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

Data received: 26 May 2021; Revised: 4 August 2021; accepted: 6 August 2021

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.1-3 Despite increasing utilization of total shoulder arthroplasty (TSA) as an effective management of various shoulder pathologies,4-6 the literature has demonstrated that enduring racial and gender disparities exist in joint replacement procedures.7-15 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.1 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.1

Studies have shown hospital operative volume as a contributing factor to racial disparities in joint replacement procedures.2,16-17 Soohoo et al.2 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...
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. 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.

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. 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. 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. 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 and other conditions. 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.

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. 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. 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    | 4    | 5    | 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.26

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.10 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.27 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.10 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 $P < 0.05$ 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%).

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.
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 White residents underwent shoulder arthroplasty than Black, Hispanic, and Other residents per 100,000 residents of their respective race. There were significant differences ($P = .043$) 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.\textsuperscript{10,28} 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.\textsuperscript{4–6,10,15,24} 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.\textsuperscript{8,13} Singh et al. in their analysis of TSA recorded in the US Nationwide Inpatient Sample (NIS) from 1998 to 2011.\textsuperscript{13} 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). More recently, Best et al. 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. 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. 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. 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. Additionally, The Institute of Medicine concluded that physicians were less likely to provide alternative treatments for patients refusing treatment or conveying mistrust. 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 have championed a three-domain systematic approach. 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. 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. 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.

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. 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 disparities 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.

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. 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) 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. 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. 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. As such, we recommend institutions ensure equal access to language concordant care and the healthcare system finds ways 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. 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. 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 executiveness of procedures 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. 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. Further research on outcomes is needed to elucidate potential health ramifications for these disparities in utilization.

