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The Impact of the COVID-19 Pandemic on Racial Disparities in Patients Undergoing Total Shoulder Arthroplasty in the United States

The Avant-garde Health and Codman Shoulder Society Value Based Care Group, Matthew J. Best, MD, Catherine J. Fedorka, MD, Robert M. Belniak, MD, Derek A. Haas, MBA, Xiaoran Zhang, MA, April D. Armstrong, MD, Joseph A. Abboud, MD, Andrew Jawa, MD, Evan A. O'Donnell, MD, Jason E. Simon, MD, Eric R. Wagner, MD, Momin Malik, PhD, Michael B. Gottschalk, MD, Adam Z. Khan, MD, Gary F. Updegrave, MD, Eric C. Makhni, MD, Jon JP. Warner, MD, Uma Srikumaran, MD, MBA, MPH

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The Avant-garde Health and Codman Shoulder Society Value Based Care Group:

Matthew J. Best, MD<sup>1</sup>, Catherine J. Fedorka, MD<sup>2</sup>, Robert M. Belniak, MD<sup>3</sup>, Derek A. Haas, MBA<sup>4</sup>, Xiaoran Zhang, MA<sup>4</sup>, April D. Armstrong, MD<sup>5</sup>, Joseph A. Abboud, MD<sup>6</sup>, Andrew Jawa, MD<sup>7</sup>, Evan A. O'Donnell, MD<sup>8</sup>, Jason E. Simon, MD<sup>9</sup>, Eric R. Wagner, MD<sup>10</sup>, Momin Malik, PhD<sup>4</sup>, Michael B. Gottschalk, MD<sup>10</sup>, Adam Z Khan, MD<sup>11</sup>, Gary F. Updegrave, MD<sup>5</sup>, Eric C. Makhni, MD<sup>12</sup>, Jon JP Warner, MD<sup>8</sup>, Uma Srikumaran, MD, MBA, MPH<sup>1</sup>

1. Department of Orthopaedic Surgery, Johns Hopkins University School of Medicine, Johns Hopkins Hospital, Baltimore, MD, USA.
2. Cooper Bone and Joint Institute, Camden, NJ, USA.
3. Department of Orthopaedic Surgery and Sports Medicine, Starling Physicians Group, New Britain, CT, USA.
4. Avant-garde Health, Boston, MA, USA
5. Department of Orthopaedics and Rehabilitation, Bone and Joint Institute, Penn State Milton S. Hershey Medical Center, Hershey, PA, USA.
6. Rothman Institute, Thomas Jefferson University Hospital, Philadelphia, PA, USA.
7. Department of Orthopaedic Surgery, New England Baptist Hospital, Tufts University School of Medicine, Boston, MA, USA; Boston Sports and Shoulder Center, Waltham, MA, USA.
8. Department of Orthopaedic Surgery, Harvard Medical School, Massachusetts General Hospital, Boston Shoulder Institute, Boston, MA, USA.

9. Department of Orthopaedic Surgery, Harvard Medical School, Newton-Wellesley Hospital, Boston, MA, USA.
10. Department of Orthopaedic Surgery, Emory University, Atlanta, GA, USA.
11. Department of Orthopaedic Surgery, Washington University in St. Louis, St. Louis, MO, USA.
12. Department of Orthopaedic Surgery, Sports Medicine, Henry Ford Health, Detroit, MI, USA.

Please address all correspondence to Uma Srikumaran, MD, Department of Orthopaedic Surgery, The Johns Hopkins University, 601 North Caroline Street, Baltimore, MD 21287, USA (Telephone: 443-546-1550; fax: 443-546-1551; E-mail: us@jhmi.edu).

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1 **The Impact of the COVID-19 Pandemic on Racial Disparities in Patients Undergoing Total**  
2 **Shoulder Arthroplasty in the United States**

3 **Abstract**

4 **Introduction:** The purpose of this study was to assess racial disparities in total shoulder  
5 arthroplasty (TSA) in the US and to determine whether these disparities were affected by the  
6 COVID-19 pandemic.

