

# Racial and Gender Shoulder Arthroplasty Utilization Disparities of High- and Low-Volume Centers in New York State

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## Abstract

**Introduction:** The literature has consistently demonstrated utilization disparities in joint replacement procedures, though no studies have evaluated disparities in total shoulder arthroplasty with regard to operative volume.

**Methods:** We queried the New York (NY) Statewide Planning and Research Cooperative System (SPARCS) database for 32 410 total shoulder arthroplasties performed between 2009 and 2017. Patients were identified using Clinical Classifications Software code 154 for Non-Hip/Knee Arthroplasty and All Patient Refined-Diagnosis Related Group code 322 for Shoulder. Racial groups included Hispanic, non-Hispanic white, non-Hispanic black, and Other. High-volume centers were facilities that performed 2 standard deviations above the mean annual procedures. Utilization rates were calculated by dividing total shoulder arthroplasties per group by the 2010 NY Census population of that group. The Fisher exact test was used to determine significance.

**Results:** Total shoulder arthroplasty utilization increased from 43/100 000 to 73/100 000, two-thirds of which was driven by an increase in white resident utilization. More White residents per 100 000 underwent shoulder arthroplasty than Black, Hispanic, and Other residents per 100 000 residents of their respective race. White residents were 90% more likely than Hispanic residents to undergo total shoulder arthroplasty at high-volume centers ( $P = .04$ ). There were no differences in utilization rate regarding operative volume comparing Black or Other residents to White residents. More females underwent total shoulder arthroplasty than males, though there was no difference in utilization rate regarding operative volume.

**Conclusion:** Though total shoulder arthroplasty utilization nearly doubled, disparities persisted across gender and minority groups particularly in Hispanic utilization as White residents were 90% more likely than Hispanic residents to undergo shoulder arthroplasty at high-volume centers.

## Keywords

Arthroplasty, shoulder, replacement

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## Introduction

Utilization, a measure of how many people in a group as a ratio of the population of that group undergo a certain procedure, has been previously studied and trended in total shoulder arthroplasty.<sup>1–3</sup> Despite increasing utilization of total shoulder arthroplasty (TSA) as an effective management of various shoulder pathologies,<sup>4–6</sup> the literature has demonstrated that enduring racial and gender disparities exist in joint replacement procedures.<sup>7–15</sup> An 18-year analysis of Medicare part A data showed that in 1991, the use of primary total knee arthroplasty (TKA) was 36% lower for African-Americans compared with Caucasians.<sup>1</sup> Though utilization more than doubled for both African-Americans and Caucasians by 2008, the usage of primary TKA was still 40% lower for African-Americans.<sup>1</sup>

Studies have shown hospital operative volume as a contributing factor to racial disparities in joint replacement procedures.<sup>2,16,17</sup> Soohoo et al.<sup>2</sup> first demonstrated this when they reported the relative risk of undergoing TKA at a low-volume center was 1.73 for Black patients and 3.13 for Hispanic patients when compared with White patients. Zhang et al. more recently followed up this study looking

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at eight states from 2001 to 2008 and similarly demonstrated minority patients were less likely than White patients to undergo TKA in high-volume hospitals.<sup>16</sup> The presence of these disparities between high- and low-volume centers are particularly significant as surgeon annual case-load has been shown to decrease complication rates and hospital length of stay in joint replacement procedures.<sup>18,19</sup>

Despite these prevalent disparities in TKA, disparities specifically in TSA have yet to be fully elucidated. Yu et al. documented some of the earliest disparities in TSA when they found that Whites accounted for 70% of the TSA, whereas blacks accounted for 5% performed from 1900 to 2009.<sup>15</sup> More recently, Einchinger et al. demonstrated regional influences to these racial disparities with Hispanics being significantly less likely to undergo TSA than Caucasians in the Northeast versus the West, respectively.<sup>10</sup> While these results suggest disparities still persist in TSA much of these data are outdated and no recent studies have evaluated these disparities with regards to operative volume. The purpose of this study was to analyze racial and gender disparities with regard to hospital operative volume in TSA via a large publicly available database. We hypothesized that despite an annual increase in the utilization of TSA, significant racial and gender utilization disparities exist when accounting for facilities and higher operative volume.

