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# Racial and Ethnic Disparities in Utilization of Total Knee Arthroplasty among Older Women

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## Abstract

**Objective:** To evaluate racial and ethnic disparities in utilization of total knee arthroplasty (TKA) in relation to demographic, health, and socioeconomic status variables.

**Design:** Prospective study of 102,767 Women's Health Initiative postmenopausal women initially aged 50–79, examining utilization rates of primary TKA between non-Hispanic Black/African American, non-Hispanic White, and Hispanic/Latina women (hereafter referred to as Black, White, and Hispanic). A total of 8,942 Black, 3,405 Hispanic, and 90,420 White women

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Contributions:

AC, AL, MR, JA, CT, and TG contributed to the conception and design of the study. AC performed the statistical analysis. All authors contributed to the interpretation of results, critical revision of the article, and final approval of the article.

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with linked Medicare claims data were followed until time of TKA, death, or transition from fee-for-service coverage. Absolute disparities were determined using utilization rates by racial/ethnic group and relative disparities quantified using multivariable hazards models in adjusting for age, arthritis, joint pain, mobility disability, body mass index, number of comorbidities, income, education, neighborhood socioeconomic status (SES), and geographic region.

**Results:** TKA utilization was higher among White women (10.7/1,000 person-years) compared to Black (8.5/1,000 person-years) and Hispanic women (7.6/1,000 person-years). Among women with health indicators for TKA including diagnosis of arthritis, moderate to severe joint pain, and mobility disability, Black and Hispanic women were significantly less likely to undergo TKA after adjusting for age [Black: HR(95% confidence interval) =0.70 (0.63–0.79); Hispanic: HR=0.58 (0.44–0.77)]. Adjustment for SES modestly attenuated the measured disparity, but significant differences remained [Black: HR=0.75 (0.67–0.89); Hispanic: HR=0.65 (0.47–0.89)].

**Conclusions:** Compared to White women, Black and Hispanic women were significantly less likely to undergo TKA after considering need and appropriateness for TKA and SES. Further investigation into personal-level and provider-level factors that may explain these disparities is warranted.

### Keywords

joint replacement; African American; Hispanic; arthritis; Medicare

## Introduction

Total knee arthroplasty(TKA) is a cost-effective treatment for severe knee arthritis, which can lead to improved physical function and quality of life.[1–3] Despite the benefits of TKAs, racial and ethnic minority groups in the United States have lower utilization of the procedure.[4] Measured disparities among older women, the demographic most likely to be in need of TKA,[5,6] range from 12–28% lower utilization among Blacks[7–10] and 5–40% lower among Hispanic women[9,10] when compared with White women. The reasons and underlying mechanisms for these disparities remain to be identified.

The majority of the research on disparities in TKA utilization has relied on healthcare administration data,[4] with many studies using Medicare data.[7,8,10–12] Analyses of Medicare claims data hold considerable value, as Medicare, the federal health insurance program for Americans aged 65 and older, is the most common primary insurance payer for TKAs[13,14] However, healthcare administration data sources, such as Medicare data, provide limited ability to identify and account for differences in need for TKA, including severity of arthritis or activity limitation. Additionally, healthcare administration data does not include information on beneficiary socioeconomic status(SES). Despite the strong association between SES and healthcare utilization, relatively few studies have investigated the influence of individual-level socioeconomic factors on racial/ethnic disparities in TKA utilization.[9,15]

This study examined disparities in TKA utilization between non-Hispanic Black, non-Hispanic White, and Hispanic/Latina women enrolled in the Women's Health

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Initiative(WHI). WHI is a prospective study that recruited post-menopausal women from across the United States. Racial/ethnic disparities in TKA utilization were examined adjusting for demographic, health, and SES variables, including variables of need for and access to the surgery.

## Methods:

### Participants:

This study used prospectively collected data from the WHI Clinical Trial(CT) and Observational Study(OS). The WHI design is described in detail elsewhere.[16,17] Briefly, 161,808 post-menopausal women, aged 50–79, were recruited from 40 clinical centers in the US, between 1993 – 1998. Participants were followed until study close in 2005, at which time surviving women were invited to participate in a series of WHI Extension Studies(ES) that have continued through today. Written informed consent was obtained from each participant. Procedures were approved by institutional review boards at all participating institutions. Medicare data has been linked to consenting WHI participants and 90% of WHI participants have Medicare data available.

