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Factors Affecting Readmission Cost After Primary Total Knee Arthroplasty in Michigan

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ABSTRACT

Background: The increasing readmission risk of primary total knee arthroplasty (TKA) represents a significant economic burden and public health challenge. Many have investigated the predictors of readmissions after TKA while little work has studied the associated readmission costs. This article investigated the factors affecting readmission cost after primary TKA at the time of initial discharges using clinical and resource-use information and compared the factors between 2 payer groups (Medicare-or-Medicaid and non-Medicare-nor-Medicaid groups).
Methods: We used data from the Michigan State Inpatient Database of the Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality. We identified readmissions after primary TKA in 2012 using *International Classification of Diseases, Ninth Revision*, code 81.54. Total readmission cost was modeled using multivariate regression to identify predictors.
Results: Of 1358 readmissions after primary TKA, 949 were in the Medicare-or-Medicaid group, and 409 were in the non-Medicare-nor-Medicaid group. The overall mean and median total readmission costs were $9335 (standard deviation $10,528) and $6810, respectively. Significant predictors of total readmission cost for the Medicare-or-Medicaid group included length of stay ($P < .001$), discharge disposition ($P < .001$), number of chronic conditions ($P = .001$), and total cost of initial admission ($P < .001$). Only total cost of initial admission was significant in predicting total readmission cost for the non-Medicare-nor-Medicaid group ($P < .001$).
Conclusion: Total cost of initial admission was a significant predictor of total readmission cost in both Medicare-or-Medicaid and non-Medicare-nor-Medicaid groups, independent of length of stay and number of chronic conditions.

Knee arthroplasty was the most frequently performed inpatient operating room procedure in the United States in 2012 [1]. The increases in both the volume of primary total knee arthroplasty (TKA) and the readmission rate after TKA have become a health care challenge in the United States. In 2011, more than 711,000 cases of knee arthroplasty were performed, and the number is projected to increase to 3.48 million cases by 2030 [2]. Owing to the large number of primary procedures, even a small increase in the risk of readmission represents a large number of readmissions nationwide. Thus, the 30-day readmission risk, which has risen from 4.2% to 5.0% between 1991 and 2010 [3], represents a significant public health challenge. The Centers for Medicare & Medicaid Services have approached this by adding TKA in the calculation of the readmissions payment adjustment factor of a hospital, which links hospital payment reductions to readmissions [4].

Many investigators have looked into the predictors of readmission after TKA [3,5–13]. Predictors of readmission reported in multiple studies included age, length of stay, gender, body mass index, number of comorbidities and complications, clinical diagnoses, and race [3,6–12]. Other predictors reported included discharge disposition, severity of illness, duration of operating procedure, and payer status [5,8,11,13]. Several investigators have studied the economic impact TKA has on the health care

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community, including identifications of predictors leading to high direct medical costs [14], diminished profit due to unplanned readmission after TKA [15,16], and the impact of increasing demand on economic burden [17]. However, little work has been done to predict readmission costs for TKA patients.

Our study investigated the predictors of readmission cost from clinical and resource-use information at the time of initial discharge. The main goal of our study was to identify predictors of total readmission cost after primary TKA. A secondary goal was to compare the predictors of total readmission cost for Medicare-or-Medicaid group and non-Medicare-nor-Medicaid group. We hypothesized that the predictive factors would remain the same for both groups of patients.

Methods

The data source used was the Michigan 2012 State Inpatient Database from the Healthcare Cost and Utilization Project (HCUP) sponsored by the Agency for Healthcare Research and Quality. The database contained clinical and resource-use information of inpatient discharge records, at the same time ensuring the protection of patient privacy. The database included more than 97% of hospital discharges, providing a representative data set for the study [18].