## Methods

### Data Source and Sample Collection

The Statewide Planning and Research Cooperative System (SPARCS) is a comprehensive inpatient and ambulatory database established in 1979 and maintained by the New York State (NYS) Department of Health.<sup>15,16,20</sup> The publicly available database has aggregated discharge records of patients admitted to licensed New York State hospitals and captures information related to patient demographics, hospital diagnoses, and in-hospital procedures. SPARCS has been used as a valid database in multiple other studies including those analyzing similar time and trend analyses in total joint arthroplasty disparities<sup>15,20,21</sup> and other conditions.<sup>22,23</sup> Though no studies directly compare SPARCS to other national databases, results from trend analyses done

by SPARCS and Medicare & Medicaid Services (CMS) public release of Medicare Provider Utilization and Payment Data show similar trends in TSA procedural volume.<sup>24</sup>

We queried the SPARCS inpatient database for all reported cases of shoulder arthroplasty between 2009 and 2017. The All Patient Refined-Diagnosis Related Group (APR-DRG) Classification system is utilized by the Centers for Medicare (CMS) to better understand the interaction between a patient disease and the resources they consume. We identified patients using Clinical Classifications Software (CCS) Procedure code 154 for Non-Hip/Knee Arthroplasty with a corresponding APR-DRG code of 322 for Shoulder. A sub-analysis excluding fractures with CCS Diagnosis Codes of 231 (Arm Fracture), 229 (Other Fracture), and 207 (Pathologic fracture) was also performed.

Covariates of interest included age, gender, race, insurance status, hospital length of stay, and Illness Severity Score. Age was binned into three groups <50 years, 50 to 69 years, and >70 years similar to prior studies.<sup>13,25</sup> Documented primary payor was used to categorize insurance as Medicare, Medicaid, Private, or Other which included but was not limited to Self-pay, Worker's Compensation, Department of Correction's, & Veteran's Administration payment methods. Racial groups included Hispanic, non-Hispanic caucasians ("White"), non-Hispanic blacks ("Black"), and non-Hispanic residents that were neither "Black" nor "White" ("Other"). Database Facility ID codes linked to each de-identified record was used to determine at which hospital a procedure was performed. High-volume centers were classified as facilities that performed 2 standard deviations above the mean annual procedures for that corresponding year while all other facilities were designated as low-volume centers. There was a consistent increase in the mean annual procedure volume per hospital but the number of high-volume centers remained relatively consistent from 2009 to 2017 as seen in Table 1.

The APR-DRG Illness Severity Score was graded 1 through 4 corresponding to minor, moderate, major, or extreme and categorizes the extent of physiologic decompensation or organ system loss of function.<sup>26</sup> It is scored by insurance through a three-phase process taking into account the impact of the principal diagnosis, age, operating room

**Table 1.** Procedure Volume per Facility with Annual Procedural Volume Cutoffs. Cutoff Procedural Volume was 2 Standard Deviations Above the Mean Annual Procedures for That Corresponding Year.

	Procedure volume per facility								
	2009	2010	2011	2012	2013	2014	2015	2016	2017
Mean annual procedure volume per facility	19	19	20	21	23	28	30	33	39
Procedure cutoff for high-volume center	106	107	113	116	125	143	150	164	192
Number of high-volume centers	5	4	4	4	4	4	5	6	5
Number of low-volume centers	146	144	148	148	140	133	131	124	126

procedures, non-operating room procedures, multiple operating room procedures, and combinations of categories of secondary diagnoses.<sup>26</sup>

### Calculation of Utilization Rates and Disparity Ratios

Utilization rates have been utilized in prior literature on total shoulder arthroplasty to describe racial and gender inequalities.<sup>10</sup> As is consistent with prior studies, gender and racial utilization rates (UR) were calculated by dividing the SPARCS estimate for procedures performed in each group by the total population of that group as determined from the 2010 New York Census.<sup>27</sup> Put another way, the utilization rate gives the number of procedures performed per persons of a certain race or gender. Annual utilization rates were also calculated to determine per year growth in TSA utilization.