WHI participants with linked Medicare data were included in this study population(Figure 1). The sample was restricted to women who self-identified with one of three mutually exclusive racial/ethnic groups: non-Hispanic white, non-Hispanic black/African American, and Hispanic/Latino, hereafter referred to as White, Black, and Hispanic, respectively. We excluded participants whose original reason for Medicare eligibility was disability benefits or end-stage renal disease(ESRD). Women with prior TKA were excluded, as determined by self-report at WHI enrollment of a history of total joint replacement (other than hip). For women over age 65 at WHI enrollment, Medicare fee-for-service(FFS) claims indicating TKA prior to date of WHI enrollment were also used to identify prior TKA. Because hospital procedural codes are available for Part A FFS beneficiaries but not Medicare managed care beneficiaries, only participants with Part A FFS coverage at WHI enrollment (for women over age 65) or who had Part A FFS coverage when they aged into Medicare (for women under age 65 at time of WHI enrollment) were included.

### Determination of TKA

Primary TKA procedures were identified using the Ninth Revision of the International Classification of Diseases(ICD-9-CM) primary procedure code 81.54 in Medicare Provider Analysis and Review (MEDPAR) files and inpatient Medicare files. For participants with more than one TKA during the study period, only the first procedure date was used.

### Independent Variables

Age, race/ethnicity, income, and education were ascertained by questionnaire at WHI enrollment. Race/ethnicity was categorized into three mutually exclusive groups according to the race/ethnicity with which the participant reported she most identified. Highest educational attainment was classified as less than high school diploma, high school or general educational development (GED), some college or vocational training, or baccalaureate degree or higher. Household income was classified as less than $20,000,

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$20,000 to less than $50,000, or $50,000 or greater, according to reported family gross annual income. Neighborhood socioeconomic status (NSES) is an index variable computed from census-tract level data including percentage of adults older than 25 years with less than a high school education, percentage of male unemployment, percentage of households with income levels below the poverty line, percentage of households receiving public assistance, percentage of female-headed households with children, and median household income.[18,19] NSES index values range 0–100 with higher scores representing more affluence. Region was classified into four categories (Midwest, Northeast, South, West) based on U.S. Census definitions and corresponding to participants' region of residence at time of WHI enrollment.

Health information was collected at WHI enrollment and follow-up. Self-reported doctor-diagnosed medical conditions were used to categorize arthritis and multimorbidity. Medical history questionnaires were administered at baseline for all participants, bi-annually for the first two years and annually thereafter for CT participants, and annually for OS participants. At baseline, women who reported ever receiving doctor-diagnosis of arthritis were additionally questioned about type of arthritis [Rheumatoid arthritis (RA) or other/don't know]. Questionnaires at follow-up specifically identified doctor-diagnoses of RA and osteoarthritis (OA). Self-report of doctor-diagnosed hypertension, coronary artery disease, diabetes, congestive heath failure, stroke or transient ischemic attack, osteoporosis, Alzheimer's disease, asthma, emphysema, or cancer was used to calculate total number of comorbidities (classified as none, one to two, three or more). This methodology is modeled from literature of multimorbidity within WHI,[20] using recommendations for standardization in research by the Multiple Chronic Condition Working Group within the Health and Human Services Office of the Assistant Secretary of Health[21,22] Joint pain was dichotomized based on report of joint pain and stiffness at a moderate or severe level. Mobility disability was categorized dichotomously according to whether participants reported any limitation in either "walking several blocks" or "climbing one flight of stairs" within the RAND 36-Item Health Survey questionnaire.[23] Joint pain data was collected from CT participants at enrollment, one year, and study close, with a 25% subsample completing additional surveys at three, six, and nine years; from OS participants at baseline and year three, and for ES participants at year two of second ES. Mobility disability data was collected from CT participants at enrollment, one year, and study close, with a 25% subsample completing additional surveys at three, six, and nine years; from OS participants at baseline and year three; and annually during the ES. Body mass index (BMI) was calculated from anthropometric measurements recorded by trained staff at WHI participants' baseline clinic visit, annually thereafter for CT participants, and at year three for OS participants. Height was measured to nearest 0.1 cm using a wall-mounted stadiometer and weight was measured to nearest 0.1 kg using a balance beam scale with participant wearing light clothes without shoes. BMI, calculated as weight in kilograms divided by height in meters squared, was categorized as follows: underweight/normal (healthy) weight (<25), overweight (25 to <30), obese I (30 to <35), obese II/ III (≥35).[24]

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### Need and Appropriateness for TKA

The National Institutes of Health (NIH) Consensus Statement on Total Knee Replacement identified the following as indicators for TKA: 1) radiographic evidence of joint damage, 2) moderate to severe pain not adequately relieved through nonsurgical management, and 3) diminished quality of life due to significant functional limitation.[1] The NIH Consensus Statement reported that few absolute contraindications to TKA exist and specified that neither advanced age nor obesity are by themselves absolute contraindications. In accordance the NIH Consensus Statement, health variables of diagnosis of OA or RA, moderate to severe joint pain, and mobility disability were used to identify a subsample of women classified as having "Need and Appropriateness for TKA." Radiographs were not available in this study and thus radiographic evidence of joint damage could not be included in the determination of need and appropriateness.

