Which Factors Predict 30-Day Readmission After Total Hip and Knee Replacement Surgery?

Cynthia L. Williams¹, George Pujalte², Zhuo Li³, Rock P. Vomer II⁴, Maruoka Nishi⁵, Lisa Kieneker⁶, Cedric J. Ortiguera⁷

¹. Therapeutics, Brooks College of Health, University of North Florida, Jacksonville, USA  ². Department of Family Medicine and Department of Orthopedics, Mayo Clinic, Jacksonville, USA  ³. Biostatistics Unit, Mayo Clinic, Jacksonville, USA  ⁴. Family Medicine, Eastern Virginia Medical School, Norfolk, USA  ⁵. Department of Family and Community Medicine, University of Oklahoma, Tulsa, USA  ⁶. Family Medicine, Mayo Clinic, Jacksonville, USA  ⁷. Orthopedic Surgery, Mayo Clinic, Jacksonville, USA

Corresponding author: Rock P. Vomer II, vomerrp@evms.edu

Abstract

Background

The Centers for Medicare and Medicaid Services enacted the Hospital Readmissions Reduction Program to impose penalties for diagnoses with high readmission rates. Despite several elective orthopedic procedures being included in this program, readmission rates have not declined, and associated costs have reached critical levels for total knee and total hip arthroplasty. Readmissions drastically impact patient outcomes. There are many known contributors to patient readmission rates, including infection, pain, and hematomas. However, evidence is inconclusive regarding other aspects, such as demographics, insurance, and discharge disposition. The purpose of this manuscript is to 1) measure hospital readmission rates for total knee and total hip arthroplasty, 2) evaluate the causes of readmissions, and 3) provide a predictive profile of risk factors associated with hospital readmissions.

Methods

Patients who underwent total knee or total hip arthroplasty were identified through a retrospective database review. An electronic chart review extracted data concerning patient demographics, comorbidities, surgical information, 30-day outcomes, and reasons for 30-day readmissions. Continuous and categorical variables were assessed with the Wilcoxon rank-sum test and the Chi-square test, respectively.

Results

A total of 6,065 patients were included, with 269 (4.4%) having at least one surgery-related 30-day readmission. No differences in readmission were noted with age, sex, or ethnicity; however, differences were found in weight and body mass index. Statistically significant comorbidities were heart failure, chronic obstructive pulmonary disease, dialysis, and alcohol use or abuse.

Conclusion

Our research indicated that surgery type, length of stay, and heart failure most significantly impacted 30-day readmission rates. By assessing readmission rates, we can take steps to optimize care for non-elective surgeries that will improve patient outcomes and cost-effectiveness.

Introduction

Hospital 30-day readmission rates (i.e., hospital admissions that occur within 30 days of initial discharge, excluding patients who were in the hospital for less than 24 hours) have increased to fiscally unsustainable proportions. Given this problem, in 2012, the Centers for Medicare and Medicaid Services enacted the Hospital Readmissions Reduction Program to impose payment penalties for diagnoses with high hospital readmission rates. In 2014, this list of diagnoses was expanded to include orthopedic surgeries, such as total knee arthroplasty (TKA) and total hip arthroplasty (THA). However, the expansion of the Hospital Readmissions Reduction Program has not led to great declines in readmissions [1-4].

Unplanned 30-day hospital readmissions for total joint replacements have reached critical numbers; they account for 55% of unplanned orthopedic readmissions, costing an average of approximately $38,953 for TKA and $36,038 for THA per readmission and contributing $18.75 billion annually to Medicare expenditures [5,6]. Thirty-day readmission rates are 5.56% and 3.21% for inpatient TKA and THA, respectively, and 4% and 2.95% for outpatient TKA and THA, respectively [7]. This significantly affects...
health care costs, as a 1% increase in hospital readmission rates is associated with an average 1.2% increase in non-reimbursable hospital expenses [5].

