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Improving Value in Total Hip and Knee Arthroplasty: The Role of High Volume Hospitals

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ABSTRACT

Background: Recent healthcare reform efforts have focused on improving the quality of total joint replacement care while reducing overall costs. The purpose of this study is to determine if higher volume centers have lower costs and better outcomes than lower volume hospitals.
Methods: We queried the Centers for Medicare and Medicaid Services (CMS) Inpatient Charge Data and identified 2702 hospitals that performed a total of 458,259 primary arthroplasty procedures in 2014. Centers were defined as low (performing <100 total joint arthroplasty [TJA] per year) or high volume and mean total hospital-specific charges and inpatient payments were obtained. Patient satisfaction scores as well 30-day risk-adjusted complication and readmission scores were obtained from the multiyear CMS Hospital Compare database.
Results: Of all the hospitals, 1263 (47%) hospitals were classified as low volume and performed 60,895 (12%) TJA cases. Higher volume hospitals had lower mean total hospital-specific charges ($56,323 vs $60,950, $P < .001$) and mean Medicare inpatient payments ($12,131 vs $13,289, $P < .001$). Higher volume facilities had a lower complication score (2.96 vs 3.16, $P = .015$), and a better CMS hospital star rating (3.14 vs 2.89, $P < .001$). When controlling for hospital geographic and demographic factors, lower volume hospitals are more likely to be in the upper quartile of inpatient Medicare costs (odds ratio 2.127, 95% confidence interval 1.726-2.621, $P < .001$).
Conclusion: Hospitals that perform <100 TJA cases per year may benefit from adopting the practices of higher volume centers in order to improve quality and reduce costs.

Recent healthcare reform efforts have focused on improving the quality of total joint arthroplasty (TJA) care while reducing overall costs [1]. These value-driven models couple compensation with quality to enhance the delivery of care. Given the large and growing numbers of TJA performed in the United States annually, it is not surprising that this has been an area of increased attention. Total knee arthroplasty (TKA) ranked among the top 10 most commonly performed procedures with the highest aggregate cost of roughly $9.2 billion in 2007 [2]. Furthermore, while several studies have shown the cost effectiveness of TJA [3,4], there remains a persistent emphasis on decreasing the overall cost burden of these procedures.

Healthcare expenditures represented 17.5% of gross domestic product and are projected to reach 20.1% gross domestic product by 2025 [5]. Osteoarthritis is the most common joint disorder in the United States and the average annual personal spending on osteoarthritis was $48 billion in 2005, with an average annual growth in personal spending of 8% [6,7]. The total healthcare expenditure for treating these patients was $353 billion in 2005 [8]. As the demand for THA and TKA continues to increase [9–11], recent healthcare

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reform has targeted joint replacement for potential cost savings to the health system. Some policy experts argue that streamlining care by performing procedures at specialty higher volume centers will result in improved patient care at a lower cost.

Higher hospital volume has been associated with lower risk of complications following THA [12,13] and TKA [4,14–17]. Few studies, however, have explored whether high volume hospitals actually provide lower cost of care. We hypothesize that higher volume joint replacement centers have lower costs and improved outcomes than lower volume centers. The purpose of this study is to determine whether a hospital's joint replacement volume influences costs, outcomes, and patient satisfaction. Specifically, we asked is there a correlation between volume and Centers for Medicare and Medicaid Services (CMS) costs? Secondary study questions included: do low volume hospitals have higher costs than high volume hospitals and do low volume hospitals have worse outcomes and patient satisfaction metrics than high volume hospitals?

Methods

We queried the CMS Hospital Compare database, which included data from 4788 hospitals participating in Medicare across the country [18]. We then accessed the Medicare Provider Utilization and Payment Data Inpatient Charge Data for 2014. This database includes cost data for over 3000 hospitals that receive Medicare Inpatient Prospective Payment System payments for using the Medicare Severity Diagnosis-Related Group (MS-DRG) for 2014 [19]. Hospitals with <11 DRG episodes during the year are excluded from the dataset. The MS-DRGs in the database represent over 7 million patients and include over 75% of total Medicare Inpatient Prospective Payment System discharges [19]. We identified all hospitals with data from patients in DRG 470 (major joint replacement of the lower extremity without major comorbidities or complications) from the Inpatient Charge Data and cross-referenced the Hospital Compare database using each hospital's unique Medicare provider ID. This study was exempt from Institutional Review Board approval as no patient information was used. No outside funding was received for this study.