The readmission window was defined as 3 months within the month of discharge, that is, any admission after the 3-month window was not considered a readmission. This readmission window approximated the 90-day readmission window commonly considered in other studies. The medical record number and the coded hospital identifier were jointly used to uniquely identify a readmitted patient. Our study included all patients who underwent primary TKA in the year 2012 with *International Classification of Diseases, Ninth Revision*, *Clinical Modification,* code 81.54 and were readmitted within the defined readmission window. These inclusion criteria resulted in 1721 patients or 6.86% of the 25087 patients who underwent primary TKA. The demographic features of the readmitted patients, stratified by Medicare-or-Medicaid and non-Medicare-nor-Medicaid, are outlined in Table 1. Owing to the unavailability of hospital costs in the database, which contained total hospital charge for each record, the hospital costs were estimated by applying the cost-to-charge ratios supplied by HCUP as companion data to the database. The cost-to-charge ratios were calculated using all-payer, inpatient cost and charge information from the detailed reports by hospitals to CMS [19].

Independent predictive factors of readmission total cost were identified by a multivariate log-linear regression analysis, with the response variable being the log-transformed readmission total cost and predictors being binary and linear variables. The identified predictive factors were variables that independently contributed to the variation of the response variable. The log-transformed response variable was selected to handle the problems of the heteroscedasticity and skewness in the readmission total cost data [20]. The regression model was then applied to the readmitted patients, stratified by Medicare-or-Medicaid and non-Medicare-nor-Medicaid.

Significant predictors were identified in the multivariate regression analysis by the associated P value <.005. We assessed the regression model by analyzing the residuals.

Results

The mean (standard deviation) readmission total cost was $9335 ($10,527); the median was $6810. The readmission cost data were found to be positively skewed, and a log transformation was necessary to mitigate the skewness.

We identified the independent significant predictors from the multivariate regression models. For all readmitted patients, significant predictors included length of stay ($P < .001$), discharge disposition ($P < .001$), number of chronic conditions ($P = .001$), and total cost of initial admission ($P < .001$). For the Medicare-or-Medicaid group, all predictors remained significant (P values < .005); and for the non-Medicare-nor-Medicaid group, only total cost of the initial admission remained significant ($P < .001$). The coefficients and P values of the predictors in the models are shown in Table 2.

Owing to the log transformation of response variable, the traditional interpretation of regression model coefficients as incremental changes in cost was not possible. Consequently, the results are illustrated through the presentation of hypothetical clinical scenarios (Table 3). The baseline scenario was developed using an average profile of the readmitted patients, with the 4

Table 1
Demographic Features of Readmitted Patients.

Variable	Overall (N = 1721)	Medicare-or-Medicaid (n = 1226)	Non-Medicare-Nor-Medicaid (n = 495)
Age (y)	68.1 ± 10.9 (11-94)	71.6 ± 9.7 (34-94)	59.4 ± 8.7 (11-87)
Gender			
Female	1068 (62.1%)	795 (64.8%)	273 (55.2%)
Male	653 (37.9%)	431 (35.2%)	222 (44.8%)
Race			
White	1236 (83.8%)	872 (82.9%)	364 (86.1%)
Black	160 (10.9%)	122 (11.6%)	38 (9.0%)
Other	79 (5.4%)	58 (5.5%)	21 (5.0%)
Missing	*246*	*174*	*72*
Discharge disposition			
Routine (Home)	259 (15.1%)	146 (11.9%)	113 (22.8%)
Short-term hospital	9 (0.5%)	6 (0.5%)	3 (0.6%)
Long term, residential, and other care	924 (53.7%)	727 (59.3%)	197 (39.8%)
Home health	528 (30.7%)	346 (28.2%)	182 (36.8%)
Against medical care	1 (<0.1%)	1 (<0.1%)	0 (0%)
Length of stay (d)	3.5 ± 2.1 (0-25)	3.6 ± 2.3 (0-25)	3.3 ± 1.4 (1-14)
Number of chronic conditions	6.3 ± 2.8 (0-20)	6.6 ± 2.9 (0-19)	5.5 ± 2.7 (1-20)
Number of comorbidities	2.8 ± 1.8 (0-11)	3.0 ± 1.8 (0-11)	2.4 ± 1.7 (0-11)
Initial total cost (USD)	15,980 ± 7324 (n = 1376, *Missing* = *345*)	16,008 ± 7694 (N = 960, *Missing* = *266*)	15,915 ± 6399 (N = 416, *Missing* = *79*)

USD, U.S. Dollars.
Continuous variables reported in mean ± standard deviation (range).
Categorical variables reported in occurrence (percentage of population).
Entries in italic represent number of missing values.