

Complications for Racial and Ethnic Minority Groups After Total Hip and Knee Replacement

A Review of the Literature

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Background: Total hip and knee replacement reduces disability associated with lower extremity osteoarthritis. It has been shown that racial and ethnic minority groups underutilize these procedures; however, little information exists on postoperative outcomes for ethnic minorities.

Methods: We conducted a systematic review of the literature to compile population-based or multicenter studies on early postoperative outcomes after total hip and knee replacement in racial and ethnic minorities.

Results: Nine studies met the inclusion criteria. Among the nine eligible studies, four examined total knee replacement, three examined total hip replacement, and two examined both. Two studies investigated mortality after total knee replacement, and one found that blacks had an increased risk of mortality. Three studies investigated infection after total knee replacement; all found an increased risk in blacks and Hispanics. Four studies examined non-infection-related complications after total knee replacement, and all four found that nonwhites had an increased risk of complications. Two studies investigated mortality after total hip replacement; one of these found that, for primary hip replacement, blacks had an increased risk of mortality.

Conclusions: There is a paucity of research on outcomes after orthopaedic procedures for racial and ethnic minority groups. On the basis of the available literature, racial and ethnic minority groups appear to have a higher risk for early complications (those occurring within ninety days), particularly joint infection, after total knee replacement and perhaps a higher risk of mortality after total hip replacement.

Level of Evidence: Prognostic Level II. See Instructions to Authors for a complete description of levels of evidence.

In the United States, musculoskeletal conditions are a major cause of disability and health problems and they constitute a large component of health-care utilization¹⁻³. More than sixty-nine million Americans are affected by arthritis or other chronic joint symptoms⁴. In 2003, the estimated earnings losses (indirect costs) for arthritis and other rheumatic conditions were \$47 billion⁵. In patients with advanced arthritis of the hip or knee, total hip replacement and total knee replacement effectively alleviate pain and improve function and quality of life in the majority of recipients⁶⁻⁹. The annual volume of total hip and knee replacements increased to approximately 900,000 procedures in 2006, with direct costs for these procedures exceeding \$35 billion¹⁰. As lower extremity osteoarthritis continues to become more prevalent and indications

for total joint replacement expand, the volume of total joint replacements per annum is projected to increase to four million procedures by 2030¹¹.

Despite increasing utilization of common orthopaedic procedures for musculoskeletal disorders, marked differences exist in the utilization of treatments among populations of different races and ethnicities. Differences in utilization exist particularly for total hip replacement and total knee replacement. These racial and ethnic differences in utilization are not explained by differences in prevalence. In fact, the burden of osteoarthritis is at least as prevalent—and possibly more prevalent—in blacks than in whites¹²⁻¹⁶. (Most of the literature that examines race or ethnicity as a factor influencing the utilization and outcome of procedures characterizes recipients

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as black, nonwhite, or white. Thus, we use these terms as well but acknowledge their lack of specificity^{17,18}.) Even after controlling for health insurance status, whites are more than twice as likely as blacks to undergo total joint replacement¹⁹⁻²⁴. Similarly, racial and ethnic differences in total joint replacement are likely not explained by disparate access to health care. Differential utilization appears to persist even after adjusting for access to clinical care²⁵. Differences in total hip replacement and total knee replacement have been documented, for example, in the Medicare population, which is insured for these procedures^{22,26}. Differences in the utilization of orthopaedic procedures among various racial groups are likely multifactorial and influenced by factors such as preferences for surgery and operative outcome expectations among racial and ethnic minorities.

While there has been considerable investigation of the racial and ethnic differences in the utilization of orthopaedic procedures, few studies have assessed differences in the outcomes of orthopaedic procedures among racial and ethnic minority groups. Our objective was to determine whether racial and ethnic minority groups have worse postoperative outcomes than white Americans do following major orthopaedic procedures. To accomplish this objective, we systematically reviewed the literature on associations between race and/or ethnicity and postoperative complications after total hip replacement and total knee replacement. As far as we are aware, this is the first review of this kind. We sought evidence from population-based or multicenter studies that assessed outcomes after total hip replacement and total knee replacement and that also incorporated race or ethnicity in a multivariate analysis. We hypothesized that minorities generally have more complications than whites do after total hip replacement and total knee replacement.

