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Socioeconomic Risk Adjustment Models for Reimbursement Are Necessary in Primary Total Joint Arthroplasty

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ABSTRACT

Background: Alternative payment models, such as bundled payments, aim to control rising costs for total knee arthroplasty (TKA) and total hip arthroplasty (THA). Without risk adjustment for patients who may utilize more resources, concerns exist about patient selection and access to care. The purpose of this study was to determine whether lower socioeconomic status (SES) was associated with increased resource utilization following TKA and THA.

Methods: Using the Michigan Arthroplasty Registry Collaborative Quality Initiative database, we reviewed a consecutive series of 4168 primary TKA and THA patients over a 3-year period. We defined lowest SES based upon the median household income of the patient's ZIP code. Demographics, medical comorbidities, length of stay, discharge destination, and readmission rates were compared between patients of lowest SES and higher SES.

Results: Patients in the lowest SES group had a longer hospital length of stay (2.79 vs 2.22 days, $P < .001$), were more likely to be discharged to a rehabilitation facility (27% vs 18%, $P < .001$), and be readmitted to the hospital within 90 days (11% vs 8%, $P = .002$) than the higher SES group. Multivariate analysis revealed that lowest SES was an independent risk factor for all 3 outcome variables (all $P < .001$).

Conclusion: Patients in the lowest SES group utilize more resources in the 90-day postoperative period. Therefore, risk adjustment models, including SES, may be necessary to fairly compensate hospitals and surgeons and to avoid potential problems with access to joint arthroplasty care.

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are among the largest and fastest growing health care expenditures [1-3], accounting for $6.6 billion in Medicare reimbursements for the year 2013 alone [4]. As the demand for THA and TKA continue to increase, recent health care reform measures in the United States have tasked hospitals, surgeons, and policymakers to reduce costs while maintaining quality in joint arthroplasty care. Programs such as the Medicare Bundled Payment for Care Improvement initiative and the Comprehensive Care for Joint Replacement model aim to align incentives to contain costs through bundling payments for an episode-of-care from the time of surgery through 90 days post discharge. While early results of these alternative payment models

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(APMs) seem promising [5-7], concerns exist about patient selection and subsequent access to care [8].

Several studies have evaluated socioeconomic disparities in both treatment and outcomes after THA and TKA, demonstrating that patients of lower socioeconomic status (SES) are more likely to have a longer length of stay (LOS) and be discharged to a rehabilitation facility [9-11]. Despite evidence that patients from disadvantaged backgrounds require more resources at an increased cost, payers have are et to provide adjustment in reimbursement based on SES. With the increasing prevalence of APMs, a recent survey of arthroplasty surgeons revealed fears that surgeons and hospitals would be disincentivized to perform THA and TKA on patients of lowest SES and may exacerbate disparities in care [8]. Using median household income of ZIP code of residence as a proxy for SES and identifying its effect on short-term outcomes after primary joint arthroplasty has yet to be addressed in the literature.

The purpose of this study was to evaluate the effect of lowest SES on outcome variables resulting in higher cost care after THA and TKA. We asked if patients from lowest SES were more likely to have a longer LOS, higher 90-day readmission rate, and were more likely to be discharged to a rehabilitation facility than those patients from higher SES. Secondary study questions included whether lowest SES resulted in these higher episode-of-care outcome variables differed between THA and TKA patients. Finally, in order to identify patients who should be included in future risk adjustment models, we sought to identify independent risk factors for prolonged LOS, readmission, and discharge disposition to a higher level of care.

Methods

We queried the Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) database for all patients undergoing a primary total hip or total knee at a 2-hospital health system from May 2012 through September 2015. The study was approved by and conducted according to our institutional review board standards. No external funding was received for this study. However, support for the MARCQI is provided by Blue Cross and Blue Shield of Michigan and Blue Care Network as part of the Blue Cross and Blue Shield of Michigan Value Partnerships program. We reviewed prospectively collected data in the hospital's MARCQI total joint registry searching for all patients with the International Classification of Diseases, Ninth Revision (ICD-9) codes 81.51 (THA) and 81.54 (TKA). Patients who underwent an arthroplasty procedure for fracture, infection, trauma, or malignancy were excluded from the study. Patient demographic data, medical comorbidities, LOS, discharge disposition, and 90-day readmission rates were noted. The data were specifically abstracted by 2 nurse clinical data abstractors from the quality department and the MARCQI registry.

