (8.1)	18 (9.0)
GI	17 (4.9)	27 (4.6)	10 (5.0)	17 (4.3)	7 (4.7)	10 (5.0)
Hematologic	20 (5.7)	26 (4.4)	13 (6.5)	15 (3.8)	7 (4.7)	11 (5.5)
Joint-unrelated infections	10 (2.9)	12 (2.0)	5 (2.5)	6 (1.5)	5 (3.4)	6 (3.0)
Psych/neuro	8 (2.3)	12 (2.0)	4 (2.0)	7 (1.8)	4 (2.7)	5 (2.5)

*The values are given as the number of readmissions, with the percentage of the number of admissions (N) in parentheses. †GI = gastrointestinal, and psych/neuro = psychiatric or neurological.

TABLE III Comparison of Potential Predictors of Readmission in Admissions That Did and Did Not Require Readmission

Variable	Thirty Days			Ninety Days		
	Yes, N = 331	No, N = 10,302	P Value*	Yes, N = 564	No, N = 10,069	P Value*
Knee joint†	190 (57.4)	5017 (48.7)	0.002	378 (67.0)	4829 (48.0)	<0.001
Simultaneous bilateral†	45 (13.6)	1237 (12.0)	0.38	67 (11.9)	1215 (12.1)	0.89
Male sex†	158 (47.7)	4390 (42.6)	0.06	257 (45.6)	4291 (42.6)	0.17
Charlson Index†			0.001			0.008
0	197 (59.5)	7239 (70.3)		358 (63.5)	7078 (70.3)	
1	102 (30.8)	2371 (23.0)		151 (26.8)	2322 (23.1)	
2	24 (7.3)	544 (5.3)		45 (8.0)	523 (5.2)	
≥3	8 (2.4)	148 (1.4)		10 (1.8)	146 (1.5)	
Age‡ (yr)	65.5 (64.1-66.9)	63.8 (63.6-64.0)	0.008	64.0 (62.6-65.4)	63.8 (63.6-64.1)	0.74
Duration of stay‡ (d)	5.1 (4.6-5.7)	3.9 (3.8-3.9)	<0.001§	4.8 (4.5-5.2)	3.8 (3.8-3.9)	<0.001§
Ethnicity†			<0.001			<0.001
White	256 (77.3)	8164 (79.2)		436 (77.3)	7984 (79.3)	
Black	60 (18.1)	1091 (10.6)		103 (18.3)	1048 (10.4)	
Hispanic	3 (0.9)	59 (0.6)		4 (0.7)	58 (0.6)	
Other	2 (0.6)	59 (0.6)		4 (0.7)	57 (0.6)	
Unknown	10 (3.0)	929 (9.0)		17 (3.0)	922 (9.2)	
BMI‡ (kg/m²)	31.3 (30.5-32.1)	30.2 (30.1-30.3)	0.003	31.1 (30.6-31.7)	30.2 (30.1-30.3)	0.001
Discharge			<0.001			<0.001
Home	128 (38.7)	5342 (51.9)		239 (42.4)	5231 (52.0)	
Inpatient	142 (42.9)	3553 (34.5)		229 (40.6)	3466 (34.4)	
Skilled nursing facility	61 (18.4)	1407 (13.7)		96 (17.0)	1372 (13.6)	
Distance to hospital‡ (km)	40.0 (25.3-54.6)	53.7 (50-57.5)	<0.001§	39.2 (30-48.5)	54.1 (50.3-57.9)	<0.001§

*Univariate analysis. †The values are given as the number of readmissions, with the percentage of the number of admissions (N) in parentheses. ‡The values are given as the mean, with the 95% confidence interval in parentheses. §Calculated after logarithmic transformation.

TABLE IV Multivariate Analysis of Predictors of Readmission within Ninety Days, Stratified by Cause of Readmission*						
	Infection		Stiffness†		All Others	
Variable	OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value
Knee joint	1.73 (1.19-2.52)	0.004	NA	NA	Excluded	NA
Unilateral	Excluded	NA	2.95 (1.16-5.39)	<0.001	Excluded	NA
Male sex	1.55 (1.09-2.20)	0.014	Excluded	NA	1.36 (1.05-1.75)	0.019
Charlson Index	Excluded	NA	0.65 (0.46-0.92)	0.015	1.14 (0.99-1.32)	0.062
Age (per yr)	Excluded	NA	0.93 (0.91-0.94)	<0.001	Excluded	NA
Duration of stay‡ (per day)	8.24 (3.42-19.86)	<0.001	Excluded	NA	10.71 (5.68-20.19)	<0.001
Ethnicity						
Black	Excluded	NA	Excluded	NA	1.0	NA
Hispanic	Excluded	NA	Excluded	NA	0.78 (0.18-3.33)	0.74
Other	Excluded	NA	Excluded	NA	0.55 (0.12-2.54)	0.44
Unknown	Excluded	NA	Excluded	NA	0.22 (0.10-0.49)	<0.001
White	Excluded	NA	Excluded	NA	0.66 (0.48-0.91)	0.01
BMI (per kg/m²)	1.04 (1.01-1.07)	0.002	0.93 (0.90-0.96)	<0.001	Excluded	NA
Discharge						
Home	Excluded	NA	Excluded	NA	1.0	NA
Inpatient	Excluded	NA	Excluded	NA	1.99 (1.50-2.64)	<0.001
Skilled nursing facility	Excluded	NA	Excluded	NA	1.43 (0.97-2.10)	0.07
Distance to hospital‡ (per km)	0.73 (0.51-1.04)	0.081	Excluded	NA	0.52 (0.40-0.66)	<0.001