To directly compare utilization rates of males and females as well as across minorities, ratios were calculated previously described as disparity ratios.<sup>10</sup> Gender disparities ratios were calculated by dividing the female UR for high- and low-volume centers by the corresponding male UR. Racial disparity ratios were calculated by dividing the Black, White, or Other UR for high- and low-volume centers by the corresponding White UR. A value of 1.0 indicates that the UR among a racial group or females matches the UR among Whites or Males, respectively. A value of <1.0 means TSA is underutilized among the minority group or females, indicating a disparity.

### Statistical Analysis

Statistical analysis was performed using R version 3.4.0. Frequencies and percentages were calculated to describe demographic categorical data with Fisher's exact test used to test for differences in these proportions with regard to high- and low-volume centers. Fisher's exact test was also used to test for significance between Black, Hispanic, and Other UR compared to White UR with regard to high- and low-volume centers. Descriptive statistics were used to compare disparity ratios. Significance was defined as  $P < .05$  for all statistical analysis.

## Results

### Demographics of Entire Cohort

The total population of patients undergoing TSA from 2009 to 2017 in the SPARCS database was 32 410 with 10 415 (32%) TSAs performed in high-volume centers and 21 995 (68%) TSAs performed in low-volume centers as seen in Table 2. The majority of patients were above the age of 50 with a slightly larger proportion of the cohort being female (58.3%) than male (41.7%). The majority of patients were White (81.2%) followed by Other (8.7%), Black (5.1%), and Hispanic (5.0%).

**Table 2.** Patient Demographics by Hospital Volume.

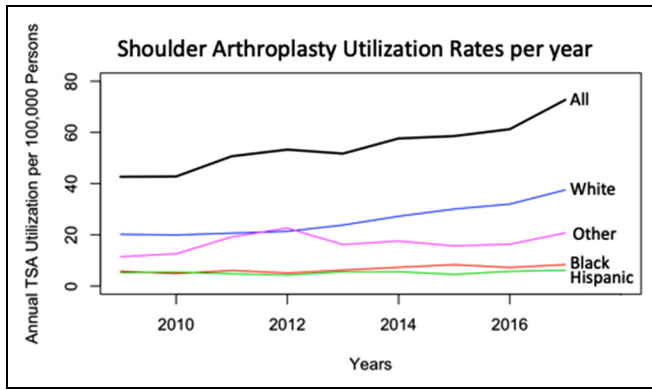
Patient demographics by hospital volume, expressed as percentages of the column				
	High volume	Low volume	P-value	All centers
N	10 415	21 995		32 410
Age (years)			.714	
<50	7.2	6.1		6.4
50-69	49.6	45.0		46.5
70+	43.2	48.9		47.1
Gender			.775	
Male	43.6	40.8		41.7
Female	56.4	59.2		58.3
Race			.755	
Black	4.5	5.3		5.1
Hispanic	2.7	6.1		5.0
Other	8.2	9.1		8.7
White	84.6	79.5		81.2
Insurance			.439	
Medicare	56.0	64.1		61.5
Medicaid	2.6	4.6		4.0
Private	29.5	23.0		25.1
Other	11.9	8.3		9.4
Illness severity			.650	
1	6.5	9.1		8.2
2	89.3	85.0		86.4
3+	4.2	5.9		5.4
Length of stay (days)			.246	
1	34.7	39.0		37.7
2	40.5	30.0		33.3
3	16.0	14.7		15.1
4+	8.8	16.3		13.9

### Demographics of High-Volume versus Low-Volume Centers

Demographic differences between high- and low-volume centers are demonstrated in Table 2. Notably, 6.1% of Hispanics made up the low-volume cohort compared to only 2.7% of the high-volume cohort. 16.3% of TSAs in low-volume centers had length of stays >4 days compared with 8.8% of TSAs in high-volume centers. Despite these findings, there were no significant differences in proportions of patients undergoing TSA comparing age, gender, race, insurance, illness severity, or length of stay with regard to hospital volume.

