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Racial/Ethnic Disparity in Rates and Outcomes of Total Joint Arthroplasty

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Abstract Racial/ethnic disparity in total joint arthroplasty (TJA) has grown over the last two decades as studies have documented the widening gap between Blacks and Whites in TJA utilization rates despite the known benefits of TJA. Factors contributing to this disparity have been explored and include demographics, socioeconomic status, patient knowledge, patient preference, willingness to undergo TJA, patient expectation of post-arthroplasty outcome, religion/spirituality, and physician-patient interaction. Improvement in patient knowledge by effective physician-patient communication and other methods can possibly influence patient's perception of the procedure. Such interventions can provide patient-relevant data on benefits/risks and dispel myths related to benefits/risks of arthroplasty and possibly reduce this disparity. This review will summarize the literature on racial/ethnic disparity on TJA utilization and outcomes and the factors underlying this disparity.

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Introduction

Total joint arthroplasty/replacement (TJA/TJR) is now considered one of the most cost-effective treatment options for end-stage arthritis [1], most commonly due to osteoarthritis (OA). Arthritis is the leading cause of physical disability in adults older than 18 years in the USA [2–5]. In the global burden of disease study 2010, musculoskeletal disorders were among the top causes of years lived with disability (YLDs) among all conditions [6]; knee OA was among the top 25 causes of YLDs globally [6]. Thus, OA has a significant impact on disability in adults.

Medical management of OA is focused on symptom relief since there is currently no pharmacologic therapy that can prevent disease onset or disease progression. Pharmacological (non-steroidal anti-inflammatory drugs (NSAIDs), glucocorticoids, serotonin and norepinephrine reuptake inhibitors (SNRIs), etc.) and non-pharmacological interventions (weight loss, exercise including quadricep strengthening, Tai Chi, etc.) are used for relief of pain and improvement of function in patients with OA [7]. When medical interventions fail in patients with severe end-stage OA, patients require a surgical option such as TJA to maintain function and treat pain. Since knees and hips are among the most common joints affected by OA, total knee and hip arthroplasty (TKA, THA) are the most common of all TJAs

[8]. Compared to 2005, annual utilization rates of TKA and THA in the USA are projected to increase by 673 and 174 % by year 2030 [8], respectively, indicating an even greater impact of these procedures on health and the health care system in the future. THA/TKA are associated with significant pain relief and improvement in function, activities of daily living (ADLs), and quality of life [9, 10•, 11•]. The National Institute of Health (NIH) consensus statement and Agency for Healthcare Research and Quality (AHRQ) summarized the evidence supporting the effectiveness of TJA for treatment of refractory, end-stage OA [12, 13]. According to the NIH consensus statement, 90 % patients demonstrate improvement in pain, physical activity, and quality of life after TKA [14]. Thus, the effectiveness of TJA is well documented.

Racial differences in the utilization of treatment options are widespread in medicine [15–17]. Leading organizations including the National Institute for Arthritis, Musculoskeletal and Skin Diseases (NIAMS) [18], the AHRQ [19•], and the American Academy of Orthopedic Surgeons (AAOS) [20] and initiatives such as the Healthy People Objective 2010 initiative [21] have proposed strategic plans for eliminating the racial disparity in arthroplasty.

Many studies have noted racial/ethnic disparities in the utilization of arthroplasty in the USA [22–26]. Various associated factors have been studied, including demographic, socioeconomic, patient-level factors, physician bias, access to health care, and patient expectations. This review will highlight key studies of differences in TJA utilization and outcomes by race/ethnicity and factors potentially responsible for the racial/ethnic disparity in TJA.

Racial Disparities in Arthroplasty Utilization

Total Hip Arthroplasty and Total Knee Arthroplasty

In an 18-year analysis of US Medicare data (1991–2008), Singh et al. demonstrated racial disparity for TJA [27••]. The racial disparity in TKA utilization increased by more than 10 % on a relative scale between the years 1991 and 2008, being 36 % in 1991 vs. 40 % in 2008 for Blacks vs. Whites, respectively ($p < 0.0001$; Table 1). Racial disparities in primary THA utilization rates remained stable over this study period ($p = 0.25$). Jones et al. studied racial disparity in TKA utilization between African American and non-Hispanic White male patients aged 50 years or above with OA using the national Veterans Affairs (VA) database (2000–2001) [28]. African Americans with OA received fewer TKA procedures compared to Whites within the study period, adjusted for demographics and comorbidities (odds ratio [OR], 0.72, 95 % confidence interval [CI], 0.65–0.80) (Table 1). The study used the denominator "population at risk" to calculate the rates of TKA among the Black and White veterans with OA. Study conclusions were consistent with previous studies, which utilized a Medicare sample [22, 23], although an accompanying editorial noted study limitations [29] including the use of population at risk (veterans with OA older than 50 years) rather than the general population as the denominator to calculate the TKA rates in the study population, restriction to male gender, and the lack of accuracy data for ICD-9 coding for OA.