Materials and Methods

Eligibility Criteria for Review

The review of the literature was performed according to the guidelines for QUORUM (Quality of Reporting of Meta-analyses) and MOOSE (Meta-analysis of Observational Studies in Epidemiology)^{27,28}. Retrospective and observational studies published between 1966 and January 2009 that described the effects of race and/or ethnicity on the rates of complication after total joint replacement were identified. These studies were retained for further review if they satisfied the following inclusion criteria: (1) the index procedure(s) included either total knee replacement or total hip replacement; (2) the sample was population-based or assembled from multiple centers in the United States; (3) one or more of the postoperative outcome measures assessed mortality, complications, reoperation, functional status, patient-reported outcomes, length of stay, and/or cost; and (4) race or ethnicity was incorporated into a multivariate model analyzing an outcome after total hip replacement or total knee replacement. Studies were excluded if the index procedure was not total knee replacement or total hip replacement, the procedures had been performed by a single surgeon or at a single surgical center, the orthopaedic intervention was provided at an institution out-

side the United States, or the study had not used multivariate analysis.

Population-based and multicenter studies were selected to avoid bias and limitations in generalizability associated with single-center studies. Studies done in the United States were selected to minimize potential variance in health-care delivery systems not based in the United States and because patterns of racial and ethnic minority differences vary considerably across countries. Multivariate analyses were selected from these papers to ensure that the studies attempted to adjust for potential confounders.

Search Strategy for Identification of Studies

Two authors (B.U.N. and A.D.K.) independently conducted a search of the PubMed literature database. We constructed a search algorithm that consisted of using "AND" statements to intersect the following groups of search terms: (1) Procedure terms: *orthopaedic, arthroplasty, total hip replacement, and total knee replacement*. (2) Outcome terms: *outcome, mortality, morbidity, function, quality of life, patient satisfaction, LOS (length of stay) and cost*. (3) Illness terms: *osteoarthritis or hip fracture*. (4) Common race descriptors: *race, black, non-white, and white*, and common ethnic descriptors: *ethnicity, African American, Asian, Asian American, Caucasian, Hispanic, Hispanic American, Latino, Native American, and Pacific Islander*.

Each search began by reviewing the results for the intersection between a procedure term and an outcome term. Relevant abstracts were selected. Then an illness term was added to the query, and articles were selected again. The illness term was included only if it increased the number of articles or the specificity of the search. Then a race or ethnicity descriptor was added to the query, and relevant articles were selected again. Lastly, disparity was added to the three-term search, and the results were reviewed. The PubMed medical subject heading (MeSH) definitions and MeSH tree were verified for each term.

To further ensure that all appropriate studies were included, we reviewed references of selected papers and sought other bibliographic sources, including abstracts from the American Academy of Orthopaedic Surgeons (AAOS) Annual Meeting (1990 to 2008)²⁹, the publication and presentation list from the National Surgical Quality Improvement Program (1992 to 2008), and the reference list from the 2003 AAOS and Agency for Healthcare Research and Quality Conference on Racial and Ethnic Disparities in Musculoskeletal Medicine and the 2000 National Institute of Arthritis and Musculoskeletal and Skin Diseases conference. By searching nonindexed databases, we were able to review ongoing and unpublished data, thereby reducing the risk of publication bias.

Some papers had descriptive data on race or ethnicity but had not described the association between race or ethnicity and the postoperative outcomes assessed. In these instances, we corresponded with the first and/or last author(s) of the paper to determine whether such analyses could still be performed.

Finally, two of the authors (E.L. and J.N.K.) identified eleven experts in health services research and treatment

outcomes for musculoskeletal disorders. These experts were chosen on the basis of their contribution to the field of health outcomes and/or affiliation with a research group that has contributed substantially to this field. The identified individuals were surveyed by e-mail and asked the following questions:

1. Are you aware of literature on racial and ethnic differences in the outcome of total joint replacement? For this question, the procedure was changed depending on the investigator's area of interest. For example, experts on the outcomes of total hip replacement were asked about total hip replacement, and experts on the outcomes of total knee replacement were asked about total knee replacement.

2. If so, can you point me to specific articles?

3. Are there any other investigators whom I should contact?

These additional steps were taken to further minimize publication bias and to ensure that all relevant published articles were identified.

Statistical Methods

Full-text articles that satisfied the eligibility criteria were retrieved. We abstracted data from the original article on multivariate analyses of the association between race or ethnicity and a postoperative outcome. The data abstracted from the studies included the year the study was published, the index procedure, sample size, study objective, data source, race or ethnicity instrument, covariates used for risk adjustment, postoperative outcome measured, point estimates for the associations between racial or ethnic groups and outcome, and the level of significance or confidence intervals.