Medical comorbidities included obesity if the patient's preoperative body mass index (BMI) was greater than 35 kg/m^2. Preoperative diagnosis of diabetes mellitus was noted from the database. Chronic kidney disease was defined as a patient's preoperative glomerular filtration rate less than 60 mL/min/1.73 m^2. Glomerular filtration rate for each patient was calculated using preoperative creatinine levels and patient age [12]. Discharge disposition from the index hospital admission was classified as home, home with home health assistance, skilled nursing facility, or inpatient rehabilitation facility. As a measure of SES, the patient's ZIP code of residence was documented and paired with each ZIP code's median household income according to the 2014 report from the United States Census Bureau [13]. Patients residing in a ZIP code representative of the bottom quartile of ZIP code median household income were defined as of low SES.

Of the 4168 consecutive patients included in the study, 2870 patients (69%) underwent primary TKA while 1298 patients (31%) underwent primary THA. The mean age of all patients in the study was 66.5 years (range, 24-95 years). There were 2677 females (64%) in the study. The mean LOS was 2.31 days (range, 0-54 days).

There were 821 patients (20%) who were discharged to a rehabilitation or skilled nursing facility, 2116 (50%) of patients who were discharged to home with home health assistance and 1231 (30%) patients who were discharged home. In addition, 349 patients (8%) were readmitted to the hospital within 90 days while 453 patients (10%) returned to the emergency department within 90 days. A total of 723 patients (17%) resided in a ZIP code in the bottom quartile of the US median household income and classified as lowest SES. Complete demographic for the study population is detailed in Table 1.

Statistical Analysis

An a priori power analysis was first performed to determine the appropriate sample size. Based upon a recent large cohort study citing a 90-day readmission rate for primary TKA and THA of 14% [14], we would need to enroll a total of 3946 patients in order to achieve a power of 0.80 to detect a 3% difference in 90-day readmission rate, assuming a type I error rate of 0.05. Descriptive statistics were calculated for all patients in the study population (Table 1). Continuous variables such as age and BMI were analyzed using a Student *t* test. Categorical data were analyzed with a chi-square test to determine any difference between the low SES status and higher SES groups (Table 2). We then performed a similar subgroup analysis to detect any difference in readmission rate, discharge disposition, or LOS among TKA and THA patients (Table 3). To control for confounding variables, a multivariate logistic regression analysis was performed to identify independent risk factors for 90-day readmission, extended hospital LOS (greater than or equal to 4 days), and discharge disposition to a rehabilitation facility (Tables 4-6). Statistical significance for all tests was set at 0.05. Statistical analysis was performed using Excel (Microsoft, Redmond, WA) and SPSS (IBM, Armonk, NY).

Results

We found no difference in the mean age (67.0 vs 66.4 years, $P = .151$), mean BMI (32.5 vs 32.0 kg/m^2, $P = .071$), or the type of

Table 1
Descriptive Statistics of All Patients in the Study Population.

Demographic Data (n = 4168)	Number
Mean age (y)	66.5
Gender (%)	
Female	2677 (64)
Male	1491 (36)
Mean BMI (kg/m^2)	32.1
Mean household income in ZIP code of residence (USD)	$63,302
Bottom quartile of median household income (%)	723 (17)
Surgery (%)	
Total knee arthroplasty	2870 (69)
Total hip arthroplasty	1298 (31)
Preoperative diabetes (%)	678 (16)
Preoperative kidney disease (%)	385 (9)
Preoperative obesity with BMI >35 kg/m^2 (%)	1224 (29)
Mean length of stay (d)	2.31
Discharge disposition (%)	
Home	3347 (80)
Skilled nursing or rehabilitation facility	821 (20)
Return to ER within 90 d (%)	453 (11)
Readmission within 90 d (%)	349 (8)

BMI, body mass index; ER, emergency room.

Table 2
Data Comparing Patients Undergoing Primary total joint arthroplasty by Socioeconomic Status.