### Utilization Rates

Annual TSA utilization for all races increased from 43 per 100 000 residents in 2009 to 73 per 100 000 residents in 2017, two-thirds of which was driven by an increase in utilization by White residents from 20 per 100 000 White residents in 2009 to 37 per 100 000 White residents in 2017



**Figure 1.** Annual total shoulder arthroplasty (TSA) utilization rate; specified as rates per 100 000 persons of their respective race.

**Table 3.** Rates and Disparity Ratios of Shoulder Arthroplasty Utilization.

Rates and disparity ratios of shoulder arthroplasty utilization					
	Utilization rate per 100 000 people		Utilization rate per 100 000 people		P-value
	High volume	Low volume	High volume	Low volume	
Gender					
Male	75	165	1.17	1.32	.651
Female	63	125	-	-	
Race					
Black	17	42	0.22	0.27	.559
Hispanic	8	39	0.10	0.25	.043*
Other	45	107	0.58	0.69	.524
White	78	155	-	-	

\*P < .05.

(Figure 1). Utilization by Other, Black, and Hispanics residents showed smaller increases respectively from 11 to 21, 6 to 8, and 5 to 6 per 100 000 residents, respectively.

Utilization rates and disparity ratios calculated based on aggregated data from all years are documented in Table 3. More White residents per 100 000 underwent shoulder arthroplasty than Black, Hispanic, and Other residents per 100 000 residents of their respective race. There were significant differences ( $P = .43$ ) in the UR with regard to Hispanic resident use of high- and low-volume centers compared to White resident use with a disparity ratio of 0.10 and 0.25, respectively. Therefore, White residents were 90% more likely than Hispanic residents to undergo shoulder arthroplasty at high-volume centers. There were no significant differences in utilization rates with regard to hospital operative volume comparing Black or Other residents to White residents. More female residents per 100 000 female residents underwent shoulder arthroplasty than male residents per

100 000 male residents with a disparity ratio of 1.17 and 1.32 for high- and low-volume centers, respectively. Though notable for an underutilization by male residents, utilization was similarly low between high- and low-volume centers such that operative volume was not a significant determinant of this disparity.

### Sub-Analysis Excluding Fractures

There were 4356 patients who underwent TSA with the diagnosis of fracture. Overall trends in demographic data were similar with no significant difference in proportions of patients undergoing TSA comparing age, gender, race, insurance, illness severity, or length of stay with regard to hospital volume. Similarly, more White residents per 100 000 White residents underwent shoulder arthroplasty than Black, Hispanic, and Other residents per 100 000 residents of their respective race. The disparity ratio with regard to Hispanic utilization was 0.10 and 0.24 for high- and low-volume centers. Though the trend was similar to the analysis including fractures, the difference in the analysis excluding fractures was not significant with regard to operative volume ( $P = .068$ ). More female residents per 100 000 female residents underwent shoulder arthroplasty than Male residents per 100 000 male residents though utilization was not significantly different with regard to hospital operative volume.

### Discussion

While shoulder arthroplasty utilization nearly doubled in annual utilization from 2009 to 2017, racial and gender utilization disparities continue to exist in total shoulder arthroplasty particularly among Hispanic residents' utilization of high-volume centers in New York State. To our knowledge, this is the first study to demonstrate that hospital operative volume is a determinant of ever-present utilization disparities in total shoulder arthroplasty.