Point estimates of odds ratios and relative risk ratios, and their level of significance or 95% confidence intervals, are presented in evidence tables.

Source of Funding

One author of this study performed investigations as part of a Doris Duke research fellowship. Other authors are supported by grants from the National Institutes of Health and by departmental funds. These funding sources did not play a role in the investigation.

Results

Overview of Eligible Studies

A search of the literature with use of our a priori algorithm retrieved 713 studies from the PubMed database. After a review of the titles and abstracts, 693 studies (97.2%) were excluded according to our exclusion criteria mentioned above. The remaining twenty studies were carefully evaluated. Seven of these studies were excluded because race or ethnicity was not included in the multivariate analysis, two studies had a non-population-based sample size, and two studies were excluded after the first and/or last author(s) were contacted for race or ethnicity analysis. Neither our search of nonpublished literature nor our poll of health-care experts yielded additional studies.

Nine studies fully satisfied the review criteria and are included in this study (see Appendix). The papers were published between 1990 and 2006. All nine were retrospective.

Three of the nine studies used the National Surgical Quality Improvement Program (NSQIP) dataset from the Veterans Affairs hospital system³⁰⁻³², three studies used Medicare claim data^{22,26,33}, and three studies used statewide databases³⁴⁻³⁶.

Of the nine studies meeting the inclusion criteria, four assessed complications after total knee replacement alone, three assessed complications after total hip replacement alone, and two incorporated both total hip replacement and total knee replacement. Five of the nine studies included analyses of more than one outcome (e.g., mortality and length of stay). All nine studies incorporated race or ethnicity as a covariate or primary predictor in a multivariate analysis of surgical outcome. All nine studies performed analyses that adjusted for age and comorbidities. Comorbidities were evaluated with a variety of methods. Five studies incorporated the Charlson comorbidity index or a variant of this index developed for administrative data, two studies included individual comorbidities, and two studies used the American Society of Anesthesiologists classification³⁷.

Of the nine studies included in this review, three provided data for length of stay after total joint replacement, four provided data for infection-related complications after total joint replacement, four provided data for mortality after total joint replacement, and seven provided data for a variety of postoperative complications after total joint replacement ranging from pulmonary embolus to hip dislocation (the data are presented in Tables I and II).

Mortality

Two studies examined mortality after total hip replacement. Mahomed et al. found that blacks had an increased risk of mortality following primary total hip replacement (odds ratio, 1.48; 95% confidence interval, 1.03 to 2.11), whereas the risk difference in mortality for revision total hip replacement was lower and not significant (odds ratio, 1.29; 95% confidence interval, 0.77 to 2.18)²². Whittle et al. found that for nonwhites, the risk of death during the three years following total hip replacement approximated the risk for whites³³. This finding persisted in a subsample in which osteoarthritis was the primary indicator for total hip replacement.

Two studies examined mortality after total knee replacement. Mahomed et al. found that, compared with whites, blacks had an increased risk of mortality in the ninety days following total knee replacement (odds ratio for blacks, 1.4; 95% confidence interval, 1.0 to 1.8). However, SooHoo et al. found that race was not significantly associated with death ninety days after a total knee replacement (odds ratio for blacks, 0.98 [95% confidence interval, 0.74 to 1.29], $p = 0.88$; and odds ratio for Hispanics, 0.90 [95% confidence interval, 0.73 to 1.11], $p = 0.31$)^{26,36}.

Infection

Two studies examined infection after total hip replacement. Ibrahim et al. found that blacks and Hispanics had an increased risk of infection after total hip replacement; however, these findings did not achieve significance (relative risk for blacks, 1.27 [95% confidence interval, 0.91 to 1.78], and relative risk for Hispanics, 1.22 [95% confidence interval, 0.63 to

TABLE I Findings from Multivariate Models That Characterize the Association Between Race or Ethnicity and Postoperative Outcomes After Total Knee Replacement