Patient Characteristic	Lowest SES N = 723	Higher SES N = 3445	*P* Value
Mean age (y)	67.0	66.4	.151
Gender (%)			
Female	528 (73)	2149 (62)	<.001
Male	195 (27)	1296 (38)	
Mean BMI (kg/m^2)	32.5	32.0	.071
Surgery (%)			
Total knee arthroplasty	492 (68)	2378 (69)	.639
Total hip arthroplasty	231 (32)	1067 (31)	
Preoperative diabetes (%)	152 (21)	526 (15)	<.001
Preoperative kidney disease (%)	83 (11)	302 (9)	.026
Preoperative obesity with BMI >35 kg/m^2 (%)	239 (33)	985 (29)	.017
Mean length of stay (d)	2.79	2.22	<.001
Discharge disposition (%)			
Home	525 (73)	2822 (82)	<.001
Skilled nursing or rehabilitation facility	198 (27)	623 (18)	
Return to ER within 90 d (%)	105 (15)	348 (10)	.001
Readmission within 90 d (%)	82 (11)	267 (8)	.002

Patients residing in a ZIP code in the bottom quartile of median household income were compared with those in the top 3 quartiles.
SES, socioeconomic status; BMI, body mass index; ER, emergency room.

surgery (68% vs 69% knees, $P = .639$) between the lowest SES and higher SES groups. There was also no difference in the proportion of elderly patients over 75 years of age (25% vs 24%, $P = .920$). There were, however, more females in the lowest SES group (73% vs 62%, $P < .001$). The lowest SES group also had more patients with a preoperative diagnosis of diabetes mellitus (21% vs 15%, $P < .001$) and chronic kidney disease (11% vs 9%, $P = .026$). Patients in the lowest SES group had a longer hospital LOS (2.79 vs 2.22 days, $P < .001$) and were more likely to be discharged to a rehabilitation facility (27% vs 18%, $P < .001$) than the higher SES group. They were also more likely to return to the emergency department (ED) within 90 days (15% vs 10%, $P = .001$) and be readmitted to the hospital within 90 days (11% vs 8%, $P = .002$). Data comparing patients grouped by SES are displayed in Table 2.

In the subgroup analysis, patients in the lowest SES were more likely to be discharged to a rehabilitation/extended care facility that underwent both primary TKA (27% vs 17%, $P < .001$) and primary THA (29% vs 20%, $P = .003$). Similarly, lowest SES patients had longer mean LOS in the TKA (2.89 vs 2.20 days, $P < .001$) and THA groups (2.59 vs 2.25, $P < .001$). While lowest SES patients in the TKA group had a higher 90-day readmission (11% vs 7%, $P = .001$) and return to ED rate (16% vs 10%, $P < .001$), we could not detect a significant difference between the lowest SES patients and higher SES patients in the THA group for readmissions (12% vs 9%, $P = .304$) or return to ED (12% vs 9%, $P = .221$) with the numbers available. Complete subgroup analysis of TKA and THA patients by SES is shown in Table 3.

In the multivariate analysis, lowest SES was found to be an independent risk factor for 90-day readmission rate (odds ratio [OR] 1.50, 95% confidence interval [CI] 1.15-1.96, $P = .003$), extended hospital LOS 4 days or greater (OR 2.34, 95% CI 1.78-3.07, $P < .001$), and discharge to a rehabilitation facility (OR 1.64, 95% CI 1.34-2.01, $P < .001$). Both age greater than 75 years and obesity were also independent risk factors for all 3 outcome measures. Detailed results from multivariate logistic regression analysis are shown in Tables 4-6.

Discussion

While other studies have examined disparities in care among patients from disadvantaged backgrounds undergoing primary TKA and THA [9,10,15,16], we present a consecutive series of 4168 patients identifying lowest SES (using ZIP code as a proxy for SES) as an independent risk factor for extended hospital LOS, readmission rate, and discharge disposition to a higher level of care. With the increasing incidence of bundled payment programs without risk adjustment reimbursement models, health care stakeholders have a financial incentive to provide care to patients at the lowest cost. And with post-discharge care accounting for over one-third of episode-of-care costs [17], patients who are identified as likely to be discharged to rehabilitation facility or be readmitted to the hospital within 90 days of surgery may face problems with access to joint arthroplasty care in the near future. We hope our study can prompt further investigation into adjusting reimbursement models for TKA and THA based upon SES.