7 **Methods:** Centers for Medicare and Medicaid Services (CMS) 100% sample was used to  
8 examine primary TSA volume from April-December from 2019-2020. Utilization was assessed  
9 for White/Black/Hispanic/Asian populations to determine if COVID-19 affected these groups  
10 differently. A regression model adjusted for age/sex/CMS-Hierarchical Condition Categories  
11 (HCC) score, dual enrollment (proxy for socioeconomic status), time fixed effects, and Core-  
12 based Statistical Area (CBSA) fixed effects was used to study difference across groups.

13 **Results:** In 2019, TSA volume/1000 beneficiaries was 1.51 for White and 0.57 for non-White, a  
14 2.6-fold difference. In 2020, the rate of TSA in White patients (1.30/1000) was 2.9 times higher  
15 than non-White (0.45/1000) during the COVID-19 pandemic ( $P < 0.01$ ). There was an overall  
16 14% decrease in TSA volume/1000 Medicare beneficiaries in 2020; non-White patients had a  
17 larger percentage decrease in TSA volume than White (21% vs. 14%, estimated  
18 difference; 8.7%,  $p = 0.02$ ). Black patients experienced the most pronounced disparity with  
19 estimated difference of 10.1%,  $p = 0.05$ , compared with White patients. Similar disparities were  
20 observed when categorizing procedures into anatomic and reverse TSA, but not proximal  
21 humerus fracture.

22 **Conclusions:** During the COVID-19 pandemic, overall TSA utilization decreased by 14% with  
23 White patients experiencing a decrease of 14%, and non-White patients experiencing a decrease

24 of 21%. This trend was observed for elective TSA while disparities were less apparent for  
25 proximal humerus fracture.

26 **Level of Evidence:** Level III; Retrospective Cohort Comparison; Descriptive Epidemiology  
27 Study

28 **Keywords:** Racial disparities; COVID-19; coronavirus pandemic; total shoulder arthroplasty;  
29 TSA; Shoulder

30 Racial disparities have been shown in many areas of medicine and have persisted through  
31 the past decade.<sup>9, 12, 15, 24, 25</sup> Achieving health equity and improving access to quality medical care  
32 for underrepresented minorities has been a focus for medical societies, patient advocacy groups,  
33 and various areas of government, prompting the development of federal programs and policies  
34 aimed at reducing health inequality.<sup>3-6, 20</sup> Despite knowledge of racial disparities and the  
35 implementation of various policies and methods to reduce them, racial disparities have persisted  
36 in the US for a myriad of surgical procedures including shoulder arthroplasty.<sup>1, 8</sup>

37 The onset of the coronavirus-19 (COVID) pandemic has led to widespread economic and  
38 healthcare crises affecting patients, providers, and the healthcare system overall.<sup>10</sup> Several  
39 reports have demonstrated that the Black community has been disproportionately affected by  
40 COVID-19 both in rates of hospitalization and risk of death.<sup>14, 21, 22, 28</sup> Price-Haygood et al  
41 showed that Black patients with COVID-19 had a significantly higher mortality rate than White  
42 patients within a large, tertiary care network.<sup>22</sup> This finding was particularly problematic given  
43 that Black patients made up less than one-third of the population studied. Worsening racial  
44 disparities during the COVID-19 pandemic have also been shown for Medicare patients  
45 undergoing hip and knee replacement surgery, with a 12.9% decreased likelihood of undergoing  
46 hip or knee replacement for non-White patients.<sup>26</sup>

47           The purpose of this study was to assess the impact that the COVID-19 pandemic has had  
48 on racial disparities in patients undergoing total shoulder arthroplasty (TSA). We also aim to  
49 evaluate these disparities in the context of indication for shoulder arthroplasty, comparing those  
50 treated for proximal humerus fracture with non-fracture cases. We hypothesize that shoulder  
51 arthroplasty utilization for all races decreased during the COVID pandemic but that a greater  
52 decrease occurred in Black, Hispanic, and Asian patients, compared with White patients.