Most other studies examining racial disparity in arthroplasty have largely been based on the Medicare data, thus limiting the generalizability of findings to the general population [30–32]. In one study in 1997, African Americans were 24 % less likely to undergo joint replacement surgeries compared to Whites with difference increasing to 46 % in 2001 [33]. In another analysis of Medicare data (2000–2006) by the US Centers for Disease Control and Prevention (CDC), disparity in the TKA utilization rate between Blacks and Whites rose from 37 to 39 % between 2001 and 2006 [34]. This limitation of generalizability to only older populations was overcome by Bang et al. who used the US Nationwide Inpatient Sample (NIS), the largest national database of all payer inpatient care in the USA [35] (Table 1). A 10-year period (1996–2005) was used to analyze the overall trend, while three time points (1996, 2000, and 2004) were selected for disparity analysis. Results documented that the total number of TKA and THAs had increased between 1996 and 2005; however, all racial minorities (especially Blacks and Hispanics) were 23 to 64 % less likely to undergo THA/TKA over the same period, demonstrating persisting disparities in THA/TKA utilization [35]. Racial disparities were not limited to the elderly or to low-income population, indicating that disparities were widespread.

Chen et al. also used the US NIS data from a different period (2002–2007) to examine the racial disparity in the rates of THA and TKA among patients with OA and RA [36••]. The probability of receiving THA or TKA was higher for Whites (0.96) than Blacks and Hispanics (0.92) (Table 1). Hospital admission source (emergency admission vs. elective) was an important contributing factor. African Americans and Hispanics were admitted through the emergency department (ED) more frequently than Whites. The authors postulated that patients admitted through ED are less likely to receive joint replacement surgery. When the result was adjusted for the admission source, there was a decline in the disparity in rates by 77 % for African Americans and 57 % for Hispanics. The study highlighted the importance of improvement in health care access to patients to narrow the gap in racial disparity in TJA utilization.

In summary, studies demonstrate that disparity in THA and TKA utilization for Blacks and Hispanics has persisted and has been slowly increasing for Blacks despite the higher prevalence of OA in African Americans as compared to Whites [37, 38]. As evident in the few sections below, similar patterns have been observed for patients undergoing arthroplasty procedures for other joints as well.

Table 1 Summary of studies of racial disparity in arthroplasty utilization and outcomes

Racial disparity in TJA utilization

Study	Data source	Type	Total procedures (*n*)	Race	Gender	Results
Singh et al. [27••]	Medicare (1991–2008)	TKA and THA	2,684,575 primary TKAs 1,328,902 primary THAs	Whites and African Americans	Both	Black-White disparity increased >10% % for primary TKA ($p < 0.001$), unchanged for primary THA ($p = 0.25$)
Jones et al. [28]	VA National Patient Care Database (2000–2001)	TKA	260,856 TKAs	Whites and African American Veterans	Males	African American patients received fewer TKA compared to Whites (OR 0.72, 95 % CI, 0.65–0.08)
Bang et al. [35]	National Inpatient Sample database (1996–2005)	TKA and THA	54,088 THAs 95,871 TKAs	Whites, African American, Hispanics, others	Both	Blacks and Hispanics 23 to 64 % less likely to undergo hip or knee arthroplasty
Chen at al. [36••]	National Inpatient Sample database (2002–2007)	TKA and THA	THA 150,525 TKA 366,085	Whites, African American, Hispanics, others	Both	The probability of THA or TKA was higher for Whites (0.96) than the Blacks and the Hispanics (0.92)
Singh et al. [41••]	National Inpatient Sample database (1998–2010)	TEA	White ($n = 3471$) Black ($n = 308$)	Whites and African Americans	Both	Absolute difference in TEA rate between Blacks and Whites increased from 0.14/100,000 to 0.32/100,000. The relative difference in TEA utilization rate was 37 % in 1998 and 35 % in 2010
Singh et al. [43]	National Inpatient Sample database (1998–2011)	TAA	White ($n = 12,122$) Black ($n = 488$)	Whites and African Americans	Both	Racial disparities in TAA utilization increased significantly ($p < 0.0001$). The absolute difference in TAA utilization rate between Blacks and Whites increased from 0.07/100,000 to 0.84/100,000.
Day et al. [42]	US National Inpatient Sample database (1993–2007)	TSA	Nationwide Inpatient Sample; *N* not provided	Whites and African Americans	Both	Blacks underwent fewer TSA procedures compared to Whites with a risk ratio of 0.60.
Dunlop et al. [30]	Health and Retirement Study (HRS) survey data (1998–2004)	TKA and THA	White ($n = 6021$) Black ($n = 1200$) Hispanics ($n = 696$)	Whites, African American, Hispanics, others	Both	Significant disparity existed in arthroplasty rates between the Blacks (0.38 % annually) and the Whites (0.97 % annually) in patients older than 65 years. Lower rates were also observed for Hispanics compared to Whites (HR 0.64, 95% CI 0.12–1.44)