Our study does have several limitations. Although data were retrospectively reviewed from the MARCQI database, we did not use administrative data. Data are tracked and specifically abstracted, as every chart was opened. Our data were limited to a single 2-hospital health system in Michigan over a 3-year period. While the urban, suburban, and rural patients included in the study represent a heterogeneous patient population, our results may not be generalizable to the rest of the country. Patients in one hospital had a higher mean household income than the other hospital ($94,164 vs $49,974) that may confound the results. Both hospitals, however, are affiliates of the same health system with standardized

Table 3
Subgroup Analysis of TKA and THA Patients Grouped by Socioeconomic Status.

Patient Characteristic	Total Knee Arthroplasty, N = 2870			Total Hip Arthroplasty, N = 1278		
	Lowest SES N = 492	Higher SES N = 2378	*P* Value	Lowest SES N = 231	Higher SES N = 1067	*P* Value
Mean age (y)	67.7	66.7	.036	65.4	65.6	.814
Gender (%)						
Female	380 (77)	1547 (65)	<.001	148 (64)	602 (56)	.032
Male	112 (23)	831 (35)		83 (36)	465 (44)	
Mean BMI (kg/m^2)	33.3	32.8	.184	30.9	30.2	.141
Preoperative diabetes (%)	102 (21)	379 (16)	.009	50 (22)	147 (14)	.002
Preoperative kidney disease (%)	57 (12)	211 (9)	.059	26 (11)	91 (9)	.189
Preoperative obesity with BMI >35 kg/m^2 (%)	178 (36)	778 (33)	.138	61 (26)	207 (19)	.017
Mean length of stay (d)	2.89	2.20	<.001	2.59	2.25	<.001
Discharge disposition (%)						
Home	361 (73)	1971 (83)	<.001	164 (71)	851 (89)	.003
Skilled nursing or rehabilitation facility	131 (27)	407 (17)		67 (29)	216 (20)	
Return to ER within 90 d (%)	77 (16)	247 (10)	<.001	28 (12)	101 (9)	.221
Readmission within 90 d (%)	55 (11)	166 (7)	.001	27 (12)	101 (9)	.304

TKA, total knee arthroplasty; THA, total hip arthroplasty; SES, socioeconomic status; BMI, body mass index; ER, emergency room.

Table 4
Multivariate Logistic Regression Analysis of Risk Factors for 90-Day Readmission After Total Joint Arthroplasty.

Patient Risk Factor	Odds Ratio	95% Confidence Interval	*P* Value
Female gender	0.68	0.54-0.85	.001
Bottom quartile household income	1.50	1.15-1.96	.003
Age >75 y	3.37	1.86-3.01	<.001
Chronic kidney disease	1.07	0.74-1.55	.713
BMI >35 kg/m^2	1.56	1.21-2.01	.001
Total hip arthroplasty	1.35	1.07-1.71	.011
Diabetes mellitus	1.44	1.10-1.90	.008

BMI, body mass index.

Table 6
Multivariate Logistic Regression Analysis of Risk Factors for Discharge Disposition to Skilled Nursing or Rehabilitation Facility After Total Joint Arthroplasty.

Patient Risk Factor	Odds Ratio	95% Confidence Interval	*P* Value
Female gender	1.60	1.33-1.92	<.001
Bottom quartile household income	1.64	1.34-2.01	<.001
Age >75 y	6.12	5.13-7.31	<.001
Chronic kidney disease	0.99	0.75-1.31	.992
BMI >35 kg/m^2	1.60	1.32-1.94	<.001
Total hip arthroplasty	1.39	1.16-1.66	<.001
Diabetes mellitus	1.28	1.03-1.59	.022

BMI, body mass index.