In light of similar studies, it can be reasonably concluded that physicians may affect changes to quality outcomes when they understand how patient characteristics, comorbidities, and decision-making influence readmissions. Hospital readmission rates for TKA and THA considerably influence patient outcomes and hospital quality. Studies have shown that surgical site infections, pain, and hematomas are significant contributors to readmissions, as is discharge disposition, which refers to the place of postoperative care, usually a skilled nursing facility or the patient’s home, where home health care is provided [6–9]. Bernatz and colleagues suggest that patients admitted to a skilled nursing facility after surgery are more likely to be readmitted to the hospital than those discharged to their homes with home health care [10].

However, other studies in the literature are inconclusive about the influence of insurance, discharge disposition, and length of stay (LOS) on hospital readmissions [9–12]. Some researchers speculate that the shorter the hospital stay, the more likely hospital readmission [9,10,13]. Basques et al. have found that men are more likely than women to suffer adverse events and are at an increased risk of hospital readmission [14]. Similarly, Black American patients, patients with lower incomes, treated at lower-volume hospitals or insured by Medicare or Medicaid, and patients who have reduced access to hospitals (i.e., because they live longer distances away) are more likely to experience increased readmission rates [7,15].

As demand and costs continue to increase for TKA and THA, readmissions have become an enormous concern for health care institutions, which seek to provide high-quality, value-based care while reducing costs. As the population ages and obesity rates continue to rise in the US, the demand for TKA and THA is expected to surpass four million cases by 2030 [16]. Therefore, developing a comprehensive understanding of the most at-risk populations is critical for effectively using resources to reduce hospital readmission rates and mitigate costs. Such knowledge of this issue will allow providers to develop a predictive profile, which can be used to target resources more effectively, lessening readmissions for the most at-risk patients. Therefore, the purpose of this research is to provide a profile of the patients who are most at risk for unexpected 30-day hospital readmissions. The study’s objectives are to 1) measure hospital readmission rates for TKA and THA, 2) evaluate the causes of readmissions, and 3) provide a predictive profile of risk factors associated with hospital readmissions.

Materials And Methods

A retrospective administrative database review was performed to identify patients who had undergone TKA or THA at Mayo Clinic between January 1, 2013, and December 31, 2018. This study was approved by the Mayo Clinic Institutional Review Board. Data were de-identified and stored in a secure Health Insurance Portability and Accountability Act-compliant database. Patients were identified by current procedural terminology for TKA, revision TKA, THA, and revision THA. Only unique patients aged 18 or older were included, such that the first episode per patient during the study period was included to mitigate selection bias caused by patients with multiple hospital readmissions for qualifying procedures. Patient demographics, baseline comorbidities, surgical information, 30-day outcomes, and reasons for 30-day readmission were retrieved from the electronic chart review. Patients who received non-elective surgery are defined TKA/THAs for fractures/trauma; elective surgeries are TKA/THA due to osteoarthritis. BMI values were classified as follows: underweight, 10<BMI<18.5; normal, 18.5≤BMI<25; overweight, 25≤BMI<30; and obese, 30≤BMI<50. Continuous variables were summarized as mean (SD) and median (range), while categorical variables were reported as frequency (percentage). Continuous variables were compared between patients with and without 30-day readmission via the Wilcoxon rank-sum test, and categorical variables were compared using the Chi-square ($\chi^2$) test.

To fit and validate the prediction model, the whole cohort was randomly split into a training set and a validation set at an 8:2 ratio. The random forest method was used to select variables of importance in the training set. A multivariable logistic regression model was fit based on the most important variables that also showed statistical significance. Validation was conducted by applying the model estimate to the validation set and calculating the area under the curve. All tests were two-sided, and R 3.6.2 statistical software (R Foundation for Statistical Computing, Vienna, Austria) was used for data analysis.

Missing data occurred for a few predictors, including ethnicity, body mass index (BMI), smoking status, and alcohol usage. When smoking or alcohol usage was not mentioned, we assumed patients did not use them. For ethnicity and BMI, a complete case analysis was used.