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References
1. Singh JA, Lu X, Rosenthal GE, Ibrahim S, Cram P. Racial disparities in knee and hip total joint arthroplasty: an 18-year analysis of national Medicare data. Ann Rheum Dis. 2014;73(12):2107–2115. doi:10.1136/annrheumdis-2013-203494
2. SooHoo NF, Zingmond DS, Ko CY. Disparities in the utilization of high-volume hospitals for total knee replacement. J Natl Med Assoc. 2008 May;100(5):559–564. doi:10.1016/S0027-9684(15)31303-1
3. Yu S, Mahure SA, Branch N, Mollon B, Zuckerman JD. Impact of race and gender on utilization rate of total shoulder arthroplasty. Orthopedics. 2016;39(3):e538–e544. doi:10.3928/01477447-20160427-14.
4. Issa K, Pierce CM, Pierce TP, et al. Total shoulder arthroplasty demographics, incidence, and complications—a nationwide inpatient sample database study. Surg Technol Int. 2016 Oct;26(29):240–246. PMID: 27608744.
5. Schairer WW, Nwachukwu BU, Lyman S, Craig EV, Gulotta LV. National utilization of reverse total shoulder arthroplasty in the United States. J Shoulder Elbow Surg. 2015;24(1):91–97. doi:10.1016/j.jse.2014.08.026
6. Zhang W, Lyman S, Boutin-Foster C, et al. Racial and ethnic disparities in utilization rate, hospital volume, and perioperative outcomes after total knee arthroplasty [published correction appears in J Bone Joint Surg Am. 2017 Mar; 15;99(6):e30]. J Bone Joint Surg Am. 2016;98(15):1243–1252. doi:10.2106/JBJS.15.01009
7. Amen TB, Varady NH, Rajaee S, Chen AF. Persistent racial disparities in utilization rates and perioperative metrics in total joint arthroplasty in the U.S.: a comprehensive analysis of trends from 2006 to 2015 [published online ahead of print, 2020 Mar 12]. J Bone Joint Surg Am. 2020;102(9):811–820. 10.2106/JBJS.19.01194.
8. Best MJ, Aziz KT, McFarland EG, Martin SD, Rue JH, Srikumaran U. Worsening racial disparities in patients undergoing anatomic and reverse total shoulder arthroplasty in the United States. J Shoulder Elbow Surg. 2021;30(8):1844–1850. doi:10.1016/j.jse.2020.10.023
9. Dunlop DD, Manheim LM, Song J, et al. Age and racial/ethnic disparities in arthritis-related hip and knee surgeries. Med Care. 2008;46(2):200–208. PMID: 18219249. doi:10.1097/MLR.0b013e31815cecd8
10. Eichinger JK, Greenhouse AR, Rao MV, et al. Racial and sex disparities in utilization rates for shoulder arthroplasty in the United States disparities in shoulder arthroplasty. J Orthop. 2019;16(3):195–200. Published 2019 Feb 28. doi:10.1016/j.joro.2019.02.029
11. Garcia IA, Chan PH, Prentice HA, Navarro RA. The association between race/ethnicity and outcomes following primary shoulder arthroplasty. J Shoulder Elbow Surg. 2020;29(5):886–892. doi:10.1016/j.jse.2019.09.018
12. Pandya NK, Wustrack R, Metz L, Ward D. Current concepts in orthopaedic care disparities. J Am Acad Orthop Surg. 2018; 26(23):823–832. doi:10.5435/JAAOS-D-17-00410
13. Singh JA, Ramachandran R. Persisting racial disparities in total shoulder arthroplasty utilization and outcomes. J Racial Ethn Health Disparities. 2015;2015:1–8. doi:10.1007/s40615-015-0138-3.
14. Statewide Planning and Research Cooperative System (SPARCS). https://www.health.ny.gov/statistics/sparc. Accessed January 1, 2020
15. Yin C, Sing DC, Curry EI, et al. The effect of race on early perioperative outcomes after shoulder arthroplasty: a propensity score matched analysis. Orthopedics. 2019;42(2):95–102. doi:10.3928/01477447-20190221-01
16. Zelle BA, Morton-Gonzaba NA, Adcock CF, Lacci JV, Dang KH, Seifi A. Healthcare disparities among orthopedic trauma patients in the USA: socio-demographic factors influence the management of calcaneal fractures. J Orthop Surg Res. 2019;14(1):359. doi:10.1186/s13018-019-1402-8
17. Ibrahim SA. Racial variations in the utilization of knee and hip joint replacement: an introduction and review of the most recent literature. Curr Orthop Pract. 2010;21(2):126–131. doi:10.1097/BCO.0b013e3181d8223
18. Hammond JW, Queale WS, Kim TK, McFarland EG. Surgeon and hospital volumes and outcomes for shoulder arthroplasty. J Bone Joint Surg Am. 2003;85(12):2318–2324. PMID: 14668500. doi:10.2106/JBJS.C.02071
19. Jain N, Pietrobon R, Hocker S, Shankar A, Higgins LD. The relationship between surgeon and hospital volume and outcomes for shoulder arthroplasty. J Bone Joint Surg Am. 2004;86(3):496–505. PMID: 14996874. doi:10.2106/JBJS.D.02071
20. Lyman S, Jones EC, Bach PB, Peterson MG, Marx RG. The association between hospital volume and total shoulder arthroplasty outcomes. Clin Orthop Relat Res. 2005;432:132–137. PMID: 15738813. doi:10.1097/01.blo.0000150571.51381.9a