Study	Outcomes Measured	Findings*
Collins et al. ³¹ (1999)	Prolonged length of stay†	Prolonged length of stay (nonwhite odds ratio = 1.6; white odds ratio = 1.00 [referent]; p ≤ 0.01)
Weaver et al. ³² (2003)	30-day mortality, 30-day morbidity‡, readmission following index procedure, and length of stay	30-day morbidity (white odds ratio = 0.79 [0.66-0.94] and nonwhite odds ratio = 1.00 [referent]) Length of stay (parameter estimate = -0.14 days for whites; nonwhite odds ratio = 1.00 [referent]; p = 0.0001)
Feinglass et al. ³⁴ (2004)	Inpatient complication§, discharge to skilled nursing home or rehabilitation hospital, and mean length of stay	Inpatient complication (black odds ratio = 1.00 [0.9-1.1] for a zip code area with a black population of >50%, and black odds ratio = 1.00 [referent] for a zip code area with a black population of <50%; p = 0.92)
Ibrahim et al. ³⁰ (2005)	30-day mortality, 30-day non-infection-related complication, and 30-day infection-related complication	30-day non-infection-related complication (black relative risk = 1.50 [1.08-2.10], Hispanic relative risk = 1.10 [0.62-1.95], and white relative risk = 1.00 [referent]) 30-day infection-related complication (black relative risk = 1.42 [1.06-1.90], Hispanic relative risk = 1.64 [1.08-2.49], and white relative risk = 1.00 [referent])
Mahomed et al. ²⁶ (2005)	90-day mortality, 90-day manipulation, 90-day pulmonary embolus, 90-day deep wound infection, and 90-day non-infection-related complication	Mortality (black odds ratio = 1.4 [1.0-1.8] and white odds ratio = 1.00 [referent]) Deep wound infection (black odds ratio = 1.5 [1.0-2.1] and white odds ratio = 1.00 [referent]) Postoperative manipulation (black odds ratio = 1.4 [1.2-1.7] and white odds ratio = 1.00 [referent])
SooHoo et al. ³⁶ (2006)	90-day mortality, 90-day readmission due to infection, and 90-day readmission due to pulmonary embolism	Mortality (black odds ratio = 0.98 [0.74-1.29], Hispanic odds ratio = 0.90 [0.73-1.11], and white odds ratio = 1.00 [referent]) Infection (black odds ratio = 1.15 [0.90-1.47], Hispanic odds ratio = 1.21 [1.03-1.43], and white odds ratio = 1.00 [referent]) Pulmonary embolism (black odds ratio = 1.74 [1.36-2.23], Hispanic odds ratio = 0.84 [0.65-1.09], and white odds ratio = 1.00 [referent])

*The 95% confidence intervals are given in brackets. †Prolonged length of stay was defined as a postoperative length of stay greater than or equal to the 75th percentile for length of stay. ‡Thirty-day morbidity included myocardial infarction, pulmonary embolism, and complications, such as urinary tract infection, prolonged ileus, superficial wound infection, and deep vein thrombosis, that were identified by the orthopaedic surgeon. §Inpatient complications included inpatient death, wound infection, iatrogenic complications, pulmonary compromise, acute myocardial infarction, gastrointestinal hemorrhage or ulceration, venous thrombosis or pulmonary embolus, pneumonia after surgery, and/or mechanical complication due to a device, implant, or graft.

2.36]). Mahomed et al. found that blacks did not have a significantly increased risk of infection after total hip replacement (odds ratio for blacks, 0.99; 95% confidence interval, 0.46 to 2.14)^{22,30}.

Three studies examined infection after total knee replacement; all three studies found that nonwhites had an increased risk of infection postoperatively^{26,30,36}. Ibrahim et al. found that both blacks and Hispanics had a greater risk of infection than whites in the thirty days following total knee replacement (relative risk for blacks, 1.42 [95% confidence interval, 1.06 to 1.90], and relative risk for Hispanics, 1.64 [95% confidence interval, 1.08 to 2.49])³⁰. Mahomed et al. found that blacks had an increased risk for a deep wound infection in the ninety days following total knee replacement

(odds ratio for blacks, 1.5; 95% confidence interval, 1.0 to 2.1)²⁶. SooHoo et al. found that, compared with whites, Hispanics had a significantly increased risk of infection in the ninety days following total knee replacement (odds ratio, 1.21; 95% confidence interval, 1.03 to 1.43). SooHoo et al. also found that blacks had a slightly increased risk of infection; however, this finding was not significant (odds ratio for blacks, 1.15; 95% confidence interval, 0.90 to 1.47)³⁶.