Results

After chart reviews and the removal of duplicate patients, 6,065 patients were included in the analysis. As noted in Tables 1–2, the median (range) age was 68 (18–101) years, and 2.571 (42.4%) were men while 3.494 (57.6%) were women.
| Characteristic                      | No 30-day readmission (n=5,796) | At least 1 30-day readmission (n=269) | Total (N=6,065) | P-value<sup>a</sup> |
|------------------------------------|----------------------------------|---------------------------------------|-----------------|---------------------|
| Age at surgery, years              |                                  |                                       |                 | 0.20                |
| Mean (SD)                          | 67.4 (13.2)                      | 68.6 (14.6)                           | 67.4 (13.3)     |                     |
| Median (range)                     | 68.2 (18.2-101.1)                | 68.8 (20.0-98.5)                      | 68.2 (18.2-101.1)|                     |
| Sex, n (%)                         |                                  |                                       |                 | 0.45                |
| Male                               | 2,451 (42.3)                     | 120 (44.6)                            | 2,571 (42.4)    |                     |
| Female                             | 3,345 (57.7)                     | 149 (55.4)                            | 3,494 (57.6)    |                     |
| Ethnicity, n (%)                   |                                  |                                       |                 | 0.91                |
| Missing                            | 167                              | 9                                     | 176             |                     |
| Hispanic or Latino                 | 180 (3.2)                        | 8 (3.1)                               | 188 (3.2)       |                     |
| Not Hispanic or Latino             | 5,449 (96.8)                     | 252 (96.9)                            | 5,701 (96.8)    |                     |
| Height, cm                         |                                  |                                       |                 | 0.16                |
| Mean (SD)                          | 168.9 (11.2)                     | 167.6 (10.6)                          | 168.8 (11.2)    |                     |
| Median (range)                     | 168.0 (123.0-463.0)              | 167.0 (126.4-191.0)                   | 168.0 (123.0-463.0)|                     |
| Weight, kg                         |                                  |                                       |                 | 0.003               |
| Missing                            | 225                              | 16                                    | 241             |                     |
| Mean (SD)                          | 86.6 (25.5)                      | 82.6 (23.5)                           | 86.4 (25.4)     |                     |
| Median (range)                     | 84.8 (31.8-780.0)                | 80.0 (38.8-173.8)                     | 84.7 (31.8-780.0)|                     |
| BMI, n (%)                         |                                  |                                       |                 | <0.001>             |
| Missing                            | 304                              | 20                                    | 324             |                     |
| Normal                             | 1,141 (20.8)                     | 60 (24.1)                             | 1,201 (20.9)    |                     |
| Underweight                        | 65 (1.2)                         | 11 (4.4)                              | 76 (1.3)        |                     |
| Overweight                         | 1,793 (32.6)                     | 82 (32.9)                             | 1,875 (32.7)    |                     |
| Obese                              | 2493 (45.4)                      | 96 (38.6)                             | 2,589 (45.1)    |                     |

**TABLE 1: Patient characteristics and demographics**

BMI - body mass index

<sup>a</sup> p-values arise from either a Kruskal-Wallis or a χ^2 goodness-of-fit test
Comorbidity | No 30-day readmission (n=5,796) | At least 1 30-day readmission (n=269) | Total (N=6,065) | P-value\(^a\)
---|---|---|---|---
Diabetes | | | | 0.14
No | 4,931 (85.1) | 220 (81.8) | 5,151 (84.9) |
Yes | 865 (14.9) | 49 (18.2) | 914 (15.1) |
Heart failure | | | | \(<0.001\)
No | 5,367 (92.6) | 223 (82.9) | 5,590 (92.2) |
Yes | 429 (7.4) | 46 (17.1) | 475 (7.8) |
COPD | | | | 0.03
No | 5,178 (89.3) | 229 (85.1) | 5,407 (89.2) |
Yes | 618 (10.7) | 40 (14.9) | 658 (10.8) |
Dialysis | | | | \(<0.001\)
No | 5,774 (99.6) | 263 (97.8) | 6,037 (99.5) |
Yes | 96 (1.7) | 9 (3.3) | 105 (1.7) |
Smoking status | | | | 0.06
Current or former | 2,585 (44.6) | 104 (38.7) | 2,689 (44.3) |
Never | 3,211 (55.4) | 165 (61.3) | 3,376 (55.7) |
Have you had alcohol abuse? | | | | 0.04
No | 5,700 (98.3) | 260 (96.7) | 5,960 (98.3) |
Yes | 96 (1.7) | 9 (3.3) | 105 (1.7) |

