Racial and sex disparities in utilization rates for shoulder arthroplasty in the United States disparities in shoulder arthroplasty

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ABSTRACT

Purpose: To investigate racial disparities in shoulder arthroplasty (SA), accounting for demographic factors such as sex and age.

Methods: Data for SAs (2011–2014) was queried from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample. Population-adjusted SA utilization rates, racial and sex differences by age, length of stay, insurer, and comorbidities were calculated.

Results: Caucasians aged 45–64 are 54% more likely than African-Americans and 74% than Hispanics to receive surgery. For patients aged 65–84, the disparity is wider for African-Americans and narrower for Hispanics.

Conclusions: Policymakers and physicians should focus on further national efforts to alleviate healthcare disparities.

1. Introduction

Shoulder arthroplasty (SA) is an effective pain-relieving and function-restoring treatment for a variety of shoulder disorders. However, a large subset of the United States population remains excluded from receiving elective joint replacement procedures due to enduring race and sex disparities.[1,2] The majority of the current literature focuses on disparities within hip and knee arthroplasty.[1,3] However, analyses of total elbow and shoulder arthroplasty utilization indicate access to all joint replacement procedures are affected by racial disparity.[4]

With the rates of SA growing faster than both hip and knee replacement,[5] disparities in access to SA warrant investigation. One previous analysis of the United States Nationwide Inpatient Sample (NIS) database from 1993 to 2007 reported lower SA procedure rates for all nonwhite races (Black, Hispanic, Asian, and Native American).[5] Furthermore, a growing body of literature also points to significant sex disparities in terms of utilization rates for joint arthroplasty, often reporting increased utilization rates in women. This may be due to a higher prevalence of disease in addition to system-level and provider-level factors.[6]

The most recent research assessing racial disparities in SA is now over a decade old and, given the rapid evolution and expanded use of shoulder arthroplasty in the past 15 years, this research may not reflect the current status of SA delivery in the United States. Additionally, a substantial shortcoming of the majority of the currently available racial disparity literature is that it is performed at a national, macroscopic level and does not account for possible geographic variations in population by region. Furthermore, none of the published literature takes into account the existing geographic variation in racial distribution based on United States Census data.

The purpose of this study is to investigate both racial and sex disparities in utilization of SA procedures from a regional perspective in the United States by using racial and socioeconomic data from United States census regions. We hypothesize that racial disparity in SA procedures persist nationwide, but at differing rates amongst areas of the US, mirroring the varying racial variation of each region. As a secondary study aim, we analyze sex disparities in SA utilization, hypothesizing that women tend to utilize the procedure at higher rates than men.

2. Methods

2.1. Data source and sample selection

This retrospective cohort study was conducted using the Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample (NIS) for the period of 2010–2014. The NIS is a representative sample of national inpatient claims. Medical service claims provide detailed inpatient encounter information, including date of service, provider type, charges, International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes, Current Procedural Terminology, 4th edition (CPT-4) codes, and Healthcare Common Procedure Coding System (HCPCS) procedure codes. Also included are patient demographic data—including age, race, geographical region, and sex. This study was deemed not human subjects research by our institution's Institutional Review Board and ethical committee.

Patients with ICD-9-CM procedure codes 81.80 for anatomic, 81.81 for partial, and 81.88 for reverse total shoulder arthroplasty (SA) were identified. Patients aged 20 and older were identified and categorized as 20–44, 45–64, 65–84 and 85 + years. Patient comorbidities were also assessed using the Deyo update to the Charlson Comorbidity Index (CCI),[7] which is a validated measure to adjust for a patient's one-year risk of mortality.[8] Diagnoses recorded during the inpatient admission were used to construct the CCI for each patient. Insurance status was classified as Medicare, Medicaid, Private insurance, and Other.

The primary variable of interest was race, and categorized in the NIS as White, Black, Hispanic, Asian or Pacific Islander, Native American, or Other. In NIS, Hispanic ethnicity takes priority over racial reporting, and is thus reported as Hispanic. For this study, the categories were combined to create the following: Black, Hispanic, White, and Other (which includes missing race).

To appropriately weight our data based on racial make-up of a particular region, we obtained the total population for each race regionally from 2010 US Census data.[9] We calculated annual shoulder arthroplasty utilization rates for each racial group per 100,000 by dividing the weighted NIS estimates by the total population of each racial group, which enabled us to calculate shoulder arthroplasty utilization rates nationally and by geographical region. Geographical regions are classified as Northeast, Midwest, South, and West in both the NIS and US Census data (Table 1). Rates were compared using White as the reference group yielding racial disparity ratios, where a value of 1.0 indicates that the rate of shoulder arthroplasty among a minority group matches the rate of shoulder arthroplasty (SA) among Whites of the same age group and geographic region; a value of less than 1.0 means SA is underutilized amongst the minority group, indicating a disparity.