### 53 **Methods**

#### 54 *Data Source*

55           The Center for Medicare and Medicaid Services (CMS) fee-for-service (FFS) inpatient  
56 and outpatient claims data 100% sample, and Medicare enrollment data spanning 2019 through  
57 2020 was used for this analysis. We identified April 2020 as the first full month after the onset of  
58 the COVID-19 pandemic, and therefore set April 1, 2020 as the start date for the COVID-19  
59 period. Since at the time of our analysis, the claims data extended through December 31, 2020,  
60 we examined cases admitted by December 18<sup>th</sup> to ensure we could capture the full length of stay.  
61 We examined the same time period of cases (April 1<sup>st</sup> to December 18<sup>th</sup> admissions) in 2019 as  
62 in 2020 to ensure comparability between the years. The study included primary total shoulder  
63 arthroplasties (TSAs) that were coded as inpatient using diagnosis-related group (DRG) 483, and  
64 outpatient using primary current procedural terminology (CPT) 23472. Outpatient TSAs only  
65 made up only a small fraction of total TSAs cases as CMS only removed TSAs from the  
66 inpatient-only list in 2021. We further divided TSAs into non-fracture anatomic arthroplasties,  
67 non-fracture reverse arthroplasties, and fracture TSAs (anatomic and reverse combined) based on  
68 each case's primary international classification of diseases 10<sup>th</sup> revision diagnosis (ICD-10-CM)  
69 and procedure (ICD-10-PCS) codes. CMS previously expanded their variables for non-white and



70 non-black race and ethnicity groups to allow for more granular data collection. Therefore, we  
71 analyzed racial and ethnic groups individually (White, Black, Hispanic, Asian) as well as in  
72 larger groups (White and non-White)

### 73 *Race/Ethnicity*

74 We defined race and ethnicity using the race variable from the Medicare beneficiary  
75 enrollment data. Race and ethnicities include White, Black, Hispanic, Asian, other, and  
76 unknown. We grouped minorities including Black, Hispanic, Asian, and other into the non-White  
77 racial group to compare with the White racial group. We also compared Black, Asian, Hispanic,  
78 and other minority groups with White separately.

### 79 *Statistical Analysis*

80 We calculated the total TSA volume per 1000 Medicare beneficiaries by different racial  
81 groups. We then compared the total TSA rate between April 1<sup>st</sup> and December 18<sup>th</sup> in 2019 and  
82 2020. The percentage change in TSA rate during-COVID was then calculated. A generalized  
83 linear model assuming a binomial distribution at beneficiary-year level was fitted with the  
84 dependent variable being if a beneficiary received a TSA between April and December during  
85 the given year. We adjusted for the minority indicator interacted with during-COVID, age, sex,  
86 CMS-hierarchical condition categories (HCC) risk score, Medicare-Medicaid dual enrollment  
87 status, and year fixed effects to study the differential effect of COVID-19 on operation rate  
88 changes across different racial populations. Bonferroni corrections were applied to p-values. We  
89 controlled for the CMS-HCC risk score because it is a measure reflecting the expected future  
90 health costs for each patient based on the patient demographics and chronic illnesses. Medicare-  
91 Medicaid dual enrollment, i.e. if a patient is enrolled in both Medicare and Medicaid, was  
92 controlled for as a proxy for economic status of the beneficiary since eligibility is income based

93 The coefficient of the interaction term between minority and during-COVID is our estimate of  
94 the impact of the COVID-19 pandemic on racial disparities between White and the minority  
95 racial population, meaning that compared to the White racial group, how much did the TSA  
96 operation rate change due to COVID-19 in the minority racial population.

## 97 **Results**

98 A total of 49,412 and 41,554 cases were observed in 2019 and 2020 between April and  
99 December, respectively. There has been an overall 14% decrease in TSA volume per 1000  
100 Medicare beneficiaries between 2019 and 2020 (1.51 vs. 1.30). Racial disparities existed for  
101 TSA nationally prior to the COVID-19 pandemic. In 2019, the TSA hospitalization volume per  
102 1000 Medicare beneficiaries was 1.69 for the White population and 0.57 for non-White, a 2.6-  
103 fold difference. In 2020, the White TSA hospitalization rate (0.45 per 1000 beneficiaries) was  
104 2.9 times higher than that of the non-White patients (0.45 per 1000 beneficiaries) during the  
105 COVID-19 pandemic. The percentage decrease between 2019 and 2020 for White and non-  
106 White was 14% and 21%, respectively (**Table 1**).