Racial disparity in total joint arthroplasty outcomes

Study	Data source	Type	Total procedures (*n*)	Race	Gender	Results
Singh et al. [27••]	Medicare (1991–2008)	TKA and THA	2,684,575 primary TKAs	Whites and African Americans	Both	30-day readmission rates for Blacks receiving primary TKA were 6 % higher than Whites in 1991, and by 2008, readmission rates for Blacks were 24 % higher ($p < 0.05$)
			1,328,902 primary THAs			No significant change observed in the readmission rates after THA from 1991 to 2008.
Singh et al. [41••]	National Inpatient Sample database (1998–2010)	TEA	White ($n = 3471$) Black ($n = 308$)	Whites and African Americans	Both	No significant Black-White disparities noted in TEA outcomes Length of hospital stay: $p = 0.61$ Mortality rate: $p = 0.83$
Singh et al. [43]	National Inpatient Sample database (1998–2011)	TAA	White ($n = 12,122$)	Whites and African Americans	Both	(A) Length of hospital stay > median was higher for Blacks than Whites

Table 1 (continued)

Racial disparity in TJA utilization

Study	Data source	Type	Total procedures (*n*)	Race	Gender	Results
						Blacks, 52.9 %
			Black ($n = 488$)			Whites, 44.3 % ($p = 0.08$)
						(B) Mortality rate: Blacks > Whites ($p = 0.02$)
Singh et al. [47]	National Inpatient Sample database (1998–2011)	TSA	Whites ($n = 176,141$)	Whites and African Americans	Both	During 1998–2000, hospital stay longer than median was noted in more Black vs. White = 62 vs. 51.4 % ($p = 0.02$)
			Blacks ($n = 7694$)			In 2009–2011, hospital stay longer than median was noted in more Black vs. White = 27.3 vs. 34.4 % ($p < 0.0001$)
						No significant racial differences in proportion of patients discharged to inpatient medical facility ($p = 0.37$)
Ibrahim et al. [48••]	Cross-sectional survey of VA patients	TKA and THA	Total ($n = 596$)	Whites and African Americans	Males	(1) Blacks more likely to experience longer hospital stay compared to Whites (OR, 4.09 [2.57–6.54])
			Whites ($n = 334$)			(2) Blacks experienced more pain than Whites (OR, 2.61 [1.74–3.89])
			African Americans ($n = 262$)			(3) Blacks had more difficulty in walking after surgery (OR, 2.76 [1.83–4.16]) compared to the Whites
Ibrahim et al. [49]	The VA National Surgical Quality Improvement Program (NSQIP) database	TKA and THA	TKA ($n = 12,108$) THA ($n = 6703$)	Whites and African Americans	Males	African Americans had a
						(A) higher 30 day complication rate after TKA compared to Whites:
						(1) non-infection complications (RR 1.50 [95 % CI 1.08–2.10] and (2) infection-related complications compared to the Whites (RR 1.42 [95 % CI 1.06–1.90])
						(B) No significant difference in complication rate after THA
						(C) The overall 30-day mortality was 0.6 % following knee arthroplasty and 0.7 % following hip arthroplasty, with no significant differences by race/ethnicity observed for either procedure
Blum et al. [50]	Pennsylvania Health Care Cost Containment Council data (2001–2007)	TKA	Total ($n = 17,385$)	Whites and African Americans	Both	(A) No significant difference in 30-day in-hospital complications between Blacks and Whites
			Whites ($n = 16,436$)			(1) Wound infection ($p = 0.77$)
						(2) Prosthesis failure ($p = 0.67$)
			African Americans ($n = 949$)			(B) No significant difference was observed for mortality rate
						(1) 30-day mortality ($p = 0.74$)
						(2) 1 year mortality ($p = 0.77$)

Table 1 (continued)

Racial disparity in TJA utilization						
Study	Data source	Type	Total procedures (*n*)	Race	Gender	Results
						(C) The revision rates (1) at 1 year: Whites = 1.56 % (95 % CI 1.38–1.76) vs. African Americans = 2.66 % (95 % CI 1.80–3.91) ($p = 0.009$) (2) At 5 years: Whites = 5.52 % (95 % CI 5.18–5.89) vs. African Americans = 8.93 % (95 % CI 7.26–10.97) ($p = 0.0001$)

Total Elbow Arthroplasty Utilization

Singh et al. demonstrated the racial differences in utilization rates and outcomes of total elbow arthroplasty (TEA) using the National Inpatient Sample (1998–2010) [39••]. The relative White-Black difference in TEA utilization rate/100,000 was 37 % in 1998 (absolute, 0.38 vs. 0.24/100,000; $p = 0.002$) and was 35 % in 2010 (absolute, 0.91 vs. 0.59/100,000; $p < 0.0001$) (Table 1).

Another study, also using National (Nationwide) Inpatient Sample (NIS), found that rates for TEA were lower for non-Whites than for Whites, but there was an overall increase in the demand and utility of upper extremity joint replacements [40].