Demographic information from each hospital was collected including ZIP code and geographic area. Hospitals were designated as urban if they resided in an urban ZIP code designated by the 2010 United States Census (area >50,000 people) [20]. Hospitals were also noted as being from a lower socioeconomic area if the median household income of the ZIP code was in the bottom quintile ($21,432) nationally [21]. Low volume hospitals were defined if they performed fewer than 100 cases falling under DRG 470 in 2014.

We recorded the mean hospital-specific charge data and mean Medicare payment data for each institution. Mean total payments included the MS-DRG amount, bill total per diem, beneficiary primary payer claim payment amount, beneficiary Part A coinsurance amount, beneficiary deductible amount, beneficiary deducible amount, and DRG outlier amount [19]. Cost data were only available for the index hospital admission. The CMS complication rate was specific to total hip and knee replacement patients and included heart attack (acute myocardial infarction), pneumonia, or sepsis/septicemia/shock during the index admission; surgical site bleeding, pulmonary embolism, or death during the index admission or within 30 days of admission; or mechanical complications or periprosthetic joint infection/wound infection during the index admission or within 90 days of admission [18]. The 30-day readmission score was also specific to total hip and knee replacement patients. The CMS complication score includes data from April 1, 2012 to March 31, 2015. The readmission score includes data from July 1, 2012 to June 30, 2015. Both the complication and readmission scores are risk-standardized according to CMS based on patient comorbidities; a lower score is more favorable.

The Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) is a patient satisfaction survey required by all hospitals in the United States. Data from each of the qualifying hospitals in the study was obtained from the Hospital Compare