### Follow-up time

Follow-up time for the full analytic sample was calculated from date of WHI enrollment for women age 65 or older and from date of Medicare enrollment for women under age 65 at WHI enrollment. Follow-up time in the subsample with need began at the first time point (baseline or later) when the participant reported diagnosis of OA or RA, moderate to severe joint pain, and mobility disability. Observations were censored at death, when participants no longer had Part A FFS coverage, or at time of the last available FFS claims data (December 2014).

### Statistical analyses:

Baseline characteristics were compared by racial/ethnic groups using Chi-square and analysis of variance tests for categorical and continuous variables, respectively. Unadjusted utilization rates stratified by baseline characteristics were calculated to examine absolute rates of disparities. Numerators included number of primary TKAs and denominators were total person-years of follow-up within the subgroup. Presentation was restricted to baseline characteristics with more than 20 observed TKAs in the stratum.

To examine relative disparities in primary TKA utilization, time to first TKA was analyzed using Cox proportional hazards (PH) regression models. Assumption of PH of race/ethnicity was assessed through visual inspection of unadjusted Kaplan-Meier survival curves. PH of the multivariable models were assessed through correlation of Schoenfeld residuals with time. Variables were assessed for collinearity using cut-off tolerance value of <0.10. Age-adjusted race-specific hazards ratios (HR) were determined in the full analytic sample and within the subsample of need. Age and year at start of follow-up were dually included to adjust for late entry into the risk set. SES variables including income, education and NSES were included in a final regression model within the full sample and within the subsample of need to evaluate whether the association of race/ethnicity and rate of TKA was independent of SES. Geographic region is strongly linked to healthcare utilization in general and TKA utilization specifically,[12,25] and thus region was also included as a covariate in this model.

Quintiles of risk for TKA were created by ranking predicted probabilities of a TKA within five years, as determined using Cox-proportional hazards models with the following known

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predictors of TKA to rank risk profiles: age, OA, RA, joint pain, mobility disability, BMI, and multimorbidity. The most recent health variables before start of the follow-up period were used for each subject. Kaplan-Meier failure curves were stratified by ethnicity to visualize cumulative probability of TKA in each quintile of risk. Survival curves were compared between White women and each minority group using the log-rank test.

Several sensitivity analyses were performed. In the first set of sensitivity analyses, the analytic population was further restricted to WHI participants with continuous FFS coverage, rather than censoring at time of transition from FFS coverage. Because of missing data for income, it was removed from the final multivariable Cox model in additional analyses.

Statistical significance was set at $P<0.05$ for the analyses. Interactions were considered significant at $P<0.10$. All analyses were performed with SAS (Version 9.4; SAS Institute Inc., Cary, NC, USA).

## Results:

The study population included 102,767 women with an average follow-up time of 9.7 years; 88.0% of subjects were White, 8.7% Black, and 3.3% Hispanic. Black and Hispanic women tended to be younger and had lower income, educational attainment, and NSES compared with White women (Table 1). Prevalence of self-reported doctor-diagnosed arthritis was highest among Black women (48.8%), followed by White (45.7%) and Hispanic women (39.0%).Black women had the greatest prevalence of moderate to severe joint pain (28%) followed by Hispanic (25.6%) and White women (23.2%). Similarly, Black women had the highest prevalence of mobility disability (33.8%) followed by Hispanic (28.7%) and White women (19.5%).

White women had the highest rate of primary TKA at a rate of 10.7 per 1,000 person-years, followed by Black (8.5 per 1,000 person-years) and Hispanic women (7.6 per 1,000 person-years; Table 2). These rates of TKA were greater in women with arthritis (15.3, 13.0, 11.0), moderate to severe joint pain (19.5, 16.5, 14.1), and mobility disability (18.9, 12.7, 11.2) respectively for White, Black and Hispanic women. Utilization rates were higher among women with higher levels of multimorbidity and BMI. Rates varied by region, with utilization in the Northeast tending to be lower than other regions. Black and Hispanic women had lower utilization in all strata of baseline characteristics compared to Whites, with most differences reaching nominal statistical significance.

In the full analytic sample, after adjusting for age, Blacks had a 22% lower rate (HR=0.78; 95% CI 0.72–0.85) and Hispanics a 32% lower rate (HR=0.68; 95% CI 0.59–0.79) of TKA, compared with White women (Table 3). Disparities in receipt of TKA were more marked in the subset of 15,477 women who fit criteria for “Need and Appropriateness of TKA” either at baseline or during follow-up. In this subsample (n= 15,477), after adjusting for age, Black women had a 30% lower rate (HR=0.70; 95% CI 0.63–0.79) and Hispanic a 42% lower rate of undergoing TKA (HR=0.58; 95% CI 0.44–0.77) compared with Whites. Further adjustment for region and SES variables of education, income, and NSES in the subsample

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of need modestly attenuated the association between race/ethnicity and TKA, but statistically lower hazards of TKA persisted for both minority groups (Full regression results available in supplementary table).