21. Jancuska JM, Hutzler L, Protopsaltis TS, Bendo JA, Bosco J. Utilization of lumbar spinal fusion in New York state: trends and disparities. Spine (Phila Pa 1976). 2016;41(15):1508–1514. PMID: 26977849. doi:10.1097/BRS.0000000000001567
22. Kurucan E, Sulovari A, Thirukumar C, Greenstein A, Molinari R, Mesfin A. Volume-outcome relationship in halo vest utilization for C2 fractures. Spine J. 2020;20(10):1676–1684. doi:10.1016/j.spinee.2020.05.543
23. Tompson JD, Syed UA, Padegimas EM, Abboud JA. Should arthroplasty utilization based on race—are black patients underrepresented? Arch Bone Jt Surg. 2019 Nov;7(6):484–492. PMID: 31970252; PMIDC: PMC6935522.
24. Zmistsowski B, Padegimas EM, Howley M, Abboud J, Jr WG, Namdari S. Trends and variability in the use of total shoulder arthroplasty for medicare patients. J Am Acad Orthop Surg. 2018;26(4):133–141. doi:10.5435/JAAOS-D-16-00720
25. Williams DM, Thirukumar CP, Oses JT, Mesfin A. Complications and mortality rates following surgical management of extradural spine tumors in New York state. Spine (Phila Pa 1976). 2020;45(7):474–482. PMID: 31651687. doi:10.1097/BRS.0000000000003294
26. Averill RF, Goldfeld N, Hughes JS. All patient refined diagnosis related groups methodology overview. National Association of Children’s Hospitals and Related Institutions, Inc. Wallingford, CT and Murray, UT: 3M Health Information Systems; 2003.
27. 2010 Census Redistricting Data (Public Law 94-171) Summary File. 2011; 2011 2017 https://www.census.gov/prod/cen2010/doc/p94-171.pdf.
28. Day JS, Lau E, Ong KL, Williams GR, Ramsey ML, Kurtz SM. Prevalence and projections of total shoulder and elbow arthroplasty in the United States to 2015. J Shoulder Elbow Surg. 2010;19(8):1115–1120. doi:10.1016/j.jse.2010.02.009
29. The CMS Equity Plan for Improving Quality in Medicare. https://www.cms.gov/About-CMS/Agency-Information/OMH/OMH_Dwndl-CMS_EquityPlanforMedicare_090615.pdf. Accessed April 30, 2021.
30. Blum MA, Ibrahim SA. Race/ethnicity and use of elective joint replacement in the management of end-stage knee/hip osteoarthritis: a review of the literature. Clin Geriatr Med. 2012; 28(3):521–532. doi:10.1016/j.cger.2012.05.002
31. Ibrahim SA, Blum M, Lee GC, et al. Effect of a decision aid on access to total knee replacement for black patients with osteoarthritis of the knee: a randomized clinical trial. JAMA Surg. 2017;152(1):e164225. Epub 2017 Jan 18. PMID: 27893033; PMCID: PMC5726272. doi:10.1001/jamasurg.2016.4225
32. Ibrahim SA, Hanusa BH, Hannon MJ, Kresevic D, Long J, Kent Kwoh C. Willingness and access to joint replacement among African American patients with knee osteoarthritis: a randomized, controlled intervention. Arthritis Rheum. 2013; 65(5):1253–1261. doi:10.1002/art.37899
33. Ibrahim SA, Siminoff LA, Burant CJ, Kwoh CK. Understanding ethnic differences in the utilization of joint replacement for osteoarthritis: the role of patient-level factors. Med Care. 2002;40(suppl 1):144–151.
34. Smedley BD, Stith AY, Nelson AR. Committee on understanding and eliminating racial and ethnic disparities in health care. In: Unequal treatment: confronting racial and ethnic disparities in health care. 2003: 180–191.
35. Thompson KA, Terry EL, Siblet KT, et al. At the intersection of ethnicity/race and poverty: knee pain and physical function. J Racial Ethn Health Disparities. 2019;6(6):1131–1143. doi:10.1007/s40615-019-00615-7
36. National Quality Forum (NQF). A Comprehensive Framework and Preferred Practices for Measuring and Reporting Cultural Competency: A Consensus. Washington, DC: NQF; 2009.
37. Greene NE, Fuentes-Juarez BN, Sabatini CS. Access to orthopaedic care for Spanish-speaking patients in California. J Bone Joint Surg Am. 2010;19(18):e95. PMID: 31567810. doi:10.2106/JBJS.18.01080
38. Bernstein JA, Ramirez JM, Walsh DF, Defroda SF, Jr CA. Evaluation of Spanish language proficiency and resources available in academic pediatric orthopaedic centers. J Pediatr Orthop. 2020;40(6):310–313. PMID: 32501928. doi:10.1097/BPO.0000000000001466
39. Burke CM, Anderson KA, Xiong Y, Guerra AW, Tschida-Reuter DA. Assessment of the efficiency of language interpreter services in a busy surgical and procedural practice. BMC Health Serv Res. 2017;17:456. doi:10.1186/s12913-017-2425-7
41. Cushnaghan J, Dieppe P. Study of 500 patients with limb joint osteoarthritis. I. Analysis by age, sex, and distribution of symptomatic joint sites. *Ann Rheum Dis*. 1991;50(1):813. PMID: 1994877; PMCID: PMC1004316. doi:10.1136/ard.50.1.8

42. Slover JD, Walsh MG, Zuckerman JD. Sex and race characteristics in patients undergoing hip and knee arthroplasty in an urban setting. *J Arthroplasty*. 2010;25(4):576–580. doi:10.1016/j.arth.2009.03.002