**TABLE 2: Comorbidities**

COPD - chronic obstructive pulmonary disease

\(^a\) p-values arise from either a Kruskal-Wallis or a \(\chi^2\) goodness-of-fit test

Two hundred sixty-nine (4.4%) patients had at least one surgery-related 30-day readmission. The comparison of demographics, comorbidities, and surgical variables between patients with and without readmission showed that there were no notable differences for at least one surgery-related 30-day readmission in age, sex, ethnicity, or height. However, significant differences were noted in risk factors such as weight with a mean of 82.6±23.5 for readmitted patients vs. 86.6±25.5 for not readmitted patients (p<0.003). Underweight patients were much more likely to have readmission (14.5%) compared to patients in other categories (normal 5%, overweight 4.4%, and obese 3.7%, p<0.001, Table 1). Statistically significant differences were also observed for heart failure (HF): readmission rate was 9.7% with heart failure vs. 4% without HF (p<0.001), chronic obstructive pulmonary disease (COPD): 6.1% with COPD vs. 4.2% without COPD (p=0.03), dialysis: 21.4% with dialysis vs. 4.4% without dialysis (p<0.001), and alcohol use or abuse: 8.6% with alcohol abuse vs. 3.7% without alcohol abuse (p<0.04), see Table 2.

Of those readmitted, the main causes for readmission were orthopedic etiology, with 183 events (68%). Statistical significance in LOS was noted for patients with and without readmission (mean 3.1±1.9 vs. 2.6±1.7 days, p<0.001), see Table 3. Etiologic causes for first and second 30-day readmission, respectively, were mainly orthopedic (68% and 50%), medical (13.4% and 16.7%), and gastrointestinal (5.6% and 16.7%) as shown in Tables 4, and the variables of importance, as determined by random forest method, are listed in Table 5. The means decrease accuracy were 26.6 for surgery type, 26.6 for LOS, 6.7 for COPD, and 6.5 for heart failure (see Table 5, Figure 1). Table 6 presents the results of the final multivariable logistic regression model. Surgery type, LOS, and heart failure made the most significant impact on 30-day readmission outcomes. The area under the curve of the model was 0.69, indicating moderate predictive power.
| Surgical variable | No 30-day readmission (n=5,796) | At least 1 30-day readmission (n=269) | Total (N=6,065) | P-value\(^a\) |
|-------------------|--------------------------------|-------------------------------------|----------------|-------------|
| Type, n (%)       |                                |                                     |                | <0.001>     |
| Elective          | 5,145 (88.8)                  | 195 (72.5%)                         | 5,340 (88.0)   |             |
| Emergent          | 651 (11.2)                    | 74 (27.)                            | 725 (12.0)     |             |
| Length of stay, days |                               |                                     |                | <0.001>     |
| Mean (SD)         | 2.6 (1.7)                     | 3.1 (1.9)                           | 2.6 (1.7)      |             |
| Median (range)    | 2.0 (0.0-46.0)                | 3.0 (0.0-13.0)                      | 2.0 (0.0-46.0) |             |
| Year, n (%)       |                                |                                     |                | 0.49        |
| 2013              | 1,067 (18.4)                  | 48 (17.8)                           | 1,115 (18.4)   |             |
| 2014              | 965 (16.6)                    | 53 (19.7)                           | 1,018 (16.8)   |             |
| 2015              | 933 (16.1)                    | 42 (15.6)                           | 975 (16.1)     |             |
| 2016              | 877 (15.1)                    | 40 (14.9)                           | 917 (15.1)     |             |
| 2017              | 975 (16.8)                    | 35 (13.0)                           | 1,010 (16.7)   |             |
| 2018              | 979 (16.9)                    | 51 (19.0)                           | 1,030 (17.0)   |             |

