Disparities in the Utilization of High-Volume Hospitals for Total Knee Replacement

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Objective: Higher hospital surgical volumes have been associated with lower complication rates following total knee replacement. The objective of this study is to identify the characteristics of patients who undergo total knee replacement at high-volume hospitals and their differences from those who receive care at low-volume hospitals.

Methods: Discharge data from patients undergoing total knee replacement in California from 1991–2001 were analyzed. Hospitals were classified into three tiers of low, intermediate or high surgical volume. The relationship between race/ethnicity and insurance status and the utilization of low-volume and high-volume hospitals were examined by creating separate logistic regression models that corrected for covariates, including age, gender and comorbidity.

Results: This study analyzed 222,684 primary total knee replacements during the study period. Patients of non-Caucasian race/ethnicity had higher relative risk ratios for being treated at a low-volume center, including black patients [relative risk ratio (RRR)=1.73, 95% confidence Interval (CI): 1.09–2.76, p=0.02]; Hispanic patients (RRR=3.13, 95% CI: 2.31–4.23, p<0.001) and Asian/Pacific Islanders (RRR=2.95, 95% CI: 1.89–4.62, p<0.001). Medicaid insurance was also an independent predictor of treatment at low-volume hospitals. Age and comorbidity were not statistically significant predictors for receiving care at low-volume centers.

Conclusions: There are substantial disparities in the characteristics of patients receiving care at hospitals performing a high volume of total knee replacements. Black, Hispanic and Asian race/ethnicity as well as Medicaid insurance were predictors of utilization of a low-volume hospital. This study supports the need to consider racial and socioeconomic disparities in efforts to improve the quality of care of patients undergoing total knee replacement at lower-volume hospitals.

Key words: health disparities ■ knee

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Several recent studies have shown that higher hospital surgical volumes are associated with lower complication rates following a variety of surgical procedures, including coronary artery bypass grafting, colon cancer resection, prostatectomy and aortic aneurysm repair.[1-12] These findings have led some organizations to advocate selective referral to high-volume hospitals in order to improve the quality of care for certain high-risk procedures such as cardiac surgery.[13] Our research group and others have confirmed a similar relationship of hospital volume to outcomes following total knee replacement, with increased rates of mortality, pulmonary embolism and infection at low-volume hospitals compared to high-volume centers. These relationships persist after correcting for patient characteristics such as age, gender, comorbidity, race/ethnicity and insurance type.[10,11]

While referral to high-volume hospitals has theoretical benefits, there may be unanticipated consequences to implementation such as decreasing the access to care for patients receiving care at lower-volume centers. Prior studies have shown that a large proportion of patients receive care at low-volume centers.[10,11,14] In addition, our research group has identified significant racial and socioeconomic disparities between patients who receive care at low-volume and high-volume centers for many complex surgical procedures.[14] The purpose of this study is to examine the extent to which the use of high-volume hospitals varies by race/ethnicity or insurance status for total knee replacement.

We analyzed discharge data from California during the period of 1991–2001 to determine the association of patient race, insurance, age and comorbidity with the utilization of low-, intermediate- and high-volume hospitals. We hypothesized that non-Caucasian minorities and individuals with safety-net insurance such as Medicaid would be less likely to receive care at high-volume hospitals and more likely to receive care a low-volume hospitals.

MATERIALS AND METHODS

Data Source

Data for all hospitalizations in California during the years 1991–2001 were obtained from California's Office of Statewide Health Planning and Development (OSHPD). The OSHPD database is compiled annually and includes discharge abstracts from all licensed nonfederal hospitals in California.[10,11] Each discharge abstract reports demographic information that includes age, gender, insurance type and the race/ethnicity of the patient. In addition, ICD-9 codes are included for up to 20 inpatient procedures and 24 diagnoses per hospitalization. Hospital characteristics are also reported, including the hospital size, status as a teaching hospital and whether the hospital is classified as rural in location. Institutional review board approval was obtained for this study.

Inclusion and Exclusion Criteria

Patients undergoing primary total knee replacement were identified using the ICD-9 procedure code for primary total knee arthroplasty (81.54). A previously published algorithm was used to exclude patients with infection, pathologic fracture or undergoing revision arthroplasty.[5,10,11] Patients with a non-California ZIP code were excluded in order to decrease the probability of the patient having prior admissions meeting exclusion criteria outside of the state. The unit of analysis was hospital discharge for each patient.