Figure 2 indicates that in the highest two quintiles of risk, Blacks and Hispanics were less likely to undergo TKA compared with Whites. Utilization was low in all racial/ethnic groups in the lowest three quintiles of risk during the five-year period.

Restricting the analytic population to women with continuous FFS coverage versus censoring time at transition from FFS led to similar hazard ratios. Results were similar when the income variable was not included in the final multivariable Cox model.

## Discussion:

In a nationwide cohort of women enrolled in Medicare FFS, Black and Hispanic women were significantly less likely to undergo TKA than Whites. After accounting for need and appropriateness for TKA, Black and Hispanic women experienced significantly lower utilization over time than Whites. SES attenuated racial/ethnic disparities slightly, but Black and Hispanic women remained significantly less likely to undergo TKA.

Similar to published findings using national Medicare claims data, we found lower TKA utilization among Blacks and Hispanics among our analytic sample of Medicare FFS-insured, older women.[7,8,11] Our evaluation of disparities within a subsample of women with "Need and Appropriateness" for a TKA procedure attempted to provide a more accurate measurement of disparity, which according to the Institute of Medicine (IOM) is defined as differences in the "quality of health care that are not due to access-related factors or clinical needs, preferences, and appropriateness of intervention."[26] Our finding of a widening of the relative disparities after restricting to this subsample with need suggests that rates calculated from healthcare administration data that use beneficiary enrollees as a denominator may be underestimating the disparities between racial/ethnic groups. Controlling for access-related factors including income, education and neighborhood SES allowed for investigation of the impact of SES on utilization patterns. While all participants had Medicare FFS insurance coverage, financial expenses including deductibles and copayments as well as lost wages are access factors expected to impact decision-making for this elective procedure. In this study, Black and Hispanic women had lower rates of TKA at all levels of SES. Inclusion of income, education, and NSES in the multivariable PH model attenuated the association between race/ethnicity and TKA, but significant differences between racial/ethnic groups remained. While few data sources have been used to investigate the impact of SES on racial/ethnic disparities to date, our findings are consistent with research showing that black-white comparisons are not explained in large part by SES alone.[10] Few studies have examined utilization disparities between Hispanic and non-Hispanic populations, and the research to date offers conflicting findings.[9,12,15] Two studies using detailed SES data from the Health and Retirement Study found that medical access factors largely explained underutilization among Hispanic White compared with non-Hispanic White older adults. However, a study by Skinner et al.[12] using Medicare data found that ethnic differences in utilization rates varied by regional income level, and in low income regions, Hispanic women had

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significantly lower utilization compared with non-Hispanic White women. In our study, access to care factors only modestly explained lower TKA utilization among both minority groups.

Medical treatment of advanced knee arthritis is considered preference-sensitive care, in which several treatment options exist and a decision to elect TKA should reflect informed patient preference. Though general indications for TKA exist, in practice, a significant portion of cases fall along a continuum of clinical certainty, where TKA would be considered the most appropriate treatment recommendation and, conversely, where TKA would not be indicated.[27] The decision to pursue TKA within the “grey zones” of clinical uncertainty may be influenced by provider opinion about the value of a TKA, and, consequently, provider biases may influence decision-making in these cases.[28] The presence of implicit racial bias and patient race preference on the part of the provider have been well-supported by the literature, yet the impact of these provider biases on clinicians’ recommendations for TKA are less clear.[28–35] In our study, we stratified rates by quintile of risk to examine whether gaps in utilization were wider in risk profiles where there would likely be more uncertainty about the value of TKA and therefore, clinician discretion might be of greater impact. However, the largest gaps in TKA utilization were found in the highest risk quintile, or among those with the clearest indication for TKA, with only minimal differences noted in the moderate quintile. While provider bias and differential recommendations by patient race/ethnicity cannot be ruled out with our study design, the large gap in utilization between racial/ethnic groups amongst those with greatest risk/indications for TKA suggests other factors may be driving disparities.