Table 1
U.S. Census regions.

Northeast	Midwest	South	West
Connecticut	Illinois	Alabama	Alaska
Maine	Indiana	Arkansas	Arizona
Massachusetts	Iowa	Delaware	California
New Hampshire	Kansas	District of Columbia	Colorado
New Jersey	Ohio	Florida	Hawaii
New York	Michigan	Georgia	Idaho
Pennsylvania	Minnesota	Kentucky	Montana
Rhode Island	Missouri	Louisiana	Nevada
Vermont	Nebraska	Maryland	New Mexico
	North Dakota	Mississippi	Oregon
	South Dakota	North Carolina	Utah
	Wisconsin	Oklahoma	Washington
		South Carolina	Wyoming
		Tennessee	
		Texas	
		Virginia	
		West Virginia	

2.2. Statistical analysis

Descriptive statistics were used to compare study populations. Means and standard deviations were calculated to describe continuous data. Frequencies and percentages were calculated to describe categorical data. Chi-square statistics were used to test for differences in proportions across demographic characteristics. For normally distributed data, 2-sample design-based t-tests were used. Utilization rates were compared using a chi-square test for differences by region and differences by race. Statistical significance was defined *a priori* at $\alpha = 0.05$. All statistical analyses were done using SAS 9.4 (Cary, NC).

3. Results

3.1. Baseline characteristics

The total population size for patients undergoing shoulder arthroplasty was 260,283. The decision was made *a posteriori* to examine population aged 45–84 (94.6% of total population, n = 246,227) due to smaller numbers of shoulder arthroplasty (SA) performed among patients in the age groups 20–44 (1.1%) and 85 + (4.3%). Therefore, only patients aged 45–84 are reported. Table 2 shows the patient characteristics.

The mean age was 69.5 years (SD 0.04) and 43.6% were male. Regarding geographic location, 14.6% lived in the Northeast, 28.4% Midwest, 37.9% South, and 19.1% West (Table 3). Medicare was the most common type of health insurance plan nationwide (69.5%) followed by private insurance (24.1%).

3.2. Rates of SA utilization

The rates of SA per 100,000 people are given in Table 4, comparing Blacks to Whites. The overall rate of SA was higher among patients in the 65–84 age group for both Blacks and Whites. Of particular interest are the disparity ratios, which compare the population-adjusted rates of SA utilization of Blacks to Whites. Nationwide, the disparity ratio among Blacks was 0.46 among those aged 45–64, and 0.34 among those aged 65–84. This means that Blacks were 54% less likely to undergo a SA than Whites in the same 45–64 age group, with similar rates across

Table 2
Patient Demographics by U.S. Census Region, *expressed as percentages of the column (nationwide or by U.S. Census Region).*

Characteristic	U.S. Census Region				
	Nationwide	Northeast	Midwest	South	West
Sex					
Male	44.1	43.2	43.1	43.9	46.6
Female	55.9	56.8	56.9	56.0	53.4
Race/Ethnicity					
Black	3.9	3.8	2.7	5.7	1.9
Hispanic	2.9	2.1	0.9	3.1	6.2
White	81.1	90.0	68.9	86.8	80.7
Other	12.2	4.1	27.5	4.4	11.2
Income Quartile					
1st	22.1	11.2	18.4	32.3	15.8
2nd	27.5	20.0	32.3	28.1	24.8
3rd	27.4	28.8	30.2	23.0	31.2
4th	22.9	40.0	19.0	16.5	28.3
Insurer					
Medicaid	2.0	2.3	2.3	1.5	2.1
Medicare	68.9	65.9	69.4	70.3	67.4
Private	24.6	26.7	24.7	23.6	25.1
Other	4.5	5.1	3.5	4.6	5.3
Charlson score					
0	69.3	70.5	67.5	69.9	69.5
1	22.1	21.8	22.6	21.6	22.3
2+	8.7	7.7	9.8	8.5	8.2

Table 3

Patient Demographics by U.S. Census Region, *expressed as weighted frequencies using NIS sampling methodology*.