*A reverse stepwise logistic regression was utilized. All variables included in the analysis are indicated below, including those excluded during the analysis. OR = odds ratio, CI = confidence interval, and NA = not applicable. †Includes only cases following total knee arthroplasty. Therefore, the type of joint was not included in this analysis. ‡Because of skewness of data for this variable, a logarithmic transformation was performed before the multivariate analysis.

unilateral replacement, decreased age, increased duration of hospital stay, decreased distance to the hospital, and discharge to an inpatient rehabilitation center rather than home were independent predictors of unplanned readmission within ninety days. White ethnicity and unknown ethnicity were protective against unplanned readmission within both thirty and ninety days compared with black ethnicity. Stratification by cause revealed substantial variations in the identity of the variables independently predictive of unplanned readmission within ninety days (Table IV). Multivariate analysis indicated that knee replacement, male sex, increased BMI, and increased duration of stay were independent predictors of readmission for infection. Independent predictors of readmission for stiffness were decreased age, unilateral arthroplasty, decreased Charlson Comorbidity Index, and decreased BMI. Independent predictors of unplanned readmission for a reason other than infection or stiffness included race (black compared with white or unknown) and discharge disposition (inpatient) as well as increased duration of stay, decreased distance to the hospital, and male sex.

Discussion

Early readmission following total joint arthroplasty has been targeted as a potential quality performance metric[19]. Therefore, it has become a factor in pay-for-performance compensation models[9,10]. With proposed changes in reimbursement policy, increased rates of unplanned readmission following arthroplasty will penalize providers. In particular, it has been proposed that specific complications—so-called "zero-tolerance" complications—are unacceptable and that their treatment will not qualify for reimbursement. As such, appreciating the characteristics of readmission following total joint arthroplasty is desirable. However, the results of efforts by many researchers to identify the incidence or causes of early readmission are conflicting and offer varying clinical guidance[7,9,11-13,15]. The aim of the present study performed at a single institution was to determine the incidence, causes, and predictors of unplanned readmission following primary total joint arthroplasty.

In the present analysis, 3.1% (331 of 10,663) and 5.3% (564 of 10,663) of admissions for joint arthroplasty required at least one readmission within thirty and ninety days, respectively. Even if only those patients residing within 10 km of the treating hospital are considered, the readmission rates within thirty days (5.5%) and ninety days (8.5%) following hip or knee arthroplasty were substantially lower than the corresponding rates of 8.5% and 11.9% reported following total hip arthroplasty in a national Medicare sample[7]. Vorhies et al. reported thirty-day readmission rates of 6.3% following total hip arthroplasty and 5.8% following total knee arthroplasty

in Medicare patients[11,12]. In contrast, ninety-day readmission rates of 2.9% following total hip arthroplasty and 3.5% following total knee arthroplasty were reported by Bini et al. in an analysis utilizing the Kaiser Permanente National Total Joint Replacement Registry[15]. The present analysis reaffirms that the readmission rate is not inconsequential. However, the differences in readmission rates among studies may be explained by the lower rate of readmission observed for both surgeons and hospitals with a higher annual volume of arthroplasty surgery[13].

The most common reason for unplanned readmission following total knee arthroplasty in the present study was stiffness (2.7%, 141 of 5207). A previous study from our institution likewise demonstrated that the most common reason for reoperation within one year following this procedure was stiffness, with >58% of the non-revision reoperations (involving 2.3% of all total knee arthroplasties) being manipulation under anesthesia[6]. Overall, the most common cause of unplanned readmission following total joint arthroplasty in the present study was joint-related infection (1.4%, 150 of 10,633). This finding of infection and stiffness as the most common causes of unplanned readmission contrasts sharply with the findings of Vorhies et al., who found cardiopulmonary disorders to be the primary cause for readmission within thirty days following both total hip arthroplasty and total knee arthroplasty[11,12]. Cardiovascular complications accounted for only 6.6% of ninety-day readmissions in the cohort in the present study. We believe that readmissions secondary to cardiovascular complications were mitigated by strict preoperative medical clearance (incorporating a multidisciplinary task force for identification and preoperative treatment of cardiovascular diseases) as well as close surveillance of these patients in the postoperative period and implementation of preventative measures. It is believed that adherence to a perioperative protocol for VTE prevention decreased this prevalence.