Length of Stay

Two studies examined length of stay after total hip replacement, and both found that nonwhites had a significantly higher risk for a longer length of stay. White et al. found that nonwhite

TABLE II Findings from Multivariate Models That Characterize the Association Between Race or Ethnicity and Postoperative Outcomes After Total Hip Replacement

Study	Outcomes Measured	Findings*
White et al. ³⁵ (1990)	Longer length of stay†, postoperative complications‡, and complications directly related to surgery§	Longer length of stay (Odds ratios for nonwhite recipients according to age and pay source, with white recipients in each category as the reference group: Age 55, government, odds ratio = 1.93 [1.24-2.99]; Age 55, nongovernment, odds ratio = 1.03 [0.54-1.97]; Age 75, government, odds ratio = 0.91 [0.65-1.97]; and Age 75, nongovernment, odds ratio = 0.49 [0.22-1.10])
Whittle et al. ³³ (1993)	Perioperative mortality and 3-year mortality	3-year mortality after total hip arthroplasty (nonwhite odds ratio = 1.01 [0.59-1.73] and white odds ratio = 1.00 [referent]) 3-year mortality after total hip replacement indicated for the treatment of osteoarthritis (nonwhite odds ratio = 1.15 [0.59-2.27] and white odds ratio = 1.00 [referent])
Weaver et al. ³² (2003)	30-day mortality, 30-day morbidity#, readmission following index procedure, and length of stay	Longer length of stay (parameter estimate for whites = -0.12 and nonwhite odds ratio = 1.00 [referent]; p = 0.0001)
Mahomed et al. ²² (2003)	Primary procedures: 90-day mortality, 90-day readmission, 90-day pulmonary embolism, 90-day hip dislocation, and 90-day infection	90-day mortality (black odds ratio = 1.48 [1.03-2.11] and white odds ratio = 1.00 [referent]) 90-day readmission (black odds ratio = 1.04 [0.86-1.26] and white odds ratio = 1.00 [referent]) 90-day pulmonary embolus (black odds ratio = 1.07 [0.69-1.65] and white odds ratio = 1.00 [referent]) 90-day hip dislocation (black odds ratio = 0.89 [0.7-1.13] and white odds ratio = 1.00 [referent]) 90-day infection (black odds ratio = 0.99 [0.46-2.14] and white odds ratio = 1.00 [referent])
Mahomed et al. ²² (2003)	Revision procedures: 90-day mortality, 90-day readmission, 90-day pulmonary embolism, 90-day hip dislocation, and 90-day infection	90-day mortality (black odds ratio = 1.29 [0.77-2.18] and white odds ratio = 1.00 [referent]) 90-day readmission (black odds ratio = 0.87 [0.64-1.17] and white odds ratio = 1.00 [referent]) 90-day pulmonary embolus (black odds ratio = 1.24 [0.53-2.92] and white odds ratio = 1.00 [referent]) 90-day hip dislocation (black odds ratio = 0.85 [0.62-1.17] and white odds ratio = 1.00 [referent]) 90-day infection (black odds ratio = 1.09 [0.49-2.44] and white odds ratio = 1.00 [referent])
Ibrahim et al. ³⁰ (2005)	30-day mortality, 30-day non-infection-related complication, and 30-day infection-related complication	30-day non-infection-related complication (black relative risk = 0.97 [0.68-1.38], Hispanic relative risk = 1.18 [0.60-2.30], and white relative risk = 1.00 [referent]) 30-day infection-related complication (black relative risk = 1.27 [0.91-1.78], Hispanic relative risk = 1.22 [0.63-2.36], and white relative risk = 1.00 [referent])

*The 95% confidence intervals are given in brackets. †Longer length of stay was defined as greater than fifteen days. ‡Postoperative complications included urinary tract infection, pneumonia, myocardial infarction, hemorrhage, deep vein thrombosis or pulmonary embolism, and death. §Complications directly related to surgery included postoperative bleeding or hematoma, wound infection, wound dehiscence, or gastrointestinal problems. #Thirty-day morbidity included myocardial infarction, pulmonary embolism, and complications, such as urinary tract infection, prolonged ileus, superficial wound infection, and deep vein thrombosis, that were identified by the orthopaedic surgeon.

patients less than fifty-five years old who had a total hip replacement were more likely to have a longer length of stay than were whites of the same age group (odds ratio, 1.93; 95% confidence interval, 1.24 to 2.99)³⁵. Weaver et al. also found that

whites were less likely to have a longer length of stay than were blacks (odds ratio, 0.88; p = 0.0001)³².