	U.S. Census Region				
	Nationwide	Northeast	Midwest	South	West
Characteristic	n = 246,227	n = 36,130	n = 69,546	n = 93,760	n = 46,791
Age, years	69.1 (0.04)	69.2 (0.11)	69.6 (0.08)	69.4 (0.07)	69.9 (0.09)
Sex					
Male	108,516	15,594	29,984	41,194	21,744
Female	137,593	20,536	39,562	52,544	24,950
Race/Ethnicity					
Black	9486	1357	1876	5352	901
Hispanic	7186	759	603	2932	2895
White	199,573	32,519	47,908	81,384	37,762
Other	29,978	1495	19,159	4092	5233
Income Quartile					
1st	53,610	4006	12,713	29,726	7165
2nd	66,563	7112	23,328	25,900	11,223
3rd	66,464	10,245	20,852	21,213	14,155
4th	55,422	14,248	13,135	15,178	12,861
Insurer					
Medicaid	4841	826	1623	1396	997
Medicare	169,556	23,802	48,284	65,926	31,545
Private	60,688	9651	17,206	22,084	11,747
Other	11,141	1851	2434	4355	2502
Charlson score					
0	170,518	25,480	46,971	65,549	32,517
1	54,316	7876	15,726	20,285	10,430
2+	21,393	2774	6849	7926	3843

Table 4

Rates and disparity ratios of shoulder arthroplasty utilization by geographic region and age group, comparing Blacks to Whites.

	Rate per 100,000		Disparity Ratio
	Black	White	
Nationwide			
Ages 45-64	43	93	0.46
65-84	178	522	0.34
Northeast Region			
45-64	35	84	0.41
65-84	147	421	0.35
Midwest Region			
45-64	45	89	0.51
65-84	205	501	0.41
South Region			
45-64	44	108	0.41
65-84	178	587	0.30
West Region			
45-64	47	82	0.58
65-84	179	530	0.34

Table 5

Rates and disparity ratios of shoulder arthroplasty utilization by geographic region and age group, comparing Hispanics to Whites.

	Rate per 100,000		Disparity Ratio
	Hispanic	White	
Nationwide			
Ages 45-64	24	93	0.26
65-84	205	522	0.39
Northeast Region			
45-64	13	84	0.16
65-84	149	421	0.35
Midwest Region			
45-64	26	89	0.29
65-84	270	501	0.54
South Region			
45-64	24	108	0.22
65-84	221	587	0.38
West Region			
45-64	27	82	0.33
65-84	200	530	0.38

all geographical regions.

The rates of SA per 100,000 people are given in Table 5, comparing Hispanics to Whites. The overall rate of SA was higher in the 65–84 age group compared to the 45–64 age group for both Hispanics and Whites. The disparity ratios comparing the rates of SA of Hispanics to Whites showed that nationwide, the disparity ratio among Hispanics was 0.26 among those aged 45–64 and 0.39 among those aged 65–84. This means that Hispanics were 74% less likely to undergo a SA than Whites in the 45–64 age group. Disparity ratios ranged from 0.16 in the Northeast census region to 0.33 in the West census region. There were no significant differences in the disparity ratios between regions for either Blacks or Hispanics.

The rates of SA per 100,000 people are given in Table 6, comparing males to females in two age groups of interests. The overall rates of SA are higher for females in the pooled age groups (196 per 100,000 for males versus 226 per 100,000 for females). SA rates for those aged 45–64 are higher for males than for females, overall and for Whites and Hispanics. However, for Blacks, males aged 45–64 are 31% less likely to

Table 6

Rates and disparity ratios of shoulder arthroplasty utilization by race and age group, comparing Male to Female.

	Rate per 100,000		Disparity Ratio
	Female	Male	
White			
Ages 45-64	84	103	1.23
65-84	563	473	0.84
Black			
45-64	51	35	0.69
65-84	223	112	0.50
Hispanic			
45-64	21	27	1.29
65-84	225	178	0.79

Table 7
Insurance status proportions of NIS patients.

Proportion of NIS patients, aged 45-84			
	Medicare	Medicaid	Private
White			
	70%	1.5%	25%
Black			
	64%	6.8%	23%
Hispanic			
	67%	5.3%	20%

utilize SA than females. For those aged 65–84, females in all racial groups had higher rates of utilization than males; with the greatest sex disparity for Blacks, where males aged 65–84 are 50% less likely to utilize SA than females. Overall, 56% of SA patients are female; within racial groups, females comprise 55% of Whites, 57% of Hispanics, and 69% of Blacks.