Total Ankle Arthroplasty Utilization

Singh et al. used the NIS database (1998–2011) to assess the utilization and outcomes of total ankle arthroplasty (TAA) [41••]. Racial disparities in TAA utilization increased significantly from 1998 to 2011 ($p < 0.0001$) (Table 1) from twofold difference in 1998 (0.14/100,000 in Whites vs. 0.07/100,000 in Blacks; $p < 0.0001$) to fourfold in 2011 (1.17/100,000 in Whites vs. 0.33 in Blacks; $p < 0.0001$).

Total Shoulder Arthroplasty Utilization

Total shoulder arthroplasty (TSA) is a newer procedure for end-stage shoulder arthritis [42, 43]. Marked improvement in shoulder function and quality of life occurs after TSA [44]. Day et al. performed a study on TSA utilization rates using the U.S. NIS sample (1993–2007) and concluded that Blacks underwent fewer TSA procedures compared to Whites with a risk ratio of 0.60 [40]. In a subsequent study, Singh et al. analyzed the racial disparity in utilization and outcomes for TSA using the NIS sample from 1998 to 2011 [45••]. Black-White disparity in utilization of TSA/100,000 increased from 1998 to 2011 ($p < 0.0001$) (Table 1) from 2.97 (Whites) vs. 0.83 (Blacks) in 1998 ($p < 0.0001$) to 12.27 (Whites) vs. 3.33 (Blacks; $p < 0.0001$) in 2011, respectively.

Racial Disparities in Arthroplasty Outcomes

Studies have also reported differences in the arthroplasty outcomes by race/ethnicity (Table 1). Using the 1991–2008 Medicare data, Singh et al. demonstrated Black-White disparity in 30-day hospital readmission rates after THA and TKA [27••]. In 1991, 30-day readmission rates for Blacks receiving primary TKA were 6 % higher than for Whites. By 2008, 30-day readmission rates for Blacks were 24 % higher ($p < 0.05$), indicating increasing racial disparity in this important outcome. Racial disparity in 30-day readmission rates also increased significantly in revision TKA and revision THA

Table 2 Factors associated with racial disparity in utilization or outcome of Total Joint Arthroplasty

Income/socioeconomic status (SES)			
Study	Data source	Total no. procedures	Difference in TJA rate according to income
Skinner et al. [32]	Medicare claims data 2000	TKA Medicare enrollees: 27,494,659	For Medicare enrollees: The association between TKA and income was stronger after adjusting for the hospital referral region (HRR); the odds ratio was 1.19 (95 % CI 1.17–1.22)
	NHANES III survey data (1988–1994)	NHANES III sample: 1926	For NHANES III sample: no significant association between income and the TKA utilization was observed OR 1.10 (95 % CI, 0.95–1.27)
Wilson et al. [22]	Multiple data sources	Multiple data source sample for TKA	Difference in the utilization of the TKA was not dependent on economic factors. The variation in the rates of TKA across the races remained consistent across all levels of income and types of medical insurance
Hanchate et al. [52]	Longitudinal Health and Retirement study survey data (1998–2004)	TKA N =18,439	Difference in the rates of TKA explained by SES and financial assets. Patients with supplemental coverage had higher rates of TKA than those without any supplemental insurance; private [OR: 1.27; 95 % confidence interval (CI): 0.82–1.96] or Medicaid (OR: 1.18; 95 % CI: 0.93–1.49) [54]
Geographical region			
Skinner et al. [23]	Medicare fee-for-service claims data (1998–2000)	TKA N = 430,726	Difference in procedure rates Blacks vs. Whites: (A) Rates were low for Blacks than Whites for nearly every region of the country ($p < 0.05$) White women = 5.97 procedures per 1000) Black women = 4.84 per 1000 White men = 4.82 procedures per 1000 Black men = 1.84 per 1000. (B) Rates of TKA when patients segregated into high- and low-income regions living in an area with higher income and a lower level of residential segregation appeared to reduce the racial disparity: Among black men, living in regions with incomes at or above the median for blacks, as compared with regions with incomes below the median for blacks, was associated with a slightly diminished difference in arthroplasty rates,: 2.42 vs. 2.79 per 1000 ($p = 0.003$) Among black women, living in a region with a low level of residential segregation was associated with a smaller difference in arthroplasty rates than living in a region with a highlevel of segregation: 0.46 vs. 1.05 per 1000 ($p < 0.001$)
Role of patient preferences, patient education, and post-surgical outcomes			
Byrne et al. [24]	Minorities preferred medical management of knee OA over surgery (odds ratio 0.63 [0.42, 0.93])		
Figaro et al. [59]	African American patients perceive TJA as an ineffective treatment. Of the AAs, 36 % believed that the TKA would not improve their pain while 45 % of the patients stated that the TKA would not improve their current health status. It was concluded that poor pre-operative expectation and perception make these patients less likely to consider TKA in the treatment of their OA		
Ibrahim SA [64]	African American patients were less likely than Whites to consider joint replacement therapy as an effective measure (OR 0.52, 95 % CI 0.28–0.98). AAs differ in their attitude towards self-care for knee or hip OA compared to the Whites		
Almazor [40]	A survey of 198 patients found that decision to consider TKA was dependent on patient preference. White patients were more likely to consider TKA on their physician recommendation (97 % of the patients [$p = 0.002$]) compared to the racial minorities (AAs 85 %, Hispanics 76 %)		