**TABLE 3: Surgery summary**

\(^a\) p-values arise from either a Kruskal-Wallis or a \(\chi^2\) goodness of fit test.
| Variable                                      | Total   |
|----------------------------------------------|---------|
| Number of readmissions within 30 days, n (%) |         |
| 1                                            | 251 (93.3) |
| 2                                            | 17 (6.3)   |
| 3                                            | 1 (0.4)    |
| First 30-day readmission                     |         |
| Category, n (%)                              |         |
| Unknown                                      | 1 (0.4)  |
| Cardiac                                      | 3 (1.1)  |
| Gastrological                                | 2 (0.7)  |
| Gastrointestinal                             | 15 (5.6) |
| Hematologic                                  | 1 (0.4)  |
| Medical                                      | 36 (13.4)|
| Neurologic                                   | 6 (2.2)  |
| Orthopedic                                   | 183 (68.0)|
| Pulmonological                               | 20 (7.4) |
| Renal                                        | 1 (0.4)  |
| Surgical                                     | 1 (0.4)  |
| LOS, days                                    |         |
| Mean (SD)                                    | 3.5 (3.9)|
| Median (range)                               | 3.0 (0.0-28.0)|
| Second 30-day readmission (n=18)             |         |
| Category, n (%)                              |         |
| Gastrointestinal                             | 3 (16.7)|
| Hematologic                                  | 1 (5.6)  |
| Medical                                      | 3 (16.7) |
| Orthopedic                                   | 9 (50.0) |
| Pulmonological                               | 1 (5.6)  |
| Renal                                        | 1 (5.6)  |
| LOS, days                                    |         |
| Mean (SD)                                    | 3.1 (2.1)|
| Median (range)                               | 3.0 (0.0-7.0)|

**TABLE 4: Thirty-day readmissions (n=269)**

LOS - length of stay
### TABLE 5: Variable of importance by the random forest method

| Variable          | Mean decrease accuracy |
|-------------------|------------------------|
| BMI category      | -3.5                   |
| Heart failure     | 6.5                    |
| COPD              | 6.7                    |
| Dialysis          | -0.4                   |
| Surgery type      | 26.6                   |
| LOS               | 26.1                   |
| Smoking status    | -1.6                   |
| Alcohol abuse     | -3.0                   |

BMI - body mass index; COPD - chronic obstructive pulmonary disease; LOS - length of stay
The predicted probability of 30-day readmission was calculated in the validation set based on the same predictors and the model coefficients estimated from the logistic regression model in the training set. The calculated probability ranged from 0.03 to 0.2. Patients were divided into the following groups: 1) predicted risk of 0.032 or less; 2) predicted risk greater than 0.032, but not greater than 0.033; 3) predicted risk greater than 0.033, but not greater than 0.053; 4) predicted risk greater than 0.050, but not greater than 0.100; and 5) predicted risk greater than 0.100, but not greater than 0.200. The readmission rate revealed an increasing trend as the predicted risk increased (Table 7, Figure 3), which confirmed that the model worked relatively well in the validation set.

### TABLE 7: Readmission by predicted risk group in the validation set

| Predicted risk group, n (%) | No 30-day readmission (n=1,093) | At least 1 30-day readmission (n=55) | P-value<sup>a</sup> |
|-----------------------------|---------------------------------|-------------------------------------|---------------------|
| Missing                     | 1                               | 0                                   | <0.001              |
| (0.000-0.032]               | 195 (17.9)                      | 5 (2.5)                             |                     |
| (0.032-0.033]               | 407 (97.4)                      | 11 (2.6)                            |                     |
| (0.033-0.050]               | 336 (95.7)                      | 15 (4.3)                            |                     |
| (0.050-0.100]               | 125 (89.3)                      | 15 (10.7)                           |                     |
| (0.100-0.200]               | 29 (76.3)                       | 9 (23.7)                            |                     |

<sup>a</sup> p-values arise from either a Kruskal-Wallis or a χ² goodness-of-fit test
Discussion