protocols for primary joint arthroplasty hospitalization pathways. Perioperative pain and rehabilitation protocols, as well as post-discharge provider networks are also generally standardized between campuses. Furthermore, defining the subset of patients from lowest SES is difficult. Several demographic factors including income, wealth, education, employment rate, and occupation have been reported as SES measures in the literature [18]. Because of the lack of individual SES data, we chose to use ZIP code median household income as a proxy for SES, an easily accessed demographic variable included in several institutional, state, and national databases. ZIP codes, however, were designed for ease of mail delivery, not socioeconomic research, and may have variability in demographics within each code [19]. The ZIP codes of patients used in this study included urban Detroit, surrounding suburbs, and rural areas. There may be overlap of wealthier and poorer areas within each ZIP code. However, ZIP codes represent the smallest geographical area routinely collected from patients and thus a better indicator of SES than state level data or even US Census–derived Metropolitan Statistical Areas. The list of medical comorbidities collected in the database for this study failed to include cardiac, pulmonary, or autoimmune disease, which can affect outcomes and disposition. Finally, we did not have cost data available to analyze for our study population. However, our outcome variables have been strongly linked to increased episode-of-care costs after TKA and THA [14,17].

Our results identifying an association with lowest SES and poorer short-term outcomes after primary joint arthroplasty are in agreement with other studies in the literature identifying disparities in care [9,10,15]. The reasons for increased LOS, higher readmission rate, and higher likelihood of discharge to a rehabilitation facility among patients with lowest SES are likely multifactorial and not well understood. Our study did have a shorter LOS and lower complication rate than others in the literature [14]; however, our patient population was not limited to Medicare data alone. Further study is needed to identify why patients from lowest SES utilize require more post-acute care resources. More work is needed to develop support systems to facilitate safe discharge to home and minimize readmissions. Improving patient's health care IQ and health system engagement and affiliation among low SES patients may help reduce disparities in care.

Table 5
Multivariate Logistic Regression Analysis of Risk Factors for Extended Hospital Length of Stay of 4 Days or Greater After Total Joint Arthroplasty.

Patient Risk Factor	Odds Ratio	95% Confidence Interval	*P* Value
Female gender	1.35	1.02-1.78	.035
Bottom quartile household income	2.34	1.78-3.07	<.001
Age >75 y	2.20	1.68-2.87	<.001
Chronic kidney disease	0.83	0.54-1.30	.433
BMI >35 kg/m^2	1.43	1.08-1.89	.012
Total hip arthroplasty	1.01	0.77-1.33	.917
Diabetes mellitus	1.21	0.88-1.66	.219

BMI, body mass index.

Our subgroup analysis found similar results with both THA and TKA patients. Patients from lowest SES in the knee and hip groups were more likely to have a longer LOS (both $P < .001$) and discharge disposition to a higher level of care ($P < .001$ for TKA and $P = .003$ for THA). Inneh et al [9,10] also reported a similar association with low SES by ZIP code and longer LOS after THA and TKA. Patients with lowest SES had a higher 90-day readmission rate than those of higher SES in TKA (11% vs 7%, $P = .001$) and THA patients (12% vs 9%, $P = .304$). However, the results in the THA group failed to achieve statistical significance. While our study was powered to detect a 3% difference in readmission rate among all patients, the risk of committing type II error when interpreting results from a subgroup analysis of only 1278 THA patients is higher.

As patients in the lowest SES group were more likely to be female and have preoperative medical comorbidities including diabetes mellitus and chronic kidney disease, we preformed a multivariate analysis to control for confounding variables. Lowest SES was found to be an independent risk factor for prolonged LOS, discharge to a rehabilitation facility, and 90-day readmission. Interestingly, both age >75 years and obesity (both $P < .001$) were also both independent risk factors for poorer short-term outcomes after total joint arthroplasty. These findings suggest that risk adjustment models should include socioeconomic variables and these comorbidities as well.

Conclusion

Concerns exist about access to care as APMs gain in popularity. Physicians and hospitals may have a disincentive to operate on patients who utilize more resources. Lowest SES is an independent risk factor for prolonged LOS, 90-day readmission, and discharge disposition to a rehabilitation facility after primary TKA and THA in the patients we studied. Risk adjustment models including SES are necessary to fairly compensate hospitals and surgeons and to avoid potential problems with access to joint arthroplasty care in the future.

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