Two studies examined length of stay after total knee replacement, and both found that nonwhites had a signifi-

cantly higher risk of a longer length of stay. Collins et al. found that nonwhite patients who had a total knee replacement had a higher risk of a length of stay of greater than fourteen days (the 75th percentile for length of stay after total knee replacement) (odds ratio, 1.6; $p \leq 0.01$)³¹. Weaver et al. used stepwise regression techniques to find that white patients who had a total knee replacement were less likely to have a longer length of stay (odds ratio, 0.86; $p = 0.0001$)³².

Other Total Joint Replacement Complications

Several studies assessed the relationship between race and a variety of other postoperative complications of total joint replacement. In a study of total hip replacement, Mahomed et al. found that, compared with whites, blacks did not have a significantly increased risk of readmission, pulmonary embolus, or hip dislocation all within ninety days after surgery²². Mahomed et al. also found these same outcome parameters to be unassociated with race even after revision total hip replacement. Ibrahim et al. found that race was not significantly associated with non-infection-related complications occurring within thirty days following total hip replacement (Table II)³⁰.

Similarly, for total knee replacement, Feinglass et al. did not find a significant association between inpatient complications and residence in neighborhoods in which >50% of the population was black³⁴. However, Weaver et al. found that, in the thirty days following total knee replacement, whites were less likely to experience a complication (odds ratio, 0.79; 95% confidence interval, 0.66 to 0.94)³². Ibrahim et al. similarly found that blacks were more likely to experience a non-infection-related complication within thirty days (relative risk, 1.50; 95% confidence interval, 1.08 to 2.10)³⁰. Hispanics, however, did not differ significantly from whites with regard to their risk for a complication in the thirty days after total knee replacement. Mahomed et al. found that, in the ninety days following total knee replacement, blacks had an increased risk of readmission to an acute care facility for manipulation under anesthesia (odds ratio, 1.4; 95% confidence interval, 1.2 to 1.7)²⁶. SooHoo et al. found that, compared with whites, blacks were at a significantly greater risk of pulmonary embolism following total knee replacement (odds ratio, 1.74; 95% confidence interval, 1.36 to 2.23), whereas Hispanics did not have a significantly increased risk³⁶.

Discussion

In this systematic review of the literature, we compiled evidence from the nine studies that fulfilled our eligibility criteria on associations between race or ethnicity and various postoperative outcomes after total knee or hip replacement. One of the most striking findings from our work is that research on orthopaedic postoperative outcomes for racial and ethnic minority groups is sparse. Ibrahim et al. performed the only study that explicitly focused on the association between race or ethnicity and postoperative outcomes after total knee replacement or total hip replacement³⁰. The findings reported by Ibrahim et al. suggest that black and Hispanic groups have more complications after total knee replacement. Evidence

from the other studies identified in our search supports this finding. Specifically, after total knee replacement, racial and ethnic minority groups have more postoperative complications on a number of dimensions including mortality, length of stay, reoperation within ninety days, infection within thirty and ninety days, pulmonary embolus within ninety days, general morbidity within thirty days, and general non-infection-related complications within thirty days^{30-32,36}.

The strongest association between race or ethnicity and an outcome following total joint replacement is the association between race and length of stay. Both of the studies examining this relationship for total hip replacement found that nonwhites are at an increased risk for a longer hospital stay following total hip replacement^{32,35}. This finding parallels evidence indicating that nonwhite groups have a longer hospital stay after total knee replacement^{31,32}. All four studies examining length of stay adjusted for comorbidities. Compared with whites, racial and ethnic minorities have been shown to be less likely to opt for total joint replacement^{20,38} and to have more advanced osteoarthritis at the time of surgery. The severity of arthritis was not adjusted for in the included studies and could potentially contribute to a longer hospital stay after total joint replacement among minorities. It is also possible that nonwhites are less likely to be referred to rehabilitation facilities after an acute hospital stay and to stay longer in the acute hospital on that basis. Further work is needed to better understand the mechanisms underlying length of stay for racial and/or ethnic minority groups following total joint replacement.