Disparities in TKA utilization are likely multifactorial in cause, involving system-level factors such as access to care, provider-level factors including bias, discrimination, and culturally competent communication, and patient-level factors including biologic and genetic characteristics as well as cultural beliefs, values, and health behaviors.[36] In our study, adjusting for region and SES only modestly attenuated racial and ethnic disparities in utilization, suggesting that while access to care impacts TKA utilization among older women, other patient- and provider-level factors may be largely contributing to such disparities. Patient preferences and willingness to undergo surgery are postulated to greatly affect utilization disparities[36–38] and may be a large factor in the gap in TKA utilization among women with highest risk and need for TKA in this study. Mistrust of the medical system and providers, fear of pain with surgery, poor knowledge about/familiarity with the TKA procedure, and a lack of perceived benefit of the TKA procedure have been documented to be highly prevalent in Black adults with arthritis.[4] These factors have been negatively associated with willingness to consider TKA as a treatment option.[39] Among Hispanics, lower perceived value of the TKA procedure has been reported.[40] Addressing fears and expectations of surgery are an integral part of communication for informed decision-making, and may be fundamental to improving uptake of TKA among minority women with highest risk/need of the procedure. Because health beliefs and attitudes regarding arthritis and surgical treatment may vary between racial/ethnic groups, communication during the decision-making process may also need to differ accordingly, in order to best achieve relationship-building and information-sharing.[33] The underrepresentation of orthopedic specialists of minority race/ethnicity presents a challenge,

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[41] as race/ethnic concordance of provider and patient has been shown to improve communication and may increase healthcare utilization by minorities.[42–44]

This study has several limitations. While diagnosis of arthritis, symptoms of moderate-to-severe joint pain, and presence of mobility disability were captured prospectively through this study design, neither radiographic evidence of severity of joint damage nor clinical examination data was available to confirm a clinical need for TKA. The prevalence of self-reported rheumatoid arthritis in our study is higher than prevalence rates in the US, [45] and may reflect inaccurate reporting of arthritis type. Because of known inaccuracies in self-reported type of arthritic disease,[46] women who self-reported diagnoses of either RA or OA were included in the subsample with need for TKA, without adjustment for type of arthritis. Evidence suggests that pain tolerance and reporting may differ by race/ethnicity,[47] and the severity of joint pain does not always correlate with level of joint damage.[48] Therefore, it is possible that participants who presented with joint pain but had no significant knee joint damage were overrepresented in the subsample with need for TKA. In addition, mobility limitation was not directly linked with knee arthritis and could have been caused to other conditions. SES covariates were attained at WHI enrollment, and, therefore, baseline characteristics of income or neighborhood may not precisely reflect individual-level characteristics over time. TKA utilization varies by geographic region,[12] and, accordingly, we found significant differences in utilization by region. While we adjusted for region in our multivariate PH model, the adjustment by general area of the U.S. may not be precise enough to accurately measure geographic patterns of healthcare utilization, and there is a possibility that associations of race/ethnicity with TKA utilization were overestimated.[12] However, use of the NSES variable, which is calculated according to participant zip code, likely provided some additional level of adjustment for regional differences in utilization. The generalizability of this study is limited to older women with FFS Medicare coverage and may not be applicable to other populations. FFS beneficiaries in the WHI population have been found to be similar to the entire WHI population in terms of health behaviors and outcomes,[49] yet differences in race/ethnicity and region exist. Therefore caution should be taken in generalizing these findings to non-FFS populations. Furthermore, these results may be not be generalizable to younger populations where insurance coverage is less universal and likely contributes significantly to disparities in utilization of the procedure. While all women had Medicare FFS coverage, we did not have information about supplemental insurance coverage during the period of follow-up, which may have impacted decisions to pursue surgical intervention.[9] Data collection procedures did not allow participants to self-identify with multiple racial/ethnic groups and did not include information about ancestry/country of origin for those identifying as Hispanic/Latina. All three groups likely embody some heterogeneity, but in particular, the Hispanic/Latina population may combine many diverse subgroups of women from different national origins, cultures, languages, and social customs. These differences may impact healthcare utilization.[50] Finally, we used the TKA utilization rate of White women as the reference. However, research suggests that women in need of TKA often delay or underutilize the procedure compared with men.[51,52] Therefore, it is important to note that the rate White women receive TKA may not be an accurate reflection of appropriate surgical treatment for end-stage arthritis and may itself be reflective of underutilization.

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Balancing these limitations, this study has several key strengths. The study adds new evidence to the current body of literature investigating disparities in receipt of TKA. We were able to use information from a large, diverse population of community-dwelling older women with prospectively collected data on severity of pain and activity limitations. Individual-level SES data allowed us to investigate the influence of medical access factors on disparities. A major strength of this study is the sample size of Hispanic women that allowed us to examine Hispanic and non-Hispanic comparisons in more detail than previous studies.