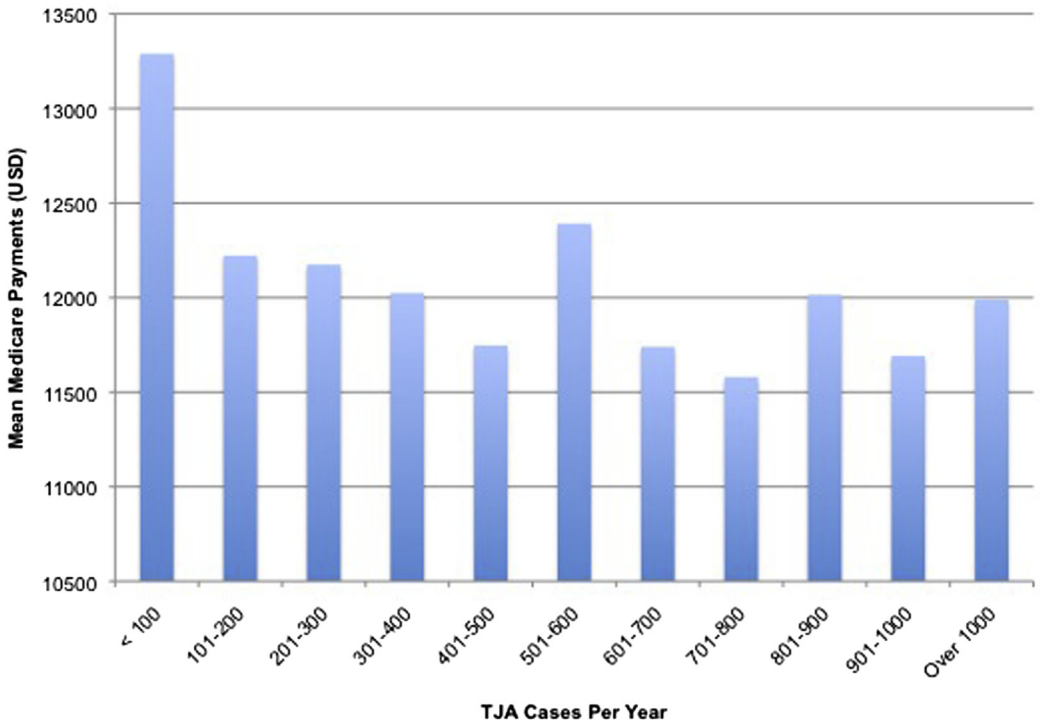

Fig. 1. Mean Medicare payments to hospitals for inpatient stay by number of cases per year in DRG 470 for primary hip and knee replacements.

Dataset including Star Rating (out of 5) and Linear Rating (out of 100) based on patient responses for physician and nurse communication, staff responsiveness, and whether they would recommend the hospital [18]. HCAHPS scores for the hospitals in this study were collected by CMS from October 1, 2014 to September 30, 2015.

Statistical Analysis

We first performed a linear regression analysis to identify any correlation between hospital volume and Medicare payments. To identify whether hospital volume was associated with high inpatient cost outliers in the top quartile of all Medicare payments (greater than $13,707), we performed a logistic regression analysis and developed a receiver operating characteristic curve to demonstrate the accuracy of the model. Figure 1 demonstrates the distribution of mean Medicare costs by hospital volume and was used to determine the high and low volume groups at 100 cases per year. We then compared the means of continuous variables including hospital-specific charges, total payments, and Medicare payments between the low volume and high volume groups using a Student's *t*-test. Outcome variables including complication, readmission, and HCAHPS scores between the 2 groups were also compared using a *t*-test. Categorical variables were analyzed using a chi-square test. Means between multiple groups such as costs between demographic areas were compared using a fixed-effects, one-way analysis of variance. Statistical significance was set at $P < .05$. To control for other confounding hospital demographic and geographic factors, we performed a multivariate logistic regression analysis to determine risk factors for a hospital being in the upper quartile of inpatient Medicare payments for DRG 470 (greater than $13,707). Finally, we performed a post hoc power analysis to determine if our sample size was adequate. Assuming a type I error rate of 0.05 with our sample size of 1263 and 1439 hospitals in the low and high volume groups, our study has a power of 1.00 to detect the $1158 mean difference in Medicare payments we found in our results. Statistical analysis was performed using IBM SPSS version 24 (Armonk, NY) and Microsoft Excel (Redmond, WA).

Results

Of the 4788 hospitals in the Hospital Compare Database, 2086 hospitals were excluded from the Inpatient Charge Dataset as they did not perform more than 10 procedures falling within DRG 470 during the year of the study period. Of the 2702 hospitals included in the study, there were 1263 (47%) low volume hospitals and 1439 (53%) high volume hospitals. A complete flowsheet of hospital selection criteria for the study is shown in Figure 2. All hospitals performed a total of 458,259 primary arthroplasty procedures (DRG 470) in 2014. Low volume hospitals performed a total of 60,895 (12%) of these procedures nationwide. Mean covered charges for all hospitals was $58,486 (standard deviation [SD] $28,109), while mean Medicare payments were $12,672 (SD $2357). The mean CMS hospital star rating was 3.02 (SD 0.88). The mean risk-adjusted complication score was 3.04 (SD 0.57), while the mean risk-adjusted readmission score was 4.61 (0.57). Descriptive statistics for all hospitals in the study are shown in Table 1.

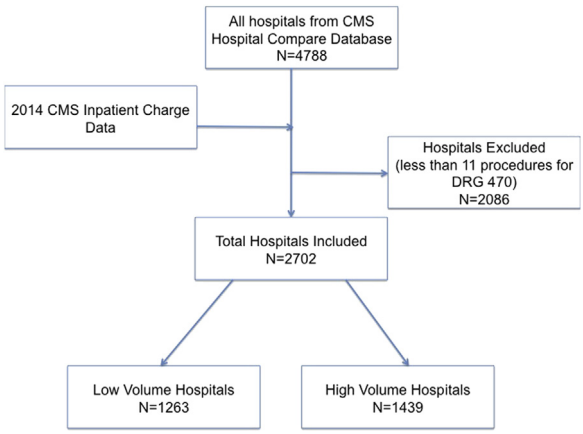

Fig. 2. Flowsheet of selection of hospitals from CMS data.