Table 2 (continued)

Income/socioeconomic status (SES)			
Study	Data source	Total no. procedures	Difference in TJA rate according to income
Parks [68]	Interview of 36 patients showed that the patient expectations about post-surgical recovery were based on real-life experiences of others around them; some reporting improved function while others of increased pain. Patient fear and anxiety regarding the surgery, its complications, and painful outcomes hinder their decision-making		
Lavernia et al. [79]	A survey of 336 patients revealed that among patients undergoing THA and TKA, African American adults experience higher fear of pain before surgery when compared with Whites. This reflects the influence of social experiences and mistrust for health care of racial minorities compared with Whites and thus its direct correlation with differences in the rates of TJA		
Racial disparity in TJA due to clinical appropriateness for surgery			
Ang et al. [77]	African Americans and Whites were equally appropriate to be considered for TJA (OR 1.2 [95 % CI 0.8–1.8]). Patient referral for surgery was dependent on severity of joint damage rather than race		
Physician bias			
Hausmann et al. [83]	Survey study reported that the AAs were less likely to be recommended for a TJA compared to Whites with same disease severity (OR = 0.46, 95 % CI = 0.26–0.83; $p = 0.01$). However, no significant difference was observed after adjusting for patient preference		
Ang et al. [84]	After controlling for potential confounders study revealed that it is the clinical appropriateness (hazard ratio (HR) = 1.95, 1.15–3.32, $p = 0.01$) that predicted referral to orthopedic surgery. Neither race (HR = 1.30, 0.94–2.05, $p = 0.1$) nor health beliefs (HR = 1.0, $p = 0.5$) were associated with referral status. AA and the Whites were equally likely to be referred to surgery by their PCP		
Oliver et al. [85]	Survey study reported variable explicit and implicit bias of physicians. Some suggested bias to be associated with the degree to patient cooperativeness rather than race, with White patients being more cooperative than Black patients ($p < 0.0001$). Overall, there was no significant association of race with TKA recommendation ($p = 0.960$)		

cohorts over the same period and increased insignificantly in primary THA cohort [27••].

Similar findings were seen for TAA in a study by Singh et al. using a representative sample from the U.S. NIS [41••]. During 1998–2011, 52.9 % Blacks vs. 44.3 % Whites ($p = 0.08$) had post-arthroplasty hospital stay greater than median hospital stay. Inpatient mortality rates were also higher for Blacks as compared to Whites ($p = 0.02$) (Table 1). For TSA, also using the US NIS, a higher proportion of Blacks than Whites had post-arthroplasty hospital stay greater than median hospital stay, 62 vs. 51 % in 1998–2000 ($p = 0.016$) and 34 vs. 27 % in 2009–2011 ($p = 0.002$); adjusted analyses showed a non-significant trend in racial differences in 1998–2000 and 2009–2011 ($p \leq 0.07$). No difference was noted in proportion discharged to the inpatient facility, and mortality was too low for any meaningful comparison [41••]. In a similar study of TEA using the US NIS, no Black-White disparity in proportion discharged to inpatient facility post-arthroplasty was noted in 1998–2000 ($p = 0.37$), but rates were significantly higher in 2009–2010 in Blacks compared to Whites ($p = 0.03$) [39••]. Adjusted differences were not significant, indicating that racial disparities in discharge disposition were at least partially attributable to differences in age, gender, diagnosis, and Deyo-Charlson index between Whites and Blacks. Length of hospital stay >median ($p = 0.61$) and mortality rate ($p = 0.83$) did not differ by race [39••] (Table 1). Differences in results between studies of TAA and TSA vs. TEA may either be due to much smaller numbers for TEA (more likely) or the lack of racial disparities in some TEA outcomes.

Ibrahim et al. studied primary TKA and THA in 596 VA patients in a cross-sectional survey and reported that compared to the Whites, Blacks were more likely to experience longer post-arthroplasty hospital course (OR 4.09 [2.57–6.54]), more pain, and a delayed post-surgical recovery with difficulty in walking [46] (Table 1). In another study, Ibrahim et al. studied 12,108 patients with TKA and THA over a 5-year period using the Veterans Affairs National Surgical Quality Improvement Program (NSQIP) database and found that Whites and Hispanics had a lower 30-day mortality risk after TJA compared to Blacks [47]. Adjusted 30-day infection and non-infection complications after TKA were higher for Blacks compared to the Whites (relative risk [RR], 1.50 [95 % CI, 1.08–2.10] and RR 1.42 [95 % CI, 1.06–1.90] respectively) [47]; Hispanics had higher rate of infectious complications after TKA compared to Whites, RR of 1.64 (95 % CI 1.08–2.49). No racial disparity was found for complications after THA (Table 1).