The findings suggest that surgery type, LOS, and heart failure most significantly impacted 30-day readmission rates. At the researchers’ institution, the 30-day hospital readmissions rate after TKA and THA was 4.4%, and most of the sampled readmissions were surgery-related (68.2%). These findings align with similar studies reporting 30-day readmission rates and reasons for readmissions [1,7,16,17]. Patient variables found to be associated with a significant risk of readmissions included weight, BMI, heart failure, chronic obstructive pulmonary disease, dialysis, and a history of alcohol use or abuse. Further examination of weight and BMI indicated that being underweight (BMI<18.5) was also a significant characteristic related to hospital readmissions. Underweight patients, particularly if they were also undernourished, tended to experience adverse outcomes after orthopedic surgery [18]. This may have been because their bodies lacked the nutrients needed to heal after the procedures [19]. However, the current research on BMI and its association with surgical adverse effects is unclear. Ali and colleagues [18] suggest that high BMI was an independent predictor of readmission; however, Scully et al. [19] suggest that categorical BMI cannot be clearly delineated, but that overweight (BMI 25.0–29.9) and obese patients (BMI ≥30) suffer different adverse effects than patients who are underweight. Maurer et al. indicate that there is a relationship between BMI, degree of trauma, and hospital readmissions and that BMI should not be considered in isolation [16,20]. It is well established in the existing literature that comorbidities increase the risk for postoperative adverse effects. Heart failure and chronic obstructive pulmonary disease are strongly associated with postoperative adverse effects, with relative risk increasing 4.5 and 2.5, respectively [21-23]. This aligns with a previous study that suggested that trauma and patients with comorbidities such as myocardial infarction, diabetes, and hypertension also had increased readmissions rates [24]. Patients with cardiovascular disease may benefit from more intense preoperative cardiology input or closer monitoring postoperatively. Dialysis and alcohol use or abuse are also notable contributors [22,25]. When readmission occurred in our study population, the average LOS increased from 3.1 to 3.5 days.

The study also indicates that LOS and non-elective surgeries were significant contributors to hospital readmissions in our study group. Patients with longer LOS were significantly more likely to be readmitted. However, LOS could also be determined by preoperative comorbidities and, to a lesser extent, patient characteristics (e.g., age, sex, smoking status) [26]. Thus, this group could also benefit from physician-directed optimization prior to surgery. Patients who undergo non-elective total joint arthroplasty have inferior outcomes compared to those who have elective surgeries [27]. In our study, non-elective orthopedic surgeries accounted for 27.5% of all 30-day hospital readmissions.

Despite legislative support for quality improvements, more must be done. During our study period, readmission rates in the US did not show significant improvement [26,28]. This underscores the concept that legislation alone is insufficient to significantly impact readmissions [1].

Studies of predictive models advocate for using them to aid decision-making that considers comorbidities, aftercare, and patient education and communication [6]. Advanced analytics and predictive models will provide surgeons with the ability to preoperatively assess patients who may or may not be good candidates for elective procedures, optimize care for those who require non-elective surgeries, and plan appropriately.
for patients who will need more preoperative or postoperative care [27]. Health care providers should integrate cost-effective measures, combining patient characteristics and risk factors. Surgeons may use such information to guide treatment decisions that optimize quality outcomes and provide patient-specific care in preoperative counseling, education, and clinical support.

Predicting the future can be difficult. However, by preoperatively using common patient information, the study team believes that a suitably accurate model can be made to aid decision-making that optimizes patient outcomes. As this model was developed to predict 30-day hospital readmissions, it may not be useful for predicting mortality or morbidity outcomes. However, these outcomes are vital, and future studies should consider similar models to predict other outcomes of interest [28]. The interactions among variables and their total contributions to the models should also be considered. For example, researchers could examine the interactions between BMI, disease severity, and hospital readmissions or determine the extent to which LOS can be modified without sacrificing quality or access to care.

Although this study had the advantage of using a large database, its retrospective nature may have introduced selection bias. It is also possible that data may have been missing from electronic health records. Some of the potential predictors, such as smoking status and alcohol consumption, came from patient surveys, which were not as complete and accurate as the other data. This created difficulty in assessing the true association between these variables and 30-day readmission outcomes. We were also unable to identify whether readmissions occurred in other institutions outside of our network. Administrative data were used to classify the International Statistical Classification of Diseases, Tenth Revision, and all nonsurgical causes of readmission were assigned based on these codes. While coding is performed by trained personnel, it may not reflect the primary reason for readmission but rather another major concern treated during hospitalization. It is important to note that patients included in this study were cleared for surgery, so they were already screened for risk. This may have affected the prediction process. The literature largely supports the use of predictive models to aid surgeons in decision-making; however, we recognize that the variables in our study are not exclusive.