107 Similar trends were observed when breaking the arthroplasties into anatomic and reverse  
108 TSAs. For anatomic TSAs, the overall decrease was 19% between 2019 and 2020, with the  
109 White population decreasing by 19%, and the non-White population decreasing by 29%. For  
110 reverse TSAs, a 13% decrease was observed across populations between 2019 and 2020, with a  
111 13% decrease for White and 19% decrease for non-White. Disparities were less apparent when  
112 analyzing non-elective cases, with a 3% decrease overall, a 3% decrease among White patients  
113 compared with a 4% decrease for non-White patients undergoing shoulder arthroplasty for  
114 proximal humerus fracture (**Table 1**).

115 By fitting a logistic regression at beneficiary-year level with receiving a TSA as  
116 dependent variable, we were able to quantify the impact of COVID-19 and race combined. **Table**  
117 **2** shows the estimate of the interaction term between COVID-19 and minorities, quantifying the  
118 exacerbation of preexisting racial disparities due to COVID-19. When pooling all non-White  
119 patients, the estimated difference in TSA utilization compared with White was -8.7% (95% CI [-  
120 14.0%, -3.1%],  $p = 0.02$ ), meaning that with TSA utilization decreasing for both White and non-  
121 White, there was an 8.7% more decrease for the non-White population. This effect was  
122 especially pronounced for the Black population, with a -10.1% (95% CI [-16.8%, -2.9%],  $p =$   
123  $0.05$ ) estimated difference compared with White. For other minorities, however, we did not  
124 observe significant differences according to the regression.

## 125 **Discussion**

126 This study showed that after the onset of the COVID-19 pandemic, preexisting racial  
127 disparities in patients undergoing TSA worsened. The overall rate of TSA hospitalization  
128 decreased by 14% across racial groups during the COVID-19 pandemic. However, the White  
129 population experienced a decrease of 14%, compared with a decrease of 21% in the non-White  
130 population. When analyzing disparities by indication for surgery, disparities were less  
131 pronounced in patients undergoing arthroplasty for proximal humerus fracture, with a decrease in  
132 rate of 3% and 4% for White and non-White patients respectively. After controlling for age, sex,  
133 comorbidities, and dual enrollment status (a proxy for economic status), the estimated difference  
134 in percent decrease between White and non-White patients was 8.7%, indicating that the non-  
135 White population had an 8.7% larger decrease in rate of hospitalization than White patients. The  
136 estimate was 10.1% for the Black patients.

137 Racial disparities have been shown in many studies throughout the orthopedic and  
138 general medical literature.<sup>1, 8, 9, 12, 15, 24, 25</sup> This is particularly concerning in the arthroplasty  
139 literature since Black patients develop osteoarthritis at a prevalence equal to or greater than  
140 White patients.<sup>16, 27</sup> In addition, various initiatives and programs have been implemented by the  
141 American Academy of Orthopedic Surgeons and other advocacy groups to reduce or eliminate  
142 differences in musculoskeletal care based on race.<sup>3, 20</sup> The Musculoskeletal Healthcare  
143 Disparities Research Symposium addressed this issue and called for increased access to  
144 arthroplasty procedures for under-represented minority patients.<sup>20</sup> Despite these initiatives and  
145 what seems to be widespread knowledge that these disparities exist, several studies show that  
146 racial disparities have persisted through 2017 for many orthopedic procedures and have  
147 worsened for some surgeries such as TSA, total hip arthroplasty (THA) and total knee  
148 arthroplasty (TKA).<sup>1, 2, 8, 9, 19, 23</sup> In a national study assessing all-payer data from 2006 to 2015,  
149 Amen et al showed that there were persistent disparities in utilization between White and Black  
150 patients undergoing TKA and worsening racial disparities in complications following TKA.<sup>1</sup> In a  
151 study evaluating racial disparities in patients undergoing TSA, Black patients had lower rates of  
152 utilization, higher rates of complications, and increased odds of mortality following surgery  
153 compared with White patients.<sup>8</sup> This lower rate of TSA utilization by Black patients worsened  
154 over the study period from 2012-2017.<sup>8</sup>