These findings have important implications for equity in delivery of healthcare services. Among older women, Hispanic and Black women were significantly less likely to undergo TKA, a procedure that is considered highly cost-effective for treatment of end-stage knee arthritis. This study contributes to the body of evidence that disparities in TKA utilization persist when accounting intergroup differences in health need and SES. Black and Hispanic women may be underutilizing a procedure that could improve mobility, reduce pain, and increase their quality of life. While personal preference and cultural beliefs should be honored, it is important that inferior medical care not be provided to minorities due to reasons such as inadequate patient knowledge or patient misconceptions, poor patient-provider communication, or discrimination. Further research into patient-and provider-level factors affecting decision-making in patients of minority race/ethnicity may help develop strategies for provision of more equitable treatment of patients experiencing painful, activity-limiting arthritis.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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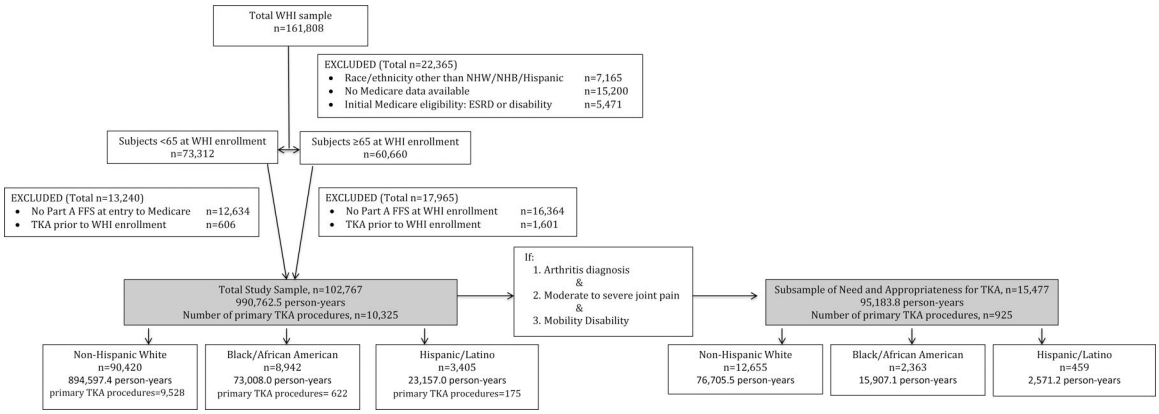


**Figure 1.**
Study population determination flow chart

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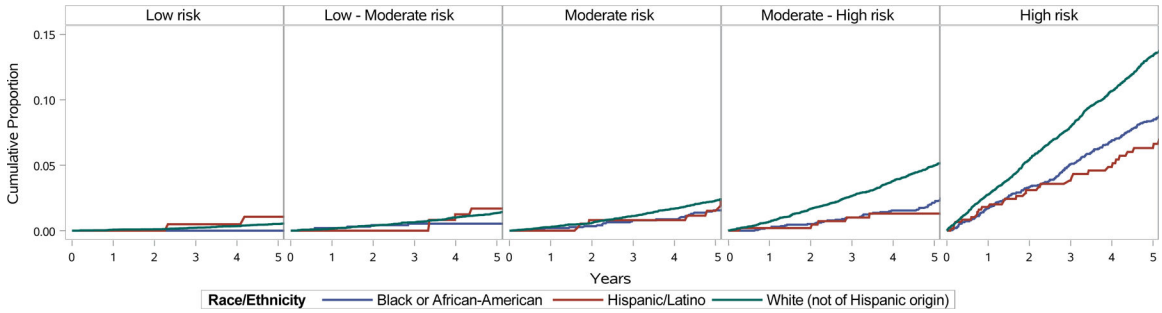


**Figure 2.**

Risk quintiles determined through predicted probabilities of TKA determined through Cox hazards regression with independent variables of age, diagnosis of OA, RA, joint pain, mobility disability, BMI, and number of comorbidities. Failure curves through Kaplan-Meier method used to determine proportion of women undergoing TKA in each quintile.

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**Table 1.**

Baseline characteristics of WHI fee-for-service Medicare enrollees by race/ethnicity (n=102,767)