There was a statistically significant, but weak inverse linear correlation with increasing hospital volume and inpatient Medicare payments ($R2 = 0.014$, $P < .001$). Similarly, there was a significant inverse relationship with increasing hospital volume and Medicare payments in the upper quartile of all hospitals (odds ratio [OR] 0.999, 95% confidence interval [CI] 0.998-0.999, $P < .001$). A receiver operating characteristic curve demonstrated statistically significant, but weak predictive value of hospital volume for this model (area under the curve 0.590, 95% CI 0.565-0.614, $P < .001$). Hospitals performing fewer than 100 procedures per year had the highest mean Medicare payments ($13,289, SD $4,008, $P < .001$). A complete breakdown of hospital volume and Medicare inpatient payments are shown in Figure 1.

When compared to high volume hospitals, low volume hospitals had higher mean hospital-specific charges ($60,950 vs $56,323, $P < .001$), total inpatient payments ($156,778 vs $14,858, $P < .001$), and total Medicare payments ($13,289 vs $12,131, $P < .001$). Low volume hospitals were also more likely to be in a non-urban ZIP code (59% vs 86%, $P < .001$) and more likely to be in the US Census designated West South Central region (16% vs 11%, $P = .002$). If all 60,895 DRG 470 procedures in low volume hospitals were performed with the same costs to CMS of high volume centers (mean savings of $1158), cost savings to Medicare would total $70,516,410 for the year 2014. A comparison of cost data between the groups is

Table 1
Descriptive Statistics of the Hospitals Included in the Study.

Variable (SD)	Number ($N = 2702$)
Mean covered charges (USD)	$58,486 ($28,109)
Mean total payments (USD)	$15,241 ($3720)
Mean Medicare payments (USD)	$12,672 ($2357)
Geographic area (%)	
East North Central	461 (17)
East South Central	178 (7)
Mid-Atlantic	312 (12)
Mountain	197 (7)
New England	130 (5)
Pacific	328 (12)
South Atlantic	500 (19)
West South Central	365 (14)
West North Central	231 (9)
Mean risk-adjusted complication score	3.04 (0.57)
Mean risk-adjusted readmission score	4.61 (0.57)
Recommend hospital: linear mean score	88.0 (4.1)
Recommend hospital: star rating	3.10 (0.75)
Doctor communication: linear mean score	91.5 (2.0)
Doctor communication: star rating	3.05 (0.93)
Nurse communication: linear mean score	91.0 (2.2)
Nurse communication: star rating	3.42 (0.83)
Staff responsiveness: linear mean score	84.6 (3.8)
Staff responsiveness: star rating	3.04 (0.89)
Overall hospital rating: linear mean score	88.5 (2.9)
Overall hospital rating: star rating	3.19 (0.89)
HCAHPS summary star rating	3.10 (0.76)
Hospital in urban ZIP code (%)	1857 (69)
Less than 100 DRG 470 procedures (%)	1263 (47)
Hospital in low SES ZIP code (%)	42 (2)

Table 2
Comparative Analysis of Costs and Outcomes of Lower Volume Joint Replacement Hospitals (100 or Fewer Cases per Year) With Higher Volume Joint Replacement Hospitals.