3.3. Racial and sex differences in age, length of stay, and Co-morbidities

Overall, females undergoing SA were significantly older than males (2.5 years, $p < 0.001$). The average age of admission across ages 45–84 and all racial groups was 69 years. No significant differences were found in average age at the time of surgery between Hispanics and Whites, but Blacks were significantly younger than Whites (3.3 years, $p < 0.001$). Hispanics had significantly longer lengths of stay in the hospital relative to Whites (means: 2.17 versus 2.04 days, $p < 0.002$), and Blacks also had significantly longer lengths of stay relative to Whites (means: 2.38 versus 2.04 days, $p < 0.001$).

There was no significant association between insurance status and racial group, with a similar proportion of each racial group utilizing Medicare and private insurance (Table 7). Medicare coverage is relatively uniform among patients aged 65–84 in the sample with 88% of Whites and 85% of Black and Hispanic patients reporting Medicare as their insurer.

The average Deyo-Charlson score in the patient population was 0.44; 69% of patients had a score of 0. The group aged 65–84 had a significantly higher average score than the group aged 45–64 (0.46 versus 0.40, $p < 0.001$). Racial differences in average Charlson scores were also observed. Hispanics did not have significantly higher Charlson scores than Whites, but Blacks on average demonstrated significantly higher scores than Whites (0.66 versus 0.43, $p < 0.001$).

4. Discussion

SA is a well-recognized and effective treatment for glenohumeral pathology, relieving shoulder pain while improving shoulder function and quality of life.[10,11] The reproducible success and expanded indications of SA in the setting of an increasingly older population has predictably led to increasing number of SAs performed every year.[5] From 2010 to 2014, 246,227 shoulder replacement procedures were performed. Despite the well-documented racial disparities in the total knee and hip arthroplasty literature, a paucity of data exists in the shoulder literature specific to racial and sex disparity in SA utilization.[12] Considering the consistently demonstrated elevated risk of osteoarthritis among Blacks and Hispanics compared to Whites,[13] we sought to further understand national and regional trends in SA utilization and identify differences in utilization based on both race and sex. To our knowledge, this is the first study to stratify disparities based on regional variations in SA utilization in the United States.

Multiple studies in the hip and knee literature have repeatedly demonstrated disparities with utilization and outcomes between Whites and Blacks.[14,15] Using the Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample (NIS) from 2010 to 2014 to

retrospectively evaluate race-based disparity among patients undergoing SA, we found substantial utilization disparities between Whites, Blacks, and Hispanics. Black SA utilization was consistently lower than White SA utilization in both age-matched categories, which is particularly concerning when juxtaposed with previous literature demonstrating greater prevalence and severity of functionally symptomatic osteoarthritis in the African-American population.[13,15,16] Nationwide, Blacks were 54% and 66% less likely to undergo a shoulder replacement than Whites in the 45–64 and 65–84 age groups, respectively. Similar rates of disparity were seen across the different geographic regions in the United States. An analysis of national and state of total knee replacement (TKR) rates among patients aged ≥ 65 years by the Center for Disease Control and Prevention (CDC) between the years of 2000–2006 found the overall rate of TKR increased by 58%. However, the TKR rates for Blacks were 37% and 39% lower than those for Whites in 2000 and 2006, respectively. The CDC recommended that both providers and public health agencies distribute TKR information that is tailored to the education and literacy level and culture of patients with symptomatic knee osteoarthritis to help reduce this disparity in utilization.[17] Blum et al.[18] in a review of the literature showed that disparities in the utilization in joint replacement surgery exist due to many factors including insurance status, access to care, cultural differences, patient expectations and preferences of joint arthroplasty surgery. Weng et al.[19] advocated for the development of educational video content and tailored decision-making aids for TKR to help address the racial disparities. We believe that the decreased shoulder replacement utilization in Blacks relative to Whites is multifactorial and may be related to patients' socioeconomic status, access to care, cultural acceptance for shoulder replacement surgery, and expectations for post-operative outcome.

Similarly, dramatic disparity of SA utilization among Hispanics compared to Whites is also seen in this study. Hispanics were 74% less likely to undergo SA than Whites in the 45–64 age group, although there was a high degree of variability between regions. For Hispanics, disparity ratios ranged from 0.16 in the Northeast census region to 0.33 in the West census region. Hispanics make up 2.9% percent of the population nationwide, making up 6.3% of the total population in 0.9% in the Midwest; population underrepresentation and high variability in the population distribution may contribute to the high variability seen in the disparity ratios for Hispanic SA utilization across the different geographic regions. Similar to our findings, Dunlop et al.[20] reported lower utilization rates of both hip and knee replacement in the Hispanic adults in all age groups compared to both White and Black patients in a longitudinal prospective health study. The authors attributed the disparity to economic differences. Although we did not evaluate racial or ethnic disparities in surgical outcomes after shoulder replacement surgery, Ibrahim et al.[3] found that both Black and Hispanic patients had a significant higher risk of infection related complications after knee replacement surgery compared to White patients.