Statistical Analysis of Patient and Hospital Characteristics

The patient sample was analyzed using descriptive statistics to report age, gender, Charlson comorbidity index, insurance type and race/ethnicity. Race and ethnicity were categorized as white, black, Asian, Hispanic or other. The categories of insurance type were Medicare, Medicaid, private or other insurance. Comorbidity was assigned using the Charlson comorbidity index, which assesses 17 comorbid conditions. The Charlson index has been validated for use in administrative database studies.[15,16]

Hospital characteristics that are analyzed include surgical volume of total knee replacement, teaching status, rural location and hospital size. Surgical volume was determined as the average number of primary total knee replacements performed yearly during the study period. Hospitals were then divided into three tiers that are designated as high, intermediate or low volume. Hospitals were categorized as low volume if they were in the lowest 40th percentile for average annual volume of total knee replacement. Intermediate-volume hospitals were defined as the next 40th percentile; high-volume hospitals were defined as the highest 20th percentile. These tiers of volume were selected as they have been associated in prior studies with statistically significant differences in risks of complications following total knee replacement.[10,11]

Statistical Analysis: Logistic Regression

All statistical analyses were conducted using Stata/SE® 8.0 (Stata Corp., College Station, TX; 2003). The dependent variable in our analysis was hospital volume category divided among low-, intermediate- and high-volume hospitals. Multinomial logistic regression models were created to examine the association between patient characteristics (race/ethnicity, insurance type, age and the Charlson comorbidity index of patients) and the likelihood of undergoing surgery at low-, intermediate-, and high-volume hospitals. Separate models were created for the use of low-volume, intermediate-volume and high-volume hospitals with predictor variables of race/ethnicity, insurance type and the other patient covariates. Models were also corrected for the hospital covariate of teaching status as well as clustering of patients within hospitals. The strength of association for different patient groups is reported as the relative risk ratio (RRR) for undergoing surgery at a low- or intermediate-volume hospital as opposed to a high-volume hospital.

RESULTS

Description of Patient Sample

During the 11-year study period, primary knee arthroplasty was performed at 413 hospitals. There were 165 low-volume and 165 intermediate-volume hospitals that each comprised 40% of the total. The remaining 20% of the hospitals made up the group of 83 high-volume centers (Table 1). The average annual volume was calculated for each hospital using the unique OSHPD iden-

Table 1. Mean annual volume of total knee replacements at high-, intermediate- and low-volume hospitals, 1991–2001

Hospital Volume	Mean Annual Volume of Total Knee Replacements (± Standard Deviation)	Number of Hospitals (n=413)
High (top 20th percentile)	145 (±47)	83 (20%)
Intermediate (middle 40th percentile)	50 (±15)	165 (40%)
Low (bottom 40th percentile)	13 (±5)	165 (40%)

tifier. The mean value for low-volume hospitals of average annual surgical volume was 13 cases with a standard deviation of five cases. The mean at intermediate-volume centers was 50 (±15) cases per year, and high-volume hospitals had a mean of 145 (±47) cases per year.

A total of 222,684 primary total knee replacement procedures were identified during the study period. There were 94,427 procedures (42.32%) performed at hospitals with low (15,200) or intermediate (79,227) surgical volumes. The remaining 128,257 procedures (57.68%) occurred at high-volume hospitals (Table 2). The race/ethnicity, insurance type, mean Charlson comorbidity index, sex and age of patients seeking care at low-, intermediate-, and high-volume hospitals are also shown in Table 2. High-volume hospitals had a higher percentage of Caucasian patients (84%) than intermediate- (77%) or low-volume hospitals (63%). Conversely, the proportion of Medicaid patients was greater at low-volume (14%) and intermediate-volume (4%) hospitals than at high-volume centers (2%). Low-volume centers had a slighter greater proportion of female patients, a small increase in the mean Charlson comorbidity score, and a two-year decrease in the mean age compared to intermediate- and high-volume centers.

Role of Race/Ethnicity in Predicting Use of High-Volume Hospitals

Black, Hispanic and Asian/Pacific-Islander patients had a statistically significant higher RRR for being treated at hospitals in the bottom 40th percentile for surgical volume when compared to Caucasian patients. Black patients had a RRR of 1.73 [95% confidence interval (CI): 1.09–2.76, p=0.02] for the use of a low-volume hospital when compared to Caucasian patients, while Hispanic patients had a RRR of 3.13 (95% CI: 2.31–4.23, p<0.001). Asians/Pacific Islanders also had a higher RRR in comparison to Caucasian patients for the use of low-volume hospitals (RRR 2.95, 95% CI: 1.89–4.62, p<0.001) (Table 3). An increased RRR for being treated at an intermediate-volume hospital was also seen for Asian and Hispanic patients. The same trend was seen for black patients but did not reach statistical significance for intermediate volume hospitals (Table 4).