Variable	100 or Fewer Cases per Year ($N = 1263$)	Greater than 100 Cases per Year ($N = 1439$)	*P* Value
Mean covered charges (USD) (SD)	$60,950 ($30,286)	$56,323 ($25,866)	<.001
Mean total payments (USD) (SD)	$15,678 ($4434)	$14,858 ($2904)	<.001
Mean Medicare payments (USD) (SD)	$13,289 ($4008)	$12,131 ($2540)	<.001
Mean CMS hospital star rating (SD)	2.89 (0.82)	3.14 (0.91)	<.001
Mean risk-adjusted complication score (SD)	3.16 (0.47)	2.96 (0.62)	.015
Mean risk-adjusted readmission score (SD)	4.69 (0.46)	4.56 (0.63)	.104
Geographic area (%)			
East North Central	214 (17)	247 (17)	.002
East South Central	80 (6)	98 (7)	
Mid-Atlantic	153 (12)	159 (11)	
Mountain	91 (7)	106 (7)	
New England	58 (5)	72 (5)	
Pacific	167 (13)	161 (11)	
South Atlantic	213 (17)	287 (19)	
West South Central	200 (16)	165 (11)	
West North Central	87 (7)	144 (10)	
Hospital in urban ZIP code (%)	705 (59)	1152 (86)	<.001
Hospital in low SES ZIP code (%)	16 (1)	26 (2)	.532

shown in Table 2. The West region (mean $15,683, SD $3838) had the highest Medicare payments of any region ($P < .001$), followed by the Northeast (mean $13,767, SD $3679), the Midwest (mean $11,932, SD $2126), and the South (mean $11,709, SD $3254). When controlling for hospital demographic and geographic factors, lower volume hospitals are more likely to be in the upper quartile of inpatient Medicare costs (OR 2.127, 95% CI 1.726-2.621, $P < .001$) (Table 3).

While there was a trend in CMS risk-adjusted readmission score (4.56 vs 4.69, $P = .104$), high volume facilities had a significantly lower complication score (2.96 vs 3.16, $P = 0.015$), and a better CMS hospital star rating (3.14 vs 2.89, $P < .001$). High volume hospitals outperformed low volume hospitals in every HCAHPS metric documented in the study including doctor communication (mean linear score 91.7 vs 91.3, $P < .001$), nurse communication (mean linear score 91.3 vs 90.6, $P < .001$), and HCAHPS summary star rating (mean 3.19 vs 3.00, $P < .001$). Detailed patient satisfaction score comparison by hospital volume is shown in Table 4.

Discussion

As healthcare reform continues to move toward value-based reimbursement, there are several shifts in care delivery that can be expected. A payment structure that rewards value inherently encourages a movement toward cost-effective and so-called quality providers and systems. Part of the challenge will ultimately be how quality is defined. In this study, we report several metrics from CMS that will likely be included in that definition, such as readmission, medical and surgical complications, and increasingly an emphasis on patient satisfaction scoring. High volume hospitals had improved CMS hospital star rating and outperformed low volume hospitals in every HCAHPS metric. Our study agrees with several of the previous reports that quality is improved in high volume centers and demonstrates that there is a concurrent cost-efficiency associated with having a procedure performed in a high volume hospital [22]. We also found a trend toward lower CMS risk-adjusted readmission score in higher volume hospitals but this did not reach statistical significance. This finding agrees with a prior study examining Kaiser Permanente Total Joint Replacement Registry indicating that lower volume hospitals had a higher readmission rate compared to higher volume hospitals [23].

We also found that high volume hospitals in this study had lower mean hospital-specific charges and total inpatient payments. Individual hospitals traditionally use the hospital-derived charges to submit charges based on procedure codes and services provided. Our Medicare cost to charge ratios were comparable to prior published studies in the literature [24]. One should not extrapolate these results, which summarize costs to Medicare, to predict specific costs to the hospital. Our study suggested that the highest Medicare payments were in the West region, followed by the Northeast, the Midwest, and the South. This finding is similar to other published reports on regional variations in Medicare reimbursement for TKA and THA. In a prior published review of Medicare data, the highest volume of TKA and THA was performed in the Southern region of the United States. The average reimbursement rates were lowest in the Midwest ($10,792 TKA, $10,749 THA) and highest in the Northeast ($12,905 TKA, $12,606 THA) [10].

Table 3
Multivariate Analysis of Hospital Demographic Factors for Medicare Costs in the Upper Quartile of All Hospitals in the Study.