Shoulder arthroplasty is a very well-recognized and effective treatment at reducing pain and re-establishing function for many common pathologies of the shoulder.<sup>10,28</sup> The reproducible success and expanded indications in the setting of an increasingly older population has led to predictable increases in utilization over the decade consistent with trends from older studies.<sup>4-6,10,15,24</sup> Our study demonstrated that TSA utilization doubled from 43 per 100 000 residents in 2009 to 73 per 100 000 residents in 2017. Despite that dramatic increase, our study demonstrated that disparities previously seen in joint replacement procedures persisted with over two-thirds of that annual increase being accounted for by an increase in utilization by White residents while annual utilization by Black residents were largely unchanged. This trend of widening annual utilization rate has been noted by multiple studies.<sup>8,13</sup> Singh et al. in their analysis of TSA recorded in the US Nationwide Inpatient Sample (NIS) from 1998 to 2011.<sup>13</sup> They found that compared to Whites,

Blacks had much a lower TSA utilization rate per 100 000 in 1998 (2.97 vs. 0.83), a difference that only widened in 2011 (12.27 vs. 3.33).<sup>13</sup> More recently, Best et al.<sup>8</sup> also documented a similar trend with the difference in the incidence of reverse and anatomic shoulder arthroplasty between black and white patients nearly doubling from 2012 to 2017.

Additionally, the high- and low-volume center disparity ratios for Black residents were notably large at 0.22 and 0.27, despite this difference not being explained by hospital operative volume. Utilization disparities between Black and White patients have been well detailed in the literature.<sup>8,10,13,15,29</sup> Blum et al. 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, socioeconomic status, cultural differences, patient expectations, and preferences of joint arthroplasty surgery.<sup>10,30–32</sup> Several studies have analyzed the role behavioral and social factors, such as patient preferences and expectations, play in influencing one's decision to seek medical care.<sup>16</sup> For example, compared with whites, blacks were more likely to rely on self-care measures such as prayer and were less likely to consider surgery for severe arthritis pain even when accounting for disease severity.<sup>16,33,34</sup> Additionally, The Institute of Medicine concluded that physicians were less likely to provide alternative treatments for patients refusing treatment or conveying mistrust.<sup>34</sup> Differences in cultural norms and patient preferences may convey a sense of mistrust in the patient-provider relationship altering recommendations for operative versus non-operative management furthering these disparities.

To combat these disparities, policy initiatives such as the 2013 Centers for Medicare & Medicaid Services Equity Plan for Improving Quality in Medicare & Medicaid have championed a three-domain systematic approach.<sup>35</sup> The three domains include increasing understanding and awareness of disparities, creating and sharing solutions and accelerating the implementation of effective actions. In line with the solutions domain of initiatives, Ibrahim evaluated the use of a decision aid in eliminating racial disparities in TJA and found a 70% increase in TKA utilization in black patients.<sup>31</sup> They posited that decision aids are associated with increased patient knowledge, more realistic patient perceptions, less decisional conflict, and improved concordance between patient values and treatment choices.<sup>31</sup> All these seek to promote shared decision-making which the National Quality Forum cited as one of the six healthcare reforms with the greatest potential to reduce disparities.<sup>31,36</sup>

Our study also asserts that hospital operative volume plays a role in such disparities with white residents being 90% more likely than Hispanic residents to undergo shoulder arthroplasty at high-volume centers. Similar effects have been demonstrated in other total joint arthroplasty procedures. Soohoo et al. demonstrated that specifically Hispanic patients were over three times as likely to undergo TKA at a low-volume center compared to White patients.<sup>2</sup> This

was the largest relative risk of any minority group in their study signifying there may be specific issues contributing to Hispanic patients' utilization of high-volume centers compared to other minorities. Some of these differences in Hispanic utilization may be accounted for by regional differences as detailed by Einchinger et al. who reported the disparity ratio for shoulder arthroplasty utilization was 0.16 in the Northeast compared to 0.33 in the West.<sup>10</sup>