Blum and colleagues studied 17,385 patients undergoing TKA [48••] using the 2001–2007 Pennsylvania Health Care Cost Containment Council data and found that compared to Whites, unadjusted revision rates were higher in Blacks: at 1 year, rate was 1.56 % (95 % CI 1.38–1.76) vs. 2.66 % (95 % CI, 1.80–3.91; $p = 0.009$), and at 5 years, 5.52 % (95 % CI, 5.18–5.89) vs. 8.93 % (95 % CI, 7.26–10.97;

$p = 0.0001$) [48••]. Adjusted hazard rates of revision at 5 years were also higher in Blacks vs. Whites, 1.39 (95 % CI 1.08–1.80). There were no racial differences in 30-day complications such as wound infection ($p = 0.77$), prosthesis failure ($p = 0.67$), or mortality ($p = 0.74$) [48••] (Table 1).

Factors Associated with Racial Disparity in Arthroplasty Utilization

Given the evidence of racial disparities in arthroplasty utilization and outcomes, there is a critical need to identify factors potentially associated with these disparities and to design and test intervention strategies to narrow this gap. Disparities in arthroplasty utilization by gender [49] and geographical barriers [32, 50, 51] have been similarly described. Some studies have reported that racial disparities in utilization are not associated with access to health care, income, or insurance plan [31]. Racial disparities may be associated with poor post-surgical outcome [46, 52]. In subsequent sections, we will discuss these factors and highlight studies that provide data supporting the role of the various factors contributing to racial disparity in arthroplasty utilization.

Demographics

Dunlop et al. examined the 1998–2004 Health and Retirement Study (HRS) survey data and reported significant disparity in arthroplasty utilization rates between Blacks (0.38 % annually) and Whites (0.97 % annually) in patients older than 65 years [30] (Table 1). However, no such racial disparity was noted in patients younger than 65 years (51 to 64 years) [30]. Hispanic patients had similar rates across all age groups. Thus, age at arthroplasty may be a potential modifier of racial disparities in arthroplasty utilization.

Income

Studies have assessed the association of income and socioeconomic status with racial disparity in TKA utilization rates (Table 2). Skinner et al. [31] used two databases to study this association: the 2000 Medicare claims data ($N = 27.5$ million) and the 1988–1994 National Health and Nutrition Examination Survey (NHANES III) ($N = 1926$) for patients with OA aged 60 years or more. After adjusting for age and income, compared to White men, the odds ratios for TKA utilization were 0.36 for Black men (95 % CI, 0.34–0.38), 0.28 for Asian men (95 % CI, 0.24–0.32), and 0.45 for Asian women (95 % CI, 0.41–0.49). Rates for Black women (1.02, 95 % CI, 0.99–1.04) were below those for White women (1.34, 95 % CI 1.33–1.36), using the Medicare data (Table 2). Separate analyses stratified by each income quartile yielded similar results, without showing any significant role of income to racial disparity. In contrast to this, the NHANES III sample demonstrated no such association between income and utilization rates of TKA (OR 1.10; 95 % CI, 0.95–1.27).

Wilson et al. analyzed data from a number of sources and found that the variation in TKA utilization rates by race remained consistent across all levels of income and types of medical insurance [22] (Table 2). TKA utilization rate ratio (Black to White) was 3:5.1 for men and 1.5:2 for women. Similarly, a Canadian study by Hawker et al. [53] and study by Bang et al. [35] concluded that underuse of TJA in minorities is independent of socioeconomic status (SES).

In contrast to the above studies, Hanchate et al. used the US Longitudinal HRS survey data (1998–2004) (Table 2) and suggested that limited insurance coverage or financial constraints may explain some of the racial/ethnic disparities in TKA rates [54]. The authors proposed that difference in the results of their study from the studies that used Medicare data was due to the fact that they used a more detailed individual level financial and insurance measure to calculate the overall utilization rates. Medicare insured patients who had any supplemental coverage had higher rates of TKA than those without any supplemental insurance, private [OR, 1.27; 95 % CI, 0.82–1.96] or Medicaid (OR, 1.18; 95 % CI, 0.93–1.49) [54].

Regional Differences

Skinner et al. described the racial difference in the rates of TKA according to geographical region [23]. Rates were significantly lower for Black men and women compared to the Whites in every region of the country with an overall difference of 2.98 per 1000 TKA procedures between the Whites and the Blacks. White women had 5.97/1000 procedures compared to 4.84/1000 procedures for Black women. Similarly, White men had 4.82/1000 procedures compared to 1.84/1000 procedures for Black men (Table 2). After correcting for the hospital referral region, the racial difference declined slightly from 2.98 to 2.50 per 1000 procedures. Difference in the rates of TKA was also observed after dividing the study population into high-income and low-income groups, such that racial differences were smaller among Blacks living in higher income areas than lower income areas [23] (Table 2).