Conclusions
Our research indicated that surgery type, length of stay, and heart failure most significantly impacted 30-day readmission rates. Once identified preoperatively, they can be adequately treated by physicians or specialists. By equipping medical professionals with added information, the authors aim to give them the ability to lessen readmission occurrence. This has practical implications for the clinical and economic effects of hospital and physician decisions.

Additional Information
Disclosures
Human subjects: Consent was obtained or waived by all participants in this study. Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Acknowledgements
The authors would like to acknowledge the contributions of Haytham Helmi, MD, now with the University of Florida, and Ellen M. Benitah Bulbarelli, MD.

References
1. Kurtz SM, Lau EC, Ong KL, Adler EM, Kolisek FR, Manley MT: Has health care reform legislation reduced the economic burden of hospital readmissions following primary total joint arthroplasty? J Arthroplasty. 2017, 32:5274-85. 10.1016/j.arth.2017.05.059
2. Postrka MA, Fonarow GC, Allen LA, et al.: The hospital readmissions reduction program: nationwide perspectives and recommendations: a JACC: heart failure position paper. JACC Heart Fail. 2020, 8:1-11. 10.1016/j.jchf.2019.07.012
3. Thirukumarapn CR, McGarry BE, Glance LG, Ying M, Ricciardi BF, Cai X, Li Y: Impact of hospital readmissions reduction program penalties on hip and knee replacement readmissions: comparison of hospitals at risk of varying penalty amounts. J Bone Joint Surg Am. 2020, 102:60-7. 10.2106/JBJS.18.01501
4. Workman KK, Angerett N, Lippe B, Shin A, King S: Thirty-day unplanned readmission after total knee arthroplasty at a teaching community hospital: rates, reasons, and risk factors. J Knee Surg. 2020, 33:206-12.
5. Bosco JA 3rd, Karkerny AJ, Hutzler LJJ, Slover JD, Iorio R: Cost burden of 30-day readmissions following Medicare total hip and knee arthroplasty. J Arthroplasty. 2014, 29:903-5. 10.1016/j.arth.2013.11.006
6. Maslow J, Hutzler L, Slover J, Bosco J: Etiology of readmissions following orthopaedic procedures and...
medical admissions. A comparative analysis. Bull Hosp Jt Dis. 2015, 75:269-75.

7. Carey K, Morgan JR, Lin MY, Kain MS, Crevey WR: Patient outcomes following total joint replacement surgery: a comparison of hospitals and ambulatory surgery centers. J Arthroplasty. 2020, 35:5-11. 10.1016/j.arth.2019.08.041

8. Bernatz JT, Tuering IL, Hetzel S, Anderson PA: What are the 30-day readmission rates across orthopaedic subspecialties?. Clin Orthop Relat Res. 2016, 474:838-47. 10.1007/s11999-015-4602-5

9. Dailey EA, Cizik A, Kasten J, Chapman JR, Lee MJ: Risk factors for readmission of orthopaedic surgical patients. J Bone Joint Surg Am. 2015, 95:1012-9. 10.2106/JBJS.K.01569

10. Keswani A, Tasi MC, Fields A, Lovy AJ, Moucha CS, Bozic KJ: Discharge destination after total joint arthroplasty: an analysis of postdischarge outcomes, placement risk factors, and recent trends. J Arthroplasty. 2016, 31:1155-62. 10.1016/j.arth.2015.11.044

11. Kirkland PA, Barfield WR, Demos HA, Pellegreni VD Jr, Drew JM: Optimal length of stay following total joint arthroplasty to reduce readmission rates. J Arthroplasty. 2020, 35:505-8. 10.1016/j.arth.2019.08.059

12. Basques BA, Bell JA, Sershon RA, Della Valle CJ: The influence of patient gender on morbidity following total hip or total knee arthroplasty. J Arthroplasty. 2018, 33:545-9. 10.1016/j.arth.2017.09.014