While the utilization of SA increased across all patient racial groups in the 65–84 age group compared to the younger cohort, utilization disparities changed disproportionately. As insurance status becomes more uniform in the older cohort with qualification for Medicare coverage after the age of 65, the direction of the change in disparity ratios between the two age cohorts may reveal the extent to which insurance status plays a role in the disparity. Black disparity increased substantially from the 45–64 age group to the 65–84 year old cohort, suggesting increasing disparity severity in the older cohort in spite of the qualification for Medicare. This trend was also reflected in every national region. While there was a persistent racial disparity in the older age group among Hispanics, the disparity ratio between Hispanics and Whites narrowed slightly in the older cohort.

Comparing utilization rates by sex between the two age cohorts reveals sex differences in SA utilization based on age. Males undergo SA at higher rates than females in the younger age cohort. However, females have higher rates of utilization in the older age cohort and, overall, are approximately 3 years older at the time of surgery. The sex

disparity ratios by age cohort were evident overall and in Whites and Hispanics, but the male to female ratio was noticeably low in both age cohorts for Blacks. Black males, specifically between 65 and 84 years of age, appear to have the lowest rates of SA utilization of all demographic groups analyzed, consistent with previous research on race and sex disparity in SA.[6] Further research is needed to investigate the intersecting biologic, socioeconomic, and cultural causes which underlie, respectively, the interaction between sex and racial disparities in SA utilization rates.

We also found Blacks undergoing SA to be demographically dissimilar to Whites. Blacks were generally younger at time of surgery, had significantly more comorbid conditions with higher Charlson Comorbidity Indexes, and had longer hospitalizations as compared to white patients. These demographic findings mirror previous orthopaedic studies evaluating joint arthroplasty surgery.[2,3,21] Although outcomes were not this study's primary focus, further research is warranted to discern demographic influences on SA results.

Several studies postulate causes and barriers to access among minorities as potential foundations for racial disparity, including socioeconomic status, lower health literacy, coping strategies, poor doctor-patient communication, higher medication non-adherence, risk aversion to therapies, access differences, cultural belief systems and general distrust of the medical community.[6,18,21–23] Furthermore, Li et al.[24] evaluate the effect of patient insurance status on the perioperative in-hospital outcomes after total shoulder arthroplasty. The authors found that private insurance payer status is associated with a lower risk of perioperative medical and surgical complications compared to an age and sex matched Medicare and Medicaid/Uninsured payer status. In their study, more Black and Hispanic patients had Medicaid/uninsured payer status compared to private insurance. A 2013 population report of nationwide demographic breakdowns of insurance status from the US Census Bureau[25] showed 72% of Whites, 50% of Blacks, and 46% of Hispanics had private insurance. This report also showed that 33% of Whites, 44% of Blacks, and 36% of Hispanics had government health insurance. These differences in the insurance status breakdown within each racial group of the total population may contribute to the observed disparities of SA utilization. Despite the proposed rationales partially responsible for increasing disparities, further investigation is certainly necessary to discern the evident and dramatic etiologies of these inequalities.

This study confirms that there are significant racial disparities in SA utilization at the national level, which are fairly consistent across geographic regions. SA utilization rates among Blacks and Hispanics are significantly lower relative to the rates in Whites despite the overall increase in the number of procedures done each year. This study serves to further support previously established nationwide racial disparities in patients undergoing elective SA, both nationally and regionally. Recognition and active awareness of these pervasive racial disparities is requisite to addressing their multifactorial origins.

5. Conclusion

Significant racial disparity in the utilization of SA persists within the United States and is consistent and across geographic regions. The severity of racial disparity appears to be persistent over time indicating that further research and directed intervention in patient and cultural education of shoulder replacement surgery along with expectations after surgery are necessary to improve SA utilization among Black and Hispanic patients in the United States.

Research involving human participants

This study was deemed not human subjects research by our institution's Institutional Review Board and ethical committee.

Disclosures

Ethical review committee statement

This study was deemed not human subjects research by the Medical University of South Carolina Institutional Review Board.

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