Risk Factor	Odds Ratio	95% Confidence Interval	*P* Value
Urban hospital	1.180	0.926-1.504	.181
Northeast region	5.352	4.012-7.318	<.001
West region	8.841	6.732-11.610	<.001
Midwest region	1.505	1.120-2.022	.007
Lower socioeconomic area hospital	3.608	1.829-7.117	<.001
100 or fewer cases per year	2.127	1.726-2.621	<.001

Table 4
Patient Satisfaction Results From the HCAHPS Survey Comparing Lower Volume Joint Replacement Hospitals With Higher Volume Hospitals.

Variable (SD)	100 or Fewer Cases per Year ($N = 1263$)	Greater than 100 Cases per Year ($N = 1439$)	*P* Value
Recommend hospital: linear mean score	86.4 (3.4)	89.3 (3.4)	<.001
Recommend hospital: star rating	3.00 (0.79)	3.19 (0.72)	<.001
Doctor communication: linear mean score	91.3 (2.3)	91.7 (1.7)	<.001
Doctor communication: star rating	2.99 (1.0)	3.11 (0.86)	.002
Nurse communication: linear mean score	90.6 (2.5)	91.3 (1.9)	<.001
Nurse communication: star rating	3.31 (0.89)	3.52 (0.76)	<.001
Staff responsiveness: linear mean score	84.3 (4.2)	84.8 (3.5)	.004
Staff responsiveness: star rating	3.0 (0.96)	3.1 (0.83)	.034
Overall hospital rating: linear mean score	87.7 (3.1)	89.1 (2.6)	<.001
Overall hospital rating: star rating	2.95 (0.91)	3.39 (0.82)	<.001
HCAHPS summary star rating	3.00 (0.79)	3.19 (0.72)	<.001

High volume hospitals had a lower complication score, which in this database accounts for heart attack, pneumonia, sepsis, surgical site bleeding, pulmonary embolism, mortality, mechanical complications, or periprosthetic infection during index admission or within 90 days of admission. Katz et al [17] reviewed Medicare patient claims data from January through August 2000 to determine the relationship between hospital and surgeon volume and perioperative outcomes following TKA and found that higher volume centers generally had lower rates of mortality, pneumonia, and deep infection than lower volume hospitals. Meyer et al [15] reported significantly higher surgical site infection rates in departments that performed 50 or fewer TKAs per year using the German national nosocomial infections surveillance system to review 43,180 TKAs.

There are several additional limitations to this study. We did not adjust for medical comorbidities, demographics, or orthopedic-specific risk factors, as these data were not available at the individual patient level in the CMS database. Our data were also averaged, which does not exclude the possibility that a certain low volume hospital may be a star performer nor that a high volume hospital may perform poorly. The CMS data used were also from 2014, the most recent year available, so the gap between charges may be different today. Using MS-DRG 470 presumably captures those without major comorbidities and complications, but this designation only reflects the ability of hospitals to code appropriately. Metadata such as the CMS records that we used for this study could introduce selection bias due to differences in coding and reporting, but it is the best data available despite this potential bias. The reports in the literature vary widely in terms of the definition of low versus high volume. We set our cutoff for high volume at 100 cases per year, which has been previously reported [12,14,22,25]. We also acknowledge that we did not have long-term follow-up data, so no conclusions can be made regarding long-term outcomes, revision rates, and implant survivorship. Prior studies have shown conflicting results whether hospital and surgeon volume influences revision rates in hip and knee arthroplasty [12,14,25]. Our study also only included inpatient costs, other studies have shown that post-actute care costs have been linked to a significant portion of the total Medicare expenditure [26]. While this study reflects a large population of Medicare patients, it should be noted that the same findings might not be generalizable to the private-insurer market.

Conclusion

Hospitals that perform greater than 100 primary joint arthroplasty cases per year have lower Medicare costs, fewer complications, and higher patient reported outcomes than low volume centers. Further study is needed to determine if lower volume hospitals may benefit from adopting the practices of higher volume centers in order to improve quality and reduce costs.

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