13. Ricciardi BF, Liu AY, Qiu B, Myers TG, Thirukumaran CP: What is the association between hospital volume and complications after revision total joint arthroplasty: a large-database study. Clin Orthop Relat Res. 2019, 477:1221-31. 10.1097/CORR.0000000000000684

14. Etkin CD, Springer BD: The American Joint Replacement Registry— the first 5 years. Arthroplasty Today. 2017, 3:67-9. 10.1016/j.artd.2017.02.002

15. Çetin Aslan E, Ağırbaş İ: Rates, causes, and types of readmissions after total joint arthroplasty. Turk J Phys Med Rehabil. 2020, 66:31-9. 10.5606/tfmr.2020.3916

16. Maurer E, Wallmeier V, Reumann MK, et al.: Risk of malnutrition in orthopedic trauma patients with surgical site infections is associated with increased morbidity and mortality - a 3-year follow-up study. Injury. 2020, 51:2219-29. 10.1016/j.injury.2020.06.019

17. Cross MB, Yi PH, Thomas CF, Garcia J, Della Valle CJ: Evaluation of malnutrition in orthopaedic surgery. J Am Acad Orthop Surg. 2014, 22:193-9. 10.5435/JAAOS-22-03-193

18. Ali AM, Loeffler MD, Aylin P, Bottle A: Predictors of 30-day readmission after total knee arthroplasty: analysis of 566,323 procedures in the United Kingdom. J Arthroplasty. 2019, 34:242-8. 10.1016/j.arth.2018.10.026

19. Scully W, Piuzzi NS, Sodhi N, et al.: The effect of body mass index on 30-day complications after total hip arthroplasty. Hip Int. 2020, 30:125-34. 10.1177/1077558720921622

20. Ayers DC, Fehring TK, Odum SM, Franklin PD: Using joint registry data from FORCE-TJR to improve the accuracy of risk-adjustment prediction models for thirty-day readmission after total hip replacement and total knee replacement. J Bone Joint Surg Am. 2015, 97:668-71. 10.2106/JBJS.N.00889

21. Hustead JW, Goltzer O, Bohl DD, Fraser JF, Lara NJ, Spangehl MJ: Calculating the cost and risk of comorbidities in total joint arthroplasty in the United States. J Arthroplasty. 2017, 32:355-61. 10.1016/j.arth.2016.07.025

22. Phruetthiphat OA, Otero JE, Zamponga B, Vasta S, Gao Y, Callaghan JJ: Predictors for readmission following primary total hip and total knee arthroplasty. J Orthop Surg (Hong Kong). 2020, 28:1-8. 10.1177/2309498020959160

23. Rosan S, Sabe H, Buller LT, Law TY, Roche MW, Hernandez VH: Medical comorbidities impact the episode-of-care reimbursements of total hip arthroplasty. J Arthroplasty. 2017, 32:5802-7. 10.1016/j.arth.2017.02.059

24. Chona D, Lakomkin N, Bulkas C, et al.: Predicting the post-operative length of stay for the orthopaedic trauma patient. Int Orthop. 2017, 41:859-68. 10.1007/s00264-017-3425-2

25. Strosberg DS, Housley BC, Vanquez D, Rushing A, Steinberg S, Jones C: Discharge destination and readmission rates in older trauma patients. J Surg Res. 2017, 207:27-32. 10.1016/j.jss.2016.07.015

26. Chen M, Grabowski DC: Hospital readmissions reduction program: intended and unintended effects. Med Care Res Rev. 2019, 76:445-60. 10.1177/1077558717744601

27. Li BY, Urish KL, Jacobs BL, et al.: Inaugural readmission penalties for total hip and total knee arthroplasty procedures under the Hospital Readmissions Reduction Program. JAMA Netw Open. 2019, 2:e1916008. 10.1001/jamanetworkopen.2019.16008

28. Greiwe RM, Spanyer JM, Nolan JR, Rodgers RN, Hill MA, Harm RG: Improving orthopedic patient outcomes: a model to predict 30-day and 90-day readmission rates following total joint arthroplasty. J Arthroplasty. 2019, 34:2544-8. 10.1016/j.arth.2019.05.051