| Characteristic | Black/African American (n=8,942) | Hispanic/Latino (n=3,405) | Non-Hispanic White (n=90,420) | p-value |
|---|---|---|---|---|
| Age at WHI enrollment | | | | <0.0001 |
| 50-<55 | 1,608 (18.0) | 840 (24.7) | 11,111 (12.3) | |
| 55-<60 | 2,148 (24.0) | 1038 (30.5) | 18,574 (20.5) | |
| 60-<65 | 2,349 (26.3) | 793 (23.3) | 21,610 (23.9) | |
| 65-<70 | 1,571 (17.6) | 457 (13.4) | 19,966 (22.1) | |
| 70-<75 | 904 (10.1) | 210 (6.2) | 13,652 (15.1) | |
| ≥75 | 362 (4.0) | 67 (1.9) | 5507 (6.1) | |
| Marital status (% married) | 4,821 (54.7) | 2,124 (64.0) | 62,556 (69.8) | <0.0001 |
| Educational Level | | | | <0.0001 |
| Less than high school | 864 (9.8) | 770 (22.9) | 2,581 (2.9) | |
| High school diploma or GED | 1,154 (13.0) | 563 (16.8) | 15,517 (17.2) | |
| Some college/vocational training | 3,410 (38.5) | 1,197 (35.6) | 33,090 (36.8) | |
| Baccalaureate degree or higher | 3,436 (38.7) | 831 (24.7) | 38,798 (43.1) | |
| Family Income | | | | <0.0001 |
| <$20,000 | 2,144 (25.7) | 1,013 (32.5) | 10,188 (12.0) | |
| $20,000-<$50,000 | 3,660 (43.9) | 1,279 (41.0) | 37,774 (44.4) | |
| ≥$50,000 | 2,541 (30.4) | 827 (26.5) | 37,164 (43.6) | |
| Neighborhood SES, *mean (SD)* | 64.47 (11.8) | 68.96 (10.5) | 77.37 (6.9) | <0.0001 |
| BMI | | | | <0.0001 |
| Underweight/Normal weight | 1,493 (16.8) | 872 (25.9) | 34,101 (38.1) | |
| Overweight | 2,939 (33.2) | 1,321 (39.2) | 31,542 (35.2) | |
| Obese I | 2,483 (28.0) | 757 (22.5) | 15,576 (17.4) | |
| Obese II | 1,198 (13.5) | 297 (8.8) | 5,865 (6.5) | |
| Obese III | 754 (8.5) | 121 (3.6) | 2,546 (2.8) | |
| # of comorbidities | | | | <0.0001 |
| 0 | 3,063 (34.3) | 1,842 (54.1) | 45,761 (50.6) | |
| 1–2 | 5,183 (58.0) | 1,424 (41.8) | 40,519 (44.8) | |
| 3 or more | 696 (7.7) | 139 (4.1) | 4,140 (4.6) | |
| Arthritis (% yes) | 4,316 (48.8) | 1,304 (39.0) | 40,957 (45.7) | <0.0001 |
| Rheumatoid arthritis (% yes) | 649 (7.3) | 175 (5.1) | 3,563 (3.9) | <0.0001 |
| Joint pain (% yes) | 2,465 (28.0) | 845 (25.6) | 20,897 (23.2) | <0.0001 |
| Mobility disability (% yes) | 2,989 (33.8) | 949 (28.7) | 17,478 (19.5) | <0.0001 |
| Region | | | | <0.0001 |
| Northeast | 1535 (17.2) | 463 (13.6) | 23,132 (25.6) | |
| South | 4,468 (50.0) | 1,563 (45.9) | 24,517 (27.1) | |
| Midwest | 2,214 (24.7) | 169 (5.0) | 23,895 (26.4) | |
| West | 725 (8.1) | 1,210 (35.5) | 18,876 (20.9) | |

Abbreviations: WHI, Women's Health Initiative; GED, general education diploma; SES, socioeconomic status; SD, standard deviation.

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**Table 2:**

Crude TKA utilization rates by baseline characteristics[a]

| | Rate per 1,000 person-years[b] | | | Absolute difference per 1,000 person-years[c] | | Percent difference[d] | |
|---|---|---|---|---|---|---|---|
| | **Black** | **Hispanic** | **White** | **White/ Black** | **White/ Hispanic** | **White/ Black** | **White/ Hispanic** |
| Crude | 8.5 | 7.6 | 10.7 | 2.1§ | 3.1§ | 19.6 | 29.0 |
| Age at WHI enrollment | | | | | | | |
| 50-<55 | 9.0 | 9.5 | 11.8 | 2.9* | 2.2 | 24.6 | 18.6 |
| 55-<60 | 9.8 | 6.4 | 12.1 | 2.4* | 5.8§ | 19.8 | 47.9 |
| 60-<65 | 9.3 | 6.4 | 11.7 | 2.4* | 5.3§ | 20.5 | 45.3 |
| 65-<70 | 7.8 | 9.9 | 10.4 | 2.6* | 1.5 | 25.0 | 14.4 |
| ≥70 | 6.6 | 6.7 | 8.6 | 2.0* | 1.9 | 23.3 | 22.1 |
| Educational Level | | | | | | | |
| Less than high school | 8.5 | 6.7 | 10.3 | 1.8 | 3.6* | 17.5 | 35.0 |
| High school diploma or GED | 9.8 | 7.8 | 11.0 | 1.2 | 3.2* | 10.9 | 29.1 |
| Some college/vocational training | 8.4 | 8.5 | 11.1 | 2.7§ | 2.6* | 24.3 | 23.4 |
| Baccalaureate degree or higher | 8.4 | 6.8 | 10.2 | 1.8* | 3.4* | 17.6 | 33.3 |
| Family Income | | | | | | | |
| <$20,000 | 7.7 | 6.8 | 9.9 | 2.1* | 3.0* | 21.2 | 30.3 |
| $20,000-<$50,000 | 8.6 | 7.5 | 10.9 | 2.3§ | 3.4* | 21.1 | 31.2 |
| ≥$50,000 | 9.1 | 8.5 | 10.7 | 1.7* | 2.2 | 15.9 | 20.6 |
| NSES | | | | | | | |
| Below median | 8.5 | 7.4 | 10.8 | 2.3§ | 3.4§ | 21.3 | 31.5 |
| Above median | 8.7 | 8.0 | 10.5 | 1.8* | 2.5* | 17.1 | 23.8 |
| Marital status | | | | | | | |
| Currently married | 9.1 | 8.2 | 10.9 | 1.8* | 2.7* | 16.5 | 24.8 |
| Not currently married | 7.9 | 6.4 | 10.1 | 2.2§ | 3.7§ | 21.8 | 36.6 |
| BMI | | | | | | | |