Patient Knowledge and Preference for Arthroplasty

Much has been documented regarding the patient preferences for a medical treatment and its association with health care and disease [55, 56]. Psychosocial factors, patient perception, willingness to undertake surgery, and their values and preferences may be important contributors to racial differences in TJA utilization rates [46] (Table 2). Byrne et al. performed a cross-sectional in-person interview using conjoint analysis and documented that minorities preferred medical management of knee OA over surgery (odds ratio, 0.63 [0.42, 0.93]), and this racial difference was higher in women and

elderly (OR, 0.69 [0.51, 0.94] and 0.98 [0.97, 0.99], respectively) [24]. Similarly, Figaro and colleagues reported that African Americans are more likely to perceive TJA as an ineffective treatment [57] (Table 2). They also reported that 36 % of the African Americans believed that the TKA would not improve their pain, while 45 % stated that the TKA would not improve their current health status. Ibrahim et al. found that African American patients were less likely than Whites to consider joint replacement therapy as effective (odds ratio, 0.52; 95 % CI, 0.28–0.98) [58]. Other authors concluded that poor pre-operative expectation makes patients less likely to consider TKA [59]. A Canadian study documented that non-Europeans which also included Blacks perceived a greater risk for joint replacement surgery as compared to the Whites and the Europeans [60]. They attributed this finding to the ineffective communication between the patient and the physician recommending TJA. In a Canadian study, Hawker et al. reported that time delay between the referral of a patient to an orthopedic surgeon and the TJA surgery was strongly predicted by the patient's willingness to consider TJA and Blacks are less willing to under arthroplasty compared to Whites [53].

Patient perception regarding any therapy depends partially on the effectiveness of patient-physician communication regarding risks and benefits of the intervention and alternatives and patient knowledge and familiarity. African American patients have less effective communication with their physicians compared to Whites [61]. African Americans were less knowledgeable about osteoarthritis and showed less understanding for the risks and benefits of joint replacement procedures compared to Whites [62, 63]. Ibrahim et al. showed that the lack of patient familiarity and understanding of the procedure as well as its risk and benefits contributed to the racial/ethnic disparity in the utilization of arthroplasty in US veterans [64] (Table 2).

Religion and spirituality have also been studied related to TJA utilization. Ibrahim et al. found that African Americans make health care decisions in accordance to their religious beliefs and perceive faith and prayer to be helpful for the management of their arthritis and associated pain and tend to choose these strategies over TJA [65].

Suarez-Almazor et al. evaluated the role of patient preferences in the racial/ethnic variation in the rates of knee replacement by addressing four important questions: (1) has their physician ever recommended a knee replacement, (2) will the patient consider the joint replacement on physician recommendation, (3) the familiarity of the procedure, and (4) perception about the efficacy and risk of TKA [62]. A survey of 198 patients with OA revealed that physician recommendation for the knee replacement was higher in African Americans (27 %) than Whites (15 %) and non-White Hispanics (11 %). However, Whites were more likely to consider TKA on their physician recommendation (97 % patients [$p = 0.002$]) than racial minorities (African Americans 85 %, Hispanics 76 %; Table 2).

Disparity in Poor Post-Surgical Outcomes and Patient Perceptions and Expectations

Goodman et al. recently showed that within census tract areas with similar income, disparities in pain and function outcome by race were minimal between Whites and African Americans in non-poor areas but were significantly worse for African Americans in areas with high poverty levels [66•]. The study was presented as an abstract at the 2015 American College of Rheumatology annual meeting. Some studies link this association to the fact that the racial minorities tend to get their joint replacement surgeries from hospitals with poor quality of care (low volume hospital compared to high volume hospital) [67, 68]. Studies also suggested that postoperative hospital stay was longer for Blacks as compared to Whites [69, 70], and there is an increased mortality rate and infection in African Americans [71], while other studies do not show any such differences by race [47, 72, 73].

Studies also suggest that patients tend to choose TJA based on peer experience, i.e., the outcomes reported by friends or neighbors and other people they know [74]. African Americans perceive a greater risk for joint surgery than Whites [62]. Parks et al. demonstrated that patients made decisions based on the positive or negative experiences of others [75••] (Table 2). A successful joint replacement experience in a patient's community had a powerful influence for deciding in favor of joint replacement and vice versa. Patient fear and anxiety regarding the surgery, its complications, and painful outcomes can hinder decision-making and may lead to decisions against surgery before an actual physician-patient encounter [75••].

In addition to the differences in patient preferences, patient expectations for post-arthroplasty outcome may also differ by race. This is important, since patient expectations have been linked to post-surgical functional outcomes and patient satisfaction after TJA [76, 77] and outcomes in other musculoskeletal conditions such as back pain [78]. Groeneveld and colleagues demonstrated that after controlling for confounding factors like income, education, and patient's trust in their physicians, African Americans had poorer expectations for outcomes following TJA surgery [52]. Lavernia et al. reported that among patients undergoing THA and TKA, African Americans feared pain before surgery more than Whites [79] (Table 2). These differences in patient expectations likely contribute to less willingness of African Americans to undergo TJA compared to Whites and possibly poorer outcomes.