Role of Insurance Status in Predicting Use of High-Volume Hospitals

Medicaid insurance was seen to be a statistically significant predictor of utilization of a low-volume center when compared to both Medicare and private health insurance (Table 3). The RRR of patients with Medicaid receiving care at a low-volume center was 5.05 (95% CI: 3.24–7.88, p<0.001) in comparison to Medicare patients. Conversely, privately insured patients had a statistically significant lower RRR for receiving care at low-volume hospitals compared to patients with Medicare (RRR 0.71, 95% CI: 0.56–0.90, p=0.005). There was also a statistically significant relationship between Medicaid and the use of intermediate-volume hospitals (RRR 2.26, 95% CI: 1.34–3.82, p=0.002) but not between private insurance and the use of intermediate volume hospitals compared to patients with Medicare. (Table 4)

Table 2. Characteristics of patient sample and distribution of patients among low-, intermediate- and high-volume hospitals

	Patient Sample (n=222,684)	Low-Volume Hospitals (n=15,200)	Intermediate-Volume Hospitals (n=79,227)	High-Volume Hospitals (n=128,257)
Mean Age (SD)	69.36 years (±10.02)	67.66 years (±10.75)	69.61 years (±9.92)	69.23 years (±9.97)
Gender				
Male	85,189 (38%)	5,347 (35%)	29,739 (38%)	50,103 (39%)
Female	137,495 (62%)	9,853 (65%)	49,488 (62%)	78,154 (61%)
Mean Charlson Comorbidity Score (SD)	0.53 (±0.91)	0.54 (±0.89)	0.53 (±0.90)	0.53 (±0.91)
Race/Ethnicity				
Caucasian	178,054 (80%)	9,529 (63%)	61,017 (77%)	107,508 (84%)
Black	10,749 (5%)	1,028 (7%)	3,884 (5%)	5,837 (4%)
Hispanic	24,474 (11%)	3,474 (23%)	10,813 (13%)	10,187 (8%)
Asian/Pacific Islander	5,362 (2%)	815 (5%)	2,042 (3%)	2,505 (2%)
Other	4,045 (2%)	354 (2%)	1,471 (2%)	2,220 (2%)
Insurance Type				
Medicare	144,873 (65%)	9,003 (59%)	51,583 (65%)	84,287 (66%)
Medicaid	7,843 (3.5 %)	2,084 (14%)	3,019 (4%)	2,740 (2%)
Private insurance	60,256 (27%)	2,941 (19%)	20,992 (26%)	36,323 (28%)
Other	9,712 (4.5%)	1,172 (8%)	3,633 (5%)	4,907 (4%)

Association between Age, Gender and Charlson Comorbidity, and Hospital Volume

There was not a statistically significant association seen between Charlson comorbidity index and the utilization of low- or intermediate-volume centers as opposed to high-volume centers (Tables 3 and 4). Similarly, the factor of age did not show consistent large effects on the RRR for receiving treatment at hospitals of differing volume. There was a small association between increasing age and an increase in utilization of intermediate-volume hospitals (RRR 1.01, 95% CI: 1.00–1.01, p=0.017). There was also a small, statistically significant association between male gender and the RRR of receiving care at an intermediate-volume (RRR 0.94, 95% CI: 0.90–0.99, p=0.005) and low-volume centers (RRR 0.93, 95% CI: 0.87–0.99, p=0.03) (Tables 3 and 4). These associations did not approach the magnitude of those seen between race/ethnicity and insurance status to the use of low-volume hospitals.

DISCUSSION

There remains significant debate about the practical implications of the known relationship between lower volume and an increase risk of adverse outcomes for surgical procedures. In the specific case of total knee replacement, there are limited data on optimal strategies for improving the quality of care for patients treated at low-volume institutions. Several authors have noted an association between utilization of low-volume hospitals and surgeons for total knee replacement and an increased risk of complications.[5,6,10,11] While some organizations advocate selective referral to high-volume centers for high-risk procedures other than total knee replacement, the impact of these recommendations on racial and socioeconomic disparities has not been rigorously examined. For example, the Leapfrog group has advocated a program of volume standards for certain high-risk surgical procedures.[13,14] The aim of this study was to examine the effect of race/ethnicity and insurance status on the receipt of total knee replacement at low-, intermediate-, or high-volume hospitals. The findings of this study indicate the importance of considering racial, ethnic and socioeco-

Table 3. Relative risk ratios of different patient groups for use of low-volume hospitals as opposed to high-volume hospitals

Patient Characteristic	Relative Risk Ratio	P Value	95% Confidence Interval
Age	0.99	0.08	0.99–1.00
Male gender	0.93	0.03	0.87–0.99
Charlson comorbidity index	0.98	0.32	0.94–1.02
Caucasian	Reference group	Reference group	Reference group
Black	1.73	0.02	1.09–2.76
Hispanic	3.13	<0.001	2.31–4.23
Asian/Pacific Islander	2.95	<0.001	1.89–4.62
Medicare	Reference group	Reference group	Reference group
Medicaid	5.05	<0.001	3.24–7.88
Private insurance	0.71	0.005	0.56–0.90