155 Racial differences were less apparent in patients undergoing arthroplasty for proximal  
156 humerus fracture with a decrease of 3% in White patients and 4% in non-White patients during  
157 the pandemic. Many shoulder arthroplasty cases performed for proximal humerus fracture are  
158 not elective surgeries and the difficulty in access to subspecialty orthopedic care may not be as  
159 marked in the trauma setting. However, racial disparities have been shown in multiple studies for

160 patients undergoing fracture care.<sup>2, 19, 23</sup> In a study of over 40,000 patients admitted to US  
161 hospitals with a proximal humerus fracture, Hispanic and Black patients were more likely to be  
162 uninsured and less likely to use post-discharge support services than White patients.<sup>18</sup> Two  
163 national studies assessed racial disparities in hip fracture care and showed longer time to surgery  
164 and higher rates of complications in under-represented minority patients compared with White  
165 patients.<sup>2, 19</sup>

166 Several reports and major news outlets have highlighted the glaring racial disparities  
167 exacerbated by the COVID-19 pandemic.<sup>14, 21, 22, 26, 28</sup> In a large cohort of patients within an  
168 integrated-delivery healthcare system, 77% of patients hospitalized with Covid-19 and 71% of  
169 those who died were Black despite the fact that Black patients comprised only 31% of the health-  
170 system population in the study.<sup>22</sup> These findings were corroborated in another study which  
171 showed that 34% of Covid deaths were among Black patients despite this group accounting for  
172 only 12% of the population in the United States.<sup>14</sup> These studies highlight that the Covid-19  
173 pandemic has magnified another pandemic in the US, which is racial and ethnic disparities in  
174 healthcare.<sup>29</sup>

175 There are several explanations for the findings of this study which have been posited as  
176 reasons for healthcare disparities throughout the pandemic. Access to primary care and specialty  
177 care has been shown to be more difficult for under-represented minorities.<sup>21, 29</sup> Implicit bias is  
178 associated with worse quality of care and poorer communication between patients and  
179 physicians.<sup>13, 17, 29</sup> Bias in behavioral attitudes can be worsened under conditions of stress such as  
180 providing medical care during the Covid-19 pandemic.<sup>29</sup> This may be reflected in data from  
181 various regions in the US which showed that African American patients with cough or fever  
182 were less likely than White patients to be offered a Covid test.<sup>7</sup> Another factor contributing to

183 racial disparities which may be exacerbated during the Covid-19 pandemic is pathogenic effects  
184 of adverse living and working conditions.<sup>21</sup> Data from New York City showed that the Bronx  
185 had the lowest income and education levels, the highest population of under-represented  
186 minorities, and the highest rate of Covid-19 hospitalizations and deaths, despite a lower  
187 population density than Manhattan.<sup>28</sup> Finally, distrust in the medical system has been shown as a  
188 factor contributing to racial disparities in patients contemplating total knee replacement and may  
189 influence decisions for patients considering total shoulder replacement as well.<sup>11</sup>

190         Although the results of the present study do not provide reasons for the worsening racial  
191 disparities in patients undergoing TSA during the Covid pandemic, they do highlight and raise  
192 awareness of this important issue. A recent viewpoint by Yancy recommends three strategies for  
193 helping to reduce racial disparities in healthcare, the first of which is to raise awareness of the  
194 problem.<sup>30</sup> Another strength of this study is that many factors such as age, sex, and economic  
195 status, or dual-enrollment status, were controlled for in our regression analysis. Although we do  
196 not have specific socioeconomic variables such as household income, dual enrollment status is  
197 based on income and can be used to as an indicator of socioeconomic status.