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| | Rate per 1,000 person-years[b] | | | Absolute difference per 1,000 person-years[c] | | Percent difference[d] | |
|---|---|---|---|---|---|---|---|
| | **Black** | **Hispanic** | **White** | **White/ Black** | **White/ Hispanic** | **White/ Black** | **White/ Hispanic** |
| Underweight/Normal weight | 2.3 | | 5.1 | 2.8§ | | 54.9 | |
| Overweight | 6.6 | 5.2 | 10.5 | 3.9§ | 5.3§ | 37.1 | 50.5 |
| Obese I | 10.1 | 12.1 | 16.9 | 6.8§ | 4.8* | 40.2 | 28.4 |
| Obese II/III | 14.1 | 19.1 | 24.8 | 10.8§ | 7.1* | 40.3 | 28.6 |
| Arthritis | 13.0 | 11.0 | 15.3 | 2.3* | 4.3§ | 15.0 | 38.6 |
| Moderate-to-Severe Joint Pain | 16.5 | 14.1 | 19.5 | 3.0* | 5.4* | 15.4 | 27.7 |
| Mobility Disability | 12.7 | 11.2 | 18.9 | 6.2§ | 7.6§ | 32.8 | 40.2 |
| # of comorbidities | | | | | | | |
| 0 | 7.5 | 6.4 | 9.6 | 2.1* | 3.2§ | 21.9 | 33.3 |
| 1–2 | 8.7 | 8.6 | 11.7 | 3.0§ | 3.0* | 25.6 | 25.6 |
| 3 or more | 11.1 | | 11.8 | 0.7 | | 5.9 | |
| Region | | | | | | | |
| Northeast | 7.5 | 6.0 | 9.1 | 1.5* | 3.1* | 16.5 | 34.1 |
| South | 9.1 | 8.3 | 10.5 | 1.3* | 2.2* | 12.4 | 21.0 |
| Midwest | 7.8 | | 12.9 | 5.2§ | | 40.3 | |
| West | 9.3 | 7.6 | 9.9 | 0.6 | 2.2* | 6.1 | 22.2 |

Abbreviations: TKA, total knee arthroplasty; NSES, neighborhood socioeconomic status; BMI, body mass index.

[a] Presentation of utilization rates restricted to cells with at least 20 observed TKAs.

[b] Crude utilization rate determined by number of primary TKAs by 1,000 person years of follow-up.

[c] Absolute difference computed as White-Minority.

[d] Percent difference computed as (White-Minority)*100/White.

* $p<0.05$.

§ $p<0.0001$.

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**Table 3.**

Adjusted hazard ratios for primary TKA, Women's Health Initiative, 1993–2014

| | Full Sample (n=102,767) | | Subsample of Need for TKA[a] (n=15,477) | |
|---|---|---|---|---|
| | Adjusted for age HR (95% CI) | Adjusted for age, region, and SES[b] HR (95% CI) | Adjusted for age HR (95% CI) | Adjusted for age, region, and SES[b] HR (95% CI) |
| Black/African American | 0.78 (0.72–0.85) | 0.77 (0.70–0.85) | 0.70 (0.63–0.79) | 0.75 (0.67–0.88) |
| Hispanic/Latina | 0.68 (0.59–0.79) | 0.69 (0.59–0.82) | 0.58 (0.44–0.77) | 0.65 (0.47–0.89) |
| White | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |

Abbreviations: TKA, total knee arthroplasty; HR, hazard ratio; CI, confidence interval; SES, socioeconomic status.

[a]Sample restricted to women with diagnosis of osteoarthritis or Rheumatoid arthritis, moderate to severe joint pain, and mobility disability.

[b]All models adjusted for age and year at start of follow-up. Final models additionally adjusted for region, highest educational attainment, income, and neighborhood SES in the full sample and subsample of need for TKA.