Table 4. Relative risk ratios of different patient groups for use of intermediate-volume hospitals as opposed to high-volume hospitals

Patient Characteristics	Relative Risk Ratio	P Value	95% Confidence Interval
Age	1.01	0.017	1.00–1.01
Male gender	0.94	0.005	0.90–0.98
Charlson comorbidity index	1.00	0.87	0.96–1.03
Caucasian	Reference	Reference group	Reference group
Black	1.30	0.27	0.82–2.06
Hispanic	1.92	<0.001	1.44–2.58
Asian/Pacific Islander	1.57	0.002	1.18–2.09
Medicare	Reference group	Reference group	Reference group
Medicaid	2.26	0.002	1.34–3.82
Private insurance	1.05	0.51	0.86–1.29

nomic disparities during the ongoing debate on how to improve quality of care at lower-volume hospitals.

Our current study identifies statistically significant disparities in the use of high-, intermediate- and low-volume hospitals among different patient groups. Specifically, black, Hispanic and Asian/Pacific-Islander patients were noted to have a higher RRR for treatment at centers in the bottom 40th percentile for volume compared to Caucasian patients. A similar statistically significant association was seen for Medicaid patients and utilization of low-volume hospital in comparison to patients with Medicare or private health insurance. Age, gender and comorbidity were not seen to be important independent predictors of treatment at low-volume hospitals. These findings highlight the importance of considering racial and socioeconomic factors in developing policies to improve the quality of care following total knee replacement.

A growing body of evidence has identified pervasive racial and socioeconomic disparities in the delivery of healthcare.[12,17-23] These findings have led the Department of Health and Human Services to make the elimination of racial and ethnic disparities one of the primary goals of the *Healthy People 2010* initiative.[17] Despite this emerging consensus, there are limited data regarding the role of race and socioeconomic status in determining access to and outcomes following orthopedic surgical procedures. Recent studies have noted significant racial and ethnic differences in the rates of use of total knee arthroplasty among Medicare patients.[21,22] Other studies have noted disparities among different racial and ethnic groups in both attitudes towards total knee replacement and the utilization of resources such as rehabilitation services.[24-26] In addition, the access to high-quality subspecialists, high-quality diagnostic imaging and non-emergency admissions available to healthcare providers has been shown to vary among different racial groups being treated.[17] Further study is required to determine the underlying factors leading to an increased relative risk for minority and poorly insured patients seeking care at low-volume centers. These factors may include racial and ethnic differences in willingness to travel longer distances for specialty care or to seek care at larger, regional referral hospitals.

Our study did not allow us to assess the geographic location of the low-volume centers, but it may be possible that these centers are located in areas where there are increased numbers of black, Hispanic or Asian/Pacific-Islander patients. In addition, Medicaid patients may not have the same ability to obtain referrals to subspecialists as Medicare or privately insured patients. Losina et. al. examined the characteristics of patient bypassing high-volume centers for low-volume centers to undergo total knee replacement in the Medicare population. They noted that poor, less-educated, rural patients and patients from urban areas with high concentrations of poor, foreign-born citizens or minorities were more likely to bypass high-volume hospitals.[27] Our study reports similar findings in a diverse sample of patients that encompasses a wide variety of insurance types across all ages.

This scope of this study is limited by the lack of information in this statewide database, which limits our ability to identify confounding variables. This study corrects only for those patient and hospital characteristics reported to OSHPD. Other patient and hospital characteristics such as preoperative ambulatory status of patients and the nursing staff ratios are examples of important predictor variables not included in our study. Information on surgeon volume was not available and could not be evaluated separately from hospital volume. The studies by Katz and Hervey suggest that both surgeon volume and hospital volume are independently associated with outcomes following total knee replacement.[5,6] This study was not able to provide information on the relative importance of hospital and surgeon volume.

The findings of this study demonstrate that black, Hispanic, Asian/Pacific-Islander and Medicaid populations are more likely to undergo total knee replacement at hospitals that perform a low volume of these procedures. Several authors have noted that low hospital surgical volume is associated with higher rates of mortality and morbidity following total knee arthroplasty.[5,6,10,11] One approach proposed for improving the overall quality of care for other high-risk surgical procedures is the selective referral of patients to higher-volume hospitals.[13] The data in this study suggest that, in the case of total knee replacement, efforts to redirect care from low-volume centers to regional centers with larger volumes may have significant effects on access to care for certain racial, ethnic and socioeconomic groups. Any implementation of selective referral to high-volume centers should explicitly address issues of access for minority and lower-socioeconomic-status populations that have been less likely to seek care at larger centers. An alternative approach to improving quality of care may be to identify and disseminate the processes of care that lead to better outcomes at high-volume centers.[20]

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