On the basis of the studies included in this review, associations between total hip replacement and postoperative outcomes for racial and ethnic minorities are less evident. The studies included in this review found that racial and ethnic minority groups were at increased risk for a longer hospital stay and mortality within ninety days after total hip replacement. However, only Mahomed et al. and Ibrahim et al. extensively studied the relationship between race and total hip replacement outcome (both primary and revision)^{22,30}. Both studies failed to find significant associations between race or ethnicity and adverse outcome on a number of measures, including infection and non-infection-related complications within thirty days; mortality within ninety days after revision total hip replacement; and pulmonary embolus, hip dislocation, and infection within ninety days after primary and revision total hip replacement. Focused work in the area of orthopaedic outcomes research for racial and ethnic minorities is required in order to better understand functional outcomes after total hip replacement. Furthermore, the relationship between race or ethnicity and mortality is unclear from the studies included in this review. For both total hip replacement and total knee replacement, two studies assessed mortality after the index procedure; in both instances, one study found a significant association between race or ethnicity and mortality, while the second study did not find an association. Such contradictory findings highlight the need for further investigation.

Since only one of the nine included studies was specifically designed to examine the association between race or

ethnicity and outcome, the other eight studies are at risk of being underpowered. Indeed, for many of the studies, the number of nonwhites undergoing the procedure is small. That observation, coupled with the rarity of most of the outcomes (e.g., infection and death), leads to underpowered analyses, with confidence intervals that cross 1.0, even in the face of clinically meaningful measures of association. We reported confidence intervals (unless authors did not provide them) to further illuminate this issue.

This review does not focus on socioeconomic status in relation to race and outcomes after total hip replacement and total knee replacement. However, socioeconomic status is a complicated construct that may confound analyses of race or ethnicity. Low socioeconomic status has been previously identified as an independent risk factor for adverse outcomes after orthopaedic procedures^{39,40}. Therefore, studies assessing race and/or ethnicity and outcome must be risk-adjusted for socioeconomic status. Six of the nine studies included in this review controlled for socioeconomic status, with low socioeconomic status defined by Medicaid eligibility, self-reported income, or zip code analysis^{22,26,32,34-36}. The remaining three studies did not adjust for race, leaving unanswered the question of whether race and ethnicity effects were actually due to socioeconomic status.


The elevated complication rates likely have substantial repercussions for resource utilization, although this issue has not been studied formally. For example, Hebert et al. found that the surgical treatment of patients with an infection after total knee replacement required three to four times the hospital resources compared with a primary procedure⁴¹. Similarly, Bozic and Ries found that the total direct medical cost associated with revision total hip replacement because of an infection is 4.8 times higher than the direct medical costs associated with primary total hip replacement⁴². Further study of this issue would be fruitful.

Our review has limitations. Only one study set its primary objective to assess the association between race or ethnicity and postoperative outcomes after orthopaedic procedures³⁰. Studies designed for other purposes may have given less careful attention to defining race or ethnicity. All studies used retrospective observational designs, which are vulnerable to bias. Many studies included in this review characterize recipients as black, nonwhite, or white. This mixing of racial and ethnic categories may result in heterogeneity, which could attenuate the effects measured for vulnerable populations, biasing findings toward the null hypothesis⁴³⁻⁴⁵. We acknowledge that our review essentially compares whites and nonwhites, and that more nuanced comparisons among specific racial and ethnic groups were not possible given the studies available. Research on postoperative outcomes after total joint replacement in racial and ethnic minority groups is also limited by underutilization

of these procedures. The disproportionately small numbers of racial and ethnic minorities who receive orthopaedic procedures provide fewer observations of postoperative outcomes. For each of the measured outcomes in this review, only one or two studies assessed the outcome of interest.

This review exposes the paucity of literature on health outcomes for racial and ethnic minority groups after orthopaedic procedures. On the basis of the available literature, racial and ethnic minority groups appear to have a higher risk for a longer hospital stay and early complications (less than ninety days), particularly joint infection, after total knee replacement. The literature on total hip replacement is less conclusive; however, racial and ethnic minority groups appear to be at increased risk for a longer hospital stay after total hip replacement. More research is needed to substantiate some of the findings in this study. Given the paucity of available literature (nine studies), the fact that the majority of these studies were not intended to compare results among ethnic groups and the percentage of nonwhites in each study was very small, combined with the fact that numerous studies did not include any data on outcomes stratified by race and/or ethnicity, we emphasize that more data are needed to address the role of race and ethnicity on outcomes of total joint replacement. Ultimately, this information may assist in improving the quality of our health-care systems and the health of patients^{46,47}.

Appendix

 A table listing the nine studies evaluated is available with the electronic version of this article on our web site at jbjs.org (go to the article citation and click on "Supporting Data"). ■

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