A major problem encountered by joint replacement surgeons stems from the growing incidence of arthroplasty-related infections[20]. Postoperative infection is a major complication with a growing impact, and the findings of the present study indicate that it cannot be easily avoided and thus does not fit a "zero-tolerance" policy. Similar reasoning applies to VTEs[5,21], which also represented a substantial portion of the readmissions in the present study. Studying the top ten indications for readmission, it is apparent that many of these are multifactorial and their incidence may therefore not provide an accurate representation of quality of care at the treating institution.

Predictors of unplanned readmission in the present analysis included patient demographics, information regarding the procedure, and the postoperative discharge disposition. Surprisingly, when all readmissions were aggregated, the Charlson Comorbidity Index was not a significant independent risk factor for unplanned readmission. This finding is not without precedence; previous analyses were unable to demonstrate a significant effect of comorbidities in predicting the all-cause readmission rate[14,15]. However, when readmissions were limited to exclude stiffness or joint infection, the Charlson Comorbidity

Index exhibited a trend toward being an independent predictor of unplanned readmission. Vorhies et al. reported that the duration of stay has been decreasing over the past decade while readmission rates have remained stable[11,12]. This conflicts with the analysis by Cram et al., who found markedly increased readmission rates in the face of a decreased duration of hospital stay[7]. The relationship between increased duration of stay and readmission observed in the present study is possibly a reflection of postoperative complications that lead to an increased duration of hospital stay and a subsequent increased risk of readmission. Bini et al. specifically identified an increased risk of readmission of patients discharged to a skilled nursing facility instead of home[15]. Similarly, the present study revealed an increased risk with discharge to an inpatient facility, primarily for readmissions not related to infection or stiffness.

Several theories could explain this increased risk relationship. For instance, patients may be monitored more closely by rehabilitation personnel than at home, improving detection of complications that lead to readmission. It is also possible that skilled facilities, acting out of fear of legal repercussions, seek input from the arthroplasty center more frequently and at a lower threshold, leading to a greater need for assessment of the patients and possible readmission. At our institution, patients who cannot comply properly with postoperative rehabilitation protocols are discharged to rehabilitation centers. It is possible that these patients are more bed-bound and less active, predisposing them to an increased rate of complications and increased readmission. Finally, the ease of transporting patients back to the index hospital from a rehabilitation center increases the likelihood of readmission. As knee replacement was an independent predictor of readmission for infection, the association of knee replacement with early readmission for all unplanned causes may reflect the more frequent development of stiffness and infection in the knee than in the hip[20,22,23]. Subanalyses of the most common causes of unplanned readmission, namely infection and stiffness, revealed different independent predictors for each. Interestingly, decreased age, decreased BMI, and improved health status were predictors of readmission for stiffness. These findings suggest that treatment for stiffness is selected more frequently for healthier, younger, and slimmer patients in whom decreased knee motion may have the greatest impact. In contrast, the independent predictors of readmission for infection were consistent with those in the literature on predictors of infection following arthroplasty[20,23-25].

Several limitations of the present study must be recognized. First, this study was retrospective, making it difficult to identify the cause of readmission and its relationship to the primary arthroplasty in some cases. In addition, at times it was not possible to identify ethnicity, BMI, or distance from the institution. Second, the data set used for this analysis may have missed those patients who sought treatment for a complication at another institution. Therefore, the incidence of readmission reported here may be an underestimate. This incidence, however, is within the range of readmission rates reported in the literature[7,9,11-13,15]. In addition, we report the readmission rate stratified by distance from the hospital, as this is most likely the

strongest factor in selection of the readmitting hospital. Third, because of the retrospective nature of the study, identifying specific comorbidities that might contribute to readmission was difficult. Therefore, the Charlson Comorbidity Index was utilized to quantify the general health of patients and was investigated as a potential predictor of readmission. For this reason, the reproducibility of this index in subsequent admissions was confirmed. Finally, analysis of predictors of ninety-day readmission for specific indications resulted in a diminished sample size. This may have led to a type-II error in establishing predictors of readmission for stiffness or infection.

Readmission following total joint arthroplasty is not inconsequential. At our high-volume institution, 5.3% of the procedures required unplanned readmission within ninety days. The most common causes of the readmissions were joint-related infection, knee stiffness, wound-related issues, and cardiovascular problems. The risk of readmission was magnified with discharge to inpatient rehabilitation and with prolonged hospitalization. It is imperative that measures to limit these complications, through appropriate prophylactic measures and prevention of increased duration of hospital stay and discharge to an inpatient facility, be effectively implemented to limit the physical and psychological impact of readmission on patients and the financial burden to society.

Appendix

eA Tables showing the results of the unstratified multivariate analysis and comparing the cases that required rehospitalization for particular causes with those that did not are available with the online version of this article as a data supplement at jbjs.org. ■

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