Effective interventions can narrow racial disparity for expectations of arthroplasty. In one such study, Weng et al. tested the efficacy of an educational videotape and a TKA decision aid in improving the patient expectation and increasing patient knowledge about TKA [80]. African American and White veterans with moderate to severe OA between ages of 55 and 85 years were enrolled. The Western Ontario and

McMaster Universities Osteoarthritis Index (WOMAC) instrument was modified to measure expectations of pain and function after TKA (0–100 scale with higher scores reporting poorer outcomes). African Americans expected more pain as compared to the Whites after TKA (WOMAC score 41 vs. 34, $p = 0.18$). Patient expectation improved after the patients underwent the educational intervention, i.e., WOMAC pain improved from 41 to 31 and expectations of post-surgical physical activity improved from 38 to 30 (lower scores are better) [80]. Thus, improvement in patient knowledge and expectations can improve with educational interventions. A potential mechanism is the increase in patient familiarity with and confidence in the effectiveness of the procedure that may alleviate their fear and anxiety associated with TJA.

Is Racial Disparity Linked to Clinical Appropriateness for Surgery?

Ang et al. studied if race was linked to the clinical appropriateness for surgery [81]. The study concluded that African Americans and Whites were considered equally appropriate for TJA (OR, 1.2 [95 % CI, 0.8–1.8]) for a similar disease severity (Table 2). Thus, race did not contribute to being considered appropriate for TJA. Ang also found that clinical appropriateness for surgery (hazard ratio (HR) = 1.95, 95 % CI, 1.15–3.32; $p = 0.01$) but not race (HR = 1.30, 95 % CI, 0.94–2.05; $p = 0.1$) or health beliefs about risks of TJA (HR = 0.98, 95 % CI, 0.93–1.04; $p = 0.5$), predicted referral by a primary care provider for TJA to an orthopedic surgeon [82] (Table 2).

Do Physician-Level Factors Contribute to Racial Disparity in Arthroplasty?

Studies suggest that a physician's treatment decisions may unintentionally be influenced by the patient's race [83, 84]. Race/ethnicity has also been well studied across various other medical conditions such as coronary artery disease and associated cardiac procedures [85–87].

Studies suggest that physician's view that surgical outcomes are likely worse in high risk patients may influence their desire to not recommend TJA in patients with comorbidities [79]. Minorities undergoing TJA have higher comorbidity load than Whites [27••]. Hausmann et al. carried out a study to identify if orthopedic surgeons are less likely to recommend TJA to African Americans compared to Whites [88]. The study reported that African Americans were less likely to be recommended for a TJA compared to Whites with same severity of arthritis (OR, 0.46, 95 % CI, 0.26–0.83; $p = 0.01$). However, no significant difference was observed after adjusting for patient preference (Table 2). This suggested that though there was a difference in the physician recommendation rates, patient preference for treatment might play a key role in the recommendation for TJA.

Oliver et al. evaluated whether racial bias predicts a physician's recommendation for TKA [89••]. Authors concluded that physicians possess significant explicit and implicit racial bias; however, these biases did not predict their recommendation for TKA ($p = 0.96$). There was a strong implicit physician preference for Whites and a greater medical cooperativeness of Whites compared to African Americans ($p < 0.0001$) (Table 2). Physicians reported similar care for both patient groups but also agreed that subconscious racial bias that could influence treatment decisions ($p < 0.0001$).

Summary

Many factors such as demographics, socioeconomic status, cultural beliefs, patient preferences, knowledge and expectations, and physician preferences may contribute to racial disparities in TJA utilization and outcomes, and as expected, no single cause can explain the racial differences in the utilization and outcomes of joint arthroplasties [90].

Improvement in physician-patient interactions and more effective communication might improve patient perception and knowledge and set realistic expectations of surgery [55, 56]. Educational programs targeting minorities undergoing TJA may increase patient awareness and help improve patient preferences and expectations of TJA.

Conclusions

In order to eliminate the growing racial disparity in TJA utilization and outcomes, it is necessary to understand patient, physician, as well as system level factors that contribute to this disparity and develop strategies to address these factors. Innovative approaches that are culturally sensitive are needed to improve effective communication between the patient and the provider, as well as improve patient awareness about their disease and treatment options. Assessing baseline patient knowledge and addressing their patients' concerns can help set appropriate expectations of surgical outcomes. Various stakeholders including patients, surgeons, policy makers, and health care system leadership should be involved in these efforts. Innovative patient educational programs in collaboration with physicians or community organizations leading to increased health knowledge might lead to better outcomes in minorities undergoing TJA. Health care systems should invest in health equity programs and emphasize and implement culturally appropriate patient care to improve physician-patient interaction and outcomes.

Further research is needed to develop and test effective interventions to reduce and eliminate barriers to minorities and eliminate health care disparities in total joint replacement surgeries.

Compliance with Ethical Standards

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