One specific issue more likely to affect our Hispanic patients is language concordance. While areas following continental migration such as the Southwest tend to have higher needs for interpreted services, greater than one in seven patients undergoing TKA in a single New York medical center required an interpreter for their visit.<sup>37</sup> However, in an analysis of 50 orthopedic surgery practices, Greene et al. found that 80% of the time Spanish-speaking patients were asked to rely on a non-qualified interpreter (family or friends)<sup>38</sup> because of lack of an available interpreter. In addition to a lack of in-visit language support, an analysis of all centers nationwide with pediatric orthopedic surgery fellowships recognized by the Pediatric Orthopaedic Society of North America found only sixteen centers (34.8%) had online information on orthopedic conditions or surgical care translated into Spanish.<sup>39</sup> In addition to these language barriers, provider referral networks may play a role. Physicians carrying for low-income populations may more readily refer patients to in-network low-volume centers. These centers may subsequently have invested in language concordant surgeons or language support services to support patients seeing them who more readily require such services. Utilizing interpreter services, while beneficial to developing the patient-provider relationship at either institution, comes at a cost. A study from the Mayo Clinic found an average of a 19 min wait time for in-person interpreter services, though this wait time was highly variable and could be greatly prolonged at times.<sup>40</sup> As suggested by Bernstein et al., unless there is a distinct need or adjustments in outcome metrics for non-English-speaking patients, institutions may be discouraged from performing elective TJA on this population furthering such disparities.<sup>37</sup> As such, we recommend institutions ensure equal access to language concordant care and the healthcare system finds way to directly compensate institutions who seek to expand both in-person interpreter and online translated services.

Additionally, we found an overutilization of shoulder arthroplasty from female residents compared to male residents through operative volume did not account for this difference. While higher rates of shoulder osteoarthritis in females likely contribute to this finding, we believe other factors may additionally be involved.<sup>41</sup> Einchinger et al. similarly demonstrated gender utilization differences in shoulder arthroplasty. However, their study found these gender utilization differences varied by both age and race. For example, among White and Hispanic patients ages 45 to 64, there was an overutilization by male residents with a disparities

ratio of 1.23 and 1.29; however, among Black patients age 45 to 64 and patients of all races age 65 to 84, there was an underutilization by male residents.<sup>10</sup> Further investigation is needed to understand possible biologic and cultural causes which underlie the interactions between sex, age, race, and shoulder arthroplasty utilization disparities.

Lastly, we posit that differences in electiveness of procedure play a role in these disparities. Despite prior studies also suggesting an underutilization of orthopedic trauma procedures in minority groups, our sub-analysis excluding fractures showed no significant difference between Hispanic resident utilization compared to White resident utilization with regard to operative volume.<sup>3</sup> Utilization disparities research within the field of orthopedic trauma is lacking with no current studies evaluating utilization within orthopedic upper extremity trauma. The authors posit that differences in the incidence of upper extremity orthopedic trauma between racial groups and the role high- versus low-volume centers play in managing upper extremity orthopedic trauma within a given county may play role in diminishing the difference in utilization disparities.


While one of the advantages of this study is the large patient population analyzed, there are limitations associated with the analysis of an administrative database. There is limited granularity within a publicly available database and as such, we were unable to consider other patient-level information such as clinical outcomes and complications when assessing racial disparities. The SPARCS database also is only representative of New York state utilization and as such, we were not able to draw distinct conclusions about disparities on a national level. Additionally, when utilizing census data, we did not factor county location into the population of a specific group and it is possible that population demographics of the state are not representative of the region where most of the procedures in New York State were performed.

## Conclusion

While shoulder arthroplasty utilization nearly doubled in annual utilization from 2009 to 2017, racial and gender utilization disparities endured and widened with regard to minority utilization compared to White utilization. We noticed an underutilization of high-volume centers by Hispanic residents compared with White residents, a difference not seen when comparing other minority groups, suggesting there may be specific barriers Hispanic residents face. Additionally, we found that more females underwent shoulder arthroplasty than males, though there was no difference with regard to operative volume. It is the authors' belief that the reasons for these prevailing disparities are most likely multifactorial with contributing factors including access to appropriate language concordant health care, cultural differences, and social attitudes toward medicine.<sup>15,33,42</sup> Further research on

outcomes is needed to elucidate potential health ramifications for these disparities in utilization.

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