198         Despite these strengths this study has several limitations. One, we were not able to study  
199 these racial trends across different geographic regions or census divisions. Since the overall  
200 incidence of TSA in the Medicare population is < 2 per 1000 beneficiaries, this did not provide  
201 sufficient sample size for accurate census division analysis. In addition, the patient population  
202 studied included Medicare beneficiaries but not private payers. This may have been beneficial in  
203 this study since a larger proportion of patients with private insurance may have undergone  
204 outpatient TSA. Among Medicare beneficiaries in our study period from 2019-2020, the  
205 percentage of outpatient TSA was just 1.4%, indicating a large catchment of our study sample.

**206 Conclusion**

207 COVID-19 exacerbated the preexisting racial disparities for TSA utilization among  
208 Medicare beneficiaries in the US. During the COVID-19 pandemic, the overall TSA  
209 hospitalization rate dropped by 14% across racial groups. However, COVID-19 impacted racial  
210 groups differently, with the White population experiencing a decrease of 14%, and the non-  
211 White population experiencing a decrease of 21%. This trend was observed for elective shoulder  
212 arthroplasty cases while disparities were less apparent in patients undergoing arthroplasty for  
213 proximal humerus fractures.

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- 308 Legend
- 309 Table 1. Changes in Rates of TSAs per 1000 Medicare Beneficiaries by Racial Group During the  
310 COVID-19 Pandemic
- 311 Table 2. Estimated Between-group Differences of TSA Rates for All Types of TSAs For Each  
312 Minority Group Compared with the White Population<sup>1</sup>

<b>Table 1. Changes in Rates of TSAs per 1000 Medicare Beneficiaries by Racial Group During the COVID-19 Pandemic</b>			
	<b>2019 Apr-Dec</b>	<b>2020 Apr-Dec</b>	<b>Change (%)</b>
<b>All TSA (Sum of Types Below)</b>	1.51	1.30	-14%
White	1.69	1.46	-14%
Non-white	0.57	0.45	-21%
Black	0.58	0.45	-22%
Hispanic	0.50	0.42	-16%
Asian	0.29	0.22	-25%
Other Minorities	0.82	0.68	-17%
Unknown	1.31	1.16	-11%
<b>Types of Hospitalizations</b>			
<b>Anatomic TSA Non-fracture</b>	0.45	0.36	-19%
White	0.50	0.40	-19%
Non-white	0.16	0.11	-29%
Black	0.18	0.12	-29%
Hispanic	0.11	0.08	-31%
Asian	0.07	0.05	-35%
Other Minorities	0.21	0.16	-23%
Unknown	0.51	0.45	-11%
<b>Reverse TSA Non-fracture</b>	0.91	0.80	-13%
White	1.02	0.89	-13%
Non-white	0.36	0.29	-19%
Black	0.38	0.30	-20%
Hispanic	0.32	0.28	-12%
Asian	0.17	0.12	-30%
Other Minorities	0.53	0.44	-17%
Unknown	0.72	0.64	-12%
<b>Anatomic + Fracture TSA Fracture</b>	0.15	0.15	-3%
White	0.17	0.17	-3%
Non-white	0.04	0.04	-4%
Black	0.03	0.03	-5%
Hispanic	0.06	0.06	-11%
Asian	0.05	0.05	9%
Other Minorities	0.08	0.08	-6%
Unknown	0.07	0.07	-4%

**Table 2. Estimated Between-group Differences of TSA Rates for All Types of TSAs For Each Minority Group Compared with the White Population<sup>1</sup>**

	<b>Estimate</b>	<b>95% CI</b>	<b>P-value</b>
Non-white vs. White	-8.7%	(-14.0%, -3.1%)	0.02
Black vs. White	-10.1%	(-16.8%, -2.9%)	0.05
Hispanic vs. White	-2.6%	(-17.3%, 14.8%)	1.00
Asian vs. White	-18.2%	(-34.7%, 2.4%)	0.64
Other Minorities vs. White	-4.5%	(-15.7%, 8.3%)	1.00

1. Estimated between-group differences for operation rate were made from the logistic regression model at beneficiary-year level, adjusted for age, sex, CMS-HCC risk score, and Medicare-Medicaid dual enrollment status. Bonferroni corrections were applied to p-values. Coefficients were converted as the percentage differences in probability of receiving a TSA for minorities compared to White. The comparisons were made based on April through December data for 2020 and 2019.